Self–Reported Musculoskeletal Symptoms and Observed Risk Factors in Bareroot Tree Nurseries

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ABSTRACT. *A cross–sectional study of jobs at four bareroot reforestation tree nurseries in Washington and Oregon investigated the prevalence of musculoskeletal symptoms and potential work–related musculoskeletal disorders (WMSDs), and analyzed their association with physical and psychosocial risk factors of the jobs. Questionnaires were used to assess symptoms and psychosocial factors. Direct observational work sampling was utilized to estimate physical risk factors. The response rate for the questionnaires was 41% (203 subjects), of which 72% reported recurring symptoms in the past year. The most common body region was the wrist/hand (42%). Pain was the most commonly reported symptom. Forty–one percent of the subjects had at least one potential WMSD, the hand region having the greatest number of cases (n = 51). The average age of those with and without potential WMSDs did not significantly differ; however, tenure at the nursery (p < 0.03) did. Being female (OR = 7.37; 95% CI = 2.75, 19.7,) high job satisfaction (OR = 0.32; 95% CI = 0.15, 0.72), and having a second job (OR = 3.76; 95% CI = 1.12, 12.57) were significantly associated with potential WMSDs. No significant difference in WMSD prevalence was found between the field and packing shed areas of the nurseries (p = 0.88). Pinch gripping was observed 24% of the time in the shed and 8% of the time in the field. Torso flexion was observed more often in the field than the shed (38% vs. 18% of the time). This study found that both physical and psychosocial factors associated with WMSDs are present in bareroot trees nurseries.*

Keywords. *Musculoskeletal symptoms, Physical risk factors, Psychosocial factors, Tree nurseries, Work–related musculoskeletal disorders.*

F orest lands, 36% of which are privately owned, cover a large portion of Washing- ton State, and most are "working" forests producing timber for wood products. Forest products comprise the second largest manufacturing industry in Washing- ton State. In 1999, the total gross business income for logging, sawmills, and planing mills was over $5 billion. The gross business income for pulp and paper mills was more than $2 billion for the same year. However, in order to be a sustainable industry, the re- placement of trees, or reforestation, is necessary. Private owners plant at least three trees for every one harvested, requiring 35 million new trees each year. Bareroot reforestation nurseries play an integral part in this process by growing the small trees that are ultimately planted in forest lands. Reforestation nursery work is largely an agricultural process in- volving the germination of seeds, the planting of the young trees, and the harvesting and packaging of the trees at maturity.

A significant body of research exists in regards to musculoskeletal injuries and illnesses in manufacturing and office environments; however, agriculture and forestry have not been examined to the same extent. The musculoskeletal risk factors and physical load associated with tree planting in forest lands have previously been studied (Smith et al., 1986; Trites et al., 1993; Giguere et al., 1993), and numerous publications and tools have been developed to educate and improve this aspect of the industry. However, very few evaluations have been conducted on the work required to grow the trees prior to final planting. In a report by Stuart et al. (1995), an ergonomic analysis of the jobs at a bareroot tree nursery found repetitive and sustained torso and neck flexion, frequent kneeling, high finger repetition, high finger force, and prolonged or repetitive wrist bending and deviation to be prevalent. Symptomatic nursery workers have been found to experience stiffer shoulders, more headaches, more tiredness, and more frequent back pain (Wallersteiner, 1987). A review of OSHA 200 injury logs and first aid reports at three California ornamental nurseries found that the back was the most commonly injured body area, followed by the hand and wrist, other upper extremities, and lower extremities (Meyers et al., 1997). A 1994 national survey of injuries among U.S. farm workers estimated that there were 7230 lost–time injuries in nursery work annually. Sprains and strains accounted for 34% of them (Myers, 1998). In the same survey, the estimated lost–time injury rate was 9.4 per 200,000 hours worked, the highest among the different farm types including cash grain, field crops, dairy, and beef, hogs, and sheep. In Washington State between 1990 and 1998, close to 400,000 State Fund workers' compensation claims were accepted for non–traumatic soft tissue musculoskeletal disorders of the neck, back, and upper extremity. This number translates into $2.3 billion in direct costs and 20.5 million lost workdays (Silverstein et al., 2000). The claims incidence rate for WMSDs in Washington State in agriculture, forestry, and fishing was 3.3 per 200,000 hours (Silverstein et al., 2000).

In addition to occupational risk factors such as repetitive motions, awkward postures, and high hand force, factors such as smoking, gender, age, years of work experience, and pre–existing medical conditions have been associated with musculoskeletal disorders. Smokers have been shown to be more likely to report an injury (McSweeney et al., 1999; Heliövaara et al., 1991). In a study of aluminum workers, Morken et al. (2000) found that the prevalence of musculoskeletal symptoms increased with the duration of employment, and that age and duration of employment were strongly correlated. The presence of a WMSD or systemic diseases, such as diabetes and hypothyroidism, can increase the risk of developing another WMSD. Solomon et al. (1999) found an association between carpal tunnel release and diabetes mellitus, hypothyroidism, and gender.

