



Trunk posture assessment during work tasks at a Canadian recycling center

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ABSTRACT

Musculoskeletal disorders are common among waste workers but preventative effort is lagging behind. This exploratory study assessed trunk posture during waste sorting tasks via statistical and experimental means. Posture exposure exceeded levels previously shown and related to elevated risk of Low Back Disorders (LBD). Results show predisposition of waste workers to LBDs.

1. Introduction

Population growth and economic development is leading to an increased generation of solid waste (Agbesola, 2013; Khalil and Milhem, 2004; Bolaane, 2006; Furedy, 1995), and this waste needs to be managed to prevent environmental hazards (Agbesola, 2013). The recycling sector is regarded as sustainable within the waste management hierarchy (Bolaane, 2006), and recovery of inorganic materials from solid waste has been identified as a key component in the management of waste (Agbesola, 2013). The term ‘recycling worker’ describes workers in a recycling sector who collect, sort, clean, and bag waste materials as a means of livelihood and contribute greatly to the recycling sector (Furedy, 1995). Recycling can be done formally or informally. Formal work has been described by Kay (2011) as an “explicit arrangement with set pay and/or benefits, a stable location, regular hours, and some type of payroll taxes and social security contribution. Informal work describes ... work with little or no job security, does not have a contract, and might not have the same employer for more than a few weeks or months” (Kay, 2011). Although the management of waste is necessary, it is a job that Mehrdad et al. reported to be associated with a variety of “physical, biological, mechanical, chemical and psychosocial hazards” (Mehrdad et al., 2008). Globally, collection and sorting of waste is considered a high-risk occupation (Thirarattanasunthon et al., 2012).

A number of studies have shown a high rate of LBD prevalence in the waste management industry. A study showed a reported 12-month prevalence of musculoskeletal disorders up to 60.8% (Abou-ElWafa et al., 2012), and a recent systematic review indicated a 12-month prevalence between 14% and 74% (Asante et al., 2018). Recycling

workers have been found to have at least twice the risk of low back disorders as other workers in both Denmark (Poulsen et al., 1995) and Taiwan (Yang et al., 2001).

The activities of recycling workers are considered to be physically demanding and seem likely to expose workers to risk factors typically associated with a high prevalence rate of musculoskeletal disorders (Poulsen et al., 1995; Yang et al., 2001). Although recycling workers are presumed to be exposed to ergonomic hazards, no known research has explicitly measured these occupational exposures in this occupational group. A recent systematic review conducted in 2016, identified several exposures, which authors suggest might be related to the development of LBD among waste workers (Asante et al., 2018). Awkward posture (Mehrdad et al., 2008; Poulsen et al., 1995; Betsinger et al., 2000; Gutberlet and Baeder, 2008; Ivens et al., 1998); repetitive motion (Mehrdad et al., 2008; Betsinger et al., 2000; Prasuna, 2013); lifting and manual handling (Yang et al., 2001; Betsinger et al., 2000; Da Silva et al., 2006; Ivens et al., 1998); high forces (Mehrdad et al., 2008; Abou-ElWafa et al., 2012); trunk twisting (Velasco Garrido et al., 2015); high physical work load (Gutberlet and Baeder, 2008; Ivens et al., 1998); were some of the suggested risk factors in the systematic review. However, these studies did not assess exposure to these risk factors nor make any statistical comparisons between risk factors and the development of low back disorders. Of all the potential workplace exposures recycling workers may encounter, static, repetitive, and prolonged awkward posture are of particular concern (Gutberlet and Baeder, 2008). Waste workers often squat, twist, and bend (Gutberlet and Baeder, 2008; Velasco Garrido et al., 2015) whilst sorting through waste for long hours. It has been hypothesized that cumulative awkward posture contributes to musculoskeletal symptoms and work

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absence; which will eventually reduce productivity (Widanarko, 2013; Prasuna, 2013). In spite of the health implications of awkward posture, to our knowledge there have not been any actual measurements or ergonomic assessments conducted on recycling workers. The aims of this exploratory pilot study were therefore to: investigate the work tasks of recycling workers in the Canadian formal recycling sector; assess prevalence of musculoskeletal disorders; and conduct an ergonomics assessment focusing on trunk posture.

