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# Correlation of Extra Systoles with Cardiac Autonomic Modulation through 12 Derivations Holter and Vital Jacket

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## ABSTRACT

**Introduction**: *The Vital Jacket® is a Holter heart rate monitor created to be used in cardiac monitoring in people during real time physical exercise where the patient can be analyzed in both indoors and outdoors. It is a diagnostic system which performs data collection at up to 5 derivations and can gather cardiac information during a period pre-established which can be until uninterrupted 72 hours. We aimed to evaluate the association of extra systoles with the autonomic cardiac modulation through Holter 12 derivations and Vital Jacket® exams.*

**Method**: *30 patients performed the Holter 12 derivations and Vital Jacket® on different days. After carrying out the examinations, it was collected the data of heart rate variability (HRV) and the number of extra systoles.*

**Results**: *There was no correlation between the values of the HRV in relation to the number of extra systoles (SDNN: r = 0,23(Holter),r =0,173 (Vital Jacket); rMSSD: r = 0,265(Holter), r=0,153 (Vital Jacket®); PNN50: r= 0,086 (Holter) r=0,078 (Vital Jacket®).*

**Conclusion**: *There was no association of extra systoles with the autonomic cardiac modulation through Holter 12 derivations and Vital Jacket®*

## INTRODUCTION

Cardiovascular changes may not lead to a symptomatology, it is often diagnosed by chance, as in routine queries, clearance for physical activity or preparation for any surgical procedure. One of the effective methods used to detect cardiac abnormalities is the examination of electrocardiogram, a non-invasive method which through electrodes arranged in specific locations of the thorax is able of capturing the electrical activity of the heart that will be displayed by the electrocardiograph[1], to be performed by a skilled professional in order to assess the possible changes of electro cardiographic tracing.

One of the possible changes to assess through the electrocardiogram is cardiac arrhythmias. Arrhythmia is defined as the frequency change, training and / or conduction of the electrical impulse through the myocardium[2].There are several types of cardiac arrhythmias, including two types of change: changes of the automatism or in the conduction of the electrical stimulus.

As some examples of changes resulting from the disturbance of the automatism and the formation of stimulus it is included the sinus tachycardia, sinus bradycardia, sinus-atrial block and extra-systole (supraventricular and ventricular). Regarding the changes in conduction of electrical stimulus, an example is the atrioventricular blocks[2].

In this study we will focus on extra systole, a type of cardiac arrhythmia which can arise from cardiac, extra cardiac or pharmacological causes. Subjectively, it can cause palpitations or precordial distress, some patients present a large number of extra systoles and do not refer this symptom[2].

From the electrocardiogram , it is also possible to assess the modulation of the autonomic

nervous system (ANS) through the heart rate monitor (HRV), which describes oscillations of gap between the consecutive heart beats (R-R interval), as well as variations between consecutive instant heart rates. A high HRV is a indicative of a healthy person, while a low HRV is a indicative of a bad physiological functioning. It is an important marker that exposes the activity of the ANS regarding the sinoatrial node and can be used as an instrument to assess health[3].

Long-term electrocardiogram is called Holter, it is a cardiac monitoring cardiologic examination which lasts 24 hours, accomplished through the connection of cables with electrodes on the patient (from 2 to 10), which will be connected to the Holter recorder[1]. The Vital Jacket is also a log-term Holter, however, the electrodes are arranged in a comfortable, lightweight fabric and washable T-shirt[4], which is dressed by the patient to make the exam. The data is stored on a small tape recorder that is connected to the T-shirt and introduced in a own pocket , data collection can be made in up to 5 derivations and can reap cardiac information during a period that can be up to 72 hours uninterrupted[5]. The purpose of the Vital Jacket ® is that the electrocardiographic analysis is held in the period in which the patient is performing the exercise.

In this sense, we aimed to evaluate the association of extra systoles with the autonomic cardiac modulation through Holter 12 derivations and Vital Jacket® exams.

