

LOW BACK DISORDERS AMONG WASTE COLLECTION WORKERS: PREVALENCE
AND RISK FACTORS

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By

Benedicta Ofosuhemaa Asante

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ABSTRACT

Background

Waste workers' activities are an important component of the waste management industry. As the sector evolves reports of injuries and fatal accidents in the industry demand notice, particularly common and debilitating musculoskeletal disorders such as low back disorders (LBD).

Objectives

The study objectives were 1) to perform a systematic review on the prevalence and risk factors of LBD among waste collection workers and 2) to conduct an ergonomics assessment among workers in a Canadian formal recycling sector.

Methods

Objective 1: A comprehensive search was conducted in three databases with search term categories “low back disorders” and “waste collection workers”. Two reviewers screened and extracted data from identified articles.

Objective 2: Recycling workers participated in a questionnaire on work tasks and musculoskeletal symptoms. A motion-tracking inertial sensor was also used to measure trunk movement, which included time spent in various movement ranges and velocities.

Results

Objective 1: Only thirteen full-text articles met the study criteria and underwent data extraction. The majority of articles reported a 12-month prevalence of LBD between 16-74%. Although none of the included studies quantified relationships between risk factors and LBD, the main suggested risk factors for LBD included awkward posture.

Objective 2: The majority (73%) of questionnaire participants reported low back symptoms in the last 12-months. The median 90th percentile values for trunk flexion/extension

were: 37.0° for workers sorting containers/polyethylene terephthalate, 29.4° for workers at pre-sorting workstations, and 20.0° for workers sorting old corrugated cardboard/browns. The workers spent 38% of their working hours flexed > 20°.

Conclusions

The ergonomic assessment suggested that recycling worker's posture exposure exceeds levels previously shown to be related to elevated risk of LBD. The awkward working posture might predispose recycling workers to developing LBD.

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DEDICATION

To all Waste Collection Workers around the world, enhance safety through ergonomics.

“A good stance and posture reflect a proper state of mind”!

[Morihei Ueshiba]

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List of Abbreviations

LBD	Low Back Disorders
LBP	Low Back Pain
SNQ	Standardized Nordic Questionnaire
DMQ	Dutch Musculoskeletal Questionnaire
WCW	Waste Collection Workers
NPRS	Numeric Pain Rating Scale
FAB	Fear Avoidance Belief Questionnaire
FAB_W	Fear Avoidance Belief Questionnaire Work Subscale
FAB_P	Fear Avoidance Belief Questionnaire Physical Activity Subscale
MSD	Musculoskeletal Disorders

Chapter 1: Introduction

Low back disorders (LBD) are common globally [1,2] and accepted as a major health issue with high direct and indirect costs worldwide [6-10]. With no standardised definition, LBD are currently considered to be a heterogeneous group of musculoskeletal problems categorized by pain, discomfort, or stiffness [3,4]. Symptoms will vary from person to person and may present anywhere in the lower back [5], anatomically defined as the area between the inferior angles of the scapulae to the gluteal folds of the buttocks [1]. Leg symptoms or sciatica may also be present. Several risk factors are associated with the development of LBD, including: personal characteristics; lifestyle and psychological factors [9,11]; the working environment; and conditions such as manual handling and awkward postures [12]. The waste-recycling sector is a working environment considered to present workers with risk factors for the development of LBD. The activities of recycling workers are known to be physically demanding, and associated with a high prevalence rate of musculoskeletal disorders [13]. Recycling activities include working in awkward postures and lifting heavy loads, factors considered to impact on the development of LBD [14,15]. LBD within the waste collection industry are likely to be an important issue requiring further study in order to highlight prevalence and risk factors, and identify specific interventions that are tailored to this unique industry's occupational needs.

1.1. Structure of Thesis

The research work is presented in four (4) main chapters. Chapter one provides a general introduction to the research including details on prevalence and burden of LBD, an overview of the waste recycling industry, LBD among waste collection workers (waste workers), and potential risk factors for LBD among waste workers. The chapter also addresses the significance and relevance of this research. Chapter two is presented in manuscript form as a systematic

review of existing literature on the prevalence and risk factors of LBD among waste collection workers. Chapter three is also presented in manuscript format as ergonomics assessment of posture among waste workers in Saskatchewan. Chapter four summarises the key findings of both studies, providing a general discussion and study conclusions, including public health implications and directions for future research.

1.2. Prevalence and Burden of LBD

LBD are an important health problem in both developed and developing countries [7]. They are among the most common forms of occupational musculoskeletal disorders [12] and affect people of all ages. According to the 2010 Global Burden of Disease study, low back pain was one of the top ten DALYs (disability-adjusted life years) causing diseases and injuries [6]. Worldwide, the adult population has a LBD point prevalence ranging from 12% to 33%, with a one-year prevalence from 22% to 65% and a lifetime prevalence from 11% [6] to 84% [6]. The majority of the general adult population (85% to 90%) will likely experience low back pain in their lifetime globally [12,25]. Prevalence increases and peaks between the ages of 35 and 55 [16]. There are variations in the prevalence rates, likely to be related to geographical settings, age, lifestyle, cultural perception, social situations, and study design [7]. For instance, the point prevalence of low back pain in Canada and the US ranges from 4.4% to 33.0% and a one-month period prevalence from 35.0% to 52.2% [18]. Lifetime prevalence rate in the UK was identified as 59%, 70% in Denmark, and 75% in Finland [19]. Despite the variable prevalence rates, the burden associated with LBD can be considerable [17]. LBD are associated with activity limitations and work absenteeism [9]. Among the 90% of workers with low back pain who return to work, 20 to 44% will have a recurrence.[9]. LBD decrease the quality of life of people in their daily activities as a result of distress, failed treatments, social separation, difficulties at work and emotional

suffering. Pain is also a reason for psychological and social consequences, irritation, sleep disorders, reduced appetite and severe physiological distress [19]. Low back pain is a public health problem of clinical, social and economic importance, which affects the majority of the population which requires effective management and prevention strategies [19].

The economic expenses and public health impacts of LBD appear to be increasing [20], with billions of dollars in medical expenditures each year [20]. For example, in the United States, the direct cost of low back pain increased from \$85.9 billion in 2005 [21] to an estimated \$560 to \$635 billion in 2010 [22]. Musculoskeletal disorders generally constitute a major proportion of all registered and/or compensable work injuries globally, signifying a third or more of all registered occupational diseases in North America, the Nordic countries and Japan [6]. They are also a major cause of disability, affecting performance at work and general well-being [16,24] and the leading cause of job limitation as well as absenteeism globally, imposing a high economic burden on individuals, families, communities, industry, and government [11,16]. LBD cause more years lived with disability (YLD) than other health or medical conditions such as diabetes [24]. The costs associated with LBD are substantial [6]. For instance in the United States, LBD accounts for roughly 175.8 million working days lost due to absenteeism and hospitalization yearly [25]. Investigation of factors associated with LBD, particularly in potentially high-risk occupational settings, is therefore important to help address the high economic burden of this condition.

Occupational LBD can occur in all workers in all types of jobs, although prevalence can vary according to the type of job [7]. Generally, agricultural workers, construction workers, drivers, mine workers and nursing aids show high prevalence [7] and the variety of prevalence “by job type is considered to depend on the types, regularity, time, duration and intensity of occupational

exposure”[7]. These occupational attributes can also be identified in the waste recycling industry. The 12-month prevalence of musculoskeletal disorders has been reported at 60.8% among waste collectors, with the low back identified as the most frequently affected body region [13].

1.3. The Waste Recycling Industry

Waste is an item or material (liquid or solid) that is generated and disposed of or intended to be disposed [26, 27]. Waste is generated globally [15] with solid waste made up of “combustibles and non-combustible” material [28] from individual homes and institutions [29]. From the above definitions, it can be deduced that every unwanted or non-useful solid substance generated in any human population is referred to as solid waste [26]. Proper waste management decreases adverse impacts on the health and quality of life of people, and their physical environment [30]. Solid waste management encompasses a wide range of activities including: collecting; sorting recyclable materials; and collection and processing of commercial and industrial waste [14]. As global population growth and economic development increases, there is a high generation of solid waste [14,26,30,31]. The generation of waste needs to be managed to prevent or minimise environmental hazards [26]. Managing waste, from collection, sorting, recycling and finally disposing, poses risks to the environment and to public health [13,26]. There are high risks occurring at each stage of waste management, from the pick-up points, during transportation, and at the sites of recycling or disposal [14]. Appropriate management of solid waste reduces or eliminates adverse impacts on the environment and on human health and serves as a source of income [32]. The composition of waste nationally and internationally is rarely the same due to factors ranging from standard of living and habits of residents to resources and climatic conditions found in each geographical location [26]. Municipal solid waste (MSW) describes the diverse collection of wastes produced in urban areas, the nature of which varies from region to

region [27]. The recycling process includes collection, segregation and processing of waste with productive value such as inorganic fractions of MSW (paper, metal, plastic, glass materials) which may be recycled [26]. Recovery of inorganic materials from MSW has been identified as a key component in the management of waste [26]. Recycling is mostly utilized within the context of using solid waste materials for other purposes than what they were originally intended, and are often segregated from other types of waste either via specified receptacles and vehicles for collection, or separated directly from unsegregated waste [26]. Prior studies have shown that recycling is a valuable tool in reducing the quality of solid wastes that are disposed at the landfill site and also serves as by-products for other industries [28,33].

Many cities in the world use manual waste collectors which has been identified as one of the highest risk occupations [12]. Waste collection workers face different work-related ailments as a result of their daily exposure to work-related hazards [12]. Waste collection workers are prone to mechanical accidents, such as “cuts, blunt trauma, falls, lacerations, and traffic accidents” [34] in their daily activities as much as ergonomic exposures and risks. Unfortunately, “there is inadequate research and statistics relative to ergonomics, safety and health problems associated with workers in the recycling industry” [34]. To help understand the burden of LBD in this potentially vulnerable workforce, research that initially describes the nature and range of these exposures is needed. It will be important to also assess factors associated with LBD and measures the work demands (particularly working postures) among waste collection/ recycling workers.

1.4. LBD among Waste Workers

LBD are often related to occupation [9]. Occupational LBD are defined as work-related LBD and classified as accidental or non-accidental [7]. Persons whose routine work involve

substantial physical activities including lifting, carrying, pulling, pushing, picking, sweeping, or bending for long hours are the most vulnerable [30]. Waste collection work is “characterized by heavy weight lifting, which affects major joints” [14,15], thus there is substantial risk for LBD and other musculoskeletal disorders [14]. Several studies on the activities of waste workers shows that mechanical loads regularly surpass upper health and safety thresholds or approved limits [14]. Heavy loads exert high shear forces on the spine which is likely increase the incidence of LBD [14]. Globally, waste workers are at a high risk of experiencing musculoskeletal disorders [30,35]. Studies conducted in different geographical locations indicate a high risk for musculoskeletal complaints among waste workers [35]. Poulsen et al. [36] found that musculoskeletal disorders were twice as high among waste workers when compared to the total work force [36]. A nearly 2 times higher incidence rate of musculoskeletal complaints for refuse collectors was reported in Denmark compared to the total Danish workforce [13]. For waste collectors in Taiwan, the risks for musculoskeletal disorders among refuse collectors were more than two times higher than office workers [13]. Waste workers have higher risk of developing low back pain than that of all other workers in America [31].

1.5. Potential Risk Factors for LBD among Waste Workers

Work-related risk factors in non-specific LBD are complex [7]. There are many factors that have been identified as contributors to LBD [9]. Low back disorders are affected by “working conditions (heavy physical loads, awkward static/ postures, manual handling and lifting), lifestyle factors, individual characteristics, and psychological factors [11]. A study by Harkness et al. indicates that long hours of standing, sitting, squatting, kneeling, bending and stretching below knee level are all correlated with incidence of LBD to some degree [9]. Other studies indicated that social and demographic factors, medical conditions, behaviour factors, and work

related factors are associated with LBD [17]. Another review focussing on low back pain and occupational exposures among waste workers showed that low back pain was associated with forceful movements and lifting (odd ratios of 2.2 to 11.0) [14]. Bernard et al. selected 12 studies and investigated the relationship between back disorders and bending, twisting and awkward postures. In many cases, the exposure was defined subjectively or in combination with other work-related risk factors [7]. It was found that people who are exposed to vibrations, or long standing positions including construction workers, hospital staff, and drivers are also more prone to LBD [11]. Workers who require continuous lifting of heavy loads as part of their job have an increased risk of developing LBD, a factor commonly observed in the waste management industry [9]. The high physical workload in refuse collecting is also seen as an important risk factor for musculoskeletal and physical fatigue complaints [35]. Municipal solid waste that is collected manually involves repetitive lifting, carrying, pulling, and pushing and thus musculoskeletal problems are common among waste workers [12,13]. Waste collection workers often squat, twist, and bend [37] whilst scavenging or sorting through waste for long hours. Chapman et al. hypothesize that aggregated awkward postures contribute to long absences from work [40], decreasing productivity. Currently there is no systematic review investigating prevalence and risk factors of LBD among waste workers. Also, there are no known published ergonomic assessments conducted in this unique occupational group. A systematic review would help summarize what is known about this understudied workforce. More detailed and clearer information on exposure-response relationships will allow for development of interventions and preventative measures at the WCW workplace to prevent LBD. There is a need for further studies to assess these risk factors through both direct and indirect measurement.

1.6. Aims of the Study

Despite the potentially high risks for development of LBD in waste workers, there is no review of published literature on the prevalence and risk factors for LBD in this understudied group. In addition, there are no published ergonomic assessments, which would help to provide a more comprehensive understanding of LBD, and working postures among recycling workers.

Although health implications of awkward posture have been identified, there are a very limited number of studies investigating working posture among waste workers. The aims of this thesis are to: (1) perform a systematic review on the prevalence and risk factors of LBD among waste collection workers, (2) investigate the work tasks of recycling workers in a recycling sector; (3) estimate prevalence of musculoskeletal disorders; and (4) conduct an ergonomics assessment focusing on trunk posture. The findings of this study would give clear task description of waste workers in general as well as postural patterns and movements of recycling workers. These findings would serve as a foundation for future studies and assist in the development of hypothesis as well as the selection of methodological strategy.

1.7. Research Questions

In order to address these research gaps, the following research questions are the prime focus of this thesis:

- 1) What are prevalence and risk factors for LBD among waste workers reported in the literature?
- 2) What are typical working postural exposures among formal sector waste workers in Saskatchewan?

These research questions are addressed through 1) a systematic review (chapter 2) of the prevalence and risk factors of LBD among waste workers and 2) an ergonomics assessment

of posture among Saskatchewan waste workers in the formal sector, with results detailed in chapter 3.