The objective of this cross–sectional study was to investigate the prevalence of musculoskeletal symptoms and potential WMSDs in bareroot tree nursery workers and to investigate the major production jobs and tasks in relation to musculoskeletal injury risk. In addition, the relationship between psychosocial risk factors of the work environment, individual factors and pre–existing medical conditions, and potential WMSDs was examined.

Materials and Methods

Site Description

The forest tree nurseries in this study produce between 10 and 30 million small seedling trees yearly, primarily for reforestation of government or private forest lands. Seedlings are grown in large fields and are sold after one to three years of growth. Intermittent laborers, employed between two and six months per year, comprise the

greater portion of the work force. Permanent laborers, who work year–round, are also employed at the nurseries. The bareroot tree nurseries involved in this study have two distinct work areas: the field and the packing shed. The yearly work cycle of a bareroot tree nursery consists of three seasons: harvest, planting, and growing.

The harvest season (from December to March) is the busiest season, and nurseries employ the greatest number of laborers during this time. In the harvest season, trees are pulled from the fields, either by machine or by hand. Jobs evaluated in these areas were ground crew (pulling trees from the ground by hand), follow crew (picking up hand–pulled trees), bin loaders (placing hand–pulled trees into bins on tractors), and equipment laborers (loading machine–pulled trees into bins). From the field, bins of trees are brought to the packing shed where they are sorted, packaged, and stored for transplanting or sale. Packing shed jobs studied were bin unloaders, sorter/graders, catchers/saw table, bagger/packers, and bag closers.

In the planting season (during April, May, and August), seedlings (grown from seed in styrofoam blocks in greenhouses) are transplanted in the field. Workers sit in a structure, pulled by a tractor, placing seedlings into clips on a wheel, which inserts the seedlings into the ground (fig. 1). Additional workers (back planters) follow behind, planting seedling by hand in missed spots. The work force during this season can be less than half of that of the harvest season. Jobs evaluated during this period were planters and back planters. During the third season (from July to December, the growing season), fields are watered, weeded by hand, and generally maintained. No jobs were evaluated during this period.

Subjects

Participants were recruited from four bareroot tree nurseries in western Washington State and Oregon between 1995 and 1997. Participation was open to all staff (year–round employees and temporary employees) and jobs except management and office staff. Recruitment occurred at individual nurseries and involved addressing employees during a series of safety meetings and distributing informational flyers. All printed material was approved by the state institutional review board and was available in three languages (English, Korean, and Spanish). In addition, interpreters of Korean and Spanish were

Figure 1. An example of planter's (sitting down) and back planter's (bending over) jobs: transplanting seedlings.

present during recruitment sessions. Each study participant was made aware of the study objectives and provided written consent when they first volunteered. Participants were able to enter the study at any point.

Self–Administered Questionnaires

Two questionnaires were distributed to the participants, a musculoskeletal symptom questionnaire and a psychosocial questionnaire, which were completed during the normally scheduled shift. The participants were released from their jobs in order to complete the questionnaires. Questionnaires were available in English, Korean, and Spanish. The self–administered musculoskeletal symptoms questionnaire has been used in previous studies (Hughes et al., 1997; Silverstein and Hughes, 1996). In addition to collecting demographic information, health history (pertinent diseases, acute traumatic injuries), personal habits (smoking, hobbies), and work history, the musculoskeletal symptom questionnaire used a body diagram, divided into ten regions, to identify recurring symptoms, such as pain, aching, and numbness. Symptoms were considered recurrent if they occurred more than three times in the past year or lasted more than a week. For each body region with recurring symptoms, more specific information, derived from the specific Standardized Nordic questionnaire (Kuorinka et al., 1987), was obtained including frequency of symptom, duration of symptoms, aggravating factors, level of discomfort now and at its worst, lost or restricted time, and treatment. The side of the body where the symptoms occurred or the location of the symptoms in relation to the frontal plane was not considered in this analysis.

Potential work–related musculoskeletal disorders (WMSDs) were identified from responses from the musculoskeletal symptoms questionnaire and were defined as by Hughes et al. (1997):

- Symptoms occurred within the past year AND;
- Symptoms occurred at least once a week OR lasted one week or more AND;
- Symptoms did not develop following an acute, traumatic event AND;
- Symptoms were first noticed on the current job.

The psychosocial questionnaire contained 37 questions pertaining to job satisfaction, psychological demands, control over job activities, and physical and mental fatigue. The questionnaire was developed using modified scales from Karasek (1985). The responses or scores to these questions were analyzed as scales (1 to 5). For each scale, the higher the score, the more extreme the job characteristic was perceived. Single–question scores relating to the frequency of physical and mental exhaustion were calculated. Three composites scores were calculated by adding or subtracting the scores of various questions. The first composite score, psychological demands, was calculated using the following psychosocial questions:

- My job requires me to work very fast + My job requires me to work very hard – I am not asked to do an excessive amount of work + My job is very hectic – I have enough time to get the job done.

