### 1. Exercise tolerance test

#### Method

The patients underwent a simple work test (walking test) by the use of a treadmill. This test was performed after warming up on the treadmill for 5 minutes at a speed of 2 km/h and an inclination of 0%. The speed of the treadmill was then increased by 1 km/h in every 1 minute until the patients could not walk any further due to tiredness. The heart rate was measured at every 1 minute after the treadmill test, and the time of the patients' walking on the treadmill until they could not walk any further was recorded. The maximum heart rate after the exercise test was calculated by subtracting the resting heart rate (before the treadmill test) from 220 years of age. The percentage of the achieved heart rate from the maximum heart rate (EX1) was calculated. The treadmill test was performed on 2 separate days to examine the reproducibility of the test results. The data of the 2 measurements were averaged to calculate the exercise tolerance test results.

#### Results

The maximum heart rate achieved by the subjects during the exercise test was 183 bpm (mean ± SD: 65.9 ± 11.5). The average value of the percentage of the achieved heart rate from the maximum heart rate (EX1) was calculated to be 70.1%. The reproducibility of the results was high with a coefficient of variation (CV) of 6.6%.

### 2. Six minutes constant-load test

#### Method

The patients underwent a constant-load exercise test using a cycle ergometer for 6 minutes. The initial workload was set at 10 W, and the workload was increased by 10 W every 30 seconds until exhaustion. The heart rate was measured every 30 seconds during the test, and the duration of the test was recorded. The maximum heart rate during the exercise test was calculated by subtracting the resting heart rate from 220 years of age. The percentage of the achieved heart rate from the maximum heart rate (EX2) was calculated. The cycle ergometer test was performed on 2 separate days to examine the reproducibility of the test results. The data of the 2 measurements were averaged to calculate the exercise tolerance test results.

#### Results

The maximum heart rate achieved by the subjects during the exercise test was 183 bpm (mean ± SD: 65.9 ± 11.5). The average value of the percentage of the achieved heart rate from the maximum heart rate (EX2) was calculated to be 69.9%. The reproducibility of the results was high with a coefficient of variation (CV) of 6.5%.

### Table: Comparison of Characteristics between Diabetic Subjects and Healthy Controls

<table>
<thead>
<tr>
<th></th>
<th>Diabetic subjects (n=8)</th>
<th>Healthy controls (n=8)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong> (years)</td>
<td>59.8 ± 8.3</td>
<td>54.0 ± 4.6</td>
<td>N.S.</td>
</tr>
<tr>
<td><strong>Height</strong> (cm)</td>
<td>168.4 ± 6.8</td>
<td>169.1 ± 9.0</td>
<td>N.S.</td>
</tr>
<tr>
<td><strong>Weight</strong> (kg)</td>
<td>67.8 ± 10.8</td>
<td>67.1 ± 8.2</td>
<td>N.S.</td>
</tr>
<tr>
<td><strong>Body mass index</strong> (kg/m²)</td>
<td>23.8 ± 3.3</td>
<td>23.4 ± 2.5</td>
<td>N.S.</td>
</tr>
<tr>
<td><strong>Blood sugar</strong> (mg/dl)</td>
<td>181.1 ± 40.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>HbA1c</strong> (%)</td>
<td>7.8 ± 1.9</td>
<td></td>
<td></td>
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<tr>
<td><strong>Duration of diabetes</strong></td>
<td>6.6 ± 9.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: N.S. = Not Significant
2. Calculation of time constants (\(\tau_{\text{VO}_2}\), \(\tau_{\text{HR}}\))

\(\tau_{\text{HR}}\) and \(\tau_{\text{VO}_2}\) represent the time constants of heart rate and oxygen consumption, respectively, which are related to the recovery patterns of these physiological indices. In this study, the time constants were calculated using a computer program written in MATLAB. The formula for calculating the time constants was given by:

\[
\tau = \frac{-1}{\ln(2)} \times \frac{1}{k}
\]

where \(k\) is the rate constant obtained from the slope of the asymptotic line on a semi-logarithmic plot. The rate constants were obtained from the slopes of the linear regression lines of the \(\text{VO}_2\) and HR vs. time plots during the recovery phase. The time constants were then calculated using the above equation.

3. Statistical processing

The statistical processing was performed using the software package SPSS (version 22). The data were analyzed using the Student’s t-test for independent samples. The significance level was set at \(p < 0.05\). The results are presented as the mean ± standard deviation. The correlation coefficients were calculated using the Pearson’s correlation coefficient.

<table>
<thead>
<tr>
<th>Diabetic subjects (n=8)</th>
<th>Healthy controls (n=8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\tau_{\text{HR}}) (sec.)</td>
<td>69.5 ± 2.2</td>
</tr>
<tr>
<td>(\tau_{\text{VO}_2}) (sec.)</td>
<td>80.9 ± 5.3</td>
</tr>
</tbody>
</table>

*: Significant difference from the healthy control group (\(p < 0.05\)).
糖尿病患者と健常者における□□間隔変動係数は
運動中の循環応答を反映するか？

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キーワード（△△△△△△）1．糖尿病 2．糖尿病性神経症 3．心循環反応

糖尿病患者と健常者の□□間隔変動係数（△△△）と運動時における循環応答との関連を検討した。対
象は2型糖尿病患者8名と、年齢をマッチさせた健常男性8名とした。対象者に自転車エルゴメータ
を用いた漸増負荷を行い、最大酸素摂取量（△△△△）と換気性作業関値（△△）を算出した。次に日を改
めて、△△% △△に相当する負荷強度で一定負荷運動を行わせた。その後、安静時における△△△と、一定
負荷運動における酸素摂取と心拍数の時定数を算出した。その結果、1）△△△と△△△△△は△△群で健
常群と比較して低下していた。また、△△△△△と△△△△△は△△群で延長していた。2）△△△△△と△△△△△
は△△群共に正の相関を、△△△△△と△△△△△は△△群に負の相関を認めた。2）△△△△と△△△△△、△△△△△
と△△△△△は健常群のみ負の相関を認めた。以上の結果から、△△△を運動に対する循環応答を反映する
指標になる可能性が示唆された。また、先行研究において、健常者では運動開始時における循環応答
特性は全身持続力を反映するものであることが示唆されているが、本研究では糖尿病患者においては
関連を認めないことが明らかとなった。