# Individual, physical, and organizational risk factors for musculoskeletal disorders among municipality solid waste collectors in Shiraz, Iran

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**Abstract: In Iran-Shiraz, municipal solid waste is collected manually requiring strenuous physical activities. This study was conducted to determine the prevalence rate of musculoskeletal disorders (MSDs) and its associated risk factors. Two hundred male waste collectors participated in this cross-sectional study, in which task analysis followed by motion and timeline analysis were performed. The data were collected using demographic, occupation-specific physical and organizational demands, and Nordic musculoskeletal questionnaires. Logistic regression analysis was used for identifying independent risk factors for MSDs. Ten motions observed during waste collection, and the most physical and organizational demands were related to the running along with bag carriage, and the time pressure, respectively. About 39% and 36.5% of the workers reported very high physical and psychological workloads, respectively. Totally, 92.5% of waste collectors reported MSDs symptom at least in one body region during the last 12 months. Lower back and knee injuries were more prevalent and more severe. Some individual factors (age, body weight, and waste collecting duration), physical demands (lifting bag/bucket, pulling/pushing waste container, walking along with bag/bucket carriage, and jumping up/down on the garbage truck), and organizational demands (low vacation and high decision authority) were the most important risk factors for developing MSDs.**

**Key words:** Iran, Municipal solid waste collector, Musculoskeletal disorders (MSDs), Organizational demands, Physical demands

## Introduction

In recent decades, the urban population's rapid growth leads to a high generation of solid waste. Municipality waste collectors exposed to ergonomic risks in both developing and developed countries[1–6]. In Iran, solid waste is collected, separated, handled, transported, stored, and disposed by municipality's solid waste management organization. Shiraz is a large city of Iran with 1,800,000 of population and 240 square kilometers of area. Nearly, 1,000 tons of solid waste is daily produced in this city which is collected by 270 waste collectors.

Around the world, solid waste has been collected using plastic/paper bags, bins/drums (110–210 l), two-wheeled containers (80–360 l), and four-wheeled containers (300–1,800 l)[7]. In Iran, the major portion of solid waste is collected using plastic bags door to door, and the rest is collected using two/four-wheeled containers. In this country, a high percentage of solid waste is manually collected due to low cost, in which prolonged walking and running as well as repetitive tasks such as lifting, carrying, pulling, and pushing of heavy loads are required. Hansen noted that nearly 80% of the collection units were sacks and containers without wheels (buckets) that imposed heavy physical activity, standing, walking, and stair-climbing on the refuse collectors[8].

Pulling/pushing containers and lifting/carrying bags that lead to repetitive bending, awkward postures, muscles static contraction, and as a result the high risk of MSDs[5, 9, 10]. Pulling/pushing two/four-wheeled containers imposes a fairly low compressive force about 400-2800N on the back while lifting bags imposes a force over 3400N (action limit of NIOSH) on the back[11–13]. Manual handling over 2 lift/min and high angular velocity of body limbs are associated with an occurrence of MSDs[14–16]. Rushton declared that waste collectors had considerable heavy lifting as well as manual handling of containers, which would increase the risk of musculoskeletal problems[17]. Da Silva *et al.* also indicated that the possible risk factors associated with low back pain among waste collectors were repetitive movements, lifting and carrying loads, awkward postures, vibration, and high physical demands during work[18].

Waste collecting as a job with strenuous physically demanding activities leads to high prevalence of musculoskeletal disorders (MSDs) during the last 12 months in Iranian waste collectors (65%)[1], and also in other developing countries such as Egypt (60.8%), Ghana (in average, 55.5% in neck, wrist and back), and India (70%)[19–21]. The most frequently affected body regions in these studies were low back, knee and shoulder and also the most important risk factors associated with MSDs were physical (lifting, pushing, pulling or carrying loads >20 kg; repetitive movements; bending; walking for long periods of time), psychological (low decision latitude; job control; socioeconomic status), and individual (age; body mass index; duration of employment; smoking; having no physical activity) factors[19–21].

Based on our field observations, municipal solid waste collectors repeatedly bend their backs to rapidly lift the bags and often carry them in jogging/running status due to time pressure during working time. So far, few studies have been conducted among Iranian waste collectors and no study has assessed the occupational risk factors for MSDs. The present study was, therefore, conducted to determine the prevalence rate of MSDs as well as to identify the individual and occupational risk factors leading to the development of MSDs among solid waste collectors in Shiraz city.

## Subjects and Methods

This cross-sectional study was carried out from November 2016 to August 2017 among solid waste collectors in Shiraz municipality and was approved by the ethics committee of Shiraz University of Medical Sciences.

