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# VELOCITY PROFILES OF SPATIO-TEMPORAL GAIT PARAMETERS: COMPARISON OF TWO REGRESSION METHODS

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## INTRODUCTION

In clinical practice, the analysis of gait velocity allows predicting health risk, functional impairment and the risk of falls in the elderly [1,2]. Gait velocity affects certain spatial and temporal (ST) parameters [3,4] and varies with age, anthropometric characteristics and pathology [5-7]. Thus, comparison of gait parameters between subjects or groups should take into account velocity. Also the evolution of gait parameters with velocity could be of clinical interest.

Moe-Nilssen [8] proposes to calculate the relationship between gait parameters and velocity by a regression procedure, known as the velocity profile. From the coefficients of these regressions, it is possible to compare, for several subjects walking at different speeds, the ST parameters computed for a standard speed or to compare the evolution of parameters as a function of speed. In general, gait analysis protocols include trials at 2 [5] or 3 [6,9] velocities. The type of regression that can be applied is dependant of the number of velocities assessed. As time constraints may apply in clinical settings, the use of only 2 velocities could reduce experimental and processing time.

Thus, the aim of this study was to assess velocity profiles of ST gait parameters using two types of regression by comparing measured data with those calculated using linear and polynomial regression equations.

## METHODS

The study sample consisted of 34 volunteers (16 men and 18 women, aged 22 to 80 years). Exclusion criteria were neurological, musculo-skeletal or vestibulo-ocular diseases as well as lower limb prostheses. An informed consent was obtained from each participant and the local ethics committee approved the study.

Data acquisition was performed using the GAITRite Walkway System (610x61x0.5 cm). The walkway includes 23 040 pressure sensors recording at 120Hz. Based on sensor activation during walking, algorithms reconstruct the footprints in two dimensions and compute ST gait parameters. The system was shown to be valid and reliable [10,11].

Anthropometric measurements (height, weight, lower limb length, age, gender) were taken. Participants were invited to walk barefoot on the walkway. Three trials were recorded at each of three velocities (preferred, slow, fast in a randomized order). Instructions were standardized. A distance of 2 m was included at each end of the walkway to avoid acceleration and deceleration bias. Nine ST parameters (velocity, cadence, stride length, step length, support base, step time, cycle time, swing time and stance time) were extracted. The left-right asymmetries of the step time, stride length and cycle time were also analyzed. Average values were retained. The variability of step time, stride length, cycle time, swing time and the stance time was obtained by calculating the standard deviation of these parameters for all cycles registered at a given velocity. For each subject and each parameter, the coefficients of the linear (y = ax + b) and second degree polynomial (y = ax² + bx + c) regression equations were computed as a function of velocity (Figure 1).

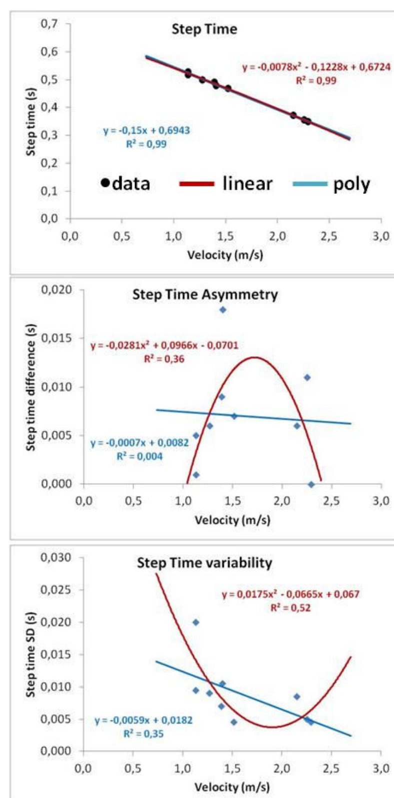


**Figure 1**: Linear and polynomial regressions of step time, its asymmetry and variability in one subject.

Normal distribution (Kolmogorov-Smirnov test) and absence of right left differences (paired t-test) were verified. Repeated-measures ANOVA was used to compare measured and regression-derived ST gait parameters (taking into account velocity) as well comparable regression coefficients (taking into account age and gender). Determination coefficients $r^2$ were used to assess the fit of regressions.

