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EVALUATING MUSCLE ACTIVATION DURING SIMULATED WALK-AND-CARRY TASKS WITH EXOROBO IN PALM OIL PLANTATIONS

Meor Syukri Affendi Meor Saedin[1,*], Wan Aliff Abdul Saad[1], Saiful Farhan Mohd Samsuri[1], Aizreena Azaman[2], Muhammad Danial Abu Hasan[1], Zair Asrar Ahmad[1]
[1] Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia.
[2] Dept. of Biomedical Engineering and Health Science, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia.
[*] Corresponding author: meorsyukriaffendi@graduate.utm.my

ABSTRACT

This study analyses the effectiveness of EXOROBO, a passive lower-limb exoskeleton intended to alleviate musculoskeletal disorders (MSDs) among palm oil harvesters. The study assesses muscle activation during walk-and-carry activities carried out both with and without EXOROBO in tandem with a motorized cutter, CANTAS™, using electromyography (EMG) monitoring. Results reveal significant reductions in muscle activation, particularly in the biceps brachii and rectus femoris, highlighting the ergonomic benefits of EXOROBO in lowering muscle tension. These findings contribute to the progress of ergonomic solutions in agricultural contexts, notably within the palm oil industry, where MSD prevalence poses substantial challenges.

KEYWORD

EMG analysis, EXOROBO, exoskeleton, palm oil harvesting, Musculoskeletal Disorders (MSDs).

INTRODUCTION

The palm oil industry, integral to Malaysia's economy, faces significant challenges related to worker health and productivity. Musculoskeletal disorders (MSDs), arising from repetitive, demanding tasks such as walking through uneven terrains and carrying heavy tools, are prevalent among palm oil harvesters. These issues not only compromise worker health but also contribute to reduced efficiency and long-term disabilities.

Usually in everyday operations, harvesters start by walking over the plantation looking for ripe fruit bunches by noticing 1 or 2 loose fruitlets on the ground near palm oil tree trunks. Usually searching for ripe fruit bunches, harvesters must roam the plantation covering 3 to 4 hectares daily. Walking takes up 13% of the harvesting time, claims Kamaruzaman (2009). With 19% respondents stating pain at both hand/arm and thigh muscle followed by elbow muscle with 18%, Ng, Y.G., et al. (2015) also found that the frequency of MSDs among harvesters was rather high. Particularly, in occupational environments like palm oil farms, walking might expose various ergonomic hazards.

Technological interventions, such as exoskeletons, offer promising solutions to mitigate these challenges. While widely utilized in sectors like manufacturing and healthcare, their adoption in agriculture, specifically in palm oil harvesting, remains limited. EXOROBO (Abdul Saad, W.A., et al., 2023), a newly developed passive lower-limb exoskeleton, aims to address this gap. By redistributing the load of tools like CANTAS™ to the ground, EXOROBO minimizes muscle strain and promotes proper posture, making it a viable ergonomic solution for palm oil harvesting tasks. This study evaluates EXOROBO's effectiveness in reducing muscle activity during simulated walk-and-carry tasks, providing preliminary insights into its potential applications.

MATERIAL AND METHODOLOGY

The study involved five healthy, right-handed male participants with no history of MSDs. Subjects performed an 8-meter simulated walk-and-carry task under two conditions: (i) using CANTAS™ without EXOROBO (No-Exo), and (ii) using both CANTAS™ and EXOROBO (With-Exo). Electromyographic signals were collected from two key muscle groups: biceps brachii (BB) and rectus femoris (RF), using the Delsys Trigno Biofeedback System. EMG signals were processed using a Butterworth filter and analysed to calculate the root mean square (RMS) values, providing a quantitative measure of muscle activation.

Figure 1 shows 3D rendering of the developed passive lower limb exoskeleton, EXOROBO and a test subject performing simulated walk-and-carry task.

Figure 1: a) 3D rendering of EXOROBO, b) Subject performing simulated task.

To ensure consistency, standardized instructions were given, and all participants underwent the same testing sequence. The exoskeleton was adjusted individually for comfort and fit, enhancing the reliability of the results. This simulated walk-and-carry activity was undertaken in the Department of Biomedical Engineering and Health Sciences, Faculty of Electrical Engineering, Universiti Teknologi Malaysia. The subjects were not confined in terms of their whole-body position and the time took to complete the exercise, to permit natural and comfortable movement and postures.

RESULT AND DISCUSSION

The results indicate a significant reduction in muscle activity when EXOROBO was utilized, as demonstrated in Table 1. The most significant decrease was observed in the left biceps brachii (51.30%), followed by the left rectus femoris (44.61%), right biceps brachii (23.98%), and right rectus femoris (7.17%). These reductions suggest that EXOROBO effectively redistributes the weight of CANTAS™ to the ground, reducing strain on the user's muscles.

Figure 2 illustrates a reduction in muscular activation in the Biceps Brachii and Rectus Femoris during the walk-and-carry test while utilizing the With-Exo intervention. The asymmetry in muscle activation reduction, particularly on the left side, is attributed to the right-handedness of participants and the positioning of EXOROBO's support arm. This design allows users to maintain control of CANTAS™ with their dominant hand while alleviating strain on the non-dominant side. These findings underscore the importance of customizing exoskeleton designs to accommodate user dominance and task-specific demands.

