

Time-Course Response of the Normalized Reflection Wave Rate Index to Active Standing

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Aims: This study aimed to introduce a new method for evaluating arterial reflection waves using an index derived from the product of the reflection index (RI) and the modified stiffness index (MSI), without height normalization. This index measures the reflection wave rate (NRRI) by dividing its normalized amplitude by its timing. We hypothesized that the time-course response of NRRI depends on simultaneous fluctuations in arterial pressure (AP) and heart rate (HR) induced by active standing (AS).

Methods: To test this supposition, we extracted the following features from the AP signal (APF) recorded in 23 healthy volunteers performing AS: systolic (SP), incisura (IP), diastolic peak (DPP), diastolic (DP), and mean (MP) pressures. We then formed time series for systolic-to-diastolic time (SDT), the period from SP to DPP; systolic time (ST), the period from DP to IP; RI (DPP/SP); MSI (1/SDT); and NRRI (RI*MSI, or (DPP/SP)/SDT).

Results: NRRI showed a time-course response across the AS phases, indicated by MP time-course changes, of: fall, fast increment, slow increment to the end, and recovery (Table). This response depended on: a) sustained shortening of SDT in most phases (Table), which showed a strong correlation with ST ($r=0.89\pm0.06$) and a weak correlation with HR ($r=0.41\pm0.28$); b) greater change in SP than in DPP during the fall and fast increment phases, and greater change in DPP than SP during the slow increment and recovery phases (Table). The correlation of DPP/SP with APF ranged from 0.59 ± 0.14 to 0.87 ± 0.05 .

Conclusions: These findings support that the dynamic fluctuations of NRRI are driven by simultaneous SDT and DPP/SP variations, which in turn depend on APF and HR changes provoked by AS, and suggest that the use of NRRI in clinical and physiological settings could extend the functional characterization of the left ventricular-arterial interaction by assessing its rate of change.

Table. Mean $\pm$ SD of NRRI, DPP/SP, and SDT in the AS phases. N=23.

	Control	Fall	Fast rise	Slow rise	Recovery
NRRI (s^{-1})	120.8 $\pm$ 21.7	29.2 $\pm$ 20.0*	129.9 $\pm$ 21.5*	157.0 $\pm$ 22.8*	90.9 $\pm$ 15.1*
DPP/SP (%)	38.4 $\pm$ 7.0	10.7 $\pm$ 7.0*	34.8 $\pm$ 5.5*	42.5 $\pm$ 6.7*	26.4 $\pm$ 4.2*
SDT (s)	0.32 $\pm$ 0.01	0.32 $\pm$ 0.02	0.27 $\pm$ 0.01*	0.26 $\pm$ 0.01*	0.29 $\pm$ 0.01*

* $p<0.02$ vs. control