Exercise capacity is associated with hospital readmission among patients with diabetes

Yaara Zisman-Ilani 1, 2, Kevin Fasing, Mark Weiner, Daniel J Rubin 3, 4

ABSTRACT

Introduction Patients with diabetes are at greater risk of hospital readmission than patients without diabetes. There is a need to identify more modifiable risk factors for readmission as potential targets for intervention. Cardiorespiratory fitness is a predictor of morbidity and mortality. The purpose of this study was to examine whether there is an association between exercise capacity based on the maximal workload achieved during treadmill stress testing and readmission among patients with diabetes.

Research design and methods This retrospective cohort study included adult patients with diabetes discharged from an academic medical center between July 1, 2012 and December 31, 2018 who had a stress test documented before the index discharge. Univariate analysis and multinomial multivariable logistic regressions were used to evaluate associations with readmission within 30 days, 6 months, and 1 year of discharge. Exercise capacity was measured as metabolic equivalents (METs).

Results A total of 580 patients with 1598 hospitalizations were analyzed. Mean METs of readmitted patients were significantly lower than for non-readmitted patients (5.7 (2.6) vs 6.7 (2.6), p<0.001). After adjustment for confounders, a low METs level (<5) was associated with higher odds of readmission within 30 days (OR 5.46 (2.22–13.45), p<0.001), 6 months (OR 2.78 (1.36–5.65), p=0.005), and 1 year (OR 2.16 (1.12–4.16), p=0.022) compared with medium (5–7) and high (>7) METs level. During the 6.5-year study period, patients with low METs had a mean of 3.2±3.6 hospitalizations, while those with high METs had 2.5±2.4 hospitalizations (p=0.007).

Conclusions Lower exercise capacity is associated with a higher risk of readmission within 30 days, 6 months, and 1 year, as well as a greater incidence of hospitalization, in patients with diabetes. Future studies are needed to explore whether exercise reduces readmission risk in this population.

INTRODUCTION

Hospital readmission is an undesirable, expensive outcome used as a measure of healthcare quality.1 2 Patients with diabetes are more likely to be readmitted than patients without diabetes,3 and up to 20% will be readmitted within 30 days of hospital discharge.4 Several readmission risk factors have been identified, including repeated hospitalizations, hospital length of stay, sociodemographic characteristics, and comorbidities.4 5 However, these risk factors are largely non-modifiable. There is a need to identify more modifiable risk factors for readmission as potential targets for intervention among patients with diabetes.

A robust body of evidence indicates that cardiorespiratory fitness is a strong predictor of morbidity and mortality in patients with diabetes.6 9–11 Exercise capacity is associated with reduced readmission/hospitalization risk in patients with other chronic conditions such as chronic obstructive pulmonary disease (COPD) and heart failure (HF).12–14 In these populations, exercise interventions decrease readmission/hospitalization risk. Whether exercise capacity is associated with readmission risk among patients with diabetes...
is unknown. The purpose of the present study was to examine whether such an association exists. We hypothesized that lower exercise capacity based on the maximal workload achieved during treadmill stress testing is associated with a higher 30-day readmission rate in patients with diabetes.

METHODS

Study design

We retrospectively analyzed the electronic health records of patients discharged from Temple University Hospital, an urban academic medical center in Philadelphia, Pennsylvania, between July 1, 2012 and December 31, 2018. Inclusion criteria were (1) being 18 years of age or older; (2) having a diagnosis of diabetes defined by an International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) code of 249.xx or 250.xx, or ICD-10-code E08 through E013, associated with a hospital discharge in any position (primary or secondary); and (3) documentation of a treadmill stress test conducted between July 1, 2008 and December 31, 2018. Patients were excluded if they lacked a treadmill stress test before the index discharge and/or if the test was performed as part of a vascular study measuring ankle-brachial index because these tests are performed at a constant workload and not validated as a measure of cardiorespiratory fitness. Index discharges were excluded if the discharge reason was death or transfer to another hospital, or if the index discharge and subsequent admission occurred on the same day (suggesting a within-hospital transfer rather than a true discharge).