The second composite score, job control, was calculated using the following psychosocial questions:

- My job requires I learn new things + My job requires me to be creative + My job requires a high level of skill + I get to do a variety of different things on my job + I have a lot to say about what happens on my job + I can take a break when I want to – My job involves a lot of repetitive work – On my job, I have very little freedom to decide how I do my work.

The job satisfaction score was calculated using the following questions:

- All in all, how satisfied are you with you job?+ How strongly would you recommend your job to someone else?+ If you were looking for a job now, how likely is it that you would decide to take this job again?

Risk Factor Field Observations

To evaluate the physical risk factors in production jobs of the tree nurseries, a form developed by the Safety and Health Assessment and Research for Prevention Program (SHARP) was used. The risk factor surveillance form provides a checklist for musculoskeletal disorder risk factors during work sampling of jobs and has been used previously in a field study of the aluminum industry (Silverstein et al., 1997). The form is divided into four categories (forceful exertions, awkward postures, contact stress, and general) with various risk factors under each. Risk factors such as gripping slippery objects, using a power tool, wrist deviation, and neck flexion/extension are included on the form. Job activities of the production jobs were identified to the greatest detail possible and used to classify observations. For short–cycle jobs, the common job activities related to the growing, harvesting, and packaging of trees were observed for a minimum of twenty cycles. During this period, observations were made every minute, and risk factors observed during this interval were marked on the checklist. For longer cycle jobs, observations were made for a minimum of twenty minutes, during which time risk factors were also recorded every minute. Risk factors to the left or right side of the body were recorded. Nursery workers were randomly chosen for observations.

Statistical Analysis

The difference in years of work experience between those respondents with potential WMSDs and those without was analyzed using a two–tailed non–parametric t–test. Categorical and dichotomous variables were analyzed using the chi–squared test of independence. An ordinal variable was used for age (19–29 years, 30–39 years, 40–49 years, and 50 or more years of age) and for work experience (0–9 years, 10–19 years, 20–29 years, and 30 or more years of experience). A significance level of 0.05 was used for all statistical tests. Fisher's exact 2–tail test was used to assess relationships between all potential WMSDs and the following variables associated with MSDs: gender, diabetes, gout, thyroid, high blood pressure, history of carpal tunnel syndrome, thoracic outlet syndrome, tendinitis, ruptured disk in the back, epicondylitis, wrist fracture, and ruptured disk in the neck.In addition, Fisher's exact 2–tail test was used to determine whether any significant relationships existed between site–specific potential WMSDs and reported musculoskeletal disorders at those sites. Non–parametric t–tests were used in a comparison of psychosocial scales scores for those with and without site–specific WMSDs. Physical load factors could not be segregated between field and shed work. Thus, these factors were not included in the models.

Results

The overall participation rate was 41%. The questionnaire response rate for the nurseries ranged between 30% and 70% (table 1). A total of 203 employees completed a musculoskeletal symptom questionnaire and 197 completed a psychosocial questionnaire.

Musculoskeletal Symptom Questionnaire

Demographic characteristics of the study participants are shown in table 2. An evaluation of participation bias was not possible as no data were collected for non–participants. Age, height, weight, and gender distribution did not differ significantly

Table 1. Percentage of employees from each nursery site who completed musculoskeletal symptoms and psychosocial questionnaires.

Site	Response Rate for Symptoms Survey	Response Rate for Psychosocial Survey
Nursery 1	61 (70%)	60 (69%)
Nursery 2	60 (55%)	60 (55%)
Nursery 3	46 (43%)	41 (39%)
Nursery 4	36 (30%)	36 (30%)

between the nurseries. Industry experience was significantly different for nursery 4. Unique identifiers were assigned to each participant and their symptoms and psychosocial questionnaires, which were administered at the same time. Non−smokers accounted for 49%, 24% were ex−smokers, and 27% were current smokers. Almost half of the respondents (46%) reported having second jobs. Twenty−three percent of those with second jobs held these jobs year round, with the remainder working in their second jobs during the nursery off−season. Of these respondents, 21% ($n = 18$) reported being injured on their second job; however, only five of these injuries were due to chronic conditions.

