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# Risk Factors to Musculoskeletal Disorders and Anthropometric Measurements of Filipino Manufacturing Workers

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*This study looked into the risk factors to musculoskeletal disorders and established anthropometric measurements of Filipino workers in 29 manufacturing industries. Anthropometric measurements of 1,805 workers were taken, and 495 workers were surveyed. Limitation of motion was found in 0.8% of the respondents, affectation in activities of daily living was seen in 1.6% and 3.2% felt discomfort in the head and neck. Upper trunk and low back pain was experienced by 23.8%. Odds ratio results (*p *= .05) showed that it is 29 times likely for workers to develop low back pain when they stand for 2–8 hrs a day than when they sit all the time. Anthropometry can be used for the design of workstations and work furniture.*

anthropometric measurements   musculoskeletal disorders   manufacturing industries
personal protective equipment   ergonomic design

## 1. INTRODUCTION

In the Philippines, the 2000 annual medical report of the Department of Labor and Employment showed that occupational hazards were commonly reported in the workplace. The most prevalent hazards included excessive physical work, prolonged standing, unfavorable work position and static monotonous work. This was especially so in the manufacturing sector [1].

The intent of the measurements was to provide data on what engineering and personal protective equipment should be used or be designed. This would ensure fit of work to the individual worker, comfort and ease of use of equipment and effectiveness of control equipment. Most equipment is bought from abroad where the design is based on the anthropometric data of foreign nationals which may not be the same as Filipino body dimensions.

An integral part of the study was to look into the profile of ergonomic problems and musculoskeletal disorders (MSDs) of the workers and then to determine the association with certain risk factors. In this way, we were able to see the importance of ergonomically designed equipment, workstation and working tools.

Delleman showed the importance of height anthropometry in working postures during visual-manual operations to minimize the load on a musculoskeletal item [2]. Factors such as viewing distance, manipulation distance, handgrip of the tool and body support all contributed to the stability of body movements. Application of the anthoprometric data in this study was varied.

## 2. METHODOLOGY

### 2.1. The Study Frame and the Sample

The study was a cross-sectional design to identify both the anthropometric measurements of workers and the prevalence and the risk factors to MSDs disorders. Anthropometry is usually sought when there is a high incidence of MSDs at work. Random sampling was employed in the selection of industries based on the sampling

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frame provided by the Philippine Economic Zone Authority. Then from the selected industries, stratified random sampling was done among the different workstations. Finally, all workers in the selected workstation were taken as a sample for the prevalence study, in the identification of risk factors and in the measurements done. Twenty-nine industries were included and 1,805 workers were measured.

The type of industries selected for the study included semiconductors, garments, electronics, textile, and the assembly part of various steel and plastic parts for manufacturing products. The workstations for garments and textile included cutting section, dyeing, visual inspection, pressing and sewing. For electronics and semiconductor industries, workers were taken from soldering, etching, degreasing, de-acidification, visual inspection, cutting, and grinding.

There were several questionnaires constructed for this sample survey: (a) a questionnaire for workers, which contained information on the nature of MSDs and associated risk factors; (b) a questionnaire guide for industrial hygienists, who evaluated the various work conditions and workstations prior to questionnaire construction; (c) a physical assessment form, where trained research assistants recorded anthropometric measurement data. All 1,805 workers were measured for anthropometry. The 495 workers who filled in the questionnaires were chosen based on their report of MSDs for the past year. Only 495 workers were taken because management allowed only a certain period of time for all the assessment procedures to be carried out. Research assistants were trained on measurements in workshops and training sessions.

### 2.2. The Questionnaire on MSD and Its Risk Factors

Questionnaires were given out to determine the risk factors associated with MSDs among workers. The risk factors identified were:

1. Work postures, such as (a) repetitive exertions, (b) static load, (c) forceful exertions, and (d) postural stresses;
2. Workplace dimensions and spatial arrangements such as fit, reach and see; and
3. Work conditions: (a) vibration, (b) cognitive demands, and (c) work pacing.

A symptom questionnaire was used to capture the presence of signs and symptoms of low back pain (LBP) such as the nature and severity of pain, limitation of joint motions, and limitation of certain activities. The questionnaire was based on the Ergonomics Standard Questionnaire, but was revised following the results of the pre-testing of the questionnaires. An example of the questionnaire is shown here.

