DESIGN OF A GAIT LABORATORY TO ENABLE BIOMECHANICAL ANALYSIS OF INDIVIDUALS WITH POST-STROKE WALKING DEFICITS: FORCE PLATFORM POSITIONING

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INTRODUCTION

Measuring bilateral ground reactions forces in persons with post-stroke hemiparesis can be quite difficult because of the wide range of asymmetry in step lengths with which they present. The purpose of this work is to outline considerations and propose solutions for laboratory design related to recording ground reaction force data (Fx,y,z; Mx,y,z) from these individuals. Design considerations include: 1) force platform (FP) placement 2) resonant frequency signals from mounting materials, 3) order of FP strikes (paretic/non-paretic) and 4) mobility aid use (i.e. cane, AFO).

This presentation primarily addresses optimal FP placement, which we define as allowing for the collection of two consecutive footfalls in order to enable analysis of forces associated with one compete walking cycle: paretic stance, non-paretic stance and the transition between stance phases. Force platform positioning is primarily dependent on step length because it determines whether ipsilateral and contralateral steps will strike two separate platforms cleanly in one stride. Specifications for spacing multiple FPs based on 76 measured step lengths are described.

METHODS

Step length data from 38 independent ambulators with post-stroke walking deficits, collected as part of a separate study, were analyzed. All volunteers demonstrated Functional Independent Motor scores of 5 to 7 (max = 7). Step length data were acquired and calculated using a 4.6 meter long GAITRite portable walkway system (CIR Systems, Inc., Clifton, NJ 07012). Paretic and non-paretic data were grouped because collecting two footfalls requires knowing only one step length.

RESULTS AND DISCUSSION

Step lengths ranged from 19.57 to 79.60 cm. While the range of step lengths demonstrated a continuum of values, step lengths were grouped into four step clearance patterns in order to make decisions about FP positioning: minimal (T) or step-to gait, short (S), medium (M) and long (L). In addition, within the S, M and L patterns (not T), volunteers demonstrated midline cross (x), i.e. a narrow base of support in which the contralateral heel crossed in front of the ipsilateral heel (Figure 1), or no midline cross.

Six of the seven step length patterns (not Sx) were accommodated with three FPs and two orthogonal walkway usage orientations (Figure 1). We related step lengths to commercially available FP dimensions: 40 x 60 cm and 46.4 x 50.6 cm. In step pattern analyses, to account for recommended space between FPs, 2 mm were added to each side length. Group T step lengths did not clear the shortest length of 40.2 cm. Group S cleared 40.2 but not 46.6 cm. Group M cleared 46.6 but not 60.2 cm. Group L cleared 60.2 cm (Table 1).

Based on these findings, Figure 1 below illustrates the design implemented to accommodate the six patterns. One 10-meter walkway (direction AB) plus a second, orthogonal, 6-meter walkway (direction CD) were created. The overlapping, central walkway area was equipped with embedded FPs: FP1 and 2 dimensions are 46.4 x 50.6cm (Advanced Medical Technology, Inc., Watertown, MA), and FP3 dimensions are 40 x 60 cm (Bertec Corporation, Columbus, OH). Note that different step patterns may be required depending on whether the paretic or non-paretic footfall is desired to be first for subjects with a substantial step length asymmetry.

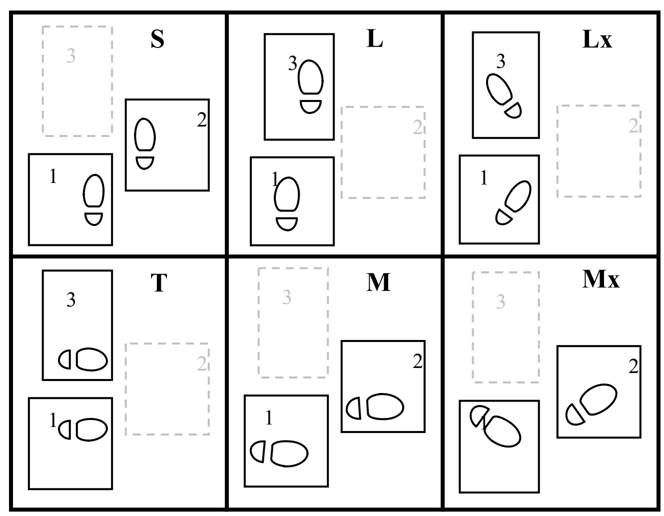

Figure 1. Step patterns are illustrated. Drawing not to scale. Top row = AB & bottom row = CD walkway orientation.

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Table 1. Step pattern data presented by group.

Step Pattern	Walkway Orientation	Platforms	n (76 total)	Step Length Mean	Step Length Range
T	CD	1 & 3	17	29.21	19.57-38.49
S	AB	1 & 2	11	43.30	41.71-45.99
M/Mx	CD	1 & 2	26	53.77	46.72-60.20
L/Lx	AB	1 & 3	22	68.56	60.28-79.60