

Relationships between walking velocity and distance and the symmetry of temporospatial parameters in chronic post-stroke subjects

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Purpose: Subjects with post-stroke hemiparesis frequently present with asymmetric gait patterns. Symmetry, reflecting similarities in temporospatial, kinematic parameters, is an important measure of gait assessment. The study was designed to examine the relationships between asymmetry of temporal, spatial and kinematic gait parameters and walking velocity and distance. *Methods:* Temporospatial and kinematic gait parameters were examined in a group of 50 chronic post-stroke subjects and in a group of 25 healthy controls. Symmetry ratio was calculated for all the parameters. Gait velocity was measured during 10-metre test, the walking distance during 2-Minute Walk Test, and balance during Up&Go Test. *Results:* The relationship between stance phase duration symmetry and gait speed was at a moderate level ($r = -0.43$, $p = 0.0173$). There was a moderate relationship between swing phase symmetry and walking velocity and distance. The findings did not show a significant correlation between step length symmetry versus gait speed and distance. *Conclusions:* There is a mild relationship between self-selected gait velocity and walking distance versus temporal parameters symmetry. The findings do not confirm a relationship between self-selected gait velocity and walking distance versus spatial and kinematic parameters as well as balance. Likewise, no evidence confirms that asymmetry of temporal, spatial, kinematic gait parameters changes with the age of post-stroke subjects or is related to the length of time from stroke onset. Given the above, gait symmetry may be recognized as an important indicator of the level of gait control in post-stroke patients because it enables unique gait assessment, independent from other parameters.

Key words: stroke, symmetry, gait analysis, velocity

1. Introduction

Impaired gait function, experienced by 75% of post-stroke subjects, is one of the main causes of permanent disability [12]. Unassisted and safe ambulation enables involvement in daily routines, and the quality of life at the highest possible level for patients and their caregivers. Therefore, each and every rehabilitation program for patients after stroke focuses on restoring their functional independence by means of gait re-education [1], [30], [15], [10]. Paresis, sensory loss, impaired muscle tone, and impaired visual field are the main causes of deteriorating gait pattern after stroke. The altered gait

pattern leads to decreased walking velocity and distance, lower efficiency, impaired postural stability and high risk of falling.

Gait assessment, carried out at an early stage and later after stroke onset, is a sensitive measure of progress in treatment, makes it possible to adequately identify the level of functional condition and provides grounds for defining therapeutic goals. Contemporary diagnostic methods enable in-depth multidimensional gait analysis, based on temporospatial, kinematic, kinetic and electromyographic parameters. Applied most often in the relevant analyses, temporospatial parameters include gait velocity, cadence, step length and duration of gait phases. A number of studies have shown that gait veloc-

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ity positively correlates with motor control level and with functional independence level in post-stroke subjects [19], [27].

It has been demonstrated that post-stroke hemiparetic subjects frequently present with asymmetric gait patterns, in terms of both temporospatial and kinematic parameters. Over 50% of those able to walk unassisted at a later period after stroke, are found with temporal and spatial asymmetry of gait pattern. The characteristics of post-stroke gait asymmetry include increased or decreased swing time and stance time, i.e., temporal asymmetry, and increased or decreased step length, i.e., spatial asymmetry [25], [17], [11]. The consequences of gait pattern asymmetry include impaired postural stability, ineffective gait requiring greater energy expenditure, and dysfunctions of musculoskeletal system, such as loss in bone mass of femoral neck, and decrease in bone mass of the paretic lower limb [18], [16].

According to many authors improvement in gait function is manifested by angular changes in the joints, increased walking velocity and distance, as well as step length. Out of the many gait parameters, velocity is most frequently assessed in order to verify effects of gait re-education. Such frequent focus on this parameter is linked with the fact that it is, indeed, the final speed which can be achieved by a post-stroke patient that is decisive for his or her ability to function within their community [28], [8], [26], [23].

Gait quality, assessed in terms of symmetry in the duration of gait phases and step length shows a systematic tendency towards greater asymmetry at the later stages after stroke, and this trend has not been observed with regard to the gait velocity [19]. Symmetry, reflecting the similarity in temporospatial, kinematic or kinetic parameters of the right and left lower limb, is an important measure of gait assessment, which may be more effective than conventional methods in describing gait mechanism in post-stroke subjects. Furthermore, gait symmetry is linked with and

correctly reflects abnormal balance and the level of motor control [20]. Swing phase asymmetry is an important indicator of gait efficiency (quality) in post-stroke subjects, and it strongly correlates with the stages of restoring motor control, as well as walking velocity and risk of falling [7], [21].

