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

Basic Study on Physiological Burden of Wearing an Upper Limb Support Suit While Holding an Endoscope

Tomoaki Sano, Kazuya Kawamura, *Member, IEEE*, Shimomura Yoshihiro, and Hiroshi Kawahira

Abstract— **Despite the increasing popularity of endoscopic surgery due to its minimal invasiveness for the patient, the associated increase in the physical burden on surgeons is a critical problem. In our previous study, we developed an upper limb support suit and evaluated the effect of this suit on reducing the physical burden on surgeons. Thus far, there has been no study of the physiological burden of wearing the device. In this study, we examined the physiological effects of this device on subjects during endoscope retention. In this experiment, four adult males of non-medical association used an endoscope to monitor a fixed point with their dominant hand until they could no longer raise their upper arm due to arm fatigue. This task simulating the motion of a camera driver was carried out two times for each subject. The influence on the autonomic nervous system was evaluated by measuring the RR intervals. The results obtained with and without the proposed device were compared. The results indicate that there was no significant difference whether the device was worn or not worn. These results suggest that the physiological burden is not increased by wearing the device. In the future, we will measure the burden for medical staff and verify the results in a real environment.**

I. INTRODUCTION

While endoscopic surgery offers increased benefits to the patient, the burden on the surgeon has increased due to the increasing difficultly of the surgical task. In particular, the greater physical burden of maintaining the arm in an elevated position for prolonged periods is considered to be a major issue. In our prior study, we developed a surgical support suit (SAS) for upper limb support to assist in raising the surgeon's upper arm [1]. We also suggested that the device could reduce the physical burden on the surgeon as it was confirmed that muscle activity decreased during a simulated surgical task for subjects wearing the SAS. However, the effect of wearing the SAS on the physiological burden has not yet been evaluated. In this study, we evaluate the physiological burden on the autonomic nervous system by acquiring electrocardiogram (ECG) signals and determining the RR intervals.

II. METHODS

The task of a camera driver was simulated, whereby the subject continuously monitored a target with an endoscope by using his dominant hand until the subject could no longer raise his upper arm due to arm fatigue. Before performing all experiments, informed consent was obtained from all the participants. The relative position of the trunk and the hand in the experiment was standardized by discussing the height that would be possible in a real environment and at which a large load would be applied with a surgeon. The analysis included the coefficient of variation (CVRR), low frequency/high frequency (LF/HF) ratio, and Lorenz plot analysis. To determine the LF/HF ratio, we used the integrated value from the spectrum in the 0.04–0.15 Hz band as the LF component and the spectrum in the 0.15–0.40 Hz band as the HF component. The RR interval was determined by resampling and interpolation. The sympathetic activity index (CSI) and the parasympathetic activity index (CVI) were defined based on the literature [2]. For comparison, a t-test with a significance level of 5% was employed.

III. RESULTS

The results showed that wearing the SAS significantly prolonged the task time. Therefore, the aforementioned indicators were compared based on the endurance time in the experiments without wearing the SAS. Table 1 presents the results with the mean, standard error, and p-value.

TABLE I. MEAN AND P-VALUE OF EACH INDICATOR FOR THE ENTIRE TASK

	CVRR	LF / HF	CSI	CVI
Non-Wear	0.07±0.01	1.33±0.12	4.19±0.15	0.30±0.05
Wear	0.06±0.01	1.55±0.26	4.08±0.16	0.34±0.07
p-value	0.19	0.29	0.41	0.62

IV. DISCUSSION & CONCLUSION

The results show that there was no difference in the physiological burden for subjects wearing and not wearing the SAS. This suggests that the physiological burden is not increased by wearing the SAS. The other reason for the lack of significant differences is the influence of individual differences. In order to reduce the influence of individual differences, the data should be normalized or compared relative to the resting state. As a next research step, we will proceed with the measurement for medical staff and verify the effects of the SAS in a real environment.

*Research supported by TAKANO Co.,Ltd

Tomoaki Sano is with Graduate School of Science and Engineering, Chiba University, 1-33, Yayoicho, Inage-ku, Chiba-shi, Chiba, 263-8522, JAPAN, phone: +81-43-290-3230; e-mail: tomo.012645@chiba-u.jp).

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