### *Participants*
Participation criteria included at least one year of work experience as a waste collector in Shiraz city. Exclusion criteria were suffering from non-occupational musculoskeletal injuries such as bone fracture, ligament damage, and intervertebral discs rupture. Out of 270 male workers mentioned above, 230 of them had the criteria for entering the study and finally 200 (87%) voluntary waste collectors participated in this study. An informed verbal and written consent was obtained from all participants. The subjects had full right to withdraw from the study at any time.

### *Data collection procedures*
Task analysis
Task analysis were performed using field observation, interview, and video capture. Workers' motion in ten different zones of Shiraz city during waste collecting for 300 min was recorded (Fig. 1), and then a motion and time study was conducted to analyze the videos.

Data gathering tools
The required data were collected using questionnaires. Trained occupational health professionals completed the questionnaires by interview because most of the workers were illiterate or had no enough skill for reading/writing.
The questionnaires covered the following data:
*a) Demographic questionnaire* included questions on age, height, weight, body mass index (BMI), marital status, number of children, education, work experience, working schedule (day or night), daily working time, waste collecting duration, smoking, exercise, and second job.
*b) Occupation-specific physical and organizational demands questionnaire*: A custom questionnaire was developed based on the conducted field study and task analysis.
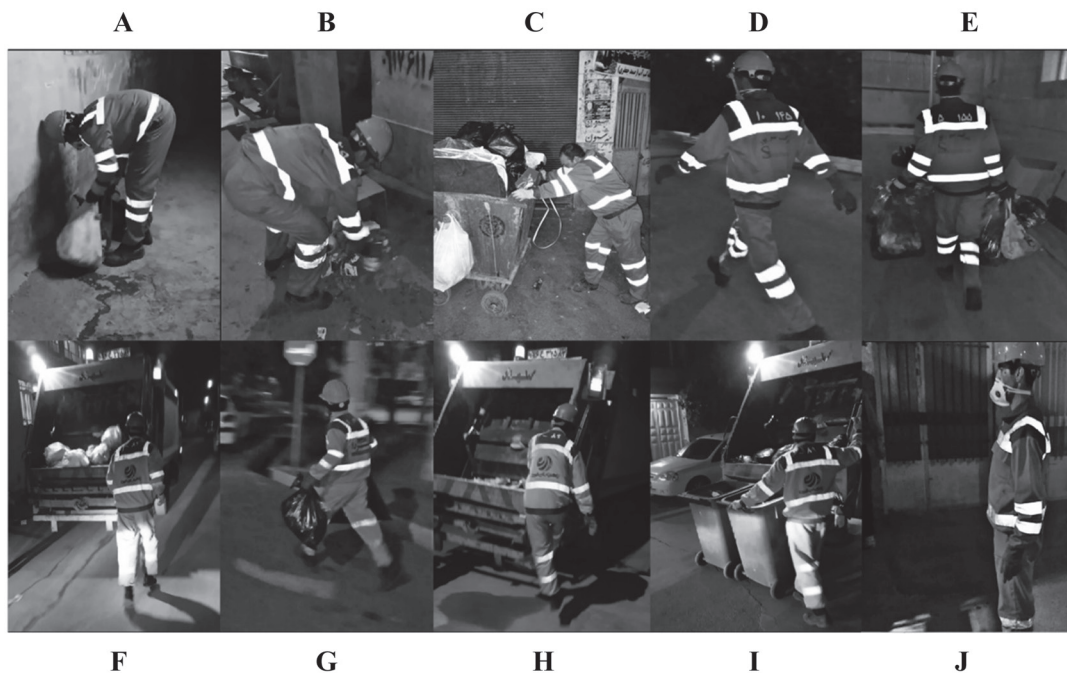
**Fig. 1.** Workers' motion analysis demonstrated the variety of main tasks. (A) Stoop lifting bag/bucket; (B) Semi-squat lifting bag/bucket; (C) Pulling/pushing waste container; (D) Walking without bag/bucket carriage; (E) Walking along with bag/bucket carriage; (F) Running without bag/bucket carriage; (G) Running along with bag/bucket carriage; (H) Jumping up/down on the garbage truck; (I) Picking up/dumping trash containers by a hand lever; (J) Stopping or standing.

The custom-made questionnaire was validated in a pilot study and then was utilized to collect the required data on physical and organizational demands. To develop and improve this questionnaire, a pilot study was conducted on 30 randomly selected waste collectors. The Pearson correlation coefficient (R) for the reliability of this questionnaire was 0.84. The initial evaluation indicates that the questionnaire has excellent test-retest reliability. The first and the second parts of the questionnaire included ten and seven items for rating occupational physical and organizational demands, respectively. The subjects rated each item on a four-point scale ranging from very low to very high (Translated version is shown in Appendix 1).

*c) Nordic musculoskeletal questionnaire (NMQ)*: The validated and reliable Persian version of NMQ was used to determine the prevalence rate of MSDs symptoms (pain or discomfort) in nine body regions among waste collectors during the past 12 months. This questionnaire has been commonly used to determine the prevalence of MSDs symptoms in various occupational groups around the world, so we decided to use it in the present study for the waste collectors. The subjects also rated the severity of MSDs symptoms using body map and numeric rating

scales ranging from zero (no pain/discomfort) to nine (unbearable pain/discomfort) [22, 23].