On fit, reach and visual distance, the following questions were asked:

- Do you have repetitive tasks (defined as work cycle repeated every minute)?
- How much load do you carry for every manual material handling you do?
- How much is the average weight that you carry during the entire work shift?

For the range of the worker's motion, an assessment form was given. It indicated the parts to be measured (the range of motion for the shoulder, hand, and others), the motion that it entailed (flexion, extension, lunar deviation, etc.), the normal range of motion expected (e.g., shoulder abduction is 0º–180º), and then the actual range of motion of the body part.

### 2.3. Anthropometric Measurement

For the anthopometric measurements, the instruments were**:** (a) grid board and blocks, (b) anthropometers, (c) calipers, (d) flexible tapes and (e) goniometers.

The following dimensions were measured: (a) body segment lengths and height and (b) breadth, depths and circumferences. Examples of measurements included hip breadth, crotch length, functional leg length, buttock-knee length, knee height, sitting, popliteal height, waist length while sitting, thigh clearance, sitting height, abdominal extension depth, gluteal furrow height, vertical trunk circumference, waist-hip length, foot length, foot breadth and lateral malleolus height. Anthropometric measurement is the science of measurement and the art of application that establishes the physical geometry, mass properties, and strength capabilities of the human body. The 50th percentile and the standard deviation for each measurement were obtained.

The use of all the instruments required a fixed and standardized reference point. For instance, in measuring the length of the lower leg, the measuring tape should start at the head of the fibula (the bone of the lower leg). For body segment breadths and circumferences, reference points were also made, such as 0.15 m (6 in.) from the hip bone for upper leg circumference.

Data were analyzed using the odds ratio measures of central tendencies and dispersion for the anthropometric measurements. Data were encoded and analyzed using SPSS 10.0.

# 3. RESULTS

## 3.1. MSDs and Risk Factors

For the symptoms and work demand questionnaire, 495 workers were interviewed and assessed for MSDs. Among the respondents, 60.2% were females, 43.7% were in the production or assembly-line station, 69.6% were single, 10.8% were 17 years old, while 10.4% were 22 years old. The mean age was 22.8 years. The majority were assigned inspector-type work, accounting for 33.6%. The majority (76.8% of the respondents) were also contractual and did not have permanent status.

In conditions of the head and neck, 17.8% reported that they experienced pain (Table 1). Conditions of the upper trunk and low back were also prevalent in the population. Trunk rigidity was found in 2% of the operators. Twenty-three point eight percent reported they experienced upper trunk and LBP. (Table 2). Fewer than 1% of the workers reported affectations in daily life activities (Tables 3 and 4).

For logistic regression analysis, Table 4 shows the results. Upper extremity pain was 17 times more likely among those who carried objects for

**TABLE 1. Frequency Distribution of Symptoms Related to Head and Neck**

| | Pain | | LOM | | ADL Affectation | | Discomfort | |
|---|---|---|---|---|---|---|---|---|
| **Head and Neck** | **Freq** | **%** | **Freq** | **%** | **Freq** | **%** | **Freq** | **%** |
| Positive | 88 | 17.8 | 4 | 0.8 | 8 | 1.6 | 16 | 3.2 |
| Negative | 406 | 82.0 | 490 | 99.0 | 486 | 98.2 | 478 | 96.6 |
| No response | 1 | 0.2 | 1 | 0.2 | 1 | 0.2 | 1 | 0.2 |
| Total | 495 | 100.0 | 495 | 100.0 | 495 | 100.0 | 495 | 100.0 |

*Notes*. LOM—limitations of motion, ADL—activities of the daily living, freq—frequency.

**TABLE 2. Frequency Distribution of Symptoms Related to Upper Extremity and Low Back**

| | Pain | | LOM | | ADL Affectation | | Discomfort | |
|---|---|---|---|---|---|---|---|---|
| **Upper Trunk and Low Back** | **Freq** | **%** | **Freq** | **%** | **Freq** | **%** | **Freq** | **%** |
| Positive | 118 | 23.8 | 7 | 1.4 | 7 | 1.4 | 25 | 5.1 |
| Negative | 376 | 76.0 | 487 | 98.4 | 487 | 98.4 | 469 | 94.7 |
| No response | 1 | 0.2 | 1 | 0.2 | 1 | 0.2 | 1 | 0.2 |
| Total | 495 | 100.0 | 495 | 100.0 | 495 | 100.0 | 495 | 100.0 |

*Notes*. LOM—limitations of motion, ADL—activities of the daily living, freq—frequency.