Treadmill stress testing and exercise capacity

Treadmill stress testing was used to determine exercise capacity. Patients performed standard tests using either the Bruce or modified Bruce protocols. Reasons for testing included evaluation of chest pain, ruling out of coronary artery disease (CAD), preoperative evaluation, evaluation of known CAD, evaluation of HF, and evaluation of post-organ transplant functional capacity. Tests were limited by signs and symptoms, including chest pain, shortness of breath, inability to maintain treadmill workload, or patient request to stop. According to standard procedures outlined by the American College of Sports Medicine, tests were terminated at maximal capacity or at the discretion of the physician for arrhythmias, abnormal hemodynamic changes, or diagnostic ST segment changes.

Exercise capacity was abstracted from the test report and expressed in metabolic equivalents (METs) based on the workload derived from maximal speed and grade achieved during treadmill testing. Values were converted using published equations for walking and running. The energy demand of stage 1 is equivalent to 4.6 METs, of stage 2 is 7 METs, and of stage 3 is 10.1 METs. To account for the heterogeneity in definitions of METs categories, exercise capacity was categorized based on the peak workload achieved as follows: ≤5 METs (low), 5–7 METs (medium), and >7 METs (high). Peak heart rate achieved during the test was recorded and calculated as a percentage of the predicted maximal heart rate (220 minus age) to validate each test. In patients with multiple treadmill tests, only the test nearest the time of index discharge was used in the analysis.

Outcomes

The primary outcome was all-cause readmission within 30 days of index discharge. Secondary outcomes were all-cause readmission within 6 months (inclusive of 30 days) and 1 year (inclusive of 30 days and 6 months), as well as total hospitalizations per patient. Multiple readmissions per patient were not counted except for total hospitalizations per patient.

Other measurements

Covariates included age, sex, self-reported race/ethnicity, body mass index (BMI), indication for exercise test, peak heart rate measured as the per cent of predicted maximal heart rate, and comorbid diagnoses related to cardiovascular disease (hypertension, hyperlipidemia, CAD, chronic kidney disease (CKD), COPD, HF, and peripheral vascular disease (PVD)). All variables were abstracted or calculated at or nearest to the time of the treadmill stress test. BMI was calculated using height and weight documented within 6 months of the treadmill stress test. The presence of hypertension, hyperlipidemia, CAD, CKD, COPD, HF, and PVD was based on an ICD-9 or ICD-10 diagnosis documented on or before the date of the treadmill stress test. The following definitions: hypertension (ICD-9 401.xx–405.xx or ICD-10 I10.xx, I15.xx, or I16.xx), hyperlipidemia (ICD-9 272.0x–272.4x or ICD-10 E78.0x–E78.5x), CAD (ICD-9 410.xx–414.xx or ICD-10 I20.xx, I21.xx, I22.xx, or 125.xx), CKD (ICD-9 585.xx or ICD-10 N18.xx), COPD (ICD-9 491.2x or ICD-10 J44.x), PVD (ICD-9 410.5x, 440.xx, 443.xx, or 444.xx or ICD-10 I73.x, I74.x, I75.x, E10.51, E10.52, E11.51, or E11.52), and HF (ICD-9 428.xx or ICD-10 I50.xxx).

Analysis

Summaries of categorical variables included counts and percentages, while means and SD or medians and IQRs were used for continuous variables. Means and percentages were calculated for the study population overall, by 30-day, 6-month, and 1-year readmission, METs category, and number of hospitalizations per patient. Univariate analyses with χ² or independent t-tests were performed for all variables to determine those associated with 30-day, 6-month, and 1-year readmission. Differences across the three METs categories were compared using analysis of variance (ANOVA) for continuous variables. Independent t-tests, ANOVA, and Pearson’s correlation coefficient were performed for all variables to determine those associated with number of hospitalizations per patient. Multinomial multivariable logistic regression models to predict 30-day, 6-month, and 1-year readmission and a linear regression
model to predict number of hospitalizations per patient were conducted. Variables independently associated with 30-day, 6-month, and 1-year readmission at the p<0.05 level were retained in the models after enter selection. Variable selection by backward elimination, forward step-wise, and enter regression produced similar models for 30-day readmission; thus, only enter regression was used for modeling 6-month and 1-year readmission. All statistical analyses were performed using IBM SPSS Statistics V.24. P values less than 0.05 were considered statistically significant.