It is assumed that post-stroke hemiparetic individuals, who are more efficient and faster walkers, have more symmetric gait pattern, yet at present there are many conflicting reports suggesting that an increase in gait velocity is not always linked with improved gait symmetry [24].

The present study was designed to answer the question whether the walking velocity and distance as well as the dynamic body balance in chronic post-stroke subjects are related to the symmetry of temporospatial and kinematic gait parameters and, secondly, whether gait symmetry in a group homogenous in terms of severity of paresis is linked with the subjects' age and time lapse from stroke onset. The adopted hypothesis assumed that lower asymmetry of the temporospatial and kinematic gait parameters coincides with a greater gait velocity and walking capacity. It was also assumed that the symmetry of the gait parameters investigated is not related to the time lapse from stroke or the age of post-stroke subjects.

2. Material and methods

2.1. Participants

The study group consisted of patients receiving treatment at the Clinical Rehabilitation Ward, Province Hospital No. 2 in Rzeszów, Poland. The qualifying criteria included: a single stroke (diagnosis based on computed tomography or magnetic resonance exami-

Table 1. Demographic and clinical characteristics of the study group

Outcome measures	Stroke participants ($n = 50$)				Healthy participants ($n = 25$)			
	Mean (SD)	median	c_{25}	c_{75}	Mean (SD)	median	c_{25}	c_{75}
Time from stroke (months)	43.8 (42.0)	26.5	12	60	–	–	–	–
Age (years)	60.9 (11.4)	60.5	55	69	59.2	58	54	69.2
Sex female/male	27/23	–	–	–	14/11	–	–	–
Paretic side right/left	35/15	–	–	–	–	–	–	–
Cadence (step/min)	68.2 (13.1)	66.0	58.2	77.0	105.3 (13.2)	102.1	98.1	112.7
Gait velocity (m/s)	0.45 (0.14)	0.43	0.36	0.57	1.21 (0.23)	1.15	0.98	1.36
2-Minute Walk Test (m)	72.3 (28.5)	70.8	46.5	89.9	154.2 (25.1)	146	135.2	165.1
Up&Go (s)	17.5 (7.5)	15.7	12.1	22.4	11.3 (2.3)	10.8	9.1	15.2

SD – standard deviation, c_{25} – 25th percentile, c_{75} – 75th percentile, p – statistical test result.

nation), more than 6 months from stroke onset, ability to walk unassisted, level of motor control assessed as stage 3–4 according to Brunnström and muscle tone in the paretic lower extremity at the level up to 1+ according to the modified Ashworth scale. The qualified subjects had no vision disturbances, sensory deficits, ataxia, cognitive impairments making it difficult for them to understand and follow instructions (Mini MentalScale over 24), and no orthopaedic disorders significantly affecting their gait.

Before the study, all the subjects received detailed information about its purpose and procedure, and they agreed to participate in writing. The study protocol was approved by the Bioethics Commission of the Medical Faculty (No. 5/11/2009).

50 subjects were qualified to participate. Their mean age was 60.9 years. The mean time from stroke onset was 43.8 months. The control group consisted of 25 healthy individuals. On average the controls were 59.2 years old. The group characteristics are presented in Table 1.

2.2. Measurements

The walking tests were carried out in Biomechanics Laboratory at the Institute of Physiotherapy of University of the Rzeszów. The system of optoelectronic motion analysis, tracking the location of passive, light-reflecting markers attached to the subject's body, was used to compute kinematic and temporospatial gait parameters, based on the first contact and displacement of the foot from the floor. The gait laboratory was equipped with six infrared cameras recording at 120 Hz (BTS Smart, BTS Bioengineering, Italy). The cameras were calibrated before each test day. The analysis was carried out using biomechanical program Tracker and Analyzer (BTS Bioengineering, Italy). At the same time two video cameras (Vicsta) were used to record the image in frontal and sagittal plane. Reference markers were placed according to internal protocol of the system (Helen Hayes (Davis) Marker Placement) on the sacrum, pelvis (anterior/posterior iliac spine), femur (lateral epicondyle, greater trochanter and in lower 1/3 of the shank), fibula (lateral malleolus, lateral condyle end in lower 1/3 of the shank), and foot (metatarsal head and heel) [6]. During the trial the subjects could use crutches, canes or tripods as well as orthoses used on a daily basis. During the trial in the laboratory the subjects were asked to walk with self-selected velocity, moving between designated points located 6 metres apart. For the needs of the analysis, 6 journeys were recorded

with complete data, and the score was the mean value for all the journeys. The assessed elements included paretic and non-paretic step length (SL), duration of the stance phase (ST), duration of the swing phase (SW), velocity of the lower extremity during the swing phase and the total range of movement (ROM) in the hip and knee joints for each limb.

