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Telemetry Option in the Measurement of Physical Activity for Patients with Heart Failure

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Abstract: *Measurement of physical activity among patients with heart failure typically requires a special approach due to the patients' physical status. Nowadays, a technology is already available that can measure the kinematic movements in 3-D by a pacemaker and implantable defibrillator giving an assessment on software. The telemetry data can be transmitted to a central system. The research aims to elaborate the methods that help to compare of the data concerning physical activity both built-in an accelerometer in Cardiac Resychrinisation Therapy (CRT) devices and data obtained from an external Actigraph GT3XE-Plus Triaxial Activity Monitor. 5 persons participated in the pilot study (n=5); mean age: 57+- 13.37; BMI: 90.6+- 7.63. The Actigraph data from CRT device were examined in a 6-day-interval, between February 28 and March 5, 2014. The investigation started conducting a 6-minute walking test and continued with the measurement of daily physical activity. For data analysis descriptive statistics and linear regression analysis were used. It is clear from the data obtained from Actigraph that the MET values (mean: 1.17 ± 0.096) of the patients in the sample were extremely low due to their disease. However, some patients with higher physical activity than average (1.26; 1.28) seemed to be noteworthy, but they showed lower performance than healthy people. The physical activity of the patients during the 6-minute walking test corresponded to 1.9-2.48 MET. The physical activity of patients was found typically in the "light or moderate range" classifying the physical activity by Actigraph. Data from Actigraph are accurate and detailed making the physical activity of the patients measurable and appreciable. The results of the 6-minute walking test were in the category from moderate to very vigorous for individualized moderate physical performance based on Actigraph. It indicates the individual performance differences among patients. However, the daily physical performance is even lower than that of the 6-minute walking. We can conclude from the data related to the percentage*

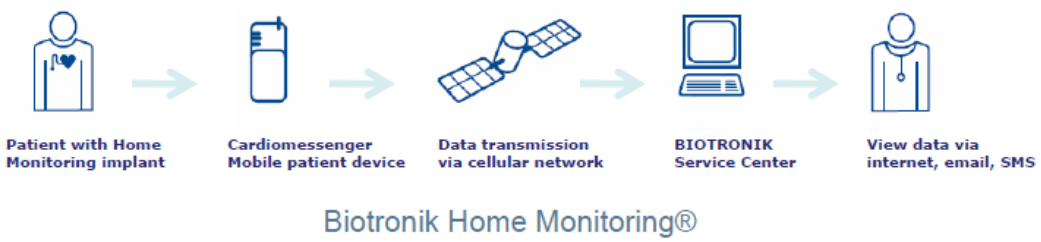
of the average activity in CRT system to the average energy consumption and the improvement in the patients' physical condition. Due to the limitations of the sampling frequency the different time intervals cannot be isolated in the different intensity ranges. Therefore, the percentage of the data of physical activity provided by the device may have a limited use.

Keywords: actigraph, CRT, physical activity, MET, quality of life

Among cardiovascular diseases the incidence and prevalence of heart failure increases to the greatest extent in the developed countries. Its cause may be due to the growing rate of elderly people. Despite the significant developments in drug therapy, heart failure has poor prognosis. Mortality is mostly caused by sudden cardiac arrest due to ventricular tachycardia or fibrillation (mostly in the 1st and 2nd phases according to the New York Heart Association) and progressive heart failure (decisively in the 3th and 4th phases, NYHA). Consequently, mortality increases exponentially in the poor functional phase. In the past years significant progress has been made in the treatments of both fields, such as cardiac resynchronization therapy (CRT) by biventricular defibrillator which is an effective therapy of electromechanical asynchrony associated with severe heart failure (Merkely, 2008). CRT as the greatest progress in the device therapy of heart failure is supported by *Butter* (2011). The combination of the two types of therapy reduces the risk of mortality and improves the quality of life in patients with heart failure (Bristow et al., 2004). The quality of life is an important issue not only for healthy persons, but also for people with heart failure. Physical activity is such a parameter that indicates the physical status and also the quality of life of patients well. Physical activity measurements can be regarded as a specific approach due to the physical status of the above persons. Another important issue concerns cost-efficiency provided by the Home Monitoring system, according to the ECOST report (Guédon-Moreau, 2012).