1.8. **Relevance of the Study**

There is an increase in waste generation as the global population grows rapidly [14,20,21], therefore there is the need for effective and prompt waste management systems to ensure there are minimum hazards posing risks to the environment and to the health of humans [22]. Improper management of waste has adverse impacts on the environment and human health [23]. There is a need for people to be employed in this sector to help manage these wastes appropriately.

Although the collection of waste is necessary; it is a job which involves physical, chemical, biological, mechanical and psychosocial hazards [13]. Many cities in the world are involved with manual waste collection and this has been found to be an occupation with high risk of low back pain [13].

LBD are well documented as a very common health problem [10,25,39,40] affecting productivity and creating a high direct and indirect economic burden [41]. However, there is inadequate research regarding risk factors of LBD associated with workers in the WCW recycling industry [42]. For a more comprehensive understanding of the occupational health and safety problems in the waste management industry, there is the need to review and conduct studies on other ‘informal’ worker groups in the waste recovery sector such as ‘scavengers’ and ‘recyclable materials sorters’[42]. This study will help address this need by summarizing the state of knowledge and identifying gaps regarding LBD in this potentially high-risk industry. The systematic review conducted as part of this study will be the first known review to perform a synthesis of LBD data within the global WCW workforce. Such a review will help summarize what is known about this understudied workforce and establish a foundation for future research

by examining the prevalence and risk factors of LBD. The ergonomic assessment will provide detailed information that will be considered useful for planning and enhancing ergonomics/ work injury prevention programs. It will also be the first to profile postural exposures in a waste workers sample, using study participants from the formal recycling sector in Saskatchewan, Canada. In addition, the information gathered from this research will inform future studies on LBD in this population and will provide a starting point for intervention development and testing.

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Chapter 2: Manuscript 1

Prevalence and Risk Factors of Low Back Disorders among Waste Collection Workers: A Systematic Review

Benedicta O. Asante¹ MPH, Catherine Trask² PhD, Olugbenga Adebayo³ MPH, Brenna Bath^{4*} PhD

^{1,3} Community Health and Epidemiology College of Medicine, University of Saskatchewan, Canada

² Canadian Centre for Health and Safety in Agriculture, College of Medicine, University of Saskatchewan, Canada

⁴ School of Physical Therapy, College of Medicine, University of Saskatchewan, Canada

*Corresponding author:

Canadian Centre for Health and Safety in Agriculture (CCHSA)

University of Saskatchewan

104 Clinic Place, PO Box 23

Saskatoon, SK S7N 2Z4

brenna.bath@usask.ca

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2.1 Abstract

Background: Waste Collection Workers' (WCW) activities contribute substantially to the recycling sector and are an important component of the waste management industry. There are increasing reports of injuries, particularly for common and debilitating musculoskeletal problems such as low back disorders (LBD) in the recycling sector as the sector advances. Waste workers are likely to be exposed to diverse work-related hazards that could contribute to LBD. However, there is currently no published review of the state of knowledge on the prevalence and risk factors of LBD within this workforce. The purpose of this chapter was to perform a systematic review on the prevalence and risk factors of LBD among waste collection workers.

Method: A comprehensive search was conducted in Ovid Medline, EMBASE, and Global Health e-publications with search term categories "low back disorders" and "waste collection workers". Two reviewers screened articles at title, abstract, and full-text stages. Data were extracted on study design, sampling strategy, socio-demographics, geographical region, and exposure definition, definition of LBD, response rate, statistical techniques, LBD prevalence and risk factors. Risk of bias was assessed with a standardized tool.

Results: The search of three databases generated 79 studies. Thirty-two studies met the study inclusion criteria for both title and abstract; while only thirteen full-text articles met the study criteria and underwent data extraction. The majority of articles reported a 12-month prevalence of LBD between 16 to 74%. Although none of the included studies quantified relationships between risk factors and LBD, the suggested risk factors for LBD among waste workers included: awkward posture; lifting; pulling; pushing; repetitive motions; work duration; and physical loads.

Conclusion: LBD is a major occupational health issue among waste workers. In light of these risks and future growth in this industry, further research should focus on investigation of risk factors, with more focus on ergonomic exposure assessment, and LBD prevention efforts.

2.2 Introduction

Low back disorders (LBD) are a common and global health problem, that the majority of people will develop in their lifetime [1]. They are amongst the most common cause of disability and have been described the “utmost prevalent musculoskeletal disorder” globally [2]. The lifetime prevalence of LBD among all workers is 85% [3-7]. LBD are also reported to be a common musculoskeletal disorder specifically in the waste management sector, presumably due to the physical and potentially high risk nature of their work [4]. Waste management involves the collection, transportation, sorting, disposal, and recycling of unwanted materials [5,6] such as plastics, paper, cans, and cardboard amongst others. This process is important for the health of the public as well as aesthetic and environmental reasons [7] . Ineffective management of waste will increase odours and degrade the quality of the human surroundings and in the long run affect the suitability of the ecosystem to human health.

Manual waste collection is the most common form of gathering waste globally and has been found to be among the highest risk occupations [7]. Workers who manually manage waste face different work-related injuries as a result of their daily exposure to work-related hazards [7]. These workers, known as waste collection workers (WCW), ‘waste pickers’, ‘recycling workers’, ‘municipal solid workers’, ‘solid waste workers’ collect materials that have been discarded as waste and add value to them by sorting, cleaning, and altering the physical shape to facilitate transport or combine materials in order to make commercially viable products [8]. The activities of these workers in managing waste can be both formal or informal [5]. Formal work is

“working for one company and having some type of working agreement, set pay and/or benefits, a stable location, regular hours and some type of payroll taxes and social security contribution”[12] while an informal work situation means “the person doing the work has little or no job security, doesn’t have a contract, and might not have the same employer for more than a few weeks or months” [12].

Waste workers’ activities are significant to the recycling sector, which are regarded as sustainable within the waste management hierarchy [21]. It is an avenue for identifying and retrieving waste as a “resource”, and likewise managing the environment as a whole [22]. Scavenging, an example of informal sector waste management, promotes social equity by providing a source of income to those who engage in it to sustain their livelihoods [22]. Scavengers habitually have decreased access and safety in the health system and are disadvantaged with regards to inequitable health outcomes, which are perpetuated with this line of work. In the process of waste scavenging and sorting, workers are likely to be exposed to awkward positions, repetitive movement, long duration of standing, and vibration [3,4,9,10]. To our knowledge there is no publication summarizing the issue of LBD in waste workers as well as the impact of their daily activities to the environment in general and the health of humans. Hence, there is a need for a review of published scientific literature on LBD related to this understudied group, and identification of hazards they are exposed to while they carry out their daily work. The aim of this study is to perform a systematic review on the prevalence of, and risk factors for, low back disorders among waste workers.

2.3 Methodology

This review has focused on waste collection workers in any global geographical region with the outcome of interest being low back disorder. All study designs were considered among articles

that were peer-reviewed journal articles and published in English language with no limitations on year of publication.

2.3.1 Search Strategy

A search was conducted in three main electronic published databases from inception: Ovid Medline (1946 to 2015), EMBASE (1974 to 2015), and Global Health ePublications (1973 to 2015). The main search terms included conceptual groups of synonyms for “low back disorders”, and “waste collection workers” (a full list of search terms is shown in appendix B). After the initial search was conducted, the reference lists of included articles were also searched for relevant articles.

Inclusion Criteria: The review included articles published in English language, all study designs, and with subjects age 18 years and older. Eligible articles were peer-reviewed journal articles that reported LBD with any prevalence period and/or risk factors for LBD.

Exclusion Criteria: Non-English language and other non-primary research articles in journals were not included.

2.3.2 Screening

Two reviewers (BA, OA) independently screened the articles generated from the three electronic databases. The two reviewers screened the articles at the title, abstract, and full-text stages. In all the three stages of screening, discrepancies were discussed and resolved by consensus.

Continued discordances were resolved with a third reviewer.

2.3.3 Data Extraction

Data extraction captured information to address the two primary research questions 1) “What is the prevalence of LBD among waste workers”? and 2) “What are the risk factors for LBD among waste workers”? Extracted information included: author’s name and date of publication, the sample size, sampling strategy, and socio-demographics of the sample, the study design, geographical region, exposure definition / levels, definition of LBD, response rate, statistical techniques, and LBD prevalence. Methodological quality and risk of bias of these articles were assessed using a modified tool developed by Hoy et al [11]. Two independent reviewers (BA & OA) extracted the relevant data. Where the results were inconsistent, the two reviewers discussed and consulted a third reviewer to arrive at consensus.

2.4 Results

2.4.1 Search Results

The search generated 79 articles; Ovid Medline (19 articles), EMBASE (55 articles), and Global Health e-publications (5 articles). There were 34 duplicate articles, which left a total of 45 unique for screening; after screening 13 articles were included in this systematic review. Figure 1 shows the results of the screening process.

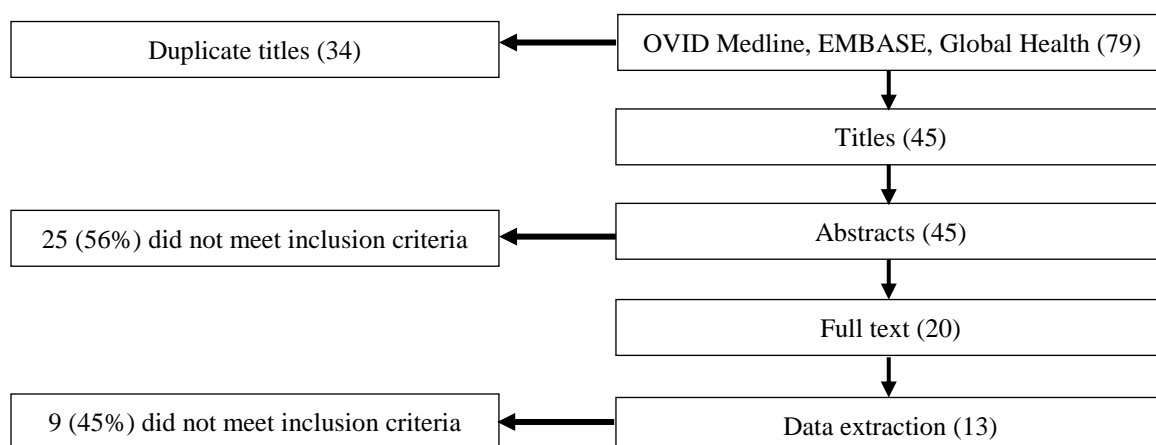


Figure 1: Literature review flow chart

2.4.2 Characteristics of the Included Articles

The articles included in the review had diverse study designs, though the majority (n=13) used descriptive cross-sectional study design (table 1). These articles had varied sample sizes, ranging from 30 to 900 participants. Five out of the 13 studies were conducted in developed countries and 8 in developing nations. The majority of the articles (9 out of the 13) included both male and female study participants. Five out of the 13 articles used only male study participants. One article out of the 13 did not state the sex of its study sample. In terms of work context, two of these studies were conducted among informal workers; six among formal and five of the studies used both formal and informal worker participants.

2.4.3 Defining LBD Prevalence

Different definitions for LBD were used in the studies, including description as ergonomic/occupational injury, musculoskeletal symptoms, or back complaints. Prevalence was estimated over a 12-month period. Of the 13 articles, 8 used standard questionnaires as a tool to collect data on LBD. Four of the articles used clinical reports, physical/clinical examinations, or interviews to collect data on LBD. Table 1 gives a summary of the included articles.

Table 1: Characteristics of the study participants and work context

Article	Research Location	Study Design	Work Context	Sector	Gender		Sample size	Data Collection Method for LBD prevalence
					%Female	%Male		
Abou-Elwafa et al. 2012	Mansoura city, (Egypt)	Cross-sectional with a comparison group	Solid waste collectors	Formal/ Informal	0	100	160	DMQ, SNQ Clinical examination
Betsinger et al. 2000	Minnesota (USA)	Cross-sectional	Household hazardous waste facility workers in 17 sites	Formal	40	60	35	Interview
E--wahab et al/2014	Alexandria (Egypt)	Cross-sectional	Solid waste workers in the main municipal company in Alexandria	Formal	0.6	99.4	346	Face-face interviews with pre-tested questionnaire Physical examination
Garrido et al /2015	Hamburg (Germany)	Cross-sectional	Workers of the Hamburg sanitation department	Formal	4.6	95.4	65	General clinical examination Standard questionnaire
Gutberlet et al/2008	Santo Andre', (Brazil)	Survey	Informal recyclers	Informal	8.5	91.5	47	Interview and observation
Ivens et al/1998	Copenhagen (Denmark)	Survey	Domestic waste workers	Formal	0	0	491	Reports from registered injuries by employees

Jariwala1 et al/ 2013	Surat City (India)	Cross-sectional study	Door to door waste collectors	Formal/ Informal	0	100	292	Questionnaire
Kuijjer et al/2005	Amsterdam(H olland)	1-year prospective study	Non-rotating refuse collectors and rotating refuse collector	Formal	0	100	130	SNQ
Mehrdad et al/2008	Tehran (Iran)	Cross-sectional study	Municipal solid waste collectors	Formal/ Informal	0	100	217	SNQ
Noriaki et al/1973	Tokyo (Japan)	Survey	Garbage collectors	Formal/ Informal	0	100	91	Direct measurement
Norman et al/2013	Accra (Ghana)	Cross-sectional study	Solid waste collectors	Formal	25	75	340	Questionnaire
Da Silva et al/2006	Pelotas (Brazil)	Cross-sectional study	Rag pickers	Informal	37	63	441	SNQ
Yang et al/2001	County of Kaohsiung (China)	Survey	household waste collectors- manually collecting waste in sack/containers	Formal/ Informal	47	53	533	Questionnaire

*SNQ = Standardized Nordic Questionnaire

*DMQ= Dutch Musculoskeletal Questionnaire

2.4.4 LBD Prevalence among Waste Workers

Table 2 presents the prevalence of LBD among waste workers extracted from the 13 included studies. The prevalence from these articles ranged from 16% to 74% for a 12-month period. One article reported a lifetime prevalence ranging from 85% to 90%. Twelve-month prevalence was based on identified symptom occurrence in the 12 months prior to the study, while “lifetime prevalence” was estimated based on the proportion of respondents who had ever experience LBD.

