Incorporation of heart rate variability into police tactical group small unit tactics selection

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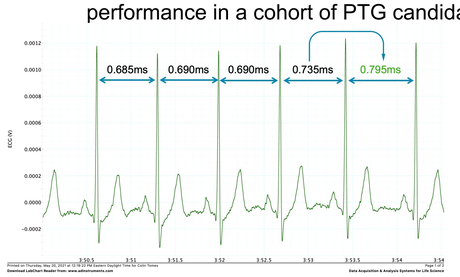
Background & Purpose

- Law enforcement is known to be a physically, mentally, and emotionally demanding profession (Andrew et. al., 2017)
  - Police Tactical Group (PTG) personnel are subject to additional demands that may include search and rescue, counterterrorism, explosive ordnance disposal, and active shooter response (Robinson, et. al., 2022)
- For these reasons, selection for PTG service is physically and technically challenging (Maupin et. al., 2017)
  - Individuals must be assessed holistically
- Heart Rate Variability (HRV) may provide quantitative measures of holistic stress and load, providing unit leadership additional information on candidate suitability (Shaffer et. al., 2017)
  - Therefore, The purpose of this study was to measure HRV relative to performance in a cohort of PTG candidates



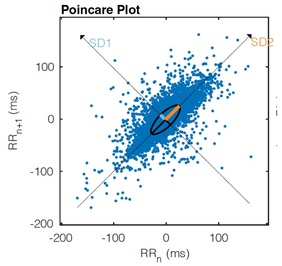


Figure 1 (Above Left). Example ECG with a pRR50 interval identified.
Figure 2 (Above Right). Example Poincaré Plot identifying nonlinear HRV (SD1 & SD2)

Methods

- This study was a prospective cross-sectional study of three male PTG candidates (n = 3)
- 3-lead seated ECGs were recorded for 5 hours during the training session, between 13:00 and 18:00.
  - Participants were supplied with body worn Equivital™ EQ02+LifeMonitor (ADInstruments, Sydney, Australia)
- Participants were introduced to a room clearance training structure comprised of residential and commercial specification rooms and hallways.
- Scaled room clearance training scenarios were performed (Figure 3)
  - Role players engaged candidates as active shooters.
  - Duration of the selection events ranged from seconds to clear a single room to several minutes for multiple room clearances.
  - Participants were assessed on movement technique, tactical proficiency and transition from primary to second weapons (Figure 4).
  - Verbal and non-verbal communication was also assessed, as was safety and overall outcome of each scenario.
- HRV (Table 1) was analysed via the following metrics:
  - Heart rate descriptives were also explored: min heart rate, max heart rate, and mean heart rate during the recording window.
  - Frequency-domain HRV: natural log (Ln) High, Low, and Very Low
  - Root-mean square of successive RR differences (RMSSD)
  - Percentage of adjacent R to R wave (RR) ECG intervals varying by at least 50ms (pRR50)
  - Nonlinear short-term (SD1) and long-term (SD2) variability

Methods

- Statistical analysis consisted of maximum, minimum, and mean for each HRV measure and visual box plot analysis (Figs. 5-9)

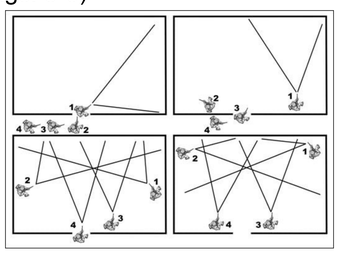
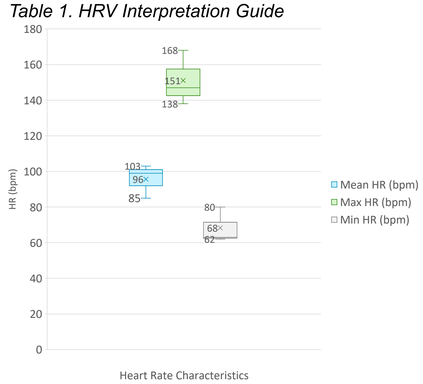


Figure 3 (Above Left). Room clearance training in a dedicated training structure (US Army).
Figure 4 (Above Right). Four-person room clearance procedure schematic (US Army).

