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Original Article

Incidence and Predictors of Hand–Arm Musculoskeletal Complaints among Vibration-exposed African Cassava and Corn Millers

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ABSTRACT

Background: Cassava and corn milling is a growing small-scale enterprise in Africa. We aimed to determine the incidence of hand–arm musculoskeletal complaints among vibration-exposed Congolese cassava and corn millers in the previous 12 months.
Methods: A cross-sectional study was conducted, prior to a follow-up study, from March to May 2013 among cassava/corn millers in Lubumbashi, Democratic Republic of Congo, in which 365 millers age-matched to 365 civil workers anonymously answered a questionnaire.
Results: Overall incidence of hand–arm musculoskeletal complaints was 25.8% in millers (vs. 5.2% in civil workers; $p < 0.001$). The risk of experiencing musculoskeletal symptoms was seven times higher in millers [vs. civil workers; odds ratio (OR) = 7.10; 95% confidence interval (CI): 4.03–12.50; $p < 0.0001$]; 2.4 times higher in smoking millers (vs. smoking civil office workers; OR = 2.36; 95% CI: 1.42–3.88; $p < 0.001$); 3.6 times higher in millers with longer daily exposure (> 8 hours; vs. those working ≤ 8 hours; OR = 3.56; 95% CI: 1.93–3.61; p = 0.026); and 7.4 times higher in young millers (vs. older millers, OR = 7.39; 95% CI: 1.29–75.52; $p < 0.001$). Smoking, number of cigarettes, and daily exposure duration were positively correlated with musculoskeletal complaints.
Conclusion: This study revealed a relatively high incidence of musculoskeletal complaints among African cassava and corn millers. The use of anti-vibration protective equipment and the regulation of this hazardous occupation may reduce the burden of musculoskeletal disorders in millers.

1. Introduction

Occupational upper extremity musculoskeletal disorders (MSDs) have become increasingly common and they are a major burden in general medical practice. MSD has a negative impact on the quality of life and, in the United States, ~19 million workers are affected annually. Hand–arm vibration is defined as the transfer of vibration from a tool to a worker's hand and arm. Prolonged exposure to hand-transmitted vibration is associated with an increased occurrence of symptoms and signs in the vascular, neurological and osteoarticular systems of the upper limbs [1,2]. There are several reports on epidemiological studies conducted among manual workers (e.g., drillers, stone carvers, forestry workers, and grinders) in the medical literature in relation to vibration-related MSDs [2–4], and hand–arm vibration is recognized as a significant hazard to workers' health and safety [5,6]. In the literature, there is a lack of occupation-specific information on the scope and causes of MSDs in the Central African region.

In most African countries, flour from cassava and corn is part of the daily diet for a large majority of the population. Cassava and corn milling facilities are among the growing small-scale enterprises in the region. Although the business seems to be lucrative,

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safety conditions of millers have not been a major concern for employers with regard to the use of protective equipment against vibration, noise, and dust. Moreover, no research has been conducted to investigate the adverse health effects of exposure to the above-mentioned hazards in cassava and corn-milling facilities. The present international collaborative study was designed to investigate the working conditions and health outcomes in African cassava and corn millers. Hereby, we report on the incidence and correlates of upper limbs' musculoskeletal complaints related to chronic hand–arm vibration exposure in Congolese cassava and corn millers occurring during the previous 12 months.

2. Materials and methods

2.1. Study site, design, and participants

Cassava and corn millers were recruited for a cohort study in Lubumbashi, the second most populous town of the Democratic Republic of Congo. Lubumbashi is a city of more than 1 million inhabitants and is believed to be the copper capital of the world [7]. It is located in the southern province of Katanga, which shares borders with Zambia and Tanzania. A baseline survey was conducted in 2013 in all seven counties of Lubumbashi using a validated questionnaire that comprised three parts, with questions related to hand–arm vibration exposure and MSD, dust exposure and respiratory health (occupational asthma questionnaire, American Thoracic Society), dermatitis, and hearing impairment. Regarding musculoskeletal health, specific questions from the Standardized Nordic questionnaire on MSDs [8] were included in our study questionnaire. All cassava and corn-milling facilities were visited by trained surveyors supervised by a panel of experts from the School of Public Health, University of Lubumbashi, thanks to a repertoire of addresses and telephone numbers obtained from local public offices.

