Symmetry in vertical ground reaction force is not related to walking and balance difficulties in people with multiple…

Article *in* Gait & Posture · April 2016

DOI: 10.1016/j.gaitpost.2016.04.010

CITATIONS
0

READS
31

1 author:

Alon Kalron
Tel Aviv University
44 PUBLICATIONS **390** CITATIONS

SEE PROFILE

Gait & Posture 47 (2016) 48–50

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Short communication

Symmetry in vertical ground reaction force is not related to walking and balance difficulties in people with multiple sclerosis

Alon Kalron [a,b,*]

[a] Department of Physical Therapy, Sackler Faculty of Medicine, Tel-Aviv University, Israel
[b] Multiple Sclerosis Center, Sheba Medical Center, Tel Hashomer, Israel

ARTICLE INFO

Article history:
Received 30 January 2016
Received in revised form 5 April 2016
Accepted 8 April 2016

Keywords:
Multiple sclerosis
Gait
Walking
Ground reaction force
Balance

ABSTRACT

Analysis of vertical ground reaction force (GRF) symmetry may benefit people with multiple sclerosis (PwMS) since it can detect important differences in gait mechanics which have not previously been discussed in the related literature. Therefore, the primary objective of the current study was to determine whether symmetry of the vertical GRF during gait is associated with validated gait and balance tests in PwMS. Additionally, we examined whether the symmetry of the vertical GRF differs between MS fallers, non-fallers and between neurological disability levels. Gait and balance data were collected from 402 PwMS (249 women) with a mean age of 42.1 (S.D = 14.1) years. Vertical GRF parameters were obtained using the Zebris FDM-T Treadmill (Zebris Medical GmbH, Germany). Clinical gait and balance tests included the 2 and 6-min Walk Test, Timed Up and Go Test, Timed 25 Foot Walk, Four Square Step Test, Multiple Sclerosis Walking Scale questionnaire, Modified Fatigue Impact Scale and the Falls Efficacy Scale International questionnaire. The vertical GRF symmetry index score of the total sample was 3.7 (SD = 3.1). In terms of fall status, non-significant differences were observed between the fallers and non-faller groups and between the neurological disability subgroups. Non-significant correlation scores were found between the vertical GRF symmetry index, all clinical walking and balance tests and self-reported questionnaires. We suggest clinicians, especially those involved in physical rehabilitation, accord low priority to this gait phenomenon in the MS population.

1. Introduction

Gait analysis has been used to classify the mobility of people with MS (PwMS), however, it has been largely limited to functional assessments and use of spatial and temporal measures [1]. A slower walking speed and shorter stride length compared to healthy controls have been reported together with differences in joint motion at the ankle and muscle firing timing in the lower extremities [2].

Winter found that ground reaction force (GRF) parameters may provide insight into the cause, rather than the effect of the movement [3]. However, only a few studies have investigated this gait variable in PwMS [4]. Moreover, these studies included only a small group of PwMS and the subjects' weight was not standardized. Symmetry values of the vertical GRF may be more informative, mainly because GRF asymmetry exposes the lower limb joints to excessive degeneration, thus, resulting in pain and muscle waste.

It is possible that analysis of the vertical GRF symmetry may benefit PwMS since it can detect notable differences in gait mechanics which have not previously been discussed in the related literature.

Therefore, the primary objective of the current study was to determine whether symmetry of the vertical GRF during gait is associated with validated gait and balance tests in PwMS. In addition, we examined whether the symmetry of the vertical GRF differs between MS fallers, non-fallers and neurological disability levels.

2. Methods

2.1. Study design and participants

Retrospective data was collected from the Multiple Sclerosis Center, Sheba Medical Center, Tel Hashomer, Israel's computerized database from 1/2012 through 12/2015.

