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Research article

Enhancing Workplace Safety for Disabled Farmers in Thailand: A Quasi-Experimental Study of Ergonomic Interventions in Vermicompost Production

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Abstract

The aim of this study was to improve the working environment for disabled farmers in vermicompost production using participatory action-oriented training (PAOT). Potential hazards were identified through Job Safety Analysis (JSA), and improvements were implemented based on the analysis. The winnowing step was found to have the highest risk, as farmers had to manually separate vermicompost and earthworms by shaking the mixture through a filter. To address this, a vermicompost winnowing machine was developed specifically for disabled farmers, reducing their working time and the risk of muscle injuries. Ergonomic assessments were conducted using Rapid Entire Body Assessment (REBA). The assessments compared the risks associated with the manual process to those when using the newly developed winnowing machine. The results indicated a reduction in musculoskeletal disorder (MSD) risk for all disabled groups. The findings of this study emphasize the importance of considering occupational health and safety for disabled individuals in agriculture. By implementing ergonomic improvements such as redesigned tools and adjusted workstations, the safety and well-being of disabled farmers can be enhanced. This contributes to creating inclusive and productive work environments. In conclusion, through the application of PAOT and ergonomic assessments, this study successfully identified potential hazards and implemented improvements in vermicompost production for disabled farmers. The development of a specialized winnowing machine reduced the risk of musculoskeletal disorders. Promoting occupational health and safety measures is crucial for supporting the participation and well-being of disabled individuals in agricultural work.

Keywords: vermicompost winnow machine; ergonomics; REBA; disabled worker

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1. Introduction

In today's world, disability is understood not just as an individual health concern but as a multifaceted phenomenon that emerges from the interaction between personal disabilities and societal structures (Frier et al., 2016). Reflecting on this, the United Nations highlights in its Declaration on the Rights of Disabled Persons that disabled individuals are those who, due to physical or mental deficiencies, are wholly or partly incapable of providing for their needs in a normal social and individual life without adequate support (UN General Assembly Resolution 3447, 1975). This perspective underlines the critical role of societal support and inclusive policies (Brown, 2015). With approximately 15% of the global population identified as living with a disability, a figure that is anticipated to rise with the aging demographic trend, the need for comprehensive support systems is more pressing than ever (WHO, 2023). The expected increase in disability prevalence underscores the importance of adapting societal structures to be more inclusive (WHO, 2024).

In Thailand, a country where over two million people or 3.23% of the population are registered as disabled, a wide range of disabilities is evident. These include physical, sensory, mental health, and intellectual disabilities. A significant portion of these individuals participate in the workforce, especially in agriculture (Department of Empowerment of Persons with Disabilities, Thailand, 2022). This sector poses unique challenges for disabled workers, such as exposure to hazardous environments, which include excessive noise, extreme temperatures, harmful chemicals, and ergonomic risks (Mazza et al., 1997; Manothum, 2018; Vudhironarit et al, 2024). Consequently, specific interventions are required to address and mitigate these risks (ILO, 2011).

Despite governmental efforts in Thailand to provide support through financial allowances and occupational health initiatives, there is an evident gap in addressing the unique challenges faced by disabled workers in agriculture, highlighting the need for workplace interventions to ensure a safe and accessible working environment for all, irrespective of physical or mental abilities (UNDP, 2022).

This study focuses on the vermicompost farming community in Sanam Yae sub-district, Tha Maka district, Kanchanaburi province, Thailand, particularly emphasizing disabled workers. Vermicomposting, a sustainable agricultural practice, offers significant opportunities for inclusion and accessibility. This method of organic waste recycling not only plays a crucial role in environmental conservation but also provides adaptable, low-impact work opportunities suitable for individuals with diverse abilities (Rastegari et al., 2023). The customizability of vermicomposting processes to accommodate various needs makes it a typical field for the employment and empowerment of disabled workers (Vuković et al., 2021).

Our research was conducted in collaboration with a community of disabled vermicompost farmers to comprehensively identify and address their unique challenges and opportunities. We utilized Participatory Action-Oriented Training (PAOT), a well-established approach in Asia, to actively involve workers in improving their safety and health (Kawakami & Kogi, 2001; Nguyen & Khai, 2014). Additionally, we conducted a Job Safety Analysis (JSA) to precisely evaluate potential risks within their work environment. Our objective was to improve the working environment for disabled farmers and develop customized workstations, tools, and practices tailored to meet the specific needs of these farmers. This initiative aimed to mitigate ergonomic risks and demonstrate how agricultural practices can be adapted to foster both safety and inclusivity for individuals with disabilities.

