INTISARI

Pekerja di sektor industri manufaktur sering kali mengalami *musculoskeletal disorders* (MSDs) akibat aktivitas fisik repetitif seperti berdiri lama, membungkuk, atau berjongkok. Penggunaan *passive lower-limb exoskeleton* (PLLE) diharapkan dapat mengurangi risiko MSDs dengan mendukung postur tubuh dan mengurangi beban fisik. Namun, dampaknya terhadap performa, persepsi kesulitan tugas (*perceived task difficulty*), dan ketidaknyamanan (*general discomfort*) pada pekerjaan dinamis belum banyak diteliti. Penelitian ini bertujuan untuk mengevaluasi pengaruh penggunaan PLLE terhadap performa, persepsi kesulitan tugas, dan persepsi ketidaknyamanan pekerja dalam aktivitas dinamis di lingkungan manufaktur.

Penelitian ini menggunakan desain eksperimen *within-subject* dengan melibatkan 30 partisipan berusia minimal 18 tahun yang belum pernah menggunakan *exoskeleton*. Partisipan mengerjakan lima tugas dinamis (*lower lifting*, *sit to stand*, berjalan, *box carrying*, dan naik turun tangga) dalam dua kondisi: tanpa PLLE dan dengan PLLE. Data waktu penyelesaian tugas, *perceived task difficulty* (PTD), dan *general discomfort* (GD) diukur menggunakan stopwatch dan kuesioner *Visual Analog Scale* (VAS). Analisis statistik dilakukan dengan uji *paired t-test* untuk data normal dan uji Wilcoxon *signed-rank test* untuk data tidak normal, dengan tingkat signifikansi $\alpha = 0,05$.

Penggunaan PLLE memperlambat waktu penyelesaian tugas secara signifikan pada aktivitas berjalan sebesar 24,17% ($p < 0,001$), *box carrying* sebesar 27,40% ($p < 0,001$), dan naik turun tangga sebesar 119,19% ($p < 0,001$). Persepsi kesulitan (PTD) meningkat signifikan saat menggunakan PLLE pada tugas berjalan dengan selisih rata-rata sebesar 1,75 poin ($p < 0,001$) dan naik turun tangga dengan selisih rata-rata sebesar 3,55 poin ($p < 0,001$). Ketidaknyamanan (GD) juga meningkat signifikan pada *lower lifting* dengan selisih rata-rata sebesar 0,65 poin ($p < 0,05$), berjalan dengan selisih rata-rata sebesar 2,83 poin ($p < 0,001$), *box carrying* dengan selisih rata-rata sebesar 1,02 poin ($p < 0,05$), dan naik turun tangga dengan selisih rata-rata sebesar 4,19 poin ($p < 0,001$). Hasil menunjukkan bahwa PLLE kurang efektif untuk tugas dinamis yang memerlukan mobilitas tinggi, dan juga berpotensi meningkatkan persepsi kesulitan serta ketidaknyamanan fisik pada aktivitas dinamis.

Kata kunci: *passive lower-limb exoskeleton*, performa, persepsi kesulitan tugas, ketidaknyamanan, *musculoskeletal disorders*, aktivitas dinamis

ABSTRACT

Workers in the manufacturing sector often experience musculoskeletal disorders (MSDs) due to repetitive physical activities such as prolonged standing, bending, or squatting. The use of passive lower-limb exoskeletons (PLLE) is expected to reduce MSD risks by supporting body posture and alleviating physical strain. However, their impact on productivity, perceived task difficulty (PTD), and general discomfort (GD) in dynamic tasks remains understudied. This research aims to evaluate the effects of PLLE on task completion time, PTD, and GD during dynamic activities in a manufacturing environment.

This study used a within-subject experimental design involving 30 participants aged at least 18 years who had never used an exoskeleton. Participants performed five dynamic tasks (lower lifting, sit-to-stand, walking, box carrying, and stair climbing) under two conditions: without PLLE and with PLLE. Task completion time, PTD, and GD were measured using a stopwatch and Visual Analog Scale (VAS) questionnaires. Statistical analysis utilized paired t-tests for normally distributed data and Wilcoxon signed-rank tests for non-normal data, with a significance level of $\alpha = 0.05$.

The use of PLLE slows down task completion time during walking activities significantly by 24.17% ($p < 0.001$), box carrying by 27.40% ($p < 0.001$), and stair climbing by 119.19% ($p < 0.001$). Perceived task difficulty (PTD) increased significantly when using PLLE during walking activities with a mean difference of 1.75 points ($p < 0.001$) and stair climbing with a mean difference of 3.55 points ($p < 0.001$). General discomfort (GD) also rose significantly during lower lifting tasks with a mean difference of 0.65 points ($p < 0,05$), walking with a mean difference of 2.83 points ($p < 0.001$), box carrying with a mean difference of 1.02 points ($p < 0,05$), and stair climbing with a mean difference of 4.19 points ($p < 0.001$). The results show that PLLE is less effective for dynamic tasks requiring high mobility and also had potential to increase the perception of difficulty and general discomfort during dynamic activities.

Keywords: passive lower-limb exoskeleton, performance, perceived task difficulty, general discomfort, musculoskeletal disorders, dynamic activities