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Review Article

Obesity and the risk for occupational injuries: A literature review

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ABSTRACT

Obesity has been associated with the increased risk of acquiring adverse health conditions and often overlooked is the direct influence that obesity has on physical limitations, fatigue and the risk for occupational injuries. The purpose of this review study was to examine the literature on the impact that obesity has as a risk factor for occupational injury to identify the associations between Body Mass Index (BMI) categories and non-fatal traumatic occupational injuries. Peer-reviewed literature was searched for studies on the risk of overweight and obesity on non-fatal traumatic occupational injuries. The initial literature search was conducted using electronic databases and the systematic search strategy yielded 308 articles. Eleven studies that investigated Body Mass Index (BMI) as a risk factor for occupational injury were further examined. Although there was diversity among the industries represented in these studies, there appears to be a strong association between obesity and risk for occupational injury such as fall-related injuries, lower extremity injuries, and sprains, strains & dislocations. The findings indicated that obese persons are significantly more likely to have had an occupational injury than their normal weight counterparts. Research also showed that the increased costs associated with occupational injuries, workers' compensation claims and obesity. Further research is needed to elucidate the mechanisms of obesity related injuries and how obesity interacts with other occupational hazards.

KEY WORDS: Obesity, body mass index (BMI), occupational injury, workers' compensation

INTRODUCTION

Obesity is an overwhelming public health concern worldwide, with increasing prevalence that has more than doubled over the past 30-years with worldwide figures reaching over 1.9 billion adults, 18-years and older who are overweight and of these, over 600 million are obese [1]. More than 39% of the world's adult population aged 18-years and older are overweight and 13% are obese and over 42 million children under the age of 5 are overweight or obese [1]. Data from World Health Organization (WHO) shows that most of the world's population live in countries where overweight and obesity kill more people than underweight and malnutrition. What was once considered a high-income country problem is now on the rise in developing countries, where the rate of increase in overweight and obesity is more than 30% higher than that of developed countries [1]. According to the Centers for Disease Control and Prevention (CDC) more than one-third (35%) of adults ages 20 years and older in the United States are classified as obese and two-thirds (69%) of United States adults are classified as either overweight or obese [2]. Obesity is defined as having a body mass index (BMI: kg/m2) value of 30 or greater, which is divided into three distinct obesity risk categories: 30-34.9 is defined as obesity level I, 35.0- 39.9 is defined as obesity level II and ≥ 40.0 is defined as obesity level III. Body mass index (BMI) of 25.0 to 29.9 is classified as overweight, and 18.5 to 24.9 is a "normal" or ideal body weight [3]. Based on 2013 data from the Behavioral Risk Factor Surveillance System, there was higher prevalence of U.S. adult obesity in the South (30.2%) and the Midwest (30.1%) with lower prevalence observed in the Northeast (26.5%) and the West (25%). Non-Hispanic blacks appeared to have the highest prevelance of obesity at 37.6% followed by Hispanics (30.6%) and non-Hispanic whites (26.6%) [4]. Another study on obesity and socioeconomic status in the U.S. adults reported that there is no significant relationship between obesity and education among men; however there is a trend among women that shows that those with college degrees are less likely to be obese compared with less educated women and that higher income women are less likely to be obese than low-income women [5].

Obesity has been associated with the increase of risk factors for acquiring health conditions such as osteoarthritis of the knees and hips, obstructive sleep apnea and chronic diseases (e.g., coronary artery disease, Type 2 diabetes, hypertension, hyperlipidemia), and has been linked to the prevalence of increased risk of stroke, anxiety, depression and certain types of cancer [2]. Often overlooked are the direct influences that obesity related health conditions and co-morbidities have on chronic disease [6], physical limitations, ergonomics and fatigue [7], and risk for occupational injuries. Occupational injuries such as back- and fall-related injuries occur frequently in the workplace and are costly in terms of workers'

compensation claims and lost productivity [2]. Moreover, obese individuals may be at increased risk of occupational injury for a number of reasons, including compromised gait and mobility, fatigue, poor ergonomic fit and the use of potentially sedating medications to treat conditions associated with obesity [8], and that such conditions result in delays in recovery, higher risk of complications with medical procedures and overall deconditioning of health [9-11]. Based on a study of youth participants obesity was associated with a higher risk of work-related injury and more likely to sustain injury at work, however the mechanism of how excessive body weight relates to occupational injury were unclear [12]. Moreover, obese persons were more likely to report occupational injuries such as sprains/strains, injuries to the lower limbs or torso and fall-related injuries than their normal weight counterparts [6, 8-10, 13-15].

