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# Postural, Physical Strain and Peak Expiratory Flow Rate Assessment of University Casual Workers

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## ABSTRACT

University-causal-works are mainly characterized by cleaning chores targeted at ensuring serenity in offices and environments. These tasks demand activities that are associated with a variety of physical and psychological hazards resulting in the proliferation of musculoskeletal disorders experienced by University-Casual-Workers (UCWs). This study assessed the postural, physical strain, and Peak Expiratory Flow Rate (PEFR) of UCWs. The postural analysis results using Rapid-Entire-Body-Assessment (REBA) revealed that a high percentage; 100, 88.2, and 83% of the cleaners, packers, and cutters respectively were subjected to a very high level of risks. Physical strain assessment showed that the working heart rate of the respondents ranged between 70 – 143 bpm and 65 – 114 bpm, for male and female UCWs respectively. PEFR results revealed that 29, 9, 18, and 13% of the cutters, trimmers, cleaner, and packers had PEFR below recommended level of 300 l/min. This study proposed two mathematical models with $R^2$ values of 0.8853 and 0.9763 to predict the PEFR of male and female UCWs respectively. Thus, employers of UCWs would find in these models, reliable, economical, effective and efficient prediction tools for adequate regulations guiding the activities of any hired worker. It is recommended that UCWs should be enlightened regularly through seminars and workshops on the dangers of bad postures while at work.

**Keywords:** Disorder; Cleaning; Physical Strain; Casual Work; Peak Expiratory Flow Rate. Musculoskeletal

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## 1. INTRODUCTION

Physical demands at work are considered as important risk factors for several musculoskeletal disorders (Lunde, 2016). Postural and physical strain is the stress imposed on the human body as a result of inefficient posture, repetitive movement, or prolong time in the same position often experienced during work activities Postural and physical strain contribute to work-related musculoskeletal disorders leading to wear and tear, premature aging, and illnesses (Restuputri, *et al.,* 2019) and cardiovascular diseases are the major cause of death worldwide (Lee, *et. al.,* 2020).

Musculoskeletal Disorders (MSDs) are injuries or pain in the human musculoskeletal system, including the joints, ligaments, muscles, nerves, tendons, and structures that support limbs, neck, and back. Work-related MSDs are those that occur due to work conditions, such as work posture, repetition, heavy activities, and static muscle loading (Sa'diyah, *et al.,* 2021). MSDs can arise from a sudden exertion (e.g., lifting a heavy object) or result from making the same motions or from repeatedly repetitive strain, or from repeated exposure to force vibration, or awkward posture (Kumaraveloo, *et al.,* 2018). They represent one of the leading causes of postural and physical strain injuries and disabilities in both developed and developing countries (World Health Organization, 1985).

The prevention of MSDs among the peculiar workforce is considered a national top priority in many countries (Spielholz, *et al.,* 2001). Several studies have demonstrated the relationship between certain jobs and risk factors that are associated with the proliferation of MSDs (Bernard, 1997; Spielholz, et al., 2001; da Costa and Vieira, 2010). Awkward working postures, repetitive use of body segments, previous or existing injuries, long periods of standing, and genetic makeup of the individual and demographic factors are known to be important predictive variables of MSDs (Kivi and Mattila, 1991; Mani and Gerr, 2000; Occupational Safety and Health Administration (OSHA), 2000; Fenske and Simcox, 2003). Manual material handling such as lifting and lowering of materials has been recognized as a cause of musculoskeletal injuries at workplaces (Waters, *et al.,* 1994; Dempsey, 2003). Also, poor postural working conditions and the absence of effective work injury prevention programs have resulted in a very high rate of MSDs (Bernard, 1997).

Musculoskeletal disorders are often related to occupation. Therefore, occupational MSDs are defined as work-related MSDs and are classified as accidental or non-accidental (Cohen, 2002). Individuals whose routine work involves substantial physical activities are the most vulnerable. Several studies on the activities of waste workers showed that mechanical loads regularly surpass upper health and safety thresholds or approved limits (Yang, 2001). Heavy loads exert high shear forces on the spine which is likely to increase the incidence of MSDs (Kuorinka, 2005). Physical and mental tasks increase the workload (Restuputri, *et al.,* 2019), and globally, casual workers are at a high risk of experiencing musculoskeletal disorders because of the nature of their works.

Studies conducted in different geographical locations indicate a high risk for musculoskeletal complaints among waste workers (Cole, 2001). Poulsen, *et al.,* (2004) found that musculoskeletal disorders were twice as high among casual workers when compared to the total workforce. Waste collection is a necessary activity all around the world and the removal of solid waste is a job associated with varieties of biological, chemical, mechanical, physical, and psychosocial hazards (Mehrdad, and Majlessi-Nasr, 2008). In many countries, solid waste is collected manually, and solid waste collection is among the highest-risk occupations in the United States (Cole, 2001). Waste collectors are at risk for a variety of occupational diseases as a result of daily exposure to work-related hazards among which musculoskeletal disorders are prevalent.

In Nigeria, like many developing countries, solid waste is collected manually and collection of household waste is also a job that requires repeated heavy physical activities such as lifting, carrying, pulling, and pushing which make musculoskeletal problems common among casual workers (Adegbite, *et al*., 2015). Although musculoskeletal disorders represent a significant occupational issue for casual workers worldwide (Keyserling, 2000).

In industrially developing countries like Nigeria, the problem of workplace injuries is extremely serious and it requires that appropriate actions should be taken to address the ugly trend (Dempsey, 2003). A study reported that 61.3% of the sampled solid waste collectors in Port Harcourt, the state capital of Rivers, Nigeria suffered from musculoskeletal injuries on their job because of the large volume of wastes they pack manually in contrast to the use of hydraulic lifts (Inyang, 2007). Waste management practice in Nigeria has largely focused on the issues of cleaning, collection, and disposal of wastes using menial tools such as brooms, rakes, and shovels, which are less costly than the mechanized cleaning and collection systems adopted in developed countries. However, little is known of the impact of the job on the health status of the workers (Happiness, *et al.,* 2015). Casual works are wearisome due to the repetitive movement and long time in the same position. Workers are prone to postural and physical stresses which often lead to musculoskeletal disorders when the body system is subjected to load beyond its limit, thus, University Casual Workers (UCWs), are no exceptions to these regards.