*Data analysis*

The data were analyzed using SPSS (version 21). Quantitative and qualitative variables were described as mean (SD) and percentages, respectively. Binary logistic regression analysis was used for prediction of independent variables (individual, physical, and organizational) for MSDs symptoms. Significant predictors for MSDs in the bivariate analysis were entered into the regression model. A $p \leq 0.05$ was considered to be statistically significant. Multiple logistic regression analysis (forward LR) was performed for modeling of MSDs risk factors in each body region.

## Results

*Individual characteristics*

Two hundred waste collectors with at least one year of job experience participated in the present study. Table 1 summarizes individual characteristics of the subjects. All workers were male, and their mean age and work experience were 35.49 ± 6.75 and 6.72 ± 5.04 yr, respectively.

**Table 1. Individual characteristics of the waste collectors participated in the study (n=200)**

| | | |
|---|---|---|
| Age (yr) | M ± SD (min, max) | 35.49 ± 6.75 (24, 57)[a] |
| Height (cm) | M ± SD (min, max) | 172.47 ± 7.48 (150, 198)[a] |
| Weight (kg) | M ± SD (min, max) | 66.75 ± 8.48 (45, 90)[a] |
| Body mass index (kg/m$^2$) | M ± SD (min, max) | 22.45 ± 2.58 (16.9, 28.7)[a] |
| Work experience as municipality worker (yr) | M ± SD (min, max) | 8.05 ± 5.52 (1, 22)[a] |
| Work experience as waste collector (yr) | M ± SD (min, max) | 6.72 ± 5.04 (1, 22)[a] |
| Daily working time (h) | M ± SD (min, max) | 8.36 ± 0.56 (7, 9.5)[a] |
| Waste collecting duration (h) | M ± SD (min, max) | 6.70 ± 0.74 (5, 9)[a] |
| Marital status | Single | 7 (3.5%)[b] |
| | Married | 193 (96.5%)[b] |
| Number of children | Zero | 26 (13%)[b] |
| | One | 48 (24%)[b] |
| | Two | 88 (44%)[b] |
| | Three | 33 (16.5%)[b] |
| | Four | 5 (2.5%)[b] |
| Education | Illiterate | 15 (7.5%)[b] |
| | Elementary | 72 (36%)[b] |
| | Intermediate | 89 (44.5%)[b] |
| | Diploma | 24 (12%)[b] |
| Working schedule | Day | 22 (11%)[b] |
| | Night | 178 (89%)[b] |
| Smoking | Yes | 100 (50%)[b] |
| | No | 100 (50%)[b] |
| Regular exercise | Yes | 46 (23%)[b] |
| | No | 154 (77%)[b] |
| Second job | Yes | 12 (6%)[b] |
| | No | 188 (94%)[b] |

[a]Values are M ± SD (min, max), [b]Values are frequency (%).

*Motion and timeline analysis*

Table 2 shows the motion and timeline analysis of waste collection during shift work. A total of 2,584 motions were carried out during 300 min of waste collection. The most and the least proportion of time during waste collection were allocated to the stoop lifting bag/bucket and pulling/pushing waste container, respectively (Table 2).

*Physical and organizational demands*

Figure 2 shows the level of physical demands among the waste collectors. The most and the least physical demands were related to running along with bag carriage and walking without bag carriage, respectively. It's worth noting that 46% and 39% of the waste collectors reported high and very high physical workload, respectively. Figure 2 also shows the level of organizational demands among the waste collectors. The most and the least organizational demands were related to time pressure of waste collection and coworkers' support, respectively. About 38% and 36.5% of waste collectors reported high and very high psychological workload, respectively.

*Prevalence of MSDs symptoms*

Totally, 92.5% of waste collectors reported MSDs symptom at least in one body region during the last 12 months. Figure 3 shows the reported MSDs symptoms in different body regions of the waste collectors. The most prevalent MSDs were related to lower back (63%), knee (60.5%), ankle/foot (45%), and shoulder (39%) regions. About 41.5% and 37.5% of waste collectors had restrictions on occupational/home activities due to lower back and knee injuries, respectively. About 35% of waste collectors had to visit a doctor for MSDs treatment, and 23% of them took medical rest due to musculoskeletal injuries. Also, 10% of workers referred to a physiotherapist for relieving the severity of pain caused by MSDs. About 53% of waste collectors reported that MSDs might make them leave their jobs in the future. It should be noted that 20% of the workers experienced temporary job leave due to MSDs. Based on body map scale, the lower back (mean ± SD; 4.08 ± 3.51) and knee (mean ± SD; 3.61 ± 3.32) had the most severe pain/discomfort among nine body regions.

