Published in final edited form as:

J Agromedicine. 2015 ; 20(4): 427–433. doi:10.1080/1059924X.2015.1074971.

A Pilot Study of Gait Function in Farmworkers in Eastern North Carolina

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Abstract

Farmworkers endure many job-related hazards including fall-related work injuries. Gait analysis may be useful in identifying potential fallers. The goal of this pilot study was to explore differences in gait between farmworkers and non-farmworkers. The sample included 16 farmworkers and 24 non-farmworkers. Gait variables were collected using the portable GAITRite system, a 16-foot computerized walkway. Generalized linear regression models were used to examine group differences. All models were adjusted for two established confounders, age and body mass index. There were no significant differences in stride length, step length, double support time, and base of support; but farmworkers had greater irregularity of stride length ($p = .01$) and step length ($p = .08$). Farmworkers performed significantly worse on gait velocity ($p = .003$) and cadence ($p < .001$) relative to non-farmworkers. We found differences in gait function between farmworkers and non-farmworkers. These findings suggest that measuring gait with a portable walkway system is feasible and informative in farmworkers, and may possibly be of use in assessing fall risk.

Keywords

gait; fall risk; farmworkers; occupational health

INTRODUCTION

Farming is one of the most dangerous industries in the United States.¹ Farmworkers face numerous immediate occupational hazards, such as accidental injury, heat-related illness, and musculoskeletal disorders. In addition, they face more chronic risks from pesticide exposure,² including cancer, respiratory illness, dermatitis, and neurological diseases.^{3–7} Farmworkers are also at considerable risk for falls. In 2011, agricultural workers reported a higher rate of fall-related injuries (48.2/10,000 workers) compared with transportation, mining and manufacturing industries.⁸ Falls are a significant cause of occupational morbidity and mortality,^{9,10} and fall injuries constitute a major financial burden to affected individuals and society.¹¹ Potential risk factors for falls include carting hay bales, working in silos, slippery or unstable surfaces, pre-existing medical conditions, ergonomic risk factors (e.g., repetitive strains and prolonged awkward postures), and chemical exposure.^{12–18} Preventing and reducing fall injuries is a strategic goal of the National Institute for Occupational Safety and Health.¹⁹

Gait analysis can be used to identify potential fallers. Gait measures such as slow speed, short step length, and narrow stride width appear to be related to falls in older adults.^{20–22} Recent studies have drawn particular attention to gait variability; that is, fluctuations in gait characteristics from one step to the next, as an indicator of gait stability.^{23–25} For example, irregularity in stride length and step length are more sensitive in predicting future falls and impaired mobility than average stride length and average step length.^{26–28} Additionally, gait analysis has been used to help diagnose and determine the severity of neurological conditions such as dementia²⁹ and Parkinson's disease.³⁰ The significance of gait variability is manifest in a variety of neurologically impaired populations;^{30–32} it is a sensitive measure of disease evolution in the prodromal phase of neurodegeneration,³³ and is predictive of future risk of dementia.^{34,35}

The objective of this pilot study is to ascertain the feasibility of performing quantitative gait measures in farmworkers and to explore their differences in between farmworkers and non-farmworkers. In this study, we report several gait parameters, including average gait speed, average stride length, average step length, and the variability of these measures, among farmworkers and non-farmworkers. We hypothesize that employment in agriculture is associated with poorer gait function. Quantitative gait assessment may be useful in identifying individuals at risk for falls and possibly suitable for preventive interventions.

MATERIALS and METHODS

This pilot study took place in early 2012 in eastern and western North Carolina. It used a design in which Latino farmworkers were compared with Latino manual workers. Data collection clinics were held in central locations in each of the two research areas (i.e., Head Start facility for farmworkers and community center for manual workers). The Wake Forest School of Medicine Institutional Review Board approved the study protocol and instruments, and each participant provided written informed consent.

