

# THE INFLUENCE OF TRAINING ON HEART RATE VARIABILITY IN HEALTHY OLDER ADULTS.

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## ABSTRACT

The effect of one-year physical training on heart rate variability in older adults was evaluated in 14 healthy men (age > 55 year). Measures of heart rate variability were obtained in both time and frequency domain. Ten-minute ECG recordings were made in supine position and in standing position. A progressive climbing exertion test till exhaustion was performed to estimate maximal oxygen consumption ( $VO_{2max}$ ) and maximal wattage level ( $W_{max}$ ). Results show a small gain in maximal oxygen consumption and no changes in HRV parameters during the first 6 months of training. In the last six months of training there was a trend towards a decreasing HRV. Also  $VO_{2max}$  and  $W_{max}$  showed a small decrease at 1 year of training. A correlation between changes in physiological and HRV parameters, suggest an accordance between  $VO_{2max}$  and power spectral analysis. It can be concluded that heart rate variability does not change by physical training in an elderly population

**Keywords:** *heart rate variability, physical training, aerobic capacity, autonomic nervous system*

## 1. INTRODUCTION

Heart rate variability (HRV) is a non-invasive technique that provides an index of cardiac autonomic regulation through measurement of beat to beat variations of heart rate [1].

Decreased HRV is associated with an increased risk of cardiac events in clinically disease-free patients. Similarly, after myocardial infarction, low HRV is correlated with mortality in patients [5].

The effect of long-term physical activity on the cardiovascular system is well known [3]. Also the autonomic regulation of the heart will change: due to a shift of the sympathovagal balance towards vagal predominance, athletes have a higher HRV compared to sedentary persons [2],[3]. Previous studies have suggested that exercise training can increase HRV in a sedentary population. In most studies a group of young sedentary subjects is compared to athletes. However, few studies examine the effect of training on indexes of heart rate variability in an elderly sedentary male population. The purpose of this study was to investigate the relationship between changes in aerobic capacity and changes in HRV parameters, resulting from exercise training in an elderly male population.

## 2. METHODS

### *Study population*

A group of 22 men were selected to start the one-year training program. Only 14 of them, age:  $63.2 \pm 6.8$ , completed the whole experiment. None of the subjects showed evidence of cardiovascular disease by history, cardiac examination and cycling exercise test. All subjects had a sedentary life style for at least 2 years before enrolment the program.

### *Measurement of maximal oxygen consumption*

Each subject underwent a progressive exertion test on the cycle ergometer (Ergometrics 800S<sup>®</sup>ergometrics, Bitz, Germany). During the entire test heart rate and a 12-lead electrocardiogram were registered continuously. This test was performed to evaluate heart rate, blood pressure and electrocardiographic response to exercise. The same test was used to determine oxygen consumption by a paramagnetic O<sub>2</sub> analyser, which was calibrated before each test according to manufacturer's instructions. Oxygen uptake ( $VO_2$ ) was determined from the continuous measurement of the inspired and expired air and the concentrations of oxygen. The workload was initially 20 Watts and increased each minute with 20 Watts. This continued till exhaustion. Oxygen uptake was measured continuously by open-circuit spirometry. This test was repeated after 6 months of training and after 1 year at completion of the program.

### *Training program*

During 1 year, subjects underwent a supervised strength and cardio-training program. The training intensity during the cardio training was based on the formula of Karvonen (1):

$$\text{Target Heart Rate} = [\text{exercise intensity} \times (\text{HR}_{\max} - \text{HR}_{\text{rest}}) + \text{HR}_{\text{rest}}]$$

where:

exercise intensity :percentage of maximal intensity  
 $HR_{\max}$  :maximal heart rate,  
 $HR_{\text{rest}}$  :heart rate at resting condition

Initial intensity of exercise was 50% and was gradually increased up to 80%.

Twenty to thirty repetition maximum (RM) was used for the strength training and then appropriate exercises were selected, one for each muscle group.

### ECG acquisition

Short time series of 10 minutes were obtained using ECG recordings in supine and standing position. After RR-peak detection and visual inspection by the operator, a file containing the consecutive RR-intervals was exported. Premature supraventricular and ventricular beats, missed beats and pauses were filtered and replaced by an interpolated value.

### HRV data analysis

Measurements of HRV in both time- and frequency domain were calculated. In time domain, measurements included mean NN and SDNN, rMSSD and pNN50. Total, low (0.04-0.15 Hz) and high frequency (0.15-0.4 Hz) spectral power density were calculated, as well as their ratio.

### Statistics

The statistical analysis of the results was performed with SPSS (Scientific Packages for Social Sciences, Inc., Chicago, IL, USA). Due to the small number of subjects, differences between measures were analysed using a non-parametric test. Because of their skewed distribution total power, LF power, HF power and LF/HF ratio were transformed by calculating their natural logarithm. Spearman correlations coefficients between HRV and physiological parameters were calculated.

## 3. RESULTS

### Physiological parameters

Figure 1 illustrates changes in  $VO_{2max}$  during the one-year period. A small increase in  $VO_{2max}$  can be observed after 6 months of training. There was no significant increase in  $VO_{2max}$ , even after 1 year of training. Changes in  $W_{max}$  follow a similar time course: a small increase after 6 months, followed by a stabilisation at 1 year.