2. Materials and Methods

2.1 Study design

A quasi-experimental study was conducted, targeting disabled farmers as participants. The study was structured into four key phases: (1) delivery of occupational health and safety training using Participatory Action-Oriented Training (PAOT); (2) hazard identification in vermicompost production through Job Safety Analysis (JSA); (3) implementation of the improvements discussed; and (4) ergonomic risk evaluation using the Rapid Entire Body Assessment (REBA) tools. The study, carried out from March to August 2016, received ethical approval from the Human Research Ethics Committee of Mahidol University, Thailand (Approval No. 2016-025).

2.2 Participants

This study encompassed the entire population of disabled farmers from the Sanam-Yae sub-district in Tha Maka District, Kanchanaburi Province, Thailand, with a total of 18 participants. These individuals were categorized based on their physical abilities into three groups: those with a disability in one arm, those with a disability in one leg, and wheelchair users with no leg function. Informed consent was secured from each participant prior to the commencement of the study, confirming their voluntary participation.

2.3 Development of the vermicompost winnowing machine

We developed a winnowing machine specifically tailored to separate vermicompost from earthworms and subsequently adjusted it to meet their requirements. This project was a collaboration between our research team and the workers, enhanced by the implementation of Participatory Action-Oriented Training (PAOT). This approach facilitated dynamic interaction, where workers actively contributed their specific needs and challenges, shaping the design process. Features such as adjustable heights, ergonomic handles, and intuitive controls were incorporated into the machine to address these needs, thereby enhancing both safety and operational sustainability while ensuring cost-effectiveness.

2.4 Ergonomic assessments

We utilized the Rapid Entire Body Assessment (REBA) tool to assess the risks associated with manual winnowing and the use of the vermicompost winnowing machine. REBA evaluates injury risks by analyzing individuals' physical movements and tasks. The scoring system categorizes risks as follows: a score of 1 indicates negligible risk; scores of 2-3 represent low risk; 4-7 are classified as medium risk; 8-10 as high risk; and scores above 10 denote very high risk (Hignett & McAtamney, 2000). The assessment process involves photographing a person while performing a task, identifying different body positions, and assigning scores using a REBA sheet. These scores are then summed to calculate a total risk level for musculoskeletal disorders (MSDs).

3. Results and Discussion

The study targeted all 18 disabled farmers in the Sanam-Yae sub-district, Kanchanaburi Province, Thailand. Of these, 66.7% (12 participants) were male, and 33.3% (6 participants) were female. The age distribution showed that the largest group, 44.4% (8 participants), was between 41 to 50 years old, with the average age of the group being 52.61 years (SD = ±2.58). Most participants, 61.2% (11 out of 18), had completed elementary education, and a similar proportion, 61.2%, had less than 10 years of experience in the field. The typical workday lasted between 5 to 8 h, averaging 6.5 h (SD = ±0.57). The distribution of disabilities was as follows: 88.9% had a single-leg disability, 5.5% had a single-arm disability, and 5.5% were wheelchair users with disabilities affecting both legs, as detailed in Table 1.

3.1 Job Safety Analysis (JSA)

We utilized Job Safety Analysis (JSA) to thoroughly assess ergonomic hazards at each stage of the vermicompost production process. Through this analysis, we pinpointed potential risks inherent in various procedures and proposed specific ergonomic enhancements to address these concerns effectively. The findings of these assessments are succinctly summarized in Table 2, which provides a clear overview of the identified ergonomic hazards for each procedure, along with the corresponding ergonomic improvements recommended to mitigate these risks. One notable highlight from the JSA was the identification of the winnowing step as particularly high-risk. This recognition encouraged an imperative design of the vermicompost winnowing machine to better accommodate the needs of disabled farmers, thereby reducing ergonomic hazards pointedly.

3.2 Development of the vermicompost winnowing machine

The vermicompost winnowing machine shown in Figure 1, designed for manual operation, offers a cost-effective and sustainable solution by eliminating the need for electricity and reducing costs. It ensures uniform distribution and efficient separation of vermicompost and earthworms with a manual agitation unit operable by hand lever or foot pedal. With a single 3 mm stainless steel mesh filter, it precisely sifts finer vermicompost particles while safely transferring earthworms. Its adjustable height feature and durable materials cater to users with diverse physical abilities, enhancing environmental sustainability and operational efficiency. Ideal for small-scale operations and resource-limited settings, the machine facilitates efficient vermicompost processing and gentle handling of earthworms, crucial for sustainable vermiculture practices.

