A Nonlinear Analysis of HR during an alpin ski experience and a day at work

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In this preliminary work we compare the deterministic pattern of period between consecutive heartbeat (RR interval) during physical activity (alpine ski) daily work. The RR interval is obtained from heart rate (HR) (beats/min) recorded beat by beat (beats/min: 60 000/RR interval in ms) by using a Garmin sportwatch (Fenix 5X Plus). Data are recorded every 2 sec. Recently, new dynamic methods of HRV quantification have been used to uncover nonlinear fluctuations in HR, that are not otherwise apparent. The basically stochastic nature of heart rate dynamics, probably reflecting the continuous adjustments to an unpredictable internal environment, well suit for recurrence quantification analysis (RQA). The estimating coupling directions in the cardio-respiratory system using recurrence properties was implemented by Marwan et al. [3], moreover the heart rate variability (HRV) is considered an adequate tool for evaluating human emotions [4]. Here we collected, from a single subject, RR time series for several hours, under different days and under two different types of activity: a typical working day and during continuous physical activity (i.e. alpine ski). The subject although is not a professional athlete, is in a good physical conditions and is a good skier. Consequently, common statistical descriptors do not allow to discriminate between the two different activity (work and alpine ski) FIG. 1. This is further confirmed by the Garmin Stress Index (GSI) higher during working days (GSI=28) than during physical activity (GSI=23). To overcome this isse, i.e in the attempt of discriminating activities, we have studied different patterns of Recurrence Plot (RP) and the change of percent of determinism in RR interval time series of about 4000 s. The unthreshold recurrence plot of RR interval for a working day and three ski activities, (by VRA, E. Kononov) is reported in Fig1-a-b-c. Input parameter are: emb=7; radius=50; line=4 (RQA software by C.L. Webber and J.Zbilut) [6]. Altitude (m), velocity (m/s) and GPS coordinates are available to study correlation with position and activities of the subject. Clear differences can be observed in the unthreshold recurrence plot of RR from the different activities, confirming the soundness of the proposed approach. Although further analysis on a larger number of subjects and for different activities are needed to confirm our results, our data demonstrate the possibility of discriminate between stress and fatigue during physical activity by using mobile and wearable devices, with relevant implication in the personalization of professional training approaches.

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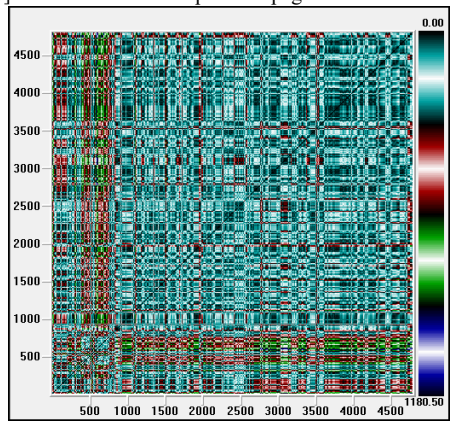

Figure 1. Unthreshold Recurrence plot of RR in a day at work (Rec=23.51%, Det=87.712%)

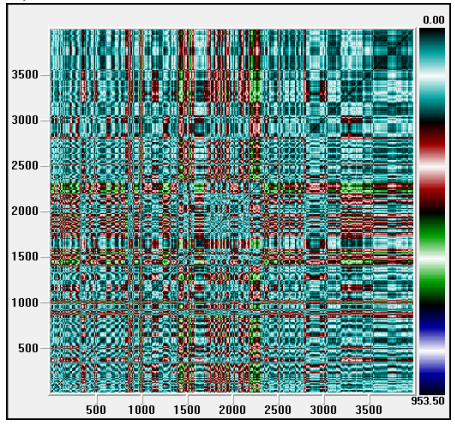

Figure 2. Unthreshold Recurrence plot of RR in the third day of holiday, during skiing experience (Rec=28.35%, Det=94.79%)

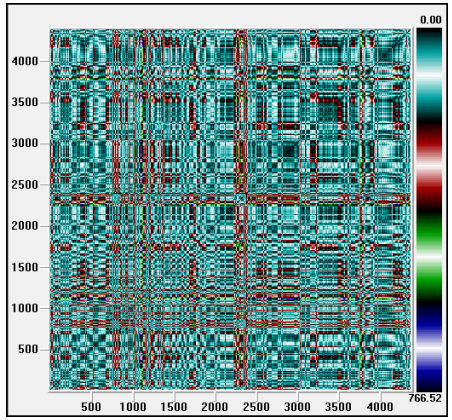

Figure 3. Unthreshold Recurrence plot of RR in the fourth day of holiday, during skiig experience (Rec=30.10%, Det=94.89%)

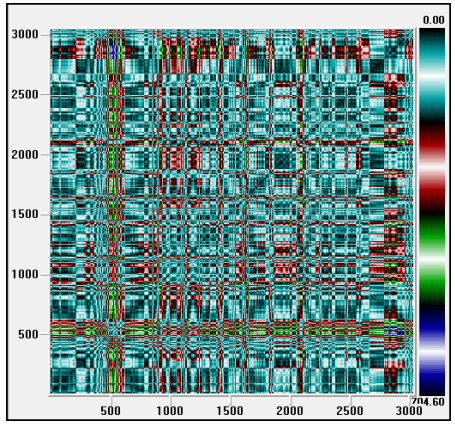

Figure 4. Unthreshold Recurrence plot of RR in the fifth day of holiday, during skiig experience (Rec=29.952%, Det=94.92%)