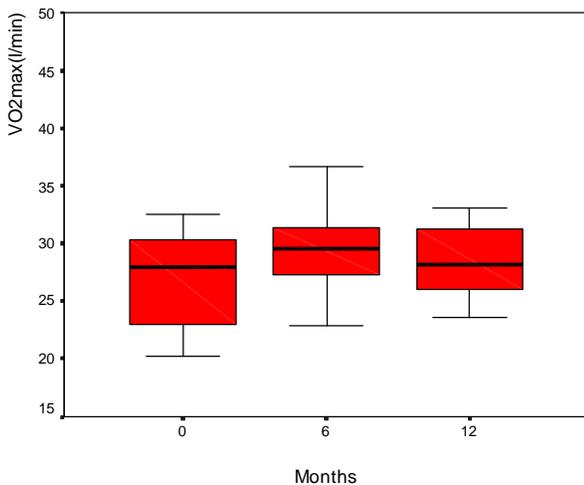


Fig 1. Average and SD of MeanNN

### HRV parameters

Small differences were observed in time domain parameters before and after training (see Table 1). At 6 months the HRV parameters show almost no difference. After 1 year, a decline in mean RR, SD, rMSSD and

pnn50 (supine) was observed. However the observed differences were not statistically significant.

**Table 1:**

Time domain HRV parameters

Supine	mean	SDNN	rMSSD	Pnn50
	(ms)	(ms)	(ms)	(%)
Initial	922.4±172.1	41.2±17.2	21.7±11.5	5±7
6 m	919.1±173.5	42.0±14.9	22.7±10.1	5.1±7
12 m	908.2±133.6	37.6±11.4	19±7	2.4±3.2
<b>Standing</b>				
Initial	825.1±136.7	34.1±12.5	16±8	2.1±3.7
6 m	813.5±130.9	34.6±130.9	16.1±7.1	1.9±3
12 m	789.8±122.1	31.5±122.1	15.6±8.8	2.5±6

The evolution of mean RR in standing and supine position is represented in figure 2.

Analysis of the spectral content (Table 2) illustrates the same trends as the time domain indices: a rather stable period of 6 months, followed by a slight decrease in values after 1 year.

### Physiological and HRV parameters

Initially there were no significant correlations between physiological and HRV parameters. After 6 or 12 months of training there were still no significant correlations.

Higher correlations were found when examining the changes of the parameters versus the index recording.

There was a significant correlation between low frequency power and  $W_{max}$  ( $r=-0.538$ ;  $p<0.05$ ).

**Table 2:**

Frequency domain HRV parameters

Supine	n(Tot P)	ln(LowP)	ln(HighP)	low/high
	(ms <sup>2</sup> )	(ms <sup>2</sup> )	(ms <sup>2</sup> )	(%)
Initial	6.6±0.69	5.75±0.74	4.46±0.84	4.22±2.78
6 m	6.65±0.83	5.71±0.85	4.37±1.07	4.61±3.52
12 m	6.21±1.01	5.34±1.0	4.03±1.11	4.27±1.81
<b>Standing</b>				
Initial	6.3±0.8	5.54±0.98	3.46±1.31	10.91±8.48
6 m	6.31±0.96	5.64±1	3.58±0.83	9.41±5.45
12 m	6.02±0.9	5.34±0.9	3.29±1.14	9.74±5.83

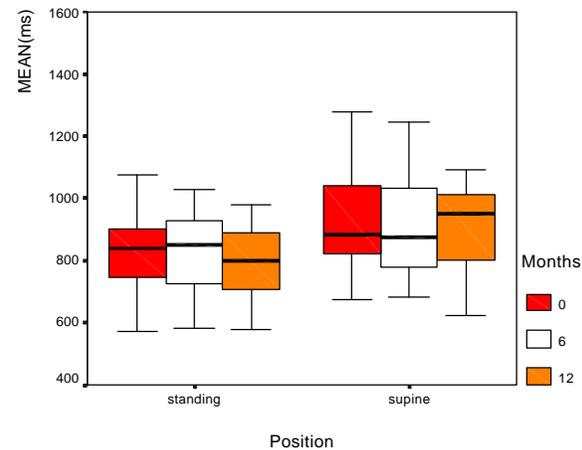


Fig 2. Average and SD of meanRR in standing and supine condition, comparison of initial measure(1), after 6 months (2) and after 1 year (3)

## 4. DISCUSSION

Although a small increase in maximal oxygen consumption was observed, all HRV parameters were stable during the first 6 months of training. The last six months of training showed a trend towards decreasing HRV. Also  $VO_{2max}$  and  $W_{max}$  showed a trend towards decreasing values. These results, together with the small correlation between changes in physiological and HRV parameters, suggest a decline of HRV parameters with age in sedentary older subjects.

The described relation in literature between exercise training and increased heart rate variability is largely based on cross-sectional studies, comparing athletes and sedentary controls [9]. In 1999, P.K. Stein et al. [11] also found little evidence of an increased HRV in an elderly population. They suggested that an elevated heart rate variability level in athletes could be caused by genetics and selection.

Previous studies also focussed on young men and women. It is well known that ageing influences the cardiovascular system and HRV [8], [6], [10]. Young people seem to react better on physical activity by changes in cardiovascular and autonomic system reflexes.

An important limitation of this study is the disposition of the training program. This study was part of a larger study in which an important percentage of the physical activity was reserved for power training. Previous studies have shown that the increase in HRV is more pronounced in endurance athletes. This could be the reason of the lack of increase in HRV up to 1 year of physical activity.

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