PROGNOSTIC SIGNIFICANCE OF HRV FOR DIFFERENT AGE GROUPS

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Abstract: Heart Rate Variability (HRV) can be measured with the variation of RR intervals exhibited in a sequence of ECG sample. For a short-term HRV, measuring time is usually defined. However, with numerous possibilities of shortening the measuring time to evaluate the HRV further precision can be exhibited. This paper elucidates on analyzing raw ECG data and then further pre-processing it to obtain a smoothened data to detect mean HRV value .Further the ECG Data subsets of different age groups is taken and analyzed to find out the implications HRV has in patient's lives and as a predictor of mortality. Heart rate variability (HRV) has been a strong predictor of heart failure and its prognostic significance is yet to be explored. The data in the experiment are taken from publically available source physionet.

Index Terms:--HRV, ECG ,Mortality, RR interval, Pre-processing, SDNN , LF ,HF

1. Introduction

Heart rate variability (HRV), are the changes in the beat-to-beat heart rate calculated from the electrocardiogram (ECG), is a key indicator of an individual's cardiovascular condition. HRV assessment has been shown to aid clinical diagnosis and resulting in better prognosis for a person's cardiac status and health.Over the past many years there has been a widespread interest in the study of variations in the beat-to-beat timing of the heart. In normal subjects, a variable heart rate is the normal physiological state. It has been suggested that the healthy heart has a long range 'memory' which prevents it from developing extremes of pace, and that this memory fades away as age or disease develops [1] . A loss of variability is associated with an increased mortality in patients post myocardial infarction [2].Although previously many papers have been published analyzing HRV as a predictor of sudden cardiac death in chronic heart patients [3] and improving the efficiency of HRV while correlating it to the ANS by applying ANN and Different Signal processing methods [4] .For instance , Bigger et al. elucidated the correlation of HRV spectral indices with arrhythmic death and Sudden Cardiac Death in patients suffering from Myocardial Infarction in the MPIP study [5] , which included 715 patients with acute Myocardial Infarction.The measurement of central autonomic activity is usually correlated to the myocardium and its thus denoted by HRV values .It is the equilibrium between sympathetic and parasympathetic activities to the myocardium, moreover , HRV analysis stands as a non invasive method of detecting the autonomic cardiac impairment early [6]. A high HRV indicates a good cardiac adaptability while a lower HRV often indicates an abnormal and insufficient adaptability of the autonomic nervous system and is associated with a high risk of cardiovascular adverse events. [7]. There are studies depicting that HRV assessment can even be extended to a timely diagnosis of impaired autonomic activity status which is linked with increased mortality in patients suffering with Rheumatoid Arthritis.[8] In heart failure, the data on prognostic significance of time-domain HRV indices in prediction of SCD are debatable and controversial as discussed in many publications before in the domain of HRV analysis
[9-12]

This paper focuses on Preprocessing of raw ECG data from publicly available source physionet.org and then creating a mother wavelet to compare the HRV. Further different Age groups have different HRV Analysis. The moment a person enters the 3rd decade of his life span and turns 30 plus, their strength drastically reduces and it is experienced in both the genders mainly predominant in males as compared to females. Autonomic down-regulation appears to play a major role in triggering the reduction in physical capacity. Bodily functions deteriorate with aging. Besides the evident changes in a person's appearances and skin, eyes, ears and hair, autonomic functions also undergoes similar modifications through the aging process .

The two subsystems of the autonomic nervous system (ANS), namely, the sympathetic and parasympathetic branches, work in sync to balance and regulate autonomous functions such as respiration, circulation, metabolism and digestion. In this study, we have focused on expounding age-related changes during the thirties compared with previous decades. This paper elucidates on how a person entering the 3rd decade of his life and his cardiac activity can be correlated to HRV analysis and the mortality factor. The raw signal undergoes pre-processing by the application of various filters then the HRV analysis is done on both the gender subsets with patient data of Age greater than 30.