Table 2: LBD prevalence among waste workers

Article	12-month Prevalence	Lifetime Prevalence
Betsinger et al. 2000	16.0%	-
Ivens et al.1998	17.0%	-
E--wahab et al.2014	17.3%	-
Abou-Elwafa et al. 2012	22.5%	-
Noriaki et al.1973	32.0%	-
Jariwala et al.2013	38.0%	-
Yang et al.2001	42.0%	-
Kuijer et al.2005	45.0%	-
Mehrdad et al.2008	45.6%	85.0 to 90.0%
Da Silva et al.2006	49.2%	-
Gutberlet et al.2008	56.0%	-
Garrido et al .2015	67.2%	-
Norman et al.2013	73.5%	-

Note: - = Not assessed in the article

2.4.5 Risk Factors for LBD

None of the included articles specifically examined the association between risk factors and LBD quantitatively. However, the included articles suggested that risk factors which may potentially be contributing to LBD in waste workers include: repetitive motion [14,17,18], lifting [4,14,15,19] force [17], twisting [15], short cycle (high repetition) [15,20], manual handling

[15,16], work duration [10,16,20,21] smoking [16], physical work load [4,10,20], vibration [20] and awkward posture during work [10,14,20,22].

2.4.6 Study Quality

Overall methodological quality was assessed based on a criteria list recommended by Hoy et al [11]. Each study was assessed individually and was scored “Yes” if it met a specific criteria and “No” if there was no satisfactory information. Table 3 shows the methodological assessment in all the 13 articles included in this review. The majority of the studies used questionnaires to collect data. Overall, only 1 of these articles met the 10 criteria. The majority of these articles did not meet criteria relating to whether their sample represented the true population (n=4 articles), whether the sample was selected randomly (n=11 articles), whether response rate was greater than 75% (n=3 articles), whether their case definition is acceptable (n=2 articles), and whether the same mode of data collection was used for all their sample (n=2 articles). Typically, articles scored “No” due to insufficient information reported. This analysis of study quality concluded that the 13 articles included in this systematic review had moderate overall quality and thus, “additional studies are likely to change the confidence in estimation” [23].

Table 3: Risk of bias assessment of articles included in the review

Article	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Abou-Elwafa et al. 2012	YES	YES	NO	YES	YES	YES	YES	YES	YES	YES
Betsinger et al. 2000	NO	NO	NO	NO	YES	NO	YES	NO	YES	YES
E--wahab et al/2014	NO	YES	NO	YES	YES	YES	YES	YES	YES	YES
Garrido et al /2015	YES	YES	NO	YES	YES	YES	YES	YES	YES	YES
Gutberlet et al/2008	NO	NO	NO	NO	YES	YES	YES	YES	YES	YES
Ivens et al/1998	YES	YES	YES	NO	YES	YES	YES	YES	YES	YES
Jariwala1 et al/ 2013	NO	YES	NO	YES	YES	YES	YES	YES	YES	YES
Kuijer et al/2005	YES	YES	NO	YES	YES	YES	YES	YES	YES	YES
Mehrdad et al/2008	YES	YES	NO	YES	YES	YES	YES	YES	YES	YES
Noriaki et al/1973	YES	YES	NO	YES	YES	NO	YES	NO	NO	NO
Norman et al/2013	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Da Silva et al/2006	YES	YES	NO	YES	YES	YES	YES	YES	YES	YES
Yang et al/2001	YES	YES	NO	YES	YES	YES	YES	YES	YES	YES

Q1. Does the target population represent the region's population in relation to variables such as age, occupation”?

Q2. Does the sample frame show a true representation of the target population?

Q3. Does the study show that the sample was randomly selected?

Q4. Does the study show that non-response bias was minimised?

Q5. Was data collected from the study sample?

Q6. Were data collection tools suitable?

Q7. Does the study indicate the same mode of data collection processes from study sample?

Q8. Was the data collection or measurement tool suitable and valid?

Q9. Does the length of the prevalence period suitable?

Q10. Does the study indicate suitable numerator and denominator parameter?

2.5 Discussion

This study reviewed 13 articles focusing on prevalence of LBD among Waste workers. The studies included in this review indicated a wide range of prevalence rates for 12-month LBD (32% to 74%), depending on the LBD definition. Although the review intended to investigate risk factors for LBD, no articles quantifying this relationship were found.

2.5.1 LBD Prevalence among Waste Workers

Low back disorders were defined differently in most of the articles; this may be linked to the variability in reported prevalence rates. All reviewed articles reported a 12-month prevalence ranged from 16% [16] to 74% [17]. It has been established that finding the true population estimate and comparing prevalence of low back disorder among populations within a given period is a very difficult task due the differences in study design and methodological approach as well as other psychosocial factors [23]. The main data collection tools used in most of these studies were standardized questionnaires, for example Standard Nordic Questionnaire (SNQ) [3, 4, 19, 21] or Dutch Musculoskeletal Questionnaire (DMQ) [4]. Four of the articles either used clinical injury report, physical examination, observation or interview as a means of collecting data from participants. Most of the studies under review did not use clinical examination for measuring the prevalence of LBD. As there is no “gold standard” for assessing LBD some of the differences in prevalence among the 13 studies may be due to how the case definition of LBD was made [1]. For example, recall of LBD was used in almost all the articles, which may be problematic in estimating the prevalence of LBD [1]. The quality of the methodological strategies used may also contribute to the differences in the reported prevalence. A study by Norman et al [17] showed that, cross-sectional studies, self-reported data, and bias in recall can under or overestimate the prevalence of LBD among waste workers. This may have resulted in

the difference of prevalence reported in the included articles. Though the included articles used a similar sample, their selection of the study sample, their mode of collecting data, as well as individual perceptions of pain may have differed, hence likely creating reported differences in prevalence.

2.5.2 Comparison to Other Industries

Although the identified range among these studies was large, the prevalence rates were not substantially different from those reported in other potentially high-risk occupational groups. The prevalence of LBD reported among textile [29], health workers [32] and office workers [33] are typically 35% to 55%, within the ranges demonstrated by the 13 articles under review. Ghaffari et al [28] concluded that the 12-month prevalence for self-reported LBD among Iranian industrial workers was 21% [28]. A cross-sectional study conducted among textile workers by Paudyal et al [29] showed a 1 month period prevalence of LBP at 35% ($n = 324$), being higher in females than males (45% versus 28%; $P < 0.001$). The high handling demands of healthcare may also provide a similar set of risk factors. Dajani et al [32] showed a 12-month prevalence of work-related LBD to be 53.2% among 300 nursing staff [32], as assessed using Standardized Nordic Questionnaire (LBD was assessed on recall period, episode duration and location of painful area). A study conducted among 74 staff in a rural hospital indicated a 12-month prevalence of LBD 69% among nurses, 55% among administrative staff, and 20% among cleaners [33]. In addition, many estimates of self-reported 12-month LBD in the western world have been close to 60% [32], as confirmed by the results of this systematic review. Construction of questionnaire items and individual cultural perceptions in reporting pain could account for some of the regional differences [33]. Comparing the 12-month prevalence reported among Iranian industrial workers (21%) [34] to the 12-month prevalence among waste workers in Iran (45.6%) [16], suggests

there an increased risk of LBD among waste workers. How study participants culturally perceive and relate to pain could have resulted in the difference in pain reporting [30].

2.5.3 Risk Factors for LBD

Risk factors are considered to be modifiable or non-modifiable variables associated with an increased risk of disease or health condition [1]. Identified risk factors of LBD would enhanced the attempts to implement preventive measures to help reduce its development [20]. Prior research has focused on age, gender, and lifestyle factors such as smoking as well as physical activity as risk factors for musculoskeletal disorders in general [42]. Others have focused on “physical characteristics, psychological characteristics, lifestyle factors, employment, social factors and genetic components” in the development of LBD [14]. Malchaire et al indicated that repetitiveness and posture are considered to be biomechanical risk factors for LBD [42]. Repetitive motion[14,17,18], lifting [4,14,15,19], high force [17], twisting [15], short cycle (high repetition) [15,20], manual handling [15,16], work duration [10,16,20,21], smoking [16], physical work load [4,10,20], vibration [20], and awkward posture during work [10,14,20,22] were the risk factors suggested in the reviewed articles. However, none of these studies specifically investigated the association between risk factors and LBD. Therefore, there is need for future studies to explore the association between these risk factors and low back disorders in this potentially high-risk occupational group.

2.5.4 Generalizability of Results

Although waste management likely occurs in most areas of the world, not all geographical regions are represented in the articles included in this review. Only 11 countries were represented. Only eight of the thirteen studies were conducted in developing countries where waste management is primarily manual, compared to economically developed western nations

where there is an increase in mechanized approaches for managing waste. However, the use of mechanical means of managing waste does not guarantee the safety of waste workers, since workers often stand for long hours and undertake repetitive movements whilst trying to control machinery [34]. As waste collection in a global context is predominantly manual [3], there is a need for further studies in other developing regions to fully understand the impact of LBD in waste workers worldwide. Certain groups such as women may not have been proportionately represented. For example, 9 articles used both men and women participants; however, in all 9 articles men represented a higher proportion (2227/3117, 71% men). Additionally, 5 out of the 13 articles used only male participants. There are proportionately more men in the waste industry, as seen in the Canadian waste management workforce where men represent 77% of the SWM workforce [23]. Still, there is the need to consider the geographical and social context in which these 13 articles were conducted to better understand the results.

The quality of the included articles were appraised based on an assessment scale proposed by Hoy et al [11] . Overall, the included articles showed moderate weakness in methodological quality assessment, in that most of the articles did not report using random sampling methods [3,4,10,14,18-,22,37] or clearly demonstrate that non-response bias was minimised [10,14,15]. Randomization prevents selection bias to a large extent [25], so not doing it might affect the reliability and validity of the study results [24] by introducing bias which would have ultimately over or under estimated the study findings. Future studies should improve their sampling strategies to mitigate bias and improve study quality.

2.6 Strengths and Limitations

This systematic review is the first of its kind on the prevalence and risk factors of LBD among waste workers, and provides a summary of prevalence of LBD among waste workers. The search for these 13 articles was undertaken systematically in 3 electronic scientific databases using an extensive comprehensive list of search terms as shown in appendix B. The dual reviewers and consistency in screening and extraction enhanced the reliability of the findings. In addition, risk of bias was assessed using a standardized tool developed specifically for LBD prevalence studies [11]. However, there are also limitations to this systematic review. Only three databases were used due to time limitations of this study. Relevant articles from specific regions, which are not in English language, could have been missed. Also, this review could have missed articles in smaller journals, which are likely to be not indexed in the databases used. Two articles were excluded from the review because full-text was not available, and it is possible inclusion of these articles might have enriched the review data.

2.7 Recommendations for Future Research

In the present review, none of the 13 articles examined risk factors. Hence, these studies did not quantitatively show sufficient evidence of the association of suggested risk factors such as lifting and twisting. An enhanced understanding of exposure-response relationships would allow for development of interventions and preventative measures at the workplace to prevent LBD. It would be particularly valuable to assess these risk factors through direct measurement to get a realistic and accurate picture of the nature of this type of work.

2.8 Conclusion

The generation of waste, if not appropriately collected and/or managed, will pose a health risk to humans and the environment at large. The activities of the informal and formal waste workers

can reduce the risk to humans of air-borne and water-borne diseases. Waste workers are faced with the risk of experiencing LBD as they carry out their daily work. This systematic review used descriptive analysis to summarize the prevalence of LBD among waste workers. The 12 month prevalence of low back pain ranged from 14% [16] to 74% [17] from the reviewed articles. None of the articles under review quantified relationships between LBD and risk factors. Therefore, there is the need for future studies to quantify the risk factors for LBD among waste workers in order to assist in developing interventions and preventive measures.

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CHAPTER 3: Manuscript 2

Trunk Posture Assessment during Work Tasks at a Canadian Recycling Center

Benedicta Asante¹, Brenna Bath^{2, 3}, Catherine Trask^{3*}

¹ Community Health and Epidemiology College of Medicine, University of Saskatchewan, Canada

² School of Physical Therapy, College of Medicine, University of Saskatchewan, Canada

³ Canadian Centre for Health and Safety in Agriculture, College of Medicine, University of Saskatchewan, Canada

*Corresponding author:

Canadian Centre for Health and Safety in Agriculture (CCHSA)

University of Saskatchewan

104 Clinic Place, PO Box 23

Saskatoon, SK S7N 2Z4

catherine.trask@usask.ca

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3.1 Abstract

Background: Musculoskeletal disorders are common among waste workers, but preventative efforts have lagged behind the need. Although it has been suggested that risk factors such as awkward posture contribute to high rates of musculoskeletal disorders, there are no known published ergonomic assessments conducted on recycling work.

Objective: The aim of this exploratory study was to assess trunk posture during waste sorting tasks in the Canadian recycling sector.

Method: Waste-sorting workers participated in a questionnaire (n=30) and workplace posture measurement (n=10). Questionnaires collected information on work tasks and musculoskeletal symptoms. Data-logging inertial sensors were used to measure trunk movement for half of a working day. Subsequent kinematic reconstruction of the workers' movements included time spent in various movement and velocity ranges as well as a descriptive comparison between tasks.

Results: The majority (73%) of questionnaire participants reported low back symptoms, and 47% indicated that their lower back has prevented them from work and other activities in the last 12 months. The median 90th percentile trunk flexion/extension angles were: 37.0° for workers sorting containers and polyethylene terephthalate, 29.4° for workers at pre-sorting workstations, and 20.0° for workers sorting old corrugated cardboard. The workers spent 38% of their working hours flexed more than 20°.

Conclusion: Posture exposure among recycling workers exceeds levels previously shown to be related to elevated risk of LBD. Though the risk increase is small, awkward working posture may predispose recycling workers to developing low back pain. Future studies should focus on

investigating the association between ergonomic and postural risk factors and LBD among a larger sample of recycling workers in order to quantify the relationship between posture and LBD. This will guide the tailored development and implementation of engineered preventive intervention and strategies at the various workstations, especially the pre-sorting station.

3.2 Introduction

Population growth and economic development is leading to an increased generation of solid waste [1-5], and this waste needs to be managed to prevent environmental hazards [1]. The recycling sector is regarded as sustainable within the waste management hierarchy [3], and recovery of inorganic materials from solid waste has been identified as a key component in the management of waste [1]. The term ‘recycling worker’ describes workers in a recycling center who collect, sort, clean, and bag waste materials as a means of livelihood and contribute greatly to the recycling sector [4]. Recycling can be done formally or informally. Formal work has been described by Kay [5] 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” [5]. 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”[6]. Globally, collection and sorting of waste is considered a high-risk occupation [6].

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 back symptoms up to 74% [10], with lifetime prevalence as high as 90% [11]. Recycling workers have been found to have at least twice the risk of low back disorders as other workers in both Denmark [8] and Taiwan [12].

