Ergonomic Risk Assessment of Backpack Leaf Blower Operation: A Case Study of Outdoor Cleaning Staff in a Malaysian Polytechnic

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Abstract

Outdoor cleaning tasks expose workers to ergonomic risks due to repetitive motions, awkward postures, and prolonged equipment handling. Poor working conditions pose significant detriments, leading to physical strain for employees and negative economic repercussions for employers. Despite these concerns, such risks remain understudied in Malaysia, prompting this study to investigate the ergonomic hazards associated with backpack leaf blower operation among cleaning staff at a Malaysian polytechnic. The research aims to assess musculoskeletal discomfort, identify ergonomic risks, and propose interventions to enhance worker safety and comfort. Five workers participated in the study, with data collected using the Ergonomic tools employed, including the Body Map Questionnaire to assess discomfort, an Initial Ergonomics Risk Checklist to evaluate postures, repetitive motions, force exertion, and noise exposure, as well as task observations and noise measurements. Results showed that musculoskeletal discomfort was prevalent, with significant discomfort reported in the lower back, shoulders, and neck. The discomfort was linked to awkward postures, repetitive arm movements, and prolonged force exertion while operating 6 kg backpack blowers for extended periods. Noise exposure also exceeded permissible limits, indicating potential hearing risks. These findings highlight a lack of ergonomic research on Malaysia's outdoor workforce and the need for targeted interventions. The study recommends advanced ergonomic assessments such as the Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA), along with preventive measures including ergonomically designed equipment, job rotation, and personal protective equipment like ear protection and anti-vibration gloves. The outcomes contribute to improving worker well-being and promoting compliance with occupational safety standards in the outdoor cleaning sector.

Keywords: Ergonomic, Backpack Leaf Blower, Risk Assessment, Musculoskeletal Discomfort

1.0 Introduction

Outdoor cleaning tasks, particularly those involving powered tools such as backpack leaf blowers, play a vital role in maintaining large campuses, parks and public spaces. These machines enhance efficiency in environments where manual cleaning is impractical; however, their operation introduces

considerable ergonomic risks. The use of backpack leaf blowers typically requires repetitive motions, awkward postures, and sustained force exertion over extended periods, all of which increase the risk of developing musculoskeletal disorders (MSDs) [1], [2], [3]. MSDs remain among the most prevalent occupational health issues, particularly in physically demanding work that involves repetitive movements, awkward body positions and high physical effort [4].

These risks are especially pronounced among outdoor workers who operate heavy tools for long durations. Common complaints include lower back pain, shoulder strain and neck discomfort. Previous studies have shown that repetitive actions, such as sweeping and tilting motions during leaf blowing, place strain on the upper limbs and spine, leading to chronic conditions such as shoulder tendinitis and lower back disorders [5], [6]. Prolonged exposure to these stressors may result in cumulative trauma, which negatively affects physical health, reduces productivity and impairs overall worker well-being [7]. In addition to physical strain, operators of backpack blowers are frequently exposed to excessive noise levels, often exceeding 85 dBA, which pose a risk of noise-induced hearing loss when appropriate personal protective equipment (PPE) is not used [8], [9]. The lack of ear protection and anti-vibration gloves further heightens the risk of both musculoskeletal and auditory injuries [10].

In the Malaysian context, outdoor cleaning staff employed by local service providers are responsible for maintaining polytechnic campuses characterised by uneven terrain and hilly landscapes. Navigating such environments while carrying and operating a 6 kg blower exacerbates ergonomic challenges and underscores the importance of systematic risk assessment. Despite growing attention to occupational safety, limited research has explored the ergonomic risks faced by outdoor cleaning workers in Malaysia, resulting in a significant knowledge gap [11], [12], [13]. Therefore, this study aims to investigate the ergonomic risks associated with backpack leaf blower operation by evaluating the musculoskeletal discomfort among workers. By addressing this objective, the study contributes to advancing workplace ergonomics through evidence-based recommendations for policy development, equipment design and safer work practices. Furthermore, it provides essential insights to support occupational health and safety improvements for Malaysia's outdoor cleaning workforce.

