Heart rate variability analysis of pre and post awakening of 10 years children

Taher A. Biala[1,2], Syamil Muhammad [2], Fernando S. Schlindwein[2] , Michael Wailoo[3] ,
[1]Higher Institute of Medical Technology, Misrata, Libya
[2]University of Leicester, Biomedical Group, Engineering Department, UK
[3]University of Leicester, Health Science Department. UK

Abstract

The main objective of the work described in this paper is to develop an algorithm to detect the start and the end of sleep stage of 10 year old children and to compute the frequency domain heart rate variability (HRV) measure before and after wake up. These measures are low frequency (LF), high frequency (HF) and the ratio of LF/HF (LF/HF). These measures are used to compare between normal and intrauterine growth restricted children (IUGR) at the age of 10 (IUGR are believed to be more prone to heart diseases in adulthood). Another comparison in this work is between boys and girls. The one hour analysis before and after wake up showed that IUGR children have higher frequency domain measures before and after wake up. Girls showed significantly higher values of LF/HF ratio than the boys. These significant differences between IUGR and normal might suggest underdevelopment or deficiency in the autonomic nervous system in IUGR and in girls at 10 years of age. .

1. Introduction

Coronary heart diseases are one the major causes of death in the world. Studies by Barker [1], showed that intrauterine growth retarded children (IUGR) are prone to coronary heart diseases and hypertension in their adulthood. Reduced HRV is known to be associated with increased risk of cardiac mortality in adults [2]. HRV is defined as the variation over time of the interval between consecutive heart beats, and it is predominantly dependent on the extrinsic regulation of the heart rate. HRV reflects the ability of the heart to respond to external stimuli and can be used to assess the overall cardiac health and the state of the autonomic nervous system (ANS), which is responsible for balancing cardiac activity [3]. Heart rate is controlled by the sympathetic and the parasympathetic branches of the ANS, the parasympathetic (vagal) branch causes the heart to slow down by means of releasing acetylcholine, while the sympathetic nerves cause the heart to beat faster through the release of noradrenalin [4]. The alterations in the ANS function reflected by reduced HRV are known to be associated with increased risk of cardiovascular mortality.

It is well known in clinical practice and research that sudden cardiac death (SCD) has high occurrence around the wake up time. There is much interest in finding indicators which could help stratify a person's risk for SCD at a young age. This work analyses the heart rate variability (HRV) during one hour pre- and post-awakening from intra-uterine growth restricted (IUGR) children against healthy children.

In this work the frequency domain HRV indices is computed before and after awaking and compared between normal and IUGR children. The pre and post awaking periods of males and females were computed and compared. The pre and post awakening periods were compared between IUGR and normal children to see if there are any significant differences between the two groups.

2. Methods

The RR sequence of a unique set of data was tested. IUGR children represents 44 of the cohort and 31 are normal. The analysis consists of detecting the start of the day and night by specifying an RR threshold. When the threshold value is reached the algorithm marks the start of the day and night.

The RR signal was subjected to cubic spline interpolation to produce a uniformly sampled time series and fast Fourier transform was computed for every 5 min segment along the 1 hour before and 1 hour after awakening. Welch method was used to calculate low frequency, high frequency, and low over high frequency components of the signal. The results of all frequency domain indices were calculated for the 75 children and a non-parametric one way ANOVA was used to compare between the two groups of children and between boys and girls.

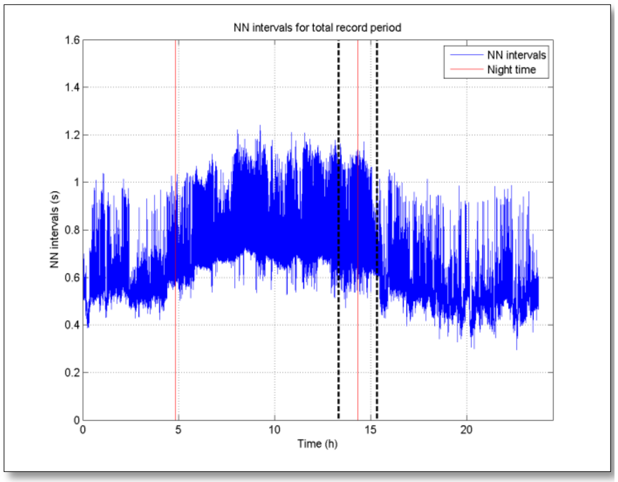

Figure 1: 24 hr RR signal of one child.

