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Exploring the feasibility and acceptability of sensor monitoring of gait and falls in the homes of persons with multiple sclerosis

Pamela Newland[a,*], Joanne M. Wagner[b], Amber Salter[c], Florian P. Thomas[d], Marjorie Skubic[e], Marilyn Rantz[f]

[a] Goldfarb School of Nursing at Barnes Jewish College, 4483 Duncan Avenue, Mailstop 90-36-697, St. Louis, MO 63110F, United States
[b] Department of Physical Therapy and Athletic Training, Doisy College of Health Sciences, St. Louis University, St. Louis, MO 63104, United States
[c] Division of Biostatistics, Washington University School of Medicine, St. Louis, MO 63110, United States
[d] Neuroscience Institute at Hackensack University Medical Center (HUMC), New Jersey, United States
[e] Electrical and Computer Engineering, University of Missouri, Columbia, MO 65211, United States
[f] Curators' Professor Emerita Sinclair School of Nursing, University of Missouri, Columbia, MO 65211, United States

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ABSTRACT

Gait parameters variability and falls are problems for persons with MS and have not been adequately captured in the home. Our goal was to explore the feasibility and acceptability of monitoring of gait and falls in the homes of persons with MS over a period of 30 days. To test the feasibility of measuring gait and falls for 30 days in the home of persons with MS, spatiotemporal gait parameters stride length, stride time, and gait speed were compared. A 3D infrared depth imaging system has been developed to objectively measure gait and falls in the home environment. Participants also completed a 16-foot GaitRite electronic pathway walk to validate spatiotemporal parameters of gait (gait speed (cm/s), stride length (cm), and gait cycle time(s)) during the timed 25 foot walking test (T25FWT). We also documented barriers to feasibility of installing the in-home sensors for these participants. The results of the study suggest that the Kinect sensor may be used as an alternative device to measure gait for persons with MS, depending on the desired accuracy level. Ultimately, using in-home sensors to analyze gait parameters in real time is feasible and could lead to better analysis of gait in persons with MS.

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1. Introduction

Multiple sclerosis (MS) is a progressive illness that affects the central nervous system (CNS) often resulting in various degrees of disability (National MS Society [NMSS]) [1]. Even though [long term loss of independence and increased disability are main concerns voiced by persons with MS, a majority still live in their own homes] [2]. Gait and balance problems affect approximately 75% of people with MS [3], they contribute to falls, adversely affect quality of life (QOL), and may lead to injury [4]. With approximately 80% of cases diagnosed as relapsing–remitting MS at onset, relapses play an important role in determining subsequent prognosis and the development of disability level [5].

[One recent longitudinal study [6] representing persons with MS, found gait velocity was significantly associated with increasing disability and progression. In addition, slower gait velocity is reported to be predictive of falls, cognitive problems, and injuries in persons with MS] [7–9]. In patients' perception, gait is considered the most valuable function [10,11]. Reduced gait speed or reduced variable step length are associated with increasing disability and falling in persons with MS [8].

[While gait parameters have been quantified in the laboratory setting, they have not been studied in the home environment. Studies [12–14] have examined gait parameters, such as speed variability of velocity, using body-worn sensors in people with MS and healthy controls. One important thing these studies lack is the immediate feedback provided by in-home mounted sensors. While body-worn sensors can detect mobility differences, detection of commonly described abnormal temporal-spatial gait parameters (e.g., velocity, step length, base of support) are warranted to strengthen the inconsistencies in prior studies. Thus, it seems that the evidence as to the association between gait and falls in persons with MS, is limited.]

* Corresponding author.
E-mail addresses: Pamela.Newland@bjc.org (P. Newland), jwagne34@slu.edu (J.M. Wagner), amber@wubios.wustl.edu (A. Salter), thomasfp@slu.edu (F.P. Thomas), SkubicM@missouri.edu (M. Skubic), rantzm@missouri.edu (M. Rantz).

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To date, no studies have used real time depth sensors to identify gait problems and falls in people with MS in their home environment. Most previous research assesses walking in a short duration clinic setting (e.g., <6 min) [15,16]. While accelerometer data provide abundant information regarding physical activity [7], this technology does not provide detailed real-time information on specific gait parameters and falls. Due to lack of recall and changes in location of where persons with MS walk and fall, prior measures may not adequately reflect real time gait and fall assessment. Thus it is important to assess persons with MS in the home. We postulate that gait monitoring in the home environment will contribute to the longitudinal assessment of worsening gait problems and falls in persons with MS.