In total, 384 cassava/corn millers were recruited (including 1 woman), and among them, 365 male millers were eligible (exposed group). Three hundred and sixty-five civil workers (nonexposed group) without exposure to vibration were recruited from a population of 446 civil workers from local public offices (Fig. 1). They were local provincial government office workers. The office workers matched to the millers were those involved only in office work (typewriting, computer work, secretarial and reception services). A large majority of millers were age-matched to nonexposed

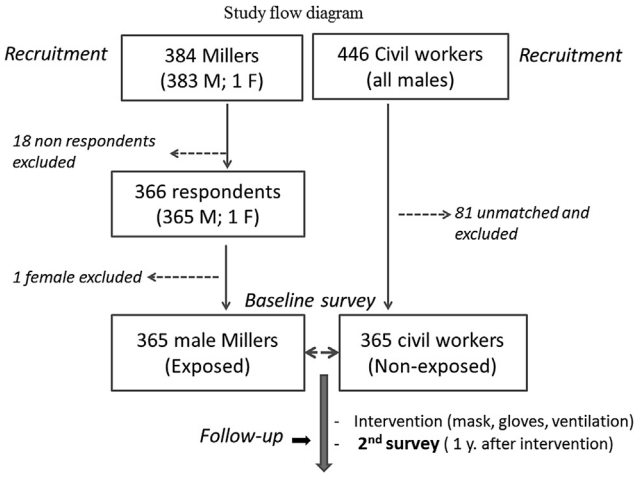

Fig. 1. Study flow diagram of the follow-up study. A total of 365 male cassava and corn millers were age-matched to 365 male civil workers. A baseline survey was conducted and then participants were followed for 1 year after the intervention (protective equipment, and good ventilation). F, female; M, male.

civil office workers; for the remaining 7%, an age difference of ≤ 5 years was considered acceptable.

The inclusion criteria for millers were as follows: being a cassava or corn miller without involvement in another activity susceptible to cause MSDs, having a permanent residence in Lubumbashi, and voluntarily agreeing to take part in the study. For the office workers' group, those involved even partially in a high-risk occupation or activity such as mining work, construction work, or farming were not recruited.

2.2. Definition of MSDs and related symptoms

According to the Centers for Disease Control and the International Classification of Diseases (ICD-10-M99-7; version 2010), MSDs are injuries or disorders of the muscles, nerves, tendons, joints, cartilage of the upper and lower limbs, neck, and lower back that are caused, precipitated, or exacerbated by sudden exertion or prolonged exposure to physical factors such as repetition, force, vibration, or awkward posture. In this study, symptoms that were considered to be related to MSDs are chronic pain, swelling, and stiffness [9,10]. Those complaints were taken into account prior to considering a worker as having experienced a hand–arm musculoskeletal condition if they that lasted more than 1 week, affecting the ability to perform usual work tasks, and occurring during the previous 12 months.

2.3. Brief description of the cassava/corn-grinding machine

The grinding mill consists of a metallic tool with a vibrating engine that produces cassava or corn flour. It is generally composed of three parts: a metallic basin where dried cassava or corn is deposited, the engine that helps broil the crops, and a collector (generally made of a cylindrical cotton fabric). There are one to three millers working in a generally narrow-space milling facility. Participation was voluntary; participants had to answer the questionnaire anonymously after receiving explanations on the objectives of the study. A written approval to conduct the study was obtained from the Ethics Committee of the School of Public Health, University of Lubumbashi in March 2013.

2.4. Statistical analysis

Data were analyzed using Stata version 10 (Stata Corp., College Station, Texas, USA) statistical software. For the analyses, most variables were dichotomized (no = 0; yes = 1). The χ^2 test was used to assess differences between groups and categories within each group of participants, whereas Spearman's correlation test was performed to assess the correlation between MSD symptoms, sociodemographic variables (age, marital status, and level of education), seniority or work experience, daily exposure duration, smoking, use of protective devices, and the nature of the product processed. Cross-tabulation was performed and odds ratios (ORs) with 95% confidence intervals (CIs) were calculated and used to determine the magnitude of associations and the level of risk of work-related MSDs, adjusting for age. A p value < 0.05 was considered statistically significant.