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 [9]. 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 by Asante et al. (2016) identified several exposures, which authors suggest might be related to the development of LBD among waste workers. Awkward posture [14,24]; repetitive motion [19,20,22]; lifting and manual handling [13,19,23]; high forces [20]; trunk twisting[13]; high physical work load [22]; 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 [14]. Waste workers often squat, twist, and bend [14,15] whilst sorting through waste for long hours. Chapman et al [18] hypothesized that cumulative awkward posture contributes to musculoskeletal symptoms and work absence; which will eventually reduce productivity. 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.

3.3 Methodology

3.3.1 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 4.

3.3.2 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 and the University of Saskatchewan's Research Ethics Board approved the study.

3.3.3 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 [20,21], Numeric Pain Rating Scale (NPRS) [22,23] and the Fear Avoidance Belief questionnaire [22] (full questionnaire shown in Appendix E). 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 sub-scales: 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 [25,26]. 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.

3.3.4 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. Figure 2 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 seconds to account for offset in the mounted sensor position. Measurements were made at a 64Hz-sampling rate during regular working tasks for 3-5 hours (half a working shift) during the working day.



Figure 2: Inertial sensor strapped on the chest to assess trunk posture

3.3.5 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 produced electromagnetic noise sources. Therefore, this study was not able to measure trunk rotation; only lateral flexion and flexion/extension data were available.

The offsets related to mounting position were accounted for by subtracting the average of the upright calibration posture performed at the start and end of the measurement. Angular velocity (degrees per second, °/sec) was recorded in three directions directly from the gyroscopes. To determine flexion/extension and lateral flexion angles (in degrees, °), three-dimensional accelerometer data was analyzed using a customized software program in MATLAB (MATLAB 8.5 Math Works, Massachusetts, USA). The time histories of angles and angular velocities from each half-shift were further processed by generating summary metrics for both lateral flexion and

flexion/extension, including: 10th, 50th, 90th percentiles; median; percent time flexed $<20^{\circ}$; $>60\%$ (for flexion/extension only); and percent time bent less than 20° (for lateral flexion only); velocity metrics of mean, 10th, 50th, and 90th percentiles. A lateral flexion value of 0 degrees indicates an upright posture that is without lateral bending; positive indicates a lean to the right while negative values indicate a lean to the left. Appendix G gives a brief description of the metrics used in this study.

3.3.6 Statistical Analysis

With respect to the questionnaire, descriptive statistics including frequencies, mean, median, and interquartile ranges (where appropriate) were calculated for socio-demographic and work characteristics as well as scores from the musculoskeletal symptoms, pain scale, and fear avoidance belief questionnaires. Although the sample size for this exploratory study precluded formal statistical evaluation, metrics were summarized descriptively and compared across work tasks to allow for hypothesis generation. Analysis of questionnaire and posture metrics was performed in Statistical Package for the Social Sciences (SPSS v 23, IBM Corporation, New York, USA).

3.4 Results

3.4.1 Task Description

Different waste materials were sorted at each sorting station; these are described in table 4. The first stage is the pre-sorting station, where three or more recycling workers monitor incoming waste on the conveyor belt, identify and remove unwanted/dangerous materials, lift plastic film to a vacuum pipe and remove contaminants off the floor. The materials then move via a conveyer belt to the old corrugated cardboard-sorting station, then to the thermoplastic products sorting station. The remaining materials then go through a series of sorting stations for higher-value

materials, including: old newspapers, deposit containers, brown paper and metals which are subsequently sorted. Figure 3 shows recycling workers sorting different materials at various workstations.



Figure 3: Recycling Workers sorting at the Recycling Center. Including a) and b) the pre-sorting station, and c) the old corrugated cardboard-sorting station

Table 4: 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	Sort newspapers	Papers
Browns	Sort cardboard	Cardboard

3.4.2 Participant's Characteristics

The characteristics of the participants from the questionnaire and posture assessment phases of the study are shown in table 5. For both phases of the study, the majority (87% total) of the study participants were male. Most participants were between 40 and 59 years, with BMI < 24 kg/m² ('normal' range) and had worked between 1-5 years at the recycling facility.

Table 5: Participant Characteristics

Characteristic	Questionnaire N (%)	Posture N (%)
N	30	10
Age		
18-29	9 (31%)	2(20%)
30-39	5 (17%)	3 (30%)
40-59	15 (52%)	5 (50%)
>60	0	0
Missing	1	
Sex		
Female	4 (13.3%)	4 (40%)
Male	26 (86.7%)	6 (60%)
Employment duration		
1-5 years	27 (90%)	10 (90%)
> 6 years	3 (10%)	1 (10%)
BMI kg/m2 [25]		
Normal 18- 24	21 (70%)	7 (70%)
Overweight 25-29	9 (30%)	3(30%)
Obese >30	0 (0%)	0 (0%)

3.4.3 Musculoskeletal Symptoms

The self-reported musculoskeletal symptoms of the recycling workers are presented in figure 4. Seventy-nine percent of the recycling workers indicated that they have experienced pain in at least one body part in the last 12 months, while 53% indicated that some type of pain prevented them from regular work activities. Lower back pain showed the highest prevalence, with 73% among recycling workers, followed by shoulder pain at 70%. A total of 67% respondents reported upper back pain, 60% reported neck pain, and 43% reported hip/thigh pain. The body regions which recycling workers reported most frequently interrupting their work during the last 12 months was the lower back (46.7%) and upper back (43.3%).

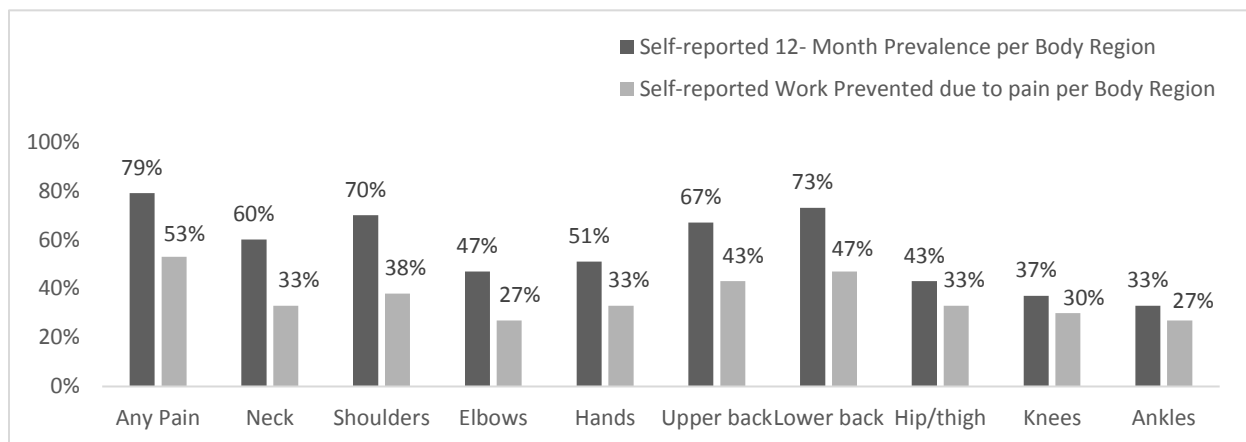


Figure 4: Self-reported 12- Month Prevalence per Body Region and Self-Reported Work Prevented due to pain per Body Region

In addition to the Standardized Nordic Questionnaire, back symptoms were assessed with the Numeric Pain Rating Scale (NPRS) and the Fear Avoidance Belief Questionnaire (FAB-P and FAB-W). The median score of the NPRS was 4.0 (S.E = 0.56); the FAB-P was 8.0 (S.E = 1.20) whilst the FAB-W was 15.0 (S.E = 1.92). The NPRS score ranged from 0 to 10; the FAB-P was 0 to 20 whilst the FAB-W ranged from 0 to 31.

3.4.4 Trunk Postures

Table 6 shows the patterns of trunk position and velocity by workstation. Although the sample size precluded inferential tests, there were qualitative differences observed between workstations. The median trunk flexion/extension angle for workers sorting containers and polyethylene terephthalate was highest at 18.0°, followed by pre-sorting at 14.3°, and workers sorting old corrugated cardboard/browns/old newspaper at 7.7°. The median trunk lateral flexion angles were typically close to zero, with -2.0° for workers at the container line/ polyethylene terephthalate, 4.0° for workers at pre-sorting, and 0.9° for workers sorting old corrugated cardboard/browns/old newspaper. With respect to 90th percentile (peak) trunk flexion values, the medians for old corrugated cardboard/browns/old newspaper sorting (20.0°) were lower than both container / polyethylene terephthalate workstation (37.0°) and pre-sorting workstations (29.4°). This pattern was consistent for 50th percentiles. When all workstations were combined, recycling workers had a median trunk flexion/extension angle of 14.2°.

The velocity metrics for the workstations for both lateral and flexion/extension directions are also shown in table 6. The median flexion/extension velocities were similar across workstations, recorded at 6.0°/s for pre-sorting, 6.0°/s for old corrugated cardboard/browns/old newspaper, and 5.2°/s for container line/ polyethylene terephthalate workstations. The median lateral flexion angular velocity was slightly higher for containers/ polyethylene terephthalate (9.0°/s) than either pre-sorting (5.3°/s) or old corrugated cardboard/browns/old newspaper (7.5°/s). Recycling center workers had a median 90th percentile (peak) angular velocity of 22.0°/s. The median 50th percentile of flexion velocity was 5.2°/s at container line/ polyethylene terephthalate workstation and 6.0°/s at pre-sorting and old corrugated cardboard/browns/old newspaper. Working time of 58% (container line/ polyethylene terephthalate workstation), 62% (pre-sorting workstation) and

72% (old corrugated cardboard/browns/old newspaper workstation) were spent with their trunk flexed $< 20^\circ$.

Table 6: Recycling Worker's Trunk posture patterns during regular work tasks at several material sorting stations. Values shown are medians of posture metrics across shifts

	Direction of Movement	Metric	Pre-sorting	Polyethylene terephthalate/ Container line	Old newspapers/Browns/ Old corrugated cardboard	All workers
N			3	3	4	10
Postural Displacement	Lateral bending	10 th percentile (°)	-9.0	-12.0	-6.7	-9.1
		50 th percentile (°)	4.0	-2.0	0.9	0.7
		90 th percentile (°)	14.0	9.6	9.0	10.1
		Median	4.0	-2.0	0.9	0.7
		Percent time spent bend <20 (°)	97.0	96.0	98.0	97.0
	Flexion/ Extension	10 th percentile (°)	4.2	5.0	1.3	3.6
		50 th percentile (°)	14.3	18.0	7.7	14.2
		90 th percentile (°)	29.4	37.0	20.0	28.2
		Median	14.3	18.0	7.7	14.2
		Percent time spent flexed <20 (%)	62.3	58.0	72.1	61.6
		Percent time spent flexed >60 (%)	0.5	1.9	1.1	1.1
Angular speed	Lateral bending	10 th percentile, °/s	0.8	1.3	0.8	0.9
		50 th percentile, °/s	5.3	9.0	7.5	6.7
		90 th percentile, °/s	26.0	27.0	23.3	26.0
		Median	5.3	9.0	7.5	6.7
	Flexion/ Extension	10 th percentile, °/s	0.8	0.9	0.8	0.8
		50 th percentile, °/s	6.0	5.2	6.0	6.0
		90 th percentile, °/s	23.0	22.0	21.2	22.0
		Median	6.0	5.2	6.0	6.0

3.5 Discussion

3.5.1 Questionnaire Findings

The aims of this part of the study were to: (1) investigate the work tasks of recycling workers in a recycling sector; (2) estimate prevalence of musculoskeletal disorders; and (3) conduct an ergonomics assessment focusing on trunk posture. In the present study the sample was predominantly male, a similar finding to what other studies have reported. Studies among waste workers conducted in both Nigeria [10] and Palestine [2] reported 100% of their samples to be male. Published self-reported 12-month rates of low back pain are higher among waste recycling workers (49%) than the general population (35%) [7,17] ; the present study showed even higher rates of 12-month prevalence of low back pain at 73%. Similar to the present study, the most frequently affected body regions among waste recycling workers in other studies are lower back, shoulder, upper back and neck [11,17], with 12-month prevalence rates of low back pain being 79% among waste workers in Ghana [15] and 45% among waste workers in Iran [7]. The variation in reported prevalence rates of low back pain may be due to different methods used in assessing LBD (i.e. definitions of ‘back pain’, language used in interpreting LBD), the cultural perceptions of pain among participants, as well as different working conditions leading to genuinely different rates.

Along with the high prevalence of low back disorders in the present study, the median NPRS was relatively high (i.e. 4.0) and the FAB score (8.0) was relatively low, particularly when compared to studies investigating clinical populations. For example, George et al have reported a mean FAB-Physical activity score of 13.1 (sd=6.1) and 3.8 (sd=2.4) pain intensity) [24]. Another study by George et al have reported clinically-relevant cut-offs for FAB-Physical activity as > 14 and FAB-W as > 29 [23]. There was lower measured fear avoidance beliefs

among this sample of recycling workers compared to a clinical study population of people seeking health care [23]. The ‘healthy worker effect’ may be a possible explanation for this difference; in this phenomenon workers may be healthier because the severely ill and chronically disabled are ordinarily excluded from employment [27]. Since work engagement requires some degree of health and participation, it is therefore expected that those engaging in work are less likely to display fear-avoidance beliefs than those actively seeking healthcare.

3.5.2 Posture Findings: Angles

One of the primary purposes of this study was to assess posture among recycling workers. Many authors have suggested that awkward trunk posture is a risk factor for the development of LBD [11,29–35]. The current study found median trunk flexion/extension angle higher among workers at container line/ polyethylene terephthalate and pre-sorting than workers at old corrugated cardboard/browns/old newspaper. For instance, the workers at the pre-sorting workstation sort high volume of waste compare to other workstation, this could have resulted in the difference of medium trunk flexion recorded in this study. A study by Patarol et al [35] illustrated that, the “constant trunk flexion and rotation movements in the manipulation” of waste volumes.

In terms of lateral flexion (i.e. side bending), the median trunk angles for the container line/ polyethylene terephthalate (-2.0°) and at pre-sorting (4.0°) were more extreme than for workers at old corrugated cardboard/browns/old newspaper (0.9°). This difference may be due to the setup of workstations, since the pre-sorting workstation set-up required workers on average to lean more to the right, and the container line/ polyethylene terephthalate station required workers to lean more to the left. This may be related to the direction of the conveyor and the workstation requirement to be consistently on one side of the conveyor during the measurement.