Ricci and colleagues pointed out that CRT works over 90% efficiency in the cases of life- threatening arrhythmias (Ricci et al., 2013). Indication for the deterioration of heart failure proved to be relatively low accounting for 58.8%. Progression of heart failure can be monitored by examining several parameters, such as heart rate variability (HRV) indicating higher value in patients with good physical status than in those with poor status. According to *Thayer* and colleagues (2012),the low value of HRV indicates mortality in patients with heart failure. *Dontje* (2014) also reports the importance of physical activity in patients with heart failure. Based on the developments of the past years, a technique is able to measure the kinematic features of movements in three dimensions (3D) via built in sensor of implanted pacemaker or defibrillator. It provides an assessment of these features by software. The data can be transmitted via telemetry to a central system. In the present case, the inner accelerometer of the implanted CRT device provides the data of physical activity (Fig.1.).

Figure 1. Biotronik Home Monitoring system



Source: http://spo.escardio.org/eslides/view.aspx?eevtid=48&fp=2175, [15.12.2014]

Objective

The aim of the study is to elaborate a method aiding the comparison of the physical activity values (percentage of the daily physical activity) of the accelerometer in the implanted CRT device. We intend to compare the data from CRT with those of the Actigraph GT3XE-Plus Triaxial Activity Monitor. First, we made the participants walk a 6-minutes-long walking test. Second, the data on physical activity both from Actigraph and CRT equipment were analysed for the whole period of the test. Third, the data from Actigraph were analysed on the energy consumption of the participants via telemetry.

Methods

Actigraph GT3X measures the strength of movements in 3D and fixes their duration. A beat means a signal whose magnitude is sufficient that the accelerometer convert an analog signal into a digital one. This technique makes to assess daily physical activities and classify them. According to a formula, *Freedson* and colleagues (1998) assigned amounts of oxygen consumption to beat/minute data, by which the MET values of categories of activity could be determined.

The participants wore the accelerometer for 6 days involving the days of a weekend. The subjects wore the device all the time, except for washing themselves and swimming. During analysing the data of the Actigraph GT3X, five epoch periods (sampling density in 5-second-units) were set in. The period was excluded when no device was on the subject.

Five activity levels were differentiated during assessment:

1. Inactivity (sedentary) correlated with <149 beat /minute, < 1.5 MET
2. Light activity correlated with 150-499 beat/minute, ≥ 1.5 MET and < 3 MET
3. Moderate activity correlated with 500-3999 beat/minute, ≥ 3 MET and < 6 MET
4. Vigorous activity correlated with 4000-7599 beat/minute ≥ 6 and < 9 MET
5. Very vigorous activity was considered to be >7600- beat/minute value, ≥ 9 MET. (Freedson et al., 1998).

N=5 (males); mean age: 57 years ±13,37; BMI 90,6 ±7,63; The CRT and Actigraph data of the patients were examined in a 6-day-long interval between February 28th and March 5th,2014. Descriptive statistics and linear regression analysis was used for data assessment.

Results

Figure 2 shows data of daily physical activity from the CRT device. The average daily physical activity of the patients was 18,17 ± 6, 47 %.

Figure 2. Daily physical activity in percentage

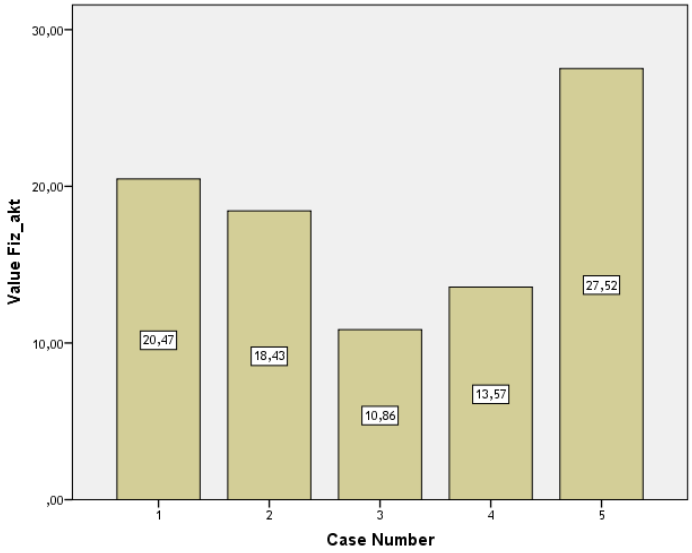


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Figure 3 shows the MET values from Actigraph during the six-day-interval. It was found that the average energy consumption of the patients was 1.17 ± 0.096 MET corresponding to physical inactivity.