From the body diagram on the questionnaire, 72% of the respondents ($n = 146$) reported recurring symptoms during the past year in at least one anatomical area. Of those workers with second jobs, 79% reported symptoms compared to 68% of the workers without second jobs, although the difference was not significant ($\chi^2 = 2.53$, p = 0.11). However, a comparison of symptom reporting between those with year−round second jobs and those with only off−season jobs was significantly different ($\chi^2 = 6.23$, p = 0.01). One hundred percent of workers with year−round second jobs reported musculoskeletal symptoms in comparison to 74% of workers with off−season jobs. Figure 2 summarizes the recurring symptoms of the respondents. The most common body regions with recurring symptoms were the wrist/hand (42%), lower back (34%), shoulder (32%), and neck (31%). Pain and aching were among the more commonly reported symptoms in nine of the ten body regions.
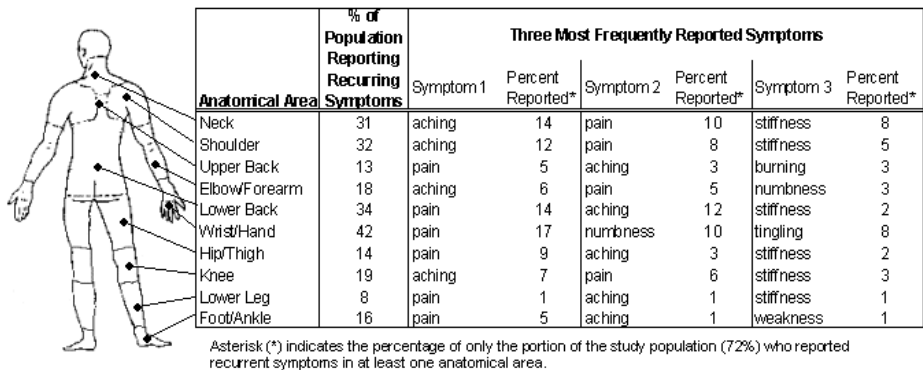
In reporting symptoms, some inconsistencies were found. Forty−two percent of the respondents indicated hand problems on the body diagram (the most frequently reported anatomical area); however, from other questions involving individual body regions, 46% described hand problems as recurrent. The location of recurring symptoms in the hand region is presented in figure 3.

Figure 4 presents the most frequently reported symptoms in the four most common hand regions with recurrent symptoms: the wrist, fingers (excluding the thumb and little finger), the thumb and thenar eminence, and the palm and back of the hand. Similar to

Table 2. General characteristics of study participants.

	Age (years)		Height (in.)		Weight (lbs)		Industry Experience (years)[a]		% Female
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
All sites	41.2	12.2	64.9	4.1	159.6	38.7	8.5	8.3	76
Nursery 1	39.3	12.7	65.1	4.1	161.4	37.7	7.5	7.7	75
Nursery 2	41.0	12.6	63.7	4.3	159.7	37.9	7.5	7.9	71
Nursery 3	40.4	9.9	65.5	4.3	148.4	30.5	7.9	9.0	82
Nursery 4	45.7	10.6	65.7	3.4	169.5	47.7	12.4	8.0	78

[a] Significant difference between nurseries (p < 0.05).

Anatomical Area	% of Population Reporting Recurring Symptoms	Three Most Frequently Reported Symptoms					
		Symptom 1	Percent Reported*	Symptom 2	Percent Reported*	Symptom 3	Percent Reported*
Neck	31	aching	14	pain	10	stiffness	8
Shoulder	32	aching	12	pain	8	stiffness	5
Upper Back	13	pain	5	aching	3	burning	3
Elbow/Forearm	18	aching	6	pain	5	numbness	3
Lower Back	34	pain	14	aching	12	stiffness	2
Wrist/Hand	42	pain	17	numbness	10	tingling	8
Hip/Thigh	14	pain	9	aching	3	stiffness	2
Knee	19	aching	7	pain	6	stiffness	3
Lower Leg	8	pain	1	aching	1	stiffness	1
Foot/Ankle	16	pain	5	aching	1	weakness	1

Asterisk (*) indicates the percentage of only the portion of the study population (72%) who reported recurrent symptoms in at least one anatomical area.

Figure 2. Percentage of respondents (*n* = 203) who reported recurring symptoms, and the three most frequently reported recurring symptoms by anatomical area.

the body diagram, pain was the most commonly reported symptom. Numbness and tingling were also commonly reported symptoms, with digits 2 to 4 most frequently identified.
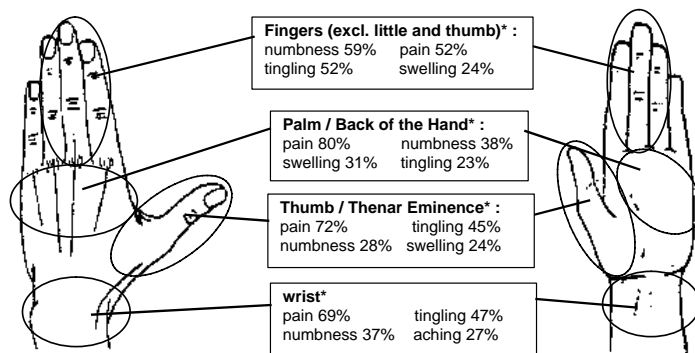
Based on the study's established criteria for potential WMSDs, 41% of the respondents had at least one potential WMSD. As shown in figure 5, the hand region had the most potential WMSD cases (*n* = 51), followed by the shoulder (24 cases), elbow (18 cases), and neck (18 cases). The lower extremity regions had the fewest number of cases.

There was no significant difference in age between those with and without potential WMSDs (42.79 ± 12.15 years vs. 40.13 ± 12.14 years, respectively, p = 0.14). Those with potential WMSDs had significantly more seniority (10.06 ± 8.59 years) than those without WMSDs (7.41 ± 7.85 years), p < 0.03, when WMSDs from all body regions were combined. When potential WMSDs were analyzed by body region, no statistically significant differences in seniority were found, with the exception of the foot (p < 0.03). Figure 6 summarizes the differences in seniority between the two groups by body region.