Among baggage handlers, a job which also has considerable manual handling demands, the reported median trunk flexion angle was 10.2° and lateral flexion was 0.6° [36]. Recycling workers and airport baggage handlers have similar work duties, as they sort and manually handle loads along conveyor belts. The lateral flexion of the recycling workers and the baggage handlers were relatively the same (0.7°) but the recycling workers had higher median trunk flexion than the baggage handlers. This may be due to the differences in the height and speed of the conveyors. Surprisingly, the trunk flexion-extension angles in the present study were similar to that reported for more static dental work. A Swedish study of dental tasks showed a median lower back flexion during patient treatment was 20.0° , and during X-ray handling was 16.1° [37]. Recycling workers had a comparable median 50th percentile flexion/extension angle of 14.2° . This finding was similar to other industrial workers' studies that have been conducted. For instance, sewing machine assemble workers had a median 50th percentile flexion/extension angle of 14° [38], material pickers in car assembly workers 14° [39], and craft-type car disassembly workers 10.1° [28]. The 90th percentile is frequently used as an estimate of peak exposures encountered during a task or work shift [28], [40]. The peak flexion angle for all workers combined was 28.2° , meaning that 10% of the time workers are bent more than 28.2° . Trunk flexion was more pronounced at the 90th percentile level at the container line/polyethylene terephthalate workstation and pre-sorting workstations. This pattern of higher exposures at these workstations was consistent for 50th percentiles as well. These workstations have a wider conveyor width, requiring workers to be in more extreme postures to sort materials.

3.5.3 Posture Findings: Velocities

All of the measured tasks showed very similar movement velocities: median of $6.0^{\circ}/s$ for the pre-sorting station; $6.0^{\circ}/s$ for old corrugated cardboard/browns/old newspaper; and $5.2^{\circ}/s$ container

line/ polyethylene terephthalate workstations. These angular velocities are low compared to a study conducted among mixed occupations in the transportation (13.0°/s) and wood product industries (22.5°/s) [40]. This may be due to different tasks being carried out in these industries. For instance, in the wood industry workers feed and stack materials at different levels, while in the recycling center workers sort materials from the same level.

The present study showed that recycling center workers had a median forward flexion velocity of 6.7°/s; workers at container line/ polyethylene terephthalate workstation had a median flexion/extension angle of 9.0°/s and pre-sorting 5.3°/s and old corrugated cardboard/browns/old newspaper of 7.5°/s. This pattern was largely within the range of velocities seen among Swedish dental workers, where the median velocities were: 2.7°/s for patient treatment, 5.6°/s for dental information, 3.2°/s for administration, 6.8°/s for material handling, 6.3°/s disturbances and 4.8°/s for X-ray handling [37]. Recycling center worker forward flexion velocities were substantially lower compared to studies among material pickers in car assembly (12°/s) [39] and craft-type car disassembly workers (15.1°/s) [28]. Similar differences were observed for velocity percentiles, with values typically being higher than recycling workers' 90th percentile of 22.0°/s among material pickers in car assembly (41°/s) [39] and craft-type car disassembly workers (69.4°/s) [28]. Lower angular velocities among recycling workers may occur, as precision demands in recycling workers appear to be as high as dentistry.

3.5.4 Posture Findings: Considering Risk of Low Back Pain

Several previous studies have indicated posture exposure levels which may be related to increased risk of back symptoms. Fathallah et al [41] investigated industrial workers performing various jobs and assessed posture using a three-dimensional electrogoniometer. They found that

spending more than 86% of time forward flexed less than 15° resulted in low risk of LBP, spending more than 76% of time forward flexed between 15° to 30° was related to a doubling of risk (OR 2.0, 95% CI 1.0 to 3.9) [42] and spending more than 67% of time forward flexed > 30° was related to a tripling of risk (OR 2.95, 95% CI 1.5 to 5.7) [42]. Recycling workers spent 62% of their working hours flexed <20°. This was below the threshold of 86% time spent in ‘neutral’ position (<15°) as indicated by Fathallah et al., indicating an elevated risk of low back disorders [41].

Punnett et al.[33] and Keyserling [43] also investigated the relationship between posture and back disorder, assessing posture by interview and questionnaire administration and defining trunk posture as ‘neutral’ when it was < 20°, ‘mild’ forward flexion as 21° to 45°, and ‘severe’ forward flexion as >45°. Punnett et al and Keyserling classified postural exposures as ‘high’ when trunk flexion was >20° during 33% of a working hour, an exposure level which led to an increased risk of LBD (OR 5.7, 95 %o CI 1.6 to 20.4). In the present study, recycling workers spent 38% of their working hours flexed >20°, which corresponds to both ‘extreme’ postures while carrying out their duties and increased risk of low back pain, according to both Punnett [33] and Keyserling [43].

A cohort study among 34 industries in the Netherlands by Hoogendoorn et al showed an increased risk of low back pain among workers who worked with the trunk in a minimum of 60° for more than 5% of their working time (RR 1.5, 95% CI 1.0 to 2.1) [44]. Recycling workers in the present study spent only 1.1% of their work time in trunk flexion > 60°, so are classified to have ‘low exposure to trunk inclination’ with reference to Hoogendoorn’s limit. In summary, three main criteria were used in assessing postural exposure levels of recycling workers. Thus, ‘neutral’ when it was < 20°, ‘mild’ forward flexion as 21° to 45°, and ‘severe’ forward flexion as

>45°. The present study followed the classifications of exposure levels suggested by Punnett et al. [33], as there was relatively similar methodological approach to that of Punnett's in terms of similar metrics.

3.6 Methodological Considerations

The present study used questionnaires and an I2M inertial posture sensor in to collect movement data among recycling center workers. The questionnaire portion of the present study used an adapted questionnaire from the Standard Nordic Questionnaire to facilitate comparability, efficiency, validity, and reliability of data collected. Questionnaires were self-administered; thus, this form of data collection was simple and inexpensive. The use of self-administered questionnaires also made it possible to record an occupational strain experienced in the past [45].

The sensors used in the measurement were light and we presume workers were able to do their duties without any distractions from the sensors since there were no complaints from workers during measurement. However, the recycling workplace did not support magnetometer data collection due to ferrous sources and running machinery such as the running conveyor belts. As a result, the present study did not measure trunk rotation, though it is an important risk factor. Hoogendoorn et al's findings indicated that workers who worked with the trunk in <30 °of rotation for more than 10% of the working time had a higher risk of back pain (RR 1.3, 95% CI 0.9-1.9) [44].

The use of direct measurement tools are generally considered superior to questionnaires or observation methods for exposure assessment in field studies, since direct methods provide an objective estimate of time spent in work postures [35,[46] and eliminate recall and response bias concerns. The present study used a sample size of only 10 participants, thus may not be a true representative sample of the full range of recycling workers. Again, generalization of study

findings should be undertaken with caution and consideration of the sample and the work context.

3.7 Strengths and Limitations

To our knowledge, this study is the first of its kind to conduct an ergonomics assessment among recycling workers. The study findings give detailed quantification of working postures, in a variety of recycling tasks. This study also provides a description of the various tasks carried out by recycling workers and their postural positions. The findings of this study could serve as a foundation for future studies by providing data on two principal trunk movement directions (forward flexion and lateral flexion) during recycling workers' work. The present study also provides descriptive data on the patterns of postural angles and movements in terms of level, duration, and frequency. This information can assist future research in the development of hypotheses and the choice of methodological approach.

There are also some limitations to consider. The study sample was not randomly selected, but based on convenience recruitment of workers who worked on the days of data collection and were willing to partake in the study. Caution should be taken before generalizing to recycling workers in other settings as a result of the small sample size and non-randomised selection of study sample. However, the study sample was appropriate for a pilot study since the size was guided by the recommendation that a "sample size 10 to 30 is sufficient for cases exploratory research and pilot studies" [47]. The study also used descriptive statistical methods in its analysis; therefore, inferential comparisons between tasks were not possible and any trends observed should be confirmed in future studies. The cross-sectional study design and small sample also meant that trunk posture could not be confirmed to be associated with

musculoskeletal symptoms and LBD in particular. Additionally, assessing postural exposures for the arm, neck and wrist would also be relevant when considering manual handling forces.

3.8 Conclusion

The present study showed a high prevalence of LBD and extreme exposures among recycling workers. These findings were similar to previous studies in other work settings. Linking the findings of this study to epidemiological research, these recycling workers may be at higher risk as a result of awkward trunk posture. There is therefore a need for further studies involving comprehensive ergonomic assessment of trunk posture in a larger group in order to develop effective preventive measures to reduce postural exposures in the recycling industry.

3.9 References

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CHAPTER 4: General Discussion and Study Implications

This thesis describes the occurrence of low back disorders (LBD) among waste workers using a systematic review approach to synthesize data on the prevalence and risk factors of LBD among waste collection workers (Chapter 2, manuscript 1). Further, the thesis used a questionnaire adapted from standard tools to explore the work tasks and estimate prevalence of LBD in recycling workers in a recycling sector; it also used a data-logging posture sensor to measure trunk posture (Chapter 3, manuscript 2). The main findings and implications of these studies are discussed in this chapter.

4.1 Waste Collection: Environmental Services Management

Human beings generate considerable waste in their day-to-day activities [1,2]. The high rate of population growth and rapid growth in economic development has led to an increase in waste generation [2]. The income level of a society and the extent of industrialization influence the composition of waste generated [3]. Most high income countries collect nearly 100% of waste generated, contrasted with low-income countries where only 30 – 60% of generated waste is collected [4]. Management of solid waste reduces or eliminates toxic substances, supports economic development and improves quality of life [4]. Waste products that are not adequately managed may create environmental hazards and eventually become a public health concern [4]. Solid waste workers manually collect waste and their job is said to be one of the highest-risk occupations in the western world [5,6]. However, there was little information about the prevalence and risk factors of health disorders, particularly musculoskeletal disorders, in the waste industry. Managing waste, from collection, sorting, recycling and finally disposing, can pose risks to the environment and to public health, especially to those directly involved at each stage of the processing line [4] from pick-up point, transportation to the transfer stage and finally

to the landfill sites [2]. The systematic review in this thesis (Chapter 2) included both formal and informal work sectors, while the ergonomics assessment (Chapter 3) focused only on the formal sector, providing a range of perspectives on waste collection work.

4.2 Systematic Review

4.2.1 Summary of Key Findings

Manuscript one presented a systematic review of articles on prevalence and risk factors of LBD in waste workers. Waste management, a manually demanding task, most often involves workers in awkward positions pulling, pushing, and lifting heavy payloads. Mehrdad et al., 2008 showed that musculoskeletal symptoms are a significant health concern among waste workers but few epidemiological studies have explored musculoskeletal disorders in waste workers [7]. Norman et al., noted that work involving physical exposures such as awkward posture for long hours, pulling, pushing, lifting, carrying, and sorting are highly prevalent in the waste sector [8]. These physical work exposures have been found to contribute to the development of LBD [8]. Two broad concepts (“waste workers” and “low back disorder”) were used in the search. The reported 12-month prevalence of LBD from the 13 included articles ranged from 16% to 74%. These differences may be due to the case definition of LBD and how the case definition was estimated either in relation to recall period or location of pain body region [9]. In terms of risk factors, none of the included articles explicitly investigated associations between low back disorder and suggested risk factors such as lifting, pulling/pushing, awkward posture, and duration of work. In fact, occupational exposure risks were not assessed in any of the articles found during this review. Hence, there is a need for further studies to assess the occupational risk factors for LBD.

4.2.2 Prevalence of LBD in comparison to other industries

Relating the findings of the systematic review to other working groups, the prevalence rates identified by the systematic review were similar to other studies conducted in other high-risk occupational groups such as the healthcare and textile industries. The prevalence of LBD reported among these industries; textile [10], health workers [11] and office workers [12] were 35% to 55%. In a study conducted by Ghaffari et al [13] among Iranian industrial workers, a 12-month prevalence of 21% [13] was reported. Though the present systematic review did not compare prevalence of LBD between males and female waste workers, a cross-sectional study conducted among textile workers by Paudyal et al [10] showed a 1-month period prevalence of LBP at 35% (n = 324), being higher in females than males (45% versus 28%; $P < 0.001$).

In the western world assessments of self-reported 12-month LBD have been close to 60% [11], this was similar to the results of the present review which showed a 12-month prevalence among waste workers between 16-74%. These findings demonstrate that the prevalence of LBD is high not only in waste workers, but also the general working population (especially industrial workers) globally. Hence the need to identify and address risk factors related to this common health disorder.

4.2.3 Occupational Risk Factors of LBD

This current systematic review did not find any studies that investigated the association between risk factors and LBD. In other industries, high volume of workload, time pressure, lack of control, seniority and social support have been shown to be contributing factors to the development of back disorder [2,7,8,14 -16]. The risk factors that were suggested to occur in waste workers (i.e. twisting, manual handling, lifting, frequent repetition, force, duration, short cycle, time and awkward posture during work tasks) are similar to risk factors for LBD reported

among other occupational groups. For example, Dajah et al [11] indicated that an “association exists between work stress, manual lifting and LBD prevalence” among nurses. Ghaffari et al [13] stated that age, sex, physical activities, and psychosocial factors influenced the prevalence of LBD among industrial workers. Spyropoulos et al. [17] found low back disorder to be significantly associated with “age, gender, body mass index, adjustable back support, position while sitting, job satisfaction, and anger duration among office workers” [17]. Even though the specific work tasks of waste workers and other groups of workers might be different, they might be facing similar risk factors such as twisting, manual handling, lifting, frequent repetition, and awkward posture when carrying out their duties. The risk factors identified by studies in other industries consistently reported a significant association with LBD. However, the present systematic review did not identify any studies quantifying exposure to risk factors, though awkward posture was suggested by majority of the included articles. To address this gap, manuscript 2 (section 4.3) of this thesis aimed to measure trunk posture among recycling workers.

4.2.4 Strengths and Limitations of the Review

The use of a systematic review as part of this study helped to summarize what is known, as well as demonstrate gaps in knowledge regarding LBD in waste workers. A search strategy was developed in conjunction with a research librarian, and conducted systematically in three main electronic published databases starting from the date of inception. This current literature review limited itself to 3 databases, which may have resulted in database or source-selection bias [18], even if the 3 databases used may be the most likely to include literature with reference to the study group and research questions. It has been recommended that, “a search of a variety of electronic databases relevant to the topic of interest is highly appropriate” [19]. The current

review also had a limitation of excluding non-English articles. This could have resulted in scope bias and might have encouraged database or source-selection biases [18]. A notable strength is that the quality appraisal for included studies were performed with the use of a reliable tool developed to appraise prevalence studies investigating LBD [20]. The criteria used in the quality assessment tool were clear and specific, as recommended by Jackson [21].