RESULTS

A total of 580 patients with diabetes were included (table 1). The mean age was 57.8±10.6 years; 39.7% were women, 31.6% were black, and 45.5% were Hispanic. A diagnosis of CAD, hypertension, hyperlipidemia, CKD, HF, COPD, and/or PVD was common. The mean METs scores of readmitted patients were significantly lower than for non-readmitted patients (5.7 (2.6) vs 6.7 (2.6), p<0.001). In addition, readmitted patients were more likely to be male and have HF and COPD, less likely to have CKD, and had a lower BMI.

During the 6.5-year study period, patients experienced a total of 1598 hospitalizations. Patients in the low METs group (n=251) had 803 hospitalizations (mean 3.2±3.6 per patient). In the medium METs group (n=181), patients had 421 hospitalizations (mean 2.3±2.3 per patient), while those in the high METs group (n=148) had 374 hospitalizations (mean 2.5±2.4 per patient, p=0.007, d=0.26 (0.09–0.43)). Patients with low exercise capacity were more likely to have a 30-day, 6-month, and 1-year readmission than patients with medium and high exercise capacity (table 2).

Patients with low exercise capacity had more than five-fold greater odds of 30-day readmission (table 3) than patients with high exercise capacity after adjusting for age, sex, race, BMI, CAD, hypertension, hyperlipidemia, CKD, HF, COPD, PVD, and peak heart rate.

Patients with low exercise capacity had almost three-fold greater odds of 6-month readmission (table 4) than patients with high exercise capacity after adjusting for all covariates.

Patients with low exercise capacity had twofold greater odds of 1-year readmission (table 5) than patients with high exercise capacity after adjusting for all covariates.

### Table 1 Demographic characteristics of 580 patients with diabetes by 30-day readmission

| Variables                        | Whole sample N=580 | 30-day readmission n=117 | No readmission n=463 | P value | Effect size (CI)* |
|----------------------------------|--------------------|--------------------------|----------------------|---------|-------------------|
| Age (years), mean (SD)           | 57.8 (10.6)        | 59.6 (10.2)              | 57.4 (10.7)          | 0.047   | 0.21 (0.00 to 0.41) |
| Sex, n (%)                       |                    |                          |                      |         |                   |
| Female                           | 230 (39.7)         | 36 (30.8)                | 194 (41.9)           | 0.028   | 0.62 (0.39 to 0.96) |
| Male                             | 350 (60.3)         | 81 (69.2)                | 269 (58.1)           |         |                   |
| Race/ethnicity, n (%)            |                    |                          |                      |         |                   |
| Black                            | 183 (31.6)         | 38 (33.3)                | 145 (31.3)           | 0.970   |                   |
| Hispanic                         | 264 (45.5)         | 54 (46.2)                | 210 (45.4)           |         |                   |
| White                            | 99 (17.1)          | 19 (16.2)                | 80 (17.3)            |         |                   |
| Other or not documented          | 34 (5.9)           | 6 (5.1)                  | 28 (6.0)             |         |                   |
| BMI, mean (SD)                   | 31.8 (6.3)         | 30.2 (5.7)               | 32.2 (6.4)           | 0.016   | 0.32 (0.01 to 0.58) |
| CAD, n (%)                       | 111 (19.1)         | 29 (24.8)                | 82 (17.7)            | 0.082   |                   |
| Hypertension, n (%)              | 220 (37.9)         | 52 (44.4)                | 168 (36.3)           | 0.104   |                   |
| Hyperlipidemia, n (%)            | 187 (32.2)         | 43 (36.8)                | 144 (31.3)           | 0.243   |                   |
| CKD, n (%)                       | 34 (5.9)           | 14 (12.0)                | 20 (4.3)             | 0.002   | 3.01 (1.47 to 6.16) |
| HF, n (%)                        | 169 (29.1)         | 51 (43.6)                | 118 (25.5)           | <0.001  | 2.26 (1.48 to 3.44) |
| COPD, n (%)                      | 123 (21.2)         | 33 (28.2)                | 90 (19.4)            | 0.04    | 1.63 (1.02 to 2.59) |
| PVD, n (%)                       | 130 (22.4)         | 29 (24.8)                | 101 (21.8)           | 0.491   |                   |
| % of predicted maximal HR, mean (SD) | 86.8 (11.2)     | 84.0 (12.6)              | 87.5 (10.8)          | 0.007   | 0.29 (0.08 to 0.49) |
| METs, mean (SD)                  | 6.5 (2.7)          | 5.7 (2.6)                | 6.7 (2.6)            | <0.001  | 0.36 (0.18 to 0.59) |

Bold values indicate a statistically significant result.

