Prevalence and risk factors of musculoskeletal disorders among Sri Lankan rubber tappers

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Background: Rubber tapping exposes workers to risk factors for musculoskeletal disorders (MSDs).

Objectives: This cross-sectional study assessed the prevalence and factors associated with MSDs among Sri Lankan rubber tappers.

Methods: Questionnaires were administered to 300 rubber tappers to measure MSDs and potential associated factors. Ergonomic exposure levels were measured for 90 tappers using the Quick Exposure Check instrument. MSD prevalence and prevalence ratios were calculated using log-binomial regression.

Results: In the past 12 months, 66% of rubber tappers in our sample experienced an MSD. Ergonomic exposure levels were high or very high in the back (94.4%), shoulders (96.7%), and neck (83.3%). Being female, older, Tamil, working two jobs, alternating tapping hands, and depression were significantly associated with increased risk of MSDs.

Conclusions: MSDs are common among rubber tappers in Sri Lanka. These results suggest a need for work process modifications to prevent MSDs.

Keywords: Musculoskeletal disorders, Rubber tappers, Occupational health, Sri Lanka

Introduction

Musculoskeletal disorders (MSDs) resulting from occupational hazards are a major public health concern. Studies show that the prevalence of MSDs is highest among unskilled workers such as agricultural workers.^{1,2} With 29.8% of the Sri Lankan population working in agriculture, many are at risk for work-related MSDs.³

Little is known about occupational influences on MSDs in Sri Lanka. One population of particular interest is rubber tappers. Rubber farming is the third largest agricultural industry in Sri Lanka and employs more than 200,000 people.⁴ The Sri Lankan rubber industry is a rapidly growing industry, with rubber exports growing an average of 12.4% per year since 2007.⁵ Growth in this industry has increased the demand for rubber tappers throughout the country. However, rubber tapping is strenuous, repetitive work that poses health concerns.

Tapping requires physical exertion, often in awkward body positions. It exposes tappers to MSD risk factors such as repetitive and high-paced work, static muscle loading,

non-neutral body postures, and forceful physical exertion.⁷ Tapping a tree involves removing dried latex from the collecting cup, performing a new cut with a special knife, and fixing the cup for collection. This all must be performed in less than two minutes, on 300–500 trees per day.⁶ Performing the cut requires the worker to bend at the waist and maintain flexion of the upper arm and wrist muscles. Examples of tapping positions are shown in Fig. 1.

In addition to the physical stress associated with rubber tapping, the socioeconomic situation of rubber tappers may contribute to MSD and injury risk. Studies from elsewhere show that factors like perceived stress, lack of social support, and low job satisfaction affect MSD risk.⁷ In Sri Lanka, 70% of rubber tappers work in the estate sector, on plantations larger than 20 acres. These tappers work and live on privately owned rubber plantations, where workers and their families reside in small barrack style housing. These living conditions provide minimal space and some lack basic facilities like running water and electricity.⁸ Moreover, rubber tappers experience low and, importantly, inconsistent pay. When it rains, tapping must be suspended and workers are not paid. For this reason, many rubber tappers may experience seasonal poverty corresponding to the rainy seasons.^{9–10}

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Figure 1 Rubber tappers in various tapping positions.

Notes: Here tapping is shown low to the ground (left), waist height (middle), and above the head (right).

Policies and regulations surrounding occupational health and safety, especially in the agricultural sector, are lacking in Sri Lanka. While occupational safety monitoring and workers compensation were established in The Factories Ordinance of 1942, the law excludes the agricultural sector, offices, mines, and fisheries from the mandatory reporting system.¹¹ Without legal requirements, it is difficult to make employers invest in the health and safety of their workers.

The present study investigates how demographics, working environment, behavioral, and psychosocial factors are related to MSDs in Sri Lankan rubber tappers. In the light of the lack of previous research on tappers, the objectives of this study were to provide a description of the rubber tapping profession, quantify the musculoskeletal problems and ergonomic job exposures experienced by rubber tappers, and assess factors associated with MSDs in the population. We also investigated differences in these associations by gender.

