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Comparison of ergonomic risk factors and work-related musculoskeletal disorders among dismantler and burners of electronic waste in Agbogbloshie, Accra Ghana

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Abstract

Rudimentary methods for electronic waste (e-waste) recycling employed in developing countries are a source of work-related musculoskeletal disorders (WRMSDs). A summarized comparison of WRMSDs and preliminary exposure assessment among e-waste dismantlers (D) and burners (B) in Agbogbloshie, Ghana is presented. A cross-sectional study was conducted to investigate WRMSDs and associated risk factors using the Cornell Musculoskeletal Discomfort Questionnaire and a newly developed ergonomic assessment tool. Results indicated higher WRMSDs prevalence in the lower back (68% D vs. 52% B; $p = 0.172$), shoulder (41% D vs. 29% B; $p = 0.279$) and upper arm (33% D vs 5% B; $p = 0.010$). Moderate to severe trunk flexion, high force exertion, repetition and vibration were prevalent risk factors among workers and were significantly higher in dismantlers than burners ($p \leq 0.001$). Detailed ergonomic studies investigating the relationship between physical exposures and WRMSDs are needed to provide a deeper understanding of WRMSD causation in e-waste workers and more particularly in unstructured, unregulated work.

INTRODUCTION

Technological advancement and the high demand for electronic and electrical appliances generates huge quantities of discarded electronic waste (e-waste) annually (Perkins et al., 2014). In developing countries such as Ghana, e-waste is recycled by low skilled, low wage workers who use basic and informal recycling methods (Acquah et al., 2019b; Akormedi et al., 2013; Amankwaa, 2013). Informal e-waste recycling includes scavenging for end-of-life electronics, manual disassembly of e-waste items to separate the different metal constituents, and open air burning of insulated components (e.g., copper cables) to retrieve valuable metals for sale (Acquah et al., 2019b). The rudimentary methods used in informal e-waste recycling presents enormous health risks to workers and the nearby population (Fischer et al., 2020; Grant et al., 2013) due to exposure to air pollutants (Amoabeng Nti et al., 2020;

Kwarteng et al., 2020), excessive noise levels (Burns et al., 2019; Burns et al., 2016) and physical agents associated with poor work methods (Acquah, et al., 2021b; Acquah et al., 2019b).

Agbogbloshie, in Accra Ghana is one of the largest e-waste dumpsites and informal e-waste processing hubs in Africa. A recent assessment of physical work exposures at this site found that prolonged walking (often over uneven terrain), sitting, standing and performing manual material handling (MMH) tasks such as carrying, lifting, and pushing of loaded collection carts were prominent among e-waste workers (Acquah et al., 2021b). These exposures are known risk factors for the development of WRMSDs (Jaffar et al., 2011; Kwon, et al., 2011; Marshall et al., 2000; Wai et al., 2010) and might explain the high prevalence (~90%) of MSD symptoms in this population (Acquah et al., 2019a; Acquah, et al., 2021a).

To better understand and systematically characterize the type, duration and intensity of ergonomic risk factors among informal e-waste workers, Acquah et al. (2020) developed an observation-based tool specifically adapted to unstructured work settings such as e-waste recycling operations at the Agbogbloshie dumpsite, in Accra. The present study aimed to provide a summary comparison of WRMSDs and likely associated ergonomic risk factors using pilot data from the newly developed ergonomic assessment tool (Acquah et al., 2020) among e-waste dismantlers and burners.

METHODS

Study Procedure

This study was approved by the College of Health Sciences Ethical Review Committee at the University of Ghana. All participants provided written informed consent prior to data collection. The Cornell Musculoskeletal Discomfort Questionnaire (Cornell-University, 1999) was used to collect information on MSD symptoms reported among 103 male e-waste workers in Agbogbloshie, comprising 82 dismantlers and 21 burners (Acquah et al., 2021a). This was followed by a pilot assessment of risk factors based on a newly developed tool adapted for unstructured work (Acquah et al., 2020). This pilot phase included 3 dismantlers and 3 burners at Agbogbloshie. The workers were observed for a full work-day with observations coded at 60s intervals onto a paper template (Acquah et al., 2020) and subsequently entered into Microsoft Excel for data processing and analysis. The proportion of time workers were exposed to various ergonomic risk factors such as posture, force, repetition, vibration, contact stress, and MMH activities (e.g., lifting and carrying) were computed as a function of their severity.