*Effect size was calculated for significant estimates: Cohen’s d was calculated for age, BMI, peak heart rate, and METs. OR was calculated for sex, CAD, HF, and COPD.

BMI, body mass index; CAD, coronary artery disease; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; HF, heart failure; HR, heart rate; METs, metabolic equivalents; PVD, peripheral vascular disease.
Cardiovascular and metabolic risk

Relative to high exercise capacity, low exercise capacity was associated with a greater number of hospitalizations per patient after adjustment for all covariates ($\beta=0.96$ (0.13–1.79), $p=0.024$) (online supplemental appendix table 6).

**DISCUSSION**

The purpose of the present study was to examine whether there is an association between exercise capacity and readmission risk among patients with diabetes. We found that lower exercise capacity based on the maximal workload achieved during treadmill stress testing was associated with a greater risk of 30-day, 6-month, and 1-year readmission rate in patients with diabetes. We also found that low exercise capacity is associated with a greater incidence of hospitalizations per patient. These findings add to the prognostic importance of exercise capacity, an established predictor of mortality and vascular complications in patients with diabetes.\textsuperscript{6, 9, 10, 20} Furthermore, the findings suggest that exercise capacity may be a modifiable risk factor for readmission up to 1 year after discharge, and suggest the hypothesis that improving exercise capacity decreases the risk of readmission for patients with diabetes.

To the best of our knowledge, this study is the first to evaluate the association between exercise capacity and
readmission in patients with diabetes. Although there are no other studies with which we can directly compare these results, our findings are consistent with studies showing similar associations in patients with COPD and HF.21 22 For example, Chawla et al21 found that patients with COPD with lower levels of physical activity over the first week after hospital discharge were more likely to have all-cause 30-day readmission. In a recent review article, Aronow and Shamiyan23 reviewed 7 meta-analyses and 48 randomized controlled trials, and recommended exercise interventions to improve exercise capacity for adults with HF in order to reduce hospitalization risk and improve the quality of life. It is plausible that exercise capacity serves as a marker for cardiopulmonary function and metabolism that is broadly applicable to patients with chronic conditions such as diabetes, COPD, and HF. Lower exercise capacity may also be associated with depression, a risk factor for readmission among patients with diabetes.5 In the Look AHEAD (Action for Health in Diabetes) study, participants with type 2 diabetes who received the intensive diet and exercise intervention had a lower incidence of depression symptoms and fewer hospitalizations.23 24

Although improving exercise capacity is important, it is a challenging endeavor for many patients to engage in physical activity. Good patient–clinician health communication guided by the use of shared decision making (SDM) approach during and after hospitalization has the potential to help patients increase their physical activity. SDM studies in general,25 26 and particularly in diabetes,27–29 indicate promising engagement outcomes for treatment uptake. However, most SDM studies in diabetes targeted treatment-related decisions, and tools for motivating patient engagement in physical activity are lacking. Studies developing and testing SDM and health communication tools to support physical activity engagement are needed.

Our study has several limitations that warrant discussion. First, the association of low exercise capacity with readmission in this retrospective observational study does not establish causation. Furthermore, the mechanisms by which lower exercise capacity may have contributed to readmission risk cannot be established. Second, the data were drawn from electronic health records not designed for research. This precludes definitive assessment of diabetes type, although it is very likely that the vast majority of patients had type 2 diabetes, consistent with the general population. Similarly, exercise tests were administered for diagnostic purposes rather than to assess fitness. In addition, exercise capacity could have changed during the study period after the baseline assessment. However, we and others believe fitness measured at one time to be informative of fitness throughout many years.30 Third, data on deaths after hospital discharge were not available, so only inpatient deaths were excluded. Finally, we cannot rule out residual confounding from unmeasured variables, including secular trends related to changes in practice that occurred during the study.

Despite these limitations, our study has several strengths. We analyzed objectively measured functional data on exercise capacity obtained through the commonly performed treadmill stress test rather than relying on subjective questionnaires of physical activity.31 Our cohort was ethnically diverse and 45% female, suggesting some degree of generalizability.