3. Results

3.1. Characteristics of participants and incidence rate of MSDs

Of the 384 vibration-exposed millers who received questionnaires, there were 365 that were returned, making a participation rate of 95.1%. For the millers, the mean age was 26.6 $\pm$ 8.7 years; 5.5% (20/365) of millers were aged 10–17 years. By contrast, civil

office workers were younger (mean age: 23.4 ± 5.2 years); however, the difference was not statistically significant ($p = 0.057$). In addition, 29.6% (108/365) of the millers were current smokers and 12.9% (14/108) of them had smoked for > 10 years; whereas there were 26.6% (97/365) of smokers among civil workers ($p < 0.001$; Table 1).

The overall incidence of MSD-related complaints was 25.8% (94/365) in cassava and corn millers, including 98.7% of those who reported a chronic pain. By contrast, it was 5.2% (19/365; $p < 0.001$) in nonexposed civil workers, including 83% of those who experienced chronic pain in the past 12 months (Fig. 2A). When the type of product processed was taken into account, no significant difference was noted in terms of incidence of musculoskeletal complaints between millers using only cassava, only corn, and those who used both ($p > 0.05$).

A greater proportion of millers who have been working for ≥ 5 years reported MSD symptoms as compared to those exposed for < 5 years (31.2% vs. 21.6%, respectively; $p = 0.054$). Millers with longer daily exposure duration (> 8 hours) had a higher incidence of hand–arm musculoskeletal complaints as compared to those who worked ≤ 8 hours (27.3% vs. 3.4%, respectively; $p = 0.027$; data not shown). Furthermore, the incidence of musculoskeletal complaints was higher in smoking millers than smoking civil workers (37.9% vs. 20.6%; $p = 0.001$; Fig. 2B).

3.2. Predictors of MSDs

Spearman correlation test showed positive correlations between MSDs and smoking ($\rho = 0.18$; $p < 0.001$), MSDs and number of cigarettes/day ($\rho = 0.26$; $p = 0.010$), MSDs and daily exposure duration ($\rho = 0.12$; $p = 0.026$). By contrast, negative correlations were found between MSD symptoms and age ($\rho = -0.11$; $p = 0.041$), and MSDs and seniority ($\rho = -0.12$; $p = 0.022$; Table 2).

The risk of experiencing hand–arm MSD symptoms was 7.4 times higher in younger millers (OR = 7.39; 95% CI: 1.29–75.52; $p = 0.006$) than in old millers; 3.5 times higher in millers who worked > 8 hours/day (OR = 3.56; 95% CI: 1.93–3.61; $p = 0.026$) than in those who worked ≤ 8 hours/day; 2.4 times higher in smoking millers (vs. non-smokers; OR = 2.36; 95% CI: 1.42–3.88; $p < 0.001$); and 1.6 times higher in millers using anti-vibration protective devices (OR = 1.64; 95% CI: 1.81–2.58) than those who did not, as shown in Table 3.