II . Methodology

Preprocessing of raw ECG Signal includes multiple steps. Mostly real time recording of ECG incurs many errors and noises. In order to increase Signal to Noise ratio and to obtain precise results for prognostic significance, we performed the initial preprocessing by (Step 1) removing power line interference. After removal of power line interference, (Step 2) multi-level wavelet decomposition is performed in which 1-D wavelet analysis is done using a standard mother-wavelet. Then reconstruction of signal branch using 'approximate' coefficient method is done.(Step 3) Baseline wandering is removed using a low pass filter and a moving average filter is applied to remove the glitches in order to obtain a smoothened waveform.(Step 4) Peak Value detection is done and then calculation of R-R interval. (Step 5) HRV Analysis of ECG signal subsets of different age groups, primarily focusing on 30 plus population. Age Related changes in both male and female subset show correlation to SDNN, TP, HF,LF VLF are computed and plotted to display dramatic results. The presented system algorithm is developed completely in MATLAB version 8.1.

A. Pre Processing of the Raw ECG Signals

i) Power Line Interference Removal

Power Line interference is common while real time recording of ECG, As the dataset used is in European data format we have used 50 Hz notch filter to remove any power line interference in the raw ECG data . The response of the filter is shown in Figure 2. The transfer function for the filter is defined by H(z) which is given in the eq. 1. The designed filter structure is direct form II transposed with non linear phase with three numerator and denominator length .

$$H(z) = \frac{0.99553 - 1.89361z - 1 + 0.995532z - 2}{1 - 1.89361z - 1 + 0.9910z - 2} \qquad (1)$$

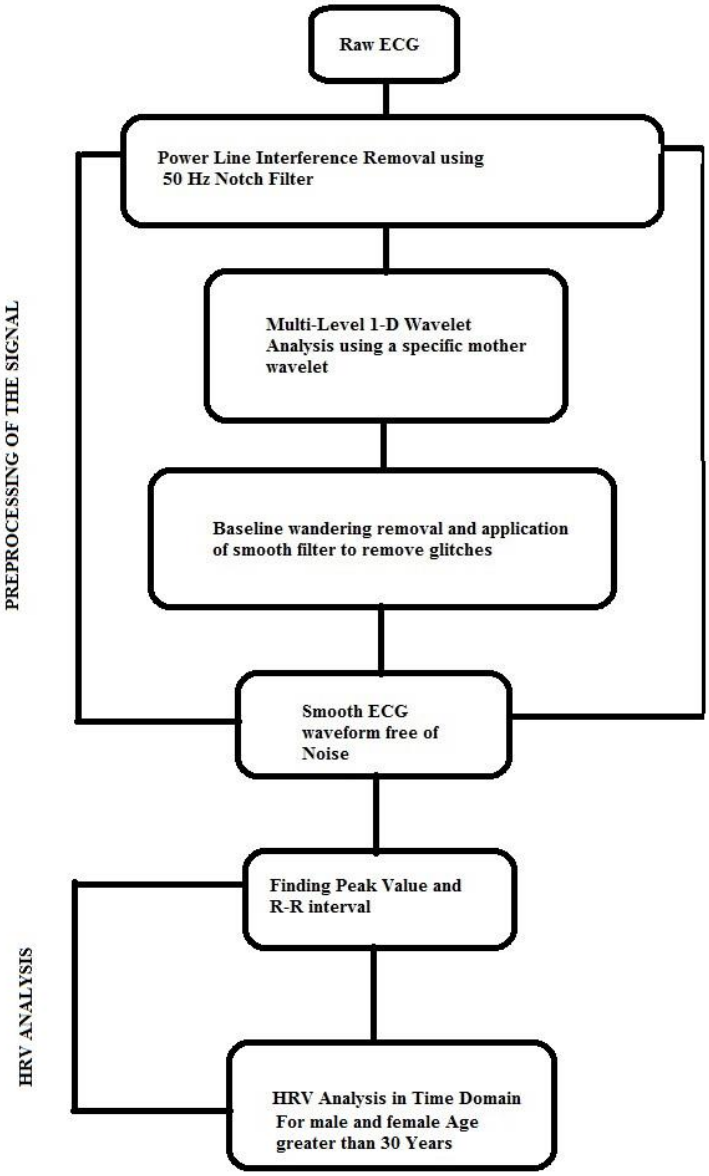


Figure 1: Methodology

(1)