In summary, lower exercise capacity is associated with a higher risk of hospital readmission in patients with diabetes. Future studies are needed to explore whether

### Table 3  Association of exercise capacity and other factors with 30-day readmission in multivariable logistic regression model

| Predictor    | OR (95% CI)       | P value |
|--------------|-------------------|---------|
| Low METs     | 5.46 (2.22 to 13.45) | <0.001  |
| Medium METs  | 1.85 (0.71 to 4.81)  | 0.21    |
| Sex (male)   | 0.41 (0.21 to 0.79)  | 0.008   |
| BMI          | 0.93 (0.88 to 0.98)  | 0.01    |
| CKD          | 2.47 (1.00 to 6.05)  | 0.049   |

Bold values indicate a statistically significant result.
*Only statistically significant covariates are presented in the table. BMI, body mass index; CKD, chronic kidney disease; METs, metabolic equivalents.

### Table 4  Association of exercise capacity and other factors with 6-month readmission in multivariable logistic regression model

| Predictor    | OR (95% CI)       | P value |
|--------------|-------------------|---------|
| Low METs     | 2.78 (1.36 to 5.65) | 0.005   |
| Medium METs  | 1.37 (0.66 to 2.85) | 0.403   |
| Sex (male)   | 0.32 (0.18 to 0.56) | <0.001  |
| BMI          | 0.94 (0.89 to 0.98) | 0.006   |
| HF           | 1.81 (1.06 to 3.08) | 0.030   |

Bold values indicate a statistically significant result.
*Only statistically significant covariates are presented in the table. BMI, body mass index; HF, heart failure; METs, metabolic equivalents.

### Table 5  Association of exercise capacity and other factors with 1-year readmission in multivariable logistic regression model

| Predictor    | OR (95% CI)       | P value |
|--------------|-------------------|---------|
| Low METs     | 2.16 (1.12 to 4.16) | 0.022   |
| Medium METs  | 1.24 (0.64 to 2.38) | 0.527   |
| Age          | 0.95 (0.92 to 0.97) | <0.001  |
| BMI          | 0.91 (0.87 to 0.95) | <0.001  |
| HF           | 2.70 (1.54 to 4.74) | 0.001   |

Bold values indicate a statistically significant result.
*Only statistically significant covariates are presented in the table. BMI, body mass index; HF, heart failure; METs, metabolic equivalents.
Cardiovascular and metabolic risk

exercise reduces readmission risk in this population and how behavioral health communication tools may motivate physical activity engagement among patients with diabetes.

Contributors 
DJR was responsible for study concept and design. YZ-I was responsible for analysis, and DJR and YZ-I were responsible for interpretation of data. YZ-I, KF, and DJR drafted the manuscript versions. MW provided access to all the data, KF prepared the data for analysis.

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Competing interests 
None declared.

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The study was approved by the Temple University Institutional Review Board (IRB # 25283).

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Data are available upon reasonable request.

