Implementing the physical activity vital sign in an academic preventive cardiology clinic

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ABSTRACT

The aims were to implement physical activity (PA) screening as part of the electronic kiosk check-in process in an adult preventive cardiology clinic and assess factors related to patients' self-reported PA. The 3-question physical activity vital sign (PAVS) was embedded in the Epic electronic medical record and included how many days, minutes and intensity (light, moderate, vigorous) of PA patients conducted on average. This is a data analysis of PAVS data over a 60-day period. We conducted multivariable logistic regression to identify factors associated with not meeting current PA recommendations. Over 60 days, a total of 1322 patients checked into the clinic using the kiosk and 72% (n = 951) completed the PAVS at the kiosk. The majority of those patients were male (58%) and White (71%) with a mean age of 64 ± 15 years. Of the 951 patients completing the PAVS, 10% reported no PA, 55% reported some PA, and 35% reported achieving at least 150 min moderate or 75 min vigorous PA/week. In the logistic model, females (AOR = 1.4, 95%CI: 1.002–1.8, p = .049) vs. males, being Black (AOR = 2.0, 95%CI: 1.04–3.7, p = .038) or 'Other' race (AOR = 1.5, 95%CI: 1.02–2.3, p = .035) vs. White, unknown or other types of relationships (AOR = 0.0.26, 95%CI: 0.10–0.68, p = .006) vs. being married/partnered, and those who were retired (AOR = 1.9, 95% CI: 1.4–2.8, p < .001) or unemployed (AOR = 2.2, 95%CI: 1.3–3.7, p = .002) vs. full-time workers were associated with not achieving recommended levels of PA.

The PAVS is a feasible electronic tool for quickly assessing PA and may prompt providers to counsel on this CVD risk factor.

1. Introduction

Globally, physical inactivity is the fourth leading risk factor for mortality (World Health Organization, 2020). According to the American Heart Association (AHA) physical inactivity is a major modifiable risk factor for cardiovascular disease (CVD) (Lavie et al., 2015). Insufficient physical activity (PA) is associated with up to 3.0% of total direct healthcare expenditures in developed countries such as the US (Benjamin et al., 2018). Despite the strong evidence regarding the hazards of physical inactivity and the benefits of PA (lower risk for CVD, hypertension, stroke, type 2 diabetes, hyperlipidemia, depression and elevated body mass index, and improved cardiorespiratory fitness and quality of life) (Physical Activity Guidelines Advisory Committee, 2018; Boniol et al., 2017; Mann et al., 2014; Kato et al., 2017; Pressler et al., 2016; Lee et al., 2012; Scollan-Koliopoulos, 2004; Ross et al., 2016)

about half (47%) of U.S. adults do not achieve the recommended levels of PA (FastStats, 2020). Moving individuals out of the lowest category of cardiorespiratory fitness results in the greatest reductions in all-cause mortality (Ross et al., 2016) and can be achieved with increased PA (Lauer et al., 2017). Healthcare providers are in a position to influence this process by routinely counseling patients on this important CVD risk factor (Patnode et al., 2017).

Organizations worldwide provide PA recommendations, including the World Health Organization (WHO) (World Health Organization, 20201) the European Guidelines on CVD prevention, (Piepoli et al., 2016) the AHA, and the American College of Cardiology (Eckel et al., 2014). The U.S. 2018 PA Guidelines for Americans recommends 150 min/week of moderate intensity PA or 75 min/week of vigorous intensity PA, or an equivalent combination of both, with vigorous activity weighted twice that of moderate (Physical Activity Guidelines Advisory

Committee, 2018).

The U.S. Preventive Services Task Force recommends referring adults with CVD risk factors seen in primary care to behavioral counseling interventions to promote PA for CVD prevention (LeFevre, 2014). Healthcare providers can be instrumental sources of health guidance for their patients (Patrick et al., 2009). Primary care behavioral counseling for CVD prevention was associated with a 35-minute/week (95% CI: 22–47) improvement in PA levels (Patnode et al., 2017). While the use of brief one-time counseling has not been shown to be enough to effect long-term change, routine office-based screening and advice coupled with ongoing support has been effective in improving PA (Patrick et al., 2009). The AHA recommends the use of goal setting, self-monitoring, follow-up, and feedback when promoting PA (Artinian et al., 2010). Improving rates of healthcare providers counseling on PA is one of the objectives of Healthy People 2020; in 2012 only 7.7% of office visits in patients with CVD, diabetes or hyperlipidemia included PA counseling (Physical Activity | Healthy People, 2019). Further, individual counseling is important given known sex and racial disparities in achieving PA guidelines (Data Finder – Health, United States - Products, 2020; Whitaker et al., 2018).