The National Council on Compensation Insurance, Inc. (NCCI) published a review of scientific literature for studies regarding the evidence of obesity contributing to the increased cost of workers' compensation and the relationship between obesity and occupational injuries. The study concluded that based on workers' compensation indemnity benefit payments, the duration of obese claimant's was more than 5 times the duration of non-obese claimant's [16]. Another study analyzed the obesity and its relationship with occupational injuries in the Canadian workforce. In the study the researchers developed a "biophysical framework" to address the link between obesity and injury. Based on existing evidence, this framework established that obesity is associated with a number of risk factors for unintentional injury (increased co-morbidities, increased use of psychotropic medications, altered gait and balance, increased forces involved in falls, lower neural sensitivity, greater extremity friction and sleep apnea and fatigue) [15]. The framework was developed to provide a theoretical base for analysis to complement existing and future research studies examining the relationship between obesity and injury, because the biophysical framework takes into account both direct and indirect risk factors from the physical effects of obesity. This biophysical framework may be an important element to consider including in future studies that examine obesity, since it takes into account both direct and indirect risk factors, which are often overlooked in statistical analysis research, but that may prove helpful in truly defining the role obesity plays in occupational injuries. Based on the growing prevalence of obesity worldwide, the aging workforce and the increasing costs of medical treatment, obesity is a public health concern that warrants additional research to explore the global health impact and costs associated with occupational injury.

This review study aimed to synthesize the available research on the risk for occupational injuries in the workplace. The specific goal of the investigation was to identify the literature on the impact that obesity has as a risk factor for occupational injury to identify the associations between Body Mass Index (BMI) categories and non-fatal trumatic occupational injuries.

METHODOLOGY

A literature review was conducted to identify articles related to the areas of obesity and occupational injury. The literature search was conducted using the electronic databases: Medline, CINAHL, PsychInfo, Applied Science and Technology Source, ProQuest, ABI/Inform, PubMed, CQ Researcher, Academic Search and Web of Science. The following a priori identified Medical Subject Headings (MeSHs) and text words were used: body mass index OR BMI OR body weight OR body size OR body mass OR adiposity OR anthropometrics OR obesity OR overweight OR body habitus AND workplace OR occupation* OR job AND safety AND injury* AND occupational health. The search period covered articles published between January 1, 2006 and May 31, 2015. Articles were not limted to the United States or research that studied only worksites in the United States, but had to be published in English. Peer reviewed articles were included if they met the following selection criteria: (1) provided rates, risk or correlation estimates between non-fatal traumatic injury and obesity (2) had a clear definition of traumatic injury, defined as damage to the body from an energy transfer with a short latency period between exposure and health event. Articles were excluded if they: (1) did not present data on occupational injuries; (2) examined weight gain after injury; (3) explored mortality; or (4) examined military populations.

Using individual key terms and word strings, the search strategy initially yielded 308 articles. After removal of inadvertently captured studies and stringent application of inclusion criteria, eleven studies remained and form the basis of this review (see Table 1). Although the methodological quality of the studies varied, all identified studies were included to better understand the scope of research on this topic. The publication year, study aims, design, sample measurement of obesity, definition of workplace injury and results were extracted for all reviewed studies. All used body mass index (BMI) to measure obesity; unless noted, BMI was calculated as weight (kg) divided by height (m)2. Many of the articles that were excluded addressed simply obesity, occupational injury or workers' compensation claims, but did not provide data or comparisons between both obesity and occupational injury. Other articles were excluded because there was not a clear definition of occupational injury and did not provide any data to correlate associations between body weight and occupational injury. Military populations were excluded from the study because of multiple confounding variables and the fact that many did not address occupational injury, but rather injuries sustained in the line of duty or during training exercises and did not provide correlation estimates between non-fatal traumatic injury and obesity. When multiple outcomes were presented, only statistical findings related to the association between obesity and injury were abstracted. However, if an included study presented data on absenteeism or sick leave related to obesity, this finding was also reported.