2.0 Methodology

2.1 Study Site

This study adopted a descriptive observational case study design to evaluate ergonomic risks among outdoor cleaning workers. The research was conducted over four weeks in March 2024 at a Malaysian polytechnic campus characterised by hilly terrain, uneven pathways and extensive outdoor areas. Cleaning staff employed by a local service provider were responsible for maintaining the campus using backpack leaf blowers. This site was selected due to its physically demanding environment, which presented a heightened

potential for ergonomic risks.

2.2 Participants

A total of five outdoor cleaning staff participated in the study, representing the entire group responsible for backpack blower operations at the study site. Participants were recruited through purposive sampling, with inclusion criteria requiring at least six months of experience operating backpack blowers. Workers with pre-existing musculoskeletal injuries or unrelated medical conditions were excluded. All participants provided informed consent before participation, and anonymity was maintained throughout the study. Participation was voluntary, and no incentives were offered.

2.3 Assessment Tools

The Initial Ergonomics Risk Checklist was employed to systematically evaluate key ergonomic risk factors, including awkward postures, repetitive movements, force exertion and noise exposure. Awkward postures were assessed based on the angles and positions workers adopted while handling the blower, particularly during extended operation [14]. Repetitive movements referred to actions such as sweeping or tilting the blower, which may increase the likelihood of musculoskeletal strain [15]. Force exertion was examined in relation to the physical effort required to operate the blower, given its 6 kg weight and the strain imposed on the upper body [16]. Noise exposure was evaluated due to the potential risk of hearing damage from prolonged exposure to high noise levels [17]. This checklist is widely recognised in ergonomic studies and provides a structured framework for identifying risks related to manual handling and environmental exposure [18].

2.4 Data Collection Procedure

To obtain comprehensive insights, both qualitative and quantitative methods were employed. Data collection included worker interviews, task observations and noise measurements.

2.4.1 Worker Interviews

Individual semi-structured interviews, each lasting approximately 30 minutes, were conducted with all participants. Questions explored the type, frequency, and intensity of discomfort, as well as perceived challenges during blower operation. Participants rated their discomfort levels and described specific tasks associated with pain or strain. These interviews provided valuable subjective data on workers' experiences and perceptions of ergonomic challenges [19].

2.4.2 Task Observations

Direct, real-time observations were conducted while participants operated the 6 kg backpack blowers. The observations focused on posture, movement patterns and physical exertion. These were evaluated using the Initial Ergonomics Risk Checklist to provide a detailed assessment of task-related ergonomic risks. Observational methods are particularly effective in identifying postural strain and repetitive motion patterns in dynamic work

environments [20].

2.4.3 Noise Measurement

Noise exposure levels were measured using a dosimeter, which provided continuous readings throughout the operational period. This enabled the assessment of time-weighted average (TWA) noise exposure. Prolonged exposure to high noise levels can contribute to hearing loss and may increase physiological stress, thereby compounding ergonomic risks [21]. Recorded values were compared against permissible exposure limits established by the Occupational Safety and Health Administration (OSHA).

2.5 Data Analysis

Quantitative data from the questionnaires and noise measurements were analysed using descriptive statistics (mean, frequency, and percentage). Qualitative data from interviews were analysed through thematic analysis to identify common patterns of discomfort and perceived ergonomic challenges. Data validity and reliability were ensured through triangulation, cross-verifying findings from questionnaires, observations and noise assessments.

2.6 Ethical Considerations

The study adhered to established ethical research principles. All participants provided written informed consent and were assured of confidentiality and anonymity. Participants were informed of their right to withdraw at any point without penalty. No personal identifiers were collected, ensuring the protection of participant privacy.

