EDITORIAL

Reference values of heart rate variability

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We read the contribution by Sammito and Böckelmann [1] with dismay. The article not only describes a problematic study but also reports inconsistent numerical values. The authors analyzed 24-hour ECG Holter recordings of 695 apparently healthy subjects and reported normative heart rate variability (HRV) values summarized by age and sex.

The major problem is the substantial difference between the small SDNN and the much larger SDANN values. This contradicts previous publications [2–5] and, as we understand, resulted from a methodologic error. The authors admittedly removed the heart rate trend over the 24 hours (by "smoothness priors" detrending). This erroneously reduced reported SDNN values, which only reflect short-term variability with ranges consistent with those typically obtained by averaging 5-minute values.[6,7] Also, trend removal completely suppressed and ignored day–night variability, although day–night differences are a major, if not the major, contributor to 24-hour SDNN. On the contrary, reported SDANN values include complete 24-hour variability.

Because SDNN reflects the total 24-hour NN interval variance whereas SDANN relates to the variance below the 0.0033-Hz spectral frequency (i.e., ultralow frequency [ULF] spectral components),[6] it is mathematically impossible to have SDNN values this much smaller than SDANN values. Unfortunately, neither the authors nor the Journal reviewers noticed this numerical impossibility.

We also note the heterogeneity of the investigated population. HRV, as well known, quantifies cardiac period responses to autonomic changes.[6] In healthy subjects, these mainly reflect environment challenges and sleep. Hence, healthy 24-hour HRV significantly depends on activity. Mixing HRV data of subjects with obviously different daily activities is inappropriate and leads to values that are of little use as age- and sex-based norms. The authors clearly have a valuable data source in their Holter recordings, but the 24-hour HRV values need to be considered in terms not only of age and sex but also of the level of daily physical and mental activity.

Sammito and Böckelmann also reported spectral HRV analyses inconsistent with their stated aims. Indeed, while stating that they "identified reference values for commonly used HRV measures for 24-hour ECG measurements," they used a nonparametric Welch spectral analysis with a fast Fourier transformation (FFT) width of 256 seconds. Thus, the reported values relate to averages over little less than 5 minutes and do not reflect 24-hour spectral analysis. As reported in the Task Force standards [6] and as more recently discussed in more detail,[8] other parameters have been suggested for 24-hour spectral indices (e.g., α coefficient).

Generally, however, even in stable data analyses,[9] the proportion of low-frequency (LF) and high-frequency (HF) HRV components depends substantially on circumstances. HF power decreases with position changes from supine or sitting/standing. Without controlling the environment, there is little value in reporting 24-hour averages of LF and HF power proportions. In uncontrolled long-term situations, LF/HF averaged values, even when accurately calculated, have no physiologic or clinical meaning. It might be argued that if similarly diverse populations were resampled with recordings obtained under similarly variable conditions and the same short-term HRV techniques were used, the reported

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LF/HF results would be more or less reproduced. However, that does not make them useful for any physiologic, epidemiologic, or clinical purposes.

We are aware of clinically relevant applications of FFT analyses of 24-hour Holter data.[2,6,10] These were primarily based on very-low-frequency (VLF) and ULF components, which are mainly, although not exclusively, influenced by day–night heart rate differences. VLF and ULF components can only be derived when the FFT is applied to the entire 24-hour data in 1 block. They cannot be estimated in very short segments of 256 seconds with subsequent averages. It could be acceptable to report some spectral data in normalized units, even if a nonparametric method is used, provided they are properly computed. However, much more importantly, reporting these values without the absolute values of LF and HF power is a methodologic mistake.

Returning to the SDNN and SDANN values, repeated reports by different groups showed that cardiac patients are at substantially increased risk if their SDNN is below 50–70 ms.[6,10–14] Regrettably, it did not appear strange to Sammito and Böckelmann that the vast majority of their *normal* subjects were apparently in the very-high-risk category because of the SDNN values.

Although ICD guidelines rely on left ventricular ejection fraction, it is not uncommon for additional factors to be used in borderline situations or when resources are limited. Autonomic indices belong to the most powerful of such factors. Of these, SDNN is the most frequently used 24-hour HRV index. Patients with true 24-hour SDNN values around 30–50 ms are at very high risk for fatal complications. Thus, it is unfortunate that **Heart**Rhythm accepted a publication that may endanger patients' lives. Regretfully, we are therefore of the unanimous opinion that the article by Sammito and Böckelmann should be revoked and withdrawn.

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