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ABSTRACT

Heart Failure Readmission and the Physical Activity Vital Sign (PAVS): Is There a Relationship?

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Background – Heart failure costs Americans billions of dollars a year and takes a toll on the patients afflicted by the disease. Recent changes in how healthcare systems and providers are reimbursed have motivated them to find new ways to prevent heart failure readmission. There is no cure for heart failure so healthcare providers try to help patients manage their symptoms. Physical activity is one of the interventions healthcare providers recommend for their patients in the management of heart failure. The Physical Activity Vital Sign is a tool that can be quickly administer and has significant validity.

Objective – The purpose of our research is to determine if physical activity, as measured by the Physical Activity Vital Sign, influences 30-day heart failure readmissions.

Methods – A retrospective chart review was used to evaluate patients' charts that had a heart failure admission between January 1, 2016 and August 31, 2018. We used multiple regression to analyze how the Physical Activity Vital Sign predicts 30-day heart failure readmission rates, while controlling for age, sex, race, ejection fraction, body mass index, length of hospital stay, brain natriuretic peptide, and compliance with the heart failure core measures.

Results – Data was analyzed from 270 heart failure admissions in the study period. The average duration of moderate intensity PA was 20.9 minutes per week; just less than three minutes per day on average. A Pearson Correlation matrix illustrated significant relationships between some of the independent variables. Multiple linear regression demonstrated $p=0.376$, which was statistically insignificant.

Conclusions – The study did not find a significant relationship between physical activity, as measured by the Physical Activity Vital Sign, and heart failure readmissions but physical activity remains important in managing heart failure.

Keywords: heart failure, physical activity, readmission

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The cost of managing heart failure (HF) is expected to more than double between 2012 and 2030, according to an American Heart Association committee, (Heidenreich et al., 2013). This statistic is based on the fact that patients with HF will live longer due to more effective therapies and because of the aging American population. The financial burden of HF on Medicare is undeniable. Readily available data from the Chronic Conditions Data Warehouse, which publishes Medicare and Medicaid research data, show that each year Medicare beneficiaries are responsible for more than 5 million inpatient claims for HF, resulting in billions of dollars of reimbursement. In October 2012, the Affordable Care Act mandated the reduction of payment for excessive readmissions, which is defined as a ratio of greater than 1 for actual readmissions compared to the risk adjusted expected readmissions. This change in payment has motivated hospital systems and healthcare providers to find ways to reduce HF readmissions.

In addition to the expense incurred by patients with HF, the symptoms they face reduce their quality of life. Patients afflicted with HF experience a multitude of symptoms, such as shortness of breath, lack of energy, and leg swelling (Lin, Chin, Sicignano & Evans, 2017). These symptoms are common chief complaints in emergency rooms and are ultimately why patients with HF are admitted to the hospital. The risk of mortality increases with each hospitalization for HF (Lin et al, 2017). Experiencing HF symptoms can, in turn, lead to other co-morbidities, including blood clots, obesity, and pneumonia, partly due to a sedentary lifestyle.

Since there is currently no cure for HF, healthcare providers focus on preventing and managing HF symptoms. Recommended interventions include a variety of strategies that focus primarily on medication, diet, and activity. Physical activity (PA) is well known to be beneficial

in the prevention and management of HF (Florido et al., 2018). Lower PA levels increase the risk for developing HF. Researchers recommend using a tool, such as the Physical Activity Vital Sign (PAVS), to assess if patients are meeting the recommended 150 minutes of moderate exercise per week because "inactivity is among the strongest risk factors for chronic disease and early mortality" (Sallis et al., 2015, p. 383). The American Heart Association recently reported that only 50% of adults in America self-report meeting national guidelines for PA and, due to the nature of self-reporting, this number may be falsely elevated (Mozaffarian el al., 2016).

Even though there may be more accurate ways for assessing PA, such as accelerometers, self-reporting can be useful and effective. The PAVS is one tool that uses self-reporting to measure PA that has been validated (Ball et al., 2015). The PAVS tool consists of only two questions, so clinicians can quickly and easily evaluate the PA level of their patients (Golightly et al., 2017). The two questions included in the PAVS survey are: "How many days in the past week have you performed physical activity where your heart beats faster and your breathing is harder than normal for 30 minutes or more? (In 3, 10-minute bouts, or 1, 30 minute bout)" and "How many days in a typical week have you performed activity such as this?" Responses, ranging from 0 to 7, to these questions are then multiplied together to get an estimate of the total number of minutes of PA for an average week. Lower scores on the PAVS have been correlated with higher body mass index (BMI) and disease burden (Ball, Joy, Gren, Cunningham, & Shaw, 2016).