A logistic regression analysis was conducted to estimate the role of age, gender, height, weight, body mass index, smoking status, years of nursery experience, and
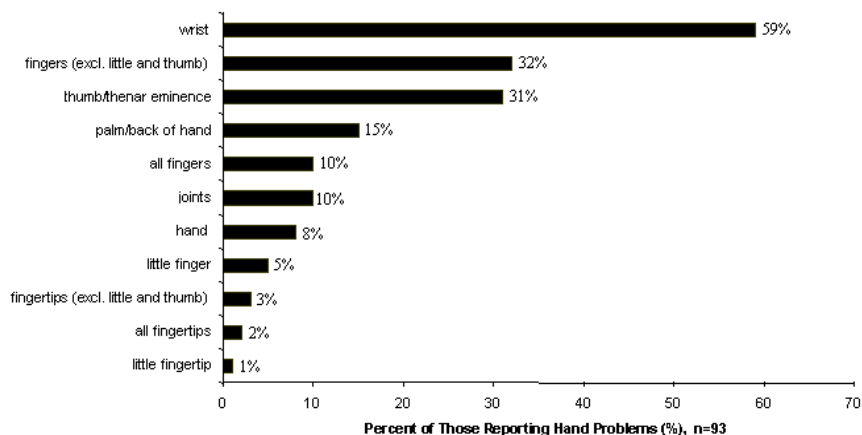
Figure 3. The distribution (%) of recurring hand/wrist symptoms occurring more than three times or lasting more than one week in the past year by hand region.

Fingers (excl. little and thumb)* :
numbness 59%   pain 52%
tingling 52%   swelling 24%

Palm / Back of the Hand* :
pain 80%   numbness 38%
swelling 31%   tingling 23%

Thumb / Thenar Eminence* :
pain 72%   tingling 45%
numbness 28%   swelling 24%

wrist*
pain 69%   tingling 47%
numbness 37%   aching 27%

* Percentage of only those reporting symptoms in specific hand regions

Figure 4. The four most commonly reported areas of the hand and wrist with recurring symptoms, and the top four corresponding symptoms.

previous history of carpal tunnel syndrome or tendinitis on reporting a potential WMSD (table 3). Results showed that only one factor had a significant effect: being female increased the risk of a potential WMSD (OR = 4.57).

A further analysis was completed to examine the relationship between previously physician–diagnosed musculoskeletal conditions of a specific body region and the corresponding site–specific WMSDs. In this study population, those with potential hand WMSDs more often had a history of carpal tunnel syndrome ($\chi^2 = 6.23$, $p = 0.01$). Additionally, those with potential elbow WMSDs more frequently had a history of tendinitis ($\chi^2 = 6.79$, $p = 0.01$), epicondylitis ($\chi^2 = 3.93$, $p = 0.05$), and carpal tunnel syndrome ($\chi^2 = 5.24$, $p = 0.02$).

Psychosocial Questionnaire

Forty–eight percent of the respondents indicated that they were somewhat satisfied with their job, while 45% indicated that they were very satisfied with their job. When asked how frequently they were physically exhausted after work, 63% were either always
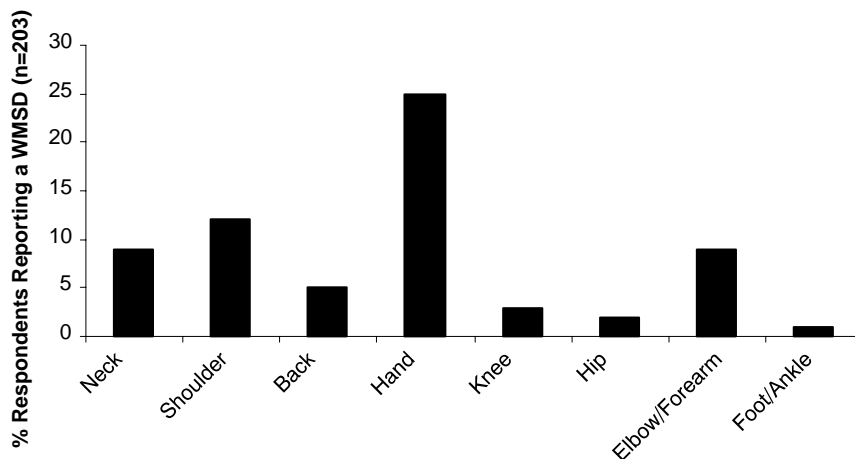
Figure 5. Workers with a potential work–related musculoskeletal disorder by body region.
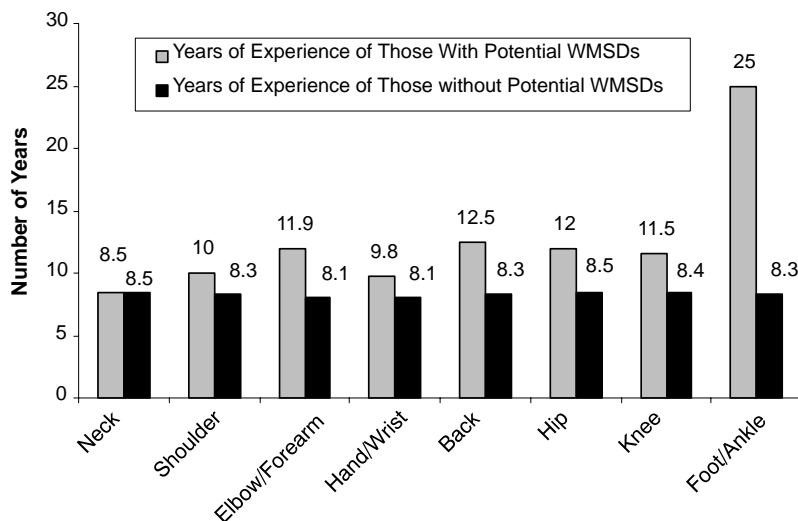
Figure 6. Comparison of average work experience between those with potential WMSDs (*n* = 83) and those without potential WMSDs (*n* = 120) by body part.

