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INTEGRATION OF EXOSKELETONS AMONG OPERATIONS AGENTS IN BAGGAGE HALLS AT CHARLES DE GAULLE AIRPORT

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ABSTRACT

For the last ten years, the prevention of musculoskeletal disorders has been a priority in airport activities, especially among luggage handlers, exposed to risks associated with repeated manual handling of heavy loads. Exoskeletons represent a promising innovation in the prevention of these risks. Despite limited data on these technologies, we set up a prevention approach aiming to integrate exoskeleton into a complex environment. Involving various internal and external actors at the CDG airport, the objectives of this project are twofold: assist in the choice of exoskeletons, and assess the impact of exoskeletons in terms of acceptability and cardiac inability at the post of an operating agent. The particularity of this project lies in the involvement of stakeholders at every stage of the process.

Keywords: exoskeleton, integration, acceptability, cardio-frequency

1. INTRODUCTION

Among air transport operations agents, occupational physicians observe that 80% of work-related accidents mainly involve lower back pain, caused by manual handling. Faced with an aging workforce with significant tenure in their roles and exposed to strenuous physical activity, baggage service provider companies report issues related to job retention, coupled with recruitment difficulties.
Furthermore, the relationships between the airport management, airlines, and service provider companies are complex, making the implementation of preventive measures challenging. To address these prevention difficulties, stakeholders in this sector are turning to exoskeleton solutions for the potential biomechanical benefits that have been announced [1]. Nevertheless, the integration of these technologies requires a structured and participatory approach.

2. MATERIALS AND METHODS

2.1 Project framework

A steering committee composed of two baggage service provider companies, an airline, two occupational health and safety services, INRS, and CRAMIF framed this project over 18 months, relying on the exoskeleton integration approach by INRS [2] and the AFNOR AC Z68-800 guide [3].
Thus, the implementation of the approach occurred in 3 stages: preparation, decision support, and evaluations in pilot situations of human-exoskeleton interaction. This approach targets the container loading activity on carousels in the baggage hall. The subjective evaluation of human-exoskeleton interaction is based on the INRS acceptability model with its 7 dimensions: enabling conditions, ease of use, performance (health and safety as well as productivity), social influence, professional identity, and affect [4].
Administering questionnaires on the acceptability process over time allowed us to understand the reasons for the adoption or rejection of the devices. Cardiac frequency monitoring (CFM) enabled us to

compare the cardiac strain at workstations, with/without exoskeleton.

2.2 Involvement of stakeholders

The progress of this project lies in the involvement of these stakeholders. Operations agents participated in characterizing the need for physical assistance. The members of the steering committee validated each step, especially the specifications of a potentially suitable exoskeleton. The support process included creating communication materials and training an "exoskeleton referent" in each subcontracting company. The referent followed the tests and assisted the agents in filling out a daily logbook.
With the support of occupational physicians, volunteers without any medical conditions were trained**,** and then tested an exoskeleton. The trials were organized for 4 weeks with:
- 3 different exoskeletons for 10 volunteers,
- 1 exoskeleton per operator,
- 2 identical exoskeleton units per pair on a carousel to promote mutual assistance,
- exoskeletons provided for a full shift.

Each volunteer received guidance to complete acceptability questionnaires before training (at T1), immediately after training (at T2), and after 4 weeks of testing (at T3).

3. RESULTS AND DISCUSSION

The need for assistance was prioritized for trunk flexion movements during dynamic tasks involving heavy lifting. Among the specifications, the device needed to weigh less than 2 kg, with the possibility of disengaging the assistance. Three exoskeleton models were selected:
- An active model
- A rigid passive model
- A textile passive model

When considering all exoskeletons, the analysis of acceptability questionnaires (at T1, T2, or T3) shows a favorable evaluation of acceptability dimensions. There is a significant difference in decreased productivity performance between T1 and T3 ($p=0.033$ - Wilcoxon test), as well as a reduction in back pain and discomfort at T3.
Regarding the sensory-motor impact associated with exoskeleton use, it is observed that freedom of movement is maintained without altering balance or movement control. Additionally, there is a tendency not to generate additional physical effort. The majority of operators reported having to adjust their way of doing things.

At the end of the tests, the rigid passive model stands out in terms of affect. The pair of volunteers who tested this model reported higher satisfaction, confirmation of expectations, and an intention to continue using it. They continue to use this model. The results are more mixed for the other two models. Lastly, there is a significant correlation between the intention to use and feeling the assistance after 10 days of usage ($p=0.021$ - U-Mann Whitney test).
Cardiac frequency monitoring revealed significant cardiac strain for 70% of the recordings, whether with or without an exoskeleton. However, the variability in baggage flow (quantity, loading speed, contingencies, etc.) does not allow us to draw conclusions about the influence of exoskeleton usage on cardiac strain. However, among 3 out of 4 volunteers who tested the active exoskeleton, a reduction in the perception of back strain is observed, despite an increase in cardiac strain.

Thanks to the collected information and despite the limitations of this project (experimentation conducted with a limited number of voluntary subjects), recommendations for the continuation of the approach could be provided: maintain enabling conditions, monitor usage, and allow time for its adoption.

4. CONCLUSION

The involvement of different stakeholders allowed for a unique experiment at CDG Airport. This project has contributed to a change in the prevention approach for all parties involved.

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