Sample

The convenience sample included 16 male farmworkers and 24 male manual laborers. Study participants were recruited by word of mouth with the assistance of personnel from community organizations who currently partner on other research studies of farmworkers and non-farmworker manual laborers in North Carolina. Inclusion criteria were male, 18 years or older, and self-defined as Latino or Hispanic (most farmworkers in North Carolina are Latino; this population is the focus of our larger research program). Farmworkers were included if they worked in farm work in the past year and lived adjacent to agricultural fields. Non-farmworker manual laborers were excluded if they had worked in farm work or any other industry (e.g., landscaping, pest control) that could involve routine exposure to pesticides in the previous 5 years and had lived adjacent to agricultural fields in the previous 5 years. Exclusion criteria also included diabetes because of neuropathy, report of having pain and stiffness in the lower extremities in the past week, and report of diagnosis with hip and/or knee osteoarthritis. Participants were given a \$30 gift card for completing the several components of the pilot study.

Measures

The study obtained data on gait function and personal characteristics including age (< 30, 30 – 49, and 50 years of age); education (years); marital status (married/living as married vs. never married/widowed/separated/divorced). Participants were asked to indicate their place of birth and the languages they speak. Height was measured using a stadiometer, and weight was measured using a digital scale. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Gait assessment and questionnaires were administered by Spanish-speaking research staff.

To assess gait, participants were instructed to walk without shoes at a self-selected and comfortable pace for four trials in a quiet, well-lit area and without any attached monitoring devices. Participants walked on a portable computerized walkway (GAITRite; CIR Systems, Havertown, PA). The GAITRite is a 16 foot long and 3 foot wide carpet with 16,128 pressure sensors embedded in the material. As the participant walks across the walkway, the vertical pressure exerted by the feet is measured by the sensors. A special algorithm detects the pressures of each footfall. The carpet interfaces with a laptop computer with a custom software program that collects, stores and graphs the incoming data in real-time. The temporal and spatial (two dimension geometric position) aspects of gait can be accurately measured to calculate average gait velocity (distance traveled/ambulation time), cadence (number of steps per minute), stride length (distance from the heel of one foot to the heel of the next same side footfall), stride length variability (stride length standard deviation/stride length mean), step length (distance from the left heel and the right heel), step length variability (step length standard deviation/step length mean), double support time (time spent with both feet in contact with the floor), and base of support (average distance in the medial and lateral direction measured from one heel to the next heel). We selected these variables a priori because they have shown excellent reliability in both young and older walkers³⁶ and concurrent validity,³⁷ and because of their associations with brain structure and function, and risk for falls and mobility disability in previous studies.^{38–43} Because the left and right gait parameters did not significantly differ in paired t-tests, we only reported

the dominant (predominantly right) leg on those variables. Dominant leg was determined by asking participants with which leg they would kick a ball.

Statistical Analysis

Descriptive statistics of characteristics of farmworkers and non-farmworkers are presented as frequency and percentage for categorical variables, or as means and standard deviations for continuous variables (Table 1). Generalized linear regression models were used to examine group differences in gait function. All models were adjusted for two established confounders, age and BMI, that have been associated with gait function.^{32,44} Because height or leg length is a known covariate of gait velocity, we normalized gait velocity to height. Statistical analysis was performed using SAS 9.1 (SAS Institute, Inc., Cary, NC).

RESULTS

Farmworkers had a mean age of 30.7 years; 62.5% were under age 30 (Table 1). Non-farmworkers had a mean age of 34.7 years; 70.8% were between the ages of 30–49. The average years worked in agriculture for farmworkers was 14.5 ($\pm$ 12.2; range 1–46). There were more men under age 30 in the farmworker group, but personal characteristics including age, education, and BMI did not differ significantly between farmworkers and non-farmworkers.

Table 2 compares gait variables of farmworkers with non-farmworkers, adjusting for age and BMI. There were no significant differences in stride length and step length. However, farmworkers demonstrated significantly greater variability of stride length ($p = .01$). There was a trend towards greater variability of step length in farmworkers ($p = .08$). Although non-farmworkers had a greater percent of the gait cycle in double support compared to farmworkers, there were no significant differences in double support time. Farmworkers had a wider base of support than non-farmworkers, but this was not statistically significant. Farmworkers performed significantly worse on gait velocity ($p = .003$) and cadence ($p < .001$), relative to non-farmworkers.