Figure 3. The average MET values of the six-day-interval

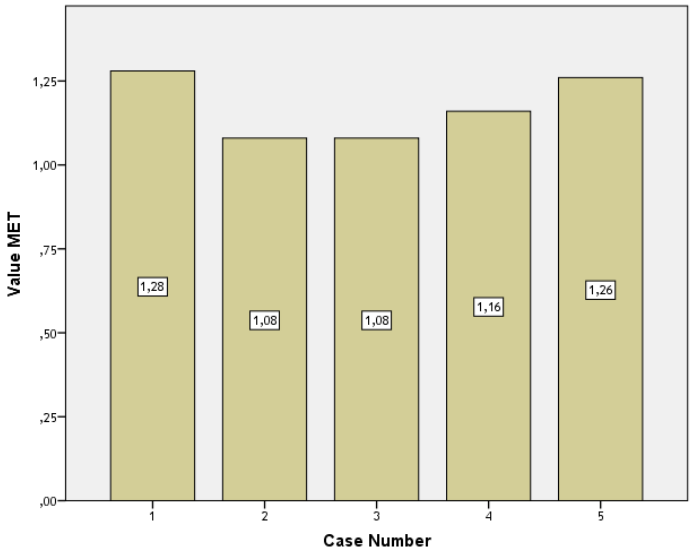

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Figure 4 demonstrates the correlation between the percentage of average daily physical activity and the average MET values in the six-day-interval. No correlation was found between the two variables (F=3,200; p>0,05).

Figure 4.

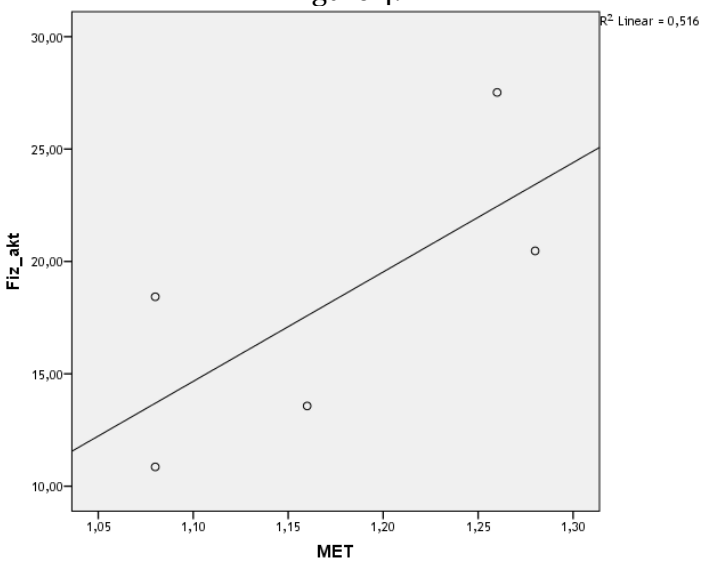

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Figure 5 shows the correlations between the percentage of the average daily physical activity and the activity levels defined by Actigraph were investigated. Correlation in two activity ranges was found between the percentage of average daily physical activity and the time spent there. Significant correlation was found between the time spent in the vigorous activity range and the percentage of average daily physical activity (F= 9,940; p<0,05) based on the linear regressive model.

Figure 5.

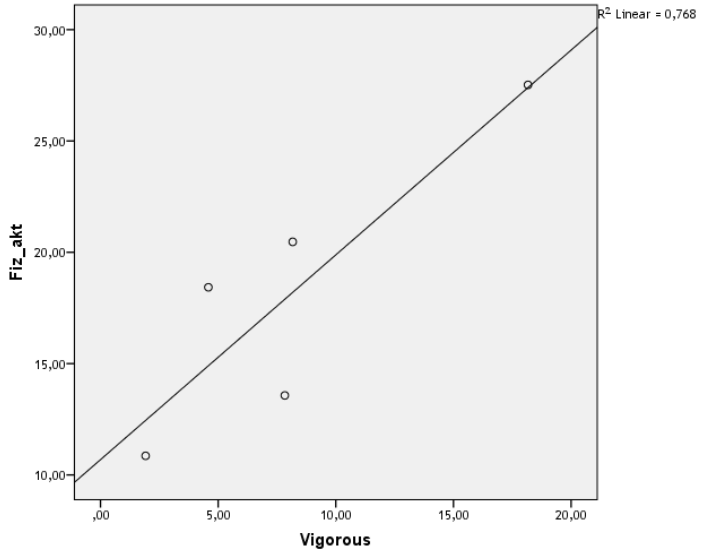

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Figure 6 demonstrates further correlation was found between the time spent with light activity and the percentage of average daily physical activity (F= 12,112; p<0,05). It highlighted the fact that participants spent more time in the light physical activity category.

