

## Ergonomic Risk Factors Evaluation of Work-related Musculoskeletal Disorders by PATH and MMH in a Construction Industry

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### ABSTRACT

One of the prevalent injurious factors and disabilities is work-related musculoskeletal disorders (WMSDs). The aim of this study is to evaluate the risks of ergonomic factors inducing musculoskeletal disorders consequent from industrial construction by means of PATH (Posture, Activity, Tools and Handling) risk evaluation and MMH (Manual Material Handling). A cross-sectional study was conducted on 357 construction workers working in 21 different jobs of construction industry in Parand New City, south-west of Tehran, Iran. Nordic musculoskeletal questionnaire (NMQ) was used to determine the prevalence of musculoskeletal disorders. PATH was served to assess different body part postures such as back, feet, hands, also weight of tools and equipment and catching by hand (hand-catch). Most prevalence of musculoskeletal disorders was around back (30.5%) and knee (28.9%), and in opposed side elbow (4.2%) respectively. The results of Nordic musculoskeletal questionnaire (NMQ) showed that there is meaningful relation through pain of neck, wrist, hand, back and knee with workers age and working experience ( $P < 0.05$ ). Also through the different jobs under study in PATH method, there is different significant statistical results ( $P < 0.05$ ) in the postures of back, feet and hands, tools & Equipment weight and hand-catch (grabbing or taking by hand). The non-neutral postures were observed in some parts such as back (more than 30%), feet (more than 40%) and hands (more than 15%). PATH can be referred as a sensitive and efficient risk evaluation technique in construction industry, as well as MMH is a complementary method for more precision assessment of manual material handling risks in jobs involved in PATH high scores.

**Key words:** Risk Evaluation, Ergonomic Risk Factors, Musculoskeletal Disorders, PATH, MMH, Construction Industry

### LIST of ABBREVIATIONS

**WMSDs:** Work-related musculoskeletal disorders;  
**PATH:** Posture, Activity, Tools and Handling;  
**MMH:** Manual Material Handling;  
**NMQ:** Nordic Musculoskeletal Questionnaire;  
**OWAS:** Ovako Working Posture Assessment System;  
**RULA:** Rapid Upper Limb Assessment;  
**REBA:** Rapid Entire Body Assessment;  
**TRAC:** Task Reducing and Analysis on Computer.

### INTRODUCTION

Multi-factorial interactions of different risk factors cause work-related musculoskeletal disorders (WMSDs) that can be divided into three basic groups including individual, psychosocial, and physical. Among the physical the most common factors are workload, body posture, repetitive and forceful activities, static muscle load, mechanical stress, vibration and cold [1-4].

Building and construction is one of the oldest activities of mankind [5]. Construction workers are exposed to a variety of ergonomic hazards, including improper postures, repetitive motions, heavy lifting, and vibrations [3, 6-9]. With attention to dynamic nature of industrial construction jobs, workers are effected for long time on improper postures with using force on around joints and muscles in different part of their body. Construction workers also experience an elevated risk of musculoskeletal disorders [10-16].

Nowadays there are different available methods to evaluate risks factors related with musculoskeletal disorders and or risk factors in specific job. These methods are observational method, tools methods (or direct method), questioner method which person reported itself and or are other mental-physiological methods [17]. The direct methods are including electromyography and electro-goniometer. These methods are less applicable because of some problems such as worker ambulation, inconvenience in the work, and more cost in buildings works. But on the other hand observational methods such as PATH [18], TRAC [19], REBA [20], RULA [21] and OWAS [22] could be easily more useful [11]. Emphasizing to more outbreak of development of musculoskeletal disorders that resulted from jobs, Prevention of this kind of disorders are especially important in the recent decades. In order to prevent skeletal-Muscular disorders resulted from work and supporting and providing manpower health, ergonomics as effective approach is helping human, measuring human abilities and then organize and regulate the machinery, work and environment according to them. Nowadays, prevent and control of skeletal-muscular disorders from work, with due attention to too much outbreak of that interested many researchers and research institutes. Therefore the target of this study is evaluating ergonomics risk factors which creating musculoskeletal disorders resulted from work in construction jobs with methods of PATH and MMH.

## MATERIALS AND METHODS

### Data gathering Methods

This study is cross sectional, descriptive- analytical. The social or people under this study are from all jobs of constructing building in Parand New City 20000-unit housing project which is in south west of Tehran Province, done by KAYSON company as Contractor in the year of 1392, the buildings under study been residential ones with concrete structure.

In order to collect data, modulation of 4 tools are used which contain direct observation or walking-talking through (to consider process and working situation also analysis of jobs and responsibilities), interview (for getting information regarding working condition and body postures), standardized Nordic musculoskeletal questionnaire (in order to determine outbreak rates of pain symptoms and signs of Musculoskeletal disorders of upper organs), PATH Risk evaluation (Posture, Activity, Tools and Handling: PATH) and also evaluating of manual handling risks (Manual Material Handling: MMH) (to defining the level of contact of building employees with risks factor which determinate

Musculoskeletal disorders resulted from work and providing ergonomics control solutions in order to improve and correct working situation and also decrease outbreak rate of Musculoskeletal disorders with the target of remove, decrease or eliminate and reach to minimize ergonomic risk factors).

### Sample size

Statistical sample size was calculated by using Power SSC software considering maximum 0.05 acceptable errors, expected population 0.4, confidence level 99% and total population 1576 persons, number of random samples got to 335 persons. . In the occupations that the number of personnel was less than 20 persons all of the personnel were taken for the study otherwise according to volume of sample selection, total sample size proposed and calculated was 357 persons.

Also with use of following statistic formula it is possible to calculate number of needed sample for study. Through previous followed study which was related to musculoskeletal disorders, different consequences were observed from disorders outbreak percentage level in different part of body that with minimum level of disorders percent Musculoskeletal in neck areas (28.1%) and using ratio formula, the number of needed sample resulted as following:

$$n = \frac{\left(z_{1-\frac{\alpha}{2}}\right)^2 \times P \times (1-P)}{d^2} = \frac{1.96^2 \times 0.281 \times 0.719}{0.0467^2} = 357$$

(1)

where, n is the sample size [23] that is calculated by

knowing  $z_{1-\frac{\alpha}{2}}$  as the selected critical value of desired confidence level, P as the estimated proportion of an attribute rate in the present studied population, d as the level of precision.

### Ergonomic risk factors identification and evaluation

In this paper, three various procedures are utilized for identification and evaluation of ergonomic risk factors as follows:

I) Nordic Musculoskeletal Questionnaire (NMQ)

Kuorinka *et al.* designed and introduced a questionnaire for determining the prevalence of musculoskeletal disorders in occupational health and safety institute of Scandinavian countries that this questionnaire became as the most important occupational surveying questionnaire and so-called as "Nordic Musculoskeletal Questionnaire; NMQ" [24]. In this study, first of all with exploit from NMQ, demographic information of study participants (such as: age, height, weight, work experience and etc.) and also outbreak rate of musculoskeletal disorders of 357 employees of occupations in PARAND

Workshop who minimum having one year experience, were collected.