## METHOD

### Population

The study was approved by the Research Ethics Committee and it was conducted a cross-sectional study in 2014 with data collected in a Cardiology Center of São Paulo city. The sample was composed of 30 patients (25 women), who performed the tests of 12-lead Holter and Vital Jacket ® on different days. We included patients who underwent both tests in the collection period.

The exclusion factors were patients undergoing heart transplants, with pacemaker and/or using beta-blockers, these factors are contraindicated because they change the analysis of HRV. All patients signed an informed consent letter.

### Procedures

The 12-lead Holter monitoring exam was done in a period of 24 hours, the patient went to the clinic where it was measured the blood pressure and made the skin cleaning with alcohol 70% and a fine sandpaper to remove the greasiness and top layer of skin, where the 10 electrodes (3 m model 2223brq) were willing. The cables were connected to the Holter recorder (Holter DMS 300 3A Recorder) and the patient was instructed to return to his residence and perform their daily activities normally except physical activity and bath (because the Unit may not be wet), including sleep, and the patient was instructed to fill out a diary, describing the activities and possible adverse events during the day and come back to the clinic on the next day for removal the appliance and electrodes.

The Vital Jacket ® was used in short (30 minutes on average), held on the own clinic, where the patient when presented himself was taken for cleaning the skin with alcohol 70% and a fine sandpaper to remove the greasiness and layer surface of the skin, and when wearing the t-shirt the 6 electrodes (3 m model 2223brq) which are engaged in it were willing in the patient (figure 1), the shirt was connected to the recorder (Vital Jacket ® HWM). Patient was referred to another room, where the investigator could use the established protocol in the institution to the completion of the examination, where it was measured the initial blood pressure to verify if there was no impossibility of conducting the examination, and then forwarded to the mat (LX1600 Movement) or exercise bike (Reebok B and 5.1) where started the exercise at low speed to heating and adaptation for two minutes.

Later it was increased the speed gradually and monitored at any moment the patient's heart rate through the Vital Jacket ® software and subjective perception of effort/fatigue in patient boundary, until it reaches the 15° min, and started to reducing the speed gradually until the 20th minute. Later the patient started the resistance exercises in full body multi-station workout, conducting the exercise of Vertical bench press and leg extension on extensor Chair, with weights that the patients themselves thought heavy enough but that could perform 15 repetitions for 3 sets. At the end of the series patients would sit and rest for 5 minutes, and it was measured again the blood pressure.

**Figure1.** *T-shirt with Vital Jacket and its electrodes in patient.*

## Data Analysis

Excel programs have been used for the preparation of the database and the SPSS program (Statistical Package for Social Research) version 17.0 for statistical analysis. The Shapiro-Wilk test was used to verify normality of the groups. The descriptive statistics were made for measures of central tendency and dispersion. We applied the Mann-Whitney test to compare extra-systole between the two methods. In order to evaluate the correlation of extra-systole between the two methods we applied the Correlation Spearman coefficient. Strong correlation was considered for r > 0.5, moderate correlation for r between 0.5 and 0.3 and weak correlation for r<0.3. Significance level was set for p<0.05

## RESULTS

The sample was composed of 25 women (83.34%) and five men (16.66%), with an average age of 51.5 ± 17 years old. Table 1 presents the descriptive statistics regarding 12-lead Holter test and Table 2 presents data related to the Vital Jacket ® exam

**Table1.** *Descriptive values of 12-lead Holter test.*

| 12-lead Holter | mean ± SD |
|---|---|
| HR-4 min intervals (bpm) | 50.0 ± 5.5 |
| Max HR-4 intervals (bpm) | 117 ± 20.1 |
| HR 12:0 am (bpm) – average | 75.0 ± 9.1 |
| HR min H-h (bpm) | 60.9 ± 7.8 |
| Max HR H-h (bpm) | 93.9 ± 12.1 |
| Beats analyzed | 85570.6 ± 22267.3 |
| Min analyzed | 1143.1 ± 260.2 |
| Mon period. ECG (hours) | 21.7 ± 2.9 |
| Total EV | 40.1 ± 160.1 |
| SDNN 24 hours | 117.6 ± 39.0 |
| SDANN index | 105.8 ± 40.0 |
| SDNN index | 48.8 ± 14.4 |
| rMSSD | 31.4 ± 14.3 |
| PNN50 | 8.0 ± 7.1 |
| Spectral analysis 24 hours | 2453.3 ± 1251.5 |
| Spectral analysis min/h | ± 809.7 490.4 |
| Spectral analysis Max/h | 5775.6 ± 3186.7 |
| Depression Max delta ST | 0 ± 0 |
| Max elevation delta ST | 0 ± 0 |
| Max episode ST. (min) | 0.06 ± 0.25 |
| Total SV | 90.5 ± 271.3 |
| Pauses longer than | 2.5 ' ' 0 ± 0 |
| QT Max (ms) | 411.0 ± 145.7 |