Table 1. Summary of findings on body weight (BMI) and non-fatal traumatic occupational injury

Reference	Study aim and research design	Study popluation	Definition of body weight (BMI)	Definition of occupational injury	Association between BMI and injury	Results
Pollack et al [22]	To examine whether increased BMI is an independent risk factor for workplace injury; retrospective cohort study	7,690 hourly, aluminum manufacturing employees from eight US plants (ages 18 to 65 years)	Weight and height measured during physical exams; BMI categorized as: 25-29.9 (overweight), 30-34.9 (obesity level I), 35-39.9 (obesity level II), ≥40 (obesity level III).	First-aid and OSHA recordable injuries; Acute sprains & strains, falls, burns, contusions, abrasions, lacerations, eye injuries, fractures, amputations, blisters, foreign bodies, punctures and bites or stings.	OR for incurring at least one traumatic injury and: obesity III (2.21 (1.34 to 3.35)); overweight (1.26 (1.06 to 1.50)) and obesity I and II (1.54 (1.22 to 1.96), p<0.02; difference in distribution of BMI for acute sprains and strains: obesity III (3.79 (1.83 to 7.87)); overweight (1.49 (1.12 to 1.97)), obesity I and II (2.22 (1.52 to 3.52)), p<0.02; all other injuries: obesity III (1.74 (1.02 to 1.72)); overweight (1.17 (0.97 to 1.43)) and obesity I and II (1.32 (1.00 to 1.72)), p<0.04	Obesity was shown to be associated with increased risk for slips, trips and falls. Obese employees seem to have a higher prevalence of bone fractures, dislocations, sprains/ strains, concussions and injuries to the both upper and lower extremities. Overweight employees had an increased risk for dislocations, sprains & strains, concussions and internal injuries.
Ostbye et al [10]	To determine the relationship between body mass index and number and types of workers compensation claims, associated costs and lost work days; retrospective cohort study	11,728 health care and university employees (34,858 full-time equivalents) at Duke University Health System and Duke University	Self reported height and weight from health risk assessment data (1/1/97 to 12/31/04); BMI categorized as: 25-29.9 (overweight), 30-34.9 (obesity class I), 35-39.9 (obesity class II) and ≥ 40 (obesity class III).	Workers compensation claims that resulted in lost workdays.	Bivariate association between lost workdays and: overweight (60.17 days), obesity class I (75.21 days), obesity class II (117.61 days) and obsesity class III (183.63 days); Adjusted rate ratio for injury(lost workdays) and: overweight (3.43 (2.81 to 4.17)), obesity class I (3.39 (2.74 to 4.20)), obesity class II (5.43 (4.34 to 6.80)), obesity class III (8.04 (6.42 to 10.07)).	There was a clear linear relationship between BMI and rates of occupational injury & workers' compensation claims. Association between lost workdays and BMI categories: overweight (60.17 days), obesity class I (75.21 days), obesity class II (117.61 days) and obsesity class III (183.63 days). BMI was strongly associated with lower extremity, wrist/hand, back pain or inflammation, sprain/strain and contusion (nature of injury) and falls/slips, lifting and overexertion (cause of injury)
Lin et al [12]	To assess the contribution of obesity to occupational injury; retrospective cohort study -National Longitudinal Survey of Youth 1979 (NLSY79)	8,941 U.S. youth ages 14-22 years as of December 31, 1978	Self reported height and weight; BMI defined as: normal weight (18.5 – 24.9 kg/m^2), overweight (25.0- 29.9 kg/m^2) and obese(≥ 30 kg/m^2).	An incident at any job that resulted in an Injury or illness.	GEE analysis: Obesity was associated with 25% higher odds of workplace injury: OR (1.25 (1.12 -1.39)); overweight was marginally significant (1.08 (1.00 – 1.18)). Random effects analysis: Obese workers were associated with a 29% higher odds of sustaining injuies than those of normal weight: OR (1.29 (1.15 – 1.45)).	Obesity was associated with 25% higher risk of occupational injury and being overweight was associated with an 8% higher risk of injury than those of normal weight.
Janssen et al [15]	To examine obesity and its relationship with occupational injury in the Canadian Worforce.	7,678 adult Canadian workers	Self-reported weight and height on National Population Health Survey (NPHS); BMI: normal (18.5-24.9); overweight (25-29.9), obese (≥ 30).	Injuries that had occurred in the past 12 months that were serious enough to limit normal activities and for which they sought medical attention from a health professional within 48 hours.	OR for risk of occupational injury in obese workers compared to normal weight workers (1.40 (0.98 to 1.99)); serious occupational injuries: (1.49 (0.99 to 2.26)) Relationships were more pronounced for sprains and strains (1.80 (1.04 to 3.11)), injuries to lower limbs (2.14 (1.12 to 4.11)) or torso (2.36 (1.13 to 4.93)), injuries due to falls (2.10 (0.86 to 5.10)) or overexertion (2.08 (0.96 to 4.50)).	Obesity was associated with a 1.5 fold increase in prevalance of serious occupational injury; increased risk of sprains and strains, injuries to the torso and lower limbs, falls and overexertion injuries. Female workers, workers ≥40 years and workers employed in sedentary occupations were particularly vulnerable to injury.