## 2. MATERIALS AND METHOD

Casual workers in the selected university were the target population in this study. The required number of subjects was determined according to Mahdavi, *et al.,* (2015) (Equation 1).

$$n = \frac{Nz^2pq}{d^2(N-1)+z^2pq} \qquad 1$$

Where n = sample size, z = level of confidence according to the standard normal distribution (for a level of confidence of 95%, z = 1.96 (≈2)), p = estimated proportion of the population that presents the characteristic (when unknown, p = 0.5), q = (1 – p = 0.5), d = tolerated margin of error (for example we want to know the real proportion within 5%), and N = total number of casual workers in the selected location.

The respondents were divided into two major groups (male and female). According to their duties, male workers were grouped as cutters and trimmers, where:

- Cutters: these are male workers that use cutlasses to clear bushes, trim flowers and trees.
- Trimmers: these are the male workers that trim flowers and use mowers to cut grasses.

While female workers were majorly grouped as cleaners and packers, where:

- Cleaners: these are female workers that sweep, clean, and mob offices, classrooms, laboratories, and halls.
- Packers: these are the female workers that water the flowers, pick litter around the campus and pack the trimmed parts of the flowers.

The techniques used for the assessment of postural and physical strain of the targeted population are

- **Self-reporting questionnaire**
  The questionnaire consists of information on the personal characteristics of the participants, information on cleaning operations and equipment used, the most hazardous part of the operation, musculoskeletal disorder and frequent accidents encountered during their operations, and occupational health hazards and safety practices.

- **BMI determination:**
  The body weight (kg) and height (cm) of the workers were measured using a weighing scale and stadiometer, respectively, and Equation 2 was used to calculate the BMI, and the results were compared with the BMI standard.

$$BMI = \frac{\text{weight (kg)}}{(\text{height})^2 (m^2)} \qquad 2$$

- **Physical Strain Assessment**

i. Relative Cardiovascular Load (% CVL), Cardiovascular Strain (% CVS), and Relative Heart Rate (%RHR) were determined using Equations 3, 4, and 5 adopted from Ernawati, *et. al.,* (2019), Ismaila, *et. al.,* (2012), and Shimaoka, *et. al.,* (1998), respectively.

   i. *Cardiovascular Load (% CVL)* – Cardiovascular load was estimated using Equation 3 and the results were then compared with the scoring.

$$\%\text{CVL} = 100\% \text{ x} \frac{HR_{work} - HR_{rest}}{HR_{max} - HR_{rest}} \qquad 3$$

Where $HRmax\ (for\ female)\ =\ 200 -\ age$ and
$HRmax\ (for\ male)\ =\ 220 -\ age$
*HRwork = average heart rate while working (bpm),*
*HRmax = maximum heart rate (bpm)*
*HRrest = resting heart rate (bpm)*

%CVL Scoring:
*acceptable category (<30%)* = acceptable level, no action required
*moderate category (30% - 59%)* =moderate level, peak loads should be reduced within a few weeks
*high category (60% -99%)* = high level, peak loads should be reduced within a few months,
*no tolerance category (100%)* = intolerable high level, peak loads should be reduced immediately or work must be stopped.

ii. *Cardiovascular Strain (% CVS*): Cardiovascular strain was estimated using

$$\%CVS = 100\text{x} \frac{\text{HRw} - \text{HRr}}{\text{HRr}} \qquad 4$$

The results were then compared with the values on the scoring table and the work intensities were also evaluated using the scoring table as presented in the results and discussion.

% CVS was classified as follows:
0%–50% = acceptable, no action required
51%–80% = moderate, action required within a few months
81%–120% = high, action required within a few weeks
121%–150% = very high, action required within a few days
151%–180% = intolerable, action required immediately

Work intensity classifications of %CVS are as follows:

Light – HRw <90;
moderate – 90 ≤ HRw < 110;
heavy – 110 ≤ HRw < 130,
very heavy – 130 ≤ HRw < 150 and
extremely heavy – 150 ≤ HRw < 170.

iii. Relative Heart Rate (RHR): %RHR, which is also an indicator of a physical workload related to muscular activities, was estimated using

$$\%RHR = \frac{\text{HRwork}-\text{HRres}}{HRmax-HRre} x100 \qquad 5$$

Where $HR_{work}$ = mean working heart rate
$HR_{rest}$ = resting heart rate;
$HR_{max}$ = predicted maximum heart rate = $210 - 0.662 \times Age$

- Rapid Entire Body Assessment (REBA)

REBA, as described by Enwerem, *et. al.,* (2017) and Ajayeoba (2019) was used to determine the workers' risk levels and the results were compared with REBA final results in Table 1.

**Table 1: REBA Final Scoring Table**

| REBA Score | Risk level | Action |
|---|---|---|
| 1 | None | change not necessary |
| 2-3 | Low | change may be necessary |
| 4-7 | Medium | change is necessary |
| 8-10 | High | change necessary and soon |
| 11-15 | Very High | change necessary and urgent |

Source: Ajayeoba (2019)

- Peak expiratory flow rate (PEFR)

The PEFR was measured using a mini-Wright peak flow meter and Microsoft Excel sheet, and Design Expert (version 6.0.8) were used in sorting, statistical analysis, and modelling of PEFR in terms of age, BMI, and years of experience.

## 3. RESULTS AND DISCUSSION

Table 1 shows that the total number of casual workers in the sampled university was one hundred and fifty-one (151) as obtained from the works department of the institution. Using Equation 1, a minimum of one hundred and ten (110) respondents was required, however, one hundred and forty (140) UCW were considered for a more accurate result. From Table 1, forty percent (56) of the respondent were male, 60%, (84) were female with 77.9% of them having primary school leaving certificate as the highest level of education.