**TABLE 3. Frequency Distribution of Symptoms Related to Lower Extremity**

| | Pain | | LOM | | ADL Affectation | | Discomfort | |
|---|---|---|---|---|---|---|---|---|
| **Lower Extremity** | **Freq** | **%** | **Freq** | **%** | **Freq** | **%** | **Freq** | **%** |
| Positive | 68 | 13.7 | 5 | 1.0 | 4 | 0.8 | 25 | 5.1 |
| Negative | 423 | 85.5 | 486 | 98.2 | 487 | 98.4 | 466 | 94.1 |
| No response | 4 | 0.8 | 4 | 0.8 | 4 | 0.8 | 4 | 0.8 |
| Total | 495 | 100.0 | 495 | 100.0 | 495 | 100.0 | 495 | 100.0 |

*Notes*. LOM—limitations of motion, ADL—activities of the daily living, freq—frequency.

**TABLE 4. Percentage Distribution of Affectation of Various Body Parts**

| Body Part | Pain (%) | LOM (%) | ADL Affectation (%) | Discomfort (%) |
|---|---|---|---|---|
| Head and neck | 17.8 | 0.8 | 1.6 | 3.2 |
| Upper extremity | 14.7 | 0.6 | 0.8 | 2.4 |
| Low back | 23.8 | 1.4 | 1.4 | 5.1 |
| Lower extremity | 13.7 | 1.0 | 0.8 | 5.1 |

*Notes*. LOM—limitations of motion, ADL—activities of the daily living.

2–8 hrs than those who did not. Lower extremity pain was more than 6 times more likely to happen when the worker walked around for most of the workday.

**TABLE 5. Odds Ratio Analysis of Musculoskeletal Disorders (MSDs) and Certain Risk Factors**

| MSDs | 2–8 hrs | *P* Value |
|---|---|---|
| Upper extremity pain vs. | | |
| reaching | 14.833 | .05 |
| carrying objects in hand | 17.224 | .05 |
| pushing | 6.682 | .05 |
| pulling | 10.333 | |
| Lower extremity pain vs. | | |
| standing | 9.666 | .05 |
| climbing | 0.000 | .05 |
| walking | 11.871 | .05 |

Tiredness and excessive fatigue were associated with poor ventilation, type of work and poor posture (Table 6). When the air that an individual breathed in was polluted with chemicals, normal oxygenation of cell tissues was not attained. This was manifested in tiredness or exhaustion. Poor posture strained muscles and joints caused fatigue. Those with poor posture at work were 2 times more likely to be tired and exhausted relative to those with good posture. Tiredness was also 2.7 more likely to develop among assembly-line workers than supervisors, holding others constant.

Factors associated with LBP included excessive work, prolonged work, poor posture, assembly line work and cold environment. Poor posture and improper body mechanics could place undue stress on the joints and muscles leading to pain, soreness or even muscle rupture.

**TABLE 6. Odds Ratio for Excessive Fatigue/Tiredness**

| Factors Associated With Excessive Fatigue | Parameter Estimate | Level of Significance |
|---|---|---|
| Type of work | 2.703 | .001 |
| Sex | 2.486 | .006 |
| Poor posture and poor body position | 2.009 | .003 |
| Poor ventilation | 0.318 | .000 |
| Excessive heat | 0.528 | .007 |
| Backache | 0.577 | .034 |

**TABLE 7. Odds Ratio for Low Back Pain**

| Factors Associated With Backache | Parameter Estimate | Level of Significance |
|---|---|---|
| Excessive Work | 0.610 | .035 |
| Prolonged Work | 0.503 | .003 |
| Poor Posture | 1.803 | .017 |
| Nature of Work | 1.768 | .050 |
| Cold | 1.759 | .008 |