* Correspondence to: Tel.: +972 9 9512726; mobile: +972 052 2436839.
E-mail address: alkalron@gmail.com

http://dx.doi.org/10.1016/j.gaitpost.2016.04.010
0966-6362/

Patients were selected according to the following inclusion criteria: (1) a neurologist-confirmed diagnosis of definite MS [5]; (2) <7.0 on the expanded disability status scale (EDSS) [6], able to walk at least 20 m without resting; and (3) relapse-free for at least 30 days prior to testing.

Exclusion criteria included: (1) orthopedic disorders that could negatively affect mobility; (2) pregnancy; (3) blurred vision; (4) cardiovascular or respiratory disorders; (5) or taking steroids or fampridine. The study was approved by the Sheba Institutional Review Board. All participating subjects signed an informed consent form for use of their data in the research project.

2.2. Measures

2.2.1. Gait analysis

Gait parameters were obtained using the Zebris FDM-T Treadmill (Zebris Medical GmbH, Germany). A description of the Zebris treadmill is detailed in our previous reports on gait performance in PwMS [7]. Following an adaptation phase of approximately 2 minutes, each participant was instructed to walk barefoot on the treadmill for one consecutive minute at his/her comfort speed. Individuals who regularly used foot assistive devices (e.g. ankle foot orthoses) for walking, were allowed to perform the walking trial with their ambulatory device and their casual walking shoes. All participants included in the analysis were able to tolerate walking on the treadmill for one minute.

2.2.2. Vertical ground reaction force symmetry index

For each gait trial, we extracted the mean vertical GRF of the right and left lower limbs and classified the scores into two levels, strong and weak. Accordingly, as proposed by Kim et al. [8], a symmetry index (SI) was used to quantify the vertical GRF SI (%):

$$\text{Vertical GRF SI}\,(\%) = \frac{\text{VGRF}_{\text{weak}} - \text{VGRF}_{\text{strong}}}{0.5(\text{VGRF}_{\text{weak}} + \text{VGRF}_{\text{strong}})} \times 100$$

The magnitude of the vertical GRF SI represents the degree of asymmetry. A symmetry value of zero represents perfect symmetry.

2.2.3. Clinical gait and balance measures

Clinical gait and balance tests included the 2-min Walk Test (2MWT) [9], 6-min Walk Test (6MWT), Timed Up and Go (TUG) Test, Timed 25 Foot Walk (T25FW) [10] and the Four Square Step Test (FSST) [11]. The self-reported questionnaires comprised the Multiple Sclerosis Walking Scale (MSWS-12) [12], the Modified Fatigue Impact Scale (MFIS) [13] and the Falls Efficacy Scale International (FES-I) [14]. Clinical gait and balance tests were performed randomly. Participants were divided into groups based on fall history (fallers and non-fallers). A faller was defined as a participant who had experienced at least two falls during the previous year.

2.3. Statistics

Descriptive statistics were calculated for age, height, weight, gender, disease duration, EDSS, ambulatory and balance tests and self-reported questionnaires. All data were normally distributed according to the Kolmogorov–Smirnov test.

Pearson's r correlation coefficients examined the relationship between vertical GRF SI and the 2MWT, 6MWT, T25FW, TUG, FSST. Spearman's rank-order correlation coefficient tests examined the correlations with the EDSS, MSWS-12, MFIS and FES-I.

The independent t-test assessed the differences in the vertical GRF SI score between fallers and non-fallers. In terms of the disability level, we subdivided the data pool into four subgroups according to their EDSS score (very mild = 0–2.0, mild = 2.5–4.0, moderate = 4.5–5.5, severe = 6.0–6.5). Differences in the vertical GRF SI between the EDSS subgroups were determined using the analysis of variance (ANOVA) test. Post hoc Bonferroni adjustment enabled multiple comparisons between subgroups. All analyses were performed using the SPSS software (Version 23.0 for Windows, SPSS Inc., Chicago, IL, USA). All reported P-values were two-tailed. The level of significance was set at $P < 0.05$.

