AUTOMATIC CARDIAC CONTROL IN ATHLETES AND NON-ATHLETES AT REST

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ABSTRACT
The effect of different types of physical training on heart rate variability was evaluated in 10 aerobic trained athletes, in 7 anaerobic trained athletes, in 7 rugby players (mixed type training) and in 10 sedentary control subjects. All groups were age matched (18-26 y). Measures of heart rate variability were obtained, from both time- and frequency analysis of 10 minutes resting heart rate, ECG tracings were recorded digitally in supine position and in standing position. After these tests, blood pressure was measured using an automatic inflation cuff. Resting heart rate was lower in aerobic and mixed type athletes compared to controls. Only aerobic athletes had evidence of increased vagal activity in the time domain compared with control subjects (increased SDNN supine, increased rMSSD supine and standing and pNN50 standing). In the frequency domain aerobic athletes presented with both higher LF and HF power in standing position and LF power in supine position compared to controls. It can be concluded that heart rate variability is affected by chronic exercise, especially in endurance athletes. This infers that especially aerobic exercising can have beneficial effects on the cardiovascular risk profile.

Keywords: heart rate variability, digital signal processing, physical training, aerobic and anaerobic athletes, power spectrum analysis.

1. INTRODUCTION
Heart rate variability (HRV) is an established non-invasive method for the assessment of autonomic influence on the heart[1]. Low HRV has been associated with increased mortality after myocardial infarction[2]. The autonomic nervous system consists of nerves that are concerned primarily with the regulation of bodily functions. These nerves generally function without consciousness. Autonomic nerves comprise sympathetic and parasympathetic nerves that control heart rate, force of cardiac contraction and state of constriction of blood vessels through the transmission of nervous impulses. Autonomic nerves thus have a pivotal role in the regulation of the cardiovascular system, both in ensuring optimal function during various activities in health and also in mediating several of the manifestations of cardiac diseases. Long-term physical training influences cardiac rhythm: sinus bradycardia in resting conditions and a slower increase in heart rate at any degree of submaximal oxygen uptake, due to a shift of the sympathovagal balance towards vagal predominance[3][4]. Therefore it can be expected that the exercise level and kind of exercise would be a factor influencing HRV parameters in a general population.

This study was performed to determine whether the type of training, on a young population, differentiates HRV parameters between athlete groups and sedentary subjects.

2. MATERIALS AND METHODS

Study population.
After informed consent, 4 groups (only male) were selected and compared: 10 endurance trained athletes (aerobic), 7 static trained athletes (anaerobic), 7 rugby players (mixed type) and 10 subjects with a sedentary life style (controls). The athletes were of national competition level and trained between 6 and 9 hours a week. Age ranged between 18 and 34 years, with no significant difference between the 4 groups.

Data acquisition.
The ECG signal of the subjects were recorded during 10 minutes in supine position, and standing and A/D converted at a rate of 1000 Hz (RR time resolution of 1 ms). After peak detection[5] a tachogram text file was created containing the consecutive RR intervals. The acquisition setup is shown in Fig. 1.
Data analysis.
Measurements of HRV in both time- and frequency domain were calculated following international standards[6]. In the time domain, measurements included mean NN and SDNN, rMSSD and pNN50. The power spectral plot of HRV was derived from the tachogram after resampling at 2 Hz (in order to obtain equidistant points) and FFT computed after Hanning windowing over 256 points (128 s)[7]. 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.
Mean and standard deviation of data were determined. A logarithmic transformation was performed in case of non-normal distribution. ANOVA was used and corrected for multiple comparison testing by the LSD procedure (SPSS software). Values were compared to the sedentary population group. Significance is reported at the level of 5% or lower.