Statistical Analysis

Descriptive statistics were used to identify the most prevalent body parts for which MSD symptoms were reported. Separate Chi-square test were used to compare differences in the proportion of e-waste dismantlers and burners reporting MSD symptoms for each of the four body parts most frequently affected. Ergonomic exposure was reported as the proportion of work time dismantlers and burners were exposed to the various physical risk factors. The proportions were computed for each worker category by dividing the total observed time the

workers were exposed to the specific risk factor being investigated by the total full day work time the worker was observed. A two-sample test of proportions was used to compare the difference in proportion of time dismantlers and burners were exposed to specific ergonomic risk factors. Statistical analyses were performed using STATA v.15 and the significance level was set at $p < 0.05$.

RESULTS

Participants' ages ranged from 18 to 42 years. The mean ± SD age was significantly higher ($p = 0.012$) for dismantlers (26.4 ± 6.5) than burners (22.9 ± 3.8). Job experience ranged from 1 to 25 years. The number of years on the job was significantly higher ($p = 0.007$) for dismantlers (7.6 ± 5.3) than burners (5.5 ± 3.1). Days worked per week ranged from 2 to 7 days with a mean of 6.1 ± 1.0 days but did not differ between dismantlers and burners. Hours worked per day ranged from 1 to 14 hours with a mean ± SD of 9.7 ± 3.0 hours but did not differ significantly between groups.

The four body parts most frequently affected by MSD symptoms were the lower back (65%), shoulders (39%), upper arms (27%), and neck (27%). MSD symptoms prevalence were higher for dismantlers compared to burners (Table 1), and this difference was statistically significant for the upper arm (33% vs. 5%; $p = 0.010$).

Sustained non-neutral neck posture is a known ergonomic risk factor for WRMSDs in the neck. Dismantlers spent a significantly higher percentage of their work time in non-neutral neck postures compared to burners (99% vs. 81%; $p \leq 0.001$). Ergonomic exposures related to lower back pain included the total duration of moderate and severe trunk flexion, which was significantly longer for dismantlers than burners (80% vs. 1%; $p \leq 0.001$). MMH is also a risk factor for low back pain, and was almost negligible for both dismantlers (1%) and burners (1.5%; $p = 0.513$).

High force exertion, repetition and vibration, which are known risk factors for shoulder and upper arm MSDs, were also observed (Table 2). Dismantlers were exposed to high force exertion and repetition for 67% and 85% of their work time, respectively, compared to 0.1% and 74% respectively for burners. These higher exposure to force and repetition for dismantlers compared to burners were statistically significant ($p \leq 0.001$; Table 2).

WRMSDs in the upper extremities were also common, e.g., 39% shoulder pain and 27% upper arm pain. Shoulder pain was higher among dismantlers compared to burners (41% vs. 29%) although the difference was not statistically significant. However, the prevalence of WRMSD symptoms in the upper arm was significantly higher in dismantlers compared to burners (33% vs. 5%; $p = 0.010$). In addition, both dismantlers and burners spent 99% of their time working with their hands below waist height, which is outside the preferred range between the shoulder and waist height, i.e., recommended "power zone", for safe MMH.

DISCUSSION

Informal e-waste workers in low and middle income countries have a high prevalence of work-related MSDs (Acquah et al., 2021a; Fischer et al., 2020; Acquah et al., 2019a;

Ohajinwa et al., 2018). Lower back pain (LBP) is generally the most commonly reported MSD symptom (Fischer et al., 2020; Ohajinwa et al., 2018; Acquah et al., 2021a). Not surprisingly, LBP was the most prevalent MSD reported in this study. LBP reported in this study (65%) was higher than LBP prevalence among e-waste workers in Nigeria reported by Ohajinwa et al. (2018), but lower than work-related back pain prevalence (91.6%) reported by Fischer et al. (2020) among e-waste workers in Ghana. The higher prevalence by Fischer et al. (2020) may have been due to a broader categorization which included all back pain as opposed to a more specific categorization of "lower back" pain in the present study. Among the known risk factors for LBP, the present study found prolonged exposures to moderate and severe trunk flexion and to MMH activities such as carrying and lifting. However, MMH (e.g., lifting and carrying) was seldom performed (~2% of total work time) by the few observed workers. This could imply a minimal contribution of carrying and lifting to work-related LBP compared to other risk factors such as non-neutral trunk posture. However, handling of heavy loads even for short durations could contribute to the development of LBP if performed with an incorrect posture (e.g., stooped vs. squat posture). Acquah et al. (2021b) found that e-waste workers perform lifting, carrying, and pushing/pulling tasks on five or more days in a work week; however, their study relied on self-reported data unlike the present study which used direct observations. Hence, the cumulative effect of MMH activities may be worth considering in future studies.

