Predictors of Sustained Walking among Diabetes Patients in Managed Care: The Translating Research into Action for Diabetes (TRIAD) Study

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BACKGROUND: Although patients with diabetes may benefit from physical activity, few studies have examined sustained walking in this population.

OBJECTIVE: To examine the factors associated with sustained walking among managed care patients with diabetes.

DESIGN: Longitudinal, observational cohort study with questionnaires administered 2.5 years apart.

PARTICIPANTS: Five thousand nine hundred thirty-five patients with diabetes walking at least 20 minutes/day at baseline.

MEASUREMENTS: The primary outcome was the likelihood of sustained walking, defined as walking at least 20 minutes/day at follow-up. We evaluated a logistic regression model that included demographic, clinical, and neighborhood variables as independent predictors of sustained walking, and expressed the results as predicted percentages.

RESULTS: The absence of pain was linked to walking behavior, as 62% of patients with new pain, 67% with ongoing pain, and 70% without pain were still walking at follow-up (p=.03). Obese patients were less likely (65%) to sustain walking than overweight (71%) or normal weight (70%) patients (p=.03). Patients ≥65 years (63%) were less likely to sustain walking than patients between 45 and 64 (70%) or ≤44 (73%) years (p=.04). Only 62% of patients with a new comorbidity sustained walking compared with 68% of those who did not (p<.001). We found no association between any neighborhood variables and sustained walking in this cohort of active walkers.

CONCLUSIONS: Pain, obesity, and new comorbidities were moderately associated with decreases in sustained walking. Whereas controlled intervention studies are needed, prevention, or treatment of these adverse conditions may help patients with diabetes sustain walking behavior.

KEY WORDS: sustained walking; diabetes patients; managed care; TRIAD study; pain; obesity; comorbidities.
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Longitudinal cohort studies have shown an association between moderate, sustained physical activity such as walking and a decrease in cardiovascular events,[1,2] cardiovascular mortality,[1,3–5] and all-cause mortality[3–6] among individuals with type 2 diabetes, followed-up to 25 years. Moderate physical activity is an effective means of reducing visceral adipose tissue,[7,8] which has been linked to insulin resistance and an increased risk of cardiovascular disease.[9] Unfortunately, few individuals are able to sustain recommended levels of physical activity for extended periods. Therefore, helping patients with diabetes initiate physical activity such as walking is important, but is insufficient to produce lasting health benefits in the absence of sustained behavioral change.

There is no clear evidence that counseling in the primary care setting is effective in maintaining long-term activity.[10] Preventing or treating clinical conditions that impede sustained physical activity, however, may augment the effect of counseling. An understanding of the patient-level factors associated with discontinuation of physical activity is important to guide this process. However, the literature in this area has focused primarily on behavioral correlates of initiating physical activity rather than examining symptoms or clinical conditions that could represent obstacles to continued activity.[11–14]

Perceived neighborhood conditions may also influence long-term physical activity. For example, people tend to walk in their immediate neighborhoods, and those who walk despite feeling that their neighborhoods are unsafe may be less willing

or able to sustain walking behavior. Whereas several cross-sectional analyses have linked unfavorable neighborhood conditions to inactivity,[15–17] few investigators have examined whether people who walk despite perceiving these adverse conditions are more likely to eventually stop walking.

We hypothesized that individuals with advanced age or low socioeconomic status, comorbid clinical conditions, or living in neighborhoods less conducive to physical activity would be less likely to sustain walking. Using data from a sample of managed care patients with diabetes who reported walking at baseline, we examined the factors associated with sustained walking behavior over a span of approximately 2 years.

METHODS

Setting and Participants

Translating Research into Action for Diabetes (TRIAD) is a longitudinal, multicenter study of diabetes care in managed care; the study's design has been reported previously.[18] The study cohort was initially enrolled between July 2000 and August 2001. Patients with diabetes were randomly sampled from 68 clinician groups within 10 health plans that served approximately 180,000 patients from 6 geographic areas across the United States. Criteria for sampling were a clinician's diagnosis of diabetes, age ≥18 years, continuous enrollment for a minimum of 18 months in a participating plan, at least 1 health care claim in the previous 18 months, receipt of the majority of diabetes care through the plan, and the ability to speak either English or Spanish. Nursing home residents, pregnant women, and individuals unable to provide informed consent were excluded. The study protocol was reviewed and approved by institutional review boards at all participating sites.

In the initial TRIAD survey fielded in 2000–2001, data were obtained from 11,927 participants. For this analysis, we used data from 2 subsequent surveys administered in 2002–2003 (defined as baseline) and 2004–2005 (follow-up). The variability in time to follow-up across the sites ranged from a minimum of 19 months to a maximum of 42 months. Between the 2000–2001 and 2002–2003 surveys, 639 participants died and 2,497 were lost to follow-up. This left 8,791 study participants in 2002–2003, and our analytic sample was drawn from a subset of these individuals.