**Table 2.   Motion and timeline analysis of waste collection during shift work (300 min)**

| Observed motions | Frequency of motion | Time average of motion(s) | Time allocated to motion(s) | Relative duration (%) |
|---|---|---|---|---|
| Stoop lifting bag/bucket | 829 | 3.85 | 3,192 | 17.73 |
| Semi-squat lifting bag/bucket | 146 | 3.96 | 578 | 3.21 |
| Pulling/pushing waste container | 64 | 9.02 | 577 | 3.20 |
| Walking without bag/bucket carriage | 393 | 8.09 | 3,179 | 17.66 |
| Walking along with bag/bucket carriage | 465 | 5.90 | 2,744 | 15.25 |
| Running without bag/bucket carriage | 276 | 6.58 | 1,816 | 10.09 |
| Running along with bag/bucket carriage | 141 | 4.82 | 680 | 3.78 |
| Jumping up/down on the garbage truck | 143 | 20.64 | 2,951 | 16.39 |
| Picking up/dumping trash containers by a hand lever | 65 | 23.38 | 1,520 | 8.45 |
| Stopping or standing | 62 | 12.30 | 763 | 4.24 |
| Total | 2,584 | 6.966 | 18,000 | 100 |
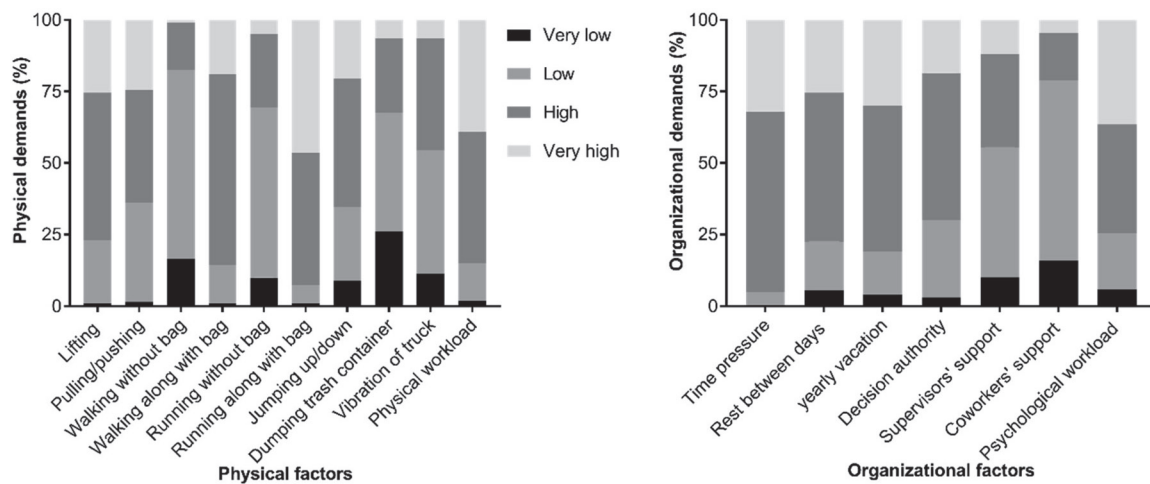


**Fig. 2.   Rating of occupation-specific physical and organizational demands among the waste collectors (n=200).**
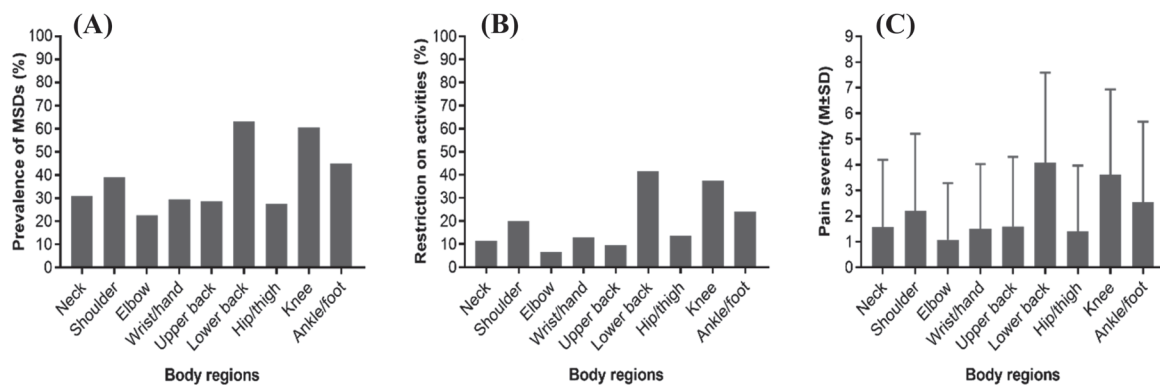