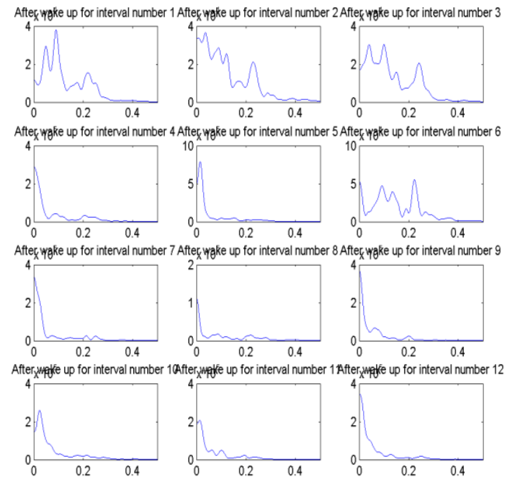

Figure 3: FFT of 1 hour after wake up segmented into 5 min intervals.

3. Results

A self-developed algorithm was used and implemented to measure the start and finish of sleep time for every subject. One hour before and after awakening was selected to calculate the FFT of 5 min intervals. The frequency domain HRV measures, (LF=0.04-0.15 Hz, HF=0.15-0.4 Hz and LF/HF) [4] for one hour duration were calculated for all the children and then normal, IUGR and gender results were compared.

Figure 2 shows FFT of one hour before awakening segmented to twelve 5 min intervals.

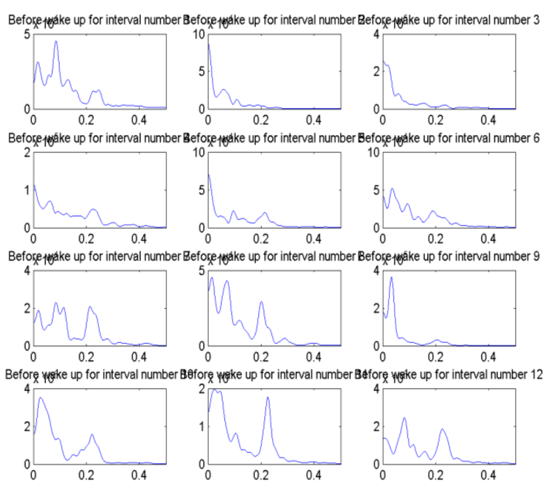

Figure 2: FFT of one hour before wake up segmented into 5 min intervals.

4. Statistical analysis

A non-parametric one way ANOVA statistical test was used to compare between IUGR and normal subjects before and after wake up. The test shows that there is significant difference in LF between normal and IUGR before and after wake up. LF is a marker of sympathetic activity of the ANS. This means that IUGR children have less LF before wake up and after wake up. Figure 4 shows the LF assessment of normal and IUGR children.

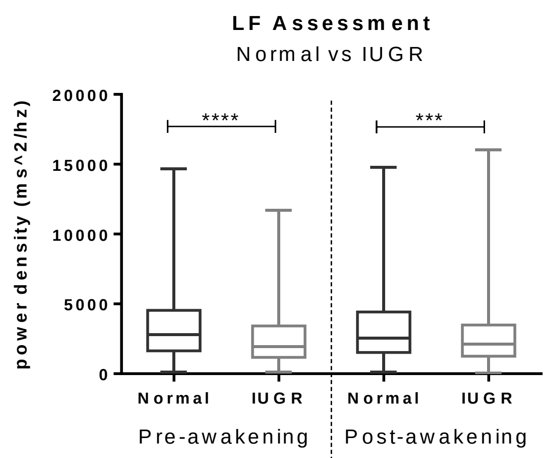

Figure 4: LF assessment before and after wake up.

When comparing the HF, the test shows that there is significant difference in HF between normal and IUGR before and after wake up. HF is a contributor of the parasympathetic (vagal) activity. This means that IUGR children have less HF before wake up and after wake up. Figure 5 shows the HF assessment of normal and IUGR children.

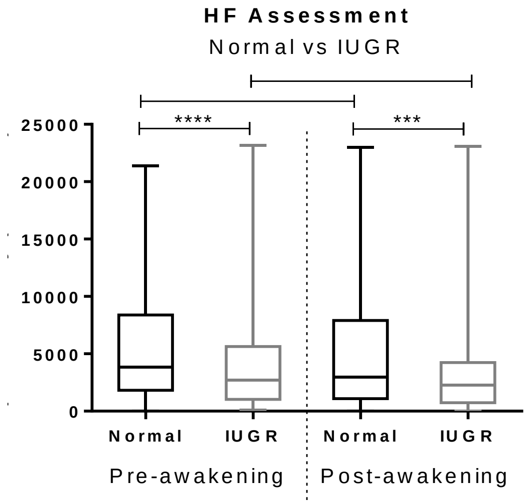

Figure 5: HF assessment of normal and IUGR children.