Lower PA levels increase the risk of developing HF. Similarly, due to the nature of HF, patients with HF are at a greater risk for a sedentary lifestyle. Since PA has been shown to have such a significant positive impact on patients with chronic diseases, such as HF, it is important to examine if there is a relationship between PA and HF readmissions. The purpose of this study

was to evaluate the effect PA, as measured by PAVS, had on time to readmission for patients with HF at a large hospital system in the Western United States.

Methods

To pursue the purpose of this study, a retrospective examination of patients' charts was performed. Before performing the review, ethical implications were considered. Institutional Review Board approval was obtained through the healthcare system. After identifying the appropriate patients' charts, the data were de-identified to safeguard the patients' personal health information. Data was obtained only through secure email due to the healthcare system's preference to further protect confidentiality.

After taking the necessary precautions, a data extractor employed by the healthcare system pulled charts for all patients with an admission for HF between January 1, 2016 and August 31, 2018. The data extractor excluded patients that were 18 years of age or younger, pregnant, and those that had a congenital heart defect. This resulted in 6,682 encounters for patients who were admitted to any of the 22 hospitals within the healthcare system during the specified timeframe while meeting the inclusion and exclusion criteria. The data extractor obtained variables from each patient's chart from initial admission. Variables included PAVS score, age, sex, height, admission weight, discharge weight, BMI, ejection fraction (EF), length of stay, brain natriuretic peptide (BNP) level, and compliance with previous Centers for Medicare & Medicaid Services (CMS) core measures as related to HF.

Even though CMS no longer requires data collection pertaining to most of the HF core measures, the healthcare system in this study continues to collect those data and abides by the measures to guide their practice. These measures include evaluating left ventricular systolic function, having an angiotensin-converting enzyme inhibitor or angiotensin II receptor blocker

prescribed for patients that have an EF less than 40% at discharge, teaching HF specific information during the hospitalization, having a follow-up appointment scheduled within 7 days of discharge and providing smoking cessation advice or counseling. The healthcare system used a binary system to code for general CMS core measures compliance, meaning that all of the CMS measures had to be completed to be considered compliant.

According to the power analysis, approximately 114 participants were needed with a significance (alpha) of 0.05, a power of 80%, and a medium effect size of 0.15. After identifying the 6,682 HF admissions within the system, the healthcare system's year-to-date readmission report was reviewed to identify patients with 30-day readmissions. Days between the initial HF admission and the subsequent readmission was also noted. The data were reviewed and duplicate entries were removed. Outliers in the PA data were also removed due to improbable data, likely from error in calculation or data entry. This left 270 unique patients included in the study. Data analysis included Pearson's correlations and multiple regression using IBM SPSS Statistics to analyze the relationship between variables and how PAVS predicts 30-day HF readmission rates, while controlling for sex, age, EF, BMI, length of hospital stay, BNP level, and compliance with previous CMS core measures. Multiple regression was used, rather than logistic regression, as days to readmission was made a continuous variable based on the number of days to readmission (0, 1, 2, 3, 4, etc.).

Results

The study included 270 patients with an almost equal number of males (n=137, 50.7%) and females (n=133, 49.3%). Patients included in the study were admitted to eight hospitals within the system with 160 (59.2%) being admitted to the largest hospital in the system. The patients included in the study ranged from 27 to 100 years old with the mean age being 72.7

years. Two hundred and eleven patients had their EF measured on admission, and data showed patients' EF ranged from 11% to 78% with a mean EF of 45.8%. BMI at discharge ranged from 15.9 to 75.1 with a mean of 32.5. The average length of stay of those included in this study was 4.5 days. The minimum length of stay was less than a day and the maximum was almost four weeks. The majority of patients (85.6%) had a BNP level measured on admission; the mean BNP level was 1016.8. Only half (50.7%) of those included in the study met all CMS core measures related to HF.

Regarding PA, 123 (45.6%) of the patients reported participating in no PA, 110 (40.7%) reported light intensity PA, 37 (13.7%) reported at least some moderate intensity PA, and only 17 (6.3%) reported getting 150 minutes of at least moderate PA per week. Five of the 270 did not have data indicating whether or not they participated in 150 minutes of moderate intensity PA weekly. The average duration of moderate intensity PA was 20.9 minutes per week. This means patients in the study averaged less than three minutes of moderate physical activity per day.