## II) PATH method

PATH (Posture, Activity, Tools and Handling) considered and used by Buchholz *et al.* in 1996 [18] in construction jobs was used in order to evaluate ergonomically risk factors of musculoskeletal disorders. PATH is a work sampling-based approach to ergonomic job analysis for construction and other non-repetitive work. This method is used in non-repeated jobs for ergonomic evaluation of postures, activities, manual tools and lifting tools. PATH Method is made and established based on using codes in OWAS Method. The paper of getting PATH information has 2 columns. In the first column of this paper the postures of different parts of body (organ, feet and hands), the material weight & Carry able tools and hands activity were registered. In the second column of these paper general activities, specific activities and manual tools used by workers are registered. Body Posture having 5 codes, feet posture 10 codes and hand postures 3 codes and the weights under studying been in 6 different groups [18].

## III) Manual materials handling (MMH)

Finally, according to this item that manual handling in construction works is Inevitable, MMH method is used. Meaning that if load weight is over 23kg or 51 Pound, using this method is mandatory. Using MMH method in long term or short term can create side effects such as: rupture, chafe, fracture, heart & blood vessels tensions, musculoskeletal disorders and finally back pain. An equation was developed for the first time in 1981 by National Institute for Occupational Safety and Health (NIOSH) to help safety and health practitioners evaluate lifting demands in the sagittal plane. Then, this equation was developed in 1991 to apply to a larger percentage of lifting tasks. The developed equation (1991 equation) is defined as follows [25]:

$$LI = \frac{L}{RWL} \quad (2)$$

Where LI is lifting index which defines the physical tension in a specific job, L is load weight or weight of equipment which shall be lifted up and RWL is the Recommended Weight Limit for especial condition to lift the load.

That if lifting tasks with a lifting index is over than one ( $LI > 1$ ) pose an increased risk for lifting-related low back pain for some fraction of the workforce [25]. The horizontal distance of the hands at the midpoint of hand-grip from midpoint between the ankles, vertical distance of the hands from the floor at the origin of the lift measured vertically from the floor to the mid-point between the hand grasps,

vertical travel distance between the origin and the destination of the lift, angle of asymmetry, frequency of lifting, and hand-to-container coupling are defined by a variable in RWL. The horizontal distance of the hands at the midpoint of hand-grip from midpoint between the ankles, vertical distance of the hands from the floor at the origin of the lift measured vertically from the floor to the mid-point between the hand grasps, vertical travel distance between the origin and the destination of the lift, angle of asymmetry, frequency of lifting, and hand-to-container coupling are defined by a variable in RWL. Recommended that if LI is over than one there is hazard probability for lower side of back According to the procedure, in different LI values one the below method must be follow followed:

- In jobs which  $LI \leq 1$ : it is OK and no need to change.
- In jobs which  $1 < LI < 3$ : corrective action is needed to reduce stress.
- In jobs which  $LI \geq 3$ : working system must be changed.

## Data analysis

Finally the collected data entered in SPSS version18 software and in descriptive statistic level the indexes such as frequency, percentage, average, variance, minimum and maximum have been used and in inferential statistic level the chi-square test and general linear models have been used for ratings data and P-value less than 0.05 were considered.

## RESULTS

In this study, 5000 observations from 357 construction workers in 21 jobs have been done. According to Table 1, average age of studied workers was  $33.06 \pm 10.40$  and their work experience was between 1 to 5 years with the average of  $9.08 \pm 9.60$  years. According to Table 2, the workers highest frequency were in painting, sentry, ceramic work and driving jobs and respectively includes 71 people (19.9%), 35 people (9.8%), 31 people (8.7%) and 25 people (7%).

As shown in Table 3, the highest incidence of musculoskeletal disorders was in waist area with 109 cases (30.5%) and knee with 103 cases (28.9%) and in return elbow with 15 cases (4.2%) had the lowest incidence.

**Table 1:** Statistical Indicators demographic characteristics of Parand workshop staff

| Factors                | Min. | Max. | Variance | Average |
|------------------------|------|------|----------|---------|
| Age (years)            | 18   | 64   | 10.40    | 33.06   |
| Work experience (year) | 1    | 50   | 9.60     | 9.08    |
| Height (cm)            | 155  | 190  | 7.02     | 174.77  |
| Weight (kg)            | 48   | 120  | 11.44    | 75.08   |

**Table 2:** Distribution of Parand workshop staff in terms of jobs

| Job            | Distribution (%) | Job                | Distribution (%) |
|----------------|------------------|--------------------|------------------|
| Painting       | 71 (19.9%)       | Forging            | 8 (2.2%)         |
| Sentry         | 35 (9.8%)        | Windows installer  | 11 (3.1%)        |
| Ceramic work   | 31 (8.7%)        | False ceiling      | 5 (1.4%)         |
| Cooking        | 13 (3.6%)        | Cement work        | 17 (4.8%)        |
| Safety officer | 12 (3.4%)        | Executive engineer | 16 (4.5%)        |
| Driving        | 25 (7%)          | Electrician        | 11 (3.1%)        |
| Wall builder   | 18 (5%)          | QC expert          | 9 (2.5%)         |
| Scaffolding    | 10 (2.8%)        | Piping             | 9 (2.5%)         |
| Plastering     | 11 (3.1%)        | Technical expert   | 9 (2.5%)         |
| Administration | 21 (5.9%)        | Carpentry          | 8 (2.2%)         |
| Restoration    | 7 (2%)           |                    |                  |

**Table 3:** Distribution of Parand workshop staff musculo-skeletal disorders in organs nine

| Body Parts     | Distribution | Percentage |
|----------------|--------------|------------|
| Neck           | 63           | 17.6%      |
| Shoulder       | 63           | 17.6%      |
| Elbow          | 15           | 4.2%       |
| Hand and wrist | 57           | 16%        |
| Back           | 42           | 11.8%      |
| Reins          | 109          | 30.5%      |
| Hip – thigh    | 19           | 5.3%       |
| Knee           | 103          | 28.9%      |
| Leg and ankle  | 49           | 13.7%      |

Musculoskeletal disorders assessment showed that:

The most frequency of neck disorders was related to the sentry job with 10 people (2.8%) and driving job with 7 people (1.96%). The most frequency of back, waist, hips and thighs disorders was related to painting job with 27 cases (7.56%) and operate engineer with the frequency of 19 cases (5.32%). The most frequency of large joints (shoulders, elbows, wrist, knees, legs and ankle) disorders was related to painting job with 50 cases (14.01%) and sentry job with 32 cases (8.96%). In the other words, we can say that jobs such as painting, sentry and ceramic work

had the higher risk of musculoskeletal disorders incidence that statistically with chi-square test job type has been recognized as an effective risk factor in musculoskeletal disorders incidence ( $P < 0.05$ ). Related results are in Table 4.

