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Research Article

Changes in Walking Spatiotemporal Parameters After Therapeutic Yoga in People with Chronic Stroke

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Abstract

Walking limitations after stroke can contribute to long-term functional impairments. Walking characteristics such as spatiotemporal step parameters may be associated with these persistent walking limitations. The purpose of this study was to investigate changes in specific spatiotemporal walking parameters such as: walking speed; step length; swing time; step parameter symmetry; and double support time in adults with stroke who were participating in a therapeutic yoga intervention. The therapeutic yoga intervention was offered as a post-rehabilitation wellness activity 2 times per week for 8 weeks and was led by a yoga therapist. Spatiotemporal walking data were collected using the GAITRite Walkway System on a sub sample (n=24) of participants in a randomized controlled trial testing the efficacy of therapeutic yoga for improving balance in adults with chronic stroke. These data demonstrated that therapeutic yoga may have a positive impact on some spatiotemporal walking characteristics such as comfortable walking speed, step length, and double support time, while other spatiotemporal walking characteristics did not change (step parameter symmetry) or change at a significant level (sustained walking speed). The clinical relevance of this study is that participation in therapeutic yoga as a post-rehabilitation wellness activity may have a positive impact on walking characteristics in adults with chronic stroke.

Keywords: Stroke; Walking speed; Spatiotemporal step parameters; Therapeutic yoga

Introduction

Stroke is a leading cause of long-term physical impairments and walking limitations [1-4]. Approximately 40%-50% of adults who have had a stroke remain unable to walk at speeds consistent with age matched healthy controls, while 30% remain unable to walk without assistance at 6 months post-stroke [5,6]. Post-stroke walking limitations frequently contribute to long-term physical disability [7-9], impaired function, and reduced life participation [2,10-14]. Spatial temporal step parameters, such as step length (distance covered from toe off to successive heel strike of the same foot), swing time (time from toe off to heel strike), step length symmetry, swing time symmetry, and double support time (time with both feet in contact with support surface) may be associated with these persistent walking limitations. Step parameter asymmetry and compensatory motor action due to the asymmetry have been observed during walking in people with stroke [15-19]. Greater variability in paretic leg step parameters compared to the non-paretic leg has also been reported after stroke [15]. Inclusion of step parameters when measuring walking limitations after stroke may help promote better understanding of walking recovery.

Walking recovery is often a focus of patients and phsycial therapists during post-stroke rehabilitation. Unfortunately, post-stroke rehabilitation is increasingly shorter in duration and often completed prior to achievement of maximal functional recovery [20,21]. Therefore, access to safe and effective physical activity that may improve walking recovery is needed for people with chronic stroke after discharge from traditional rehabilitation. Therapeutic yoga is a form of physical activity that incorporates connecting the mind, body, and spirit as a holistic wellness practice [22,23]. Therapeutic yoga has been safely implemented for people with chronic stroke after discharge from rehabilitation [24-27]. Specifically, people with stroke who have participated in therapeutic yoga have been reported to demonstrate significant

improvements in balance, [24,27] walking distance, [28] and other physical measures [24-28]. In addition, walking speed has been used to predict walking status based on the following categories:

- household walking ability at speeds lees than 0.4 meters/second (m/s).
- limited community walking ability at speeds between 0.4 m/s and 0.8 m/s.
- full community walking ability at speeds greater than 0.8 m/s [29].

what is the gap or the question you need to answer? However, changes in these spatiotemporal walking parameters have not been evaluated for people with stroke who are participating in yoga. Therefore, the purpose of this study was to investigate changes in walking speed, step parameter symmetry, and double support time in people with chronic stroke after participation in therapeutic yoga. We expected that following the intervention, subjects would show improvements in

- comfortable walking speed.
- step length and swing time.
- step parameter symmetry (step length & swing time).
- double support time.
- sustained walking speed.

Methods

Design

This was a secondary data analysis of specific walking and step parameter measures derived from a randomized control trial exploring the efficacy of group therapeutic yoga on improving balance in people with stroke.

Participants

All subjects included in these secondary analyses were required to meet the primary study inclusion criteria:

- 18 years of age or older.
- survived a stroke.
- finished with physical rehabilitation.
- scored at least 4 out of 6 on the short mini mental status exam (MMSE).
- have ongoing physical impairment.
- have available transportation to/from yoga sessions.
- No inpatient stays for drug and/or alcohol abuse in the previous year.