There were 36 patients that had more than one admissions included in the study. One patient had four admissions during the study period, meaning that this single patient was readmitted three times within the study period. Days to readmission ranged from zero to 442 with the average number of days to readmission for those 36 patients being 104.5 days. See full demographic data in Table 1.

To further interrogate the data, a Pearson Correlation matrix was created with the control variables and a 30-day mortality index. The length of hospitalization was significantly positively correlated with both 30-day mortality and number of admissions during the study period. The 30-day mortality index was negatively correlated with sex and EF on admission, while it was positively correlated with weight change in the hospital. On the sex variable, males = 0 and

female = 1, so the 30-day mortality and sex correlation means that males had a higher incidence of being included in the 30-day mortality index. The number of admissions was correlated with a higher BNP on admission. Being female correlated with having a higher EF on admission. Both an increase in age and CMS compliance were associated with lower BMI on discharge. BNP was negatively correlated with EF on admission, weight change in hospital, and BMI on discharge. EF on admission was positively related to weight change in the hospital and BMI on discharge. See Table 2 for full details.

A multiple linear regression was performed to calculate the number of hospitalizations during the study period based on age, sex, CMS compliance, age, EF on admission, length of hospital stay, discharge BMI, and if the patient met the national guideline for PA. Due to the nature of this specific analysis 207 patients were included. The mean and standard deviation was ascertained for all of the variables. The same binary systems were used for sex and CMS compliance as previously mentioned. A binary system was also used for PA for this analysis, meaning that the patients were meeting the recommended guidelines for PA or they were not. The regression formula used was ($F(7,199)=1.083$, $p < 0.376$) with an R^2 of 0.037. The estimated number of admission in the study period is the sum of 0.823 + 0.104 (Sex) + 0.046 (CMS compliance) + 0.003 (Age) – 0.003 (EF on admission) + 0.008 (Length of hospital stay) + 0.003 (Discharge BMI) – 0.148 (150 minutes of MVPA per week?). The binary systems were sex is coded as 0=Male, 1=female, CMS compliance is coded as 0=Non-compliant, 1=compliant, and meeting the recommend 150 minutes of PA per week coded as 0=No, 1=Yes. The other dependent variables were measured in appropriate intervals; Age is measured in years, EF is measured in a percentage, length of stay is measured in days, and BMI is measured in kg/m^2. None of the dependent variables met the set alpha of 0.05 and, therefore, were not significant

independent predictors of the number of admissions during the study period. The analysis of variance showed $p = 0.376$, which is statistically insignificant.

Discussion

Only 6.3% of the patients in the study reported meeting at least the 150 minutes of moderate-to-vigorous PA recommended by the Department of Health and Human Services compared to the 20% of the general public reported in the Physical Activity Guidelines for Americans, 2nd edition, 2018. The guidelines recommend those with chronic conditions, such as HF, participate in the same amount of activity, if they are able (Piercy et al., 2018). The physically limiting nature of HF may explain why the patients' participation in PA was lower than the general public.

The Pearson Correlation matrix that was used in this study may be helpful in suggesting areas to research in future HF studies. While not suggesting causation, the correlations are interesting. Length of hospitalization may be a significant predictor in mortality. This might be due to the fact that sicker patients typically have lengthier hospital stays. The inverse correlation between EF on admission and the 30-day mortality index was also note worthy. While this study did not differentiate between patients with HF with reduced EF (≤40%, HF with preserved EF (≥50%), and HF with borderline EF (41-49%), the correlation might suggest that having a lower EF may have a higher 30-day mortality rate, which would be consistent with a recent study (Toma et al., 2014). It should be mentioned that the PA variables did not significantly correlate with any of the other variables in the Pearson Correlation.

Limitations

This study used the PAVS tool that has been validated, but it does rely on self-reported data that may or may not be accurate. Additionally, only 270 unique patient admissions were

used of the 6,682 HF admissions within the system during the study period mostly due to limited PAVS data. Although the study had a sufficient number of participants to show significance according to the initial power analysis, included patient data represented only about four percent of the HF admissions in the healthcare system in this study. Consistent collection of PA data on admission to the hospital may enhance participation in studies similar to this one in the future. Measuring PA is important because PA is a useful tool in preventing HF, managing HF, and predicting HF outcomes (Cattadori, Segurini, Picozzi, Padeletti, & Anzà, 2018). After knowing a person's PA level, a healthcare provider can make appropriate recommendations regarding PA.