3.0 Results and Discussion

3.1 Musculoskeletal Survey / Assessment Findings

A musculoskeletal discomfort assessment was conducted among five outdoor cleaning workers who regularly operated backpack leaf blowers. Data were obtained using the Body Map Questionnaire, which records the location of discomfort, its frequency (Rarely, Sometimes, Often, Always) and severity on a five-point scale (1 = mild, 5 = severe). Table 1 presents the distribution of reported discomfort across various body regions.

The findings revealed that all participants (100%) experienced discomfort in the lower back, identifying it as the most critically affected region. This was followed by shoulder and lower leg discomfort, each reported by 80% of the workers, and neck pain, reported by 60% (Table 2). These results indicate that operating a 6 kg backpack blower for prolonged periods places considerable strain on the musculoskeletal system, particularly the trunk and upper extremities, consistent with findings from prior ergonomic studies on grounds maintenance workers [22], [23].

Table 1: Summary of musculoskeletal symptoms reported by workers

Body Part	Number of Workers Reporting Discomfort	Frequency (R/S/O/A)
Neck	3	Sometimes
Shoulders	4	Often
Upper Back	2	Sometimes
Upper Arm	1	Rarely
Lower Back	5	Often
Forearm	2	Sometimes
Wrist	1	Rarely
Hip/Buttocks	2	Sometimes
Thigh	3	Often
Knee	2	Rarely
Lower Leg	4	Often
Foot	1	Rarely

Table 2: Musculoskeletal symptoms reported by workers

Body Part	Workers Reporting Symptoms (%)	Frequency	Severity (1–5)*
Neck	60%	Sometimes	3.2
Shoulders	80%	Often	4.0
Lower Back	100%	Often	4.8
Lower Legs	80%	Often	4.2

*Scale: 1 = Mild, 5 = Severe

The high prevalence of lower back and shoulder discomfort observed in this study aligns with previous research on landscaping and grounds maintenance workers in Southeast Asia, where similar ergonomic risk factors, such as awkward trunk postures and repetitive arm movements, were identified as major contributors to musculoskeletal disorders [24], [25]. Furthermore, the force exertion required to counteract blower vibrations and maintain directional control added another dimension of physical risk. Operators were required to apply continuous pressure through the dominant arm, particularly when handling strong air resistance, thereby increasing localised muscle fatigue in the forearm and shoulder region. This repetitive exertion, combined with the weight of the blower and the need to maintain a stable stance, created a compounded ergonomic burden. These results underscore the ergonomic challenges faced by outdoor cleaning workers using powered tools and highlight the importance of implementing interventions such as posture training, rest breaks and equipment redesign to mitigate musculoskeletal risks.

3.2 Level of Discomfort Among Workers

All participating outdoor cleaning staff (100%) reported discomfort in the lower back, identifying it as the most affected area. Figure 1 presents the distribution of self-reported musculoskeletal discomfort by body region. This aligns with common ergonomic findings that prolonged static postures and

asymmetric loading from backpack equipment increase compression forces on the lumbar spine and fatigue in the erector spinae muscles. The weight of the backpack blower, approximately 6 kg, combined with vibration exposure and sustained trunk flexion during sweeping and directional control, likely contributed to this high prevalence.