Table 1: Summary of the collected data of the workers

| Variable | Freq. (%) | Variable | Freq. (%) |
|---|---|---|---|
| **Gender** | | **Pain experienced on the shoulder** | |
| Male | 56 (40) | Agree | 132 (94.3) |
| Female | 84 (60) | Strongly Agree | 1 (0.7) |
| **Level of education** | | Disagree | 7 (5) |
| None | 16 (11.4) | Strongly Disagree | 0 (0) |
| Primary | 109 (77.9) | **Pain experienced on the neck** | |
| Secondary | 15 (10.7) | Agree | 48 (34.3) |
| Post- Secondary | 0 (0) | Strongly Agree | 3 (2.1) |
| **Last time any MSDs (months) was treated** | | Disagree | 89 (63.6) |
| < 1 | 62 (44.3) | Strongly Disagree | 0 (0) |
| 1.0 – 3.0 | 45 (32.1) | **Pains are experienced on the arm** | |
| 4.0 – 6 .0 | 17 (12.2) | Agree | 72 (51.4) |
| 7.0 – 9.0 | 14 (10) | Strongly Agree | 5 (3.6) |
| 10.0 – 12.0 | 2 (1.4) | Disagree | 63 (45) |
| **Years of experience** | | Strongly Disagree | 0 (0) |
| 1 – 5 | 36 (25.7) | **Pain experienced on the wrist** | |
| 6 – 10 | 74 (52.9) | Agree | 92 (65.7) |
| 11 – 15 | 19 (13.6) | Strongly Agree | 14 (10) |
| > 15 | 11 (8.0) | Disagree | 34 (24.3) |
| **Common musculoskeletal disorders** | | Strongly Disagree | 0 (0) |
| Bruises | 8 (5.7) | **Pain experienced on the trunk** | |
| Joint Dislocation | 11 (7.9) | Agree | 79 (56.4) |
| Pain / strain | 115 (82.1) | Strongly Agree | 12 (8.6) |
| Muscle Cramp | 6 (4.3) | Disagree | 49 (35) |
| **Health challenges experience due to work** | | Strongly Disagree | 0 (0) |
| Headache | 15 (10.7) | **Pain experienced on the legs** | |
| Cough | 3 (2.1) | Agree | 118 (84.3) |
| Body pain | 77 (55) | Strongly Agree | 1 (0.7) |
| Skin Infection | 4 (2.9) | Disagree | 21 (15) |
| General Body Weakness | 41 (29.3) | Strongly Disagree | 0 (0) |
| None | 0 (0) | **Energy consuming task** | |
| **Pains are experienced at backbones** | | Sweeping | 39 (27.9) |
| Agree | 138 (98.6) | Mobbing | 30 (21.4) |
| Strongly Agree | 0 (0) | Packing | 8 (5.7) |
| Disagree | 2 (1.4) | Watering | 7 (5) |
| Strongly Disagree | 0(0) | Cutting | 56 (40) |

This shows that the work does not require much education. Table 1 also shows that 52.9% of the workers had a minimum of 6 – 10 years of experience on the job and only 8% had spent above 15 years on the job. This revealed that very few people stay more than 15 years on this particular job mostly because of the stressful tasks involved and the low pay. Also, the data revealed that the majority of the workers (44.3%) had treated MSDs in less than a month, as all of them had one MSDs or the other at the end of the day and body pain was the most common health challenge experienced a work.

The back, shoulder, and leg were the most common body parts where pains were experienced. This is because their work involves awkward bending and lifting of heavy loads. The workers work for an average of five hours a day and five days a week and the common equipment used were brooms, packers, cutlass, (which involved bending awkwardly while using them) lawnmower, mobbing stick, and watering cans, where cutting is the most difficult task among all the tasks (as agreed by the 40% of the UCW). The research revealed that the majority of the workers had other private jobs they do mostly after the casual work. This also contributed to the unrest which eventually resulted in high MSDs.

### 3.1 BMI Results

The height range (as shown in Table 2) of the male and female UCWs are 1.50 – 1.84 m and 1.50 – 1.75 m, respectively, their weight ranged 51 – 90 kg and 50 – 81 kg, respectively, while their BMI ranged from 17.8 – 32.3 kg/m$^2$ and 20.0 - 30.5 kg/m$^2$, respectively.

The BMI results in Table 3 revealed that only 55.3 and 53.5% of the male and female, respectively, of the UCW are at a normal weight, thus, others need to seriously readjust, especially, the 3 men and one female who were obese need urgent adjustment. This might be a contributory factor to the high rate of MSDs experienced by UCWs because, obese workers are reported to have a higher risk of MSDs compared to workers with normal weight (Viester, *et al.,* 2013).

Table 2: Summary of Calculated BMI and Physical Strain

| Sex | UCW | No of UCW | Variables | Age (years) | Height (m) | Weight (kg) | BMI (kg/m$^2$) | %CVL | %CVS | RHR | PEFR @ work (l/min) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Male | Cutters | 47 | Min | 33.0 | 1.50 | 51.0 | 17.8 | 9.1 | 12.3 | 10.8 | 200.0 |
| | | | Max | 59.0 | 1.84 | 90.0 | 32.3 | 68.7 | 98.4 | 112.1 | 380.0 |
| | | | Av. | 44.7 | 1.66 | 67.2 | 24.6 | 9.7 | 24.4 | 15.6 | 329.6 |
| | | | Sd | 33.0 | 8.7 | 9.9 | 3.4 | 9.3 | 24.1 | 15.1 | 31.3 |
| | Trimmers | 9 | Min | 33.0 | 1.56 | 53 | 18.3 | 12.8 | 22.5 | 14.5 | 290.0 |
| | | | Max | 62.0 | 1.78 | 75 | 27.7 | 61.4 | 83.7 | 110.2 | 380.0 |
| | | | Av. | 41.3 | 1.68 | 64.8 | 23.1 | 15.8 | 28.8 | 19.2 | 331.1 |
| | | | Sd | 7.4 | 7.7 | 7.7 | 3.1 | 3.2 | 6.6 | 3.3 | 28.0 |
| Female | Cleaners | 67 | Min | 32.0 | 1.50 | 50.0 | 17.9 | 13.9 | 16.8 | 15.2 | 200.0 |
| | | | Max | 59.0 | 1.75 | 81.0 | 30.5 | 65.1 | 80.4 | 110.9 | 400.0 |
| | | | Av. | 44.0 | 1.61 | 62.6 | 24.2 | 18.8 | 34.7 | 22.0 | 260.3 |
| | | | Sd | 7.3 | 5.3 | 7.0 | 3.1 | 6.3 | 12.1 | 6.7 | 32.6 |
| | Packers | 17 | Min | 33.0 | 1.56 | 50.0 | 20.0 | 12.1 | 13.1 | 12.8 | 200.0 |
| | | | Max | 53.0 | 1.73 | 78.0 | 29.7 | 62.7 | 80.3 | 110.3 | 390.0 |
| | | | Av. | 43.6 | 1.61 | 63.2 | 24.5 | 2.4 | 4.3 | 2.8 | 266.5 |
| | | | Sd | 5.9 | 5.4 | 7.2 | 3.0 | 2.2 | 4.2 | 2.5 | 42.7 |