LF/HF reflects the balance between the sympathetic and vagal activity and higher values of LF/HF ratio were found to be associated with cardiac heart failure (CHF) [5]. The statistical test shows that there is significant difference in LFHF between normal and IUGR after wake up. This means that IUGR children have higher LFHF before and after wake up. Figure 6 shows the LFHF assessment of normal and IUGR children.

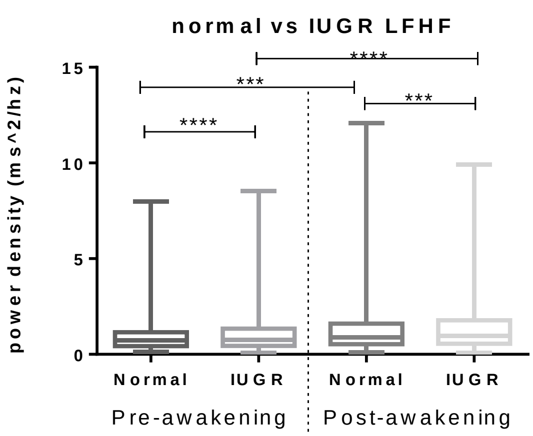

Figure 6: LFHF assessment of normal and IUGR children.

The gender assessment was calculated and LFHF was found for both males and females. Pre and post awakening and statistical analysis in figure 7 shows that there is no significant difference in LFHF between males and females before wake up and there is significant difference after wake up. There was significant difference of LFHF for both male and female comparing before and after wake up and this is due to the increase of the sympathetic activity during day time.

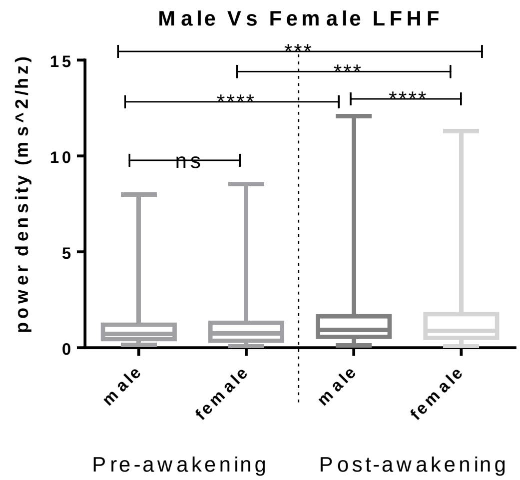

Figure 7: Assessment of LFHF for males and females.

The comparison between 5 min intervals (segments 7-12 before wake up) in LF, HF and LF/HF are shown in table 1. The p value is significant between normal and IUGR before wake up for LF in segments 8, 9 and 11. HF is SD at segment 9. The ratio LFHF is NS at shown segments.

Table 1: The p value of 5 min intervals before wake up

P value	7	8	9	10	11	12
pLF Normal IUGR	0.102	0.050	0.016	0.153	0.065	0.389
pHF Normal IUGR	0.078	0.094	0.048	0.323	0.832	0.382
pLF/HF Normal IUGR	0.114	0.232	0.554	0.363	0.886	0.090

pLF male female	0.038	0.047	0.026	0.011	0.029	0.530
pHF male female	0.131	0.914	0.687	0.649	0.621	0.894

The gender comparison before wake up shows that LF is SD at segment 7 to 11, but the HF is NS during these segments. The previous assessments shown in figures 4 to 7 evaluated the statistical difference between all the segments before and after wake up rather than comparing interval by interval.

5. Conclusions

The developed algorithm was used to compute the start and end of children's sleep stage and to assess the frequency domain measures for normal and IUGR children before and after wake up. In addition gender frequency domain analysis was assessed to find the differences between the males and females before and after wake up. Frequency domain measures for IUGR and normal (LF, HF and LF/HF) were found to be SD before and after wake up. This might suggest that IUGR have less developed ANS. It is well documented in research and clinical that Heart Rate Variability is low in subjects with diabetes and cardiac diseases. Females have higher LF/HF ratio than males. Higher values of LF/HF ratio were found to be associated with cardiac heart failure.

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Address for correspondence.
Taher Ali Biala
Engineering Department,
University of Leicester,
University Road, Leicester,
LE1 7RH, United Kingdom
E-mail: bialco2000@yahoo.com