

Full Shift Physical Activity among Reforestation Hand Planters: A Feasibility Study

Robert Granzow, Mark C. Schall, Jr., Mathew Smidt

Auburn University

Reforestation in the Southeastern United States is predominantly accomplished through the use of hand planting methods. A high prevalence of musculoskeletal pain has been reported among reforestation hand planters. This feasibility study aimed to characterize the intensity of physical activity using inertial measurement units (IMUs) placed on the upper arms, trunk, and waist of ten reforestation hand planters during full shift work. Results indicated that participants spent the majority (>50%) of their time performing moderate, vigorous, or very vigorous levels of physical activity. Exposure estimates among planters exceed many other occupations that commonly report a high prevalence of musculoskeletal health outcomes, including healthcare and construction workers. Additional research into the working demands of reforestation hand planters is warranted.

INTRODUCTION

Work-related musculoskeletal disorders (MSDs) are widespread and are a major cause of lost productivity and disability in the United States (Putz-Anderson et al., 1997). Across industry sectors, MSDs represent approximately 33% of all non-fatal occupational injuries and illnesses (BLS, 2015). Among goods-producing sectors, workers in the Agriculture, Forestry, and Fishing (AFF) sector incurred the second highest rate of MSDs with 41.5 cases per 10,000 full-time workers, falling just behind construction workers at 41.9 cases (BLS, 2015).

Hand planting is physically intensive labor that involves carrying a large bag of seedlings and planting them one at a time at the desired spacing using a planting tool (e.g., spade, hoedad, dibble bar, etc.). Several studies have examined the production rates of hand planting crews across a variety of geographic worksites. Hand planters of containerized seedlings in eastern and central Canada have been observed to average 11.7 seconds per tree, with planting and other productive time exhausting 88% of the workday (Stjernberg, 1988). In British Columbia, average production rates were above 1900 trees per day, or about 10 seconds per seedling (Stjernberg, 2003). Another survey of planters in Canada reported an average productivity of 1245 trees per day (Giguère, 1993). These values demonstrate the high rate of production that hand planters are expected to achieve.

A high prevalence of work-related musculoskeletal pain has been reported among reforestation planters (Slot, 2010). Agriculture and forestry workers are exposed to similar postural and physical demands. Neck/shoulder and low back pain, in particular, have

been identified as negative health effects of agriculture (Fathallah, 2008) and forestry (Gallis, 2006) work. Although a few descriptive studies are available describing the main elements of the planting cycle and exposures to some physical risk factors associated with MSDs (e.g., wrist postures and forces; Denbeigh, 2013; Giguère, 1993; Hodges, 2011; Upjohn, 2008), limited information is available documenting other common risk factors (e.g., intensity of occupational physical activity) among reforestation hand planters. Characterization of such exposures during a full work shift are needed to develop interventions capable of mitigating exposures and prevent MSDs among this important workforce.

The objective of this study was to characterize the intensity of physical activity of reforestation hand planters working a full shift in the Southeast region of the United States. This study directly addresses Strategic Goal #7 identified within the AFF industry sector of the National Occupational Research Agenda (NORA). Specifically, the research improves the scientific community's understanding of the health risks related to the strenuous work forestry workers perform over long work shifts.

METHODS

Participants

A sample of 10 healthy, male hand planters (mean age=25.8 ± 5.9 years; mean body mass index [BMI]=24.9 ± 1.8kg/m²) was recruited from a reforestation contractor registered with the Alabama Forestry Commission for hand planting services in the state of Alabama in January 2016. The workers all

belonged to the same crew and worked a “dawn to dusk” shift that varied daily depending on environmental conditions such as temperature and precipitation (mean shift duration=7.3 ± 1.7 hours). Frozen ground and daily acreage demand were the greatest contributors to fluctuations in shift length.

Participants self-reported 1) no history of physician-diagnosed MSDs in the neck/shoulder or back regions, 2) no neck/shoulder or back pain two weeks prior to enrollment, and 3) no history of neurodegenerative disease (e.g., Parkinson’s disease). All study procedures were approved by the Auburn University Institutional Review Board.

Physical Activity Assessment

Four Actigraph GT9X Link (Actigraph, Pensacola, Florida, USA) physical activity monitors were used to obtain estimates of physical activity. The monitors were worn over the right hip (the anterior superior iliac spine), the trunk (secured to the anterior torso at the sternal notch), and both upper arms (secured to the lateral aspect of the upper arm approximately one-half the distance between the lateral epicondyle and the acromion) using elastic straps. Each ActiGraph GT9X Link contains an IMU comprised of a tri-axial accelerometer, gyroscope, and magnetometer. The units sample at a constant rate of 100 Hz.