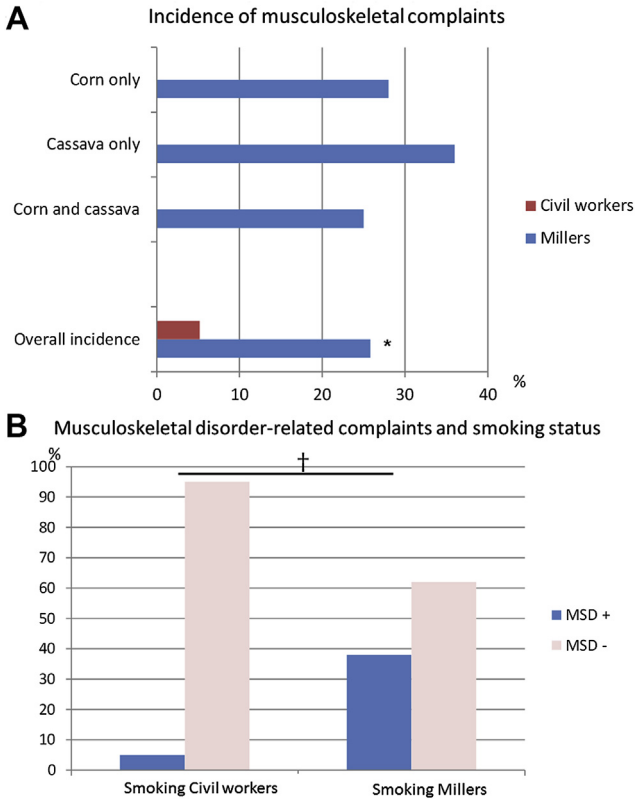

Fig. 2. Incidence of hand–arm musculoskeletal-disorder-related complaints among cassava/corn millers and civil workers. (A) Higher overall incidence of hand–arm musculoskeletal complaints in cassava and corn millers' group as compared with civil workers ($p < 0.05$). No significant difference was observed when comparing millers who processed both cassava and corn with those who worked on only one of the crops ($p > 0.05$). Incidence of hand–arm musculoskeletal complaints according to smoking status. (B) Higher incidence of hand–arm musculoskeletal complaints among smoking millers than in smoking civil workers ($p = 0.001$). *$p < 0.05$. †$p < 0.001$.

Table 1
Characteristics of study participants

Characteristics of participants	Office workers n1 (%)	Millers n2 (%)	p
Age (y)			
10–17	20 (5.5)	9 (2.5)	
≥ 17	345 (94.5)	356 (97.5)	0.057
Total	365 (100)	365 (100)	
Education			
Elementary	16 (4.4)	19 (5.2)	
High school*	77 (21.1)	88 (24.1)	
High school†	255 (69.8)	249 (68.2)	
College/university	17 (4.7)	9 (2.5)	0.318
Total	365 (100)	365 (100)	365 (100)
Seniority			
< 5 y	207 (56.7)	189 (51.7)	
≥ 5 y	158 (43.3)	176 (48.2)	0.207
Total	365 (100)	365 (100)	
Daily exposure			
≤ 8 h	271 (74.3)		
> 8 h	94 (25.7)		
Total	365 (100)		
Smoking			
Yes	108 (29.6)	39 (10.7)	< 0.001
No	257 (70.4)	326 (89.3)	
Total	365 (100)	365 (100)	
Product			
Cassava	11 (0.3)		
Corn	86 (23.6)		
Cassava + corn	264 (73.4)		
Total	365 (100)		

* High school, joined but never graduated from junior high school.
† High school, joined senior high school.

4. Discussion

One of the objectives of the present study was to determine the incidence of self-reported, long-lasting hand–arm musculoskeletal complaints in Congolese cassava and corn millers for the previous

Table 2
Predictors of musculoskeletal complaints among Cassava and Corn Millers

Predictors of musculoskeletal complaints	Civil workers		Millers	
	ρ	p	ρ	p
Age (y)	−0.11	0.041	0.02	0.718
Education	−0.01	0.891	0.01	0.861
Product	0.03	0.493		
Seniority	−0.12	0.022	0.01	0.879
Daily exposure	0.12	0.026		
Smoking	0.18	< 0.001	0.01	0.718
Smoking duration	−0.12	0.232	0.05	0.391
Number of cigarettes/d	0.26	0.01	0.01	0.276
Use of protective device	−0.06	0.083		

Table 3
Distribution of ORs and their 95% CIs for factors associated with musculoskeletal complaints

Determinants of musculoskeletal complaints	OR	95% CI	*p*
Age (y)	7.39	1.29–75.52	0.006
Daily exposure	3.56	1.93–3.61	0.026
Smoking	2.36	1.42–3.88	< 0.001
Smoking duration	1.24	0.56–2.78	0.593
Number of cigarettes/d	1.09	1.02–1.17	0.011
Use of protective device	1.64	1.81–2.58	0.015

CI, confidence interval; OR, odds ratio.

12 months. In the medical literature, there are several reports on vibration-induced MSDs among drilling miners, construction workers, farmers and other workers worldwide, but little is known about MSDs in African workers [11–14]. In particular, cassava and corn milling work represents one of the neglected occupations despite its potential hazards, and the health effects of exposure to vibration, as well as organic dust, in this category of workers have not been investigated prior to our study.