or often physically exhausted, 7% were never exhausted. In comparison, 40% of the respondents were either always or often mentally exhausted after work, and 13% never experienced mental exhaustion after work. Table 4 compares the psychosocial scales of those employees with potential WMSDs with the scores of those without potential WMSDs. When all WMSDs were combined into a single variable, those workers with potential WMSDs scored higher on the psychological demands scale and lower on the job control and job satisfaction scales, although only the job satisfaction scores were significantly different. When the scores were analyzed for individual WMSDs, only job satisfaction scores for back and neck WMSDs differed significantly.

Forty–eight percent of the study population said they had high control over their activities (job control score >13, range 4 to 22), 61% reported high psychological demands (psychological demands score >4, range 0 to 10), and 49% indicated high satisfaction with their jobs (job satisfaction score >8, range 3 to 12). Twenty–eight percent of the participants worked in a high–strain environment (low job control/high psychological demands). A final logistic regression analysis included job satisfaction,

Table 3. Logistic regression analysis between personal characteristics, previous musculoskeletal conditions, and potential WMSDs.

Explanatory Variable	Odds Ratio	95% CI
Age	0.99	0.96, 1.03
Height	0.88	0.78, 1.01
Weight	1.01	1.00, 1.02
Body mass index	0.85	0.54, 1.33
Smoking status	1.29	0.81, 2.03
Years of industry experience	1.02	0.97, 1.07
Gender	4.57[a]	1.53, 13.65
Previously diagnosed carpal tunnel syndrome	0.86	0.23, 3.15
Previously diagnosed tendinitis	2.79	0.83, 9.35

[a] Denotes significant finding.

Table 4. Mean psychosocial scale score for those with and without potential WMSDs.

Psychosocial Scales	All WMSDs Combined		Back WMSDs		Hand WMSDs		Neck WMSDs		Shoulder WMSDs	
	Those Without	Those With	Those Without	Those With	Those Without	Those With	Those Without	Those With	Those Without	Those With
Psychological demands	2.9	3.7	3.2	4.2	2.9	4.0	3.1	3.9	3.2	3.5
Job control	9.6	8.8	9.2	9.0	9.3	9.0	9.3	8.6	9.3	8.7
Job satisfaction	9.8[a]	8.9[a]	9.5[a]	7.7[a]	9.6	9.0	9.6[a]	8.3[a]	9.5	9.0

[a] Denotes statistically significant difference (p < 0.05).

high job strain (a combination of high psychological demands and low job control), gender (shown to be a risk factor of WMSDs from the previous regression), age, seniority, having a year–round second job, physical exhaustion, mental exhaustion, and having a potential WMSD. Due to missing values, data from 161 participants were used in the analysis. High job satisfaction had a protective effect (OR = 0.32; 95% CI = 0.15, 0.72). Being female (OR = 7.37; 95% CI = 2.75, 19.7) and having a second job (OR = 3.76; 95% CI = 1.12, 12.57) increased the risk. Physical factors were not included in these analyses since the study design did not allow physical factors to be matched at the individual level.

Risk Factor Field Observations

Table 5 summarizes the results of the risk factor field observations of the inside (packing shed) and outside (field) jobs. A total of five packing shed jobs were evaluated: bin unloading, sorting/grading, catching/saw table operators, bag packing, and bag closing. Four field jobs were observed: ground crew, follow crew, bin loading, and equipment laborers. Most workers in the tree nurseries rotated jobs; however, the rotation schedule varied between nurseries. In general, most of the workers were observed rotating between the majority of jobs in either the packing shed or field, and in some cases between the shed and field jobs. A rotation schedule was assumed in calculating an estimated exposure duration for risk factors. The shed jobs were assumed to have a duration of one hour for bin unloading and bag closing, and two hours for the other three jobs. The field jobs were assumed to have an equal duration over an eight–hour day. Time–weighted exposure durations were calculated based on the percentage of observations for each risk factor. These weighted averages are presented in table 5. Measures that were observed for the left and right side were averaged. The sampling error for the 865 observations of shed jobs and the 445 observations of the field jobs, based on a binomial distribution, was less than 2%.