Metric	Units	Definition	Application	Interpretation
RMSSD	ms	Root-mean square of successive differences	Primary measurement for short term PNS assessment	Values generally increase with cardiovascular fitness
pRR50	%	Percentage of adjacent intervals that differ by more than 50ms	Accepted cardiovascular disease risk assessment in epidemiological literature	Decreasing trends in time-domain components over repeated measurements may indicate failure to adapt or overstress
SD1	ms	Standard deviation with the respect to the y-axis on Poincare plot	Nonlinear short term detrended assessment	Surrogate for time-domain measures when recordings contain noise or other flaws
SD2	ms	Standard deviation with respect to the x-axis on Poincare plot	Nonlinear long term detrended assessment	Surrogate for LF power when recordings contain noise or other flaws

Table 1. HRV Interpretation Guide



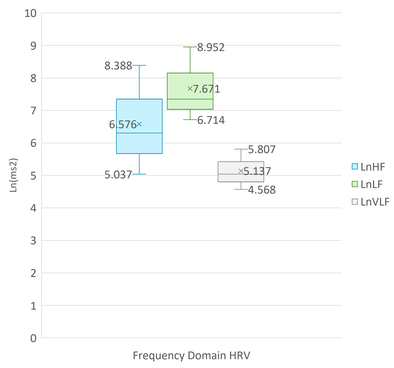
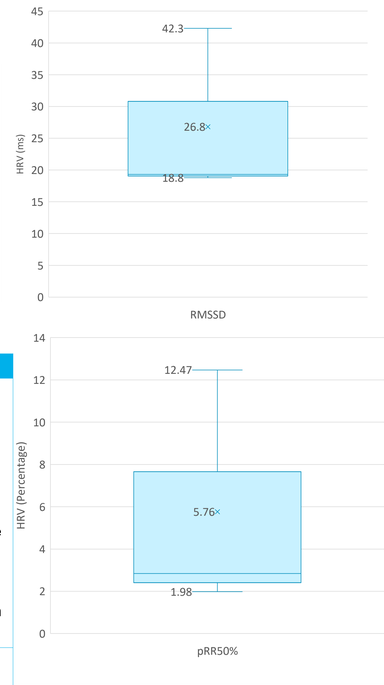


Figure 5 (Above Left). Heart Rate Characteristics, with max, min, and mean values
Figure 6 (Above Right). Ln Frequency Domain HRV, with max, min, and mean values

Results

- All three candidates successfully completed the selection procedures
  - Only one participant was approved to progress beyond this stage of selection
- Data from that participant appeared to consistently skew results
  - Maximum values for mean RRI, RMSSD, pRR50, SD1, and SD2 were all derived from a single participant.
  - That same participant also held the lowest maximum heart rate and lowest mean heart rate.

Results



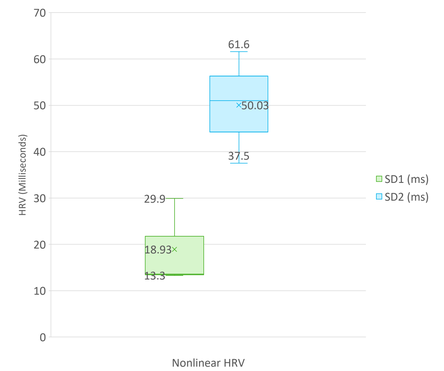


Figure 7 (Above left). RMSSD HRV, with max, min, and mean values
Figure 8 (Above Right). Nonlinear HRV, with max, min, and mean values of SD1 and SD2
Figure 9 (Below Left). pRR50% HRV, with max, min, and mean values

Discussion

- The maximum pRR50 value was above the 6.25% threshold posited as a cardiovascular disease risk indictor (Mietus et. al., 2002).
  - both the mean and minimum were below.
- The levels of agreement between the HRV values observed in this study and previous specialist police candidate studies are also of note.
- Even this tentative finding is of potential interest for determining the presence of excessive stress in the present personnel

Conclusion & Recommendations

- HRV may be a valuable metric for quantifying load holistically in tactical police training
  - The individual with the highest rated performance by the directional staff also demonstrated the most optimal HRV values.
- HRV can be collected and measured in instances where leadership can immediately utilise the data

References

Figure 10. (Right) Reference List QR code
Figure 11 (Left). tru.bond.edu.au