The physical activity vital sign (PAVS) is a valid clinical tool to assess PA (Greenwood et al., 2010). The PAVS can be the basis for PA promotion and counseling, and several large healthcare systems have implemented the PAVS for assessment of PA (Sallis, 2015). Data from almost 20 hospitals indicate the PAVS has strong face and discriminant validity (between patients with differing activity levels) (COLEMAN et al., 2012). Use of the PAVS had a clinical impact on the frequency of provider counseling compared to visits where the PAVS was not collected (88% vs.76%, p < .001) (Golightly et al., 2017). However, despite strong endorsement from the AHA, (Eckel et al., 2014) many healthcare providers continue to describe barriers to PA counseling, including lack of time, required counseling skills, reimbursement, and routine screening of PA (AuYoung et al., 2016).

The first step in counseling patients on their current PA levels is to assess their current level of PA, allowing providers to counsel accordingly. Currently about 53% of US adults meet guidelines for aerobic PA although that varies by state. For example in New York about 49% of adults while in California 57.5% meet guidelines (Data, 2019). Achievement also varies by age, sex and race/ethnicity. In a national sample, the percentage of U.S. adults meeting current PA guidelines decreased with increasing age (Zenko et al., 2018). In the 25–45-year-old age group 68% met recommended levels of PA, which declined in the 45–64-year-old age group (58%), and declined further in those age 65+ (30%). In 2018, more males reported adequate PA than females (58.1% vs. 50.6%) (Physical Activity | Healthy People, 2019). In 2018, White non-Hispanic adults had the highest level of sufficient PA (57.6%) as compared to Asian (54.8%), Hispanic (47.8%), or African American (46.2%) adults (Physical Activity | Healthy People, 2019). Given the importance of assessing routine PA and the differences noted in achievement across location, sex, race/ethnicity, the aims of this study were to implement physical activity screening as part of the electronic kiosk check-in process in an adult preventive cardiology clinic in an academic medical center and assess factors related to patients' self-reported PA using the PAVS results. This study will test the feasibility of the PAVS data collection and allow us to compare PA levels to national data.

2. Methods

This was a cross-sectional secondary data analysis of PA data from adult patients (age 18 and above) seeking care in a preventive cardiology clinic. The clinic for data collection was a faculty practice group of 10 cardiologists located in an academic medical center. The cardiologists treat adults with CVD risk factors (>50% of patients) or with established CVD. Patients with established CVD have repeat visits every three to six months, with more variation for patients with only CVD risk

factors. There are approximately 100 patient visits per week.

The physical activity vital sign (PAVS) was embedded into the Epic electronic health record in the clinic and includes 3 questions about the average days, minutes and intensity (light, moderate, vigorous) of PA they engaged in per week. Upon checking in for their appointment each patient was presented with the following questions on the electronic check-in kiosk: 1) "On average, how many days per week do you engage in PA or exercise?"; 2) "On average, how many total minutes of PA or exercise do you perform on those days?"; and 3) "Describe the intensity of your PA or exercise (light = casual walk, moderate = brisk walk, or vigorous = jogging)." (Coleman et al., 2012; Golightly et al., 2017) The options for number of days range from 0 to 7 days. Time increments are as follows: 10, 20, 30, 40, 50, 60, 90, 120, 150 or greater. The number of days and minutes are multiplied to give the number of minutes per week. These data in combination with the intensity (light, moderate, vigorous) allow the provider to assess achievement of PA guidelines. Light activity is recorded to acknowledge the effort by the patient but does not count toward the achievement of 150 min of moderate or 75 min of vigorous PA. There is a final statement under the PAVS questions "Physical activity not assessed due to" with four response options: 1) physical disability/wheelchair bound; 2) Patient lacks mental capacity; 3) Patient declines screening; 4) Other/comment. These patient data were retained in their Epic electronic medical record.

2.1. Data analysis

We conducted an analysis of de-identified patient records from all preventive cardiology clinic visits during a 60-day period (May to June 2019). This included descriptive statistics on demographic and clinical data, and the percent of patients at three levels of PA: (1) no PA, (2) some PA but not at goal, or (3) ≥ 150 min moderate or 75 min vigorous PA/week. Using bivariate statistics (analysis of variance, Chi-square tests) we assessed for significant relationships between factors previously known to be associated with PA: age, sex, race, marital status, employment, smoking status, blood pressure, body mass index, and lipid levels. All data were taken from the patient's electronic health record and were used as follows: age in years; sex (male, female); race (White, African American (Black), Asian, other; marital status (single, married, legally separated/divorced/widowed, & other [which included 'partnered or unknown']); employment (full-time, retired, unemployed, & other [part-time, student, self-employed, unknown]); smoking status (never, current, quit); blood pressure (categorized as normal [systolic ≥ 90 and < 120 and diastolic ≥ 60 and < 80], elevated [systolic 120–129 and diastolic < 80], or hypertension [systolic ≥ 130 or diastolic ≥ 80]) (New and High Blood Pressure Guidelines Lower Definition, 2021); body mass index in kg/m (Lavie et al., 2015); and total cholesterol, HDL, and triglycerides. The most recent value available was used for all clinical data.

The bivariate analyses were then followed by multivariable logistic regression to identify the sociodemographic or clinical factors that were associated with not achieving current PA recommendations. Factors significantly related to PA at p < .05 in the bivariate analyses were included in the logistic regression (sex, race, marital status, and employment status). Given the small contribution of the physiological variables to the logistic regression model, and the expected directionality of influence (PA would be expected to impact physiological measures, not vice versa) these variables were not included the logistic regression and the results from the more parsimonious model is presented. Appropriate IRB review was conducted for this study.