4.3 Ergonomics Assessment

4.3.1 Summary of Key Findings

Manuscript 1 recommended further studies to be conducted on occupational risk factors for LBD. Occupational postural exposures are a known risk factor for LBD in other industries [22]; therefore, Manuscript 2 conducted an onsite ergonomics assessment using data-logging posture sensors to assess trunk posture. This part of the study descriptively assessed a single risk factor, awkward posture, out of the many suggested in the systematic review. Manuscript 2 explored the work tasks and estimated prevalence of LBD in recycling workers in the Canadian formal recycling sector through the use of questionnaire, then assessed trunk posture through the use of an I2M posture sensor. Data from these two methods were descriptively presented. The key findings from the questionnaire (N= 20) showed a high rate (73%) of 12-month prevalence of low back pain; 46.7% of recycling workers indicated that their lower back has prevented them from performing their normal work as a result of pain. Lower back had the highest prevalence compared to other body parts of the human body. This finding was similar to other studies conducted among waste workers [23,24]. For instance, 12-month prevalence was reported among rag pickers as 49% [14], and 67% among waste collection workers [25]. However, another study of Abou-Elwafa et al. showed a low 12-month prevalence of 17% [15].

The wide range of prevalence between seemingly similar occupational groups is surprising. The cultural perceptions of pain among working groups and their working conditions may have led to these different rates. Although the median self-reported pain intensity (determined via the Numeric Pain Rating Scale) among the sample in manuscript 2 was similar to clinical populations [26], the reported Fear Avoidance Belief scores related to both work and physical activity were considerably lower than those previously reported as clinically important [27]. This suggests differences between the current study population and those who may seek health care for LBD, perhaps indicating presence of a healthy worker effect [28].

The ergonomics assessment of manuscript 2 focused on evaluation of posture among 10 worker participants working at 3 different stations. Findings from the use of a chest-mounted posture sensor to assess trunk posture indicated that median trunk flexion/extension angle was higher for workers at the container line/polyethylene terephthalate (18.0°) and pre-sorting (14.3°), compared to 7.7° for workers at old corrugated cardboard/browns/old newspaper. The volume of waste at the pre-sorting workstation (which includes all of the waste on the line since nothing has been removed or sorted at this stage) requires workers to repeatedly flex for longer hours while sorting. Also, this could account for the increase in the median trunk flexion over the paper and cardboard lines. The median trunk flexion/extension angle was 14.2° among all recycling workers when all workstations were combined; this was similar to other studies among other industrial workers. For example, sewing machine assembly workers had a median 50th percentile flexion/extension angle of 14° [29], and material pickers in car assembly workers 14° [30]. There was a similar pattern of Median forward flexion velocity among recycling workers and a study of Swedish dental workers. The recycling workers showed lower movement velocities ($5.2^{\circ}/s$ at container line/ polyethylene terephthalate workstation and $6.0^{\circ}/s$ at pre-

sorting and old corrugated cardboard/browns/old newspaper) compared to a study conducted among mixed occupations in the transportation (13.0°/s) and wood product industries (22.5°/s) [31]. In the wood industry, workers feed and stack materials, while in the recycling center workers sort materials from the same level; the difference in task demands likely influenced the movement speeds observed. The extent to which the lumbar spine is flexed when lifting and lowering is important, as it contributes to the bending moments and anterior shear forces acting on the passive tissues of the spine [32]. These movements are seen among recycling workers as they bend and lift while sorting [32]. The present analysis of trunk posture among recycling workers compares extreme trunk flexion angles across recycling work tasks and to workers in other industries. These work tasks, which require the extreme flexion angles exhibited by recycling workers while they sort, have been identified to have a significant association with degeneration of lumbar discs [33], which in turn can contribute to development of low back pain. In the long run, these working exposures may lead to disability and interfere with quality of life. Though the mechanisms underlying the link between trunk posture and LBD are not fully understood, it is important to assess exposure to LBD risk factors such as awkward trunk posture.

There is no standard or maximum threshold of postural exposure levels in relation to risk of low back pain. However, a comparison of the directly-measured postural exposures in this study to epidemiological studies that have established association with trunk posture and LBD [34,35,36] can be made. Recycling workers in the current study spent only 62% of their working hours flexed <20°, indicating a ‘high risk’ for low back disorders according to a criterion of at least 87% of time laid out by Fathallah [34]. Similarly, the recycling workers spent 38% of their working hours flexed >20°, which corresponds a high risk based on a criterion of no more than

33% set out by a study conducted to investigate the relationship between posture and back disorder [35,36]. Recycling workers are at high risk of developing LBD; this health disorder may cause limitation in recycling worker's activity and increase absenteeism. Economically, LBD among recycling workers may burden the individual and society as a whole if measures are not put in place to prevent extreme postures.

4.3.2 Methodological Considerations

The thesis used two main methods in addressing the objectives of this study. A questionnaire was used for the first aim of the manuscript 2, while the second aim of the manuscript 2 used I2M posture sensor in collection data of movements in recycling workers. Questionnaires were self-administered, and this was inexpensive and time-efficient. However, this method might be less valid due to difficulties with recall [37]. The sensors used in the trunk posture measurement were light and did not reportedly interfere with work tasks. The posture sensors were not able to measure trunk rotation posture due to the electromagnetic noise sources produced from ferrous sources and running machinery such as the conveyor belts and driving engines.

The present study did not use observation methods. Jonker et al.[38] suggested that the use of standardized video observation may enhanced validity and reliability of assessments [38,39].

Also, the use of video observational methods provides enough detail to qualitatively and quantitatively analyse work environment and human interaction [40]. Video observational methods could have helped in capturing complex activities in their natural setting [40].

However, issues of privacy are raised in using video observational methods [40], both in terms of individual privacy and proprietary industrial processes. The direct measurement used specified estimated time spent in work postures [41,42] and eliminated recall bias. The summarized metrics chosen were based on reports from previous studies. Such is the study of Kazmierczak et

al.[43], where posture levels were expressed in 10th, 50th, 90th and 99th percentiles of the cumulative posture distribution. Summary metrics were used to describe the range of postural positions at various waste workers' workstations. Overall, the methods used were able to address research questions though there were limitations.

4.3.3 Beyond Trunk Posture: Additional Risk factors for LBD

Manuscript one summarized risk factors suggested in prior studies of LBD, including: twisting, manual handling, lifting, frequent repetition, force, duration, short cycle and awkward posture. Manuscript two descriptively compared trunk flexion angle of time spent by recycling workers to level of risk of LBD. However, neither of these studies investigated the relationship between trunk posture and LBD. The task of recycling workers requires frequent lifting, shovelling of waste, and bagging of waste materials resulting in repetitive movements of the wrist, arms, neck, and upper back. Further research investigating physical risk factors such as twisting, manual handling, lifting and duration, as well as psychosocial and individual factors would help to provide a more comprehensive understanding of risk factors for LBD in this potentially high-risk occupational group.

4.3.4 Beyond the Formal sector in Canada: Considerations for the Global Waste Workforce

Globally, solid waste management is mostly managed manually, even though most developed countries have over the years incorporated advanced technology to reduce human contact with toxic materials to reduce contact with toxic materials. Despite the environmental and health goals within the sector, the core workforce continues to be exposed to physical, mechanical, biochemical hazards [7]. Findings from the Canadian recycling sector shows that the activities of recycling workers in Canada (a developed country) are no different from what is reported globally. Hence, exposure levels among Canadian recycling workers are expected to be similar

to global data when similar work tasks are performed. However, developing countries such as Iran, Ghana, and Brazil generally manage waste manually with little mechanical influence, thus conventional practise is dominated by manual work done by informal workers [7,8,14]. Waste workers in these countries routinely bend, scavenge, pull, push, sort and sweep for longer hours, and their employment and healthcare context can be considered vulnerable [8,14]. In most settings, activities of the both informal and formal workers require physical activities such as pulling, pushing, and lifting [7] and these physical exposures have been known to contribute to high risk LBD [7]. Nevertheless, it has been reported that the association between these physical exposures and LBD is unknown among waste workers. Even though manuscript 2 did not investigate relationships between awkward posture (a known risk factor) and LBD, it compared posture measures to published guidelines of risks of LBD to estimate the nature of risk to recycling workers. Though some of the postures showed lower risk, some posture categories do indicate recycling workers are at elevated risk of LBD. Again, findings from the two manuscripts showed the magnitude LBD as a health disorder among waste workers and is consistent with what has been published globally [7,8,14,15].

4.4 Public Health and Policy Implications

This research determined the prevalence of LBD among waste collection workers through a systematic review, confirming a relatively high prevalence rate of LBD compared to studies conducted among other occupations. Furthermore, this research determined that formal recycling workers are exposed to trunk postures that may elevate their risk of LBD. Recycling workers spent 38% of their working hours with their trunk flexed at ‘extreme’ postures. According to a Canadian report [44], the waste management industry employs 3% of Saskatchewan’s provincial workforce. Despite the relatively small proportion, waste management workers directly

contribute to maintaining healthy environmental standards and living space for the entire populace, a requirement for economic progress. In light of this, the current study's findings of a self-reported LBD prevalence rate of 73% among the waste collection workers suggest a lack of sustainability in the workforce whose efforts ensure the environment is truly healthy. Out of the study sample, 47% of the recycling workers reveal that pain at the lower back prevented them from working effectively. These findings require that further studies should be conducted to help understand the risk factors for LBD in this workforce and develop appropriate prevention strategies.

In as much as technological advancements seek to eliminate human labor and increase work/economic output, little can be said of their operation without human involvement and monitoring, especially in waste management. It is obvious that waste collection workers play a very significant role in this much-needed process of health and environmental safety, and thus more effort should be invested to protect their health. Imagine a world without waste workers: the result is poor health and a negative impact on our society; poor sanitary conditions, low-health workforce, and poor economic yields will be our price. Given the relatively high prevalence and impacts of LBD in this occupational group, waste management and recycling companies, as well as the government agencies charged with ensuring the health of workers, should develop policies and interventions to mitigate potentially high-risk exposures among waste workers.

4.5 Directions for Future Studies

Chapter 2 and 3 of this thesis report the current state of the prevalence of LBD and trunk posture assessment among waste workers. These findings can serve as a guide for future research.

Although Chapter 2 of this study sought to review risk factors of LBD, none of the included

articles statistically relates these risk factors to LBD. Studying waste workers' exposure LBD risk factors would be a natural way to fill this gap. Chapter 3 focused primarily on direct measurement of postural exposure among recycling workers. Relatively little research has focused on this potentially vulnerable workforce. Future studies should use prospective cohort study designs to investigate the association between potential risk factors and LBD Future research investigating ergonomic risk factors should also employ a larger sample size to ensure adequate power. Research involving the development and evaluation of exposure-reducing interventions are required to improve the work environment of waste workers. This will guide evidence-based implementation of engineered preventive strategies at the workplace.

4.6 Conclusion

This thesis synthesized evidence on the prevalence and risk factors of LBD and assessed trunk posture exposure and musculoskeletal symptoms among recycling workers. Although the trunk posture assessment used a small sample size, it added a unique contribution to the knowledge of occupational health in this under-studied population. Chapter 3 used comparisons to prior epidemiological studies to predict the risk of LBD among waste workers. The findings of this study indicate the need for further work on comprehensive ergonomic assessments of risk factors mentioned in manuscript 2 in a large group of recycling industry workers to be able to recommend cost-effective preventive measures to reduce the exposures in the recycling plant. This systematic review and the working posture assessment provide researchers and policy makers within the waste industry a baseline to plan future research and develop effective interventions. Evidence from the systematic review shows the magnitude of low back disorder as a health ailment among waste collection workers. There is a need for health policies and development of cost-effective interventions in the waste management industry as a whole. When

such policies are introduced and implemented in the waste management and recycling companies, the health and economic burden to individuals and the society will be decreased.

4.7 References

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Appendix A: Ethics Approval



**UNIVERSITY OF
SASKATCHEWAN**

Behavioural Research Ethics Board

Certificate of Approval

PRINCIPAL INVESTIGATOR
Catherine Trask

DEPARTMENT
Canadian Centre for Health and Safety in Agriculture 15-316

BBH#

INSTITUTION(S) WHERE RESEARCH WILL BE CONDUCTED
Saskatoon
Saskatchewan, Canada

SUB-INVESTIGATOR(S)
Brenna Baril

STUDENT RESEARCHER(S)
Benedicta Asante

FUNDER(S)
UNIVERSITY OF SASKATCHEWAN COLLEGE OF
MEDICINE

TITLE
Ergonomics exposure assessment of Posture in Waste Collection Workers: A Descriptive Study

ORIGINAL REVIEW DATE 21-Oct-2015	APPROVAL ON 27-Nov-2015	APPROVAL OF: Application for Behavioural Research Ethics Review Recruitment Poster Participant Consent Forms Questionnaires	EXPIRY DATE 26-Nov-2016
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Full Board Meeting ☐

Delegated Review ☒


CERTIFICATION

The University of Saskatchewan Behavioural Research Ethics Board has reviewed the above named research project. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research project, and for ensuring that the authorized research is carried out according to the conditions outlined in the original protocol submitted for ethics review. This Certificate of Approval is valid for the above time period provided there is no change in experimental protocol or consent process or documents.

Any significant changes to your proposed method, or your consent and recruitment procedures should be reported to the Chair for Research Ethics Board consideration in advance of its implementation.