*Mean ± DP-mean ± standard deviation; HR min – minimum heart rate; BPM-.beats per minute; Max HR-maximum heart rate; HR average 24 hours – Frequency average heart rate in 24 hours; HR min H-h-minimum heart rate every hour; Max HR Hh -Maximum heart rate every hour; Min analyzed – Minutes reviewed; Period Mon. ECG-electrocardiogram monitoring Period; Total EV – Total of extra systoles ventricular; SDNN 24 hour-standard deviation of all normal RR intervals recorded on a time interval expressed in MS in 24 hours; SDNN-the average standard deviation of normal RR intervals every 5 minutes, expressed in ms; SDANN-standard deviation of the averages in the normal RR intervals, every 5 minutes, in a time interval, expressed as Ms; rMSSD-square root of the average of the square of the differences between normal RR intervals adjacent, in a time interval, expressed in ms; Pnn50- percentage of intervals with adjacent difference of RR duration greater than 50ms; twenty-four-hour spectral analysis – spectral analysis in 24 hours ; Spectral analysis min/h – spectral analysis in minutes per hour; Spectral analysis Max/h-maximum spectral analysis per hour; Depression Max delta ST- maximum depression delta ST (ST segment of the QRS complex); Max elevation delta ST- maximum lift delta ST (ST segment of the QRS complex); Max episode ST. (min)-maximum episode ST. (minutes); Total – total of ventricular systole SV; QT Max – maximum time QT segment.*

**Table2.** *Descriptive values Vital Jacket ® exam.*

| Vital Jacket ® | Mean ± Sd |
|---|---|
| Max HR (bpm) | 138,7 ± 30,7 |
| AVG. HR (bpm) | 109,7 ±24,5 |
| FC min (bpm) | 78,1 ±18,0 |
| Total QRS | 2366,0 ± 766,4 |
| Noise % | 5,5 ± 15,9 |
| Max HR H-h (bpm) | 137,5 ± 30,9 |
| HR min H-h (bpm) | 78,4 ± 17,7 |
| Min analyzed | 21,8 ± 6,5 |
| Total EV (%) | 6,3 ± 23,5 |
| SV Total (Percent) | 5,4 ± 11,8 |
| Total delay | 0,63 ± 2,1 |
| Total breaks | 0 ± 0 |
| Bradycardias | 0 ± 0 |

*Mean ± SD-mean ± standard deviation; Max HR-maximum heart rate; BPM-beats per minute; HR average-average heart rate; HR min – heart rate minimal; QRS total – Total of QRS complexes; Noise%-percentage of noise; Max HR H-h- maximum heart rate every hour; FC min H-h-hour minimum heart rate time; Min analyzed – Minutes reviewed; Total EV (percent) – Total of extra ventricular systole in percentage; SV total (percent) – Total of ventricular systoles in percentage; Total delay brady – Total delay bradycardia.*

Table 3 represents the comparison of the total number of extra systoles between the Holter and Vital Jacket ® exams, there was no statistical significance.

**Table3.** *Comparison of the number of Extra systole between Holter and Vital Jacket®.*

| | Mean ± Sd | p |
|---|---|---|
| Holter | 40,1 ± 16 | |
| | | 0,258 |
| Vital Jacket® | 6,3 ± 2,5 | |

ES-Extra systoles; Mean ± SD-mean ± standard deviation.

Table 4 present coefficient correlation index of the HRV index between Jacket and Vital exams and we reported no significant correlation.