3. Results

Over 60 days, a total of 1322 patients checked into the preventive cardiology clinic using the electronic kiosk. Of the 1,322 patients, 72% (n = 951) completed the 3 PAVS questions from the single prompt at the check-in kiosk. Those who did not complete the PAVS (n = 371) were

older (72 ± 15 vs 64 ± 15 years, p < .001), less likely to be employed full time and more likely to be retired (p < .001) (Table in Appendix). The majority of the 951 patients with complete PAVS data were male (58%), White (71%) and married (62%). The sample had a mean age of 64 ± 15 years, 41% worked full-time and the majority (57%) were never smokers. The three most common primary diagnoses were hyperlipidemia (21%), coronary artery disease (20%), and hypertension (13%). Complete demographics of this sample are listed in Table 1.

Of those patients completing the PAVS, 10% reported no PA, 55% reported some PA but not at goal, and 35% reported achieving at least 150 min moderate or 75 min vigorous PA/week. In bivariate analyses (achieving recommended PA vs. not achieving recommended PA), factors significantly associated with PA included sex (p < .001), race (p = .045), marital status (p < .001), employment (p < .001), body mass index (p = .004) and triglycerides (p = .011). Those who had higher percentages of achieving PA recommendations were: males (as compared to females); White race (as compared to other racial categories); in 'other or unknown' types of relationships (compared to married, single, legally separate, divorced, widowed); working full-time (as compared to retired, in other employment categories or unemployed); overweight (as compared to under/normal or obese); and had lower triglycerides (Table 2).

In the logistic regression, Black adults were two times more likely (OR = 2.0, 95%CI: 1.04–3.7, p = .038) and 'Other' race adults were 1.5

Table 1
Sample Characteristics (n = 951).

Characteristic	Mean ± SD or n (%)
Female	398 (42%)
Race	
White	673 (71%)
Non-Hispanic Black	63 (7%)
Asian	55 (6%)
Other	160 (17%)
Age (years)	64 ± 15
Marital Status	
Married/Partnered/Significant Other	606 (64%)
Single	188 (20%)
Legally separated/divorced/widowed	136 (14%)
Unknown/Other	21 (2%)
Employment	
Work full-time	388 (41%)
Retired	284 (30%)
Other (part-time, student, self-employed, unknown)	172 (18%)
Unemployed	107 (11%)
Smoking Status	
Never smoked	545 (57%)
Quit	360 (38%)
Current smoker	24 (2.5%)
Blood Pressure Categories*	
Normal	276 (29%)
Elevated	170 (18%)
Hypertension	477 (50%)
Body Mass Index	
Underweight	11 (3.6%)
Normal (18.5 – < 25 kg/m^2)	98 (31.9%)
Overweight (25- < 30 kg/m^2)	100 (32.6%)
Obese (≥30 kg/m^2)	98 (31.9%)
Lipids	
Cholesterol	157 ± 43
HDL	52 ± 16
Triglycerides	112 ± 68
Most Common Primary Diagnoses	
Hyperlipidemia	197 (36%)
Coronary Artery Disease	189 (35%)
Hypertension	127 (23%)
Physical Activity Vital Sign	
No physical activity	97 (10%)
Some physical activity	525 (55%)
150 min moderate or 75 min vigorous physical activity	329 (35%)

* Normal: Systolic ≥90 and < 120 and Diastolic ≥60 and < 80; elevated: Systolic 120–129 and Diastolic < 80; Hypertension: Systolic ≥130 or Diastolic ≥80.

Table 2
Bivariate Associations with Achieving Physical Activity Recommendations (n = 951).

Variable	Yes (n = 329)	No (n = 622)	p
Sex			<0.001
Female	112 (28%)	286 (72%)	
Male	217 (39%)	336 (61%)	
Age years	62.5 ± 13.7	64.3 ± 15.0	0.077
Race			0.045
White	250 (37%)	423 (63%)	
Non-Hispanic Black	14 (22%)	49 (78%)	
Asian	16 (29%)	39 (71%)	
Other	49 (31%)	111 (69%)	
Marital Status			0.009
Married/Partnered/Significant Other	220	386	
Single	(36.3%)	(63.7%)	
Legally separated/divorced/widowed	58 (31%)	130 (69%)	
Unknown/Other	38 (28%)	98 (72%)	
	13 (61.9%)	8 (38.1%)	
Employment			<0.001
Work full-time	163 (42%)	225 (58%)	
Retired	76 (27%)	208 (73%)	
Other (part-time, self-employed, student, unknown)	66 (38%)	106 (62%)	
Unemployed	24 (22%)	83 (78%)	
Body Mass Index (BMI)*			0.004
Under/normal weight	34 (31%)	75 (69%)	
Overweight	33 (33%)	67 (67%)	
Obese	14 (14%)	84 (86%)	
High Density Lipoproteins	53 ± 16	51 ± 16	0.063
Triglycerides	104 ± 68	117 ± 68	0.011