**Fig. 3.   Reported MSDs symptoms in nine body regions of the waste collectors (n=200). (A) MSDs symptoms during the last 12 months; (B) Restrictions on occupational/home activities due to MSDs; (C) Pain/discomfort severity of MSDs symptoms (expected score from body map numerical scale was zero to nine).**

*Risk factors associated with MSDs symptoms*

Table 3 presents significant risk factors associated with MSDs symptoms for each body region. Multiple logistic regression showed that some of the individual, physical, and

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Table 3. Risk factors associated with MSDs symptoms in different body regions of the waste collectors (n=200)

| Body region | Variables retained in the model | Category | Odds ratio (95%CI)* | p-value |
|---|---|---|---|---|
| Neck | Picking up/dumping trash containers by a hand lever | Low demand | Reference | |
| | | High demand | 3.03 (1.58–5.82) | 0.001 |
| | Vacation throughout the year | High vacation | Reference | |
| | | Low vacation | 4.10 (1.48–11.40) | 0.007 |
| Shoulder | Lifting bag/bucket | Low demand | Reference | |
| | | High demand | 2.45 (1.16–5.18) | 0.019 |
| Elbow | Body weight | >65 kg | Reference | |
| | | ≤65 kg | 2.43 (1.14–5.15) | 0.021 |
| | Picking up/dumping trash containers by a hand lever | Low demand | Reference | |
| | | High demand | 3.29 (1.59–6.83) | 0.001 |
| | Lifting bag/bucket | Low demand | Reference | |
| | | High demand | 6.19 (1.39–27.59) | 0.017 |
| Wrist/Hand | Physical workload during work time | Low demand | Reference | |
| | | High demand | 4.36 (1.26–15.07) | 0.020 |
| Upper back | Pulling/pushing waste container | Low demand | Reference | |
| | | High demand | 2.38 (1.18–4.80) | 0.016 |
| Lower back | Age | ≤35 yr | Reference | |
| | | >35 yr | 2.28 (1.18–4.39) | 0.014 |
| | Education | Low education | Reference | |
| | | High education | 2.10 (1.10–3.99) | 0.024 |
| | Waste collecting duration | Short time | Reference | |
| | | Long time | 2.38 (1.26–4.48) | 0.007 |
| | Lifting bag/bucket | Low demand | Reference | |
| | | High demand | 3.94 (1.90–8.15) | <0.001 |
| Hip/Thigh | Pulling/pushing waste container | Low demand | Reference | |
| | | High demand | 2.81 (1.26–6.28) | 0.011 |
| | Decision authority in performing work duties | Low authority | Reference | |
| | | High authority | 2.09 (1.04–4.20) | 0.039 |
| Knee | Walking along with bag/bucket carriage | Low demand | Reference | |
| | | High demand | 3.94 (1.59–9.76) | 0.003 |
| | Jumping up/down on the garbage truck | Low demand | Reference | |
| | | High demand | 2.14 (1.13–4.06) | 0.019 |
| Ankle/Foot | Physical workload during work time | Low demand | Reference | |
| | | High demand | 3.99 (1.52–10.50) | 0.005 |

organizational factors were associated with risk of reported MSDs. Age, body weight, level of education, and waste collecting duration were the significant individual factors retained in the regression model (OR>2). As Table 3 shows, some items of physical demands (i.e., picking up/dumping trash containers by a hand lever, lifting bag/bucket, pulling/pushing waste container, walking along with bag/bucket carriage, and jumping up/down on the garbage truck) as well as organizational demands (i.e., low vacation throughout the year, and high decision authority in performing work duties) are the significant associated risk factors with MSDs symptoms in different body region (OR>2).

## Discussion

*Prevalence of MSDs symptoms*

In the present study, 92.5% of municipal waste collectors reported MSDs symptoms at least in one of the nine defined body regions during the last 12 months. Previous studies in developing countries showed that the prevalence of MSDs symptoms among waste collectors were 60.8% in Egypt-Mansoura[19], 61.3% in Nigeria-Port Harcourt[2], 65% in Iran-Tehran[1], 70% in India-Chennai[21], 79% in India-Mumbai[24], and 88.2% in Brazil-Pelotas and Rio Grande[25]. The prevalence of MSDs has also been high even in developed countries such as Germany, Nether-

lands, and USA[6, 7, 26]. Two different studies in South Korea reported that the prevalence of MSDs symptoms among municipal sanitation workers, waste collectors and street cleaners, were 44.8% in Seoul[27], and also 72.2% in Seoul & Gyeonggi[28]. One study among Iranian workers in different industries showed that prevalence rates of MSDs at least in one body region are the highest among health-care workers (90.3%), followed by manufacturing industries (86.9%), hand-weaving industry (79.7%), office workers (74.7%), and petrochemical workers (61.5%), respectively[29]. Prevalence of MSDs among the waste collectors who participated in this study was higher than Iranian workers in different occupations[29]. Generally, these results depicted that waste collection job can lead to high level of MSDs symptoms among workers.

