SURFACE EMG-BASED MUSCLE FATIGUE ANALYSIS IN REPETITIVE LIFTING TASK

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Introduction

Undetected fatigue caused by repetitive and monotonous tasks with light weights can lead to injury and is a financial burden to industry and society (Shin, 2007). There is a need to assess fatigue and to detect the time point at which injury risk could be considered to have risen above a baseline level (Nussbaum, 2001). We introduced the Time to Substantial Fatigue Onset (TSFO) in order to quantitatively assess the rate of muscle fatigue accumulation.

Methods

A total of 8 male volunteers with a mean age of 27.66 ± 1.76 years participated in this study. The protocol consisted of electromyographic recording of the erector spinae muscle, during a repetitive symmetric load lifting from the floor to a 0.75m height table. For the present study demands, the lifting task was executed into 4 Lifting Trials (LT) and after each LT the participants received 5-minutes duration rest-break. Every LT consisted of 16 load lifts. sEMG signal of the erector spinae muscle was recorded at a sampling frequency of 6000Hz using EMG recorder (Dantec Keypoint 6-channel amplifier) with a pair of surface Ag/Agcl electrodes. sEMG raw data were filtered using a 4th order Butterworth filter (Balasubramanian, 2011). The Mean Power Frequency (MPF) regression line slope of each LT was analyzed for every 4 load lifts to better focusing on the fatigue rate. Muscle activation (MACT) was calculated as:

$$MACT = [\frac{MPF_{ni} - MPF_{11}}{MPF_{11}}]*100\% \qquad (1)$$

i=2-4, number of LT, n=1 1st lifting load of each LT, MPF_{11}=non-fatigue state (muscle MPF value of the 1st lifting load of the 1st LT). Statistical analysis was conducted using SPSS and the significance level was set to be 0.05.

Results

Regression line slopes indicate that fatigue gradually increases during the performance of the LTs 1, 2 and 3. The TSFO factor was determined by the highest negative regression line slope, in each LT correspondingly. The crucial value of TSFO factor was found to be between 1st and 4th load lift in the 4th LT.

	Load Lifts			
	1-4	**5-8**	**9-12**	**13-16**
LT 1	0.0302	-0.0172	-0.393	-0.2711
LT 2	0,4575	-0,0104	0,5383	-0,2537
LT 3	0,0763	-0,4294	0,0081	-0,5413
LT 4	-0,5314	-0,3969	-0,2404	0,0775

Table 1: MPF regression line slopes in every 4 load lift in all 4 LTs. Mean values of all volunteers.

Figure 1 showed that muscle activation is lower in the 4th LT despite the fact that a five-minute rest-break elapsed.

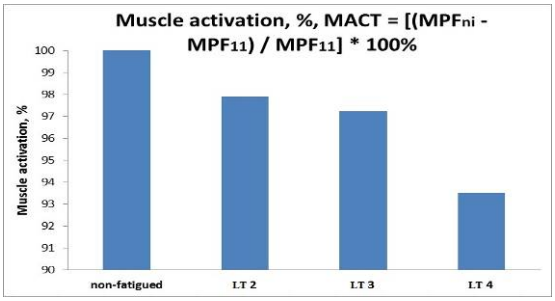

Figure 1: MACT, based on MPF values

Discussion

The results of regression line slopes and MACT indicated high level fatigue accumulation in the beginning of the 4th LT. this time point of the task is proposed to be the TSFO. Thus the TSFO factor should be considered for the design of the work/rest ratio in the workplace.

References

Balasubramanian *et al*, App Ergon, 42:913-918, 2011.

Nussbaum, Eur J Appl Physiol 85:299-309, 2001.

Shin *et al*, Int j ind ergon, 37:545-551, 2007.

Acknowledgments

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