During the assessment of gait velocity (m/s) over 10 meters, the participants walked at a comfortable speed within their own orthopedic capabilities [5]. The result was the average of the two trials. The 2-Minute Walk Test (m) was performed on the corridor where a 30-meter distance was marked with two lines [4]. Auxiliary lines were also marked every 5 meters. The participants walked for 2 minutes between the two lines marking the 30-meter distance. During the trial, the subjects walked at self-selected velocity and could use their own orthopedic aids. During the "Up&Go" test, participants were asked to get up from a sitting position in a chair with a backrest of standard height, walk the distance of three meters, turn around at a marked location, return to the chair and sit down unassisted [22].

2.3. Data and statistical analysis

Temporal and spatial gait symmetry ratios were calculated for each participant for the self-selected walking velocity, taking into account the appropriate mean swing and stance values in seconds and right and left step length values in centimeters, as well as the total left and right hip and knee range of motion in degrees [11]. The symmetries were each used in a ratio with the largest value in the numerator so that all values for every individual were >1.0 . A ratio value of 1.0 denotes perfect symmetry. The following ratios for temporal, spatial and kinematics symmetry were calculated:

- swing symmetry ratio (swing SR) = paretic swing time/nonparetic swing time,
- stance symmetry ratio (stance SR) = paretic stance time/nonparetic stance time,
- intra-limb ratio of swing to stance time (SW/ST) = swing time/stance time (for both paretic and nonparetic limbs).

Spatial step symmetry ratio (step length SR) = paretic step length/nonparetic step length.

Range of motion symmetry ratio (hip ROM SR) = paretic hip range of motion/nonparetic hip range of motion.

Range of motion symmetry ratio (knee ROM SR) = paretic knee range of motion/nonparetic knee range of motion.

Symmetric gait or asymmetric gait, in terms of both temporospatial and kinematic parameters, were determined with reference to 95% confidence interval (95% CI). The confidence interval was established around the mean value of the symmetry rates in the gait parameters identified in the group of 25 healthy controls. Gait was classified as asymmetric if the mean value of the parameters examined was outside 95% CI.

All calculations and statistical analyses were performed using STATISTICA ver. 10.0 (StatSoft, Poland). Characteristics of the parameter values distribution for the study group and for the controls were presented as the mean value, median and standard deviation. Parametric distribution of the characteristics investigated was assessed using the Shapiro–Wilk test. Significance of the differences in the distribution of the results for the paretic and non-paretic limb was calculated using Wilcoxon non-parametric test. The significance of differences between these two groups was assessed with the non-parametric precise version for small samples. A significance threshold level of $\alpha < 0.05$ was assumed. The correlation levels between gait velocity, walking distance and the score in Up&Go

test versus the symmetry ratios for the spatial, temporal and kinematic parameters were calculated using the Spearman rank correlation test.

3. Results

The post-stroke subjects' mean walking velocity, at the level of 0.45 m/s, was significantly lower than the mean walking velocity of the healthy controls. Likewise, significantly lower scores were obtained by the post-stroke subjects in the category of the walking distance in the 2-Minute Walk Test and with regard to the balance assessed by Up&Go test (Table 1).

In terms of the temporospatial and kinematic gait parameters, statistically significant differences between the group of subjects after stroke and the group of healthy controls were identified for all the parameters investigated. In the study group, it was shown that the mean paretic step length was greater than the non-paretic step length. The mean paretic step length was 0.3 m while the mean non-paretic step length was 0.25 ($p = 0.0001$) (Table 2).