Table 1. Resume

Reference	Study aim and research design	Study popluation	Definition of body weight (BMI)	Definition of occupational injury	Association between BMI and injury	Results
Kouvonen et al [17]	To examine obesity & overweight as predictors of occupational injuries & whether the associations are different in relation to types, anatomical sites & manner in which they were produced/ inflicted	69,515 Finnish public sector employees working in 10 towns and 21 hospitals in 6 hospital districts; prospective cohort study	Self-reported weight and height from questionnaire surveys; BMI.	An injury caused by an accident due to an unexpected, sudden external event. Categories of injuries: wounds and supeficial injuries; bone fractures; dislocations, sprains and strains; concussions and internal injuries; burns, scalds and frostbite; poisonings and infections, drowning and asphyxiation; other multiple injuries.	Crude rate ratio for risk of occupational injury and: obese (1.51 (1.43 to 1.49)) and overweight (1.33 (1.28 to 1.38)). Adjusted rate ratio for risk of injury and: obese (1.21 (1.14 to 1.27)) and overweight (1.13 (1.08 to 1.18)), p<0.0001; OR for type of injury and obese: bone fractures (1.37 (1.10 to 1.70)), dislocations, sprains and strains (1.36 (1.25 to 1.49)), concussions and internal injuries (1.26 (1.11 to 1.44)), injuries to lower extremities (1.62 (1.46 to 1.79)) and injuries to whole body or multiple sites (1.37 (1.10 to 1.70)); OR for cause of injury and obese: slipping, tripping, stumbling & falling (1.55 (1.40 to 1.73)), sudden body movement with or without physical stress (1.24 (1.10 to 1.41)), shock, fright, violence, aggression, threat or unexpected presence (1.33 (1.03 to 1.72)).	Sprains, strains and disclocation were the most frequent type of injuy (41% of all injuries) Upper extremities (36%) were the most common injury location Slips, trips and falls (25%) were the most common injury cause.
Chau et al [18]	To assess the relationships between physical job demands, lifestyle and injury in workers; population based cross-sectional study	2,888 employed individuals radomly selected from the population	Self reported height and weight from a survey administered; BMI: ≥ 30 kg/m^2	Presence of at least one occupational injury in the 2-year period before the survey. Occupational injury had to result in sick leave fromwork and lead to compensation.	OR for BMI ≥30 and injury by age categories: <30 years (0.4 (0.0 to 3.2)); 30-44 years (0.9 (0.4 to 2.2)); ≥45 years (2.6 (1.2 to 5.5)); p<0.05.	Obesity was associated with a 27% increase injury risk for subjects ≥ 45 years Obese employees are at greater risk of falls and injuries in environments with high ergonomic demands.
Tobari et al [19]	To examine whether body mass index is a risk factor for injuries related to professional horse racing; prospective cohort study	546 male grooms and exercise horse riders.	Baseline survey was performed to measure height and body weight; BMI categorized as: <20, 20.0-22.9, 23.0, 24.9 and ≥25.0 based on WHO BMI cut-off for Asian people.	Application for compensation to the Workers' Accident Compensation Insurance Benefits.	Age adjusted hazard ratio for injury and BMI for Grooms: <20.0 (3.5 (1.5 to 8.1)), 20.0-22.9 (1.0), 23.0 -24.9 (1.4 (0.7 to 2.9)) and ≥25.0 (2.4 (1.2 to 4.7)); Exercise Riders: <20 (2.5 (1.0 to 6.0)), 20.0-22.9 (1.0), 23.0 -24.9 (1.5 (06 to 3.7)), ≥25.0 (3.8 (0.9 to 17.4)).	High BMI was found to be associated with low back and lower extremity injuries in professional horse racing, presumably due to high load on musculoskeletal structures of the excess weight. Physical movements were less efficient in obese riders leading to decreased balance control. Grooms with high BMI sustained injuries to the upper trunk and falls associated with body imbalance.
Lombardi et al [20]	To examine the risk of a work-related injury as a function of total daily sleep time and BMI; population based cross-sectional study	101,891 employed U.S. adults; data derived from US National Health Interview Survey (2004-2010)	Self reported height and weight from interviews; BMI categorized as: healthy weight (<25 kg/m^2), overweight (25-29.9 kg/m^2) and obese (≥ 30 kg/m^2).	Injury or poisoning episode that occurred "while working at a paid job" that required medical attention, in the 3 months prior to the interview.	Adjusted injury risk OR comparing workers wj were obese to healthy weight workers: (1.34 (1.09 = 1.66)), whereas the risk comparing overweight to health weight workers was elevated, but not statistically significant: (1.08 (.88 – 1.33)).	Risk of acute traumatic injury was 34% greater in obese workers (BMI ≥ 30 kg/m^2) to healthy weight workers (BMI <25 kg/m^2) Most common cause of injuries were overexertion, falls, being cut or pierced and being struck by an object or person.