ONGOING REVIEW REQUIREMENTS

In order to receive annual renewal, a status report must be submitted to the RBH Chair for Board consideration within one month prior to the current expiry date each year the study remains open, and upon study completion. Please refer to the following website for further instructions: <http://research.ussask.ca/for-researchers/ethics/index.php>


Vivian Ramsden, Chair
University of Saskatchewan
Behavioural Research Ethics Board

Please send all correspondence to:

Research Ethics Office
University of Saskatchewan
Box 5500 RPO University, 1607-110 Gymnasium Place
Saskatoon S4S 0N6
Telephone: (306) 926-2975 Fax: (306) 926-2029

Appendix B: Database Search Strategy

Search Engine	Years of coverage
Medline	1946- July week 1 2015
Embase	1974- 2015 July 10
Global Health	1973-2015 week 27

MEDLINE

Search History

- 1 Low back pain/
2. (Musculoskeletal adj (symptom* or injur* or disorder* or pain or dysfunction* or problem*)).ab,ti.
3. ((orthopedic or orthopaedic) adj (injur* or problem* or disorder* or dysfunction*)).ab,ti.
4. Musculoskeletal disease.mp. or exp Musculoskeletal Diseases/
5. "Muscle strain".ab,ti.
6. Back/ or lumbosacral region/ or sacrococcygeal region/
7. Spine/ or coccyx/ or intervertebral disc/ or lumbar vertebrae/ or sacrum/ or exp spinal canal/ or thoracic vertebrae/
8. (spine or spinal or coccyx or "intervertebral disc" or lumbar vertebrae or sacrum or "spinal canal" or "thoracic vertebrae").ab,ti.
9. (Back or "lumbosacral region" or "sacrococcygeal region").ab,ti.
10. 2 or 3 or 4 or 5
11. 6 or 7 or 8 or 9
12. 10 and 11
13. Sciatica/
14. sciatica.ab,ti.
15. lumbago.ab,ti.
16. (Hip adj2 pain).ab,ti.
17. (Lumbar adj pain).ti,ab.
18. Dorsalgia.ti,ab.
19. coccydynia.ti,ab.
20. spondylosis.ti,ab.
21. discitis.ti,ab.
22. (Disc adj degeneration).ti,ab.
23. (Disc adj prolapse).ti,ab.
24. (Disc adj herniation).ti,ab.
25. (Facet adj joints).ti,ab.
26. Intervertebral Disc/
27. arachnoiditis.ti,ab.
28. Spinal Fusion/
29. postlaminectomy.ti,ab.
30. (Back adj (injur* or disorder* or pain or dysfunction* or problem* or ache*)).ab,ti.
31. Backache*.ti,ab.
32. Back Pain/
33. (Failed adj back).ti,ab.
34. (low* adj back).ti,ab.
35. Recycling/

36. Landfill.mp. or Waste Disposal Facilities/
37. Solid waste work*.mp.
38. Waste collect*.mp.
39. Municipal solid waste.mp.
40. Domestic waste collect*.mp.
41. Recycling sector.mp.
42. Refuse collect*.mp.
43. Recycling cooperative*.mp.
44. Urban recycl*.mp.
45. Informal job*.mp.
46. Garbage collect*.mp.
47. Waste pick*.mp.
48. Waste recovery.mp.
49. Sewage/ or sewage work*.mp.
50. Sanitation/ or sanitation work*.mp.
51. Solid waste management.mp. or waste management/
52. Municipal solid waste collect*.mp.
53. ((Landfill* or disposal site* or transfer station* or dumpsite* or waste recovery site* or solid waste landfill* or material recovery facilities* or material recovery plant* or resource recovery*) adj2 (work* or pick* or scaveng* or employ* or recycl* or collect* or garbage* or bin* or handle* or sort*)).mp.
54. 1 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34
55. 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53
56. 54 and 55

EMBASE

Search History

1. Low back pain/
2. (Musculoskeletal adj (symptom* or injur* or disorder* or pain or dysfunction* or problem*)).ab,ti.
3. ((orthopedic or orthopaedic) adj (injur* or problem* or disorder* or dysfunction*)).ab,ti.
4. Exp musculoskeletal diseases
5. "Muscle strain".ab,ti.
6. Back/ or lumbosacral region/ or sacrococcygeal region/
7. Spine/
8. Coccygeal bone/
9. Intervertebral disk/
10. Lumbar vertebra/
11. Sacrum/
12. Vertebral canal/
13. Vertebra/
14. (Spine or spinal or coccyx or "intervertebral disc" or lumbar vertebrae or sacrum or "spinal canal" or "thoracic vertebrae").ab,ti.
15. (Back or "lumbosacral region" or "sacrococcygeal region").ab,ti.
16. 2 or 3 or 4 or 5
17. 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15
18. 16 and 17
19. Sciatica/
20. sciatica.ab,ti.
21. lumbago.ab,ti.
22. (hip adj2 pain).ab,ti.
23. (lumbar adj pain).ti,ab.
24. Dorsalgia.ti,ab.
25. coccydynia.ti,ab.
26. spondylosis.ti,ab.
27. discitis.ti,ab.
28. (disc adj degeneration).ti,ab.
29. (disc adj prolapse).ti,ab.
30. (disc adj herniation).ti,ab.
31. (facet adj joints).ti,ab.
32. arachnoiditis.ti,ab.
33. Spine Fusion/
34. postlaminectomy.ti,ab.
35. (Back adj (injur* or disorder* or pain or dysfunction* or problem* or ache*)).ab,ti.
36. Backache*.ti,ab.
37. Backache/
38. (failed adj back).ti,ab.
39. (low* adj back).ti,ab.
40. Recycling/
41. Landfill/
42. Solid waste work*.mp.
43. Waste collect*.mp.
44. Municipal solid waste/

45. Domestic waste collect*.mp.
46. Recycling sector.mp.
47. Refuse collect*.mp.
48. Recycling cooperative*.mp.
49. Urban recycl*.mp.
50. Informal job.mp.
51. Garbage collect*.mp.
52. Waste pick*.mp.
53. Waste recovery.mp.
54. Sewage/ or sewage work*.mp.
55. Sanitation/ or sanitation work*.mp.
56. Solid waste management/
57. Municipal solid waste/ or Municipal solid waste collect*.mp.
58. ((Landfill* or disposal site* or transfer station* or dumpsite* or waste recovery site* or solid waste landfill* or material recovery facilities* or material recovery plant* or resource recovery*) adj2 (work* or pick* or scaveng* or employ* or recycl* or collect* or garbage* or bin* or handle* or sort*)).mp.
59. 1 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39
60. 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58
61. 59 and 60

GLOBAL HEALTH

Search History

1. Low back pain.mp.
2. (Musculoskeletal adj (symptom* or injur* or disorder* or pain or dysfunction* or problem*)).ab,ti.
3. ((orthopedic or orthopaedic) adj (injur* or problem* or disorder* or dysfunction*)).ab,ti.
4. Musculoskeletal Diseases.mp.
5. "Muscle strain".ab,ti.
6. Back/
7. Lumbosacral region.mp.
8. Sacrococcygeal region.mp.
9. exp Spine/
10. Coccyx.mp.
11. Intervertebral discs/
12. Lumbar vertebrae.mp.
13. Sacrum.mp.
14. Spinal canal.mp.
15. Thoracic vertebrae.mp.
16. (Spine or spinal or coccyx or "intervertebral disc" or lumbar vertebrae or sacrum or "spinal canal" or "thoracic vertebrae").ab, ti.
17. (Back or "lumbosacral region" or "sacrococcygeal region").ab, ti.
18. 2 or 3 or 4 or 5
19. 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17
20. 18 and 19
21. Sciatica.mp.
22. Sciatica.ab, ti.
23. lumbago.ab, ti.
24. (Hip adj2 pain).ab, ti.
25. (Lumbar adj pain).ti, ab.
26. Dorsalgia.ti,ab, ab.
27. coccydynia.ti, ab, ab.
28. spondylosis.ti,ab, ab.
29. discitis.ti, ab.
30. (Disc adj degeneration).ti, ab.
31. (Disc adj prolapse).ti, ab.
32. (Disc adj herniation).ti, ab.
33. (Facet adj joints).ti, ab.
34. arachnoiditis.ti, ab.
35. Spinal Fusion.mp.
36. postlaminectomy.ti, ab.
37. (Back adj (injur* or disorder* or pain or dysfunction* or problem* or ache*)).ab, ti.
38. Backache*.ti, ab.
39. Back Pain.mp.
40. (Failed adj back).ti, ab.
41. (Low* adj back).ti, ab.
42. Recycling/
43. Landfills/

44. Solid waste work*.mp.
45. Waste collect*.mp.
46. Municipal solid waste.mp.
47. Domestic waste collect*.mp.
48. Refuse collect*.mp.
49. Recycling cooperative*.mp.
50. Urban recycl*.mp.
51. Informal job*.mp.
52. Recycling sector.mp.
53. Garbage collect*.mp.
54. Waste pick*.mp.
55. Waste recovery.mp.
56. Sewage work*.mp.
57. Sanitation work*.mp.
58. Solid waste management.mp.
59. Municipal solid waste collect*.mp.
60. ((Landfill* or disposal site* or transfer station* or dumpsite* or waste recovery site* or solid waste landfill* or material recovery facilities* or material recovery plant* or resource recovery*) adj2 (work* or pick* or scaveng* or employ* or recycl* or collect* or garbag* or bin* or handle* or sort*)).mp.
61. 1 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41
62. 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60
63. 61 and 62

Appendix C: Screening Tool

Is the article published in English language?

IF no.... Discard

IF yes or unsure... Go onto the next level of screening (abstract or full text)

Is the study population above 18 years of age?

IF no.... Discard

IF yes or unsure... Go onto the next level of screening (abstract or full text)

Is it a peer-reviewed journal or primary research article?

IF no.... Discard

IF yes or unsure... Go onto the next level of screening (abstract or full text)

Does the article capture LBP prevalence or its risk factors?

IF no.... Discard

IF yes or unsure... Go onto the next level of screening (abstract or full text)

Is the article related to Waste Collection Workers?

IF no.... Discard

IF yes or unsure... Go onto the next level of screening (abstract or full text)

Appendix D: Methodological Evaluation

Risk of Bias Questions	Origin	Response	Remarks
Does the target population represent the region's population in relation to variables such as age, occupation”?	Hoy et al (2012)	Yes/No	Modified
Does the sample frame show a true representation of the target population?	Hoy et al (2012)	Yes/No	Modified
Does the study show that the sample was randomly selected?	Hoy et al (2012)	Yes/No	Modified
Does the study show that non-response bias was minimised?	Hoy et al (2012)	Yes/No	Modified
Was data collected from the study sample?	Hoy et al (2012)	Yes/No	Modified
Were data collection tools suitable?	Hoy et al (2012)	Yes/No	Modified
Does the study indicate the same mode of data collection processes from study sample?	Hoy et al (2012)	Yes/No	Modified
Was the data collection or measurement tool suitable and valid?	Hoy et al (2012)	Yes/No	Modified
Does the length of the prevalence period suitable?	Hoy et al (2012)	Yes/No	Modified
Does the study indicate suitable numerator and denominator parameter?	Hoy et al (2012)	Yes/No	Modified

**University of Saskatchewan
Community Health and Epidemiology**

***Note: This appendix contains the full questionnaire as given to the recycling workers. However, not all questions were used in this thesis.*

ID Code :	<div>Filled in by Researcher</div> <div> <div></div> <div></div> <div></div> <div></div> <div></div> </div>
Date :	<div> <div></div> <div></div> <div></div> <div></div> <div>/</div> <div></div> <div></div> <div></div> <div></div> <div>/</div> <div></div> <div></div> <div></div> <div></div> <div></div> </div> <div> <div>D</div> <div>D</div> <div>/</div> <div>M</div> <div>M</div> <div>/</div> <div>Y</div> <div>Y</div> <div>Y</div> <div>Y</div> </div>

1. Sex

- i. Male ☐1
- ii. Female ☐2

i. Single ☐ 1

ii. Married (and not separated) ☐ 2

iii. Divorced ☐ 3

3. Age _____ years

4. What is your height? Feet _____ Inches _____ OR _____ cm

5. What is your weight? Pounds_____ OR _____kg

i. Less than High School ☐ ¹

ii. Completed High School ☐ ²

iii. Completed University ☐ ³

iv. Technical/Community College ☐ ⁴

7. How many years have you been working as a waste collection/ recycling worker?
_____yrs

8. Are you self-employed?

Yes ☐¹

No ☐²

9. On average, how many hours per week do you work as a waste collection/recycling worker?

_____ hours/week.

10. Do you have any other work?

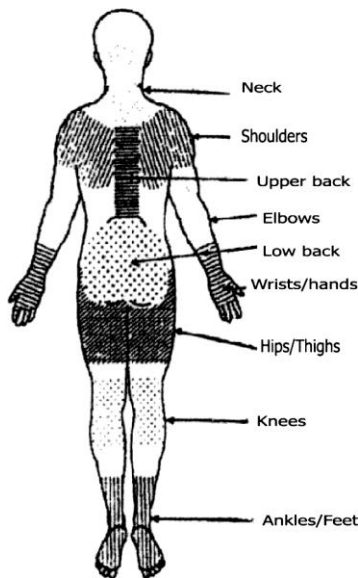
Yes ☐¹

No ☐²

11. If Yes, please specify the job title _____

I. Please specify the number of hours per week (on average) that you work on your other job? _____hours/week

Section 2: LOW BACK PAIN



Have you at any time in the last 12 months had trouble (ache, pain, discomfort) in:		Have you at any time in the last 12 months been prevented from doing your normal work (at home or away from home) because of the trouble?
Neck	Yes ¹ <input type="checkbox"/> No ² <input type="checkbox"/>	Yes ¹ <input type="checkbox"/> No ² <input type="checkbox"/>
One or both shoulders	Yes ¹ <input type="checkbox"/> No ² <input type="checkbox"/>	Yes ¹ <input type="checkbox"/> No ² <input type="checkbox"/>
One or both elbows	Yes ¹ <input type="checkbox"/> No ² <input type="checkbox"/>	Yes ¹ <input type="checkbox"/> No ² <input type="checkbox"/>
One or both Hands	Yes ¹ <input type="checkbox"/> No ² <input type="checkbox"/>	Yes ¹ <input type="checkbox"/> No ² <input type="checkbox"/>
Upper Back	Yes ¹ <input type="checkbox"/> No ² <input type="checkbox"/>	Yes ¹ <input type="checkbox"/> No ² <input type="checkbox"/>
Lower Back	Yes ¹ <input type="checkbox"/> No ² <input type="checkbox"/>	Yes ¹ <input type="checkbox"/> No ² <input type="checkbox"/>
One or both hips/thighs	Yes ¹ <input type="checkbox"/> No ² <input type="checkbox"/>	Yes ¹ <input type="checkbox"/> No ² <input type="checkbox"/>
One or both knees	Yes ¹ <input type="checkbox"/> No ² <input type="checkbox"/>	Yes ¹ <input type="checkbox"/> No ² <input type="checkbox"/>
One or both ankles	Yes ¹ <input type="checkbox"/> No ² <input type="checkbox"/>	Yes ¹ <input type="checkbox"/> No ² <input type="checkbox"/>

12. Have you ever been hospitalized because of low back trouble?

Yes ☐¹

No ☐²

13. Do you feel your back pain is caused by you work?

Yes ☐¹

No ☐²

14. How long has low back pain been a problem for you?

Less than 1 month

☐¹

1-3 months

☐²

3-6 months

☐³

6 months- 1 year

☐⁴

1-5 years

☐⁵

More than 5 years

☐⁶

15. If you have not had back pain in the last 4 weeks, how long has it been since you had a whole month without back pain?

0-3 months

☐¹

More than 3 months

☐²

16. Over the past 24 hours, on a scale of 0-10, with 0=no pain and 10=pain as bad as it could be, how much pain did you feel? Please pick only one number.