Activity “counts” at each data sample were summed across non-overlapping epochs of one minute to attain counts/min. Finally, the counts/min at each epoch were categorized into different intensities of physical activity. Definitions from Freedson et al. (1998) were used to categorize physical activity as “sedentary” (0-100 counts/min), “light” (101-1952 counts/min), “moderate” (1953-5724 counts/min), vigorous (5725-9498 counts/min), and “very vigorous” (>9498 counts/min). For each participant and sensor, the total number of minutes assigned to each physical activity category across the full sampling duration was calculated. The proportions of time in each physical activity category were used as the exposure variables.

RESULTS

Physical activity data were successfully obtained for all 10 participants. On average, participants spent the majority (>50%) of their time performing moderate, vigorous, or very vigorous levels of physical activity (Table 1). The results indicate a large (>15%) standard deviation for some of the physical activity estimates.

Table 1. Mean (SD) of percentage of time in various physical activity intensity categories by IMU location.

IMU Location	Sedentary / Light	Moderate	Vigorous	Very Vigorous
Left Arm	8.8 (3.8)	28.1 (9.2)	60.3 (8.5)	2.8 (5.4)
Right Arm	7.4 (3.2)	19.1 (5.7)	43.9 (16.7)	29.6 (20.7)
Trunk	13.4 (4.0)	49.8 (20.1)	36.8 (22.0)	0.0 (0.0)
Waist	15.9 (4.5)	75.2 (7.6)	8.9 (9.4)	0.0 (0.0)

Comparisons of the physical activity estimates with studies performed using a similar methodology within other job sectors suggests that hand planters are exposed to levels of physical activity higher than that of registered nurses (Schall et al., 2015), commercial construction workers (Arias et al., 2015), and patient care workers (Umukoro et al., 2013). Table 2 shows physical activity data from the IMU located on the right hip, consistent with the other studies.

Table 2. PA comparisons by study for IMU located on the right hip

	Sedentary	Light	Moderate	Vigorous/ Very Vigorous
Hand Planters (Granzow et al., 2016)	3.2	12.7	75.2	8.9
Registered Nurses (Schall et al., 2015)	30.3	61.9	7.9	0.0
Construction Workers (Arias et al., 2014)	37.0	51.0	12.0	0.0
Patient Care Workers (Umukoro et al., 2013)	54.0	45.0	1.0	0.0

DISCUSSION

The results of this study indicate that reforestation hand planters routinely engage in high intensity physical activity exceeding levels reported for several other occupational groups that traditionally report high rates of MSDs (construction and healthcare workers). These preliminary results suggest that reforestation hand planting is a physically demanding job that warrants additional research.

The large percentage of work time performing vigorous and very vigorous intensity work as measured for the left and right arms, in particular, suggest that the worker is exposed to pronounced arm movements during the process of planting. These movements, over the entire planting season, may result in cumulative damage and the development of MSDs. Additional analysis of the movement velocities and postures of the upper arms

and trunk will be completed using the data obtained with the IMUs in this study.

Occupational physical activity comparisons between this study and others only incorporated the data from the IMU worn on the right hip. Previous research indicates that IMUs worn on the waist may not accurately represent overall occupational physical activity because they are incapable of capturing high intensity upper body occupational physical activity (Bassett et al., 2000; Hendelman et al., 2000; Matthews, 2005; Matthews et al., 2012; Schall et al., 2016). A comparison of the data collected during this study with future studies that incorporate arm and trunk activity of workers in comparable jobs with similar prevalence of MSDs may show the relative physical risk that hand planters are experiencing.

Several limitations were identified during the conduct of this feasibility study that may be beneficial to other investigators. First, this study involved a small number of participants (N=10) that may have contributed to large variability in physical activity estimates as evidenced by large standard deviations for some IMU locations. Future studies that include a larger sample of hand planters may provide more stable estimates of exposure. Second, most participants in this study were native Spanish speakers. Although the crew supervisor provided a means to translate between the researchers and the subjects, other investigators may be wise to involve a research team member as a translator. By incorporating a translator into the study team, subjects may be more comfortable and willing to report feelings of fatigue and psychosocial demands about their work than to a direct supervisor. Finally, the forestry workers that participated in this study were compensated at an hourly rate, a practice which is not representative of all forestry work. Piece rate payment strategies are typically used to compensate reforestation hand planters, providing workers an incentive to work at an even more strenuous pace for longer hours than what was observed in this study (McDaniel and Casanova, 2003). Future work involving reforestation hand planters compensated via a piece rate payment strategy is needed.

A comparison of hand planting with mechanized forestry workers is necessary to compare possible worker health benefits of different planting methods. Such additional work may lead to the development of better tools that can reduce exposure to physical risk factors associated with musculoskeletal health outcomes among reforestation hand planters.

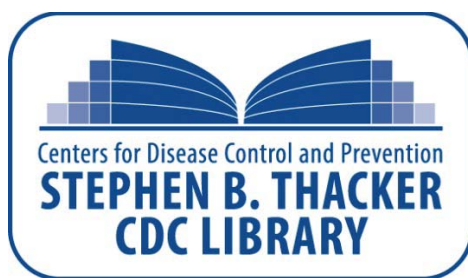
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