**Table4.** *Correlation between the values of the heart rate variability in relation to the number of extra systoles.*

| | Holter ("r") | Jacket ("r") |
|---|---|---|
| SDNN | 0,23 | 0, 173 |
| RMSSD | 0,265 | 0, 153 |
| pNN50 | 0,086 | 0, 078 |

*SDNN 24 hours-standard deviation of all normal RR intervals recorded on a time interval expressed in MS in 24 hours; cardiovascular manifestations; RMSSD - square root of the average square of the differences between normal RR intervals adjacent, in a time interval, expressed in ms; PNN50 - percentage of intervals adjacent difference of RR duration greater than 50ms.*

## DISCUSSION

In our study we reported that there was no significant difference of extra systoles between Holter and Jacket Vital exams, which may perhaps be explained by the difference in time of recording of electrocardiographic tracing where the Holter is approximately twenty-four hours and the Vital Jacket ® approximately thirty minutes and also for the sample used in the research be of healthy individuals. There was no correlation of HRV indices between the both methods.

Amelsvoort LGPM et al[6] (2001), through a cohort study that used a sample of day (22) and nocturnal (49) workers, aimed to analyze the change of HR and HRV during one year of work from Holter analysis found based on the data analyzed, the correlation of increased extra systoles during the period of one year in the Group of nocturnal workers with the number of nights worked, where they obtained significant value of correlation by Spearman test ($r = 0.33$, $p = 0.004$) and with the relationship between the HRV between the groups there was no significant difference.

As well as in the study of Härenstam The et al[7] (1987), where evaluating a group of 66 men prison staff Swedes, through using Holter electrocardiographic recordings associated to occurrence of extra systoles with the night's work. In this case, our study correlated by Spearman test values regarding the relationship with HRV related to the extras systoles, and as noted there we did not achieve significant correlation.

In the study of Hoffmann J et al[8] (2000), where the goal was to investigate the relationship between the HRV and the baroreflex sensitivity, using a sample composed of 160 patients with idiopathic dilated cardiomyopathy, it was possible to observe weak correlation between variables, suggesting that the same explored different aspects of autonomic control of the heart, and even when correlated to the HRV and baroreflex sensitivity with the predictors of risk as left ventricular ejection fraction, end diameter diastolic left ventricular and arrhythmias in the Holter, obtained weak or absent correlation between variables. Our study population was of individuals without presence of heart defects, idiopathic or acquired, what may have interfered in the correlation of our variables.

In the proposed study model for Tekiner F et al[9](2007), he wished to evaluate the efficacy and prognostic value of the study of variability in 24 hours or shorter periods using the Holter method, to determine Autonomic dysfunction in patients with congestive heart failure. They concluded that the analysis of HRV in both methods were useful to evaluate cardiac autonomic dysfunction in patients studied, however only the twenty-four-hour analysis obtained a value of prognosis. The correlation of our work was performed between two distinct tests in its methodology, based on long-term electrocardiography, however the analysis time between the two differed, being one in 24 hours, and another in 30 minutes as in the study quoted above.

Engel G et al[10](2007) studied the relationship between heart rate rest and the extra ventricular systoles to obtain prognostic value, through an analysis of electrocardiogram in a sample consisting of 1,731 individuals, where they found that individuals with presence of ventricular extra systoles also showed a cardiac frequency higher in rest. At the end of the study it was concluded that the presence of any extra ventricular systole on a single ECG is a powerful predictor of causes of cardiovascular mortality, the presence of elevated heart rate in rest is an important prognostic factor and the combination of increased heart rate and ventricular extra systoles dramatically increases mortality. Found even if the heart rate was an important and independent indicative of the presence of ventricular extra systole and suggested even if the results go in favor of the hypothesis that the activation of the sympathetic nervous system, it is an important factor in the genesis of extra systoles and other ventricular arrhythmias.