Methods

Study design

A cross-sectional study was conducted in southern Sri Lanka between September and November of 2014. Study participants were recruited from six estates, representing two plantation companies. Three estates were selected from each of the two plantations, henceforth called Plantation A and Plantation B. Both plantations are privately owned and located in the Galle District. Ethical approval for this study was obtained from the Institutional Review Boards of the University of Ruhuna and Duke University.

Participants

Rubber tappers working on these six estates encompassed the sampling frame. Based on power calculations, the target sample size for the questionnaire was 300. Additionally,

researchers returned to perform an ergonomic observation of 90 tappers during their tapping activities, some of whom participated in the questionnaire survey. Inclusion criteria for both parts of the study included: (a) employment as a rubber tapper by one of the study plantations and (b) more than one year of experience working as a rubber tapper. The plantation managers informed rubber tappers of the study prior to researcher arrival. As employment lists and contact numbers for rubber tappers were not available, participants were selected using a convenience sample of tappers available and willing to participate. Additional subjects were recruited until the target sample sizes were met.

Measures

Questionnaire

Data were collected using an interviewer developed and administered questionnaire by trained Sinhala speaking staff, allowing participation from tappers unable to read or write. All scales in the questionnaire were translated into Sinhala and back translated to check for accuracy of translation. The questionnaire was adapted from the Standard Nordic Musculoskeletal Questionnaire. This questionnaire has been widely validated for use in agricultural settings and has been used with rubber tappers in previous studies.^{12–14} The modified questionnaire contained questions on five body regions of particular interest: neck, shoulders, back, arms, and wrists. For each body region, tappers were asked if they had experienced trouble, including aches, pain, or discomfort, in the last 12 months. Workers were then asked to rate their pain on a weighted scale from 0 to 10, with 0 being no pain and 10 being the worst possible pain. Only even numbers were selectable.

Five additional sections included questions on demographics, medical history, work-related injuries, psychosocial factors, and substance use. Demographic information

included: gender, age, ethnicity, literacy, and income. Work-related factors included self-report of the following: number of years working as a rubber tapper, age started working as a rubber tapper, average number of trees tapped per day, hand used while tapping (left, right, or alternating), method used to transport rubber (head, shoulder, hand, cart, or other), and average amount of rubber transported at a time.

Stress was measured using the Perceived Stress Scale, which measures past month stress experiences.¹⁵ The scale consists of 10 questions and participants are asked to respond using a 5-point Likert scale ranging from never (0) to very often (4). It is a widely used and validated measure of stress as a predictor of disease and has been implemented in Sri Lanka previously.^{15–16}

Depression was measured using the Peradeniya Depression Scale, a tool developed in Sri Lanka that takes into account cultural considerations specific to the country.¹⁷ Questions categories include: biological symptoms, somatic symptoms, effect of depression, depressive thoughts, and depressive behaviors. Example questions include “Are you experiencing sleep disturbances?” and “Are you neglecting your family maintenance and housework?” This instrument has high sensitivity and specificity for clinical diagnosis of depression.^{17–18}

Quick Exposure Check

The ergonomic analysis was performed using Quick Exposure Check (QEC) to assess physical exposure to ergonomic stressors. QEC is an observational ergonomic analysis to determine exposure to ergonomic hazards for work-related MSDs. It has been used in previous studies to determine ergonomic risk factors for MSDs in agricultural and industrial settings.^{12,19,20} In QEC, researchers observe the work of participants to assess the posture and repetition related to four main body segments: the back, wrists, shoulders, and neck. Each body region is scored based on the amount of rotation, the degree of flexion, and the frequency of movement encountered during the work task. The analysis also considers the worker’s perception of weight handled, time spent on task, force, visual demand, driving, vibration, and stress. In the analysis, each response is assigned an exposure level and these exposure levels are combined to make the individual score for each body part. Results are tabulated into four exposure categories: low, moderate, high, and very high. Ergonomists suggest prompt intervention into those areas with exposure scores in the moderate, high, or very high range.²⁰ A trained investigator (KS) with a background in biomedical engineering and prior experience with the tool completed the QEC.