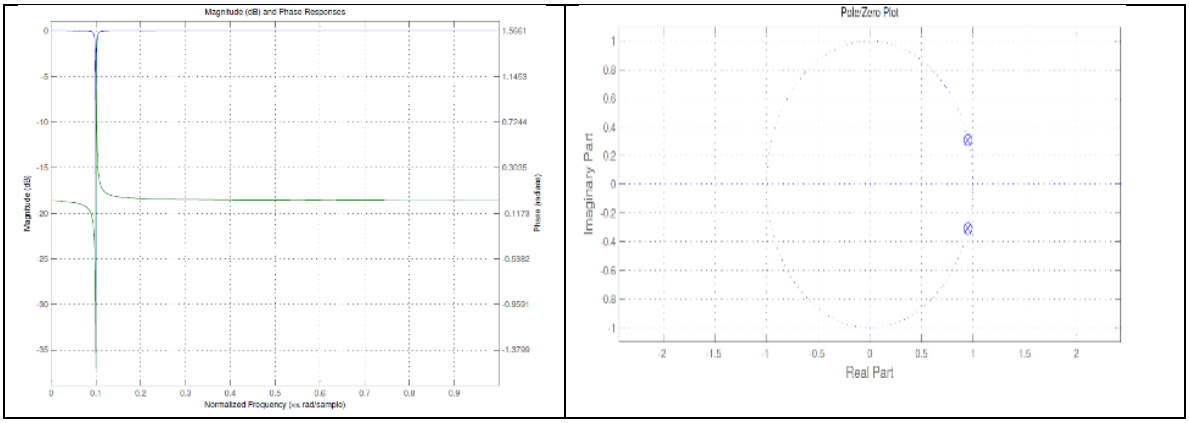


Figure 2: Notch filter response (a) Magnitude and phased delay response(b) Pole –zero plot

ii) Multilevel 1-D wavelet analysis using a mother wavelet and Glitches Removal

` Multilevel one dimensional analysis using a mother wavelet db4 and db6 of debecius family is used , which convolutes the signal with the specified mother wavelet at required frequency as the wavelet is also in the form of filter then the signal is reconstructed using approximate coefficients and then computes the vector of reconstituted coefficients. A low frequency level of reconstruction is used to remove the baseline wandering in the processed ECG signal. After this we have applied a moving average filter to smoothen the waveform, thereby the smooth filter removes any glitches available in the waveform.

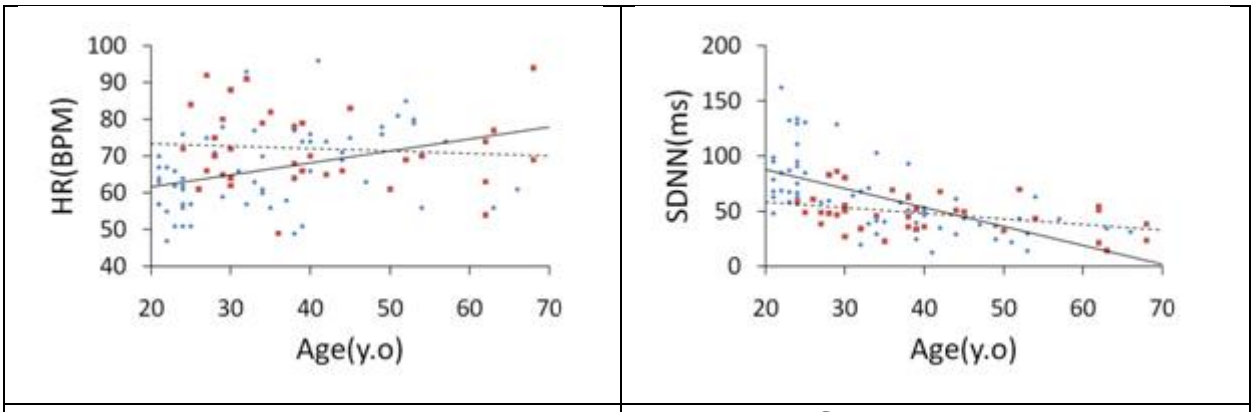
B.Heart Rate Variability Analysis

Analysis of heart rate variability (HRV) includes time and frequency domain measures. Respiratory Sinus Arrhythmias denote heart rate fluctuations which can be estimated by computing Standard deviations of N-N interval (SDNN) derived from time-domain analysis, SDNN emulates the parasympathetic activity [13]. Power spectral analysis of time indices yields frequency domain measurements. Total power (TP), the overall spectral power, is regarded as an index of comprehensive autonomic activity [14]. Additionally, HRV is categorized into three levels of power: high-frequency (HF), low-frequency (LF) and very-low frequency (VLF). As with SDNN, HF denotes components derived from respiratory sinus arrhythmia and is considered to represent vagal control. LF is jointly contributed by sympathetic and vagal nerves and represents the feedback regulation of blood pressure. Currently VLF is utilized solely for the standardization of LF and HF as its physiological significance is much less defined.