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REFERENCES

1. Axon RN, Williams MV, v WM. Hospital readmission as an accountability measure. JAMA 2011;305:504–5.
2. Lansgarda D, Englander H, Salanitro A, et al. Risk prediction models for hospital readmission: a systematic review. JAMA 2011;306:1688–98.
3. Russell LB, Volgyesi E, Roman SH, et al. Hospitalizations, nursing home admissions, and deaths attributable to diabetes. Diabetes Care 2005;28:1611–7.
4. Rubin DJ. Correction to: Hospital readmission of patients with diabetes (current diabetes reports, (2015), 15, 4, (17), 10.1007/s11892-015-0584-7). Current Diabetes Reports 2018;18.
5. Karunakaran A, Zhao H, Rubin DJ. Predischarge and Postdischarge risk factors for hospital readmission among patients with diabetes. Med Care 2018;56:634–42.
6. Sluik D, Buijsse B, Buitkelder R, et al. Physical activity and mortality in individuals with diabetes mellitus: a prospective study and meta-analysis. Arch Intern Med 2012;172:1285–95.
7. Reddigan JJ, Riddell MC, Kuk JL. The joint association of physical activity and glycaemic control in predicting cardiovascular death and all-cause mortality in the US population. Diabetologia 2012;55:632–5.
8. 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;134:e653–99.
9. Seyoum B, Estacio RO, Berhanu P, et al. Exercise capacity is a predictor of cardiovascular events in patients with type 2 diabetes mellitus. Diab Vasc Dis Res 2006;3:197–201.
10. Blomster JI, Chow CK, Zoungas S, et al. The influence of physical activity on vascular complications and mortality in patients with type 2 diabetes mellitus. Diabetes Obes Metab 2013;15:1008–12.
11. Pi-Sunyer X. The look ahead trial: a review and discussion of its outcomes. Curr Nutr Rep 2014;3:387–91.
12. Najafi F, Nalini M, Nikbakht MR. Changes in risk factors and exercise capacity after cardiac rehabilitation and its effect on hospital readmission. Iran Red Crescent Med J 2014;16:e4899.
13. Mikkelsen N, Cadarso-Suarez C, Lado-Balleo O, et al. Improvement in VO2peak predicts readmission after a disocvascular disease and mortality in patients undergoing cardiac rehabilitation. Eur J Prev Cardiol 2020;27:811–9.
14. Maddocks M, Kon SSC, Singh SJ, et al. Rehabilitation following hospitalization in patients with COPD: can it reduce readmissions? Respir Res 2015;20:295–404.
15. American College of Sports Medicine. ACSM’s Guidelines for Exercise Testing and Prescription. 9th Ed. Lippincott Williams & Wilkins, 2014.
16. Balass S, Dwyer GB. ACSM’s Metabolic Calculations Handbook. Baltimore, Md: Lippincott Williams & Wilkins, 2007.
17. Colberg SR, Sigal RJ, Fernhall B, et al. Exercise and type 2 diabetes: the American College of sports medicine and the American diabetes association: joint position statement. Diabetes Care 2010;33:e147–67.
18. Mendes MDea, da Silva I, Ramires V, et al. Metabolic equivalent of task (Mets) thresholds as an indicator of physical activity intensity. PLoS One 2018;13:e0200701.
19. Nylen ES, Kokkinos P, Myers J, et al. Prognostic effect of exercise capacity on mortality and heart failure among adults with diabetes mellitus. J Am Geriatr Soc 2010;58:1850–6.
20. Physical fitness predicts survival in men with type 2 diabetes. Ann Intern Med 2000;132:605.
21. Chawla H, Bulathsinghala C, Tejada JP, et al. Physical activity as a predictor of thirty-day readmissions after cardiac rehabilitation (ACR’s shared care quality improvement in cardiovascular medicine task (Mets) thresholds as an indicator of physical activity intensity). PLoS One 2018;13:e0200701.
22. Aronow WS, Shamiyan J. Exercise for preventing hospitalization and readmission in adults with congestive heart failure. Cardiol Rev 2019;27:41–8.
23. Espeland MA, Glick HA, Bertoni A, et al. Impact of an intensive lifestyle intervention on use and cost of medical services among overweight and obese adults with type 2 diabetes: the action for cholesterol and diabetes mellitus. Diabetes Care 2014;37:2548–56.
24. Rubin RR, Wadden TA, Bahnson JL, et al. Impact of intensive lifestyle intervention on depression and health-related quality of life in type 2 diabetes: the look ahead trial. Diabetes Care 2014;37:1544–53.
25. Wierenga TH, Rodriguez-Gutierrez R, Spencer-Bonilla G, et al. Decision AIDS that facilitate elements of shared decision making in chronic illnesses: a systematic review. Syst Rev 2018;9:121.
26. Zisman-Illan Y, Barnett E, Hank J, et al. Expanding the concept of shared decision making for mental health: systematic search and scoping review of interventions. Ment Health Rev 2017;22:191–213.
27. Moin T, Duru OK, Turk N, et al. Effectiveness of shared decision-making for diabetes prevention: 12-month results from the prediabetes informed decision and education (pride) trial. J Gen Intern Med 2019;34:2652–9.
28. Tamhane S, Rodriguez-Gutierrez R, Hargraves I, et al. Shared decision-making in diabetes care. Curr Diab Rep 2015;15:112.
29. Serrano V, Rodriguez-Gutierrez R, Hargraves I, et al. Shared decision-making in the care of individuals with diabetes. Diabet Med 2016;33:742–51.
30. Al-Mallah MH, Keteyian SJ, Brauer CA, et al. Rationale and design of the Henry Ford exercise testing project (the fit project). Clin Cardiol 2014;37:456–61.
31. Troiano RP, Berrigan D, Dodd KW, et al. Physical activity in the United States measured by accelerometer. Med Sci Sports Exerc 2008;40:181–8.