Note. Data presented as n (%) or mean ± standard deviation; *(n = 307 available data for BMI).

times more likely (AOR = 1.5, 95%CI: 1.02–2.3, p = .04) than White adults to not achieve recommended levels of PA. An adult with unknown relationship status or being in other types of relationships were 74% less likely to not achieve recommended levels of PA (AOR = 0.26, 95%CI: 0.10–0.68, p = .006) vs. those who were married/partnered/significant other. Those who were retired were almost two times more likely (AOR = 1.9, 95% CI: 1.4–2.8, p < .001) and those who were unemployed were over two times more likely (AOR = 2.2, 95%CI: 1.3–3.7, p = .002) to not achieve recommended levels of PA as compared to full-time workers. The remaining variables were not significantly associated. Women were more likely than men to not achieve recommended levels of PA, (AOR = 1.35, 95%CI: 1.002–1.8, p = .049) (Table 3). Asian adults had higher odds of not achieving PA recommendations than White adults but this was not significant (AOR = 1.56; 95% CI: 0.84–2.9; p = .16). Being

Table 3
Logistic Regression on Not Achieving Physical Activity Recommendations (n = 951).

Parameter	Odds Ratio	95% CI	p
Female (vs. Male)	1.4	1.002–1.8	0.049
Race			
White	REF		
Black	2.0	1.0–3.7	0.038
Other	1.5	1.0–2.3	0.035
Asian	1.6	0.84–2.9	0.16
Marital Status			
Married/Partnered/Significant Other	REF		
Unknown/Other	0.26	0.10–0.68	0.006
Single	1.1	0.79–1.6	0.48
Legally separated/divorced/widowed	1.1	0.74–1.7	0.54
Employment			
Working full-time	REF		
Retired	1.9	1.4–2.8	<0.001
Unemployed	2.2	1.3–3.7	0.002
Other (part-time, self-employed, student, unknown)	1.2	0.83–1.78	0.31

single (AOR = 1.1; 95% CI: 0.79–1.6; p = .48) or in the separated/divorced/widowed group (AOR = 1.1; 95% CI: 0.74–1.7; p = .54) as compared to being married/partnered/having a significant other was not significant. Lastly, being in the group of part-time, self-employed, student, or unknown employment (AOR = 1.2; 95% CI: 0.83–1.8; p = .31) was not significantly associated with not achieving PA recommendations.

4. Discussion

In this study we analyzed data obtained from electronic PA screening in a preventive cardiology clinic and identified several factors associated with not achieving recommended levels of PA. These self-report data were collected as part of usual clinical care when patients checked in for their clinical appointment, providing important data to providers but not requiring time and effort from clinic staff, nor an order from the physician. Building this PAVS electronic assessment tool did not require external integrations with other systems, allowing it to be built with minimal cost. Further, our hospital system has standard workflows across the organization, making it straightforward and easy to scale from an internet technology perspective.

PA screening tools have been infrequently used in clinical care but they can play a role in documenting PA for monitoring and in identifying those who are not meeting PA guidelines who may benefit from an intervention (Wald and Garber, 2018). Brief PA screening has been implemented in two major hospital systems in the U.S. An electronic exercise vital sign was implemented in Kaiser Permanente (Coleman et al., 2012) as well as in Intermountain Healthcare (Ball et al., 2016) for use in primary care. A systematic review of physical activity as a vital sign found that healthcare practices that incorporated brief PA screening (vs. those that did not) demonstrated a greater frequency of physicians counseling on PA (Golightly et al., 2017). Exercise is Medicine® is a global health initiative to include PA assessment and promotion in clinical care, and provides evidenced-based PA resources for healthcare providers (Exercise is Medicine, 2017). Adding an activity tracker can build upon healthcare providers counseling, since it can act as a source of motivation and allow self-monitoring and the ability to take independent action (Donnachie et al., 2017). In adults with CVD, wearing an activity tracker coupled with PA advice resulted in greater improvements in cardiorespiratory fitness versus not wearing an activity tracker (Hannan et al., 2019). Future interventions may test different components to establish the most effective combination to effect change in patients' PA levels.

Over the 60-day period of data analyzed the majority of patients, but not all, provided enough PAVS data to analyze. From our data we were not able to ascertain the reason for non-response. Going forward, it may be helpful for the clinic staff to review the PAVS data with patients who were not able to answer all three questions. This review may clarify any confusion about the questions and allow patients to provide full data on their next clinic appointment. Incorporating patient reported outcomes into the electronic health record can improve both patient-centered care and population health (Gensheimer et al., 2018).