Table 2. Kinematic and temporospatial parameters in the group of post-stroke patients

Outcome measures	Paretic				Non paretic			
	Mean (SD)	median	c_{25}	c_{75}	Mean (SD)	median	c_{25}	c_{75}
Stance phase [s]	1.08 (0.24)	1.06	0.90	1.25	1.25 (0.32)	1.21	1.02	1.42
Swing phase [s]	0.62 (0.16)	0.62	0.51	0.71	0.48 (0.16)	0.45	0.38	0.56
V Swing phase [m/s]	0.88 (0.44)	0.77	0.54	1.13	1.02 (0.44)	0.96	0.76	1.20
Step length [m]	0.30 (0.08)	0.28	0.24	0.35	0.25 (0.08)	0.25	0.19	0.29
ROM hip [°]	27.3 (5.1)	26.1	24.3	30.7	29.8 (6.3)	28.9	25.9	34.7
ROM knee [°]	34.6 (9.8)	33.5	26.7	40.3	42.4 (8.7)	41.6	35.1	49.3
SW/ST	1.84 (0.5)	1.72	1.46	2.15	2.82 (1.08)	2.64	1.99	3.47

SD – standard deviation, ROM – range of motion, V Swing phase – swing phase speed, c_{25} – 25th percentile, c_{75} – 75th percentile, p – test probability values calculated using the Wilcoxon test.

Table 3. Rate of symmetry in kinematic and temporospatial gait parameters in the group of post-stroke patients and the group of healthy subjects

Outcome measures	Stroke participants				Healthy participants			
	Mean (SD)	median	c_{25}	c_{75}	Mean (SD)	median	c_{25}	c_{75}
Stance phase SR	1.17 (0.16)	1.14	1.05	1.21	1.02 (0.02)	1.02	1.02	1.04
Swing phase SR	1.39 (0.24)	1.24	1.07	1.51	1.02 (0.02)	1.01	1.01	1.03
V Swing phase SR	1.36 (0.25)	1.27	1.15	1.42	1.03 (0.04)	1.02	1.02	1.04
Step length SR	1.38 (0.24)	1.27	1.10	1.54	1.02 (0.03)	1.01	1.02	1.05
ROM hip SR	1.21 (0.19)	1.16	1.09	1.33	1.04 (0.03)	1.02	1.03	1.07
ROM knee SR	1.37 (0.27)	1.34	1.15	1.54	1.03 (0.02)	1.02	1.04	1.08
SW/ST SR	1.59 (0.27)	1.40	1.13	1.70	1.04 (0.03)	1.03	1.03	1.07

SD – standard deviation, SR – symmetry ratio, ROM – range of motion, V Swing phase – swing phase speed, c_{25} – 25th percentile, c_{75} – 75th percentile, p – test probability values calculated using the Wilcoxon test.

The symmetry ratios for the investigated temporospatial and kinematic parameters in the control group approximated the value of 1. In the study group the values of symmetry ratios were considerably higher than 1 and differed significantly from the symmetry ratios identified in the control group (Table 3). The highest value of the symmetry ratio in the study group was found in the case of swing time to stance time ratio (SW/ST ratio). In the control group, SW/ST ratio was found at the level of 1.04 and in the study group SW/ST ratio amounted to 1.59 ($p = 0.0004$).

Correlation coefficients and probability values for the symmetry ratios of the parameters investigated versus the walking velocity and distance as well as the score in Up&Go Test are shown in Table 4. The findings show moderate and weak correlation between the self-selected walking velocity of the post-stroke subjects and the temporal gait parameters. Negative relationship was shown for gait velocity and symmetry of stance phase duration ($r = -0.43$; $p = 0.0173$) as well as for gait velocity and symmetry of swing phase duration ($r = -0.41$; $p = 0.0395$).

Table 4. Relationship between the symmetry of kinematic and temporospatial parameters and the gait velocity, distance and balance

Symmetry ratio	V gait [m/s]	2-Minute Walk Test [m]	Up&Go Test [s]
Stance phase SR	$r = -0.43$ ($p = 0.0173$)	$r = -0.31$ ($p = 0.0452$)	$r = 0.11$ ($p = 0.4307$)
Swing phase SR	$r = -0.41$ ($p = 0.0395$)	$r = -0.40$ ($p = 0.0045^{**}$)	$r = 0.22$ ($p = 0.1185$)
V Swing phase SR	$r = -0.32$ ($p = 0.0262$)	$r = -0.38$ ($p = 0.0068^{**}$)	$r = 0.34$ ($p = 0.0164^*$)
Step length SR	$r = 0.23$ ($p = 0.2145$)	$r = -0.01$ ($p = 0.9617$)	$r = -0.01$ ($p = 0.9193$)
ROM hip SR	$r = 0.12$ ($p = 0.4221$)	$r = 0.08$ ($p = 0.5816$)	$r = -0.07$ ($p = 0.6359$)
ROM knee SR	$r = 0.11$ ($p = 0.4451$)	$r = 0.11$ ($p = 0.9464$)	$r = 0.02$ ($p = 0.9023$)
SW/ST SR	$r = -0.33$ ($p = 0.0228$)	$r = -0.31$ ($p = 0.0271^*$)	$r = 0.20$ ($p = 0.1548$)

SR – symmetry ratio, ROM – range of motion, V Swing phase – swing phase speed, r – Spearman rank correlation coefficient, p – test probability values calculated using the Wilcoxon test.

