The Gait Variability Index: A new way to quantify fluctuation magnitude of spatiotemporal parameters during gait

Arnaud Gouelle a,*, Fabrice Mégrot b, Ana Presedo c, Isabelle Husson d, Alain Yelnik e, Georges-François Pennéco t c

a AP-HP, Hôpital Robert Debâtre, Plateforme d'Analyse du Mouvement, Paris, France
b Centre de Médecine Physique et de Réadaptation pour Enfants Buis-Larriès, Unité Clinique d'Analyse de la Marche et du Mouvement, Lamorlaye, France
c AP-HP, Hôpital Robert Debâtre, Service de Chirurgie Orthopédique, Paris, France
d AP-HP, Hôpital Robert Debâtre, Service de Neurologie Pédiatrique, Paris, France
e AP-HP, Hôpital Fernand Widal, Service de Médecine Physique et de Réadaptation, Paris, France

ARTICLE INFO

Article history:
Received 9 May 2012
Received in revised form 7 October 2012
Accepted 15 January 2013

Keywords:
Gait variability
Fluctuation magnitude
Spatiotemporal parameters
Friedreich's Ataxia

ABSTRACT

This article describes a conglomerate measure of gait variability based on nine spatiotemporal parameters: the Gait Variability Index (GVI). Concurrent validity, inter-session reliability and minimum detectable change (MDC) were evaluated in 31 patients with Friedreich's Ataxia (FRDA), through comparisons with classically used evaluation tools such as the International Cooperative Ataxia Rating Scale (ICARS).

GVI scores for the healthy population were 100.3 ± 8.6 and were significantly reduced in FRDA patients (70.4 ± 7.9). The GVI was correlated with the global ICARS score and was sensitive enough to differentiate between groups of FRDA patients categorized by the Posture and Gait Disturbances sub-score. The GVI was found to have a high inter-session reliability with an intraclass correlation coefficient of 0.91. A MDC of 8.6 points was found necessary to ensure that a change in GVI reflects a true change rather than measurement error.

The GVI provides a quantitative measure of variability which behaves well statistically in both healthy patients and patients with FRDA. It can be easily implemented using the supplemental data provided with this article. Complementary work is necessary to strengthen the GVI validation.

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1. Introduction

Balance control during gait can be affected by different pathologies which alter stability (capacity to recover from perturbations), thus leading to falls. Because this is an important public health issue, many studies have attempted to identify markers relating to fall risk.

Gait analysis techniques provide objective data including spatiotemporal parameters (STP). Two approaches have been used to assess fall risk from STP. The most classical approach is based on comparison of mean values between healthy subjects and patients; it has caused a paradox which has been well described. The same characteristics are associated with an increased risk of falls and have also been explained as the adoption of a safer, more stable gait strategy [1]. The second approach is based on the measure of reproducibility of coordinated limb movements from one step or one stride to the next. This within-trial variability could be assessed using an analysis of the fluctuation magnitude (the variance, the size of fluctuations) [2]. There are indications that fall risk can be more precisely evaluated by the STP variability rather than by mean values [2,3]. Although gait variability was originally considered to represent noise, more recent research suggests that it reflects the underlying motor control and may be relevant to quantify age-related and pathological alterations in locomotor control-system, as well as to provide a clinical measure of mobility and functional status [2]. Subtle changes in variability have been reported among identified older fallers [4] and in future fallers [3]. Variability has also been reported to increase under dual-task conditions, when walking on irregular surfaces or with the eyes...
MDC suggests that a change of 9 points in GVI is necessary in FRDA patients.

The present study has limitations with regard to the number of strides used to compute the index. Owing and Grabiner found that accurate estimation of step kinematic variability required at least 400 steps while walking on a treadmill [27]. Hollman found that 60 strides were required to calculate variability in stride velocity during normal walking in elderly subjects [28]. In our work, each GVI was calculated from minimum of five absolute differences, which corresponds to 13 consecutive steps. Furthermore, the raw STP were obtained from several walks on GAITRite™. Paterson showed that STP variability differs depending if data are obtained from single, continuous trial or multiple short trials [29]. This was taken into consideration in the conception of GVI by trying to reduce inter-trial variability. We recommend the use of the highest number of cycles possible but, based on the recommendations of the European GAITRite™ Network Group about clinical evaluation of cycle-to-cycle variability [30], three values for each alternative parameter is the minimum requirement for GVI calculation. In our opinion, the most important consideration for use of GVI (or for measurement of gait variability) in the clinical assessment is to make sure that the conditions are always similar.

We proposed an index to improve the quantification of gait variability. The results obtained in FRDA patients seem to support the use of GVI. Future studies should continue to validate the measure; however, the GVI provides a useful method for many studies of variability and stability.

Acknowledgments

This work was supported by a research grant from the Délartement de la Recherche Clinique et du Développement, Assistance Publique – Hôpitaux de Paris, which was also the sponsor of the study (AOM 07 049). We also thank the French Association against Friedreich Ataxia (AAFA), the French Association against Myopathies (AFM) and Takeda Laboratory.

Conflict of interest statement

The authors of this manuscript have no financial or personal relationships with other people or organizations that could inappropriately bias this work.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.gaitpost.2013.01.013.

References