III RESULT

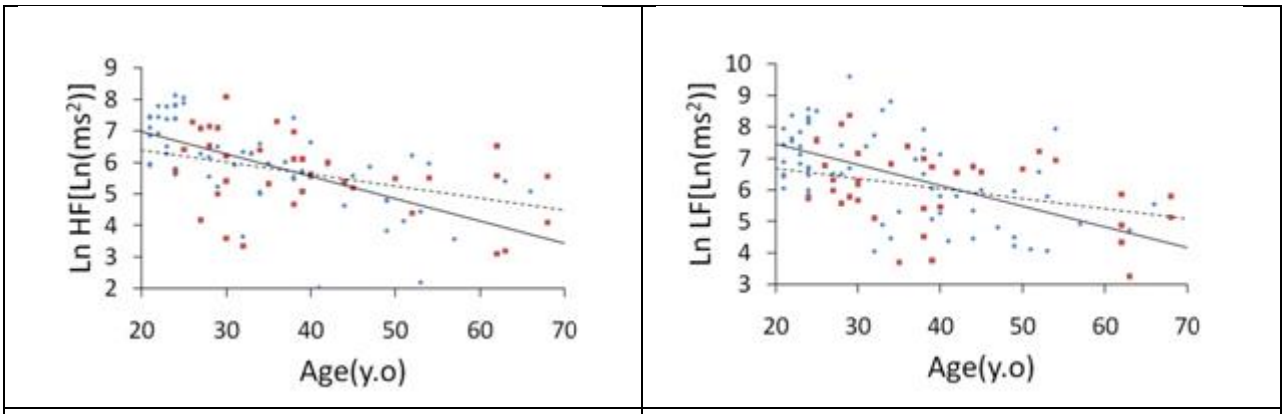
Scatter plot and the analysis are presented for age and hrv parameters are shown in figure3, figure 4,figure 5. Mean HRV parameters according to age and gender is shown in Table 1 and Table 2 respectively. A correlation was seen in heart rate and age for men but not for women. Other than Ln (LF/HF) ratio all parameters have shown negative correlation for age in both male and female. No relation was associated for Ln (LF/HF) ratio and age for both male and female. A very high correlation of (-0.7 <r < -0.5) for age and SDNN,

Ln LF, Ln HF and LN TP was observed. All results indicates that around 44.2% of Ln TP is the closest and the best fit. Negative correlation was also observed for women with (-0,5 r< -0.3), though a lesser degree of predictive accuracy can be observed than men from regression analysis. If slope for regression analysis was observed for each parameters, data associated with men had less steep than that for women, only Ln LF/HF was exception. The parameters declined in greater proportion compared to women with advance in age.



