Regularity Changes with Age in Hemodynamic Profiles during Passive and Active Stands

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Abstract

The objective of this study was to determine the effect of aging on regularity of blood pressure and pulse interval in resting and active conditions. We studied two normotensive subjects groups: young (20 to 40 years, n=23) and elderly people (60 to 80 years, n=23). No differences of gender have been found between young and elderly groups. Beat-to-beat blood pressure was measured by Finapres system during the six-minutes walk distance test. Overall systolic and diastolic blood pressures and pulse intervals regularity were determined. Differences in blood pressure and heart rate regularity were found between age groups. These results show the efficiency of nonlinear methods to characterize cardiac dynamic.

1. Introduction

Hemodynamic parameters display certain variability. Modulation of heart rate (HR) and blood pressure (BP) is achieved by baroreflex mechanism and by the central nervous system, through it should be also noted the existence of hemodynamic response to body movements and to emotional states and also it has been observed aging changes [1–4].

Cardiovascular system is complex and it results from the interaction of many subsystems, self-sustained oscillators and feedback loops reacting to internal and external inputs.

Linear analysis provide information on the magnitude of variability within the system and are typically reported using the range, standard deviation, and coefficient of variation of the time series and frequency domain measures [5–7]. Moreover, hemodynamic parameters, such as HR variability show a degree of chaos [8]. Nonlinear tools focus on understanding how pattern variations change over time and may provide more stable and repetitive results and hidden abnormalities that might not otherwise be detected [9–11].

In addition, the healthy aging process is associated with a reduced ability to interact between the subsystems of the body that can be characterized by nonlinear measures, with a decrease of randomness, as well as changes in complexity of physiologic dynamics [12–14], reflecting a reduction in overall HR variability in aged people [4]. In addition, the "physiological" age-related increase in blood pressure may be a confounding factor in the determination of age effects on blood pressure variability [15], where nonlinear measures can be helpful.

Moreover, due to body movements or emotional stress, both, BP and HR increase, followed by a decrease at the end of the action. Nevertheless, aging and hypertensive subjects are not associated with a decrease BP [16].

During exercise, there are a lot of circulatory changes produced because our body must increase the amount of blood provided to our muscles. These types of answer may vary among children, adults and elderly people provoking effects related to age [17].

Several studies have analysed BP response to exercise, as risk factor to develop possible diseases. Nevertheless, physical activity seems to reduce BP and the mechanism used for this reduction seems to be related to a change in the cardiac output and in the peripheral vascular resistance, but depends on the age range and the intensity of physical activity especially among the group of elderly people, as it is showed in some studies [18]. Nevertheless, casual BP measurements are of limited value because these measures do not reflect the overall variation of other factors in BP, therefore ambulatory BP monitoring can assess the circadian changes in BP by measuring BP frequently during the daytime and night time, but this method presents the problem of patient acceptance, arm discomfort, and sleep disturbance associated with 24-h BP measurements [19]. Nevertheless, six-minute walk distance (6MWD) is technically easy to apply, repeatable and reflects daily living activities better than laboratory tests, and is well tolerated by patients [20].

In this work, we propose the evaluation of the changes in hemodynamic parameters in different aged patients during passive and active stands. These parameters were registered by 6MWD. We will be dealing with the role of 6MWD in the determination of functional exercise capacity, treatment assessment, and prognostic evaluation.

Nowadays, elderly people constitute a large and constantly growing proportion of the population that challenges cardiovascular research. This article is focused on the assessment of simultaneous hemodynamic parameters in active and passive conditions and in different aged patients. The goal of this work is to

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evaluate if there are differences in autonomic cardiovascular measures between both groups in different conditions.

2. Materials

The database is composed of two groups of 46 subjects. Young people compose one group with 23 subjects aged from 20 to 40 years (30.83±3.90 years) and elderly people composed the other group with 23 subjects with an average age of 69.78±6.36 years. Non-differences of gender have been found between young and elderly patients (Table 1).

Table 1. Database used to carry out our study.

		Women	Men
Elderly	Participants	15	8
	Age	71.07±5.20	67.37±7.93
Young	Participants	10	13
	Age	32.00±4.45	29.92±3.33

The participants were evaluated in the Techonology Resarch for Independent Living Clinic (TRIL) at St Jame's hospital in Dublin.