Table 1. Resume

Reference	Study aim and research design	Study popluation	Definition of body weight (BMI)	Definition of occupational injury	Association between BMI and injury	Results
Arlinghaus et al [21]	To examine fatigue related direct and indirect potential risk factors for occupational injury; population based cross-sectional study using structural equation modeling.	86,317 employed U.S. adults ages 18-74 yrs.; data derived from US National Health Interview Survey (2004-2009)	Self reported height and weight from interviews; BMI categorized as: healthy weight (<25 kg/m^2), overweight (25-29.9 kg/m^2) and obese (≥ 30 kg/m^2).	Injury or poisoning episode that occurred "while working at a paid job" that required medical attention, in the 3 months prior to the interview.	639 occupational injuries were reported (0.7%); including 11 work-related poisonings (1.7% of all injuries)	High BMI was directly associated with an elevated injury risk. BMI led to an increase in risk for short sleep duration, which in turn increased injury risk.
Thomas et al [23]	To examine the risk factors for work-related injuries in hospital workers; retrospective case-control study.	2,050 healthcare workers from Central Arkansas Veterans Healthcare System (CAVHS) from 1997 to 2002	BMI was collected by reviewing employee health charts, documents and computer databases; BMI calculated as weight in kilograms divided by height in meters squared.	Lost time workers' compensation claims because of work-related injury.	Risk for Strain, Reptitive Motion, Exposure/reaction and Contact/Assault work relaed injuries increased with increasing BMI.	Higher risk for strain, reptitive motion, exposure/reaction and contact/assault work related injuries with increasing BMI.
Tsai et al [24]	To examine employee illness absence in relation to overweight and obesity in industrial workforce.	4,153 petrochemical employees actively employed between January 1994 and December 31,2003	Baseline biometric and risk factor data from pre-employment and periodic physical exams; BMI defined as: normal weight (18.5 – 24.9 kg/m^2), overweight (25.0- 29.9 kg/m^2) and obese(≥ 30 kg/m^2).	Illness or injury absences lasting 6-days or more.	Absence frequency due to illness increased with BMI, ranging from 132.8 absences per 1000 normal-weight employees to 193.5 absences per 1000 overweight employees and 239.7 per 1000 obese employees.	Obese employees lost nearly three times as many workdays compared with normal-weight employees due to musculoskeletal system disorders. Absence frequency due to illness/injury increased with body mass index (BMI).