In addition to the primary study inclusion criteria, subjects in this study also had to be randomized to the intervention group and complete their walking measures with the GAITRite Mat Walkway System. Each subject signed IRB approved informed consent and HIPAA authorization prior to completing study activities.

Outcome measures

Baseline assessments included demographic (age, gender, race, time since stroke), stroke characteristics (time since stroke, type of stroke, and side of hemiparesis), and walking and step parameter data. The walking and step parameter data were collected again at 8-week assessments (after the completion of an 8-week yoga intervention).

Walking speed: Comfortable walking speed (CWS) was measured while subjects walked across the GAITRite Walkway System. This gait mat system has been found to be a reliable and valid measurement tool for walking characteristics in people with stroke [16,30-32]. Subjects completed two walks at a self-selected comfortable walking speed on a 10-meter straight path with the gait mat placed in the middle of the path. Walking speed was determined by the gait mat based on both passes. Additionally, an analysis of sustained walking speed was completed with data collected during a walking distance test. Subjects completed the 6-minute walk test by walking back and forth along a 100-foot walking path with the gait mat in the middle of the path. Walking distance data have been previously reported for the full sample in the primary study. These analysis include walking speed changes from the beginning to the end of the walking distance test with walking speed collected at the first and last pass of the test. Walking speed was recorded for each pass over the gait mat and the difference between the first and last pass (last - first) of the test was calculated to determine if the subject was sustaining, increasing, or decreasing walking speed during the test. No difference between the first and last pass indicated the same speed from the beginning to the end of the test. A positive difference indicated an increase in speed in the last pass compared to the first pass and a negative difference indicated slower speed on the last pass compared to the first pass. No difference and positive findings are considered favorable for sustained walking speed.

Spatiotemporal step parameters: Spatiotemporal step parameters were collected at baseline and 8-week assessments with the gait mat during the comfortable walking speed test. The sensors in the gait mat recorded participant footfall data for each of the two passes across the mat during the CWS test. These footfall data were used to quantify spatial and temporal walking characteristics including speed, step length, swing time, and double support time.

Intervention

The intervention was a progressive 8-week group therapeutic-yoga intervention. The intervention, developed for this study by a yoga therapist and the research team, included breathing, postures, and guided relaxation. Participants attended group therapeutic-yoga classes 2 times per week for 8 weeks for a total of 16 visits. Each class was led by a yoga therapist with trained assistants to help subjects as needed. The intervention has been described previously. [24].

Data analysis

Data analysis was completed with SPSS 23.0. Demographics and stroke characteristics were analyzed with descriptive statistics. Spatiotemporal step data were processed and quantified with GAITRite software. A symmetry ratio (1=complete symmetry and >1 = asymmetry) was calculated for step length and swing time. The symmetry ratio was calculated for each spatiotemporal variable (spV) with spV larger/spV smaller for analysis. Double support time was calculated as a percentage of full gait cycle time. Baseline to 8-week comparisons of comfortable walking speed, step length, swing time, step parameter symmetry, double support time, and sustained walking speed were analyzed with paired t-test or non-parametric equivalent if appropriate (p=0.05).

Results

Demographics

Table 1: Demographics.

Variable	Value
Age (years)	53-80 (63)
Time since stroke (months)	6-155 (61)
Gender (male)	16 (66%)
Race (white)	15 (62%)
Ischemic (self-report)	16 (66%)
Marital status (married)	15 (62%)
Education level (some college)	12 (50%)

Twenty-four (51%) of 47 subjects from the primary study were included in these analyses. These analyses included a subset of subjects in the intervention group that completed their walking tests with gait mat. The average age of this sample was 63 years (range, 53-80). Sixteen (66%) of the subjects were male and 15 (62%) were white. The average time since stroke was 61 months (range, 6-155) with 16 (66%) self-reporting an ischemic stroke (see Table 1).

Walking speed

CWS significantly increased between baseline and 8-week testing (0.87 m/s to 0.96 m/s, p=0.001). Sustained walking speed (difference between first and last pass, last – first) improved from -0.725 cm/s at baseline to 3.30 cm/s at 8-week assessment. Even though the data suggest the subjects were walking faster at the end of the test at 8-week testing compared to slower at the end of the test at baseline testing, the difference was not statistically significant (p=0.547).