Contact information for participants was not available, making follow-up for participant observation logistically difficult. As a result, the 90 participants who participated in the QEC were not necessarily a subset of the 300 survey

participants. For this reason, survey results and QEC results were not directly compared.

Analysis

The data were entered into REDCap version 5.5.21 software for storage.²¹ All analyses were conducted using SAS software version 9.4. As relationships between work factors and musculoskeletal pain may not be linear,^{22,23} continuous variables were categorized at natural break points to examine non-linear relationships. Summary statistics were used to describe demographics, working environment, behavioral characteristics, and psychosocial factors. Prevalence of self-reported musculoskeletal symptoms in the past 12 months was tabulated. QEC scores were calculated for the back, shoulders, wrists, and neck. Scores were tabulated by exposure level: low, moderate, high, and very high.

Some risk factors were highly correlated, including: education and literacy, income and trees per day, and years working as a rubber tapper and age. In these instances, one of the variables was excluded from the final regression models to reduce the potential for statistical over control.

Univariate models were constructed using log-binomial regression to estimate prevalence ratios (PR) and 95% confidence intervals between covariates and MSDs. Since the prevalence of MSDs in the population was high, the log-binomial model was chosen to provide a direct estimate of the PR, as recommended over the logistical model.²⁴ This was accomplished using PROC GENMOD in SAS, as described by Spiegelman et. al.²⁵ We were also interested in understanding how factors affecting MSD risk differ by gender. Further models were constructed to assess whether there were significant interactions between gender and all potential covariates analyzed in the univariate models. Second, we performed multivariate regressions, to determine which factors remained associated with the outcome after adjusting for covariates. Covariates and interaction terms were included in the multivariate model if the *p*-value was 0.1 or less in either the univariate or interaction models. Using this approach, the log-binomial regression did not converge. This problem has been noted in the literature, and was addressed using a Poisson regression with robust error variance.²⁶ A backward elimination strategy was used to remove covariates from the model, one at a time. Variables were retained if the PR was greater than or equal to 1.25 (or less than or equal to 0.80), or if the *p*-value was 0.1 or less.

Results

Characteristics of study participants

Characteristics of the study participants and analyses results are presented in Table 1. Three hundred rubber tappers completed the questionnaire. The majority were female (61%) and Tamil (57%). The mean age was 46.1 ± 10.9 years and the ages ranged from 21- to 89-years old. The literacy rate was 65%.

Table 1 Crude and Adjusted Prevalence Ratios (PR) and 95% confidence intervals (CI) of musculoskeletal disorders by demographics, work environment, behavioral characteristics, and psychosocial conditions in Sri Lankan rubber tappers (n = 300)