RESULTS

Eleven studies were identified that investigated Body Mass Index (BMI) as a risk factor for non-fatal traumatic occupational injury. Although there were varying industries represented in these studies, many of the studies investigated slips, trips & fall-related injuries (n = 7), upper/lower extremity injuries (n = 5), and sprains, strains & dislocations (n = 6). Seven of the eleven studies relied on self-reported BMI obtained through surveys or health risk assessments. Table 1 provides the summary of findings on body weight (BMI) and non-fatal traumatic occupational injury.

Slips, trips & fall-related injuries

Seven of the eleven studies reviewed reported associations between BMI and increased risk of slipping, tripping and/or falling. A study of 69,515 public sector employees demonstrated that obesity was associated with a higher risk of injuries caused by slipping, tripping, stumbling and falling (odds ratio (OR) = 1.55; 95% CI: 1.40 to 1.73) [17]. Its authors concluded that excess weight can hinder physical functioning and gait, which in turn can increase the risk of occupational injury by slips, trips and falls [17]. Another study showed BMI to have a pronounced association for risk of occupational injury due to falls among a cohort of 7,678 adult Canadian workers classified overweight (OR = 1.61, 95% CI: 0.67 to 3.91) and those who were classified obese (OR = 2.10, 95% CI: 0.86 to 5.10) [15]. A study of 2,888 workers in France found that obese workers were at a greater risk for falls and that obesity was associated with a 2.7 fold increased risk for occupational injury for subjects aged ≥45 years (OR = 2.6, 95% CI: 1.2 to 5.5) [18]. A cohort study of 546 male professional horse racing employees in Japan utilized injury data for those who applied for workers' compensation benefits showed a statistical signficance associated with BMI and increased risk for occupational injuries among professional horse racing employees. The highest overall injury rate was that of falls (out of 100 reported occupational injuries 32 cases were fall related) [19]. Based on a study of 101,891 U.S. adults from data derived from the National Health Interview Survey [20], of the 723 employees who experienced an occupational injury, approximately 21% were fall injuries associated with employee's being either overweight or obese [20]. Moreover, a study used structural equation modeling to examine fatigue-related direct and indirect potential risk factors for occupational injury of 86,317 employed workers from the National Health Interview Survey [21]. One of its findings indicated that high body mass index (BMI) led to an increase in risk for short sleep duration, which in turn increased occupational injury risk [21].

Upper/lower extremity injuries

Of the five studies that investigated upper/lower extremity injuries, four studies reported significant associations with BMI, showing that obesity adversely affects the lower

extremities, with injuries to the legs, knees and hips being especially prevalent. A study of 7,690 hourly aluminum manufacturing employees reported that there were statistically significant differences between BMI categories for the primary body part that was injured showing that almost 10% of all injuries in the highest (severe) obesity category (BMI: ≥ 40 kg/m2) were to the knee and leg [22]. A cohort of 69,515 public sector employees derived from self-reported height and weight showed that obesity was associated with a higher overall risk of occupational injury to the lower extremities (OR = 1.62; 95% CI: 1.46 to 1.79) [17]. Another study of Canadian workforce (7,678 adults) using self-reported weight and height on National Population Health Survey (NPHS) found that obese workers experience up to a 49% higher risk of occupational injury and showed a pronounced association for injuries to the lower limbs for those workers who were overweight (OR = 1.03, 95% CI: 0.50 to 2.11) and those who were obese (OR = 2.14, 95% CI: 1.12 to 4.11) [15]. Risk factors were examined for lower extremity injuries using workers' compensation insurance benefit data from a cohort of 546 male employees in the professional horse racing industry [19]. High BMI was associated with increased risk for occupational injuries among professional horse racing employees and that overweight or obesity was found to be associated with low back and lower extremity injuries, most likely due to the high load on musculoskeletal structures of the excess weight. Of 100 reported occupational injuries 26 cases were associated with injuries to the lower extremities [19].