Table 3: Results of BMI Analysis

| Level | Value range | Male Frequency (%) | Female Frequency (%) |
|---|---|---|---|
| Underweight | < 18.5 | 3 (5.4) | 2 (2.4%) |
| Normal weight | 18.5 – 24.9 | 31 (55.3) | 45(53.5%) |
| Over Weight | 25 – 29 | 19 (33.9) | 36(42.9%) |
| Obesity | ≥ 30 | 3 (5.4) | 1(1.2%) |

### 3.2 Physical Strain Assessment Results

Results of physical strain analysis presented in Table 2 revealed that the youngest participant is a female cleaner of 32 years of age while the oldest is a male trimmer of 62 years of age. The resting heart rate varied from 60 – 86 bpm and 62 – 86 bpm for males and females, respectively, which is normal adult resting HR values (Avram, *et al.,* 2019) while the working heart rate varied from 70 – 143 bpm and 65 – 114 bpm, for males and females, respectively. The %CVL in Table 4 shows that none of the UCWs was found at an intolerable high-level category, however, a considerable percentage of not more than 25.5% of the UCWs was at a high level, thus, a considerable reduction in load is expected for those under this category. Similarly, the %CVS in Table 5 shows that the effects of cardiovascular strain on female workers are lesser compared with its effects on males. This revealed that female works were less stressful compared with men's work as a fewer percentage of female UCWs (1.5% of the cleaners and 5.9% of the packers) were working at a high level of %CVS compared with men, where 21.3% of the cutters and 22.2% of the trimmers were working at a high level of %CVS. Thus, proactive actions are required to be taken within a short while to reduce the strain.
Likewise, Table 6 shows that cutters had the highest work intensity among all the UCWs while the cleaners had the least. Nevertheless, all the UCWs with high intensity need to be considered for workload reduction. Table 6, also confirmed that every aspect of activities of the UCWs was characterized with a high cardiovascular load with the highest in cutting and least in cleaning.

This however buttressed the fact that some of the UCWs are highly cardiovascular loaded because they spend few hours at work, thus, their working activities should be reviewed to reduce or eradicate the cardiovascular load that may lead to high musculoskeletal disorders and injuries (MSDs/Is). However, the RHR results show that majority of the UCWs (70.2, 77.8, 86.6, and 82.% for cutters, trimmers, cleaners, and packers, respectively) were Low cardiovascular loaded (Table 7).

### 3.3 Postural Analyses Results

Some pictures of UCWs at work are presented in the appendices. Scores A, B, and C for REBA analysis were determined and the final REBA score for each of the UCWs was obtained (as shown in Table 8). The postural analysis results using REBA revealed that a high percentage; 100, 88.2, and 83% of the cleaners, packers, and cutters were subjected to a very high level of risks i.e. high level of MSDs/Is due to bad postures at work. The few cutters with a low, medium, and high level of risk were the ones using lawnmowers which is ergonomically better compared with the use of cutlass. The trimmers, however, got the least level of risk because the trimming activities involve little awkwardness compared with others.

### 3.4 PEFR Results

According to Musa, *et. al.,* (2016), the normal values for PEFR for a healthy adult and non-exposed to dust are between 300 – 600 l/min with variation for age, body mass, height, and gender but the UCWs PEFR are 200 - 380 l/min, 290 – 380 l/min, 200 – 400 l/min, and 200 – 390 l/min for cutters, trimmers, cleaner and packers, respectively as shown in Table 2.

This research revealed that 29, 9, 18, and 13% of the cutters, trimmers, cleaner, and packers had PEFR below 300l/min, recommended level, thus, the nearest polluted air conveyed in the direction of the respondents and dusts generated when activities are being carried out did affect some of the sampled UCWs.

**Table 4: Summary of CVL Results**

| Scoring | Level | Male | | Female | |
|---|---|---|---|---|---|
| | | Cutters Freq. (%) | Trimmers Freq. (%) | Cleaners Freq. (%) | Packers Freq. (%) |
| <30 | Acceptable | 13 (27.7) | 5 (55.6) | 39 (58.2) | 8 (47.1) |
| 30-59 | Moderate | 22 (46.8) | 2 (22.2) | 17 (25.4) | 5 (29.4) |
| 60-100 | High | 12 (25.5) | 2 (22.2) | 11 (16.4) | 4 (23.5) |
| >100 | Intolerable High | 0 (0) | 0 (0) | 0 (0) | 0 (0) |

**Table 5: Summary of CVS Results**

| Scoring | Level | Comments | Male | | Female | |
|---|---|---|---|---|---|---|
| | | | Cutters Freq. (%) | Trimmers Freq. (%) | Cleaners Freq. (%) | Packers Freq. (%) |
| 0%-50% | Acceptable | No action required | 16 (34) | 6 (66.7) | 45 (67.2) | 9 (52.9) |
| 51%-80% | Moderate | Action required within few months | 21 (44.7) | 1 (11.1) | 21 (31.3) | 7 (41.2) |
| 81%-121% | High | Action required within few weeks | 10 (21.3) | 2 (22.2) | 1 (1.5) | 1 (5.9) |
| 121%- 150% | Very High | Action required within few days | 0 (0) | 0 | 0 (0) | 0 (0) |
| 151%-180% | Intolerable High | Action required immediately | 0 (0) | 0 | 0 (0) | 0 (0) |

Table 6: Summary of work intensity classification analysis

| Range | Level | Male | | Female | |
|---|---|---|---|---|---|
| | | Cutters Freq. (%) | Trimmers Freq. (%) | Cleaners Freq. (%) | Packers Freq. (%) |
| HRW<90 | Acceptable | 17 (36.2) | 3 (33.3) | 34 (50.7) | 9 (52.9) |
| 90>=HRW <110 | Moderate | 19 (40.4) | 4 (44.5) | 28 (41.8) | 6 (35.3) |
| 110>=HRW <130 | High | 11 (23.4) | 2 (22.2) | 5 (7.5) | 2 (11.8) |
| 130>=HRW <150 | Very high | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| 150>=HRW < 170 | Intolerable High | 0 (0) | 0 (0) | 0 (0) | 0 (0) |