DISCUSSION

In this pilot study, we found differences in gait function between farmworkers and non-farmworkers. However, the eight gait variables were not associated equally with occupational status. There were no significant differences in stride length, step length, and double support time; but variability or irregularity of stride length and step length was greater in farmworkers. Farmworkers walked significantly slower, taking fewer, slower steps than non-farmworkers. Farmworkers had a substantially wider base of support; typically a wider base indicates more unsteady gait.⁴⁵ This pattern of findings is non-specific; but one possible explanation for the slower speed but greater step to step variability in farmworkers is a compensatory response to gait instability. Previous studies have shown that individuals with increased gait variability can compensate for walking instability through adjustment of other kinematic variables such as reduced gait speed.^{45–46}

Although gait impairment has been noted as a significant factor in predicting falls in elderly and neurologically impaired populations, its role in predicting farmworker injuries has not been explored. Some measures of gait such as slower gait speed and greater gait variability have often been viewed as important markers of fall risk in older adults.²⁸ Within the agricultural sector specifically, occupational falls are prevalent both in the US^{47,48} and internationally.⁴⁹ Indeed, falls appear to be a leading cause of farm injuries, accounting for 20–33% of all injuries across all ages except ages 15–24.⁴⁷ The findings in this study suggest that further investigation of the association between gait abnormalities and falls in farmworkers may be informative. Of interest may be the possible association between pesticides and gait impairment in farmworkers, particularly compounds known to be associated with a higher risk of subsequently developing Alzheimer's disease and Parkinson's disease in those chronically exposed.^{4,6}

Limitations of our study include the small sample size and the limited number of confounding covariates measured. Because the study was designed to determine feasibility, we did not screen participants prior to gait measurements for strenuous activity, alcohol/drug intake, sleep, use of medications, caffeine, medical conditions (e.g., prior head injury) and other variables that could affect gait function. Chronic conditions, such as osteoarthritis, and history of falls, that may affect gait are based on self-reports. A strength of the study is the demonstration that the portable GAITRite mat is suitable for use in community centers adjacent to farmworker residences.

In conclusion, our findings suggest that measuring gait with a portable walkway system is feasible and informative in farmworkers and may possibly be of use in assessing fall risk. Future studies using this device may help identify ways to improve farmworker safety and reduce accidental injury.

Acknowledgments

Funding was provided by grants from the National Institute of Environmental Health Sciences (R21-ES019720 and R01-ES08739) and the National Institute on Aging (P30-AG021332).

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Table 1

Characteristics of participants by group*

	Farmworker (n = 16)		Non-farmworker (n = 24)	
	n (%)	Mean $\pm$; range	n (%)	Mean $\pm$; range
Age (years)		30.7 $\pm$ 12.6; 18–62		34.7 $\pm$ 11.5; 18–72
Age group				
< 30	10 (62.5)		6 (25.0)	
30–49	4 (25.0)		17 (70.8)	
50	2 (12.5)		1 (4.2)	
Education (years)		5.9 $\pm$ 4.8; 0–12		8.4 $\pm$ 3.8; 0–13
Married	7 (43.7)		16 (66.6)	
BMI (kg/m ²)		28.6 $\pm$ 5.2; 22.0–38.6		28.9 $\pm$ 4.1; 20.5–38.2
Born in Mexico	13 (81.2)		17 (70.8)	
Speaks English	5 (33.3)		9 (37.5)	
Speaks Spanish	16 (100.0)		24 (100.0)	

* Age, education, marital status, BMI, born in Mexico, speaks English, and speaks Spanish did not statistically significantly between farmworkers and non-farmworkers.

Table 2

Comparison between gait scores in farmworkers and non-farmworkers in North Carolina

	Farmworker (n = 16) Mean ±SD	Non-farmworker (n = 24) Mean ±SD	P-value*
Gait velocity (m/s)	1.0 ±0.2	1.2 ±0.1	0.003
Cadence (steps/min)	100.9 ±10.4	111.2 ±4.8	<0.001
Stride length (m)	1.2 ±0.1	1.3 ±0.1	0.26
Stride length variability (%)	3.4 ±2.3	2.3 ±0.8	0.01
Step length (m)	0.6 ±0.1	0.6 ±0.1	0.59
Step length variability (%)	3.7 ±1.7	3.0 ±1.2	0.08
Double support time (%)	23.7±3.0	24.1±2.2	0.83
Base of support (m)	0.9±0.3	0.1±0.2	0.50

* All models were adjusted for age and BMI.