2. Methodology

2.1. Workplace description

Participants were recruited from a recycling facility charged with sorting single-stream municipal recycling. At this facility, waste collected from residential and commercial sources is off-loaded at the transfer station. Forklifts feed material into a drum feeder, where it is transported by conveyor belts to several sorting stations. Sorted materials are then bailed for storage and later transported off-site. There are two shifts per day through the 5-day workweek. Approximately 15 recycling workers perform sorting tasks on each shift. Duties may vary from day to day and exposures are expected to be linked to the type of material being handled at a particular workstation. A detailed description of the facility's workstations and associated tasks is shown in Table 1.

2.2. Study participants and sampling strategy

A total of 30 recycling workers were recruited for the questionnaire, and 10 recycling workers were recruited through a convenient for the posture measurement. Workers were invited to participate on a voluntary basis if they: (1) had a minimum of six months working experience as recycling workers; (2) were aged 18 and above; and (3) were working as full- or part-time. All participants completed an informed consent form (sample shown in Appendix C) and the University of Saskatchewan's Research Ethics Board approved the study (copy shown in Appendix A).

Table 1
Recycling workers' task classification and description.

Workstation	Description	Examples of Material (s) Handled
Pre-sorting	Monitor incoming waste on the conveyor belt Identify and remove unwanted/dangerous materials Lift plastic film to vacuum pipe Discard specific materials into chutes Remove contaminants off the floor	Plastic film Wire hangers Hazardous chemical containers Scrap metals Styrofoam
Old corrugated cardboard	Sort corrugated boxes	Cardboard Cartons
Polyethylene terephthalate	Sort thermoplastic products	Plastic resin
Container line	Sort beverage containers, plastics etc.	Tetra-pak containers Milk cartons Juice boxes Bottles
Deposit line	Sort metals Changing bags	Tins cans Pie trays Foil
Old newspapers Browns	Sort newspapers Sort cardboard	Papers Cardboard

2.3. Questionnaire data collection

Self-administered questionnaires were employed to collect data on demographics, work experience, as well as musculoskeletal symptoms using the Standardized Nordic Questionnaire (Hildebrandt et al., 2001), Numeric Pain Rating Scale (NPRS) (George et al., 2008; Waddell G et al., 1993) and the Fear Avoidance Belief questionnaire (George et al., 2008; Waddell G et al., 1993) (full questionnaire shown in Appendix B). Numeric Pain Rating Scale is a segmented scale which recycling workers choose from 0 to 10 that describes the intensity of their pain. The Fear Avoidance Belief (FAB) questionnaire consisted of 2 subscales: the 5-item FAB-Physical activity (FAB-P) subscale and the 10-item FAB-Work (FAB-W) subscale. All FAB items were scored 0 to 6, with higher scores representing greater levels of fear-avoidance behavior related to either physical activity or work (George et al., 2008; Alexopoulos et al., 2008). The Fear Avoidance Belief (FAB) questionnaire has "gold standard" thresholds for determination of "low" or "high" scores; however, this thesis compared its scores to other published studies to interpret the fear avoidance belief level related to work and physical activity among recycling workers.

2.4. Posture: direct measurement

Trunk posture was measured with an SXT I2M posture measurement system (NexGen Ergonomics, Montreal, Canada) mounted on the recycling workers' chest with an elastic strap. Fig. 1 shows the mounting position of the equipment. Recycling workers were asked to stand upright while the chest (trunk) sensor was fixed on the body using an elastic trunk harness. The chest (trunk) sensor was placed on the chest, on top of the sternum close to the medial end of the collar bones. The strap was then tightened so the sensor does not swing while sorting and also adjusted based on the comfort of recycling workers. Before and after the measurement, upright calibration postures were recorded for 5 s to account for offset in the mounted sensor position. Measurements were made at a 64 Hz-sampling rate during regular working tasks for 3–5 h (half a working shift) during the working day.

2.5. Data processing

The inertial sensor contains 3 orthogonal gyroscopes, accelerometers, and magnetometers. The gyroscopes measure angular velocity, accelerometers measure acceleration (for example, related to the force of gravity), and the magnetometers assess position relative to the earth's magnetic field. The recycling workplace did not support magnetometer data collection due to large ferrous sources and running machinery (such as the conveyor belts and driving engines), which



Fig. 1. Inertial sensor strapped on the chest to assess trunk posture.

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