Table 7: Summary of RHR analysis

| | | Male | | Female | |
|---|---|---|---|---|---|
| RANGE | | Cutters Freq. (%) | Trimmers Freq. (%) | Cleaners Freq. (%) | Packers Freq. (%) |
| RHR < 30 | Low cardiovascular load | 33 (70.2) | 7 (77.8) | 58 (86.6) | 14 (82.4) |
| RHR ≥ 30 | High cardiovascular load | 14 (29.8) | 2 (22.2) | 9 (13.4) | 3 (17.6) |

Table 8: Summary of REBA results

| | | Male | | Female | |
|---|---|---|---|---|---|
| Score | Level of risk | Cutters Frequency (%) | Trimmers Frequency (%) | Cleaners Frequency (%) | Packers Frequency (%) |
| 0 – 1 | Negligible | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| 2 – 3 | Low | 1(2.1) | 1 (11.1) | 0 (0) | 0 (0) |
| 4 – 7 | Medium | 6(12.8) | 5 (55.6) | 0 (0) | 0 (0) |
| 8 – 10 | High | 1(2.1) | 3 (33.3) | 0 (0) | 2 (11.8) |
| 11 – 15 | Very High | 39 (83.0) | 0 (0) | 67 (100) | 15 (88.2) |

### 3.5 Diagnostic tests on developed male and female predictive models

Experimental PEFR data collected was modelled alongside the age, BMI and year of experience (i.e., factors) of the respondents with a view to developing mathematical equations, which can be used to predict PEFR of male and female UCWs respectively. Also, the modelling was used to investigate the interactive effects of the factors on the response. Implementation of diagnostic tests on the developed models was ensured. Therefore, the predicted vs actual plots as well as normal plots of residuals revealed how perfectly the PEFR was modelled. They also gave ample opportunities of establishing how reliable the developed models are. According to Fajobi, *et al.,* (2017), an important condition that needs to be fulfilled to ascertain that any developed model is reliable is that all the points should line up nicely and the deviation of data points of the response from normality should be insignificant.

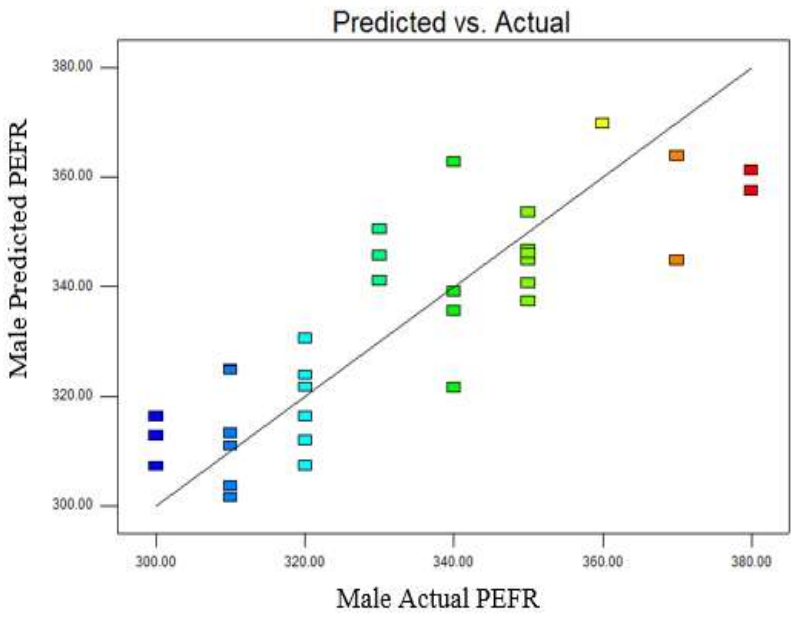
### 3.6 Predictive model developed for male UCWs

Plots shown in Figures 1a & 1b, showed that the preceding conditions in the study of Fajobi, *et al.,* (2017) were met and these confirmed the models developed are reliable and adequate. Figure 1a shows the plot of male predicted PEFR against the male actual PEFR while the one in Figure 1b shows the normal plots of residuals for male PEFR having normal % probability on the y-axis and internally studentized residuals on the y-axis. The alignment of the data points observed in the two plots to the line of fit is also an indication of the suitability of the developed model (Okediran, *et al.,* 2021). The R-squared value obtained for the developed model is 0.8853. The R-Squared value which was recorded is also commonly regarded as the coefficient of determination which indicates that using the experimental data (specifically the age, BMI and year of experience) as factors, the model was able to efficiently predict not less than 88.5% of the response (male PEFR) values, which is statistically acceptable. Another implication of this is that for any values of age, BMI and year of experience known respectively, the developed model can be used to efficiently predict any other PEFR of male UCW outside those covered in this study.

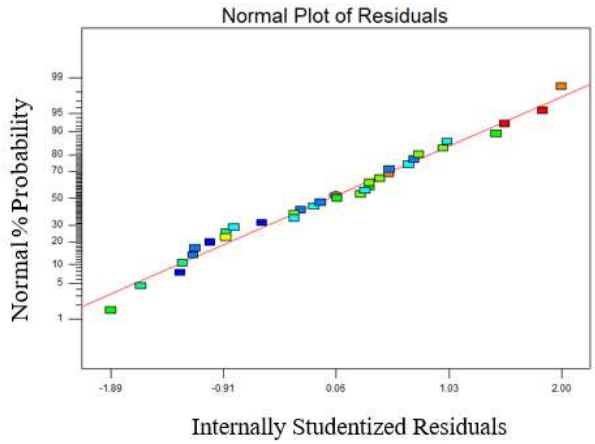
The resulting mathematical model for predicting the male UCWs is presented in Equation 6.

$$PEFR = 458.98611 - 0.057629(A) - 4.49034(B) - 1.71926(C) \qquad 6$$

Where;
A = Age of respondent (years)
B = Body mass index, BMI of the respondent (kg/m$^2$)
C = Year of experience of the respondent in the job (years)