Results showed that trunk neutral posture in office jobs, operate engineering, safety officer, quality control expert had allocated 90% of the observations. The maximum and minimum percentages of trunk neutral postures respectively related to light bent mode and sharp bent mode. The most frequency of trunk posture in state of light bend mode observed in jobs such as restoration work (32.5%), cement work (28%) and plastering (25.5%) and in return the most frequency of trunk posture in state of sharp bend mode observed in jobs such as ceramic work (46.6%) and painting (31%) also painting job's trunk posture in state of bending and twisting compared to other jobs was more than 8% (Table 5).

Some jobs of construction industry involved in ergonomic risk factor assessment process can be seen in Fig. 1.

**Table 4:** prevalence of musculoskeletal disorders in various work groups in construction jobs

| Job type           | Various body organs |                            |              |
|--------------------|---------------------|----------------------------|--------------|
|                    | Neck                | Back, reins, hip and thigh | Large joints |
| Painting           | 6(1.67%)            | 27(7.56%)                  | 50(14.01%)   |
| Sentry             | 10(2.80%)           | 17(4.76%)                  | 32(8.96%)    |
| Ceramic work       | 4(1.12%)            | 18(5.04%)                  | 25(7.00%)    |
| Cooking            | 0(0%)               | 2(0.56%)                   | 3(0.84%)     |
| Safety officer     | 3(0.84%)            | 8(2.24%)                   | 16(4.48%)    |
| Driving            | 7(1.96%)            | 11(3.08%)                  | 17(4.76%)    |
| Wall builder       | 4(1.12%)            | 11(3.08%)                  | 14(3.92%)    |
| Scaffolding        | 3(0.84%)            | 6(1.68%)                   | 11(3.08%)    |
| Plastering         | 0(0%)               | 2(0.56%)                   | 0(0%)        |
| Administration     | 6(1.67%)            | 10(2.80%)                  | 17(4.76%)    |
| Restoration        | 0(0%)               | 4(1.12%)                   | 6(1.68%)     |
| Forging            | 3(0.84%)            | 5(1.40%)                   | 13(3.64%)    |
| Windows installer  | 2(0.56%)            | 5(1.40%)                   | 7(1.96%)     |
| False ceiling      | 0(0%)               | 0(0%)                      | 1(0.28%)     |
| Cement work        | 2(0.56%)            | 5(1.40%)                   | 3(0.84%)     |
| Executive engineer | 5(1.40%)            | 19(5.32%)                  | 28(7.84%)    |
| Electrician        | 1(0.28%)            | 1(0.28%)                   | 5(1.40%)     |
| QC expert          | 3(0.84%)            | 10(2.80%)                  | 12(3.36%)    |
| Piping             | 1(0.28%)            | 3(0.84%)                   | 14(3.92%)    |
| Technical expert   | 2(0.56%)            | 5(1.40%)                   | 2(0.56%)     |
| Carpentry          | 1(0.28%)            | 1(0.28%)                   | 11(3.08%)    |

Chi-squared statistic = 53.81 and significance value = 0.044, large joints include shoulders, elbows, wrist, knees, leg and ankle

**Table 5:** distribution of observations based on trunk postures with PATH method in studied construction jobs

| Jobs               | Trunk posture |               |               |                             |                      |
|--------------------|---------------|---------------|---------------|-----------------------------|----------------------|
|                    | Neutral       | Light bending | Sharp bending | Bending to side or twisting | Bending and twisting |
| Painting           | 332(47.4%)    | 100(14.3%)    | 217(31%)      | 32(4.6%)                    | 19(2.7%)             |
| Ceramic work       | 132(26.4%)    | 112(22.4%)    | 233(46.6%)    | 16(3.2%)                    | 6(1.2%)              |
| Sentry             | 155(77.5%)    | 31(15.5%)     | 9(4.5%)       | 1(0.5%)                     | 4(2%)                |
| Driving            | 188(94%)      | 0(0%)         | 0(0%)         | 12(6%)                      | 0(0%)                |
| Safety officer     | 191(95.5%)    | 4(2%)         | 5(2.5%)       | 0(0%)                       | 0(0%)                |
| Executive engineer | 185(92.5%)    | 7(3.5%)       | 8(4%)         | 0(0%)                       | 0(0%)                |
| Forging            | 127(63.5%)    | 29(14.5%)     | 29(14.5%)     | 7(3.5%)                     | 8(4%)                |
| False ceiling      | 134(67%)      | 32(16%)       | 32(16%)       | 2(1%)                       | 0(0%)                |
| Restoration        | 86(43%)       | 65(32.5%)     | 44(22%)       | 2(1%)                       | 3(1.5%)              |
| Administration     | 191(95.5%)    | 5(2.5%)       | 4(2%)         | 0(0%)                       | 0(0%)                |
| Plastering         | 114(57%)      | 51(25.5%)     | 30(15%)       | 4(2%)                       | 1(0.5%)              |
| Scaffolding        | 112(56%)      | 31(15.5%)     | 47(23.5%)     | 4(2%)                       | 6(3%)                |
| Cement work        | 110(55%)      | 56(28%)       | 14(7%)        | 16(8%)                      | 4(2%)                |
| Wall builder       | 142(71%)      | 36(18%)       | 14(7%)        | 8(4%)                       | 0(0%)                |
| Technical expert   | 100(100%)     | 0(0%)         | 0(0%)         | 0(0%)                       | 0(0%)                |
| QC expert          | 187(93.5%)    | 6(3%)         | 7(3.5%)       | 0(0%)                       | 0(0%)                |
| Piping             | 219(73%)      | 36(12%)       | 33(11%)       | 8(2.7%)                     | 4(1.3%)              |
| Electrician        | 202(67.3%)    | 44(14.7%)     | 24(8%)        | 26(8.7%)                    | 4(1.3%)              |
| Carpentry          | 113(56.5%)    | 48(24%)       | 30(15%)       | 2(1%)                       | 7(3.5%)              |
| Windows installer  | 81(81%)       | 11(11%)       | 8(8%)         | 0(0%)                       | 0(0%)                |
| Cooking            | 178(89%)      | 13(6.5%)      | 7(3.5%)       | 0(0%)                       | 2(1%)                |

Vertical linear models test for ranking data  $P < 0.001$

Neutral: bending ahead or to side less than 20 degree or twist less than 20 degree

Light bending ahead: bending ahead between 20 to 45 degree

Sharp bending ahead: bending ahead more than 45 degree

Bending to side or twisting: bending ahead less than 20 degree with bending to side more than 20 degree or bending ahead less than 20 degree with twist more than 20 degree

Bending and twisting: bending ahead and twisting more than 20 degree (Buchholz et al., 1996)

According to Table 6, hands position between different construction jobs statistically showed significant difference ( $P < 0.05$ ), so that hands positions in light construction jobs such as sentry, driver, safety officer, operate engineer, administrative affairs and also cement work was in neutral position (two hands below shoulder height) more than 90% and in return hands position in jobs such as scaffolding, blacksmith and painting were mostly in the position of one hand over shoulder height. Totally it could be found that hands in heavy construction jobs such as false ceiling, scaffolding ... are in more inappropriate position comparing to other construction jobs.