Lower back, knee, and ankle/foot problems were more prevalent and more severe among municipal waste collectors of Shiraz city. A high rate of reported symptoms in lower back, knee and ankle/foot was expected due to the frequent stoop lifting of bag/bucket as well as the long period of bag carriage. Lower back symptom (63%) was the most prevalent problem. This is in agreement with the results of other studies conducted on the municipal waste collectors[1, 6, 19, 30]. Reddy *et al.* reported that knee (60%), shoulder (38.6%), and lower back (34.5%) injuries were the most prevalent problem among Indian (Chennai) waste collectors[21]. Another study among Indian (Mumbai) waste pickers showed that lower back (54%), knee (48%), and upper back (40%) were the most prevalent MSDs[24]. Zakaria *et al*. reported that the most prevalent MSDs injuries were related to lower back (54.5%) and upper back (27.3%) among Malaysian waste collectors[30]. Due to the different methods of the waste collection around the world, the prevalence of MSDs among the waste collectors have minor differences in various studies. But most studies showed that low back injuries had the greatest contribution among the nine defined body regions of these workers[1, 6, 19, 24]. It is worth noting that the prevalence of low back injuries among waste collectors in this study was higher than that of low back problems in Iranian health-care workers (57.9%), and manufacturing industries (56.2%)[29], as well as stone mining (39%), and stone industry workers (54%)[31].

In the present study, 35%, 23%, and 10% of waste collectors had to seek for medical treatment, took medical rest, and referred to physiotherapy for relieving severe pain caused by MSDs, respectively. The previous study among employees of an Iranian petrochemical industry was also reported that 33.2%, 13.4%, and 7.7% of participants had to visit a physician, take medical rest, and use physiotherapy service, respectively[32]. Alan and Leung pointed out that "among 24 workers that were interviewed, only two had consulted physicians owing to the neck problem, three workers had sought medical help because of the back problem and no employee had visited doctors or health care providers for any musculoskeletal treatment"[33]. Woods and Buckle. stated that 52% of cleaners were seeking medical advice[34].

About half of the waste collectors in the present study reported that MSDs might make them leave their jobs. In their opinion, back pain is one of the most likely causes for their job leaving in the future. The results of one study among recently qualified eldercare trainees in Denmark showed that duration and severity of low back pain in the last year were predictors for job change 2 yr later[8].

*Risk factors associated with MSDs symptoms*
Individual risk factors

Multiple logistic regression analysis showed that some of the individual factors such as age, education, body weight, and waste collecting duration were the significant predictors for MSDs in different body regions of the waste collectors.

Higher age was an independent factor for MSDs in the lower back (OR=2.28). Similar to the present study, Reddy and Yasobant and Salve *et al.* also reported a positive relationship between age and MSDs among Indian solid waste workers[21, 35]. On the contrary, Abou-ElWafa *et al.* showed that age was not an independent factor for developing MSDs among Egyptian waste collectors[19].

In this study, high level of education was associated with high risk of MSDs in lower back (OR=2.10). Other studies in Iran[1] and in Egypt[19] revealed that education was not an associated factor for MSDs among waste collectors. In contrast, Reddy and Yasobant depicted that low level of education such as primary education and illiteracy were associated with high risk of MSDs with ORs of 4.46 and 6.73, respectively[21]. It may be assumed that high-educated workers lift loads from the ground in a more appropriate style, but time pressure and rapid collection of waste require that these workers, like their low-educated coworkers, lift loads in an inappropriate stoop style. Although the relationship between the levels of education with MSDs among municipality workers is still uncertain, the positive relationship found in the present study is probably due to more accurate self-report of workers with higher education levels.

Lower body weight (≤65 kg) was associated with higher risk of elbow pain among the waste collectors (OR=2.43).

Previous studies showed that lower weight is associated with lower risk for MSDs[19, 21, 25]. Less elbow pain among higher-weighted workers in this study is probably due to the strength of workers' upper extremity. If we assume that lower-weighted workers have less muscle in their body, this might require imposing higher force to load the two-wheeled container on the forks of the truck lifter. These workers might need to apply more force to drag up/down the hand lever in activities such as picking up, emptying, and dumping the trash containers. There might be so many other reasons for this finding, but this outcome shows that for future studies more variables should be investigated when body weight is included in regression analysis.

As expected, the results shows that collection of waste for long periods of time ($\geq$7 h) is associated with MSDs in the lower back (OR=2.38). This can be due to repeated and prolonged motions such as bending at the waist during the waste collection. Luttmann *et al.* suggested at least a 10 min rest break per hour while collecting four-wheeled containers[36].