Overall, only 35% of our sample reported achieving current aerobic PA recommendations, which is lower than currently reported national data with 53% achievement of sufficient aerobic PA (FastStats, 2020). Our finding that females were more likely to not achieve PA recommendation is consistent with previous research. In a diverse sample of adults in the Multi-Ethnic Study of Atherosclerosis (MESA) study (n = 5,379), females achieved less PA than males (338 ± 490 vs. 468 ± 672 MET-min/week, p < 0.001) (Osibogun et al., 2019). In national U.S. data from 2017, males were more likely to achieve aerobic and muscle strengthening exercise guidelines than females (29% vs. 20.2%) (Data Finder - Health, United States - Products, 2020). Further, as females aged, the percent who engaged in adequate PA declined steadily, from 24.1% in females age 18–44 to a low of 6.9% in females ≥ 75 years. In those adults experiencing a myocardial infarction, males were

significantly more physically active (achieving recommended PA) than females at baseline (prior to the myocardial infarction), as well as one month and 12 months after the myocardial infarction (Minges et al., 2017). These trends are concerning given the role of physical activity in reducing cardiovascular and all-cause mortality (Exercise is Medicine, 2017).

We also found racial differences in achievement of recommended PA. Those of Black or 'other' race were more likely to report not achieving recommended PA as compared to Whites. This disparity is consistent with previous data across the U.S. In 2017, fewer Blacks (20.8%), American Indian/Alaska Native (23.8%) and Asians (22.3%) met both aerobic-activity and muscle-strengthening guidelines vs. Whites (25.3%) (Data Finder - Health, United States - Products, 2020). However, the trend for Black as well as White adults has been improving in the past 20 years since only 11.7% and 14.8% respectively, met PA guidelines in 1998. In the Coronary Artery Risk Development in Young Adults (CARDIA) study, cardiovascular health behaviors were assessed for smoking, PA and diet (Whitaker et al., 2018) and scored according to American Heart Association's criteria for ideal cardiovascular health (poor, intermediate, ideal) (Lloyd-Jones et al., 2010). Over 30 years of follow-up, Blacks had poorer health behavior scores than Whites, with individual socioeconomic factors mediating the largest proportion of the association between race and cardiovascular health behavior score (Whitaker et al., 2018). These patterns strongly suggest a need to promote not only PA to Black adults at risk of CVD, but all heart healthy behaviors.

We found that those who were retired or unemployed were twice as likely to report not achieving PA guidelines as those who were working. It may be that these working adults were obtaining more occupational or travel PA, but it points to a need to encourage those who are currently unemployed or retired to remain physically active. Our findings for retired adults are inconsistent with a previous systematic review of PA in retirement (Barnett et al., 2012). In that review, 19 studies from all countries were included and ten were conducted in the U.S. Unfortunately, only three studies used validated PA questionnaires to assess PA, nine used a single question to assess PA and most studies were of low or modest quality. Regardless, the time of transition to retirement presents a window of opportunity for encouraging patients to remain or become physically active (Barnett et al., 2012).

Lastly, we found those who were in other or unknown types of relationships vs. being married/partnered/significant other were much less likely to report not achieving PA guidelines. Spousal PA levels can be an important influence on their partner's PA levels. In data from the Atherosclerosis Risk in Communities (ARIC) study involving 3,261 pairs, individuals were more likely to meet PA guidelines if their spouse also met PA guidelines (Cobb et al., 2016). However, in a sample of U.S. adults aged ≥ 60 (n = 1317), those who were not married were more likely to meet PA guidelines as compared to adults who were married or in a domestic relationship (OR = 1.25 (95% CI:0.86–1.82) (Zytnick et al., 2021). It is unclear from our results why we found these differences within marital status. Future qualitative research may be needed. Interventions that target both members of a couple (whether married or not) may be successful in improving PA for both adults.

Although age has been associated with PA in previous research, it was not associated with achieving PA guidelines in this sample. It is possible that age was not significantly associated with PA given the homogeneity of a sample of patients receiving care in a preventive cardiology clinic, as compared to large national samples. The impact of age on PA can be tested in future analyses that include additional diagnostic or clinical data.

5. Limitations and strengths

This study had several limitations. The data collected from the electronic health record for this analysis were cross-sectional and therefore limited our ability to establish causality between the predictor

variables and the PAVS results. The PAVS was self-report aerobic PA data, which may not be as accurate as collecting objective PA data from an activity tracker. It did not include questions of muscle-strengthening activity, which is also part of current PA guidelines. This secondary data analysis was limited by the variables available in a report generated by the data services team and included some missing data. We also did not assess the reasons for the incomplete PAVS data on those who did not provide answers to all three questions (e.g., unable to understand the questions, or too busy to enter the data) which will be important data moving forward. Finally, we were not able to explain the differences in PA achievement among different types of couples' relationships. Future qualitative study might clarify these differences. Despite these limitations, we demonstrated that the assessment of PA is feasible in a clinic setting. By using existing technology, EHR data collection was possible with minimal staffing resources. Our findings support the fact that sociodemographic differences remain in PA achievement. Lastly, these PAVS data are easily accessible and can facilitate PA counseling by the provider during a brief patient visit.

6. Conclusion

In an academic preventive cardiology clinic, only approximately one-third of the patients who completed the PAVS questions at check-in reported achieving AHA recommended levels of PA. In the sample of patients that responded, the data support particular attention to PA counseling and prescription in females, minorities and those who are retired. Additionally, embedding the PAVS into a clinical electronic health system is a feasible and scalable intervention to collect PA data. These data are part of the patients' electronic health record and can be viewed by their healthcare provider before or during their appointment, prompting a discussion to address this CVD risk factor.