As shown in Table 7, legs position in different construction jobs had statistically significant difference ( $P < 0.001$ ). The most neutral posture percentage observed in windows installer job (83%) and plaster work and cement work had the posture with one or two curved feet in more than 20% of cases, also crawl and sitting on feet on the ground postures were the less between construction jobs postures.

The weight of used tools and objects as a weight group in kilograms in different construction jobs statistically had significant difference ( $P < 0.001$ ). On the other words in studied jobs tools and objects with different weight will be used, so that in jobs such as administrative and affaires, driving and sentry significant weight will not carry. In return the most weight carried observed in jobs such as scaffolding, ceramic work, cement work, masonry, piping, and chef ..., related results are shown in Table 8.

Hand grip as the final assessment with PATH method showed that scaffolding, plastering and cement work had the most observed frequency of strong hand grip and in return light jobs such as administration, experts and engineers had the less hand grip ( $P < 0.05$ ), related results are shown in Table 9.

Finally according to the results presented in table 10, scaffolding and carpentry had the most load profile respectively with 3.13 and 2.08 values and in return sentry had the less load profile with value of 0.01.

In Table 11 each job with its coding number, frequency, duty descriptions and descriptions coding number are presented.

**Table 6:** distribution of observations based on hand postures with PATH method in studied construction jobs

| Jobs               | Hand Posture                    |                               |                                |
|--------------------|---------------------------------|-------------------------------|--------------------------------|
|                    | Two hands under shoulder height | One hand over shoulder height | Two hands over shoulder height |
| Painting           | 482(68.9%)                      | 130(18.6%)                    | 88(12.6%)                      |
| Ceramic work       | 500(100%)                       | 0(0%)                         | 0(0%)                          |
| Sentry             | 190(95%)                        | 5(2.5%)                       | 5(2.5%)                        |
| Driving            | 188(94%)                        | 12(6%)                        | 0(0%)                          |
| Safety officer     | 190(95%)                        | 5(2.5%)                       | 5(2.5%)                        |
| Executive engineer | 193(96.5%)                      | 2(1%)                         | 5(2.5%)                        |
| Forging            | 111(55.5%)                      | 65(32.5%)                     | 24(12%)                        |
| False ceiling      | 73(36.5%)                       | 17(8.5%)                      | 110(55%)                       |
| Restoration        | 163(81.5%)                      | 30(15%)                       | 7(3.5%)                        |
| Administration     | 189(94.5%)                      | 8(4%)                         | 3(1.5%)                        |
| Plastering         | 165(82.5%)                      | 25(12.5%)                     | 10(5%)                         |
| Scaffolding        | 75(37.5%)                       | 51(25.5%)                     | 74(37%)                        |
| Cement work        | 187(93.5%)                      | 9(4.5%)                       | 4(2%)                          |
| Wall builder       | 163(81.5%)                      | 25(12.5%)                     | 12(6%)                         |
| Technical expert   | 100(100%)                       | 0(0%)                         | 0(0%)                          |
| QC expert          | 194(97%)                        | 2(1%)                         | 4(2%)                          |
| Piping             | 213(71%)                        | 22(7.3%)                      | 65(21.7%)                      |
| Electrician        | 274(91.3%)                      | 21(7%)                        | 5(1.7%)                        |
| Carpentry          | 183(91.5%)                      | 11(5.5%)                      | 6(3%)                          |
| Windows installer  | 43(43%)                         | 37(37%)                       | 20(20%)                        |
| Cooking            | 200(100%)                       | 0(0%)                         | 0(0%)                          |

Vertical linear models test for ranking data P<0.05

**Table 7:** distribution of observations based on leg postures with PATH method in studied construction jobs

| Jobs               | Leg postures |                    |                       |            |           |          |              |               |          |
|--------------------|--------------|--------------------|-----------------------|------------|-----------|----------|--------------|---------------|----------|
|                    | Neutral      | One leg in the air | One or two curved leg | Squat      | Walk      | Kneel    | Sit on chair | Sit on ground | Crawl    |
| Painting           | 548(78.2%)   | 4(0.6%)            | 59(8.4%)              | 29(4.1%)   | 58(8.3%)  | 0(0%)    | 0(0%)        | 2(0.3%)       | 0(0%)    |
| Ceramic work       | 256(51.2%)   | 30(6%)             | 35(7%)                | 107(21.4%) | 25(5%)    | 32(6.4%) | 0(0%)        | 1(0.2%)       | 14(2.8%) |
| Sentry             | 103(51.5%)   | 8(4%)              | 6(3%)                 | 10(5%)     | 60(30%)   | 0(0%)    | 13(6.5%)     | 0(0%)         | 0(0%)    |
| Driving            | 6(3%)        | 0(0%)              | 0(0%)                 | 0(0%)      | 4(2%)     | 0(0%)    | 190(95%)     | 0(0%)         | 0(0%)    |
| Safety officer     | 30(15%)      | 0(0%)              | 3(1.5%)               | 2(1%)      | 65(32.5%) | 0(0%)    | 100(50%)     | 0(0%)         | 0(0%)    |
| Executive engineer | 28(14%)      | 0(0%)              | 2(1%)                 | 6(3%)      | 64(32%)   | 0(0%)    | 100(50%)     | 0(0%)         | 0(0%)    |
| Forging            | 136(68%)     | 12(6%)             | 12(6%)                | 28(14%)    | 8(4%)     | 4(2%)    | 0(0%)        | 0(0%)         | 0(0%)    |
| False ceiling      | 146(73%)     | 0(0%)              | 8(4%)                 | 37(18.5%)  | 4(2%)     | 5(2.5%)  | 0(0%)        | 0(0%)         | 0(0%)    |
| Restoration        | 124(62%)     | 3(1.5%)            | 24(12%)               | 29(19.5%)  | 10(5%)    | 0(0%)    | 0(0%)        | 0(0%)         | 0(0%)    |
| Administration     | 12(6%)       | 0(0%)              | 8(4%)                 | 5(2.5%)    | 5(2.5%)   | 0(0%)    | 170(85%)     | 0(0%)         | 0(0%)    |
| Plastering         | 113(56.5%)   | 7(3.5%)            | 40(20%)               | 9(4.5%)    | 29(14.5%) | 0(0%)    | 0(0%)        | 2(1%)         | 0(0%)    |
| Scaffolding        | 97(48.5%)    | 9(4.5%)            | 23(11.5%)             | 20(10%)    | 46(23%)   | 5(2.5%)  | 0(0%)        | 0(0%)         | 0(0%)    |
| Cement work        | 113(56.5%)   | 2(1%)              | 41(20.5%)             | 10(5%)     | 28(14%)   | 0(0%)    | 0(0%)        | 6(3%)         | 0(0%)    |
| Wall builder       | 112(56%)     | 3(1.5%)            | 23(16.5%)             | 17(8.5%)   | 22(11%)   | 5(2.5%)  | 0(0%)        | 8(4%)         | 0(0%)    |
| Technical expert   | 3(3%)        | 0(0%)              | 0(0%)                 | 0(0%)      | 7(7%)     | 0(0%)    | 90(90%)      | 0(0%)         | 0(0%)    |
| QC expert          | 30(15%)      | 0(0%)              | 2(1%)                 | 5(2.5%)    | 63(31.5%) | 0(0%)    | 100(50%)     | 0(0%)         | 0(0%)    |
| Piping             | 232(77.3%)   | 0(0%)              | 14(4.7%)              | 20(3.3%)   | 25(8.3%)  | 6(2%)    | 0(0%)        | 3(1%)         | 0(0%)    |
| Electrician        | 181(60.3%)   | 3(1%)              | 32(7.3%)              | 38(12.7%)  | 40(13.3%) | 5(1.7%)  | 0(0%)        | 11(3.7%)      | 0(0%)    |
| Carpentry          | 130(65%)     | 0(0%)              | 29(14.5%)             | 14(7%)     | 12(6%)    | 5(2.5%)  | 0(0%)        | 0(0%)         | 0(0%)    |
| Windows installer  | 83(83%)      | 0(0%)              | 8(8%)                 | 3(3%)      | 6(6%)     | 0(0%)    | 0(0%)        | 0(0%)         | 0(0%)    |
| Cooking            | 148(74%)     | 0(0%)              | 2(1%)                 | 0(0%)      | 20(10%)   | 0(0%)    | 30(15%)      | 0(0%)         | 0(0%)    |