Variable	Frequency (%)	Prevalence (n=# cases)	Crude PR (95% CI)	Adjusted PR (95% CI)
Demographics				
Gender				
Male	117 (39.0)	58.1 (68)	1	1
Female	183 (61.0)	71.0 (130)	1.2 (1.0, 1.5)*	1.5 (1.1, 1.9)*
Age (in years)				
<35	53 (17.7)	54.7 (29)	1	1
35–55	188 (62.7)	66.5 (125)	1.2 (0.9, 1.6)	1.2 (1.0, 1.6)
55 +	59 (19.7)	74.6 (44)	1.4 (1.0, 1.8)*	1.4 (1.1, 1.9)*
Literacy				
Illiterate	105 (35.0)	72.4 (76)	1	–
Literate	195 (65.0)	62.6 (122)	0.9 (0.7, 1.0)*	–
Income				
≤140000	153 (51.0)	63.4 (97)	–	–
>140000	147 (49.0)	68.7 (101)	–	–
Ethnicity				
Sinhalese	129 (43.0)	58.1 (75)	1	1
Non-Sinhalese	171 (57.0)	71.9 (123)	1.2 (1.0, 1.5)*	1.3 (1.1, 1.6)*
Has another working adult family member				
No	223 (74.3)	69.5 (155)	0.8 (0.6, 1.0)*	–
Yes	71 (23.7)	54.9 (39)	1	–
Working environment				
Plantation				
A	150 (50.0)	60.0 (90)	1	–
B	150 (50.0)	72.0 (108)	1.2 (1.0, 1.4)*	–
Years working as a rubber tapper				
1–10	82 (27.3)	63.4 (52)	1	–
11–30	143 (47.7)	64.3 (92)	1.0 (0.8, 1.3)	–
>30	75 (25.0)	72.0 (54)	1.1 (0.9, 1.4)	–
Age started working as a rubber tapper				
<20-years old	125 (41.7)	64.8 (81)	–	–
20–30-years old	117 (39.0)	61.5 (72)	–	–
>30-years old	58 (19.3)	77.6 (45)	–	–
Trees/day				
≤300	246 (82.0)	65.9 (162)	1	–
300–600	54 (18.0)	66.7 (36)	1.0 (0.8, 1.2)	–
Tapping method				
One hand	232 (77.3)	63.3 (147)	1	1
Alternating hands	66 (22.0)	75.8 (50)	1.2 (1.0, 1.4)*	1.2 (1.0, 1.4)*
Missing	2 (0.7)	(2)	–	–
Transport method				
Not on head	19 (6.3)	47.4 (9)	1	1
On head	281 (93.7)	67.3 (189)	1.4 (0.8, 2.3)	1.3 (0.9, 2.0)
Kg latex transported, average				
≤8	236 (78.7)	64.4 (152)	1	–
>8	64 (21.3)	71.9 (46)	1.1 (0.9, 1.3)	–
Among females:				
≤8	–	72.1 (111)	1	1
>8	–	65.5 (19)	0.9 (0.7, 1.2)	0.9 (0.7, 1.2)
Among males:				
≤8	–	50.0 (41)	1	1
>8	–	77.1 (27)	1.5 (1.2, 2.0)	1.5 (1.1, 2.0)*
Works an additional job				
No	122 (40.7)	60.6 (108)	1	1
Yes	178 (59.3)	73.3 (90)	1.2 (1.0, 1.4)*	1.3 (1.1, 1.6)*
Behavioral characteristics				
BMI				
Underweight (<18.5)	83 (27.7)	67.5 (56)	1.1 (0.9, 1.3)	–
Healthy weight (18.5–22.9)	146 (48.7)	62.3 (91)	1	–
Over weight (≥23)	71 (23.7)	71.8 (51)	1.2 (1.0, 1.4)	–
Among females:				
Underweight (<18.5)	–	63.8 (30)	0.9 (0.7, 1.2)	0.9 (0.7, 1.2)
Healthy weight (18.5–22.9)	–	69.6 (55)	1	1
Over weight (≥23)	–	79.0 (45)	1.1 (0.9, 1.4)	1.2 (1.0, 1.5)
Among males:				
Underweight (<18.5)	–	72.2 (26)	1.3 (1.0, 1.8)	1.4 (1.1, 1.9)*
Healthy weight (18.5–22.9)	–	53.7 (36)	1	1
Over weight (≥23)	–	42.9 (6)	0.8 (0.4, 1.5)	0.8 (0.4, 1.3)
Smoking behavior				
Non-smoker	257 (85.7)	66.9 (172)	1	–
Smoker	43 (14.3)	60.5 (26)	0.9 (0.7, 1.2)	–

(Continued)

Table 1 (Continued)

Variable	Frequency (%)	Prevalence (n=# cases)	Crude PR (95% CI)	Adjusted PR (95% CI)
Betel chewing behavior				
Non-chewer	88 (29.3)	62.5 (55)	1	–
Chewer	212 (70.7)	67.5 (143)	1.1 (0.9, 1.3)	–
Alcohol use				
Non-drinker	216 (72.0)	67.6 (146)	1	–
Drinker	82 (27.3)	61.0 (50)	0.9 (0.7, 1.1)	–
Psychosocial measures				
Depression				
Not depressed	267 (89.0)	62.6 (167)	1	1
Depressed	33 (11.0)	93.9 (31)	1.5 (1.32, 1.71)*	1.2 (1.1, 1.4)
Stress				
Not high stress	260 (86.7)	64.6 (168)	1	–
High stress	40 (13.3)	75.0 (30)	1.2 (1.0, 1.4)	–