### 3.2. Anthropometric Data

One thousand, eight hundred and five workers were selected for the anthropometric measurement. There were 46.7% males and 53.3% females. Out of the total of 1,805 subjects, 60.40% (73) of workers were single, 38.94% (1090) were married and 0.66% (12) were in other categories (separated, widowed). Forty point seven percent of the workers were high school graduates, 23.3% were vocational school graduates and 17.6% reached college level. There were 76.99% people who were 30 years old and below, which shows a relatively young working population. Twenty-one point four one percent were between 31 and 50 years old and only 1.61% of were above 50 years old. Out of the 1,805 workers surveyed, 80.50% were about 150–174 cm height. The shortest was 54 cm and the tallest was 191 cm. Most of the workers (92.69%) weighed less than 80 kg. The lightest one was 40 kg and the heaviest was 170 kg.

Tables 8–16 show the workers' anthropometric measurements. The mean standing height for males was higher than for females at 167 cm and 153.92 cm respectively. The mean sitting height for males was 84.84 cm, while it was 79.92 cm for females.

**TABLE 8. Anthropometric Measurement for Standing (cm)**

| | Male (*n* = 843) | | | Female (*n* = 962) | | |
|---|---|---|---|---|---|---|
| **Measurement** | ***M*** | ***Mdn*** | ***SD*** | ***M*** | ***Mdn*** | ***SD*** |
| Standing height | 167.01 | 167.00 | 8.03 | 153.92 | 155.00 | 8.28 |
| Eye height | 155.01 | 155.00 | 6.92 | 143.05 | 143.00 | 6.15 |
| Shoulder height | 137.45 | 137.00 | 6.07 | 127.21 | 127.00 | 5.80 |
| Shoulder width | 44.67 | 44.00 | 7.33 | 40.24 | 40.00 | 8.29 |
| Shoulder elbow length | 33.05 | 33.00 | 3.98 | 31.39 | 31.00 | 10.28 |
| Length of upper arm | 25.99 | 26.00 | 4.54 | 24.92 | 25.00 | 8.38 |
| Length of lower arm | 25.83 | 25.00 | 4.42 | 24.16 | 24.00 | 4.18 |
| Forearm hand length | 44.06 | 44.00 | 4.13 | 40.47 | 41.00 | 5.39 |
| Length of arm and hand | 72.60 | 73.00 | 6.35 | 66.04 | 67.00 | 5.77 |
| Elbow height | 104.14 | 104.00 | 6.72 | 96.28 | 97.00 | 7.39 |
| Knuckle height | 72.51 | 73.00 | 5.80 | 67.77 | 68.00 | 6.33 |
| Chest height | 123.36 | 123.00 | 7.23 | 111.28 | 112.00 | 10.50 |
| Chest breadth | 36.35 | 35.50 | 6.18 | 32.63 | 31.00 | 7.22 |
| Waist height | 97.32 | 98.00 | 8.43 | 95.47 | 96.00 | 6.09 |
| Waist hip length | 10.11 | 9.00 | 6.44 | 10.19 | 9.00 | 6.32 |
| Hip width | 43.50 | 44.00 | 8.33 | 43.38 | 44.00 | 7.10 |
| Hip height | 87.66 | 89.00 | 8.57 | 85.34 | 86.00 | 9.01 |
| Knee height | 49.73 | 50.00 | 5.99 | 45.88 | 46.00 | 3.09 |
| Popliteal height | 46.35 | 47.00 | 3.00 | 42.05 | 42.00 | 4.02 |
| Upper reach | 193.40 | 190.00 | 10.80 | 190.19 | 191.00 | 10.28 |
| Overhead fingertip reach | 212.08 | 213.00 | 9.10 | 196.46 | 196.00 | 8.91 |
| Arm span | 167.92 | 169.00 | 9.15 | 153.18 | 153.00 | 8.53 |

