

# 心血管疾患患者に対する,リアルタイム心拍変動解析による 運動強度調節方法の妥当性の検討

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## Exercise Support Program Using Real-time Assessment of Heart Rate Variability

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### ABSTRACT

**Introduction:** The current exercise prescription, defined by a cardiopulmonary test (CPX) for patients with cardiovascular disease, makes it difficult to offer an appropriate aerobic exercise in accordance with the patients' daily conditions. Heart rate variability (HRV) is the beat-to-beat alterations in heart rate, which reflects the cardiac autonomic nervous activity. Therefore, we examined whether real-time analysis of HRV makes it possible to determine the ventilatory threshold during cardiac rehabilitation sessions.

**Methods:** A total of 25 patients ( $66 \pm 8$  y/o, 22 males) with heart failure who underwent cardiac rehabilitation on a bicycle ergometer for 25 minutes were enrolled. The oxygen uptake ( $\text{VO}_2$ ) and high-frequency component (HF) quantified by the power spectral analysis of HRV reflecting the parasympathetic nervous tone, were continuously measured during the rehabilitation session. The workload was adjusted every 2 minutes so that the HF power was kept between 5 and 10. All the patients had undergone a CPX session within a week before their ventilatory threshold (VT) - $\text{VO}_2$  determination and had the exercise intensity prescribed. We compared the  $\text{VO}_2$  during the rehabilitation session (re- $\text{VO}_2$ ) to the VT- $\text{VO}_2$  determined by the CPX.

**Results:** The re-VO<sub>2</sub> reached to 95.3 ± 12.0% (13th minute after the initiation of the exercise session) , 100.7 ± 17.3% (17th min) , 101.5 ± 18.0% (21th min) , and 97.7 ± 18.3% (25th min) of the level of VT-VO<sub>2</sub> in the second half of the exercise. The mean differences between the re-VO<sub>2</sub> and the VT-VO<sub>2</sub> were not statistically significant at any time point.

**Conclusions:** Real-time assessment of the HRV during rehabilitation could offer exercise intensity of the ventilator threshold in accordance with the condition of patients with cardiovascular diseases.

## 要 旨

度の運動が可能であった.

【目的】心肺運動負荷試験 (CPX) を用いて決定する運動処方では、日々変化する状態に則した換気性代謝閾値の運動は困難だった。以前、運動中の心拍変動 (HRV) 分析により換気性代謝閾値 (VT) を検出することができることを報告した。今回、HRV のリアルタイム分析により心臓リハビリテーション中の嫌気性代謝閾値での運動強度を決定することが可能か検討した。

【方法】25人の心血管疾患患者 (66 ± 8歳, 男性22人) を登録した。換気性代謝閾値の酸素摂取量 (VT-VO<sub>2</sub>) を決定するために、全ての患者で1週間以内にCPXを実施した。リハビリテーション中、VO<sub>2</sub>と心拍変動の高周波成分 (HF) を連続的に測定し、負荷強度はHF (目標のHF: 5 ~ 10) に基づいて決定した。リハビリテーション中のVO<sub>2</sub>とVT-VO<sub>2</sub>を比較し、その類似性の検証にはBlandとAltmanの手法を適用した。

【結果】VT-VO<sub>2</sub>に対するリハビリテーション中のVO<sub>2</sub>は95.3 ± 12.0% (運動開始後13分)、100.7 ± 17.3% (17分)、101.5 ± 18.0% (21分)、97.7 ± 18.3% (25分)であり、リハビリテーション中のVO<sub>2</sub>とVT-VO<sub>2</sub>の一致率は高く、両者の間に有意差を認めなかった (P > 0.05)。

【結論】HRVのリアルタイム評価により心血管疾患患者の状態に応じた換気性代謝閾値の運動強