**RESULTS AND DISCUSSION**

For asymmetries and variabilities (see e.g. Figure 1), $r^2$ were generally very low, both for linear ($r^2 \leq 0.37$) and polynomial regressions ($r^2 \leq 0.56$), and most coefficients did not differ from zero. The same was true for the base of support. For these reasons, the regression approach was not considered appropriate for ST parameter asymmetry and variability and base of support. For the remaining ST parameters, polynomial regression appeared more appropriate, based on the same criteria (Figure 2). However, at high velocities, the goodness of fit was lower for cycle and step time. Moreover, variation coefficients on all regression coefficients averaged 760%, indicating the impossibility of use of average equations.

**CONCLUSIONS**

The method of velocity profiles [15] is appropriate nor for ST parameter asymmetry and variability, nor for the base of support. For other ST parameters, a second order polynomial regression is more appropriate than a linear regression, implying the recommendation of three gait speeds during clinical tests. However, an average regression equation should not be used, due to the large individual variations.

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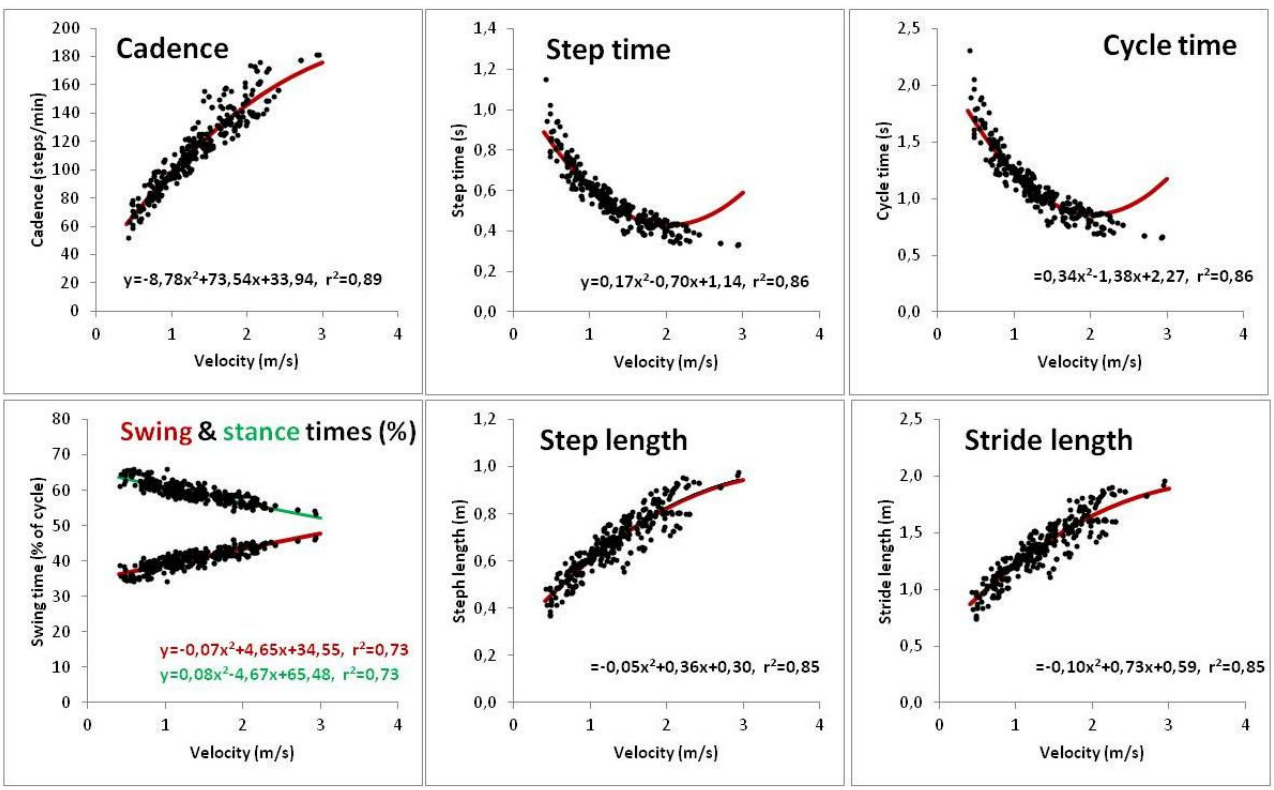


**Figure 2:** Average second order polynomial regression equations and individual data points for ST parameters.