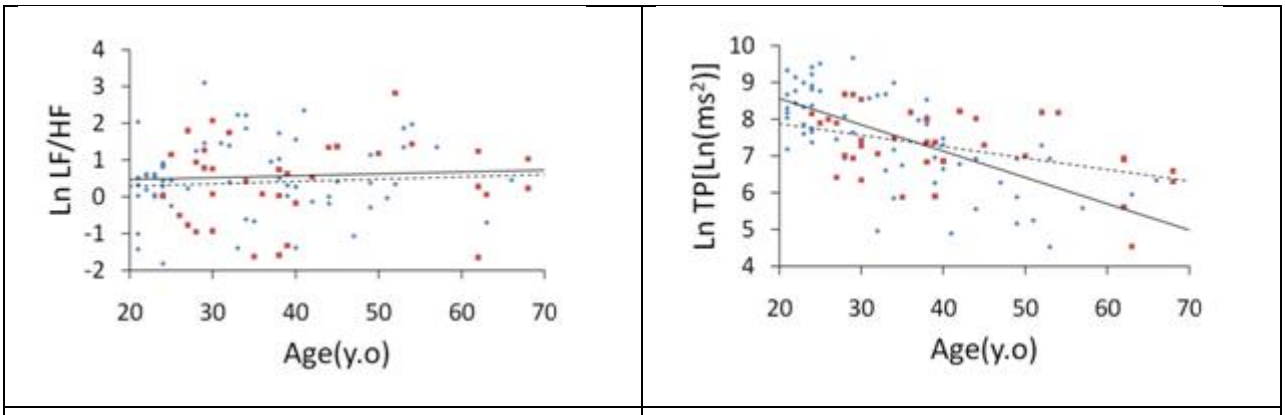
HR parameters	SDNN Parameters

Figure 3 HRV Parameters: HR & SDNN , Red cluster for Female and Blue cluster for Male



HF parameter	LF parameter

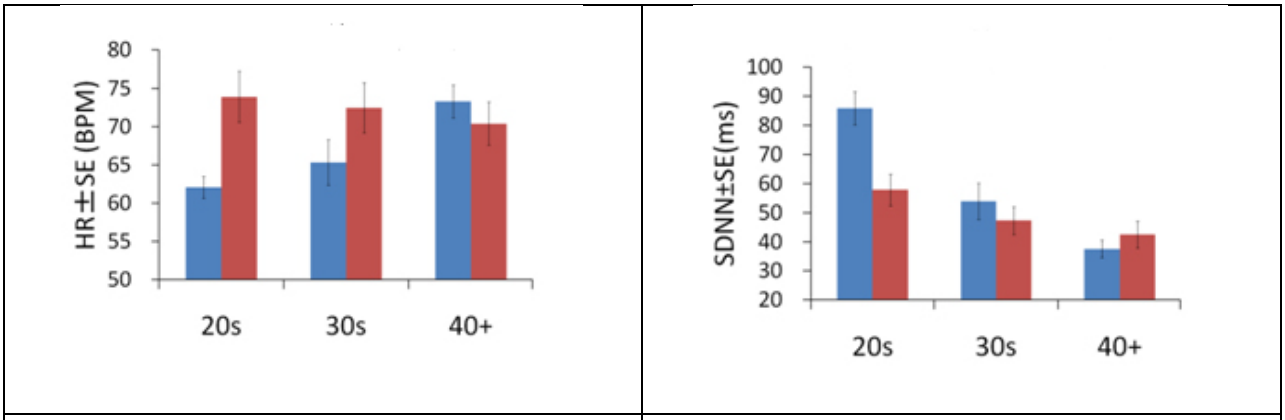
Figure 4: HRV Parameters: HF & LF , Red cluster for Female and Blue cluster for Male



LF/HF parameter	TP parameter

Figure5: HRV Parameters: LF/HF & TP , Red cluster for Female and Blue cluster for Male

If we compare changes in heart rate with age for SDNN, TP, HF, LF, and LF/HF ratio as shown in Figure 6, Figure 7 and Figure 8. The following observations were made. For men with maturity reduction was shown except for heart rate and LF/HF ratio. There was a prominent difference in SDNN was observed for men in between their twenties and forties plus , Differences in LP for age between twenties and thirties, thirties and forty plus was observed . 36 % reduction in LF/HF was shown in forty plus men compared to thirties. For women HRV indices other than LF/HF declined with age. LF/HF ratio of thirties had a 79 % reduction and after forty LF/HF ratio was eight fold higher than thirty and 79% greater than twenty.



HR parameters	SDNN PArameters

Figure 6: HR and SDNN parameters for Age-related changes in Heart Rate, Red for female and Blue for Male