3.3 Ergonomic assessments

Ergonomic assessments conducted using the Rapid Entire Body Assessment (REBA) method revealed noteworthy improvements in reducing the risk of musculoskeletal disorders (MSDs) when using the adjustable vermicompost winnowing machine, compared to traditional manual winnowing processes. As detailed in Table 3, these improvements were particularly noticeable among individuals within specific disability groups. For instance, an individual with a disability affecting one arm experienced a reduction in MSD risk from a medium to a low level when utilizing the machine. Similarly, the risk level for an.

Table 1. Demographic and occupational profile of the disabled participants in vermicomposting study

Information	Number	Percentage
Sex		
Male	12	66.7
Female	6	33.3
Age (year)		
< 40	2	11.1
41-50	8	44.6
51-60	3	16.6
61-70	3	16.6
>70	2	11.1
Average(SD) = 52.61(±2.58)		
Min-Max = 39-73		
Education level		
No education	2	11.1
elementary school	11	61.2
Junior high school	2	11.1
Senior high school or Vocational certificate	3	16.6
Working experience (years)		
<10	11	61.2
11-20	2	11.1
>20-30	2	11.1
>30-40	1	5.5
>40	2	11.1
Average (SD) = 26.22(±3.24)		
Min-Max = 8-50		
Working hour (hours per day)		
≤2	1	5.5
>2-5	5	27.8
>5-8	10	55.6
>8	2	11.1
Average (SD) = 6.5(±0.57)		
Min-Max = 2-10		
Disabled group		
Having a disability in one arm	1	5.5
Having a disability in one leg	16	88.9
Having disabilities in both legs (the person uses a wheelchair)	1	5.5

Table 2. Ergonomic improvements in vermicompost production processes assessed by Job Safety Analysis (JSA)

Procedure	Potential Hazard	Ergonomic Improvement
1. Preparing the earthworm feed	• Pains and aches on upper limbs from holding a heavy harrow handle	• Use a lighter wooden handle instead of steel
2. Putting the feed into containers and onto racks	• Pains and aches from lifting with poor posture	• Use proper lifting posture as per ergonomic rules • Reduce the container size and rack height
3. Winnowing vermicompost manually	• Pains and aches from repetitive winnowing motion	• Redesign the winnowing machine to minimize repetitive motions and reduce work time
4. Packaging the vermicompost	• Pains and aches from improper posture during packing	• Redesign the workstation to eliminate unnecessary reaching and elevate the product position

Table 3. Results of the ergonomic assessment by REBA for disabled worker representatives

Disabled Group	Winnow with Hand	Winnow with Machine
Having a disability in one arm	Medium	Low
Having a disability in one leg	Medium	Low
Having disabilities in both legs (the person uses a wheelchair)	High	Low

The REBA scoring system categorizes ergonomic risk levels as follows: low represents minimal concern, medium indicates moderate concern, and high denotes serious concern requiring immediate intervention.

individual with a disability affecting one leg also decreased from medium to low. Most meaningfully, a wheelchair user with disabilities affecting both legs experienced a reduction in risk level, moving from high to low when using the machine. These findings underscore the ergonomic benefits of the adjustable vermicompost winnowing machine, highlighting its potential to suggestively enhance workplace safety for disabled workers engaged in vermicomposting activities