Physical risk factors

Using multiple logistic regression analysis revealed that some of the physical demands were significant predictors for MSDs in different body regions of the waste collectors with OR>2. These physical demands included picking up/dumping trash containers by a hand lever, lifting bag/bucket, pulling/pushing waste container, walking along with bag/bucket carriage, and jumping up/down on the garbage truck.

Picking up/dumping trash containers by a hand lever was associated with high risk of MSDs in the neck (OR=3.03) and elbow (OR=3.29). The main observed postures to do this task were neck bending, static arm abduction, holding arm at/above shoulder level, and frequent elbow extension. In contrast, Abou-ElWafa *et al.* reported that neck bending/twisting and also holding arm at or above shoulder level were not as risk factors for MSDs among municipality waste collectors[19]. Woods and Buckle stated that main observed risk factors among cleaners were static neck flexion, excessive wrist deviations, frequent arm abduction, back rotation and flexion[34]. Fabrizio mentioned that the workers who often expose to awkward and sustained postures and repetitive motions of the upper extremities will develop pain in their shoulder and neck[37].

Lifting bag/bucket was associated with high risk of MSDs in the shoulder (OR=2.45), lower back (OR=3.94), and elbow (OR=6.19). Waste collectors in this task had frequent excessive back flexion, back rotation, and repetitive arm abduction, and as well as static elbow extension during bag holding and carrying. Adopting such postures along with repeated exertion of force for a long period of time makes workers susceptible to MSDs. It seems that one of the possible reason for shoulder and elbow pain is throwing bags off during loading the garbage truck. Woods and Buckle also stated that cleaners who lifted the equipment frequently were more likely to report pain and discomfort than those who did not do this task (OR=3.4)[34]. Milhem noted that 37.4% of waste collectors lifted more than their capacities[38]. Ncube *et al.* pointed that trunk severe flexion (20–60°) and neck flexion (>20°) were common during quickly and forcefully lifting the refuse bins by waste collectors[39]. Zakaria *et al.* showed that 43.2% of the waste collectors' working posture was at the high level of risk. The aforementioned study reported that workers bend their back and also stretch their arm and shoulder when they lift the garbage bins[30]. Sommerich *et al.* pointed that awkward or static postures, heavy work, direct load bearing, repetitive arm movements, working with hands above shoulder height, and lack of rest were associated risk factors with shoulder injuries[40]. One of the corrective actions is the use of wearable loading auxiliary equipment, such as exoskeleton, to reduce the pressure on workers' musculoskeletal system and thus to prevent the incidence of MSDs, especially low back pain among waste collectors.

Pulling/pushing waste container was associated with high risk of MSDs in the upper back (OR=2.38), and hip/thigh (OR=2.81). The main risk factors observed in this task were high force exertion by upper and lower limbs and also the partial flexion in the upper part of the trunk. Hoozemans *et al.* pointed that an increased risk of shoulder and low back injuries are associated with regular push/pull work[41]. Abou-ElWafa *et al.* reported that pulling, pushing, lifting, and carrying loads >20 kg were independent risk factors for developing musculoskeletal symptoms among municipality solid waste collectors (OR=5.5)[19]. Milhem stated that 35.6% of waste collectors had slip and trip experience while pulling or pushing the waste trolley[38].

Walking along with bag/bucket carriage was associated with high risk of MSDs in the knee (OR=3.94). When waste collectors had to carry several garbage bags at the same time, they usually went to the truck with a walking or jogging mode. Therefore, the knee pain could be expected due to the excessive weight of the bags in walking mode during their daily works. It should be noted that the lighter load was usually associated with running mode

among waste collectors. Abou-ElWafa *et al.* showed that walking for long periods of time was independently associated with the likelihood of musculoskeletal symptoms occurrence (OR=2.6)[19]. Woods and Buckle showed that cleaners who carried the load frequently had more risk for MSDs than those who did not do (OR=4.1) or did this task occasionally (OR=2.1)[34]. An effective administrative measure is to put more garbage bins in the streets and alleys to reduce the long distance walking along with bag carriage, as well as to reduce the frequency of bending of workers while taking the garbage from the ground as the most important risk factor for MSDs occurrence.

Jumping up/down on the garbage truck was associated risk factor with knee pain and discomfort (OR=2.14). Cardoso *et al.* noted that the repetitive movements and loads, running and crouching, jumps to go up and down the truck, as well as footwear without a good damping sole might be the main associated risk factors for knee and leg injuries[25]. One of the engineering measures is to lower the platform height behind the garbage truck to reduce the pressure on the knee while waste collectors jump up and down from the platform.

Physical workload during work time was an independent risk factor for MSDs in ankle/foot (OR=3.99) and wrist/hand (OR=4.36). Cardoso *et al.* depicted that high volume of waste was one of the factors associated with MSDs among waste collectors. The workers had to collect waste in average 8.5 h and in some days up to 14 h[25]. Woods and Buckle reported that high workload (i.e., working under time pressure, keeping up with work, difficulty in doing a good job in the time allocated, never having enough time to complete the work) was associated with MSDs among cleaners. Those who frequently had difficulty keeping up with their work were more likely to report pain and discomfort than those who did not (OR=5.8)[34].