3. Results

The patient group included 402 PwMS (249 women) with a mean age of 42.1 (S.D = 14.1) years. The EDSS score of this group was 2.7 (SD = 1.7) indicating minimal-moderate neurological disability. In terms of EDSS categories, the scores of the pyramidal, cerebellar and sensory divisions were 1.6 (S.D = 1.2), 0.9 (S.D = 1.1) and 0.9 (S.D = 1.0), respectively. Other participants' related clinical scores are outlined in Table 1.

The vertical GRF SI score of the total sample was 3.7 (SD = 3.1). In terms of fall status, non-significant differences were observed between the fallers (n = 188) and non-faller (n = 214) groups; 3.9 (S.D = 3.5) vs. 3.5 (S.D = 3.0), P = 0.225. In terms of the EDSS disability subgroups, non-significant differences were observed between the very mild (n = 184), mild (n = 141) and moderate (n = 46) groups. A significant score was found solely between the very mild to the severe groups; 3.2 (S.D = 0.2) vs. 5.2 (S.D = 0.6); P = 0.009, respectively.

Non-significant correlation scores were found between the vertical GRF symmetry index, all clinical walking and balance tests and self-reported questionnaires including perceived fatigue. A weak correlation was observed between the vertical GRF symmetry index and the EDSS score (Pearson's rho = 0.136, P = 0.007). Table 2 presents scores of all outcome measures and correlation coefficient scores within the vertical GRF symmetry index.

4. Discussion

The primary finding of the current study is that PwMS do not experience asymmetry of the vertical GRF during gait. Given the knowledge that perfect GRF symmetry is not possible in normal human gait [15], the score of 3.7% obtained in the present MS study group, is acceptable. Moreover, we found a similar GRF asymmetry between MS fallers and non-fallers and that the asymmetry is not associated with walking and balance assessment tools. Furthermore, with the exception of PwMS with mobility aids, we observed that the GRF asymmetry is comparable between patients at different neurological levels and is not related with fatigue. The

Table 1
Demographic, anthropometric and clinical characteristics of the study population.

Variable	MS (n = 402)
Age (years)	42.1 (14.1)
Female/Male	249:153
Disease duration (years)	6.0 (7.4)
MS type	
Relapsing-remitting	389
Progressive	13
Height (cm)	168.2 (9.1)
Body mass (kg)	69.0 (15.5)
EDSS	2.7 (1.7)
Pyramidal	1.6 (1.2)
Cerebellar	0.9 (1.1)
Sensory	0.9 (1.0)

All data is presented as mean (SD).
Abbreviation: EDSS, expanded disability status scale.

Table 2
Correlation scores between the vertical GRF symmetry index and gait and balance outcome measures.

Variable	MS ($n=402$)	Correlation coefficient with vertical GRF SI
Vertical GRF SI (%)	3.7 (3.1)	–
EDSS (score)	2.7 (1.7)	0.136* ($P=0.007$)
Clinical walking and balance tests		
TUG (s)	8.8 (5.5)	0.045 ($P=0.520$)
T25FW (s)	7.4 (5.1)	0.006 ($P=0.930$)
2MWT (m)	149.0 (44.9)	0.029 ($P=0.673$)
6MWT (m)	428.0 (134.1)	0.020 ($P=0.773$)
FSST (s)	11.4 (5.4)	0.007 ($P=0.925$)
Self-reported questionnaire's		
MSWS-12 (score)	30.2 (15.0)	0.089 ($P=0.088$)
MFIS (score)	31.3 (21.7)	0.100 ($P=0.102$)
FES-I (score)	28.2 (12.3)	0.021 ($P=0.696$)

All data is presented as mean (SD).
Abbreviations: GRF SI, ground reaction force symmetry index; EDSS, expanded disability status scale; 2MWT, 2-min Walk Test; 6MWT, 6-min Walk Test; TUG, timed up-and-go test; T25FW, timed 25-foot walk; MSWS-12, multiple sclerosis walking scale; MFIS, modified fatigue impact scale; FES-I, falls efficacy scale international; FSST, four square step test.
* P-value <0.05.

relatively large sample pool of the study ($n=402$) validates our statements.