3. RESULTS
Basal conditions of the study population showed a lower heart rate in aerobic athletes (50±4.6 vs. 73±14 b/min in controls). Time domain analysis (Table 1) also showed a higher mean NN in aerobic athletes and SDNN, rMSSD in supine position, and higher mean NN, rMSSD and pNN50 in standing position.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>HRV parameters in time domain</th>
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<tbody>
<tr>
<td></td>
<td>Supine</td>
</tr>
<tr>
<td>Mean NN (ms)</td>
<td>Control 880.7±263.8</td>
</tr>
<tr>
<td>SDNN (ms)</td>
<td>69.7±37</td>
</tr>
<tr>
<td>rMSSD (ms)</td>
<td>45.5±26.8</td>
</tr>
<tr>
<td>pNN50 (%)</td>
<td>21.8±19.7</td>
</tr>
<tr>
<td>Control</td>
<td>Aerobic 1103.4±158.5*</td>
</tr>
<tr>
<td></td>
<td>Anaerobic 842.3±85.1</td>
</tr>
<tr>
<td></td>
<td>Rugby 840.2±204.7</td>
</tr>
<tr>
<td>Control</td>
<td>Control 69.7±37</td>
</tr>
<tr>
<td></td>
<td>Aerobic 97.9±15.7*</td>
</tr>
<tr>
<td></td>
<td>Anaerobic 73.5±23.7*</td>
</tr>
<tr>
<td></td>
<td>Rugby 55.0±24.2</td>
</tr>
</tbody>
</table>

High frequency power in the standing position. Rugby players showed a higher L/H ratio in the supine position. Standing compared to supine produced a significant increase in the ratio of LF- to HF power in all groups.

4. DISCUSSION
Analysis of HRV is thought to allow insight in the modulation of heart rate by the autonomous nervous system[8], especially activity in the HF spectrum (above 0.15 Hz) has been correlated with parasympathetic modulation. The results of this study show that aerobic athletes, with a low resting heart rate, have indications of increased parasympathetic modulation as well in the time- and frequency domain. Static exercise (javelin and high jump) and mixed type activity (rugby), do not seem to influence HRV significantly. The mechanisms underlying the relationship between HRV and the training response are at present unclear.

On the other hand low frequency oscillations governing HRV are enhanced during orthostatic stress, leading to the speculation that humoral factors, such as circulating catecholamines, probably play a more dominant role than neural input.

It should be stressed however that this study concerns only a young (18-34 years of age) and all male population.

The importance of these findings lies in the application of HRV for risk stratification in patients. The impact of age and gender on HRV are well known. As HRV indices, especially from aerobic athletes, are different from those of sedentary subjects, it can be concluded that training level and –type have to be taken into account as well for prognostic stratification from HRV. It can be hypothesized further that physical activity has beneficial effects on the cardiovascular risk profile.

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REFERENCES

CONTROL CARDIACO AUTÓNOMO EN ATLETAS Y NO-ATLETAS EN REPOSO

RESUMEN

Se evaluó el efecto de diferentes tipos de entrenamiento físico sobre la variabilidad del ritmo cardíaco en 10 atletas con entrenamiento aeróbico, en 7 atletas con entrenamiento anaeróbico, en 7 jugadores del rugby (entrenamiento mixto) y en 10 sujetos sedentarios. Todos los grupos eran de edades comprendidas entre 18-26 años. Se obtuvieron medidas de variabilidad del ritmo cardíaco a partir del análisis tiempo-frecuencia durante 10 minutos de ritmo cardíaco en reposo, se registraron digitalmente la señal de ECG en posición sentada y parada. Después de estas pruebas, la presión sanguínea fue medida usando brazalete con inflado automático. El ritmo cardíaco fue menor en atletas con entrenamiento mixto y entrenamiento aeróbico. Sólo los atletas con entrenamiento aeróbico tenían evidencia de actividad vagal aumentada en el dominio del tiempo comparado con los sujetos de control (SDNN aumentado en posición sentada, el rMSSD aumentado en posición sentada y parada y el pNN50 aumentado en posición parado). En el dominio de la frecuencia, los atletas con entrenamiento aeróbico presentaron mayor potencia LF y HF en posición parada y LF en posición sentada. Puede concluirse que la variabilidad del ritmo cardíaco es afectada por el ejercicio crónico, sobre todo en atletas sedados. Esto infiere que especialmente la ejercitación aeróbica puede tener efectos beneficiosos sobre el perfil de riesgo cardiovascular.