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Intra-individual effect of hydration and exercise on heart rate variability: a single case study

Introduction

Heart rate variability (HRV) is an indirect marker of cardiac autonomic control. Dehydration induces a rise in heart rate (HR) due to lower stroke volume and seems to reduce vagal modulation of HR. Purpose of this study is **to observe HRV responses to hydration status in a single individual in supine and standing positions before and after a submaximal exercise.** This study is part of the WeCare project, aiming to develop a sweat-monitoring sensor for athletes (SNF-Sinergia grant)

Fig.1 Exercise setting with participant equipped with a heart rate monitor and absorbent patches.

Methods

A 22-year-old healthy athlete (173cm, 64.6 kg, maximal oxygen consumption: 67 $mlO_2 \cdot min^{-1} \cdot kg^{-1}$, maximal aerobic power: 400W) completed 32 sessions of 3 consecutive 20-minute exercise bouts on an ergocycle, at 55 % of his maximal aerobic power, in a lab with temperature- and humidity-controlled atmosphere (Fig. 1). He performed 16 sessions with water intake (WI) *ad libitum* and 16 with no water intake (NWI). Total % dehydration was calculated with weight difference before and after exercise. Before and after each session, R-R intervals were collected in a quiet environment with a Polar V800 heart rate monitor for 5 minutes supine and 5 minutes standing (Fig. 2A and 2B). Time-domain (mean HR, root mean square successive differences (RMSSD)) and frequency-domain (low frequency power (LF), high frequency power (HF) and total power (TP)) HRV analysis were performed with Kubios Premium 3.4.0. Graphpad Prism 8.3.0 was used for statistical analysis.

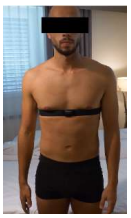

Fig.2 A and B Heart rate variability measurement settings in supine and standing positions.

Results

In supine position, LF increased after WI sessions whereas HR increased after NWI sessions ($p = 0.033$ and 0.048, respectively). In standing position, HR increased after WI sessions ($p = 0.008$). After NWI sessions, RMSSD and HF were reduced ($p = 0.013$ and <0.0001, respectively) with HR increasing ($p = <0.0001$). Table 1 presents overall results. HR and RMSSD supine differences and HR, RMSSD and HF standing differences were significantly higher after NWI sessions. HR differences are presented in Fig. 3A and 3B. In both positions, HR (Fig. 4) and RMSSD differences before and after exercise significantly correlated with level of dehydration.

		WI			NWI			
		PRE	POST	p-value	PRE	POST	p-value	Comparison of differences p-value
Supine	HR (bpm)	70.7 ± 3.5	70.2 ± 3.1	0.603	70.7 ± 4.9	73.4 ± 4.2	**0.048**	**0.044**
	RMSSD (ms)	29.5 ± 8.8	31.4 ± 7.7	0.147	34.8 ± 13.5	28.6 ± 9.3	0.226	**0.042**
	LF (ms^2)	520.4 ± 934.4	757 ± 791.1	**0.033**	1349 ± 1965	794 ± 583.5	0.934	0.423
	HF (ms^2)	666.3 ± 408.5	754.3 ± 502.6	0.298	731.8 ± 518.5	576.2 ± 525.6	0.175	0.24
	TP (ms^2)	1655 ± 1028	2030 ± 899.5	0.144	2513 ± 2205	1764 ± 805.5	0.528	0.107
Standing	HR (bpm)	79.6 ± 5.6	83.4 ± 3.7	**0.008**	78.2 ± 5.2	89.4 ± 6.2	**<0.0001**	**0.0004**
	RMSSD (ms)	21.3 ± 6.2	23 ± 5.8	0.235	23.3 ± 8.6	18.1 ± 6.3	**0.013**	**0.01**
	LF (ms^2)	927.1 ± 724.7	1429 ± 1013	0.056	986.2 ± 1147	1092 ± 630.7	0.159	0.423
	HF (ms^2)	301.5 ± 197.8	283.7 ± 149.2	0.72	349.6 ± 227.4	160.5 ± 116.3	**<0.0001**	**0.001**
	TP (ms^2)	1546 ± 1004	2019 ± 1090	0.083	1747 ± 1431	1482 ± 869.3	0.72	0.078

Table 1. Pre-/post- exercise comparisons in time- and frequency-domain HRV variables in WI and NWI conditions with comparison of differences between conditions. Comparisons in each conditions were calculated with paired t-test or Wilcoxon matched-pairs signed rank test depending on data distribution. Comparison of the differences was calculated with unpaired t-test or Mann Whitney test depending on data distribution. WI, water intake; NWI, no water intake; HR, heart rate; RMSSD, root mean square successive differences; LF, low frequency power; HF, high frequency power; TP, total power.

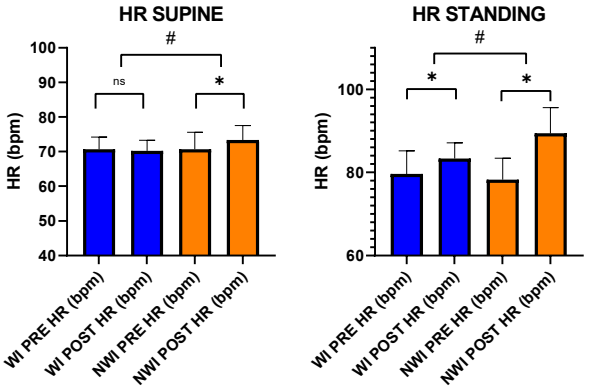

Fig.3 A and B Differences in HR Pre- and post-exercise in WI and NWI conditions. *, significant difference pre-/post- exercise. #, significant difference of differences.

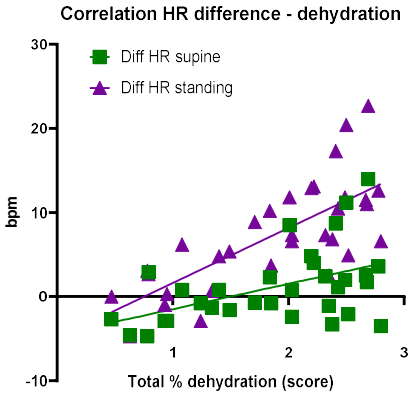

Fig.4 A and B Correlations between total dehydration in % of bodyweight and HR differences pre-/post- exercise. Correlations were significant for both positions ($r = 0.48$, $p = 0.006$ and $r = 0.73$, $p = <0.0001$ for supine and standing respectively).

Discussion: In this single individual, a 3x20-minute submaximal exercise bout induced little change in HRV when he could hydrate *ad libitum*. When no water intake was allowed, HRV decreased, especially in standing position, where parasympathetic-related variables were reduced. Carter and al. described a reduction in HRV with hypohydration but with higher HF. However, no information on position measurement is available (1). Another study supports a decreased vagal activity with dehydration (2). HR is closely linked to hydration status and our results confirm that the more dehydrated, the higher the cardiac drift, which is mainly due to stroke volume reduction (3).

Conclusion: HRV interpretation must take into account hydration status.

References
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2. Castro Sepúlveda, M. C. K., and al. (2015) *Nutricion Hospitalaria*
3. Achten, J. and Jeukendrup, A.E. (2012) *Sports Med*

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