**TABLE 9. Anthropometric Measurement for Sitting (cm)**

| | Male (*n* = 843) | | | Female (*n* = 962) | | |
|---|---|---|---|---|---|---|
| **Measurement** | ***M*** | ***Mdn*** | ***SD*** | ***M*** | ***Mdn*** | ***SD*** |
| Sitting height | 84.84 | 85.00 | 5.81 | 79.92 | 80.00 | 4.50 |
| Eye height | 73.36 | 73.00 | 3.83 | 68.38 | 69.00 | 4.85 |
| Elbow height | 22.23 | 22.00 | 4.21 | 21.89 | 22.00 | 4.09 |
| Waist height, sitting | 19.44 | 19.00 | 6.15 | 22.41 | 22.00 | 3.21 |
| Hip height | 13.28 | 13.00 | 4.06 | 15.29 | 15.00 | 6.71 |
| Hip breadth, sitting | 35.60 | 35.00 | 4.19 | 36.39 | 36.00 | 4.83 |
| Thigh clearance height | 13.49 | 13.00 | 4.45 | 12.82 | 12.00 | 6.97 |
| Buttock knee length | 54.80 | 55.00 | 5.21 | 52.73 | 53.00 | 4.56 |
| Buttock popliteal length | 746.40 | 46.00 | 3.72 | 45.14 | 45.00 | 3.69 |
| Knee height, sitting | 50.03 | 50.00 | 3.99 | 46.98 | 47.00 | 4.43 |
| Popliteal height | 43.33 | 43.00 | 2.57 | 40.34 | 40.50 | 2.90 |
| Buttock width | 48.45 | 48.00 | 7.40 | 47.66 | 48.25 | 6.85 |
| Length of upper leg | 36.80 | 36.00 | 6.12 | 35.96 | 36.00 | 5.25 |
| Length of lower leg and foot | 45.27 | 46.00 | 4.53 | 42.14 | 42.50 | 4.31 |
| Thumbtip reach | 71.30 | 72.00 | 7.12 | 65.44 | 66.00 | 7.63 |
| Overhead fingertip reach, sitting | 127.92 | 128.00 | 7.81 | 116.87 | 117.00 | 9.77 |

**TABLE 10. Circumference Anthropometric Measurement (cm)**

| | Male (*n* = 843) | | | Female (*n* = 962) | | |
|---|---|---|---|---|---|---|
| **Circumference** | ***M*** | ***Mdn*** | ***SD*** | ***M*** | ***Mdn*** | ***SD*** |
| Head | 55.28 | 55.50 | 3.086 | 53.88 | 54.00 | 2.63 |
| Shoulder | 106.67 | 106.00 | 9.243 | 94.52 | 95.00 | 10.86 |
| Biceps | 28.10 | 27.50 | 5.499 | 25.28 | 25.00 | 3.97 |
| Lower arm | 25.62 | 25.00 | 4.794 | 22.28 | 22.00 | 4.45 |
| Buttock | 92.69 | 93.00 | 9.035 | 92.53 | 92.00 | 7.52 |
| Upper leg | 46.14 | 46.00 | 6.401 | 45.46 | 45.00 | 5.21 |
| Lower leg | 35.68 | 35.00 | 5.292 | 33.83 | 33.00 | 4.59 |
| Chest | 86.66 | 87.00 | 9.344 | 84.42 | 84.00 | 9.31 |
| Waist | 79.42 | 79.00 | 8.566 | 72.74 | 71.00 | 9.05 |
| Hips | 88.34 | 88.00 | 7.934 | 86.64 | 86.00 | 9.44 |

**TABLE 11. Grip Strength Measurement for Standing (cm)**

| | Male (*n* = 843) | | | Female (*n* = 962) | | |
|---|---|---|---|---|---|---|
| **Grip Strength** | ***M*** | ***Mdn*** | ***SD*** | ***M*** | ***Mdn*** | ***SD*** |
| Standing (left) | 38.53 | 39.00 | 8.56 | 20.72 | 20.85 | 7.00 |
| Standing (right) | 40.64 | 41.00 | 9.35 | 22.36 | 22.00 | 8.89 |
| Sitting (left) | 38.60 | 39.00 | 8.40 | 20.21 | 20.00 | 5.66 |
| Sitting (right) | 40.41 | 40.00 | 8.46 | 21.84 | 22.00 | 5.72 |

**TABLE 12. Depth Anthropometric Measurement (cm)**

| | Male (*n* = 843) | | | Female (*n* = 962) | | |
|---|---|---|---|---|---|---|
| **Depth** | ***M*** | ***Mdn*** | ***SD*** | ***M*** | ***Mdn*** | ***SD*** |
| Forward reach, functional | 76.58 | 78.00 | 7.61 | 69.64 | 70.00 | 6.83 |