The measurement of the blood pressure wave was done using the method Finapres (Finger Arterial Pressure). Different hemodynamic parameters were registered during the three Phases: Phase 1 (pre-exercise), in which the patients are standing for 3 minutes, Phase 2, in which the patients walk for 6 minutes and Phase 3 (post-exercise), in which the patients, are standing after having walked for 3 minutes.

3. Methods

In this study regularity of the hemodynamic patterns during passive and active states were studied, to analyse possible changes between rest and exercise states related to the increase of age. To carry out this study, hemodynamic measurements were analysed data from the subjects in all the Phases.

The 6MWD was applied, which is considered a protocol of simple effort, easy to do and which has proved to be a good reflection of the activities of a daily life. This test consists basically on measuring the distance which a person can walk in 6 minutes and it must be done along a long, flat and straight 30 meter long corridor. The 6MWD test is divided into the following phases:

- Patients as were standing for 3 minutes before starting to walk.
- Patients were told to walk for 6 minutes at a fast pace but confortable, with a turn of 180º marked by a cone each 30 meters.
- In this last Phase patients were standing for 3 minutes when finishing the test.

As a result three Phases have been clearly identified and differentiated: a first Phase of rest with a duration of 3 minutes (pre-exercise), a second Phase, with a duration of 6 minutes, in which patients are doing the exercise and a third Phase with a duration of 3 minutes (post-exercise).

The following hemodynamic measurements beat by beat were registered:

- SBP: as the maximum blood pressure in the systole (mmHg).
- DBP: as the minimum value of pressure in the diastole (mmHg).
- MBP: as the mean pressure during the cardiac cycle (mmHg).
- HR: cardiac frequency derived from the pulse interval (bpm).

3.1. Shannon entropy

For a discrete random variable X with possible values $x_1,....x_n$ and probabilities associated $p(x_1),\ldots,p(x_n)$, Shannon entropy (SE) $H(X)$ of a discrete random variable X is defined as:

$$H(x) = -\sum_{i=1}^{n} p(x_i) \ln p(x_i) \qquad (1)$$

SE is defined as the average value of the logarithms of the function of density of probability, where n in the number of discrete values which the considered variable can assume and $p(x_i)$ is the probability of assuming the i^{th} value. It provides a measure of the information contained in hemodynamical parameter over time, and therefore indicates the amount of information carried by that measurement during different states.

SE was applied to evaluate hemodynamic parameters regularity in the in different Phases in both groups. It was extracted intervals of equal size of 180 samples in each phase.

3.2. Statistical analysis

The models of unpaired t-tests and analysis of variance with repeated measurements ANOVA and with the Student-Newman-Keuls test were used to study the effect of one or more factors when at least one of them is a within-subjects factor or related measurements. The results were regarded as statistically for $p<0,05$.

4. Results

In a first analysis, differences in the evolution of the hemodynamic measurements between the group of the young people and the group of the elderly people were studied (figure 1).

SBP was higher in the post-exercise phase compared with the pre-exercise phase, in the group of the young people as well as in the one of the elderly people. Older people showed higher SBP in the three phases (figure 1).

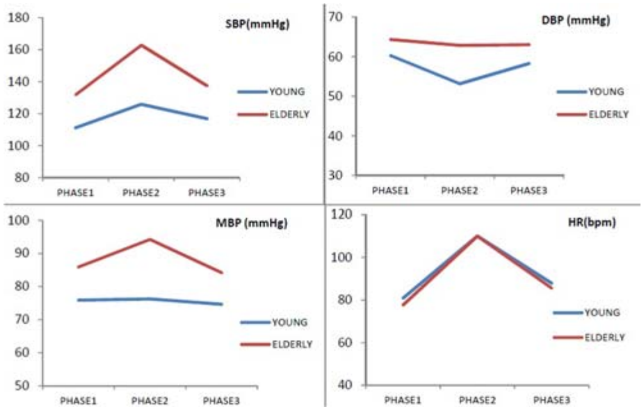

Figure 1. Hemodynamic measurements obtained in the three Phases: SBP (mmHg) (up-left), DBP (mmHg) (up-right), MBP (mmHg) (down-left) and HR (bpm) (down-right).

The analysis showed statistical significant differences in Phase 1 with a ($p < 0.001$) between the group of young people with 111.15±13.40 mmHg and the group of the elderly people 131.82±16.20 mmHg. In the active Phase the same trend was observed with statistical significant differences (125.8±19.9 mmHg vs. 162.7±20.8 mmHg, $p<0.001$). Moreover, in Phase 3 there were also statistically significant differences between both groups, with 105.85±12.72 mmHg for the group of the young vs. 131.35±20.64 mmHg for the group of the elderly people.