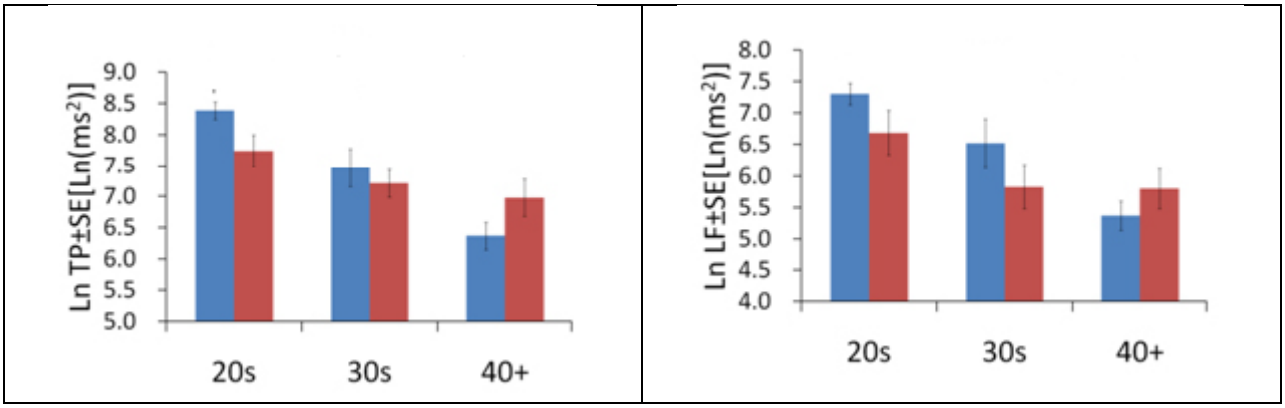
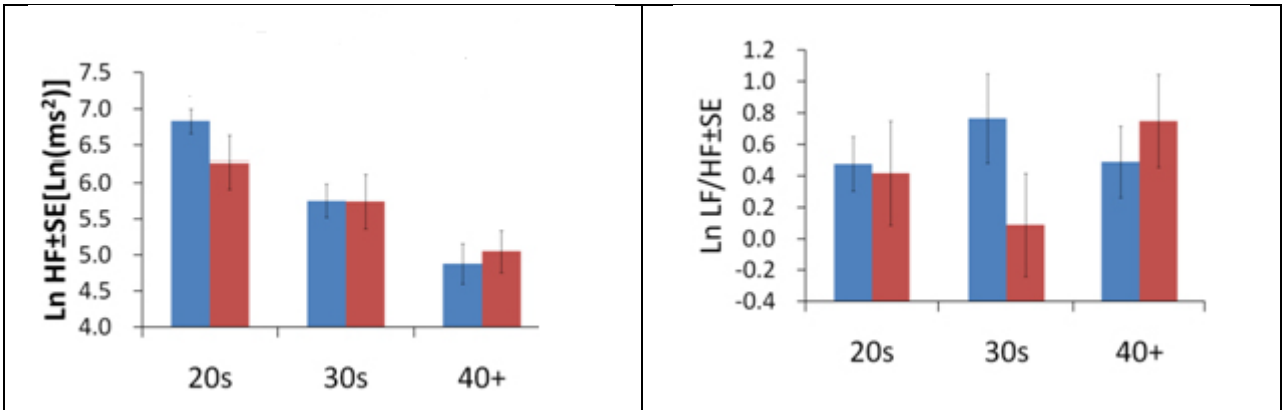


Figure 7: TP and LF for Age-related changes in Heart Rate, Red for female and Blue for Male



LF/HF parameter	TP parameter

Figure 8: HF and LF/HF parameters for Age-related changes in Heart Rate, Red for female and Blue for Male

Parameters	**20-29(age)**	**30-39(age)**	**40+(age)**
HR	62.07	65.33	73.30
SDNN	85.91	53.94	37.5
Ln TP	8.39	7.46	6.37
Ln LF	7.30	6.52	5.36
Ln HF	6.83	5.75	4.88
Ln LF/HF	0.47	0.77	0.49

Table 1: Mean HRV parameters for male according to age and gender

Parameters	**20-29(age)**	**30-39(age)**	**40+(age)**
HR	73.89	72.46	70.38
SDNN	57.83	47.28	42.54
Ln TP	7.74	7.21	6.98
Ln LF	6.69	5.82	5.80
Ln HF	6.27	5.74	5.05
Ln LF/HF	0.42	0.09	0.75

Table 2: Mean HRV parameters for Female according to age and gender

IV CONCLUSION

Based on the results of age groups for both the genders , HRV was significantly observed higher for men than women during their twenty and also thirty while the case reversed in their forty .TP had a remarkable evaluation in men .In forties women showed greater activity against all HRV parameters. If we summarize in terms of para and autonomic activities with age in men and women., a significant variation or decline in parasympathetic and autonomic activities with age in men and women is observed, a significant decline is seen in thirties due to sudden decrease in physical vitality on the flip side a more gradual decline was seen in women which accounts for higher longevity in women than men.

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