CRediT authorship contribution statement

Margaret M. McCarthy: Conceptualization, Data curation, Project administration, Formal analysis, Methodology, Writing - original draft, Writing - review & editing. **Jason Fletcher:** Conceptualization, Formal analysis, Writing - review & editing. **Sean Heffron:** Conceptualization, Data curation, Writing - review & editing. **Adam Szerencsy:** Conceptualization, Data curation. **Devin Mann:** Conceptualization, Data curation. **Allison Vorderstrasse:** Conceptualization, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2021.101435.

References

Artinian, Nancy T., Fletcher, Gerald F., Mozaffarian, Dariush, Kris-Etherton, Penny, Van Horn, Linda, Lichtenstein, Alice H., Kumanyika, Shiriki, Kraus, William E., Fleg, Jerome L., Redeker, Nancy S., Meininger, Janet C., Banks, JoAnne, Stuart-Shor, Eileen M., Fletcher, Barbara J., Miller, Todd D., Hughes, Suzanne,

Braun, Lynne T., Kopin, Laurie A., Berra, Kathy, Hayman, Laura L., Ewing, Linda J., Ades, Philip A., Durstine, J. Larry, Houston-Miller, Nancy, Burke, Lora E., 2010. Interventions to promote physical activity and dietary lifestyle changes for cardiovascular risk factor reduction in adults: a scientific statement from the American Heart Association. Circulation. 122 (4), 406–441. https://doi.org/10.1161/CIR.0b013e3181e8edf1.

AuYoung M, Linke SE, Pagoto S, et al. Integrating Physical Activity in Primary Care Practice. AmJMed. 2016;(Journal Article).

Ball, T.J., Joy, E.A., Gren, L.H., Cunningham, R., Shaw, J.M., 2016. Predictive validity of an adult physical activity "vital sign" recorded in electronic records. J. Phys. Act Health 13 (4), 403–408. https://doi.org/10.1123/jpah.2015-0210.

Barnett, I., van Sluijs, E.M.F., Ogilvie, D., 2012. Physical activity and transitioning to retirement. Am. J. Preven. Med. 43 (3), 329–336. https://doi.org/10.1016/j.amepre.2012.05.026.

Benjamin EJ, Virani SS, Callaway CW, et al. Heart Disease and Stroke Statistics-2018 Update: A Report From the American Heart Association. Circulation. 2018;(Journal Article).

Boniol, M., Dragomir, M., Autier, P., Boyle, P., 2017. Physical activity and change in fasting glucose and HbA1c: a quantitative meta-analysis of randomized trials. Acta Diabetol. 54 (11), 983–991. https://doi.org/10.1007/s00592-017-1037-3.

Cobb, L.K., Godino, J.G., Selvin, E., Kucharska-Newton, A., Coresh, J., Koton, S., 2016. Spousal influence on physical activity in middle-aged and older adults: the ARIC study. Am. J. Epidemiol. 183 (5), 444–451. https://doi.org/10.1093/aje/kwv104.

Coleman KJ, Ngor E, Reynolds K, et al. Initial validation of an exercise "vital sign" in electronic medical records. MedSciSports Exerc. 2012;44(11):2071-2076. doi: 10.1249/MSS.0b013e3182630ec1.

Data Finder - Health, United States - Products. Published March 31,s 2020. Accessed July 1, 2020. https://www.cdc.gov/nchs/hus/contents2018.htm.

Data, Trends and Maps | Physical Activity | CDC. Published July 23, 2019. Accessed January 6, 2021. https://www.cdc.gov/physicalactivity/data/databases.htm.

Donnachie C, Wyke S, Mutrie N, Hunt K. "It's like a personal motivator that you carried around wi' you': utilising self-determination theory to understand men's experiences of using pedometers to increase physical activity in a weight management programme. IntJBehavNutrPhysAct. 2017;14(1):61-017-0505-z. doi: 10.1186/s12966-017-0505-z.

Eckel RH, Jakicic JM, Ard JD, et al. 2013 AHA/ACC guideline on lifestyle management to reduce cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. JAmCollCardiol. 2014;63(25 Pt B):2960-2984. doi:10.1016/j.jacc.2013.11.003.

Exercise is Medicine. Healthcare Provider Resources. Published online 2017. http://www.exerciseismedicine.org/support_page.php/health-care-providers/.

FastStats. Published August 10, 2020. Accessed January 26, 2021. https://www.cdc.gov/nchs/fastats/exercise.htm.

Gensheimer SG, Wu AW, Snyder CF, PRO-EHR Users' Guide Steering Group, PRO-EHR Users' Guide Working Group. Oh, the Places We'll Go: Patient-Reported Outcomes and Electronic Health Records. Patient. 2018;11(6):591-598. doi: 10.1007/s40271-018-0321-9.