Many of the observed risk factors are associated with the repetitive work of moving seedlings from the ground in the field and sorting and moving seedling bundles on a conveyor line in the shed. Field jobs were more often characterized as medium repetitive (60%), by more torso flexion (38% of the time compared to 18% of the time in the shed), and handling weights greater than 6 lbs (15% of the time). Shed jobs were characterized by more awkward lower arm postures such as wrist flexion/extension (31%), elbows away from the body (63%), and forearm rotation (20%). Hand tools were very rarely used. Shed jobs were characterized by more pinch gripping and forceful gripping. Pinch gripping was observed 24% of the time in the shed while handling seedlings and 8% of the time in the field. These observations indicate a prevalence of awkward body postures and hand/arm repetition in both shed and field jobs.

Participants of the study were assigned to a work area, either the shed or field, based on the symptom survey responses and how many jobs they indicated they performed in

Table 5. Time weighted exposure durations (% of time) of physical risk factors observed from work sampling of tree nursery packing shed and field jobs during harvest.

Risk Factor		Shed Jobs Exposure Duration (*n* = 865)	Field Jobs Exposure Duration (*n* = 445)
Repetition	Medium repetition	34	60
	High repetition	8	7
Posture	Wrist flexion/extension	31	23
	Ulnar/radial deviation	18	16
	Twisting forearm	20	9
	Elbows away from body	63	53
	Full elbow flexion	2	7
	Full elbow extension	17	20
	Hand above shoulder	18	18
	Reaching behind body	0	1
	Neck flexion/extension	32	18
	Neck twisting	12	18
	Torso flexed	18	38
	Torso side bending	20	9
	Torso twisting	38	39
Force	Weight >6 lbs/hand	7	15
	Grip slippery object	0	3
	Using hand tool	0	0
	Forceful grip	11	4
	Pinch grip	24	8
	Push/pull	25	34
	Asymmetric lift	9	11
	Lift/carry	67	50

each area. Univariate analysis was then performed to compare potential WMSDs in each work area. There was no significant difference between the shed and field for all WMSDs combined ($\chi^2 = 0.02$, p = 0.88). There was also no significant difference in site–specific WMSDs (shoulder, hand, neck, back, and elbow) and work area.

Discussion

This study found that both physical and psychosocial factors associated with work–related musculoskeletal disorders were present in bareroot tree nurseries. Bareroot tree nursery work involves working at ground level in the field, continuous handling of small trees, and manual handling of the packaged trees in the packing shed. Nearly three–quarters of the respondents in this study reported recurrent symptoms in predominantly the upper extremities. The most common body sites were the wrist/hand, lower back, shoulder, and neck. The most commonly reported symptoms in these areas were pain, aching, and stiffness. Direct observations of risk factors in the packing shed and field jobs support these findings.

The wrist was the hand region reported by the greatest proportion of those experiencing recurrent problems in the hand. The three most common symptoms reported in this region were pain, numbness, and tingling, symptoms that may indicate a vascular or nerve impingement. In addition, the areas of the hand affected by median nerve compression are the palmar side of the hand from the thumb to the fourth finger, and on the dorsal side, the tips of the second to fourth finger. Pain, numbness, and tingling

were indicated in all these areas on the hand diagrams. Direct observations of risk factors found medium–repetition jobs in both the field and shed areas, pinch gripping in the shed, and non–neutral wrist postures in both field and shed jobs.

No significant relationship was found between age and potential WMSDs. However, a significant difference in work experience (seniority) was found between those with and without potential WMSDs. This result is consistent with the findings of other studies that asymptomatic workers tended to stay on the job longer than workers with injuries. Morken et al. (2000) found that the prevalence of musculoskeletal symptoms increased with age and duration of employment. However, a study of workers at an aircraft engine manufacturer (Cannon et al., 1981) found that the years on the job were less for those with carpal tunnel syndrome than for those without carpal tunnel syndrome.

The jobs studied at the bareroot tree nurseries were physically exhausting (63% were either often or always physically exhausted) and psychologically demanding, as indicated by the high scores. More than 50% of the study population scored low on the job control scale, which is consistent with the organization of this type of work. Many of the jobs, especially in the packing shed, are machined paced, which reduces the control a worker has over his or her work pace. In the field, much of the work pace was determined by the weather (e.g., harvesting trees before a frost, rainfall, or warming temperatures). Production deadlines and seasonal deadlines may also decrease the sense of job control among the workers. Despite these issues, the majority of the respondents were somewhat or very satisfied with their jobs, and the job satisfaction score was high.