Vertical linear models test for ranking data P<0.001

**Table 8:** distribution of observations based on carried weight (kg) with PATH method in studied construction jobs

| Jobs               | Wight of carried tools and objects (kilograms) |               |            |           |          |              |
|--------------------|--|---------------|------------|-----------|----------|--------------|
|                    | Carry no weight                                | Less than 2.5 | 2.5-5      | 5-10      | 10-15    | More than 15 |
| Painting           | 150(21.4%)                                     | 497(71%)      | 0(0%)      | 6(0.9%)   | 47(0.7%) | 0(0%)        |
| Ceramic work       | 130(26%)                                       | 147(29.4%)    | 149(29.8%) | 41(8.2%)  | 0(0%)    | 33(6.6%)     |
| Sentry             | 200(100%)                                      | 0(0%)         | 0(0%)      | 0(0%)     | 0(0%)    | 0(0%)        |
| Driving            | 200(100%)                                      | 0(0%)         | 0(0%)      | 0(0%)     | 0(0%)    | 0(0%)        |
| Safety officer     | 123(61.6%)                                     | 77(38.5%)     | 0(0%)      | 0(0%)     | 0(0%)    | 0(0%)        |
| Executive engineer | 170(85%)                                       | 30(15%)       | 0(0%)      | 0(0%)     | 0(0%)    | 0(0%)        |
| Forging            | 54(27%)  | 103(51.5%)    | 43(21.5%)  | 0(0%)     | 0(0%)    | 0(0%)        |
| False ceiling      | 81(40.5%)                                      | 79(39.5%)     | 23(11.5%)  | 17(8.5%)  | 0(0%)    | 0(0%)        |
| Restoration        | 66(33%)  | 112(56%)      | 0(0%)      | 0(0%)     | 22(11%)  | 0(0%)        |
| Administration     | 167(83.5%)                                     | 33(16.5%)     | 0(0%)      | 0(0%)     | 0(0%)    | 0(0%)        |
| Plastering         | 56(28%)  | 115(57.5%)    | 16(8%)     | 13(6.5%)  | 0(0%)    | 0(0%)        |
| Scaffolding        | 17(8.5%)                                       | 63(31.5%)     | 68(34%)    | 0(0%)     | 0(0%)    | 52(26%)      |
| Cement work        | 21(10.5%)                                      | 99(49.5%)     | 57(28.5%)  | 5(2.5%)   | 0(0%)    | 18(9%)       |
| Wall builder       | 82(41%)  | 38(19%)       | 57(28.5%)  | 5(2.5%)   | 0(0%)    | 18(9%)       |
| Technical expert   | 100(100%)                                      | 0(0%)         | 0(0%)      | 0(0%)     | 0(0%)    | 0(0%)        |
| QC expert          | 103(51.5%)                                     | 97(48.5%)     | 0(0%)      | 0(0%)     | 0(0%)    | 0(0%)        |
| Piping             | 75(25%)  | 67(22.3%)     | 32(10.7%)  | 126(42%)  | 0(0%)    | 0(0%)        |
| Electrician        | 135(45%)                                       | 146(48.7%)    | 15(5%)     | 4(1.3%)   | 0(0%)    | 0(0%)        |
| Carpentry          | 112(56%)                                       | 55(27.5%)     | 33(16.5%)  | 0(0%)     | 0(0%)    | 0(0%)        |
| Windows installer  | 15(15%)  | 15(15%)       | 35(35%)    | 35(35%)   | 0(0%)    | 0(0%)        |
| Cooking            | 41(20.5%)                                      | 79(39.5%)     | 28(14%)    | 35(17.5%) | 7(3.5%)  | 10(5%)       |

Vertical linear models test for ranking data P<0.0001

**Table 9:** distribution of observations based on hand grip with PATH method in studied construction jobs

| jobs               | Hand grip     |             |              |           |
|--------------------|---------------|-------------|--------------|-----------|
|                    | No. of strong | No. of weak | No. of empty | other     |
| Painting           | 424(60.6%)    | 174(24.9%)  | 95(13.8%)    | 7(1%)     |
| Ceramic work       | 394(56.3%)    | 61(8.7%)    | 43(8.6%)     | 5(1%)     |
| Sentry             | 0(0%)         | 0(0%)       | 200(100%)    | 0(0%)     |
| Driving            | 178(89%)      | 12(6%)      | 0(0%)        | 10(5%)    |
| Safety officer     | 10(5%)        | 25(12.5%)   | 100(50%)     | 65(32.5%) |
| Executive engineer | 10(5%)        | 25(12.5%)   | 100(50%)     | 65(32.5%) |
| Forging            | 80(40%)       | 72(36%)     | 41(20.5%)    | 7(3.5%)   |
| False ceiling      | 8(4%)         | 170(85%)    | 22(11%)      | 0(0%)     |
| Restoration        | 22(11%)       | 135(67.5%)  | 43(21.5%)    | 0(0%)     |
| Administration     | 90(45%)       | 3(1.5%)     | 25(12.5%)    | 82(41%)   |
| Plastering         | 147(73.5%)    | 26(13%)     | 21(10.5%)    | 6(3%)     |
| Scaffolding        | 184(92%)      | 0(0%)       | 16(8%)       | 0(0%)     |
| Cement work        | 173(86.5%)    | 0(0%)       | 21(10.5%)    | 6(3%)     |
| Wall builder       | 100(50%)      | 52(26%)     | 42(21%)      | 6(3%)     |
| Technical expert   | 10(10%)       | 0(0%)       | 8(8%)        | 82(82%)   |
| QC expert          | 88(44%)       | 38(19%)     | 10(5%)       | 65(32.5%) |
| Piping             | 158(52.7%)    | 82(27.3%)   | 60(20%)      | 0(0%)     |
| Electrician        | 185(61.7%)    | 60(20%)     | 36(12%)      | 19(6.3%)  |
| Carpentry          | 120(60%)      | 46(23%)     | 27(13.5%)    | 7(3.5%)   |
| Windows installer  | 78(78%)       | 0(0%)       | 8(8%)        | 14(14%)   |
| Cooking            | 33(16.5%)     | 92(46%)     | 72(36%)      | 3(1.5%)   |