Sprains, strains and dislocations

Six of the studies explored risk factors for occupational sprain, strain and dislocation injuries. A study of 7,690 hourly aluminum manufacturing employees revealed that the odds ratio for sprain and strain injuries was greatest for the heaviest employees and that the odds of injury are signficanly greater for acute sprain and strain injuries than for all other traumatic injuries across all of the BMI categories. The difference in distribution of BMI for acute sprains and strains: Obesity III (OR = 3.79, 95% CI:1.83 to 7.87); Overweight (OR = 1.49, 95% CI: 1.12 to 1.97 and Obesity I and II (OR = 2.22, 95% CI: 1.52 to 3.52) [22]. Particularly, almost 10% of all injuries in the highest obesity category were injuries to the knee and leg [22]. Another study involving 2,050 healthcare workers found that 224 of the 509 occupational injuries (~44%) reported were associated with strain/sprains from lifting, pushing, pulling or positional strain and that increased BMI appeared to significantly increase the risk of strain injuries [23]. In a cohort study of 69,515 Finnish public sector employees found that sprains/strains and dislocations (41% of all injuries) were the most frequent type of injuries [17]. The researchers concluded that obesity and overweight increase the risk of occupational injuries and that obese employees are particularly vulnerable to sprains, strains and dislocations (OR = 1.36; 95% CI: 1.25 to 1.49) [17]. Another study consisting of 7,678 adult Canadian workers found that obesity was associated with a 1.5-fold increase in the adjusted relative odds of serious occupational injury, in particular with increased odds of sprain and strain injuries (OR = 1.80, 95% CI: 1.04 to 3.11) [15]. A retrospective cohort study from the Duke Health and Safety Surveillance System (11,728 health care and 34,858 university employees) determined the relationship between BMI and the number and types of workers' compensation claims, associated costs and lost workdays [10]. Results of the study show a direct correlation between obesity and the number of workers' compensation claims filed (11.65 claims per 100 full-time equivalents (FTEs) for obese employees) as compared to(5.80 claims per 100 FTEs for recommended weight employees. The comparison on lost workdays was (183.63 vs. 14.19 lost work days per 100 FTEs), medical expenses ($51,091 vs. $7503 per 100 FTEs) and indemnity claim costs ($59,178 vs. $5396 per 100 FTEs). The study also presented strong evidence that workers' compensation claims affected by BMI were related to lower extremity, wrist, hand and back and that falls, slips, lifting and overexertion were the main cause of the injuries and that Certified Nursing Assistants, Housekeepers, Laundry Staff, Nurses and Facility Maintenance employees had the greatest risk for occupational injuries [10]. A 10-year follow-up study in a petrochemical industry workforce showed that employees with preexisting overweight/obesity were absent from work due to injury/illness more frequently and for more days than normal-weight employees. Obese employees lost nearly three times as many workdays compared with normal-weight employees due to musculoskeletal system disorders [24].

DISCUSSION

This literature review study aimed to examine the impact that obesity has as a risk factor for occupational injury to identify the associations between Body Mass Index (BMI) categories and non-fatal traumatic occupational injuries. The basis for research of this topic was to gain additional insight regarding the impact obesity plays as a risk factor for occupational injury, frequency, severity and cost of workers' compensation claims (WC) and the cost drivers based on co-morbidities that lead to increased risk of acquiring other serious health conditions. Workers' compensation benefits showed a statistical significance associated with BMI and increased risk for occupational injuries among nurses and nursing assistants, housekeepers, laundry staff, and facility maintenance employees. The highest overall injury rate was that of fall-related injury, low back and lower extremity injuries due to the high load on musculoskeletal structures of the excess body weight. The indemnity benefit durations of obese claimants were more than five times the duration of non-obese claimants. Moreover, the medical costs of morbidly obese employees were nearly seven times the costs of normal-weight counterparts [10,16].