As well as in the study of Soliman EZ et al[11] which the intention was to assess the relationship between the low resting heart rate and ventricular arrhythmogenesis using 867 patients referred to a clinic to analyze the twenty-four-hour Holter. For such used the heart rate rest, HRV for dominance of the time (SDNN, rMSSD and PNN50), the presence of extra systoles were obtained through the Holter and evaluated and confirmed by a doctor. Other variables were taken into consideration, such as hypertension, diabetes, arterial disease coronary, heart failure, the use of anti-arrhythmic medications, FEVE, body mass index (BMI)

and smoking were obtained from patients ' health records. The results have been grouped in accordance with the HR, who were divided into smaller than 67 bpm, 67-77 bpm, 68-93 bpm and greater than 93 bpm, where the HRV indices were decreasing significantly according to the increase of heart rate in rest and about the extra systoles/24 hours was increasing significantly as the increase of heart rate in rest. These results which shows the strong association between high frequency resting heart rate and ventricular arrhythmogenesis. Analysis of HRV, present in our study represents the analysis of autonomic modulation, given by interaction of the sympathetic and parasympathetic systems, which in the study of Engel G et al[10] (2007) the activation of the sympathetic system was cited as a factor influencing in the genesis of cardiac arrhythmias, and in the study following the membership autonomic modulation and the ventricular arrhythmogenesis were evidently associated.

Ciszewski P et al[12] (2013), where he had as one of his goals to know if the pre-operative assessment (of large pulmonary resection) parameters heart rate variability, allows to predict which patients are likely to suffer from AF (atrial fibrillation) postoperatively, where it was used a sample composed of 117 patients, divided into two groups, Group A (patients without AF) and Group B (patients with AF). It can be observed that the Group B patients presented a higher RMSSD (median value 22,3-17.4 s), this shows that the patients of Group B, showed lower variation of related variables in almost all HRV. It turned out that the higher risk of postoperative AF, was in patients who had higher extra number systoles, according to the Holter test. It was concluded that the assessment of HRV parameters must be taken into consideration before any major pulmonary resection, and the disturbance of the balance between the sympathetic and parasympathetic nervous systems is responsible for the AF. In our study it was not observed a significant correlation between the HRV and extra systoles, again in our sample number was lower and the characteristic of healthy individuals, may have been responsible for this divergence, in order that the population of the above study was of individuals with a certain commitment to health and its larger sample.

Oflaz MB et al[13] (2013), evaluated a group of 34 children with cardiomyopathy dilates idiopathic, which aimed to examine the effects of carvedilol therapy (adrenergic beta blocker) on the autonomic control of heart. A significant correlation was found between changes in parameters of FEVE (ventricular ejection fraction) and time domain of HRV, including SDNN, rMSSD and PNN50. After treatment with carvedilol SDNN was correlated with the clinical score of heart failure heart rate, congestive, FEVE and total extra systoles. There was statistically significant increases in media SDNN, SDNN, RMSSD, and PNN50 ($p = 0.002$; $p = 0.001$; $p = 0.008$ and $p = 0.026$, respectively). The SDNN was significantly correlated with the basal heart rate and the total of extra systoles. In this study we evaluated improvements in RMSSD and PNN50 correlated with the improvement in FEVE. The improvement in FEVE was correlated positively with HRV data, in other words, the improvement of autonomic modulation was essential to reduce markers of arrhythmia heart rate in patients with heart failure installed (idiopathic dilated cardiomyopathy and congestive heart failure), in addition SDNN have been significantly correlated with heart rate and extra systole, differing from our study where we didn't get this correlation.

Our study used a small sample, heterogeneous and without pathologies affecting analysis of cardiac HRV or predispose the arrhythmia analyzed, the extra systole, although the same can occur without there being a associated pathology, which may have interfered in our results. No shortage of work to study the changes of HRV in relation to cardiac rhythm disturbances, whether in healthy individuals, or individuals with cardiac changes installed. Just as there is no published works on literature with respect to one of the tests used in our study, the Vital Jacket ®, which would provide more relevant information to the subject.

## CONCLUSION

There was no statistically significant correlation between the parameters of cardiac autonomic modulation and the extra systoles between Holter exams 12 derivations and Vital Jacket ®, as well as in the comparison of the total value of extra systole between them.

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