Vertical linear models test for ranking data P<0.05

**Table 10:** distribution of lifting load combinations profile in studied construction jobs

| Jobs               | Lifting load profile | Jobs              | Lifting load profile |
|--------------------|----------------------|-------------------|----------------------|
| Painting           | 0.4                  | Plastering        | 0.5                  |
| Ceramic work       | 1.1                  | Scaffolding       | 3.13                 |
| Sentry             | 0.01                 | Cement work       | 0.5                  |
| Driving            | 0.13                 | Wall builder      | 0.4                  |
| Safety officer     | 0.02                 | Technical expert  | 0.1                  |
| Executive engineer | 0.1                  | QC expert         | 0.1                  |
| Forging            | 0.1                  | Piping            | 1.2                  |
| False ceiling      | 0.6                  | Electrician       | 0.2                  |
| Restoration        | 0.2                  | Carpentry         | 2.08                 |
| Administration     | 0.1                  | Windows installer | 1.4                  |
|                    |                      | Cooking           | 0.7                  |

**Table 11:** jobs and their duties in PARAND workshop

| No. | Job          | Job code | Frequency | Duties                 | Duty code | Activities  |
|-----|--------------|----------|-----------|------------------------|-----------|---|
| 1   | Painting     | PA       | 71        | 1.Making primer        | PA1       | <ul style="list-style-type: none"> <li>- Opening of the primer bag by hand</li> <li>- Pouring primer by hand into the bucket</li> <li>- Pouring some water into another bucket</li> <li>- Add water to primer</li> <li>- Mixing water and primer with mixer</li> </ul>  |
|     |              |          |           | 2.Priming              | PA2       | <ul style="list-style-type: none"> <li>- Do polish</li> <li>- Cleaning surfaces with spatula</li> <li>- Pick up the Primers with spatula</li> <li>- Knead the Primers to the wall with a spatula</li> <li>- Smooth the Primers with spatula</li> <li>- Climb the stool</li> <li>- Coming down from the stool</li> </ul>   |
|     |              |          |           | 3.Making color         | PA3       | <ul style="list-style-type: none"> <li>- Open the Paint Bucket</li> <li>- Add paint thinner</li> <li>- Mixing paint thinner and paint with mixer</li> </ul>   |
|     |              |          |           | 4.Paint Primer         | PA4       | <ul style="list-style-type: none"> <li>- Pick up a bucket of paint</li> <li>- Pour some paint into the container</li> <li>- Paint rollers dipping into the container</li> <li>- Lifting rollers</li> <li>- Drag rollers to the wall</li> </ul>  |
|     |              |          |           | 5.Paint wall           | PA5       | <ul style="list-style-type: none"> <li>- Pick up a bucket of paint</li> <li>- Pour some paint into the container</li> <li>- Paint rollers dipping into the container</li> <li>- Lifting rollers</li> <li>- Drag rollers to the wall</li> </ul>  |
|     |              |          |           | 6.Making Knytex        | PA6       | <ul style="list-style-type: none"> <li>- Opening of paint bucket</li> <li>- Opening of perlite bags</li> <li>- Pouring perlite into the bin by hand</li> <li>- Pouring some water into another bucket</li> <li>- Add water to the paint and perlite</li> <li>- Mixing them with mixer</li> </ul>  |
|     |              |          |           | 7.Painting ceilling    | PA7       | <ul style="list-style-type: none"> <li>- Pick up knytex bucket</li> <li>- Pouring knytex into paint gun</li> <li>- Pressing the Paint gun lever</li> <li>- Painting</li> </ul>  |
| 2   | Ceramic work | T        | 31        | 1.Making mortar        | T1        | <ul style="list-style-type: none"> <li>- Opening of the cement bags</li> <li>- Pick up the cement with a shovel</li> <li>- Pouring cement on the sand</li> <li>-Mixing cement with sand</li> <li>- Fill the bucket of water</li> <li>- Water pouring cement and sand</li> <li>- Mixing mortar with a shovel</li> <li>- Pick up the mortar with a shovel</li> <li>- Pouring mortar into wheelbarrows</li> <li>- Carrying wheelbarrows to the desired location</li> </ul> |
|     |              |          |           | 2.Ceramic cutting      | T2        | <ul style="list-style-type: none"> <li>- Lifting grinding</li> <li>- On / off grinding</li> <li>- Ceramics cutting</li> </ul>   |
|     |              |          |           | 3.Ceramic Installation | T3        | <ul style="list-style-type: none"> <li>- Pour the mortar on the surface</li> <li>- Spreading mortar with trowel For infrastructure</li> <li>- Leveling with cotton twine</li> <li>- Ceramic paste</li> <li>- Ceramic hit with plastic mallet</li> <li>- Aligning ceramics</li> </ul>  |
|     |              |          |           | 4.Making slurry        | T4        | <ul style="list-style-type: none"> <li>- Opening of plaster and cement bags</li> <li>- Pour water into the container</li> <li>- Add plaster and white cement to water</li> <li>- Mixing plaster and cement with water by mixer</li> <li>- Carry slurry made to the desired location</li> </ul>  |
|     |              |          |           | Pouring slurry         | T5        | <ul style="list-style-type: none"> <li>- Pick up the slurry container</li> <li>- Pouring slurry on the joints between the tiles</li> <li>- Ceramic Cleaning with napkins</li> </ul>   |