The Zambian National Labor Force Survey on occupational exposures conducted among 64,119 workers in 2009 showed that hand–arm vibration exposure accounted for 3% of the participants; however, the proportion of those who have experienced MSD-related symptoms remains unknown [15].

The present study showed a relatively high incidence of hand–arm musculoskeletal complaints (25.8%) among Congolese cassava and corn millers in the previous 12 months. In Nigeria, Tinubu and coworkers [14] reported an even higher proportion of MSDs, 78%, in a sample of 128 Nigerian nurses in the previous 12 months. In a South African study, a lower prevalence (15%) was found among gold miners [16]. Moreover, recently, a Rwandan population-based study estimated that 5.2% of the general population had been diagnosed with musculoskeletal impairment, including 31% MSDs of trauma and 9% of MSDs of neurological origin [17]; however, no job-specific prevalence of MSDs was reported.

Work-related MSDs of the upper limbs are reported to be associated with the longest absences from work and a greater loss of productivity than ailments of other body regions [18]. In the medical literature, there are several reports on hand–arm MSDs among vibration-exposed workers [19,20]. Thus, ensuring work safety in hazardous occupational settings is of utmost importance.

In occupational settings with vibration-exposed workers, it is advised to use appropriate preventive measures such as anti-vibration padding, gloves to keep hands dry and warm, and vibration-reducing gloves that help protect the workers [16]. In our study, a greater proportion of millers, 82.2% (300/365), did not use any protective equipment; a higher proportion of workers who had MSDs was from this category, 24.7% (74/300). Of the remaining 65 workers, 26 were using appropriate gloves and the prevalence of self-reported MSDs in this group was 12.3% (8/65) ($p = 0.075$). These data suggest that, despite being at risk, a large majority of cassava and corn millers from Lubumbashi do not utilize preventive measures.

Our study also showed that smoking millers had a higher risk of experiencing MSDs than non-smokers, suggesting that smoking might be a trigger for MSDs in workers exposed to vibrating tools. Although cigarette smoking has a negative effect on the vascular and neurological systems, its association with musculoskeletal health impairment has not been described in most previous studies. Given the vasoconstrictive effects of cigarette smoking on the peripheral arteries, some researchers have stated that smoking cessation should be recommended in workers exposed to vibration [21,22]. McGeoch and Gilmour have found no association between neurological components of MSDs with smoking in a cross-sectional study of workers from a heavy engineering company [20].

In addition, this study also showed a negative correlation between age and MSDs, suggesting a higher proportion of MSDs in younger than older millers. In fact, there were 93.3% of millers aged 10–17 years, whereas only 72.4% of older millers (> 17 years) reported MSDs in the previous 12 months. The strong correlation between younger age and MSDs in this report should be taken with caution, when considering a longer period of exposure (prevalence study), or the subsequent ongoing cohort study, might show an opposite outcome.

This study had some limitations. The appropriateness of the reference group (office workers) may be questioned. Normally, unexposed participants should have been enrolled at the same workplace as for exposed workers. However, given the fact almost all cassava/corn-milling facilities do not have unexposed personnel, we managed to have a group of workers without a record of exposure to vibration or other high-risk occupation such as farming, construction work, and mining work, which are the main economic activities in the region.

In conclusion, the present report reveals the poor safety conditions in which Congolese cassava and corn millers work and their negative impact on musculoskeletal health. The report shows a relatively high incidence of self-reported hand–arm MSDs among cassava and corn millers and highlights the negative impact of long exposure to vibration and smoking on millers' musculoskeletal health. There is a need for regulation of this growing small-scale enterprise and the provision of necessary protective equipment to exposed workers which, combined with smoking cessation, could help reduce the burden of MSDs.

Conflicts of interest

The authors declare no conflict of interest.