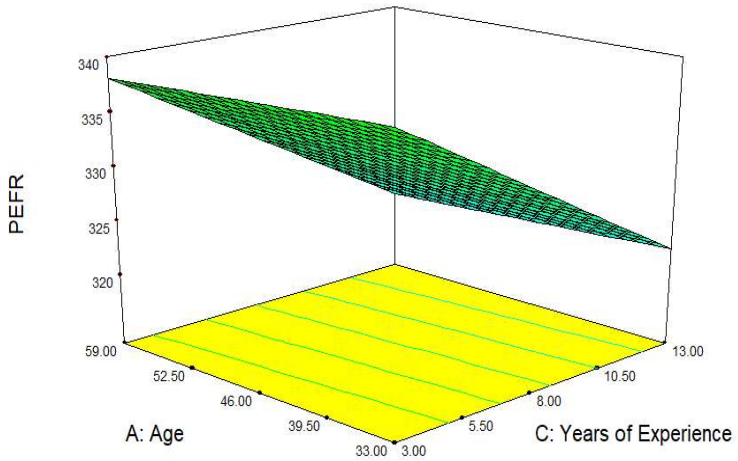

(a)



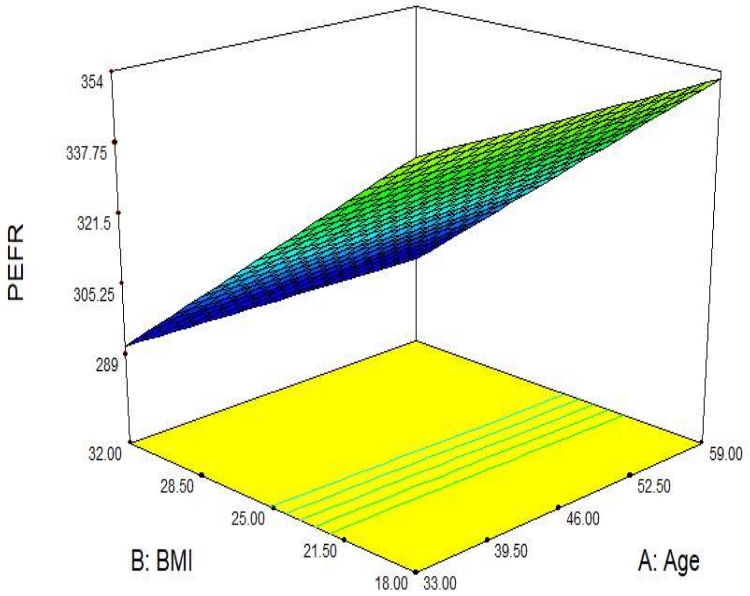

(b)

**Figure 1: (a) Male predicted PEFR vs actual PEFR plot (b) Normal plot of residual for PEFR**

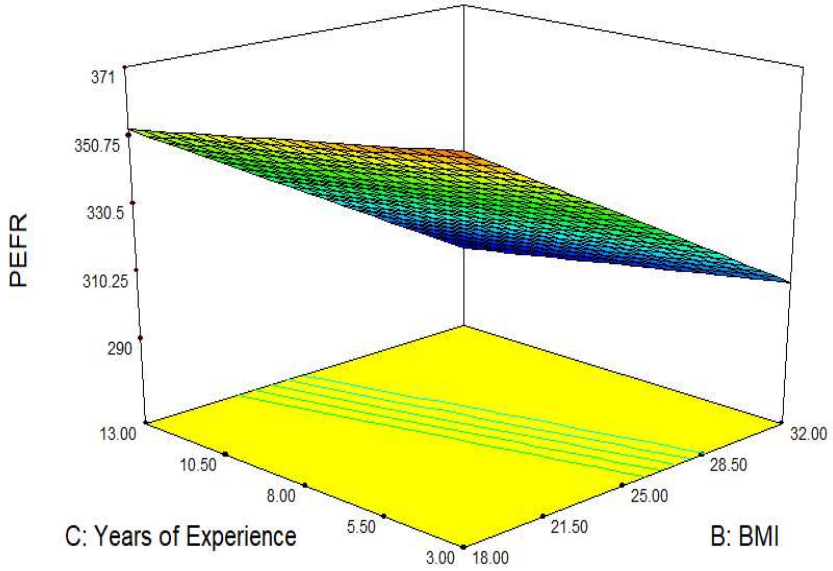
Figure 2a shows the interactive effect of age and year of experience on the PEFR of male UCWs. At low and high values of the year of experience (3 and 16 years), PEFR decreased from 30.1 to 10.02 l/min as age increased from 33 to 59 years. This depicts an inversely proportional relationship. The overlapping in the relationship at both low and high values of the year of experience is suggested to be as a result of the data trend. Figure 2b shows the interactive effect of BMI and age on PEFR. At a low value of BMI (18 kg/m$^2$), PEFR decreased from 353.9 to 352.4 l/min, as age increased from 33 to 59 years. Similarly, at high BMI (32 kg/m$^2$), PEFR decreased from 291 to 289.5 as age increased from 33 to 59 years. This implies an inversely proportional relationship for the two cases. Figure 2c has the plot of the interactive effect of year of experience and BMI. Therefore, at a low value of the year of experience (3 years), PEFR decreased from 31.65 to 30.1 l/min while BMI increased from 18 to 32 kg/m$^2$. The same trend of BMI was observed at a high value of the year of experience (13 years), but PEFR increased from 277 to 340.6 l/min. The relationship between the factors and the response was inversely proportional at a low value of the year of experience while it was directly proportional at the high value of the year of experience.




(a) Age and Years of Experience




(b) BMI and Age




(c) BMI and Years of Experience

**Figure 2: Plots of Interactive effects of predictors on PEFR for male UCWs**

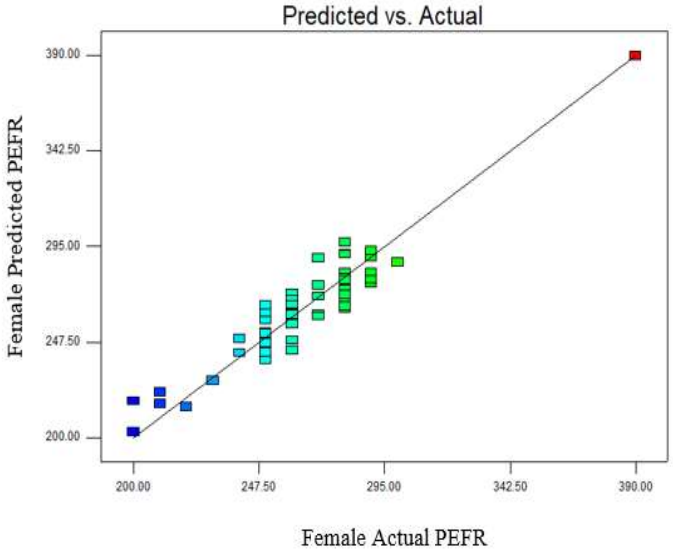
### 3.7 Predictive Model Developed for Female UCWs