From a clinical standpoint, we suggest clinicians, especially those involved in physical rehabilitation, accord low priority to this gait phenomenon in the MS population. Nevertheless, further research is still needed to achieve a clearer analysis as to role of this phenomenon on lower limb joint deterioration and musculoskeletal pain in the MS community.

Conflict of interest statement

The author confirms that there are no known conflicts of interest regarding the work described in the current manuscript.

Funding source

None.

Sources of support

None.

References

[1] Bethoux F. Gait disorders in multiple sclerosis. Continuum 2013;19:1007–22.
[2] Givon U, Zeilig G, Achiron A. Gait analysis in multiple sclerosis: characterization of temporal–spatial parameters using GAITRite functional ambulation system. Gait Posture 2009;39(1):297–302.
[3] Winter DA. Use of kinetic analysis in the diagnostics of pathological gait. Physiother. Can. 1981;33:209–14.
[4] Wurdeman SR, Huisinga JM, Flipi M, Stergiou N. Multiple sclerosis affects the frequency content in the vertical ground reaction forces during walking. Clin. Biomech. 2011;26:207–12.
[5] Polman CH, Reingold SC, Banwell B, Clanet M, Cohen JA, Fillippi M, et al. Diagnostic criteria for multiple sclerosis: 2010 revisions to the McDonald criteria. Ann. Neurol. 2011;69:292–302.
[6] Kurtzke JF. Rating neurologic impairment in multiple sclerosis: an Expanded Disability Status Scale (EDSS). Neurology 1983;33:1444–52.
[7] Kalron A, Dvir Z, Frid L, Achiron A. Quantifying gait impairment using an instrumented treadmill in people with multiple sclerosis. ISRN Neurol. 2013;2013:867575.
[8] Kim CM, Eng JJ. Symmetry in vertical ground reaction force is accompanied by symmetry in temporal but not distance variables of gait in persons with stroke. Gait Posture 2003;18:23–8.
[9] Baert I, Freeman J, Smedal T, Dalgas U, Romberg A, Kalron A, et al. Responsiveness and clinically meaningful improvement, according to disability level, of walking measures after rehabilitation in multiple sclerosis: a European multi-center study. Neurorehabil. Neural Repair 2014;28:621–31.
[10] Learmonth YC, Paul L, McFadyen AK, Mattison P, Miller L. Reliability and clinical significance of mobility and balance assessments in multiple sclerosis. Int. J. Rehabil. Res. 2012;35:69–74.
[11] Wagner JM, Norris RA, Van Dillen LR, Thomas FP, Naismith RT. Four square step test in ambulant persons with multiple sclerosis: validity, reliability, and responsiveness. Int. J. Rehabil. Res. 2013;36:253–9.
[12] Hobart JC, Riazi A, Lamping DL, Fitzpatrick R, Thompson AJ. Measuring the impact of MS on walking ability: the 12-Item MS Walking Scale (MSWS-12). Neurology 2003;60:31–6.
[13] Tellez N, Rio J, Tintore M, Nos C, Galan I, Montalban X. Does the Modified Fatigue Impact Scale offer a more comprehensive assessment of fatigue in MS. Mult. Scler. 2005;11:198–202.
[14] van Vliet R, Hoang P, Lord S, Gandevia S, Delbaere K. The Falls Efficacy Scale International: a cross-sectional validation in people with multiple sclerosis. Arch. Phys. Med. Rehabil. 2013;94:883–9.
[15] Herzog W, Nigg BM, Read LJ, Olsson E. Asymmetries in ground reaction force patterns in normal human gait. Med. Sci. Sports Exerc. 1989;21:110–4.