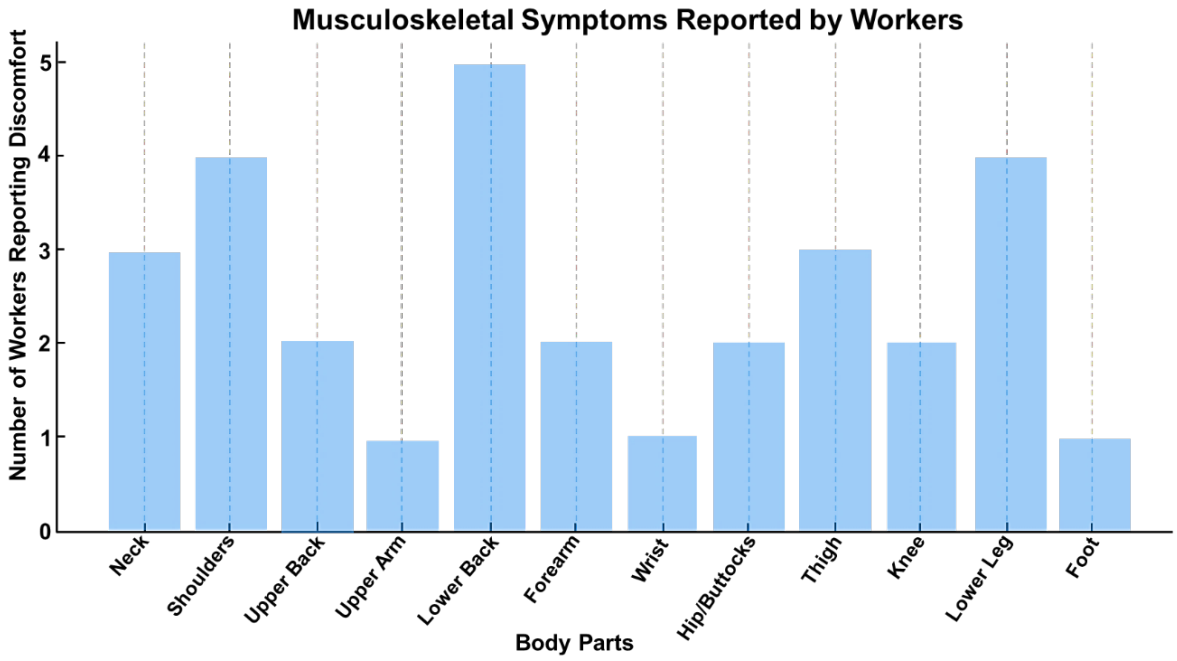

Figure 1: Number of workers reporting discomfort by body parts

High incidences of discomfort were also observed in the shoulders and lower legs (80% of workers), indicating considerable strain associated with repetitive arm elevation, static abduction while holding the blower nozzle, and extended periods of standing or walking on uneven ground surfaces. These conditions can restrict blood flow and accelerate localised muscle fatigue, particularly in the deltoid and gastrocnemius regions. Previous EMG-based research has shown that sustained arm abduction under compressive load increases deltoid fatigue due to local blood flow impairment [26], while prolonged static standing has been associated with gastrocnemius muscle fatigue [27]. Moderate discomfort was reported in the neck and thighs, possibly due to compensatory postures and prolonged forward head inclination during blower operation. Symptoms in the wrist and feet were less frequent, suggesting these areas experience intermittent rather than sustained mechanical loading.

As illustrated in Figure 2, there is a clear relationship between discomfort frequency and severity, with the lower back and shoulders showing both high prevalence and high discomfort scores. This pattern reflects persistent musculoskeletal strain in regions primarily responsible for supporting and stabilising the equipment. In contrast, the upper arm and wrist showed relatively low frequency and mild symptoms, suggesting less ergonomic load transfer to distal extremities during operation.