Table 5. Relationship between the symmetry of kinematic and temporospatial parameters and the subjects' age and time from stroke

Symmetry ratio	Age [years]	Time from stroke [months]
Stance phase SR	$r = -0.16$ ($p = 0.2640$)	$r = 0.00$ ($p = 0.9837$)
Swing phase SR	$r = -0.07$ ($p = 0.6073$)	$r = 0.26$ ($p = 0.0665$)
V Swing phase SR	$r = -0.04$ ($p = 0.7610$)	$r = 0.32$ ($p = 0.0252^*$)
Step length SR	$r = 0.19$ ($p = 0.1805$)	$r = 0.14$ ($p = 0.3154$)
ROM hip SR	$r = 0.00$ ($p = 0.9968$)	$r = 0.10$ ($p = 0.4938$)
ROM knee SR	$r = -0.32$ ($p = 0.0215^*$)	$r = 0.10$ ($p = 0.4688$)
SW/ST SR	$r = -0.14$ ($p = 0.3151$)	$r = 0.22$ ($p = 0.1274$)

SR – symmetry ratio, ROM – range of motion, V Swing phase – swing phase speed, r – Spearman rank correlation coefficient, p – test probability values calculated using the Wilcoxon test.

There was a weak correlation between the self-selected gait velocity and the temporospatial and kinematic gait parameters; for walking velocity and step length symmetry it was $r = 0.23$ ($p = 0.2145$), and for walking velocity and hip range of movement it was $r = 0.12$ ($p = 0.4221$). Similarly, moderate and weak correlation was found between the walking distance in 2-Minute Walk Test and the temporal gait parameters. There was a weak correlation between the scores in 2-Minute Walk Tests versus the temporospatial and kinematic gait parameters. Likewise, the relationship between the symmetry of temporospatial and kinematic gait parameters versus the score in Up&Go Test was found to be weak (Table 4).

Analysis of correlations between the symmetry rate of the gait parameters and the time from stroke onset showed there was a weak correlation only between the symmetry of swing phase velocity and time from stroke onset ($r = 0.32$; $p = 0.0252$). The remaining correlations were at a low or barely visible level. Assessment of relationships between the symmetry of the relevant gait parameters and the subjects' age showed a weak negative correlation between the symmetry of knee range of motion and the subjects' age. The remaining correlations were at a low or barely visible level (Table 5).

4. Discussion

The present findings support earlier observations that chronic post-stroke subjects, with moderate level of paresis and able to walk unassisted are characterized by impaired symmetry of gait pattern in terms of the temporospatial and kinematic parameters. As was expected, majority of the subjects were found with the mean symmetry ratios of gait parameters under investigation at the levels outside the 95% CI determined for the controls and the relevant values were significantly higher. The asymmetry orientation is important from the clinical viewpoint, but the present study focused only on the symmetry amplitude. The gait pattern of the post-stroke subjects showed an asymmetry resulting from a prolonged duration of the stance phase on the healthy leg and a simultaneous increase in the paretic step length. The asymmetry of paretic stance phase duration was found in 76% of the subjects, the asymmetry of swing phase duration in 82%, the asymmetry of step length in 88% and SW/ST asymmetry in 89% of the subjects.

This is consistent with the findings reported by Balasubramanian et al. [3] who examined gait of chronic

post-stroke subjects and observed that longer paretic steps in comparison to the nonparetic steps may compensate for lower propulsive force and they showed that step length asymmetry increases with a reduced motor control in the paretic leg. The proportionally large number of individuals with asymmetric gait pattern resulted from the fact that subjects with moderate impairment of motor control in the paretic leg were qualified for the study.