**TABLE 13. Breadth Anthropometric Measurement (cm)**

| | Male (*n* = 843) | | | Female (*n* = 962) | | |
|---|---|---|---|---|---|---|
| **Breadth** | ***M*** | ***Mdn*** | ***SD*** | ***M*** | ***Mdn*** | ***SD*** |
| Elbow to elbow breadth | 39.17 | 39.00 | 5.19 | 37.53 | 37.00 | 5.24 |

**TABLE 14. Anthropometric Measurement for Standing (cm)**

| | Male (*n* = 843) | | | Female (*n* = 962) | | |
|---|---|---|---|---|---|---|
| **Head Dimensions** | ***M*** | ***Mdn*** | ***SD*** | ***M*** | ***Mdn*** | ***SD*** |
| Head breadth | 17.22 | 17.00 | 6.21 | 16.50 | 16.00 | 6.96 |
| Head length | 20.53 | 20.00 | 7.48 | 19.23 | 19.00 | 2.76 |
| Interpupillary distance | 7.74 | 7.50 | 4.63 | 7.37 | 7.00 | 5.18 |
| Bitragion subnasale arc | 28.62 | 29.00 | 3.03 | 27.09 | 27.00 | 1.43 |
| Bitragion chin arc | 30.57 | 31.00 | 2.07 | 28.85 | 29.00 | 1.68 |

**TABLE 15. Hand Anthropometric Measurement (cm)**

| | Male (*n* = 843) | | | Female (*n* = 962) | | |
|---|---|---|---|---|---|---|
| **Hand Dimensions** | ***M*** | ***Mdn*** | ***SD*** | ***M*** | ***Mdn*** | ***SD*** |
| Sleeve outseam | 54.02 | 54.00 | 4.72 | 49.38 | 50.00 | 4.65 |
| Hand length | 19.75 | 19.00 | 7.82 | 17.95 | 18.00 | 3.44 |
| Hand breadth | 9.80 | 9.50 | 4.07 | 9.23 | 8.50 | 6.97 |
| Hand circumference | 20.78 | 21.00 | 1.64 | 18.39 | 18.00 | 7.44 |
| Wrist center of grip length | 9.20 | 9.00 | 3.93 | 8.69 | 8.50 | 4.10 |

**TABLE 16. Foot Anthropometric Measurement (cm)**

| | Male (*n* = 843) | | | Female (*n* = 962) | | |
|---|---|---|---|---|---|---|
| **Foot Dimensions** | ***M*** | ***Mdn*** | ***SD*** | ***M*** | ***Mdn*** | ***SD*** |
| Foot length | 25.42 | 25.50 | 1.67 | 22.63 | 23.00 | 1.64 |
| Foot breadth, horizontal | 10.52 | 10.00 | 6.37 | 9.50 | 9.00 | 4.41 |
| Ankle circumference | 24.18 | 24.00 | 2.23 | 21.93 | 22.00 | 2.80 |
| Functional leg length | 93.34 | 93.00 | 4.08 | 90.70 | 90.00 | 4.60 |
| Step height | 27.67 | 28.00 | 7.79 | 25.63 | 25.00 | 9.11 |

## 4. DISCUSSION

Pain in the head and neck, low back, lower and upper extremity was prevalent ranging from 13.7 to 23.8%. The samples were chosen using stratified random sampling and a level of significance at $p$ = .05; the results can be concluded to apply to the target population of workers in manufacturing industries in the country. Discomfort was reported high from 2.4 to 5.1% for various body parts. Interference of activities of daily living was also noted from 0.8 to 1.6% for various body parts. MSDs are therefore a problem among workers in the Philippine manufacturing sector. Risk factors consisted of performing the following activities for 2–8 hrs during the entire workshift: overreaching, carrying objects in the hand, pushing, pulling, climbing and walking ($p$ = .05). It was also noted that significant factors to LBP included poor posture, prolonged work and excessive work ($p = .05$).