Figure 6.

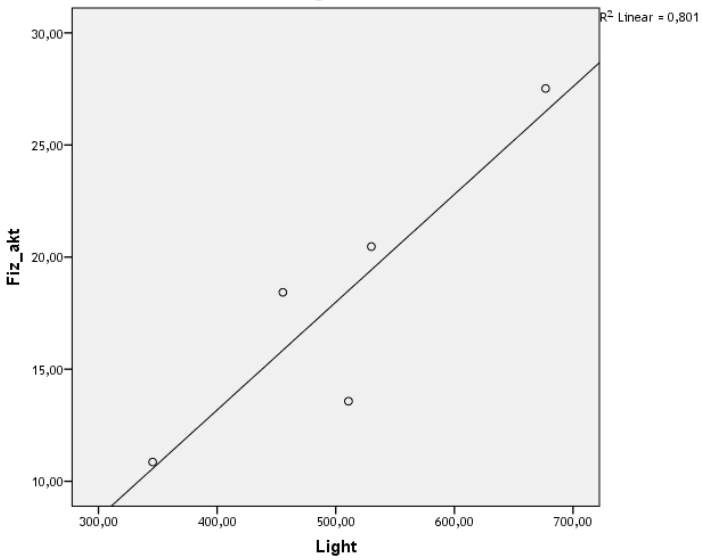

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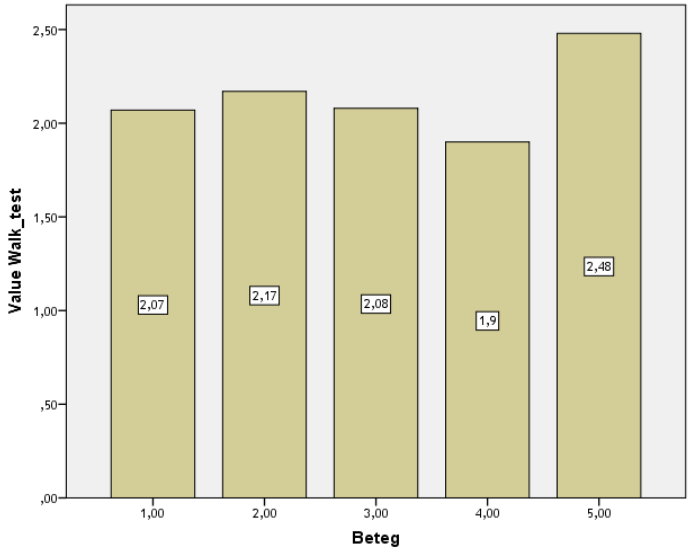
Figure 7 shows the results of the 6-minute-long walking test. Participants were found to have performed well above the average MET values during the six-day-interval 2,14 ± 0,21. Consequently, it indicates the efficiency of instrumental therapy.

Figure 7.



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Discussion

Based on our examination, we can claim that patients with heart failure in our sample spent longer period of time in the light activity range. Moreover, significant time was spent in the vigorous activity category. Thus, CRT implantation improved their quality of life. However, investigating energy consumption, participants performed well below the MET value (3-6 MET) of the moderate activity level, as 1,17 ± 0.096 MET energy consumption was found in the data. Consequently, participants were able to reach the activity level of the healthy people to a shorter period of time. As a conclusion, the physical activity of the participants at home was significantly lower compared to the improvement in cardiac output by CRT therapy. Thus, the six-minute-long walking test also indicated the safe load level that should be performed by the patients at home.

However, we can infer the average energy consumption from the data concerning the percentage of physical activity of the implanted CRT system, as the intervals spent in different activity ranges cannot be differentiated. Thus, the percentage data of the physical activity can be used to a limited extent. A demand has emerged to analyse data of physical activity serving the base of measures and services improving the quality of life. Therefore, a software should be created to obtain quantitative data similar to Actigraph indicating the physical activity of the patient. Thus, patients' individualized physical activity will be planned and controlled at home. Processing of other data (heart rate, HRV, CRT %, VES aktivity, etc) obtained by remote control from the implanted device makes a more complex and remote control of patients suffered from heart failure living with resynchronization device. The latter device is a hopeful means that may contribute to cost-efficiency and further improvements.

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