Gender was one factor found to be associated with potential WMSDs. Females have been shown to more frequently report musculoskeletal symptoms or have a higher risk for symptoms (Bernard et al., 1994; Coury et al., 2002; Morken et al., 2000). However, several factors may have influenced these results in this study, most notably the possible differences in exposure between genders. The number of males participating in this study was small (24% of the study respondents); therefore, the number of potential WMSDs among this sub–group was small (9 cases compared to 74 cases among the female respondents). In addition, the majority of participants were from the production jobs, which were typically held by females and are more repetitive. The men generally operated more of the heavy equipment in the field and the warehouse. Punnet and Herbert (2000) outlined gender differences in relation to differing exposures, WMSD site, and symptom reporting. Won et al. (2003) found that the relationship between disorders and female gender in an office–based study could also be explained by differences in hand geometry. These studies point to the possibility that female gender may actually be an indication of non–symmetric physical and/or psychosocial stress dispersion between males and females in the workplace.

Although one criterion in the determination of potential work–related musculoskeletal disorders was that symptoms were first noticed on the current job, it was not possible to determine exacerbating factors. Nearly half of the respondents had second jobs (46%), many of which held the nursery job and the second job at the same time. In this study, having a year–round second job increased the odds of a WMSD. However, the majority of injuries reported on the second job were acute rather than chronic conditions. The nature of the second job was not asked, and it was not possible to determine non–nursery work risk factors and their potential effects on the development of WMSDs. In a 1996 report from the USDA, it was found that 1 in 5 rural workers employed in farming, forestry, and fishing held more than one job (Economic Research Service, 1997). Most rural workers held second jobs in the same occupation as their first job. A study by Park et al. (2001) found that farmers in Iowa with a second job were more likely to experience back pain than farmers who did not have a second job. This may increase exposure to the

same WMSD risk factors experienced in the first job. Additionally, the increased number of work hours may reduce the recuperative or recovery time.

Not accounting for the physical risk factors, job satisfaction was an important psychosocial predictor of potential WMSDs, while controlling for other factors in logistic regression analyses. Studies have previously found an association between the combination of low job satisfaction and job control and back injury (Bigos et al., 1991; Holmström et al., 1992). Low job satisfaction has also been associated separately with upper extremity and back WMSDs in multiple studies (Tola et al., 1988; Bergenudd and Nilsson, 1988; Svensson and Andersson, 1983). The findings from this study show that this may also be an important factor in the agricultural environment.

An important limitation of this study was that physical risk factors were documented by job and not by individual worker. Therefore, it was not possible to associate observed risk factors with possible WMSDs by individual. As a surrogate measure, individual workers were linked to specific work areas (field or packing shed), each having unique activities. There was no difference in the prevalence of potential WMSDs between these work areas. These results could be expected because both areas had relatively high physical loads and did not offer a high versus low exposure comparison. However, the prevalence of physical risk factors of awkward postures, hand force, and repetition for different tree nursery tasks are comparable to previous studies showing an association with work–related musculoskeletal disorders (Silverstein et al., 1987; Sakakibara et al., 1995). Spielholz et al. (2001) found that the mean hand force for three shed jobs in the same tree nurseries was greater than 10% of the maximum voluntary contraction, and hand repetition levels were greater than 15/minute. The levels of physical exposure measured in these studies point to the work content as a likely contributor to the high prevalence of musculoskeletal symptoms.

While the participation rate at the first two nurseries was acceptable, the third and fourth nurseries had lower rates. Several factors may have contributed to the difference in study involvement. At nursery 3, hiring practices were changing and employees were to be replaced with contractual workers. Workers may have been hesitant to share their health information and jeopardize the remainder of their employment. The desire to improve the working conditions at the nursery also may not have been as strong since departing employees would not receive any of the benefits resulting from the study. At nursery 4, production lines and not the individual decided participation in the study. Therefore, those who may have been willing to participate could not because others in the same line chose not to. This may have artificially lowered the participation rate at this nursery. The first two nurseries had unionized employees, which may have positively influenced the participation at those facilities. Despite the low participation rate at nurseries 3 and 4, the study participants can still be considered as representative of the tree nursery working population.

Management support was crucial to worker participation because nursery work has strict seasonal time constraints. Nurseries offered support for the study only if production was not affected. Several other factors may have had an impact on the results. Different seasons, weather, and the production needs of a tree nursery can have a large effect on the task performed and the intensity with which the work is performed. The questionnaires and field observations were completed at specific points in time and may have been influenced by these variations. The field observations were made on routine jobs that led directly to the packaging of the trees. Non–routinized or non–cyclic jobs such as maintenance and housekeeping were not observed due to time and resource constraints. Task variability between workers due to technique and pace introduced between–subject variance into the physical work assessment because data were pooled by job.

Conclusion

The number of bareroot tree nurseries is diminishing despite an increase in demand for seedlings. The reasons for this are numerous, including higher production costs with diminishing returns and unfavorable growing conditions. Many in the nursery industry believe the future will be in container nurseries. As a result, much of the attention of those in the industry has been directed toward changes in production processes and not possible improvements in worker health and safety. In whatever form tree nurseries exist, the risk of musculoskeletal injuries and illnesses will remain. Future work on intervention strategies and injury risk assessment would be valuable for the tree nursery industry and other areas of agriculture.

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