2021 43rd Annual International Conference of the
IEEE Engineering in Medicine & Biology Society (EMBC)
Oct 31 - Nov 4, 2021. Virtual Conference

Wearable biomedical device based on IMUs to evaluate upper limb physical work demands

Marianne Boyer[1], Jean-Sébastien Roy[1], Laurent Bouyer[1] and Alexandre Campeau-Lecours[1]

***Abstract*— This paper presents the development of a biomedical device based on inertial measurement units (IMUs) that estimates (keeps tract of) the physical work demands of the upper limb by evaluating the amplitude and frequency of arm elevations. The arm elevation is obtained with a data fusion algorithm using accelerometer and gyroscope data. The physical work demands are evaluated by four different metrics which give information on the time spent with the arms in elevation and the number of elevations.**

I. INTRODUCTION

Work-related upper extremity musculoskeletal disorders (WRUED) are a major problem in modern societies as they affect workers' quality of life and lead to absenteeism, productivity loss and early retirement. Despite prevention efforts, the prevalence of these disorders is increasing [1]. There is currently a lack of adapted tools that can evaluate physical work demands quantitatively and for long periods (especially for upper limb tasks), give a real-time feedback and warn workers if they are at risk of injury.

The long-term objective is to develop and validate a real-time biomedical device able to analyze physical work demands (shoulder movements) in order to provide feedback in real-time to the workers on their accumulation of physical stress. In this paper, we present the proposed metrics to evaluate the physical work demands.

II. METHODS

A data fusion algorithm was developed based on IMU data to measure arm elevations. The proposed algorithm's inputs are the IMU 3-axis accelerations and angular velocities while the output is arm elevation [2].

The four proposed metrics are : 1) Total time over θ◦ since the beginning of the task; 2) Time over θ◦ in the last x minutes; 3) Number of elevations (over θ◦) since the beginning of the task; 4) Number of elevations (over θ◦) in the last x minutes.

where θ and x are parameters that can be adjusted. The metrics choice was made according to an interdisciplinary team composed of engineers, physiotherapists and occupational therapists.

*Research supported by the Canadian MSK Rehab Research Network, by INTER (Engineering of Interactive Rehabilitation Technologies), by the Natural Sciences and Engineering Research Council of Canada

1 M. Boyer, A. Campeau-Lecours, JS. Roy and L. Bouyer are with the Centre for Interdisciplinary Research in Rehabilitation and Social Integration, CIUSSS de la Capitale-Nationale, Canada and Université Laval, Canada

III. RESULTS

Metrics of the arm elevation were calculated for a subject doing manual work for four hours (Fig.1) with parameters θ of 60° and x of 20 minutes. Subplots are described in the figure's caption.

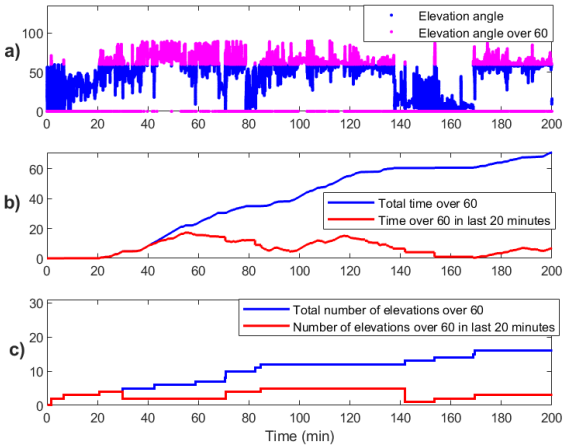

Figure 1. a) Arm elevation above 60◦ (blue) and over 60◦ (pink) obtained with the proposed data fusion algorithm for a manual worker (4 hours) b) Total time over 60◦ since the beginning of the task (blue) and time over 60◦ in the last 20 minutes (red) c) Number of elevations (over 60◦) since the beginning of the task (blue) and number of elevations (over 60◦) in the last 20 minutes (red)

IV. DISCUSSION & CONCLUSION

The next step will be to integrate the metrics calculation algorithm within a microcontroller to be used in real-time and to give feedback to the user.

ACKNOWLEDGMENT

This work was supported by the Canadian MSK Rehab Research Network, INTER (Engineering of Interactive Rehabilitation Technologies) and the Natural Sciences and Engineering Research Council of Canada.

REFERENCES

[1] M. Huisstede, S. M. Bierma-Zeinstra, B. W. Koes, and J. A. Verhaar,"Incidence and prevalence of upper-extremity musculoskeletal disor-ders. a systematic appraisal of the literature,"BMC musculoskeletaldisorders, vol. 7, no. 1, pp. 1–7, 2006

[2] M. Boyer, A. Frasie, L. Bouyer, J.S. Roy, I. Poitras, and A. Campeau-Lecours, "Development and validation of a data fusion algorithm with low-cost inertial measurement units to analyze shoulder movements in manual workers, Rehabilitation Engineering and Assistive Technology Society of North America Conference. 2020