*P < 0.05

The mean number of years employed as a rubber tapper was 21.3 ± 12.2 , with a minimum of 1 year and a maximum of 52 years. Tappers regularly tapped either one block (300 trees or less) or two blocks (300–600 trees) per day, with 82% tapping 300 trees or fewer. Two tapping styles were identified: one in which tappers used one hand exclusively to apply the force needed to tap (77%), and another in which tappers alternated hands (22%). After tapping their blocks, tappers return to the trees to collect the latex. This latex is collected in metal buckets, which are then transported to a collecting station. The mean weight of the collected latex was 8 ± 3.1 kg per load, with a minimum of 5 kg and a maximum of 25 kg. Some tappers chose to make more than one trip to transport less weight. Tappers were asked how they transported latex and were allowed to select more than one answer. Most tappers transported the latex on their heads (94%), while others used their hands (7%), shoulder (3%), hip (0.7%), or back (0.3%). During the observational portion of the study, we measured the distance to the collecting site. The average distance traveled was 360 m (approximately a quarter mile). Workers were also asked about the use of personal protective equipment while tapping. Of the 300 tappers surveyed, none reported using close-toed shoes, gloves, or eye protection.

Prevalence of MSDs

The prevalence of MSDs in this population is shown in Table 2. The prevalence of MSDs in one or more body region in the last 12 months was 66%. The body region with the highest prevalence of pain was the back (43%), followed by the shoulders (28.3%), neck (19.3%), hands or wrists (16%), and the arms (15.3%). In those who experienced pain, the pain was very frequent, with more than 30% of people experiencing pain daily. The intensity of pain was also highest in the back, with 71% of those with back pain experiencing moderate to very severe pain.

Quick Exposure Check

Table 3 shows the results of the QEC for the back, shoulders, wrists, and neck. Shoulders and back scores showed

the highest exposure to ergonomic stress, with exposure levels of “high” or “very high” in 96.7 and 94.2% of participants, respectively. Neck problems were also of concern, with 83.3% of participants with a “high” exposure level.

Factors associated with occupational MSDs

The prevalence of MSDs across demographic, work environment, behavioral, and psychosocial characteristics, as well as crude and adjusted PRs, is shown in Table 1.

The final multivariate model showed higher prevalence in non-Sinhalese female tappers who use an alternating hand tapping method, tappers who work an additional job, and tappers who reported depression symptomology. The prevalence of MSDs increased with age. The relationships between some variables and MSDs differed by gender. Among males, MSD prevalence was significantly higher among those who transported >8 kg of latex (vs. <8 kg). Among females, MSD prevalence did not vary by weight of latex transported. Additionally, among males, an inverse relationship was observed between MSD prevalence and BMI. In contrast, among females, there was a slight increase in MSD prevalence with increasing BMI.

Discussion

This study assessed the prevalence of MSDs among rubber tappers on two large plantations in Sri Lanka and several demographic, work environment, behavioral, and psychosocial factors of interest. Despite the great potential for MSD risk in this population, no previous studies have assessed MSD prevalence or associated factors in Sri Lankan rubber tappers. The results of this study indicated that the prevalence of MSDs in the last 12 months was very high: 66% of tappers suffered from at least one MSD. The most common body regions involved were the back (43%), shoulders (28.3%), and neck (19.3%). In line with these findings, the results of QEC show high or very high levels of ergonomic exposure in the back (96.7%), shoulders (94.2%), and neck (83.3%). Factors associated with increased MSDs included: being female, increased age, being Tamil, working two jobs, alternating tapping hands, and depression.