Spatiotemporal step parameters

Step length significantly increased on both the right and left lower extremities (right, 52 cm to 56 cm, p=0.014; left, 53 cm to 57 cm, p<0.0001). Swing time and step length symmetry did not change significantly (see Table 2). Double support time significantly decreased (32+11% of gait cycle to 30+11% of gait cycle, p=0.038) between baseline and 8-week testing.

Table 2: Step Parameters.

Variable	Baseline	8-week	P-value
R step length (cm)	52+15	56+16	0.014
L step length (cm)	53+16	57+16	<0.0001
R swing time (seconds)	0.45+0.10	0.50+0.24	0.15
L swing time (seconds)	0.43+0.07	0.48+0.28	0.384
Step length symmetry	1.16+0.17	1.13+0.16	0.483
Swing time symmetry	1.17+0.2	1.42+0.87	0.105
Double support time (% gait cycle)	32+11%	30+11%	0.038

Discussion

The aim of this study was to investigate spatiotemporal changes in walking and step parameters in people with stroke who participated in a therapeutic-yoga program. As expected, subjects demonstrated significant improvement in CWS. While the group began the program classified as full community walking ability (>0.80 m/s), 35 they were still able to achieve improvements in CWS, which may contribute to improved function and quality of life. People with stroke have previously been reported to experience better function and quality of life as walking speeds increase. [14,33] Although there is evidence of improved walking speed with walking task practice interventions and progressive balance exercise interventions, [8,34] the evidence related to walking speed and therapeutic yoga in people with stroke is, to our knowledge, limited to this secondary analysis and the primary study.24 Also, interesting in this sample, was faster walking speed at the end of the walking distance test at 8-week testing.

Although, the difference from baseline testing was not statistically significant, it raises interesting questions about the potential impact of non-gaitbased interventions on walking distance that warrant further investigation. Altenburger, et al. reported that people with chronic stroke demonstrated a significant decline in sustained walking speed during the 6MWT, and that people in the full community ambulatory sub-group demonstrated the most significant sustainability differences. [35] However, this sample, also in the full community ambulatory sub-group, demonstrated a non-significant change towards improved sustained walking speed after participation in therapeutic yoga. This observation suggests that therapeutic yoga might improve physical activity intensity tolerance, which has been found to be associated with minimizing the risk of post-stroke complications and a second stroke. [21].

Decreased double support time is considered a positive finding in this study. Decreased double support time has been attributed to better postural control and dynamic balance as well as more efficient expenditure of energy while walking in people with stroke. [34,36] This improved double support time may be related to the improved balance scores reported in the primary study, [24] and may also contribute to decreased fall risk.

The final significant change between baseline and 8-week testing in this study was step length. The change in step length may be related to the decreased double support time allowing more time during swing with each foot. Increased stride length has been correlated to overall walking performance and dynamic walking balance.34 Even with the increased step length and decreased double support time suggesting improved walking balance and efficiency of movement, this sample of people with chronic stroke did not demonstrate improvement in step parameter asymmetry. Improved step parameter symmetry may also impact overall walking efficiency, speed, and balance while decreasing fall risk and musculoskeletal injury risk. [16,34] Therefore, the findings of this study suggest that therapeutic yoga may influence some spatiotemporal walking parameters in a positive way such as comfortable walking speed, double support time, and step length, but that other potentially important characteristics such as step parameter symmetry may need a more specific intervention to show improvement.

Limitations

This study has a number of limitations including a convenience sub-sample of participants enrolled in the primary study and that not all participants completed their walking assessments on the gait mat. The overall sample size was small, and there was no control group for comparison in these analyses.

Conclusion

The impact of group therapeutic-yoga on walking recovery in this sample of adults with chronic stroke was mixed. Positive effects related to walking were noted for comfortable walking speed, double support time, and step length, while other factors such as step parameter symmetry were unchanged between baseline and 8-week assessments. The importance of the parameters that were positively affected related to balance and efficiency of movement warrant further consideration of therapeutic yoga as it relates to walking recovery. Therapists may want to consider encouraging people post-stroke to participate in yoga as a post-rehabilitation wellness activity.

Acknowledgment

None.

Conflict of interest

No conflict of interest.

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