Considering the inconsistent findings in prior studies, a detailed assessment of ergonomic exposures is needed. Given the high variability in recycling tasks performed by this population (Acquah et al., 2021b), the preferred method to study physical exposure and MSD relationships among this population may be to observe workers for the entire work week and their MSD symptoms assessed before and at the end of the work week.

Upper extremity pain has also been reported among e-waste workers in Chile (51% pain prevalence in the wrist/hand) and Nigeria (14% prevalence in shoulder pain). Our results differ slightly. These differences may stem from differences in the categories of workers observed, the diversity of their tasks, as well as the work methods used (e.g., use of manual hand tools). In our study, job category (dismantler vs. burner) appears to be a significant factor as dismantlers used higher force exertion for much longer periods than burners. The repetition of manual activities was also greater for dismantlers than burners. The combination of the observed risk factors might explain the higher prevalence of upper extremity WRMSDs in dismantlers compared to burners.

Overall, comparison of WRMSD prevalence between studies may be difficult as exposure assessment may not be detailed. Furthermore, our pilot work indicates substantial work variability within and between workers, and thus requires an assessment method adapted to unstructured work. Limited access to measurement instrumentation and financial resources for ergonomics research in Ghana present additional challenges to using direct methods for measuring physical exposures among informal e-waste workers.

Study Implications and Limitations

The present study attempted to provide an overview of WRMSD prevalence among e-waste dismantlers and burners. Findings draw attention to the identification of ergonomic risk

factors that may be associated with these MSDs. Despite the preliminary nature of this study with a small number of participants, it shows the importance of using a low-cost method adapted to this type of informal work and for differentiating exposures between worker categories. This study was not intended to determine precise associations between work-related MSDs and physical exposures. The MSD and physical exposure data were obtained about a year apart. Considering these limitations, the information presented should be considered preliminary. However, the findings are potentially useful for guiding the study design of more rigorous investigations of physical exposures in unstructured work, and for developing a method to identify the most harmful risk factors, such as by computing severity scores, when prioritizing targets for ergonomics interventions.

RECOMMENDATION

The present findings emphasize variability in the context of unstructured work. Hence, we recommend use of an observation-based exposure assessment tool adapted to the work context and extending the observation sampling over periods of at least a week to obtain stable estimates of key exposure variables associated with WRMSDs. Findings also point to the need for stratifying exposures by job category.

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Table 1:

Comparison of MSD discomfort prevalence among e-waste dismantlers (n = 82) and burners (n = 21).

Body Part	MSD Prevalence (% work time)		Test Statistic
	Dismantlers (n = 82)	Burners (n = 21)	
Neck	23 (28%)	5 (24%)	$\chi^2 = 1.51$, $p = 0.697$
Lower back	56 (68%)	11 (52%)	$\chi^2 = 1.86$, $p = 0.172$
Shoulder	34 (41%)	6 (29%)	$\chi^2 = 1.17$, $p = 0.279$
Upper arm	27(33%)	1(5%)	**$\chi^2 = 6.70$, $p = 0.010$**

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Table 2:

Comparison of ergonomic exposures among e-waste dismantlers (n = 3) and burners (n = 3).

Risk Factor	Average Exposure (% work time)		Two-sample test
	Dismantlers	Burners	
Non-neutral neck posture	99%	81%	$\mathbf{p \leq 0.001}$
Moderate trunk flexion	80%	1%	$\mathbf{p \leq 0.001}$
Severe trunk flexion	19%	76%	$\mathbf{p \leq 0.001}$
Working with hands below waist height	99%	100%	$p = 0.098$
High force exertion	67%	0%	$\mathbf{p \leq 0.001}$
High repetitions	85%	74%	$\mathbf{p \leq 0.001}$
Vibration	78%	3%	$\mathbf{p \leq 0.001}$
Lifting/Carrying	1%	2%	$p = 0.513$