The research found that the risk of injury was increased for obese workers; however when associations were identified, the mechanism of obesity-related injuries remain unclear. The studies most commonly hypothosized that obesity related physical limitations, fatigue and chronic conditions such as sleep apnea and osteoarthritis were the factors leading to a higher risk of occupational injuries such as slip, trip and fall injuries [25]. It is important as researchers to investigate both the direct and indirect risk factors associated with the physical effects of obesity in order to mitigate the risk of occupational injuries. By exploring the potential associations between obesity and traumatic occupational injury we can better understand and identify areas for future investigation, which would include studying the impact obesity plays in the frequency and cost of workers' compensation claims associated with occupational injuries, the cost drivers based on the co-morbidities of obesity, the obesity related mechanism of injuries and the increased risk of acquiring health conditions due to obesity. These findings quantify the costs and can help employers consider whether to introduce workplace interventions or provide coverage for weight loss programs [26].

There are some research limitations that exist and although a number of terms were used to capture all potential studies related to obesity, studies may have been missed that found a negative association between obesity and injury, but were indexed by terms related to the positive findings for other risk factors. The potential omission of studies with negative findings further supports the need for additional research before drawing firm conclusions. Searching for unpublished studies can reduce publication bias, but this review included only peer-reviewed published studies. Potential confounding variables that may need to be addressed when selecting study groups for future research would include: age, sex, type of occupation, race /ethnicity, smoking status, income, education level, activity level of occupation and chronic health conditions (co-morbidities). Age and sex may need to be considered by gathering an evenly split sample of ages and sexes within each group. The type of occupation may need to be examined and grouped based on activity level of occupations, such as sedentary, moderate activity and heavy (labor intensive). Smoking status could be broken down by current smokers and non-smokers or could be evaluated further by current smokers, former smokers and non-smokers. Finally, chronic health conditions and co-morbidities may play a dramatic role in the risk factors associated with other health outcomes and risk factors for occupational injury, that may impact the results of the study; however it may be too difficult to identify and examine chronic health conditions given the retrospective nature of the study and existing data, unless it is well defined within the context of previous research design.

Given that limited research exists on the impact of obesity on the increased risk of occupational injury and the correlation obesity has on the rising cost of workers' compensation claims, additional studies may be necessary to better establish the impact on occupational injuries and lost work time. Research does show a direct correlation with increased costs associated with occupational injuries, workers' compensation claim costs and obesity; however additional research is necessary to clearly explore the direct relationships between obesity and traumatic occupational injuries, especially the mechanism of obesity related injuries. Further research may also be necessary to determine the possible cost impact of obesity related weight reduction programs for employers and delay in recovery from injury due to de-conditioned physical state, which reduces the ability to physically participate in physical therapy and work conditioning programs, which in turn contribute to increased lost time from work and increased duration of treatment. Limited statistical analysis exists on the correlation between increased workers' compensation claim costs and obese employee populations; however by targeting obesity in the workplace, employers can impact the overall health of its workforce to reduce absenteeism and decrease the frequency, duration and cost of workers' compensation claims associated with obese employees and improve employee safety.

CONCLUSION

This review study investigated and summarized the associations between body weight (BMI) and non-fatal traumatic occupational injuries. The published research indicates that there is a strong relationship between obesity and the risk for non-fatal traumatic occupational injury, particularly for fall-related injuries, lower extremity injuries, and sprains, strains & dislocations. Research also showed that the increased costs associated with occupational injuries, workers' compensation claims and obesity. However when associations were identified, the mechanisms for obesity-related injuries remain unclear. There currently appears to be insufficient published data exploring the mechanisms of occupational injury associated with obesity; therefore further research is needed to elucidate the mechanisms of obesity related occupational injuries and how obesity interacts with other occupational hazards. The strong association between obesity and risk for occupational injury further support the need for employer focused preventative interventions with a strong emphasis on weight reduction, lifestyle changes, physical fitness and education and training on ergonomics and workplace safety. Future research to measure the potential cost impacts of employer based integrated health programs including health promotion and wellness, weight control and workplace injury prevention programs, may help us better understand the global impact that obesity has in relation to occupational injuries.

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