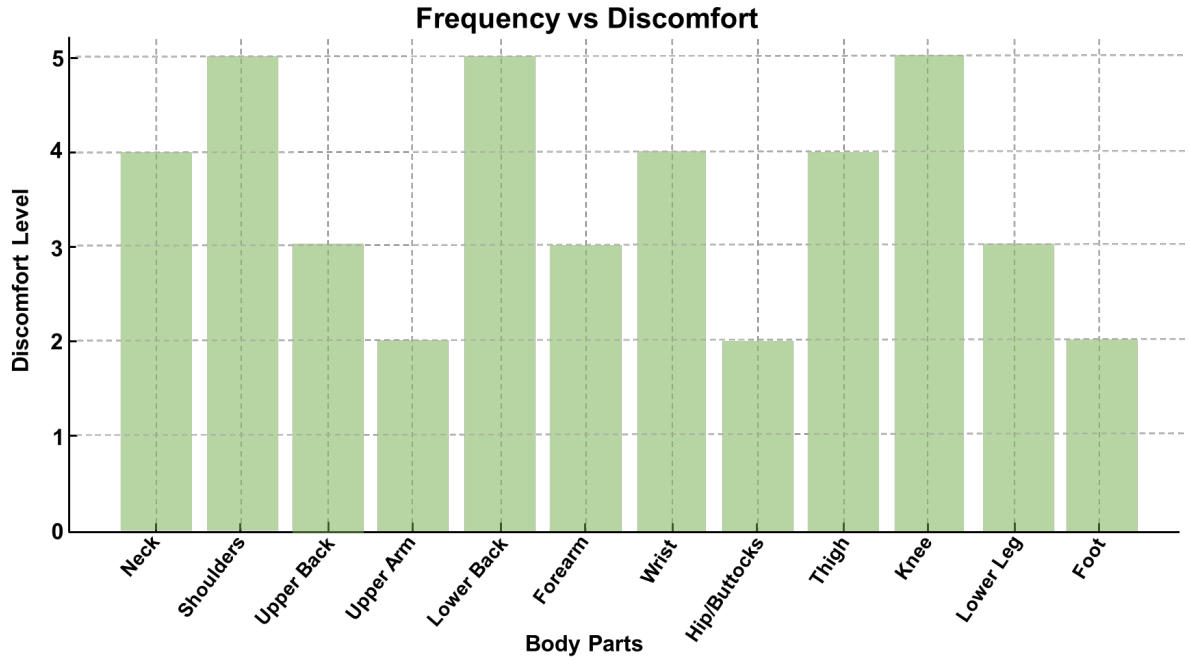

Figure 2: Frequency of symptoms vs. level of discomfort among workers

Overall, the data demonstrate a strong correlation between task demands, notably equipment weight, repetitive motion and static posture and localised musculoskeletal discomfort. The lower back and shoulders are identified as the primary ergonomic risk zones, consistent with prior research on backpack blower and similar outdoor equipment use. These findings highlight the need for targeted ergonomic interventions, such as redesigning harness systems to better distribute load across the torso and hips; implementing task rotation and scheduled rest breaks to reduce cumulative muscle fatigue; and providing training on posture adjustment and dynamic movement techniques to minimise sustained trunk flexion. Conversely, the relatively lower discomfort levels in the upper limbs suggest that future task modifications should prioritise reducing trunk and shoulder loading rather than arm movement frequency.

3.3 Interference with Work Performance

The level of interference in work performance depicts the relationship between the frequency of musculoskeletal symptoms reported by workers and the level of interference these symptoms cause in their ability to perform tasks effectively. The data highlights how symptoms in various body parts impact work productivity, with a particular focus on areas of high frequency and interference. The Body Map Questionnaire also assessed interference with work performance. Figure 3 shows that discomfort in the lower back and neck caused the highest interference, often hindering task efficiency. While some symptoms (e.g., hip/buttocks, lower legs) were reported, their impact on work performance was comparatively lower. This suggests that the discomfort experienced in these body parts not only causes pain but also significantly impacts the workers' productivity and efficiency [28]. On the other hand, areas like the hip/buttocks and lower leg show lower levels of interference,

implying that while discomfort may be present, it does not considerably hinder work activities.