In this study, 23.8% of the workers had LBP ($p = .05$). This is a considerable high prevalence of LBP in the country. The risk factors identified were repetitive and excessive work ($p = .05$). Guo [3] found the same risk factors among workers in the USA. The results of his study showed that the prevalence of back pain increased as the number of working hours spent on RSPA (repeated strenuous physical activities) or RBTR (repeated bending, twisting, or reaching) increased. The estimated overall prevalence of back pain was 8.9% among male workers and 5.9% among female workers. The number of hours spent on repeated activities at work was associated with the prevalence of back pain [3]. The same was seen in Hoogendoorn et al.'s study [4] where they noted flexion and rotation of the trunk, lifting, and low job satisfaction as risk factors for sickness absence due to LBP. In another study, a significant increase in risk was found in the high physical and high psychosocial exposure group for symptoms of hand or wrist and upper limb disorders [5]. Several work-related mechanical exposures predicted a new onset of LBP including lifting heavy weights with one or two hands, lifting heavy weights at or above shoulder level, pulling heavy weights, kneeling or squatting for 15 min or longer [6].

This study also showed the relationship between lower extremity pain and pushing and pulling ($p = .05$). Other studies validate this. In 2002 Hoozemans et al. [7] noted that for shoulder complaints a dose-response relation was observed for exposure to pushing/pulling, and that greater association was noted for more severe cases of low back and shoulder complaints. Pushing and pulling in this study increased the odds of upper extremity pain by about 6 or 10 times respectively.

The study population for the anthropometric data consisted of 962 (53.29%) women and 843 (46.71%) men since the majority of workers now in manufacturing industries are females. The burden of work on women should be further investigated. In her 2003 study, Brown [8] said that in the USA, 9,000 women healthcare workers sustained a disabling injury while performing work-related tasks. Disabling back injury and back pain affected 38% of nursing staff. The article cited (p. 401) that "twelve percent of all nurses intending to leave nursing permanently cited back pain as either a main or contributing factor (Owen, 2003)" This was reiterated in Ylinen et al. [9], where they said that occupational health care system should focus on women workers.

Anthropometric data can be used in industrial ergonomics. This study was conducted in order to come up with baseline anthropometric measurements of Filipino manufacturing workers. In this way, performance and productivity of workers can also be achieved. In Gualdi's study [10], 234 male athletes (aged 24.7 ± 4.4 years) and 244 female athletes (aged 23.1 ± 4.4 years) from Italian volleyball leagues underwent anthropometric measurements. With these measurements, he was able to establish the somatometric components of elite male and female volleyball players in relation to their different game roles and levels of performance.

The anthropometric measurement of industrial workers is also important in establishing the design principles for workstations, work furniture, personal protective equipment and the industrial design for optimal comfort, health and safety. Spear et al. [11] identified the protection factor that must be provided by a respirator to ensure compliance with the Occupational Safety and Health Administration (OSHA) Lead Standard to reduce exposures to or below the permissible exposure limit. A new dimension is the inclusion of the fit factor, which is the ratio that represents a quantitative measure of the fit of a particular respirator facepiece to a particular worker. This incorporates the penetration of vapor or dust that occurs through the respirator face-seal interface. The need for fit testing of respirators was also documented in McKay et al.'s study [12]. Based on the same principle, a fit-tested hard hat and dust mask for Filipino workers should consider certain dimensions (Figure 1).

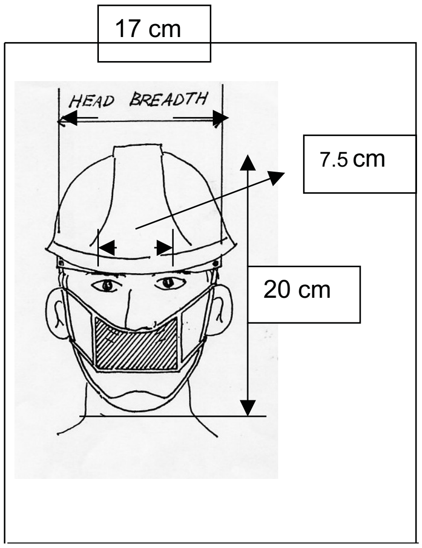


**Figure 1. 50th percentile anthropometric measurement of Filipino male workers for design of hard hat and gas mask.**

In 1985, Miasnikow [13] evaluated the mental strain of six operators who performed multiparameter compensatory tracking of a moving object. The study showed that the special identification of the zone of functional comfort in the design of data display devices could be done in a way so as to improve human's performance. In 1993, Ohashi [14] concluded that new work situations designed at the stage when new machine systems were introduced into the company were advisable as they eliminated previous poor work habits, and allowed back-up systems which would function when machine systems malfunctioned. In the same manner, this study proposes certain design prototypes for Filipino manufacturing workers (Figures 2 and 3).