Organizational risk factors

Low vacation throughout the year was an independent risk factor for neck pain and discomfort among waste collectors (OR=4.1). As expected, accumulation of physical stress on the musculoskeletal system due to low vacation and rest can be a contributing factor in the occurrence of MSDs. One of the administrative measures is recruiting more waste collectors to provide them more vacations and reduce the cumulative tensions on their musculoskeletal system, thereby reducing the occurrence of MSDs among waste collectors.

In the present study, about one-third of the waste collectors had high decision authority in performing their work

duties. High decision authority was associated with high risk of MSDs in hip/thigh region (OR=2.09). Garbage in any area of streets and alleys should be collected by two waste collectors, so their workload is almost constant. Workers with high authority collect the garbage faster and without the break so that they can return home sooner. As a result, heavy physical work without frequent rest to relieve muscle fatigue can lead to MSDs. In contrast, one study stated that low decision latitude was associated with high risk of MSDs among waste collectors. Of course, this study noted that "the pace of work and opportunities for rest and recovery should be considered when assessing the risk of MSDs"[19]. Torp *et al.* also reported that low decision authority or job control (control over work speed, breaks, decisions etc.) predicted neck, low back, and total musculoskeletal pain among workers at automobile repair garages[42]. Woods and Buckle depicted that the majority of cleaners were able to decide how to work (55% often; 31% sometimes) but reported low control over what they did at work (53%) and when they could take rest breaks (38%)[34]. The aforementioned study noted that there wasn't an increased risk of pain and discomfort for those who did not have a choice in how/what they did at work and when to take breaks[34]. It should be noted that the psychological workload was not an independent risk factor for MSDs among the waste collectors who participated in the present study. In contrast, Choobineh *et al.* founded the significant association between psychological demands and reported MSDs among workers of a petrochemical industry[32]. Torp *et al.* also reported that psychological demands were a predictor variable for MSDs symptoms[42].

This study has some limitations; the collected data on MSDs were mainly self-reported not the medical diagnosis. Most workers had the low level of education, hence there was a possibility of bias due to subjective responses. Regarding the cross-sectional design of the study and the data collection by a self-report method, the findings of this study should be interpreted with caution. Finally, since the analysis was limited to currently working employees, workers who had left jobs due to musculoskeletal symptoms might have been excluded. Thus, the data may underestimate reported symptoms and the association of perceived demands with MSDs. Selection bias may exist due to enrolling the voluntary waste collectors in this study.

Some of the study's strengths include: i) use of validated data collection tools and ii) the study was undertaken in a developing country, which helps to fulfil the lack of research in such contexts.

## Conclusion

The results of the present study showed that the prevalence rate of MSDs was high among municipality waste collectors during the last year prior to the study. The most prevalent MSDs symptoms were reported in the lower back, knee, ankle/foot, and shoulder regions. Some occupation-specific physical demands such as lifting bag/bucket, pulling/pushing waste container, walking along with bag/bucket carriage, picking up/dumping trash containers by a hand lever, and jumping up/down on the garbage truck were the most important risk factors for developing MSDs. Some organizational demands including low vacation throughout the year and high decision authority in performing work duties were also associated with risk of MSDs. Taking ergonomic corrective measures such as newly designed engineering tools, administrative control, and personal protective devices seemed necessary for reducing the prevalence rate of MSDs. Waste collectors also needed to be aware of the problems of forceful, rapid and repetitive postures, and stoop lifting method through training.

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## Conflicts of interest

The authors have no personal benefit in conducting this study and there are no conflicts of interest.

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# Appendix 1. Translated version of occupation-specific physical and organizational demands questionnaire

**Part 1: Physical factors**

| Items | Very low | Low | High | Very high |
|---|---|---|---|---|
| Lifting bag/bucket | | | | |
| Pulling/pushing waste container | | | | |
| Walking without bag/bucket carriage | | | | |
| Walking along with bag/bucket carriage | | | | |
| Running without bag/bucket carriage | | | | |
| Running along with bag/bucket carriage | | | | |
| Jumping up/down on the garbage truck | | | | |
| Picking up/dumping trash containers by a hand lever | | | | |
| Vibration during standing on the platform behind the garbage truck | | | | |
| Physical workload during work time | | | | |

**Part 2: Organizational factors**

| Items | Very low | Low | High | Very high |
|---|---|---|---|---|
| Time pressure of waste collection | | | | |
| Rest between working days to relieve fatigue | | | | |
| Vacation throughout the year | | | | |
| Decision authority in performing work duties | | | | |
| Supervisors' support | | | | |
| Coworkers' support | | | | |
| Psychological workload during work time | | | | |