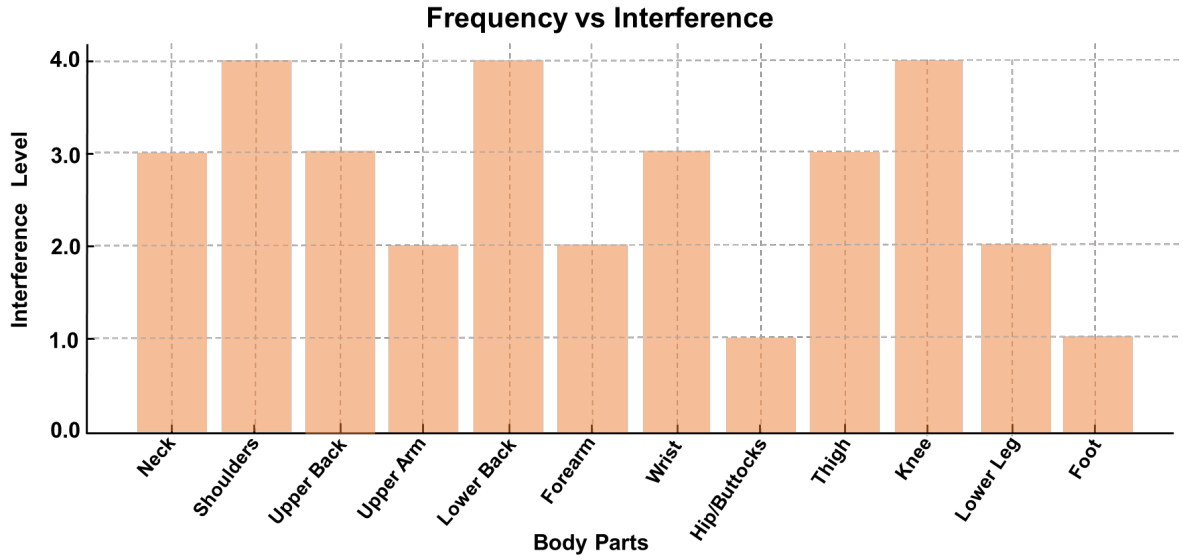

Figure 3: Frequency of symptoms vs. level of interference in work performance

3.4 Ergonomics Risk Factors Assessment (Initial ERA)

The Initial Ergonomic Risk Assessment checklist (Department of Occupational Safety and Health, Malaysia, 2017) was applied during observation. Key risk factors are summarised in Table 3. The checklist results confirmed that awkward postures, repetitive movements and forceful exertion exceeded the threshold values, indicating the need for advanced ergonomic assessments such as Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA) [29], [30].

Table 3: Ergonomic Risk Factors Identified

Risk Factor	Observation	Impact	Duration
Awkward Postures	Forward bending, raised arms	Back/Shoulder	2 hours
Forceful Exertion	Handling 6kg blowers	Muscle fatigue	2 hours
Repetitive Tasks	Sweeping and tilting motions	Arm/Neck strain	60 mins
Noise Exposure	Levels >85 dBA	Hearing loss	>8 hours

4.0 Conclusion

This study sought to evaluate the ergonomic risks associated with backpack leaf blower operations among outdoor cleaning personnel. The findings indicated a high prevalence of lower back, shoulder and neck discomfort, largely resulting from awkward postures and sustained physical exertion.

Noise exposure levels exceeded recommended thresholds, posing potential long-term auditory risks, which were further aggravated by inadequate use of personal protective equipment (PPE), particularly hearing protection. These outcomes underscore the need for systematic ergonomic evaluations and targeted interventions, including ergonomically designed tools, job rotation and consistent PPE usage. Such measures can promote worker health, enhance productivity and ensure compliance with occupational safety standards. However, the small sample size (n = 5) limits the generalisability of the findings. Future research with larger cohorts and advanced ergonomic assessment methods (e.g., REBA, RULA) is recommended to confirm and extend these results.

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Author Contributions

Rossitah Selamat: Conceptualisation, Methodology, Investigation, Data Curation, Formal Analysis, Writing-Original Draft, Writing-Review and Editing, Visualisation; **Raemy Md Zain**: Supervision, Writing-Review and Editing.

Conflicts of Interest

The manuscript has not been published elsewhere and is not under consideration by any other journal. Both authors have reviewed and approved the manuscript, consent to its submission, and declare that there is no conflict of interest.

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