The main purpose of the present study was to find out whether the walking velocity and distance as well as the dynamic body balance in chronic post-stroke subjects are related to the gait quality expressed by the symmetry of temporospatial and kinematic parameters. The acquired results have not fully confirmed the assumed hypothesis. It has been shown that the gait velocity depends on temporal parameters symmetry. The symmetry of stance time, swing time, and velocity of lower limbs swing phase was related to the higher gait velocity. There was moderate strength of correlation which may have resulted from the fact that the study group was homogenous in terms of motor control level (Brunnström stage 3–4). It was also shown that individuals with more symmetric gait patterns in terms of temporal parameters were able to cover a longer distance during 2-Minute Walk Test. Patterson and colleagues in their study assessed the relationship between gait velocity and asymmetry and the frequency of asymmetry in terms of temporospatial parameters in chronic post-stroke patients able to walk unassisted. They reported that asymmetry of the temporal parameters may affect many post-stroke patients able to walk unassisted. In a group of 54 individuals long-term post-stroke, 55.5% were found with statistically significant asymmetry of the temporal parameters, and 33.3% with significant spatial asymmetry. Positive relationship was identified between asymmetry of temporal gait parameters and the ability to control gait velocity, and no significant correlations were found between gait velocity and symmetry of spatial parameters [17]. Likewise, the present findings showed only barely visible relationship between spatial parameters symmetry versus self-selected walking velocity and the covered distance. The lack of relationship between the symmetry of knee range of motion and the symmetry of hip range of motion versus the walking velocity and distance may have resulted from the fact that the group was homogenous in terms of motor control level. Greater diversification of the group perhaps would show certain correlations. On the other hand, Lewek et al. [13], [14] examined the relations between temporospatial gait asymmetry and balance in chronic post-stroke subjects. These authors

demonstrated that temporospatial gait asymmetry is linked with impaired static and dynamic balance in individuals with chronic stroke. In particular, gait velocity, asymmetry ratios of stance time and swing time positively correlated with step width during 8 gait, while the asymmetry ratios of swing time and step length negatively correlated with Berg Scale. Greater asymmetry related to dynamic balance, which suggests that gait asymmetry may be responsible for frequent falls after stroke. In the present study, the only positive relationship was shown between swing velocity symmetry ratio and dynamic balance. This may be linked with the fact that this group of patients presents with higher gait velocity and consequently better balance control which significantly facilitates performance in Up&Go Test. These findings are in conflict with the results published by Hendrickson and colleagues [9] who also investigated the relationship between gait asymmetry and balance in individuals after stroke. These authors showed that impaired ability of the paretic limb to control balance may result in gait asymmetry in post-stroke subjects. These findings suggest that rehabilitation strategies aimed at improving balance control in the paretic limb may increase gait symmetry after stroke.

The present study has confirmed the hypothesis saying that gait symmetry is not related to subjects' age. Such conclusion is consistent with findings reported by Patterson and colleagues [18], who examined symmetries of temporospatial gait parameters in a group of 172 subjects post-stroke and in 81 healthy individuals. Symmetry ratio was calculated for swing phase, stance phase and step length. No statistically significant relationships were found between the subjects' age and any of the symmetry ratios, among both post-stroke subjects and healthy individuals. Likewise, Alexander and co-authors [2] failed to identify relationships between temporal ratios of gait symmetry and age of subjects after stroke. Therefore, gait symmetry ratio may be a useful tool to access relationship of stroke and walking capacity of patients, regardless of their age.

The present findings show no relationship between gait symmetry and time from stroke. On the other hand, there is evidence that gait asymmetry may worsen later after stroke. Research suggests that the quality of walking, measured with the symmetry of temporospatial parameters shows a tendency towards deterioration at later stages after stroke, while no such effects have been observed with regard to gait velocity [17], [29].

Limitations. The presented study has focused on gait analysis in only one group of patients, homogeneous in terms of motor control and time from stroke.

It does not provide a complete picture of gait patterns from the viewpoint of their asymmetry in the entire community of individuals after stroke. Additionally, the cross-sectional study conducted does not provide an opportunity to investigate the evolution of asymmetric gait pattern. It is also necessary to take into account the process of gait rehabilitation and training, and answer the main question whether gait training at an earlier as well as later time after stroke makes it possible to reduce asymmetry and whether that enables improvement in self-selected gait velocity, gait capacity and, most importantly functional performance of patients.

5. Conclusion

There is a mild relationship between self-selected gait velocity and walking distance versus symmetry of temporal parameters. The findings do not confirm a relationship between self-selected velocity and walking distance versus spatial and kinematic gait parameters as well as dynamic balance. Likewise, it has not been confirmed that asymmetry of temporal, spatial and kinematic gait parameters changes with post-stroke subjects' age or is related to the length of time from stroke onset. Given the above, gait symmetry may be recognized as an important indicator of the level of gait control in post-stroke patients because it enables unique gait assessment independent of other parameters.

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