Plots shown in Figures 3a & 3b, showed that the preceding conditions in the study of Fajobi, *et al.,* (2017) were met and these confirmed that the models developed are reliable and adequate. Plot in Figure 3a shows the plot of female predicted PEFR against the female actual PEFR while Figure 3b shows the normal plots of residuals for female PEFR having normal % probability on the y-axis and internally studentized residuals on the y-axis. The alignment of the data points observed in the two plots to the line of fit is also an indication of the suitability of the developed model (Okediran, *et al.,* 2021). The R-squared value obtained for the developed model is 0.9763. R-Squared value which was recorded, is also commonly regarded to as the coefficient of determination which indicates that, using the experimental data (specifically the age, BMI and year of experience) as predictors, the model was able to efficiently predict not less than 97.6% of the response (female PEFR) values, which is statisitcally acceptable. Another implication of this is that for any values of age, BMI and year of experience known respectively, the developed model can be used to efficiently predict any other PEFR of female UCW outside those covered in this study. The resulting mathematical model for predicting the female UCWs is presented in Equation 7.

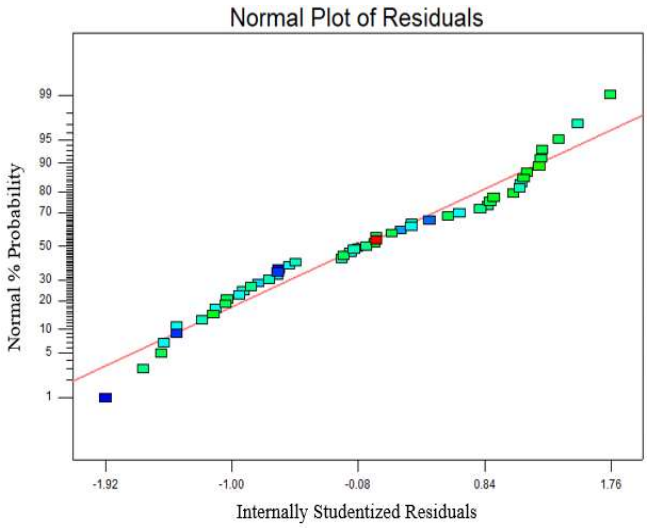
$$PEFR = -5677.89204 + 530.96308(\mathrm{A}) - 124.14352(\mathrm{B}) - 248.12879(\mathrm{C}) + 6.12325(\mathrm{AB}) + 17.71054(\mathrm{AC}) - 3.57623(\mathrm{BC}) - 15.9005(\mathrm{A}^2) + 1.36439(\mathrm{B}^2) - 10.3779(\mathrm{C}^2) - 0.047719(\mathrm{ABC}) + 4.13479(10^{-3})(\mathrm{A}^2B) - 0.27632(\mathrm{A}^2C) - 0.1314(\mathrm{AB}^2) + 0.43557(\mathrm{AC}^2) + 0.13215(\mathrm{B}^2C) - 0.05435(\mathrm{BC}^2) + 0.1401(\mathrm{A}^3) + 0.033168(\mathrm{B}^3) - 0.2738 \qquad 7$$

Where;

A = Age of respondent (years)
B = Body mass index, BMI of the respondent (kg/m$^2$)
C = Year of experience of the respondent in the job (years)




(a)

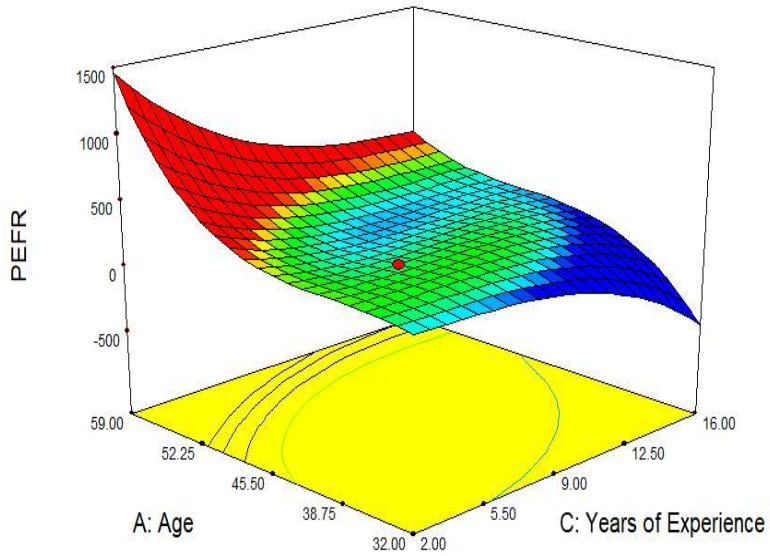



(b)

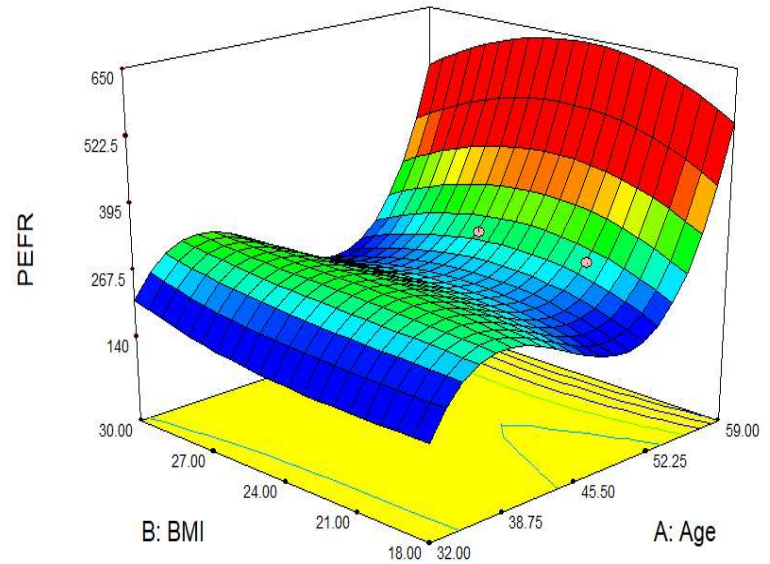
**Figure 3: (a) Female predicted PEFR vs actual PEFR plot (b) Normal plot of residual for PEFR**