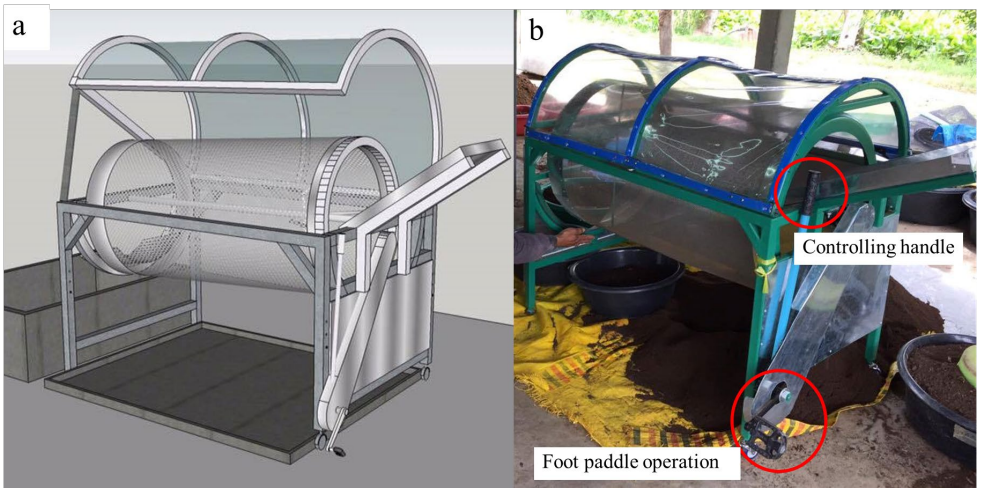

Figure 1. Accessible vermicompost winnowing machine for disabled workers: Hand and foot operation, low-cost design (a) model (b) machine

3.4 Discussion

This study highlights the essential need to address safety and ergonomic challenges in the workplace, particularly for disabled farmers involved in vermicompost production. Using a comprehensive quasi-experimental method, the study integrated steps like hazard identification, job safety analysis, intervention implementation, and ergonomic assessments to improve working conditions and safety for these disabled farmers. A key strength of our research was its participatory approach, which actively included disabled farmers in both hazard recognition and in devising solutions. Through Participatory Action-Oriented Training (PAOT), researchers worked closely with participants to tailor interventions to their specific needs, resulting in the development of a customized winnowing machine. This collaborative method ensured that solutions were both effective and specifically suited to user requirements. Additionally, PAOT encouraged direct involvement in identifying risks, crafting solutions, and making low-cost enhancements, fostering a sense of ownership and facilitating knowledge transfer and sustainable practices to improve safety and inclusivity in the workplace (Kawakami & Kogi, 2001). PAOT's effectiveness has been demonstrated in various environments such as small businesses, home-based workplaces, and the agricultural sector (Nguyen & Khai, 2014; Kim et al., 2015; Priyoko et al., 2021). It allows participants to learn from exemplary practices and initiate practical workplace improvements (Kawakami et al., 2005). Furthermore, PAOT programs have enabled the training of many locals to undertake voluntary safety improvements, particularly in reducing workplace risks and preventing accidents in settings like Thailand (Arphorn et al., 2006).

This study highlights the ergonomic challenges encountered in vermicomposting, particularly during the winnowing phase. To address these challenges, a specially designed adjustable vermicompost winnowing machine was developed for disabled workers. This machine, equipped with height adjustments and easy-to-operate controls, is tailored to accommodate various disabilities. REBA method evaluations demonstrated that musculoskeletal disorder (MSD) risks decreased from medium to low for operators using

this machine. Its user-friendly design not only enhances workplace safety and productivity but also mitigates muscle injuries and discomfort. The noteworthy reduction in ergonomic risks following the machine's introduction underscores the critical importance of ergonomic design in improving occupational health and preventing workplace injuries. Moreover, when disabled workers engage in repetitive tasks for prolonged periods, they are at risk of developing fatigue, MSDs, and decreased productivity. It is crucial to design work environments and tasks that preventively address such health issues to maintain worker efficiency (Cavatorta & DiPardo, 2012). Since MSDs can arise from repetitive motions, inadequate ergonomics, and continuous physical strain, it is important for disabled workers to be aware of these factors and proactively adapt their work environments to mitigate these risks (Soares et al., 2020). Therefore, interventions must be specifically tailored to suit the unique needs of each worker's disability, ensuring that all ergonomic adjustments and workplace practices effectively minimize the risk of MSDs and create a safe, productive environment for disabled workers (Nevala-Puranen et al., 1999).

4. Conclusions

This study underscores the importance of addressing ergonomic and safety concerns in vermicomposting, particularly for disabled farmers. It employed a comprehensive approach, including hazard identification, ergonomic assessments, and the development of an adjustable Vermicompost Winnowing Machine. Through Participatory Action-Oriented Training (PAOT), disabled farmers were directly involved in solution development, leading to significant reductions in musculoskeletal disorder risks. The study emphasizes the necessity of creating safe and productive work environments tailored to the unique needs of disabled workers. Further research is recommended to evaluate the machine's performance across different environments and refine ergonomic assessments. This approach sets a solid foundation for enhancing occupational health and preventing injuries in workplaces suitable for workers with disabilities.

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6. Conflicts of Interest

There is no conflict of interest.

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