A 3D infrared depth imaging system (SensorForesite Healthcare System) has been developed to measure gait and falls in the home environment objectively. This system has been validated in the geriatric population [17] (Fig. 1). The details of the system are described elsewhere [13,18]. Briefly, 3D infrared depth cameras are used to sense a room environment. The floor plane is detected, and people are segmented as they move through the environment, effectively creating 3D silhouettes while maintaining the privacy of the person being monitored. A tracking algorithm is used to identify walks [14]. The system calculates stride length, stride time, and walking speed by analyzing the motion of these 3D silhouettes. As part of a larger study, our goal here was to explore the feasibility and acceptability of monitoring of gait and falls in the homes of persons with MS over a period of 30 days.

2. Methods

2.1. Participants

This study represents subjects from a larger study. Participants were recruited from a MS clinic in the Midwest and a database of previous research participants. The inclusion criteria were: [internet access, age 18 years or above, diagnosis of any subtype of MS, no relapse in the prior 30 days due to possible increase in Self-Report Expanded Disability Status Scale (SR-EDSS) score [19],]

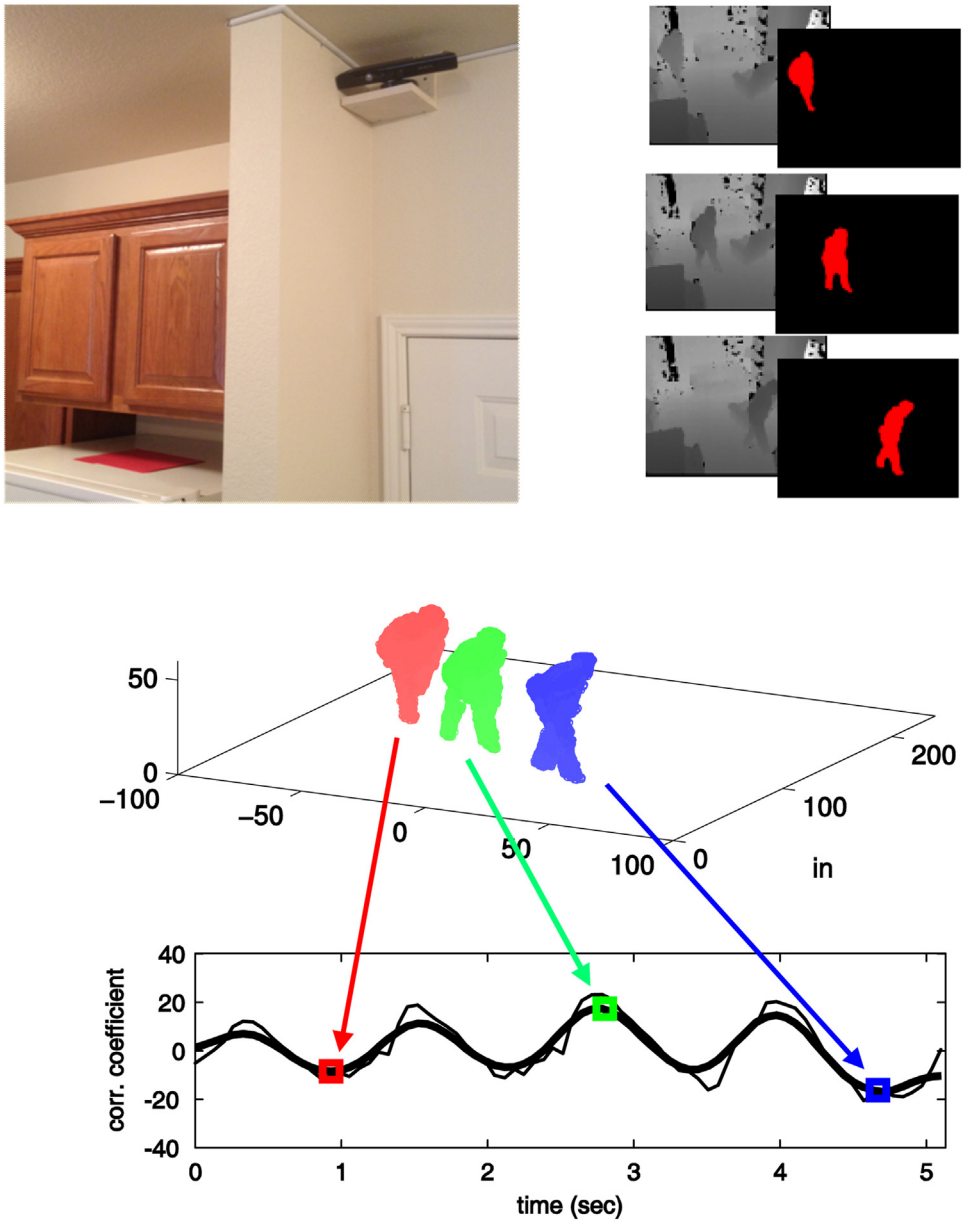

Fig. 1. Sensor placement (a) and sensor silhouette. Wang.

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