The average of the values of the measurement of DBP is similar in all Phases for elderly people (figure 1), with a higher average in the three Phases in this group. In this case, it was observed statistically significant differences in the active Phase ($p = 0.021$) between the group of young people 53.15±13.52 mmHg and the group of elderly people, 62.84±13.90 mmHg.

MBP average from both groups showed values slightly lower in the post-exercise phase when comparing with the pre-exercise Phase. As well as in the previous cases the group of elderly people showed a higher average in the three Phases (figure 1). Average of MBP showed statistically significant differences in Phase 1 ($p = 0.003$) between the group of young people (75.90±11.34 mmHg) and the group of elderly people (85.92±9.95 mmHg). In the active Phase, MBP average also showed statistical significant differences ($p < 0.001$) between the group of young people (76.23±13.96 mmHg) and the group of elderly people (94.22±16.81 mmHg). Moreover, in Phase 3 average of MBP showed the same trend (74.6±10.6 mmHg vs. 86.2±11.4 mmHg, $p = 0.001$).

Furthermore, non-statistical significant differences were observed in HR average between groups in any of the three phases.

HR regularity differences were found in the three phases between both age groups. During Phase 1 statistical significant differences were found ($p<0.001$) between the group of young people 3.11±0.30 and the group of elderly people 2.29±0.46. In Phase 2 statistical significant differences showed a similar signification to the Phase 1 between the group of young people 2.64±0.45 and the group of elderly people 1.74±0.56 ($p<0.001$). In Phase 3, statistical significant differences were observed (<0.001) between the group of young people 3.08±0.36 and the group of elderly people 2.34±0.62 (figure 2).

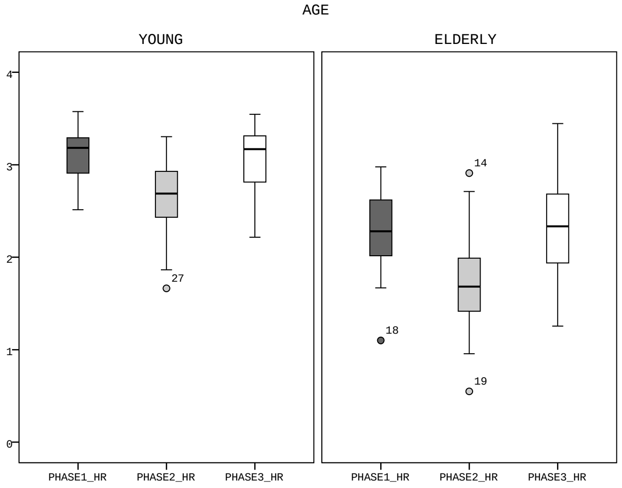

Figure 2. HR Shannon Entropy

5. Conclusion

HR showed higher levels in the post-exercise phase compared with the pre-exercise phase. This response was reflected in both age groups (figure 1). Some previous studies reported very similar results, showing an increase of the HR in the phase subsequent to the physical activity, being the group of elderly people the one which restored these levels in a later way [17].

HR entropy showed higher differences between both groups, being the group of young people the one which reflects a bigger irregularity with higher levels of entropy (figure 3(a)). Previous articles showed a high degree of variability in the HR in healthy individuals with healthy hearts, however, some physiological states and diseases produce alterations in the autonomous functions which mitigate the changes in the HR [21]. In addition, in previous studies show similar results, with a increase of HR regularity throughout age, so it can be a biological indicator in the aging process [12–14]

It was observed that the SBP averages were higher in the post-exercise phase in both groups, compared with the pre-exercise phase. In previous studies similar results were found, in which the recovery time in this hemodynamic measure increased regarding age and it seemed to decrease with the increase of the intensity of the physical activity. Previous studies revealed that most elderly people increased their levels of SBP in a remarkable way after exercise and came back to the levels of the pre-exercise phase later than young people. These differences might be strongly related to the maximum amount of oxygen that our organism can absorb and a decrease of the HR when these variables matched initially with the recovery of the SBP [22].

In addition, DBP did not show remarkable differences between phases. Moreover, similar values were observed in both groups, being elderly patients the ones who showed slightly higher values. In previous studies, very similar conclusions were observed, where it was not found a clear correlation between age and DBP [23].

As conclusion, Shannon linear and non linear measures can be helpful to extract information from hemodynamic parameters.

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