Declaration of source of funding

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References

[1] Bernard B, Nelson N, Estill CF, Fine L. The NIOSH review of hand-arm vibration syndrome: vigilance is crucial. National Institute of Occupational Safety and Health. J Occup Environ Med 1998;40:780–5.
[2] Mattioli S, Graziosi F, Bonfiglioli R, Bernardelli S, Acquafresca L, Violante FS, Farioli A, Hagberg M. A case of vibration-induced hand comorbidities in a spotwoman. BMC Musculoskelet Disord 2011;12:47.
[3] Fryomeyer JW, Cats-Baril WL. An overview of the incidences and costs of low back pain. Orthop Clin North Am 1991;22:263–71.
[4] Bovenzi M. Exposure-response relationship in the hand-arm vibration syndrome: an overview of current epidemiology research. Int Arch Occup Environ Health 1998;71:509–19.
[5] Mirbod SM, Akbar-Khanzadeh F, Onozuka M, Jamali M, Watanabe K, Inaba R. A four-year follow-up study on workers using hand-held grinders. Ind Health 1999;37:415–25.

[6] Hagberg M. Clinical assessment of musculoskeletal disorders in workers exposed to hand–arm vibration. Int Arch Occup Env Health 2002;75:97–105.
[7] Report from Wikipedia [Internet]. Lubumbashi (Congo). [cited 2013 Nov 22]. Available from: http://fr.wikipedia.org/wiki/Lubumbashi [in French].
[8] Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sorensen F, Andersson G, Jorgensen K. Standardized Nordic questionnaires for the analysis of musculoskeletal symptoms. Appl Ergon 1987;18:233–7.
[9] Centers for Disease Control and Prevention. Musculoskeletal disorders [Internet]. [cited 2013 Nov 02]. Available from http://www.cdc.gov/niosh/programs/msd/.
[10] World Health Organization. International Classification of diseases (ICD 10) [Internet]. 2010. Available from: http://apps.who.int/classification/icd10/browse/2012/en.
[11] Schierhout GH, Meyers JE, Bridger RS. Work related musculoskeletal disorders and ergonomic stressors in the South African workforce. Occup Environ Med 1995;52:46–50.
[12] Louw QA, Morris LD, Grimmer-Somers K. The prevalence of low back pain in Africa: a systematic review. BMC Musculoskelet Disord 2007;8:105.
[13] Booyens SJ, van Wyk PJ, Postma TC. Musculoskeletal disorders amongst practicing South African oral hygienists. SADJ 2009;64:400–3.
[14] Tinubu BM, Mbada CE, Oyeyemi AL, Fabunmi AA. Work-related musculoskeletal disorders among nurses in Ibadan, South-west Nigeria: a cross-sectional survey. BMC Musculoskelet Disord 2010;11:12.
[15] Siziya S, Rudatsikira E, Mweemba A, Rachiotis G, Mugala D, Bowa K, et al. Exposure to occupational health hazards among Zambian workers. Occup Med 2013;63:109–15.
[16] Nyantumbu B, Barber CM, Ross M, Curran AD, Fishwick D, Dias B, et al. Hand–arm vibration syndrome in South African gold miners. Occup Med (London) 2007;57:25–9.
[17] Atijosan O, Rischewiski D, Simms V, Kuper H, Lingnwa B, Nuhi A, et al. A national survey of musculoskeletal impairment in Rwanda: prevalence, causes and service implications. PloS One 2008;3:e2851.
[18] Bovenzi M, Vedova AD, Nataletti P, Alessandrini B, Poian T. Work-related disorders of the upper limb in female workers using orbital sanders. Int Arch Occup Environ Health 2005;78:303–10.
[19] Barr AE, Barbe MF, Clark BD. Work-related musculoskeletal disorders of the hand and wrist: epidemiology, pathophysiology and sensorimotor changes. J Orthop Sports Phys Ther 2004;34:610–27.
[20] Sauni R, Paakkonen R, Virtema P, Toppila E, Uitti J. Dose-response relationship between exposure to hand-arm vibration and health effects among metal-workers. Ann Occup Hyg 2009;53:55–62.
[21] Weir E, Lander L. Hand-arm vibration syndrome. CMAJ 2005;172:1001–2.
[22] McGeoch KL, Gilmour WH. Cross-sectional study of a workforce exposed to hand-arm vibration: with objective tests and the Stockholm workshop scales. Occup Environ Med 2000;57:35–42.