No Pain											Pain as bad as it could be
0	1	2	3	4	5	6	7	8	9	10	

17. Over the past 24 hours, on the same scale of 0-10, how much pain did you feel when it was ***at its worst?*** Please pick only one number.

No Pain											Pain as bad as it could be
0	1	2	3	4	5	6	7	8	9	10	

18. Over the past 24 hours, on the same scale of 0-10, how much pain did you feel when it was ***at its least?*** Please pick only one number.

No Pain											Pain as bad as it could be
0	1	2	3	4	5	6	7	8	9	10	

SECTION 3: FEAR AVOIDANCE BELIEF QUESTIONNAIRE

19. For each statement please circle any number from 0 to 6 to say how much physical activity such as bending, lifting, walking or driving affect or would affect your back pain.

	Completely Disagree			Unsure			Completely Agree
My pain was caused by physical activity.	0	1	2	3	4	5	6
Physical activity makes my pain worse.	0	1	2	3	4	5	6
Physical activity might harm my back.	0	1	2	3	4	5	6
I should not do physical activities which (might) make my pain worse.	0	1	2	3	4	5	6
I cannot do physical activities which (might) make my pain worse.	0	1	2	3	4	5	6

20. The following statements are about how your normal work affects or would affect your back pain. Do not answer any statements that are not applicable to you. For each statement please circle any number from 0 to 6 to say how much physical activity such as bending, lifting, walking or driving affect or would affect your back pain.

	Completely Disagree			Unsure			Completely Agree
My pain was caused by my work or by an accident at work.	0	1	2	3	4	5	6
My work aggravated my pain.	0	1	2	3	4	5	6
I have a claim for compensation for my pain.	0	1	2	3	4	5	6
My work is too heavy for me.	0	1	2	3	4	5	6
My work makes or would make my pain worse.	0	1	2	3	4	5	6
My work might harm my back.	0	1	2	3	4	5	6
I should not do my normal work with my present pain.	0	1	2	3	4	5	6
I cannot do my normal work with my present pain.	0	1	2	3	4	5	6
I cannot do my normal work until my pain is treated.	0	1	2	3	4	5	6
I do not think that I will be back to my normal work within 3 months.	0	1	2	3	4	5	6
I do not think that I will ever be able to go back to that work.	0	1	2	3	4	5	6

SECTION 4: WORK QUESTIONS

21. What is your primary work location? _____

22. What is your job title? _____

23. Of all the things you do as a waste collection worker, which do you feel are the hardest tasks for your back?

Task 1: (Worst) _____

Task 2: _____

Task 3: _____

24. How many hours do you in your work have to:

i. Work in uncomfortable posture _____ hours/day

ii. Work in the same posture for long periods of time _____ hours/day

iii. Make frequent repetitive movements _____ hours/day

25. How many hours do you in your work have to:

i. Lift, push or carry heavy loads (more than 5 kg) _____ hours/week

ii. Lift, pull, push or carry heavy loads (more than 20 kg) _____ hours/week

26. Do you collect waste/recyclables from locations outside a facility?

Yes ☐¹

No ☐²

IF NO, Please proceed to Question # 21

27. Where do you collect waste/ recycling material?

- | | |
|-------------------------------|---------------------------------------|
| Households | <input type="checkbox"/> ¹ |
| Industries | <input type="checkbox"/> ² |
| Landfill sites | <input type="checkbox"/> ³ |
| Streets | <input type="checkbox"/> ⁴ |
| Health centers | <input type="checkbox"/> ⁵ |
| Others (Please specify) _____ | <input type="checkbox"/> ⁶ |
| I do not collect waste | <input type="checkbox"/> ⁷ |

28. On average, how long are do you travel from the collection points to the recycling center?

.....	_____ km
.....	_____ mins
.....	_____ hours

29. What type of products do you gather? (check all that apply)

Bottles	<input type="checkbox"/> ¹
Plastics materials	<input type="checkbox"/> ²
Electronic components	<input type="checkbox"/> ³
Ferrous	<input type="checkbox"/> ⁴
Glass materials	<input type="checkbox"/> ⁵
Organic materials	<input type="checkbox"/> ⁶
Paper and Cardboard	<input type="checkbox"/> ⁷
Cans and Metals	<input type="checkbox"/> ⁸
Used oil	<input type="checkbox"/> ⁹
Others (Please list)	
.....	
.....	

30. How do you transport these products? (check all that apply)

By Bus	<input type="checkbox"/> ¹
Personal Truck	<input type="checkbox"/> ²
Walk	<input type="checkbox"/> ³
Bike	<input type="checkbox"/> ⁴
Others (Please list)	
.....	
.....	

Facility Workers:

31. Do you sort waste/recyclables within a facility?

Yes ☐¹

No ☐²

IF NO, Please proceed to Question # 21

32. Please identify your primary responsibility today

Manual sorter	<input type="checkbox"/> ¹
Mechanical sorter	<input type="checkbox"/> ²
Baling material for storage	<input type="checkbox"/> ³
Transporting and loading baled material on trucks	<input type="checkbox"/> ⁴

33. How long have you been in this position?











1-5 years ☐¹

5- 10 years ☐²

> 10 years ☐³

Section 5: POSTURE

1. While working today, how many minutes/hours did you do the following

Stand		<div> <div> <div>_____</div> <div>H</div> </div> <div> <div>_____</div> <div>:</div> </div> <div> <div>_____</div> <div>M</div> </div> <div> <div>_____</div> <div>M</div> </div> </div>
Walk		<div> <div>_____</div> <div>H</div> </div> <div> <div>_____</div> <div>:</div> </div> <div> <div>_____</div> <div>M</div> </div> <div> <div>_____</div> <div>M</div> </div>
Sitting		<div> <div>_____</div> <div>H</div> </div> <div> <div>_____</div> <div>:</div> </div> <div> <div>_____</div> <div>M</div> </div> <div> <div>_____</div> <div>M</div> </div>
Squatting		<div> <div>_____</div> <div>H</div> </div> <div> <div>_____</div> <div>:</div> </div> <div> <div>_____</div> <div>M</div> </div> <div> <div>_____</div> <div>M</div> </div>
Bend sideways		<div> <div>_____</div> <div>H</div> </div> <div> <div>_____</div> <div>:</div> </div> <div> <div>_____</div> <div>M</div> </div> <div> <div>_____</div> <div>M</div> </div>
Back extended		<div> <div>_____</div> <div>H</div> </div> <div> <div>_____</div> <div>:</div> </div> <div> <div>_____</div> <div>M</div> </div> <div> <div>_____</div> <div>M</div> </div>
Back bent >45		<div> <div>_____</div> <div>H</div> </div> <div> <div>_____</div> <div>:</div> </div> <div> <div>_____</div> <div>M</div> </div> <div> <div>_____</div> <div>M</div> </div>
Back bent >90		<div> <div>_____</div> <div>H</div> </div> <div> <div>_____</div> <div>:</div> </div> <div> <div>_____</div> <div>M</div> </div> <div> <div>_____</div> <div>M</div> </div>
Back Twisting		<div> <div>_____</div> <div>H</div> </div> <div> <div>_____</div> <div>:</div> </div> <div> <div>_____</div> <div>M</div> </div> <div> <div>_____</div> <div>M</div> </div>
Knelling		<div> <div>_____</div> <div>H</div> </div> <div> <div>_____</div> <div>:</div> </div> <div> <div>_____</div> <div>M</div> </div> <div> <div>_____</div> <div>M</div> </div>

SECTION 6: GENERAL HEALTH

2. In general, would you say your health is?

Excellent

☐1

Very Good

☐2

Good

☐3

Fair

☐4

Poor

☐5

3. How would you describe your cigarette smoking?

Current Smoker

☐1

Used to smoker, but have now quit

☐2

Never smoked

☐3

4. Have you been told by a doctor or other health care provider you have (check all that apply):

a. Arthritis

☐1

b. High Blood Pressure

☐2

c. Heart Disease

☐3

d. Diabetes

☐4

e. Stomach or intestinal problems

☐5

f. Asthma or other lung conditions

☐6

g. Hearing Loss

☐7

h. Depression

☐8

i. Chronic or constant pain

☐9

j. Other bone and joint problems

☐10

k. Other: _____

Is there anything else you'd like to tell us about your back health or your work tasks?

.....

.....

.....

.....

.....

Thank you for your time and your contributions to this study. You have been very helpful.



Participant Consent Form

Project Title:

Ergonomics Exposure Assessment of Posture in Waste Collection Workers (WCWs)

Researcher(s):

Benedicta Asante, Graduate Student, Department of Community Health and Epidemiology, College of Medicine, University of Saskatchewan, 306-881-1967, benedicta.asante@usask.ca

Supervisor:

Brenna Bath (PhD), School of Physical Therapy, College of Medicine, University of Saskatchewan, Phone- 306 966 6573, brenna.bath@usask.ca

Catherine Trask (PhD), Canadian center for health and safety in Agriculture, College of Medicine, University of Saskatchewan, Phone- 306 966 5544, cmtrask@gmail.com

Purpose(s) and Objective(s) of the Research:

- We would like to understand how back injuries happen to waste collection workers. We would like to learn more about your work by measuring your back movements while you do your work. We hope that eventually this will help prevent injuries.

Procedures:

- Answer some questions about yourself, about your work, and about your experience with low back pain; Wear 2 back movement monitors attached under your clothes to your chest and low back. This will allow us to track the movements your back does during your daily activities. Monitors will be sanitized before and after use. According to Ergonomics Lab protocols
- Please feel free to ask any questions regarding the procedures and goals of the study or your role.

Potential Risks:

- There are minimal known risks associated with participation in this study
- The medical tape used to attach the monitors may cause minor skin irritation.
- If completion of the questionnaires related to emotional symptoms and feelings created undue psychological discomfort for the participant, then referral to a registered psychologist may be arranged through the participant's primary care provider.
- Participation is entirely voluntary and participants may withdraw at any time. Withdrawing from the study will not affect your relationship with the University.

Potential Benefits:

- Findings from this research may help develop interventions and health policy which could benefit study participants in the future

Compensation:

- In appreciation for study participant's time, they will receive an occupational health and safety souvenir consisting of safety glasses and WorkSafe stationary materials

Confidentiality:

- All participant information will be confidential. All documents will be identified only by code number and kept in a locked filing cabinet at Canadian Center for Health and Safety in Agriculture. Electronic data will be stored on a secure, password-protected server at the University of Saskatchewan. Only research staff will have access to paper and electronic data.
- Study participants will not be identified by name in any reports of the completed study. The data will be kept for minimum five (5) years following completion of the study.
- We will take precautions to protect the identity of participants. However, because participants will be seen to be participating at the worksite, their participation cannot be secret. It is also possible that small sample sizes make it possible to identify a worker's job title or work task.

Right to Withdraw:

- Your participation is voluntary and you can answer only those questions that you are comfortable with. You may withdraw from the research project for any reason, at any time without explanation or penalty of any sort.
- If you agree to take part and later change their minds, they are free to withdraw from the study and their data will be shredded. Likewise, there will be no penalty.
- Your right to withdraw data from the study will apply until March 2016. After this date, it is possible that findings from this study had been shared and it may not be possible to withdraw your data.

Follow up:

- An overview of the research results will be presented to all participants and key informants at a small gathering in a location that will be favorable for the study participants by the end of August, 2016.
- During the debriefing session, researchers will thank all participants and key informants for supporting the research and encourage them to ask any questions they may have or give thoughts and suggestions about the research. Also all participants and key informants will be informed that copies of the final research report will be available on request.

Questions or Concerns:

- Contact the researcher(s) using the information at the top of page 1;
- This project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board (certificate #XXXX). Any questions regarding your rights as a participant may be addressed to the committee at 306-966-2975 or ethics.office@usask.ca
- This research project has been approved on ethical grounds by the University of Saskatchewan Research Ethics Board. Any questions regarding your rights as a participant may be addressed to that committee through the Research Ethics Office ethics.office@usask.ca (306) 966-2975. Out of town participants may call toll free (888) 966-2975.

SIGNED CONSENT

Your signature below indicates that you have read and understand the description provided; you have had an opportunity to ask questions and your questions have been answered. You consent to participate in the research project. A copy of this Consent Form has been given to you for your records.

Participant's Name *Signature* *Date*

Visually Recorded Images/Data: Please provide initials:

- Photos may be taken of me for: Analysis _____ Dissemination* _____
- Videos may be taken of me for: Analysis _____ Dissemination* _____

*Even if no names are used, you may be recognizable if visual images are shown as part of the results.

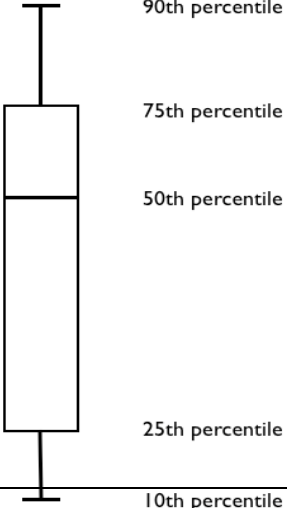
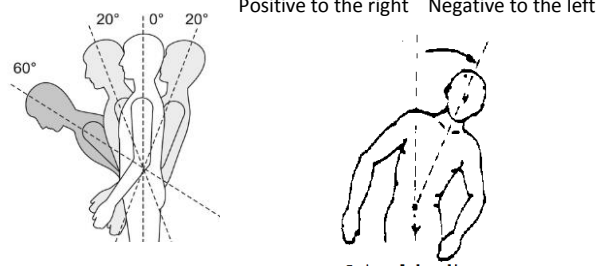
Researcher's Signature *Date*

ORAL CONSENT

Oral Consent: If consent has been obtained orally, this should be recorded as follows:
 Consent Form dated and signed by the researcher indicating that
"I read and explained this Consent Form to the participant before receiving the participant's consent, and the participant had knowledge of its contents and appeared to understand it."

<i>Participant's Name</i>	<i>Researcher's Signature</i>	<i>Date</i>
_____	_____	_____

Appendix G: Description of Metrics

Metric	Interpretations	Image
10th percentile in degrees (°)	10% of values are lower than this value; used as an estimate of lowest exposures encountered during a task or work shift while being less vulnerable to noise.	
50th percentile in degrees (°)	50% of values that are lower, this is the median and a measure of central tendency	
90th percentile in degrees (°)	90% of values that are lower than this value; used as an estimate of peak exposures encountered during a task or work shift while being less vulnerable to noise	
Time in neutral (<20°), %	Percent of time spent in neutral posture in < 20 degree bending -Bending in < 20° is considered as a neutral working posture	
Time in extreme (>60°), %	Percent of time spent in an extreme posture > 60 degree - Bending > 60° is considered as an extreme working posture	