Figure 4a presents the plot of interactive effect of age and year of experience on PEFR of female UCWs. At low age value (32 years), PEFR was observed to decrease from 254.1 l/min to nearly infinity as the year of experience increased from 2 to 16 years. This suggests an indirect proportional relationship. Similarly, at high age value (59 years), the PEFR decreased from 1456.5 to 476.4 l/min as the year of experience increased from 2 to 16 years, thus having same relationship as that of low age value. Figure 4b presents the combinational effect of BMI and age on PEFR of female UCWs. It shows that at low BMI value (18 kg/m$^2$), PEFR increased from 152.3 to 273 l/min, while the respondent age increased from 32 to 36.5 years. Also, the PEFR decreased from 273 to 185 l/min as age increased from 36.5 to 48.9 years. Also, PEFR increased from 185 to 549.4 l/min as the age increased from 48.9 to 59 years. This suggests that at first, direct proportional relationship exists, then indirect proportional relationship and later, direct proportional relationship. Furthermore, at high BMI value (30 kg/m$^2$), PEFR increased from 211.7 to 294 l/min as the age increased from 32 to 36 years, thus displaying a direct proportional relationship. Conversely, PERF decreased from 294 to 180 l/min as age increased from 36 to 50.5 years, then PEFR later increased from 180 to 532 l/min as the age increased from 50.5 to 59 years.

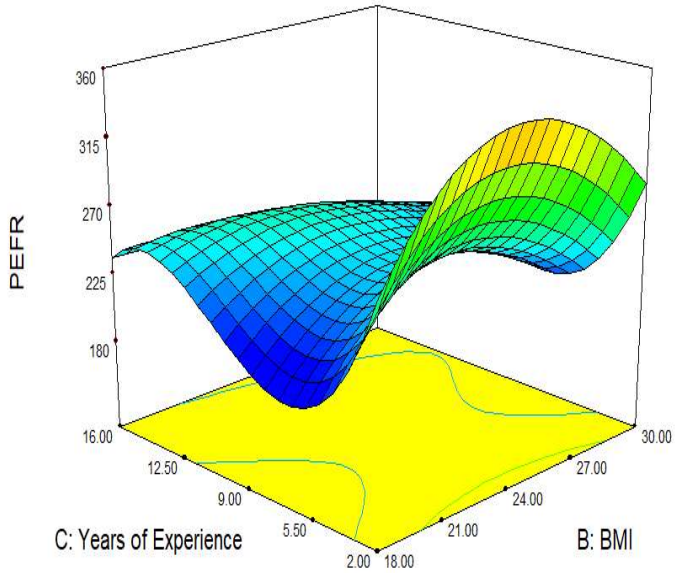
This trend suggests a direct at first and indirect proportional relationship at the latter. Figure 4c shows the interactive effect of BMI and years of experience on PEFR. At low value of year of experience (2 years), PEFR was observed to increase from 273.9 to 349 and BMI increased 18 to 24 kg/m$^2$, suggesting a direct proportional relationship. Later, PEFR decreased from 349 to 286.1 l/min, while the BMI increased from 24 to 30 kg/m$^2$, which by implication suggests an indirect proportional relationship. At high value of year of experience (16 years), PEFR decreased from 237.3 to 185.2 l/min as BMI increases from 18 to 30 kg/m$^2$. This trend established an indirect proportional relationship. Also within this range, increase in BMI relative to year of experience had negative effect on PEFR of the female UCWs studied.




(a) Age and Years of Experience




(b) BMI and Age




(c) Years of Experience and BMI

**(d) Figure 4: Plots of Interactive effects of predictors on PEFR of female UCWs**

## 4. CONCLUSIONS AND RECOMMENDATION

Globally, postural, and physical strain have led to the proliferation of work-related musculoskeletal disorders which often result in wear and tear, premature aging, illnesses, expiratory inadequacy, as well as cardiovascular diseases among workers of diverse occupational groups. In the case of university casual workers, UCWs were not in exemption because of the peculiarity of the activities demanded by the work such as; repetitive lifting, carrying, pulling, pushing, sudden exertion, and static muscle loading. Therefore, this study assessed the postural, physical strain, and peak expiratory flow rate of UCWs. The population studied comprised 40 and 60% of male and female UCWs respectively with 77.9% of them having primary educational attainments, which shows that enrollment for causal work in the university system does not necessarily require higher level certificates. Repetitive, awkward bending, and lifting of heavy loads are the common activities in casual work and it was established that they posed health challenges on the respondents especially incessant body pain experienced at their back, shoulder, and leg regions. Evidently, in less than a month, 44.3% of the respondents had treated one MSDs or the other.

The height and weight ranges of the male are 1.50 – 1.84 m, 51 – 90 kg and female 1.50 – 1.75 m, 50 – 81 kg respondents with respective BMI ranged from 17.8 – 32.3 kg/m$^2$ and 20.0 - 30.5 kg/m$^2$. 55.3 and 53.5% of the male and female UCWs respectively are at regulated BMI normal weight while others did not conform to the standard. Physical strain assessment showed that the working heart rate of the respondents ranged between 70 – 143 bpm and 65 – 114 bpm, for male and female respondents respectively.

This study also revealed that every aspect of activities of the UCWs was characterized with a high cardiovascular load with the highest in cutting and least in cleaning. The postural analysis results using REBA revealed that a high percentage; 100, 88.2, and 83% of the cleaners, packers, and cutters respectively were subjected to a very high level of risks i.e., high level of MSDs/Is due to bad postures at work. PEFR results revealed that 29, 9, 18, and 13% of the cutters, trimmers, cleaner, and packers had PEFR below 300l/min, recommended level, thus, the nearest polluted air conveyed in the direction of the respondents and specks of dust generated when activities are being carried out did affect some of the sampled UCWs.

Therefore, this study proposed two mathematical models to predict the PEFR of male and female UCWs respectively. The resulting models exhibited quadratic properties to model the real-life scenarios with the coefficient of determination ($R^2$) of 0.8853 and 0.9763 respectively. Thus, employers of UCWs would find in these models reliable, economical, effective and efficient prediction tools to make adequate regulations guiding the activities of any hired worker. This study recommends that UCWs should be enlightened regularly through seminars and workshops on the dangers of musculoskeletal disorders and associated risks factors to prevent them. Use of personal preventive equipment and adequate training on how to correctly carry out the activities required of a casual job should be enforced.

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