|    |                    |     |    |                           |      |   |
|----|--------------------|-----|----|---------------------------|------|---|
| 3  | Sentry             | G   | 35 | 1.Traffic control         | G1   | - Stop the car when leaving<br>- Vehicle inspection<br>- Inspection personnel   |
|    |                    |     |    | 2.Equipment Control       | G2   | - Patrolling the area<br>- Patrolling the floors<br>- Control of the means available in the building  |
| 4  | Driving            | D   | 25 | 1.Movement of persons     | D1   | - Picking up people<br>- Drive the vehicle to the desired location<br>- Getting off people  |
|    |                    |     |    | 2.Materials Handling      | D2   | - Load materials<br>- Transport materials<br>- Unloading of materials at the desired location   |
| 5  | Safety officer     | SO  | 12 | 1.Monitor the work        | SO1  | - Presence in work areas<br>- Control Equipment and Tools<br>- Ensure the work safely<br>- On-site training to workers  |
|    |                    |     |    | 2.Repoting                | SO2  | - Writing by hand<br>- Using the computer and typing reports  |
| 6  | Executive engineer | EE  | 16 | 1.Monitor the work        | EE1  | - Presence in work areas<br>- Providing equipment and materials<br>- Run technical office agendas   |
|    |                    |     |    | 2.Repoting                | EE2  | - Writing by hand<br>- Using the computer and typing reports  |
| 7  | Forging            | B   | 8  | 1.Structure building      | B1   | - Providing iron<br>- Measured by the meter<br>- Metal cutting with saw<br>- Iron cutting with grinding<br>- Welding<br>- Polishing<br>- Painting   |
|    |                    |     |    | 2.Structure Installation  | B2   | - Marking<br>- Installation of corners with Hilti<br>- Put the iron structure in their position<br>- Alignment<br>- Pre-welding<br>- Ensure the alignment<br>- Welding  |
| 8  | False ceiling      | K   | 5  | 1.Installation of support | K1   | - Measuring with meter<br>- Cutting support to appropriate size<br>- Climb the stool<br>- Screw up part of the support<br>- Aligning Support<br>- Screw the rest of the support<br>- Coming down from the stool                                     |
|    |                    |     |    | 2.Panel Placement         | K2   | - Measuring with meter<br>- Cutting the panels to size<br>- Replacing panel on support  |
| 9  | Restoration        | R   | 7  | 1.Making mastic           | R1   | - Open cement bag<br>- Open cans of concrete adhesive<br>- Open Primers bags<br>- Open Limestone bags<br>- Pouring cement and limestone on Primers powder<br>- Add water<br>- Mixing them with a spatula<br>- Stirring the mortar made with spatula |
|    |                    |     |    | 2.Mastic Press            | R2   | - Dipping spatula into mortar bucket<br>- Pick up the spatula<br>- Drag spatula on the wall<br>- Climb the stool<br>- Coming down from the stool  |
| 10 | Administration     | CLE | 21 | 1.Work with Computer      | CLE1 | - Typing Letter and Report<br>- Record personnel data in computer   |
|    |                    |     |    | 2.Work with Hands         | CLE2 | - Put the documents in the binder<br>- Documentation  |

|    |                  |     |    |                        |      |   |
|----|------------------|-----|----|------------------------|------|---|
|    |                  |     |    |                        |      | - Answering the Phone   |
| 11 | Plastering       | PLA | 11 | 1.Making plaster       | PLA1 | - Fill the bucket of water<br>- Pour water into the container<br>- Open bag of plaster<br>- Pick up the plaster with shovel<br>- Add plaster to water<br>- Mixing it by hand  |
|    |                  |     |    | 2.Plastering           | PLA2 | - Pick up the plaster with a trowel<br>- Rubbing plaster to the wall with a trowel<br>- Smooth the plaster with a trowel<br>- Smooth plaster with aluminum tube<br>- Cleaning rod with spatula<br>- Cleaning tube with spatula  |
| 12 | Scaffolding      | S   | 10 | 1.Scaffolding assembly | S1   | - Stand erect a scaffold basis<br>- Installation of bracing and cross<br>- Lifting platform<br>- Put the platform on the basis<br>- Basic installation on the upper floor<br>- installation of cross and bracings<br>- Lifting platform<br>- Handoff platform to upper floor people<br>- Put the platform on the basis<br>- Install inhibits  |
|    |                  |     |    | 2.Scaffold Dismantling | S2   | - Open bracing and cross<br>- Separating the platform from the base<br>- Separate base<br>- Lifting platforms and scaffolding accessories separately<br>- Giving them to people in the lower floors<br>- Open inhibitory  |
| 13 | Cement work      | CEM | 17 | 1.Making Mortar        | CEM1 | - Opening of cement bags<br>- Pick up the cement with a shovel<br>- Pouring cement on the sand<br>- Mixing cement with sand<br>- Fill the bucket of water<br>- Water pouring cement and sand<br>- Mixing mortar with a shovel<br>- Pick up the mortar with a shovel<br>- Pouring mortar into wheelbarrows<br>- Carrying wheelbarrows to the desired location                            |
|    |                  |     |    | 2.Cement working       | CEM2 | - Pick up cement with the trowel<br>- Cement splashing to the wall with a trowel<br>- Smooth the cement with a trowel<br>- Smooth with aluminum tube  |
| 14 | Wall builder     | M   | 18 | 1.Material Preparation | M1   | - Opening of cement bags<br>- Pick up cement with the trowel<br>- Pouring cement on the sand<br>- Mixing cement with sand<br>- Fill the bucket of water<br>- Water pouring cement and sand<br>- Mixing mortar with a shovel<br>- Pick up the mortar with a shovel<br>- Pouring mortar into wheelbarrows<br>- Carrying wheelbarrows to the desired location<br>- Breaking bricks with ax |
|    |                  |     |    | 2.Brick picking        | M2   | -Pick up the mortar with a trowel<br>-Pour the mortar on the ground<br>- Brick pick<br>- Alignment  |
| 15 | Technical expert | TE  | 9  | 1.Work with Computer   | TE1  | -Preparing agendas for carrying out activities<br>-Typing reports and letters   |
| 16 | QC expert        | QCE | 9  | 1.Monitoring the work  | QCE1 | - Presence in work areas<br>-To ensure the best possible quality of work  |
|    |                  |     |    | 2.Reporting            | QCE2 | - Writing by hand<br>- Using the computer and typing reports  |
| 17 | Piping           | PLU | 9  | 1.Destruction          | PLU1 | - Chipping pneumatic Pick up<br>- On / off chipping   |

|    |                   |     |    |                                |      |  |
|----|-------------------|-----|----|--------------------------------|------|--|
|    |                   |     |    |                                |      | - Destruction of a small section of the floor  |
|    |                   |     |    | 2.Support Installation         | PLU2 | - Measuring with Meter<br>- Cutting support to appropriate size<br>- Climb the stool<br>-Clinch part of the support<br>-Aligning Support<br>-Clinch the rest of the support<br>-Coming down from the stool |
|    |                   |     |    | 3.Pipe installation            | PLU3 | -Pipe cutting<br>-Assembly of pipes and elbows<br>-Piping installation<br>- Climb the stool<br>-Coming down from the stool   |
| 18 | Electrician       | E   | 11 | 1.Carving                      | E1   | -On / off grinding<br>-Cutting brick wall<br>-Removing redundancies with mallet and chisel   |
|    |                   |     |    | 2.Tubing                       | E2   | -Holes the wall with a pen<br>-Cutting Tube<br>-Connecting tube with glue<br>-Tube Connecting elbow<br>-Put the tube in place<br>-Pulling Tubes  |
|    |                   |     |    | 3.Wiring                       | E3   | -Enter a spring in the tube<br>-Pulling Springs<br>-Wire Stripping<br>-Close the wire to spring<br>-Open the wire from spring<br>-Wire Cutting   |
| 19 | Carpentry         | CAR | 8  | 1.Door Preparation             | CAR1 | - Measuring with Meter<br>-Removing additional parts of the door with the chipper<br>-Unload lock place with the cavern<br>-Lock installation<br>-Bringing the hinges on the door                          |
|    |                   |     |    | 2.Door Installation            | CAR2 | -Pick up the Door<br>-Replacing door hinges<br>-Adjusting the door   |
| 20 | Windows installer | DM  | 11 | 1.Window Installation          | DM1  | -Putting in place the required window<br>-Pick up drills<br>-Holes the wall<br>-Pick up cordless screwdriver<br>-Screw the window to the wall  |
| 21 | Cooking           | CAT | 13 | 1.Preparation of raw materials | CAT1 | -Wash raw materials<br>-Clean rice and beans<br>-Peel off the vegetables<br>-chopping  |
|    |                   |     |    | 2. Cooking                     | CAT2 | -Cook raw materials<br>-Frying raw materials<br>-Mixing the desired ingredients together<br>-Cooking   |