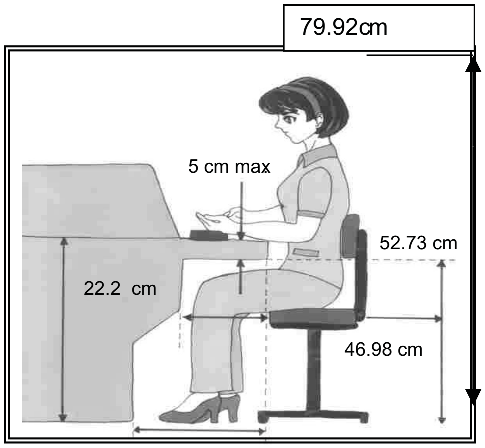


**Figure 2. Prototype design for computer seated work for Filipino manufacturing workers using 50th percentile.**

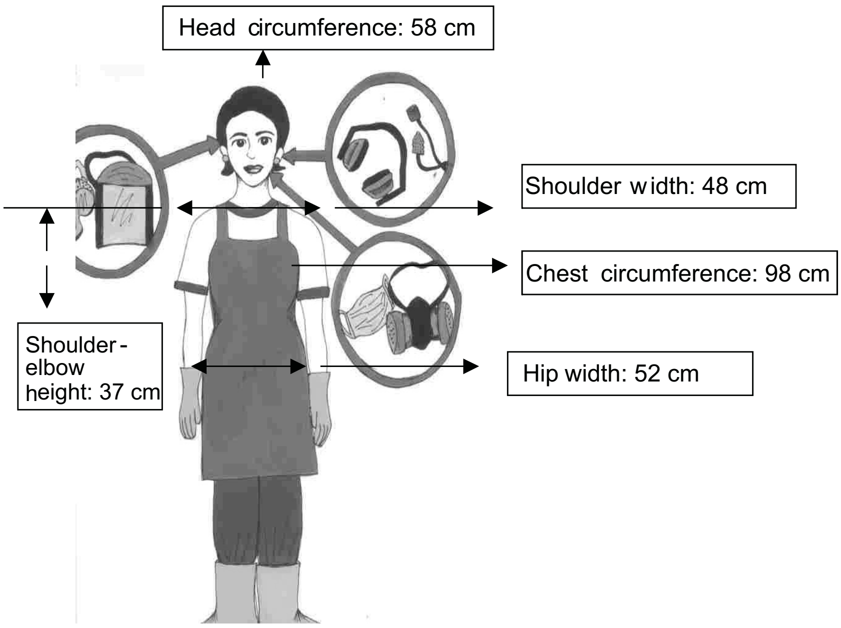


**Figure 3. Prototype design for personal protective equipment and clothing for Filipino manufacturing workers using 95th percentile.**

## 5. CONCLUSION

The study showed the prevalence and risk factors to MSDs at work ranged from 13.7 to 23.8% for the whole body. The anthropometric measurements that were established in this study covered the entire range of lengths, breadths, circumference of body segments. The anthropometry was applied in workstation, tool, equipment and layout designs for Filipino workers.

This study recommends that besides the aforementioned measurements, body fat should also be determined. The determination of body fat should be incorporated in anthropometric measurements since this may affect the physical capabilities of the workers. In a study, it was shown that body fat allowance for young soldiers who scored very well on the physical fitness test could have benefited 25% of the soldiers exceeding fat standards and acknowledged biological variability in body fat thresholds. It is also recommended that anthropometric measurement should be complemented with proper biomechanics and exercises. It has been shown that short-term workstation exercises can lower musculoskeletal discomfort and postural changes in seated video displayed unit workers [15].

For the prevention of MSDs, focus should also be given to psychological risk factors. The results of Devereux et al.'s 2002 study [5] showed that workers highly exposed to both physical and psychosocial workplace risk factors were more likely to report symptoms of MSDs than workers highly exposed to one or the other. Ergonomic intervention strategies should therefore include psychosocial work factors.

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