BMI was calculated on both admission and discharge weights. Discharge BMI was used as a control since it was believed to be more accurate. Data gathered showed that one patient gained 57 pounds between admission and discharge. That amount of weight gain during a hospitalization is highly unlikely and is most likely due to an error in data entry. Error could have occurred with the data entry itself or the healthcare professional could have asked the patient to estimate their current weight and obtained an incorrect weight. One recommendation to limit this type of suspected error is using an objective measurement of weight, such as a standing or bed scale, each time a weight is recorded for a patient. In addition to recording correct weights on admission to the hospital, patients should keep track of their weight at home since recording one's weight daily in a diary has been shown beneficial in reducing HF admissions (Jones et al., 2014). The reduction in readmissions may be due to the fact that when patients are tracking their weight daily, they are able to see if they are gaining weight and are able to intervene more quickly rather than waiting for other symptoms to occur before seeking medical care.

This study did not differentiate between patients who were admitted with an initial presentation of HF or had been diagnosed previously. This could be a significant factor in the

patients' understanding of the HF disease process, how they manage their symptoms, and knowing how the disease is progressing. A patient who presents with an initial episode of HF may need more education regarding symptoms of HF and the disease process. Someone who is admitted with HF who has been diagnosed previously may be more aware of symptoms related to HF and so may seek treatment earlier or, conversely, a patient may delay seeking care in an attempt to self-manage which could result in needing more aggressive therapy. Knowing whether or not it is a first encounter with HF could give some insight into how the disease is progressing especially regarding their EF.

Conclusion

While this study did not show a significant correlation, either positive or negative, between PA as measured by the PAVS tool and HF readmissions, PA remains an important aspect of managing HF. A healthcare provider should oversee and encourage PA, especially in those who have HF.

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Table 1
Descriptive Statistics

	N	Minimum	Maximum	Mean
Age	270	27	100	72.7
BNP on admission [a]	231	15	5000	1016.8
Discharge BMI [b]	270	15.9	75.1	32.5
EF on admission	211	11	78	45.84
Length of hospital stay [c]	270	0.8	26.6	4.5
MVPA minutes per week [d]	265	0	420	20.9

[a] BNP= brain natriuretic peptide and is measured in pg/mL
[b] BMI=body mass index and is measured in kg/m^2
[c] Length of stay measured in days
[d] MVPA=moderate to vigorous physical activity

Table 2
Significant Findings in the Pearson Correlation Matrix

	Correlated variable	N	r	p
Length of hospital stay	30-day mortality	270	0.151	0.013
	# of admission during study	270	0.174	0.004
30-day mortality index	Sex (Male)	270	0.158	0.009
	EF on admission	211	-0.166	0.016
	Weight change in hospital	270	0.148	0.015
# of admissions during study	BNP on admission	231	0.213	0.001
Sex (Female)	EF on admission	211	0.202	0.003
Age	BMI on discharge	270	-0.413	<0.001
CMS compliance	BMI on discharge	270	-0.192	0.002
BNP on admission	EF on admission	185	-0.404	<0.001
	Weight change in hospital	231	-0.177	0.007
	BMI on discharge	231	-0.353	<0.001
EF on admission	Weight change in hospital	211	0.202	0.003
	BMI on discharge	211	0.196	0.004

Note: BNP=brain natriuretic peptide, CMS=Centers for Medicare & Medicaid Services, EF=Ejection fraction

Table 3
Multiple Linear Regression Results: Number of Readmissions

	Mean	Std. Deviation	Sig.
(Equation Constant)	1.15	±0.474	0.009
Sex (Female)	0.49	±0.501	0.124
CMS compliance	0.51	±0.501	0.534
Age	73.35	±13.162	0.322
EF on admission	45.92	±17.078	0.215
Length of hospital stay	4.34	±2.984	0.478
Discharge BMI	32.54	±10.306	0.380
PAVS: 150 minutes of MVPA per week?	0.07	±0.260	0.255

Note: Result of multiple linear regression was ($F(7,199)=1.083$, $p = 0.376$) with an R^2 of 0.037. BMI=Body mass index, CMS=Centers for Medicare & Medicaid Services, EF=Ejection fraction, MVPA=Moderate-to-vigorous physical activity, PAVS=Physical Activity Vital Sign