**Fig. 1:** Some jobs of construction industry involved in ergonomic risk factor assessment process.

## DISCUSSION

In this study according to average age and work experience of construction workers it can be said that the studied sample was relatively young and at the same time experienced then their comments about work situation and the prevalence of musculoskeletal disorders assessing can be trustable and valid. Study showed that the most prevalence of musculoskeletal disorders was in waist area, knee, neck and shoulder and generally the most prevalence was in large joints with 80.4% and after that back and buttocks with 47.6% which is consistent with the findings of other studies [26, 27]. Increasingly, the prevalence of musculoskeletal had significant difference in different jobs that this difference can result from jobs requirements while doing and work arrangement [17, 18]. In this regard some studies [27] showed that the prevalence of musculoskeletal disorders in the upper extremities and posture pressure of various tasks had meaningful relation. In many studies interventions for improving disorders in different jobs under different situations have been done [28-30]. High prevalence of musculoskeletal disorders in these mentioned body regions can be related to the repeated activities, highly force exertions, long-term static works, highly muscle activity and mobility, excessive pressure exertion on low back, insufficient rest intervals among work intervals for muscular recovery after muscle contractions, vertical pressure on L4/L5 and L5/S1 lumbar vertebrae, personal genetic susceptibility to WMSDs, inadequate nutrition program or regime, awkward postures during construction works, incorrect design of construction equipments and hand tools, repetitive tasks, and other additional and effective factors (sharp-edged objects, precision work, , etc.), environmental parameters such as exposure to cold, heat, vibration including

hand-arm vibration (HAV) or whole body (WBV) vibration, personal or social psychological problems, etc.[30].

In addition to job type, other factors such as the worker's age and work experience had an important role in prevalence of musculoskeletal disorders so it is necessary that in studies in which the main goal is to create intervention and control or improvement the symptoms of MSDs disorders, these factors as disturbance variables must become under control of the researcher.

The results of trunk, legs and hands postures assessment with PATH method in different construction jobs showed that job type was different in the different postures so it could be said that each job with the proportion of working conditions and operational requirements faces a series of undesirable postures. In the trunk and hand postures neutral position was found more than 90% of cases in light construction jobs such as administration, engineering and experts and in return in the jobs such as cement work, plastering, restoration and painting trunk posture had the most undesirable situation in the case of bending or bending and twisting. Heavy construction jobs such as false ceiling, scaffolding, etc. had inappropriate hand situation comparing to other jobs.

Regarding the leg posture, windows installer job with 83% had the most neutral posture percentage and in return plastering and cement work jobs had one or two curved leg posture in more than 20% of cases, and then are can be said that undesirable posture can be a significant factor in prevalence of musculoskeletal disorders. The main reason of undesirable and fixed postures can be non-adjustable work stations [31]. Within most studies done in different jobs [31-37], the effect of work posture was checked and its effect on musculoskeletal disorders was confirmed. Also in line with present study, Buchholz *et al.* in 1996 [18] presented PATH method to ergonomic assessing of hard works and non-routine works. Results showed that non-neutral trunk postures are different in various jobs so the workers spend lots of their time with non-neutral trunk postures. Buchholz *et al.* (2003) in another study showed that leg, trunk and hand postures statistically had significant difference between various duties of reinforcement job [17].

Most of construction jobs need frequent kneeling, squatting or bending because they are near ground surface. Kneeling on hard surfaces will push large direct pressure on knee, squatting will push stress on tendons, ligaments and cartilage in joints. Working in both mentioned situations for long period of time will cause knee disorders specially osteoarthritis. In construction jobs brick pickers mostly bend to pick

bricks, blocks and mortar and put them on wall. This will cause body lots of twisting and bending and also more situations like this. Then certainly it can be considered significant relation between job type and work posture and consequently undesirable posture are known as a significant factor in prevalence of musculoskeletal disorders.

Wight of tools and objects and also hand grip in different construction jobs had significant deference so light construction jobs such as experts, administrative affairs, sentry and drivers will not carry significant weight and in return scaffolding, cement work, ceramic work, plastering ... will carry the most weighted tools and in more than 50% of cases had strong hand grip.

According to studies done, work groups that in their work there is static contraction, long time static loads and undesirable postures and will involve neck and shoulder muscles, are extremely at risk of neck and shoulder musculoskeletal disorders [38]. In line with this study, a study showed that in jobs such as painting and false ceiling that a part of work is done over head height, the combination of hand non-neutral postures and weight of tools will cause more load to musculoskeletal system [39]. So using low weight tools as much as possible is advised in these situations. Some studies also showed that manual material handling in group will push less pressure on workers than when it is done individually [40].

Finally results from MMH method showed that according to the load profile index most manual material handling was in scaffolding job (3.13), this can be because of scaffold platforms with over 23 kilograms weight. On the other words due to the variables defined, scaffolding load profile was more than 3 so the change in work system is needed, carpentry load profile was 2.08 and corrective actions are needed to reduce stress. Therefore it is recommended to use lifting equipment such as trap handler in scaffolding job to transfer scaffold platforms to upper floors.

Therefore the lack of health and safety rules and guidelines for jobs and also government's inability to cover different jobs from the perspective of occupational health [34] can enumerate as the reasons of lack of attention to occupational health and safety so, it is recommended to create and implement a training program in connection with musculoskeletal disorders and the ways to prevent it for all jobs.

Some examinations such as optometry and different musculoskeletal diagnosis tests, including standard clinical provocation tests (Finkelstein's test, Phalen's test and Tinel's test), joint stress test, Allen test, Mills test, Impingement test, Speed's test, Yergason test, biceps resistance test, Roos test, Adsons test, elevated

arm stress test, foramina test, and the like can help to reach this preventive purpose [30].

## CONCLUSION

PATH can be referred as a sensitive and efficient risk evaluation technique in construction industry, as well as MMH is a complementary method for more precision assessment of manual material handling risks in jobs involved in PATH high scores.

## ETHICAL ISSUES

Ethical issues including plagiarism have been taken into account by the authors.

## CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

## AUTHORS' CONTRIBUTION

All authors work equally.

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