Table 1. Recorded Peak RMS for Biceps Brachii (BB) and Rectus Femoris (RF) During Simulated Walk-and-Carry Task

Recorded Peak Root Mean Square (mV)				
	Biceps Brachii (BB)		Rectus Femoris (RF)	
Intervention	**Left BB (L_BB)**	**Right BB (R_BB)**	**Left RF (L_RF)**	**Right RF (R_RF)**
No-Exo,With CANTAS™	0.1444	0.1615	0.0500	0.0236
With-Exo,With CANTAS™	0.0703	0.1228	0.0277	0.0219
Difference*	-0.0741	-0.0387	-0.0223	-0.0017
%Effectiveness (%)	-51.30	-23.98	-44.61	-7.170

* Difference = Peak RMS Value$_{\text{With-Exo}}$ - Peak RMS Value$_{\text{No-Exo}}$

** The negative values in difference and %effectiveness (%) indicate a reduction in With-Exo muscle activation compared to No-Exo intervention.

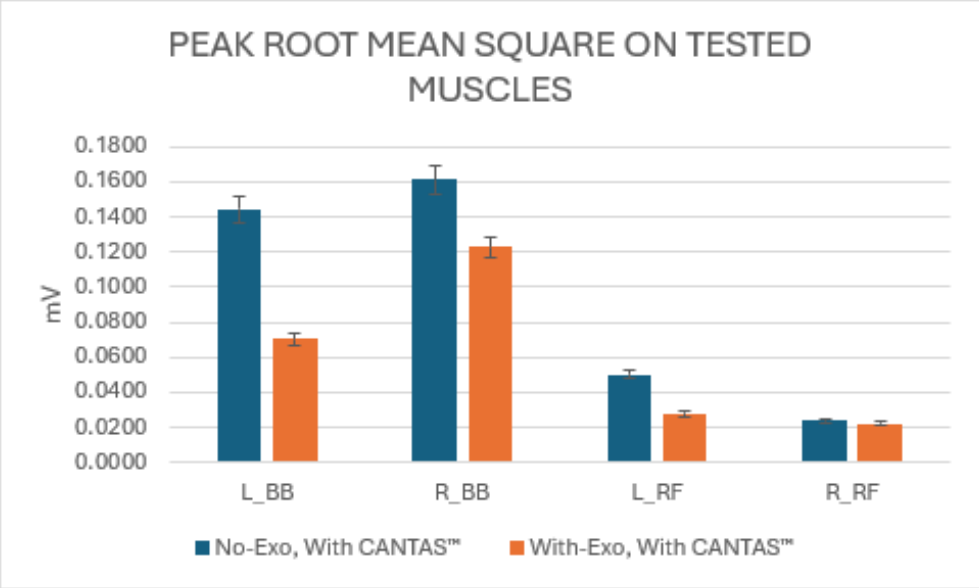

Figure 2: Peak RMS on Left Biceps Brachii (L_BB), Right Biceps Brachii (R_BB), Left Rectus Femoris (L_RF), and Right Rectus Femoris (R_RF)

CHALLENGES AND FUTURE DIRECTIONS

While the study reveals EXOROBO's potential in lowering muscle tension, it is limited by its small sample size and the focus on a specific set of muscles. Expanding the sample size and integrating more muscle groups in future studies will provide a more comprehensive knowledge of its benefits. Additionally, the study's simulated environment does not fully duplicate the physical demands of palm oil harvesting, such as extended durations and uneven terrains.

Future study should integrate field experiments in genuine palm oil plantations to evaluate the exoskeleton's performance in real-world situations. Engaging experienced harvesters in these trials will provide vital information regarding the usability and feasibility of EXOROBO. Moreover, longitudinal studies are necessary to determine the long-term influence of exoskeleton usage on MSD prevention and worker productivity.

CONCLUSION

This study demonstrates the potential of EXOROBO in improving worker safety and efficiency in the palm oil industry. The significant reductions in muscle activity seen during simulated workloads show that EXOROBO can alleviate the physical demands of harvesting operations. However, further study involving field trials and larger sample numbers is necessary to evaluate its effectiveness and optimize its design for broader applications. By tackling the frequent issues of MSDs, EXOROBO offers a key step toward promoting ergonomic solutions in agriculture.

DECLARATION OF COMPETING INTEREST

The author states that he does not have conflicts of interest.

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REFERENCE

Abdul Saad, W.A., Abu Hasan, M.D. and Mohd Samsuri, S.F. (2023). EXOROBO. Patent PI2023004917 (Malaysia).

Kamaruzaman, J. and Fauzi, Z (2009). 'Musculoskeletal Disorders in Oil Palm Fruit Bunches Harvesting in Malaysia.' Journal of Environmental Science & Engineering, 3(7), pp.64–67.

Ng, Y.G., et al. (2015) 'Risk factors of musculoskeletal disorders among oil palm fruit harvesters during early harvesting stage', Annals of Agricultural and Environmental Medicine, 22(2), pp. 286-292. [Online]. DOI: 10.5604/12321966.1152101