Golightly, Yvonne M., Allen, Kelli D., Ambrose, Kirsten R., Stiller, Jamie L., Evenson, Kelly R., Voisin, Christiane, Hootman, Jennifer M., Callahan, Leigh F., 2017. Physical activity as a vital sign: a systematic review. Preven. Chronic Dis. 14 https://doi.org/10.5888/pcd14.170030.

Greenwood, J.L., Joy, E.A., Stanford, J.B., 2010. The physical activity vital sign: a primary care tool to guide counseling for obesity. J. Phys. Act Health 7 (5), 571–576.

Hannan, A.L., Harders, M.P., Hing, W., Climstein, M., Coombes, J.S., Furness, J., 2019. Impact of wearable physical activity monitoring devices with exercise prescription or advice in the maintenance phase of cardiac rehabilitation: systematic review and meta-analysis. BMC Sports Sci. Med. Rehabil. 11, 14. https://doi.org/10.1186/s13102-019-0126-8.

Kato, M., Kubo, A., Nihei, F., Ogano, M., Takagi, H., 2017. Effects of exercise training on exercise capacity, cardiac function, BMI, and quality of life in patients with atrial fibrillation: a meta-analysis of randomized-controlled trials. IntJRehabilRes 40 (3), 193–201. https://doi.org/10.1097/MRR.0000000000000232.

Lauer, E.E., Jackson, A.W., Martin, S.B., Morrow Jr., J.R., 2017. Meeting USDHHS physical activity guidelines and health outcomes. Int. J. Exerc. Sci. 10 (1), 121–127.

Lavie, C.J., Arena, R., Swift, D.L., Johannsen, N.M., Sui, X., Lee, D.-C., Earnest, C.P., Church, T.S., O'Keefe, J.H., Milani, R.V., Blair, S.N., 2015. Exercise and the cardiovascular system: clinical science and cardiovascular outcomes. CircRes. 117 (2), 207–219. https://doi.org/10.1161/CIRCRESAHA.117.305205.

Lee, I.-M., Shiroma, E.J., Lobelo, F., Puska, P., Blair, S.N., Katzmarzyk, P.T., 2012. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. Lancet 380 (9838), 219–229. https://doi.org/10.1016/S0140-6736(12)61031-9.

LeFevre, M.L., 2014. U.S Preventive Services Task Force. Behavioral counseling to promote a healthful diet and physical activity for cardiovascular disease prevention in adults with cardiovascular risk factors: U.S Preventive Services Task Force Recommendation Statement. Ann. Int. Med. 161 (8), 587–593. https://doi.org/10.7326/M14-1796.

Lloyd-Jones, Donald M., Hong, Yuling, Labarthe, Darwin, Mozaffarian, Dariush, Appel, Lawrence J., Van Horn, Linda, Greenlund, Kurt, Daniels, Stephen, Nichol, Graham, Tomaselli, Gordon F., Arnett, Donna K., Fonarow, Gregg C., Ho, P. Michael, Lauer, Michael S., Masoudi, Frederick A., Robertson, Rose Marie, Roger, Véronique, Schwamm, Lee H., Sorlie, Paul, Yancy, Clyde W., Rosamond, Wayne D., 2010. Defining and setting national goals for cardiovascular health promotion and disease reduction: the American Heart Association's strategic Impact Goal through 2020 and beyond. Circulation 121 (4), 586–613. https://doi.org/10.1161/CIRCULATIONAHA.109.192703.

Mann, S., Beedie, C., Jimenez, A., 2014. Differential effects of aerobic exercise, resistance training and combined exercise modalities on cholesterol and the lipid profile: review, synthesis and recommendations. Sports Med. 44 (2), 211–221. https://doi.org/10.1007/s40279-013-0110-5.

Minges, Karl E, Strait, Kelly M, Owen, Neville, Dunstan, David W, Camhi, Sarah M, Lichtman, Judith, Geda, Mary, Dreyer, Rachel P, Bueno, Héctor, Beltrame, John F, Curtis, Jeptha P, Krumholz, Harlan M, 2017. Gender differences in physical activity following acute myocardial infarction in adults: a prospective, observational study. Eur. J. Prev. Cardiolog. 24 (2), 192–203. https://doi.org/10.1177/2047487316679905.

New ACC/AHA High Blood Pressure Guidelines Lower Definition of Hypertension. American College of Cardiology. Accessed January 28, 2021. http%3a%2f%2fwww.acc.org%2flatest-in-cardiology%2farticles%2f2017%2f11%2f08%2f11%2f47%2fmon-5pm-bp-guideline-aha-2017.

Osibogun, Olatokunbo, Ogunmoroti, Oluseye, Tibuakuu, Martin, Benson, Eve-Marie, Michos, Erin D, 2019. Sex differences in the association between ideal cardiovascular health and biomarkers of cardiovascular disease among adults in the United States: a cross-sectional analysis from the multiethnic study of atherosclerosis. BMJ Open 9 (11), e031414. https://doi.org/10.1136/bmjopen-2019-031414.

