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Correlation Between Valve Event Amplitudes in the Seismocardiogram and VO_2-max

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***Abstract*—Cardio Respiratory Fitness (CRF) is a strong predictor of mortality. Because of this the American Heart Association recommends that ideally all patients should have measured CRF with a maximal effort test on a regular basis. However, this is not practically possible. Seismocardiography (SCG) is a measure of the vibration produced by the beating heart, measured on the sternum. This study investigates the correlation between amplitudes in the SCG and VO_2-max from 17 females and 9 males. All amplitudes investigated correlated significantly with VO_2-max.**

I. INTRODUCTION

According to an American Heart Association (AHA) Scientific Statement from 2016, CRF is potentially a stronger risk predictor of mortality than smoking, diabetes and hypertension [1]. CRF can be estimated by maximal oxygen consumption (VO_2-max) with a maximal effort cycle ergometer test. This test is not well suited for the elderly or obese patients. In this study we investigated using recordings of vibrations on the chest produced by the beating of the heart, SCG, and its correlation to VO_2-max. SCG is a deterministic signal recorded non-invasively on the sternum with an accelerometer [2].

II. METHODS

Seventeen females and 9 males were recruited for the study. All subjects signed written informed consent form. Demographic data, SCG and electrocardiography (ECG) was recorded for 5 minutes at rest. VO_2-max was measured with a Vyntus CPX during a maximal effort bike ergometer test. The female subjects participated in a follow up recording session, after 8 weeks of structured high intensity training for 2 hours a week. Based on the ECG R-peak, the SCG was divided into individual beats and one mean SCG beat was calculated for each subject. From the mean SCG beats the peak-to-peak amplitudes between the location of the mitral valve closure (E_s) and the following valley F_s, F_s to aortic valve opening (G_s), aortic valve closure (B_d) to the following valley C_d and lastly C_d to D_d was measured (see Fig I) [3]. The amplitudes were correlated with the VO_2-max using the Pearson's Correlation.

III. RESULTS

The mean VO_2-max for the females was 28.7 (± 4.5) (mL/kg)/min prior to the 8 weeks of training, compared to 31.2 (± 6.5) (mL/kg)/min after training ($p < 0.05$). The mean VO_2-max for the males was 40.1 (± 8.4) (mL/kg)/min. The correlations between the amplitudes of the valve events and VO_2-max are listed in Table I.

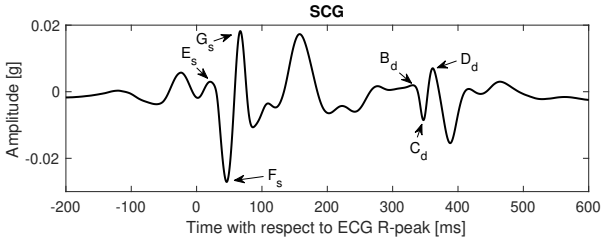

Fig. 1: A normal SCG with notation of the fiducial points.

TABLE I. PEARSON'S CORRELATION COEFFICIENT AMD P-VALUE BETWEEN VALVE EVENT AMPLITUDES AND VO_2-MAX

Event	n	Correlation [r]	p-value
E_s to F_s	48	-0.47	< 0.001
F_s to G_s	48	0.47	< 0.001
B_d to C_d	48	-0.72	< 0.001
C_d to D_d	48	0.81	< 0.001

IV. DISCUSSION & CONCLUSION

The amplitude of C_d to D_d could be caused by the heart moving towards its apex when the aortic valve closes [2]. The amplitude of this event could be manipulated by the speed of the pressure drop in the left ventricle. Faster ventricular relaxation has previously been shown in athletes compared to normal subjects.

This study shows a correlation between amplitudes measured in the SCG and VO_2-max, presenting a novel non-exercise method for estimating CRF.

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