Table 2 Frequency and Intensity of musculoskeletal pain by body region, last 12 months (n = 300)

	Neck	Back	Arms	Hands/Wrists	Shoulders
	n (%)	n (%)	n (%)	n (%)	n (%)
Number with pain	58 (19.3)	129 (43)	46 (15.3)	48 (16)	85 (28.3)
<i>Frequency</i>					
Daily	21 (36.2)	43 (33.3)	19 (41.4)	19 (39.6)	36 (42.4)
1–4 times a month	24 (41.4)	68 (52.7)	23 (50)	20 (41.6)	37 (43.5)
Every 2–6 months	11 (19.0)	15 (11.6)	2 (4.3)	6 (12.5)	10 (11.8)
Other	2 (3.4)	3 (2.3)	2 (4.3)	3 (6.3)	2 (2.4)
<i>Intensity (0–10 scale)</i>					
Mean (SD)	2.9 (1.2)	4.0 (1.8)	3.7 (1.8)	2.9 (1.2)	3.5 (1.4)
No pain (0)	1 (1.7)	2 (1.6)	0 (0)	0 (0)	1 (1.2)
Mild (2)	22 (37.9)	33 (26)	18 (40)	30 (62.5)	30 (35.3)
Moderate (4)	30 (51.7)	65 (51.2)	18 (40)	15 (31.2)	45 (52.9)
Severe (6)	4 (6.9)	18 (14.2)	8 (17.8)	3 (6.3)	7 (8.2)
Very severe (8)	1 (1.7)	9 (7)	0 (0)	0 (0)	2 (2.4)
Worst possible (10)	0 (0)	0 (0)	1 (2.2)	0 (0)	0 (0)

Table 3 Quick Exposure Check Exposure Levels, (n = 90)

	Exposure level			
	Low	Moderate	High	Very High
Score	n (%)	n (%)	n (%)	n (%)
Back	0 (0)	5 (5.6)	83 (92.2)	2 (2.2)
Shoulders	0 (0)	3 (3.3)	78 (86.7)	9 (10)
Wrists	40 (44.4)	49 (54.4)	1 (1.1)	0 (0)
Neck	1 (1.1)	14 (15.6)	75 (83.3)	0 (0)

These findings are similar to the results of other studies involving rubber tappers, where MSD rates have ranged from 30–72.2%.^{27–29} Also in line with our results, a previous study in Malaysia found the highest prevalence of MSDs to be in the neck, lower back, and shoulders.²⁹ One study on palm oil plantations that employed the QEC reported a similar percentage of high or very high exposure scores: 77.4% in the back, 77.3% in the shoulders, and 78.6% in the neck.²⁰ A similar study in Iranian rubber factories also found that 85.5% of workers had exposure scores of high or very high.¹⁹

Further data suggest rubber tappers experience higher rates of MSDs than other occupational populations in Sri Lanka. A 2011 study examined the rates of MSDs in Sri Lankan nurses over the last 12 months and found 21% of nurses reported at least one MSD.³⁰ A similar study of garment workers in the country found the 12-month prevalence of MSDs at only 15.5%.³¹ An additional study surveyed mail-sorting officers and observed an MSDs prevalence of 59.6%.³² This finding is not surprising, as previous literature has shown that MSD prevalence is higher in agricultural occupations than other occupational populations, due to the high physical demands of the job.^{1,33–35}

The current study found several demographic factors associated with MSDs, including gender, age, and ethnicity. Women were 1.5 times more likely to experience an MSD than males. This supports previous literature, in which studies have demonstrated that women have higher MSD rates than men.^{36,37} However, the reason for this gender difference is not obvious. When looking at

the QEC results of the tapping process, there are not large differences in ergonomic hazard exposure levels between women compared to men. In Sri Lanka, women are largely responsible for housework, cooking, and childcare; varying risk factors encountered outside of work could account for the observed difference. Additionally, prevalence of MSDs varied by the weight of latex transported by males and females. Heavier latex loads caused a significant increase in MSD prevalence in males, but not females. This could stem from males traveling longer distances, which was not considered in this study.