Patnode, C.D., Evans, C.V., Senger, C.A., Redmond, N., Lin, J.S., 2017. Behavioral counseling to promote a healthful diet and physical activity for cardiovascular disease prevention in adults without known cardiovascular disease risk factors: updated evidence report and systematic review for the us preventive services task force. JAMA 318 (2), 175–193. https://doi.org/10.1001/jama.2017.3303.

Patrick K, Pratt M, Sallis RE. The healthcare sector's role in the U.S. national physical activity plan. JPhysActHealth. 2009;6 Suppl 2(Journal Article):S211-9.

Physical Activity Guidelines Advisory Committee. Physical Activity Guidelines Advisory Committee Scientific Report. Washington, DC: U.S. Department of Health and Human Services. Published online 2018. https://health.gov/paguidelines/second-edition/report/pdf/PAG_Advisory_Committee_Report.pdf.

Physical Activity | Healthy People 20Accessed December 9, 2019. https://www.healthypeople.gov/2020/topics-objectives/topic/physical-activity/objectives.

Piepoli, M.F., Hoes, A.W., Agewall, S., Albus, C., Brotons, C., Catapano, A.L., Cooney, M.-T., Corrà, U., Cosyns, B., Deaton, C., Graham, I., Hall, M.S., Hobbs, F.D.R., Løchen, M.-L., Löllgen, H., Marques-Vidal, P., Perk, J., Prescott, E., Redon, J., Richter, D.J., Sattar, N., Smulders, Y., Tiberi, M., van der Worp, H.B., van Dis, I., Verschuren, W.M.M., De Backer, G., Roffi, M., Aboyans, V., Bachl, N., Bueno, H., Carerj, S., Cho, L., Cox, J., De Sutter, J., Egidi, G., Fisher, M., Fitzsimons, D., Franco, O.H., Guenoun, M., Jennings, C., Jug, B., Kirchhof, P., Kotseva, K., Lip, G.Y.H., Mach, F., Mancia, G., Bermudo, F.M., Mezzani, A., Niessner, A., Ponikowski, P.,

Rauch, B., Rydén, L., Stauder, A., Turc, G., Wiklund, O., Windecker, S., Zamorano, J.L., 2016. European Guidelines on cardiovascular disease prevention in clinical practice: The Sixth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of 10 societies and by invited experts): developed with the special contribution of the European Association for Cardiovascular Prevention & Rehabilitation (EACPR). Eur. J. Prev. Cardiol. 23 (11), NP1–NP96. https://doi.org/10.1177/2047487316653709.

Pressler, A., Christle, J.W., Lechner, B., Grabs, V., Haller, B., Hettich, I., Jochheim, D., Mehilli, J., Lange, R., Bleiziffer, S., Halle, M., 2016. Exercise training improves exercise capacity and quality of life after transcatheter aortic valve implantation: A randomized pilot trial. Am. Heart J. 182, 44–53.

Ross R, Blair SN, Arena R, et al. Importance of Assessing Cardiorespiratory Fitness in Clinical Practice: A Case for Fitness as a Clinical Vital Sign: A Scientific Statement From the American Heart Association. Circulation. 2016;(Journal Article).

Sallis, R., 2015. Exercise is medicine: a call to action for physicians to assess and prescribe exercise. Phys. Sportsmed. 43 (1), 22–26. https://doi.org/10.1080/00913847.2015.1001938.

Scollan-Koliopoulos, M., 2004. Theory-guided intervention for preventing diabetes-related amputations in African Americans. J. Vasc. Nurs. 22 (4), 126–133. https://doi.org/10.1016/j.jvn.2004.09.003.

Wald, Adrienne, Garber, Carol Ewing, 2018. A review of current literature on vital sign assessment of physical activity in primary care. J. Nurs. Scholarsh. 50 (1), 65–73. https://doi.org/10.1111/jnu.2018.50.issue-110.1111/jnu.12351.

Whitaker, Kara M, Jacobs, David R., Kershaw, Kiarri N., Demmer, Ryan T., Booth, John N., Carson, April P., Lewis, Cora E., Goff, David C., Lloyd-Jones, Donald M., Gordon-Larsen, Penny, Kiefe, Catarina I., 2018. Racial disparities in cardiovascular health behaviors: the coronary artery risk development in young adults study. Am J Prev Med. 55 (1), 63–71. https://doi.org/10.1016/j.amepre.2018.03.017.

[40] World Health Organization. Global Recommendations on Physical Activity for Health. Published online 2010. http://apps.who.int/iris/bitstream/10665/44399/1/9789241599979_eng.pdf.

Zenko Z, Willis EA, White DA. Proportion of Adults Meeting the 2018 Physical Activity Guidelines for Americans According to Accelerometers. Front Public Health. 2019; 7. doi:10.3389/fpubh.2019.00135.

Zytnick D, Kumar GS, Folta SC, Reid KF, Tybor D, Chomitz VR. Wearable Activity Monitor Use Is Associated With the Aerobic Physical Activity Guidelines and Walking Among Older Adults. Am J Health Promot. Published online January 7, 2021:0890117120985834. doi:10.1177/0890117120985834.