IMUs-based kinematic and temporal analysis of upper limbs during doffing medical gown: a preliminary study

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Summary

This preliminary study explores the use of inertial measurement units (IMUs) to assess the kinematics of upper limbs during the medical gown doffing process. Utilizing RMS for change point detection, the doffing was segmented into three phases: untying the waistband, untying the neck strap, and gown dropping. The findings suggest that IMU-driven models effectively capture complex upper limb movements, offering potential for designing better medical protective clothing by correlating these movements with contamination risks.

Introduction

Medical gown is commonly used in healthcare settings to protect staff from healthcare-associated infections [1]. Different doffing methods of medical gowns may lead to varying contamination risks for healthcare workers [2]. However, traditional motion capture systems are hindered by garment interference, resulting in insufficient kinematic analysis of the doffing process. This study explores the feasibility of using IMUs for kinematic analysis during doffing in hopes of providing reliable quantitative parameters for the design of medical protective clothing in the future.

Methods

One healthy young adult was recruited. A polypropylene isolation gown was as the sample in this study. Five IMU sensors (SageMotion, USA) were used to collect kinematic data of upper limbs during doffing medical gown (1 on xiphoid process, 2 on the outside of the upper arms and 2 on the outside of the forearms). The static standard anatomical position was used for IMUs system calibration. Joint angles of the shoulder and elbow of both arms were calculated using customized app in SageMotion with 4th order Butterworth low-pass filter (15 Hz). A customized Matlab program was used to detect key events during doffing through utilizing root mean square (RMS) to detect change points in the signal.

Results and Discussion

Based on the RMS-based change point detection results, the entire process of doffing medical gowns could be primarily divided into three phases, untying waistband, untying neck strap, and gown dropping. By matching with video recordings, these three stages can accurately reflect the true sequence of doffing medical gowns (Fig. 1). Upon analyzing upper limb kinematic data acquired through IMUs and juxtaposing it with video recordings, it becomes evident that the IMU-driven motion model employed in this pilot study efficaciously describe the complex upper limb movements throughout the process of medical gown doffing. In the untying neck strap phase, characterized by symmetrical movements across both upper limbs, there was a marked consistency in the range of motion (RoM) of bilateral shoulder and elbow joints. Meanwhile, during phases featuring asymmetrical bilateral movements (untying waistband and gown dropping), the IMU measurements precisely delineate the kinematic attributes of each upper limb (Fig. 2).

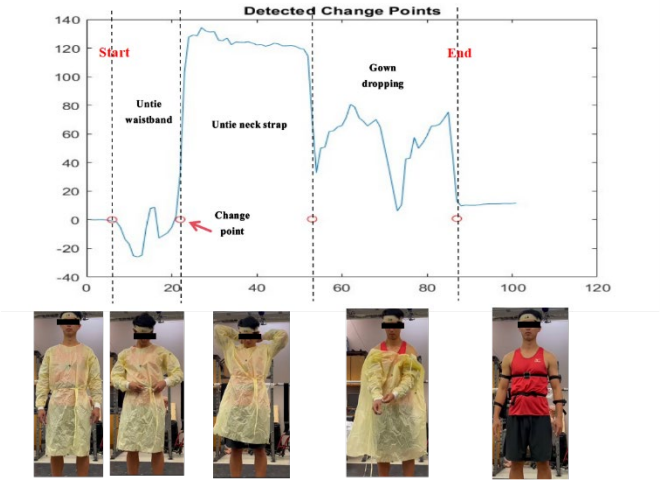

Figure 1: Temporal classification of doffing

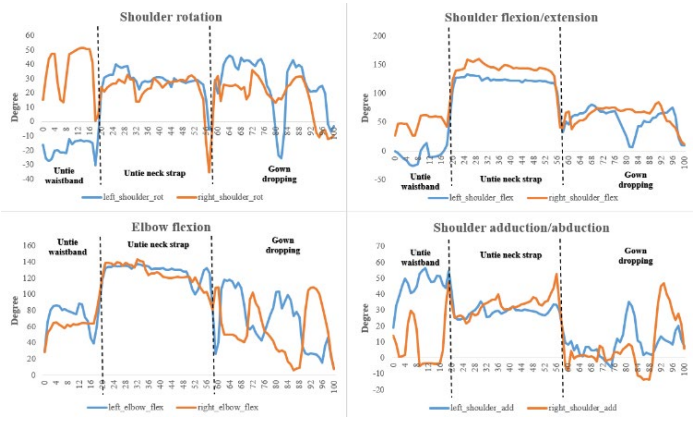

Figure 2: RoM of shoulders and elbows

Conclusions

This preliminary study demonstrated the feasibility of using IMUs to measure kinematic parameters during the process of doffing medical gown. Additionally, the use of change point detection allows for the temporal classification of this process, supporting subsequent quantitative analyses aimed at correlating the doffing process with contamination risk and enhancements in medical gowns.

References

[1] Chughtai, et al. (2018). *Am J Infect Control*, **46** (12).
[2] Gurses, et al. (2019) *Infect Control Hosp Epidemiol*, **40** (2).