Ethnicity was also found to be a significant predictor of MSDs, with Tamils experiencing a 30% higher prevalence of MSD compared to Sinhalese. The Tamil population in Sri Lanka has been historically disadvantaged, with higher mortality rates and less access to formal healthcare than other ethnic groups in Sri Lanka.³⁸ It is plausible that lifestyle factors differ between ethnic groups and were not captured in our questionnaire. Some studies have suggested that pain is perceived differently by different ethnic groups,³⁹ which could have resulted in differential reporting of pain by either ethnic group.

Many aspects of the working environment were associated with increased prevalence of MSDs including working an additional job providing income. Additional jobs were typically in landscaping, manual laborers (67%), or other agricultural sectors such as tea plucking and oil palm harvesting (39%). These jobs are also highly physical and demanding, which could result in the increased PR. This finding is particularly concerning, given that workers' compensation is not common in the Sri Lankan

plantation sector. Many tappers miss work due to pain and it is plausible that many do not receive compensation. Lack of compensation for missed work due to injury could cause workers to seek additional work to supplement lost income, potentially perpetuating MSDs.

Workers who tapped using an alternating hand method had a higher prevalence of MSDs than those that used solely their left or their right hand. As this study is cross-sectional in nature, the causal direction of this association is unclear. It is plausible that workers who experienced MSD symptoms choose to alternate hands in an attempt to alleviate pain. The QEC identified high ergonomic risk for the shoulders, neck, and back. These scores are, in part, driven by the heavy weight of rubber transported by tappers. If the weight of latex transported by workers was limited to 5 kg or less, exposure scores from high to very high in the back would decrease from 94.4% to only 2.2%. Furthermore, the observed frequency of back and shoulder movements (8–12 times per minute) and working in excessively flexed postures while tapping contribute to high exposure levels. The frequency of back and neck movement and the extent of shoulder extension depend on the height at which the tree is tapped. Tapping is cyclical, with tappers starting high and working down the tree over a number of years. When tapping is near the ground, it results in frequent back movements in excessively flexed positions. When tapping is above the head, it causes shoulder extension and neck flexion. Both of these tapping heights result in high, but different exposure scores, suggesting that interventions should be targeted based on tapping height.

Neck scores were also driven by the high visual demand of the task. Accurate vision is very important in rubber tapping, as making a cut too deep can cause permanent damage and prevent the tree from producing further latex. While workers were well educated about this fact, some complained that they knew their vision was bad, but did not have access to affordable eye glasses.

Study strengths and limitations

This study examined a population to which little or no previous research has been devoted. The measures used were widely accepted, making results comparable to studies of other populations. The measure of depression was culturally relevant and developed in Sinhala for use in Sri Lanka. Limitations of this study include the cross-sectional design, the limited sample size, and the use of convenience sampling. Despite the limited sample size, many risk factors were significant. Random sampling was not possible as employment lists and contact information were not available. Furthermore, as re-contacting participants was logistically difficult, the QEC respondents were not a subset of the questionnaire respondents, preventing us from drawing direct comparisons between questionnaire and QEC data. While our population, from the southern province of Sri Lanka, was a mix of both Tamil and Sinhalese,

many other plantations on the island employ almost solely Tamil workers. This difference in demographics, as well as the differing landscapes throughout the country, implies that caution must be made to generalize these results to all of Sri Lanka.

Conclusion

MSDs, particularly of the back and shoulders, are a prevalent occupational concern among Sri Lankan rubber tappers. This study shows that a wide range of factors including being female, being Tamil, increased age, alternating hands while tapping, working an additional job, and depression may be associated with MSDs. Tapping requires repetitive work in excessively flexed positions, contributing to high ergonomic exposures in the back, shoulders, and neck. More research may be needed to understand the underlying causes and mechanisms of the identified associations. Prevention efforts focused on reduction of heavy lifting, reduced back flexion, and providing proper eyeglasses could be beneficial. Expansion of the Factories Ordinance of 1942 to cover agricultural workers should help increase surveillance in this population. Given the constraints of the current depressed prices for rubber, the direct and indirect economic costs of any interventions need to be carefully considered to ensure that the most important and effective changes are prioritized.

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