Measurement

We limited our analytic sample to those participants (n=5,935) who were actively walking in 2002–2003, a determination based on an ordinal variable measuring daily time spent walking in 10-minute increments. We were unable to distinguish between walking for physical activity and walking for lifestyle-related activities such as household chores. We defined active walking as at least 20–29 minutes/day at baseline. This definition is consistent with recent recommendations by the American Diabetes Association for (1) at least 150 minutes/week of moderate-intensity physical activity and (2) no more than 2 consecutive days of inactivity.[19] We were unable to capture those participants who may have walked more than 150 minutes/week but did not walk every day, and those individuals are not included in the analysis. We defined sustained walkers as participants who walked at least 20–29 minutes/day in both 2002–2003 and 2004–2005.

We examined 3 groups of predictor variables: demographic, neighborhood, and clinical characteristics. Demographic variables included age group (18–44, 45–64, and ≥65 years), sex, race/ethnicity (non-Latino white, non-Latino African American, Latino, and Asian/Pacific Islander), education (less than high school, high school graduate, and some college), and annual income (<$15,000, between $15,000 and $40,000, between $40,000 and $75,000, and >$75,000). We also included 4 self-reported neighborhood characteristics: crime, trash and litter, access to recreational facilities, and lighting at night.[20] Respondents characterized each characteristic as a problem or not a problem.

We examined 5 self-reported clinical variables. These included body mass index at baseline (BMI; measured as weight in kg divided by height in m^2) categorized as normal (BMI <25), overweight (BMI ≥25 to <30), or obese (BMI ≥30), and type of diabetes treatment categorized as no antiglycemic medications, oral medications, insulin only, or insulin and oral medications. We included a 4-level variable to assess pain, measured at baseline and follow-up by the pain/discomfort question in the EuroQol/EQ-5D scale. We classified participants as having either new pain since baseline, persistent pain, pain that resolved between baseline and follow-up, or no pain. We also examined symptoms of depression, defined as a score of ≥10 on the 8-item version of the Patient Health Questionnaire.[21] Participants either had new depressive symptoms since baseline, depressive symptoms at baseline and follow-up, depressive symptoms that resolved between baseline and follow-up, or never reported having depressive symptoms. The TRIAD survey did not measure the adequacy of treatment for pain and depression. Finally, we included a variable measuring the onset of new comorbidities between baseline and follow-up, specifically myocardial infarctions, cerebrovascular accidents, amputations, or initiation of renal dialysis.

We controlled for additional covariates, including whether patients had an existing major comorbidity (history of myocardial infarction, cerebrovascular accident, amputation, renal dialysis, or transplant) at baseline, and employment status. We included covariates measuring mean monthly temperature at the 6 TRIAD sites when the baseline and follow-up surveys were administered as a continuous variable. These variables were included to adjust for differences between study sites in the likelihood of adverse seasonal weather conditions.

Statistical Methods

We used multiple imputation methods to account for missing data. We imputed all variables with any missing data, including those for participants lost to follow-up (IVEware Version 2.0).[22] IVEware uses a sequence of multiple regressions to impute missing values. Missing values for each variable are imputed using all of the observed values. The types of regressions depend upon the distribution of the imputed variable. For example, we used logistic regressions for binary variables and generalized logit for categorical variables. Imputed missing values are used cyclically to update previously imputed values until stable predictions are achieved. We used 20 iterations, and appropriate restrictions and bounds on imputed values are incorporated. Estimates were pooled according to the formulas of Rubin and Schenker.[23]

Using the imputed data, we constructed a multivariate logistic regression model using demographic, clinical, and neighborhood variables from our initial hypotheses to predict the likelihood of sustained walking at follow-up for all of the 5,935 patients who were walking at baseline. We included all predictor variables and several covariates (baseline comorbidities, employment status, and outdoor temperature) in the regression. We used the MIAnalyze procedure in SAS Version 9.1 to evaluate the regression coefficients using a multivariate (multiple degrees of freedom) test.[24] From this model, we generated predicted percentages of sustained walking for each predictor variable and derived 95% confidence intervals.

We replicated our main regression models using only complete cases without missing data. Overall, we observed patterns of results similar to those obtained in our main model using multiple imputations, although several comparisons that were significant in the model restricted to complete cases did not reach a level of significance when multiple imputations was used. We report only the results from our multiply imputed model. As an additional analytic step, we investigated interaction terms between age and each of 4 variables: BMI, pain, baseline comorbidity, and new comorbidity. None of these interaction terms were significant predictors of sustained walking.

RESULTS

The analytic sample was limited to the 5,935 (67.5%) TRIAD patients who were walking regularly at baseline. The characteristics for this group along with those for TRIAD participants who were not walking at baseline are shown in Table 1. The walkers were younger, more likely to be male, and had somewhat higher levels of education and annual income than the nonwalkers, consistent with previously published data from a nationally representative sample of patients with diabetes.[25]

Among patients walking at baseline, 20% had new pain with a similar percentage not reporting any pain. Approximately 50% had persistent pain, whereas 11% had pain that resolved by the time of follow-up. Only 5.5% had new depression, whereas 77% never reported depressive symptoms. Approximately 10% had depression that improved over time, whereas 7% had persistent depression.

Predicted percentages of sustained walking are shown in Table 2. Older patients were less likely to sustain walking, including 73% of those aged 18–44 years, 70% of those aged 45–64, but only 63% of those aged 65 or older (p=.04). We did not find significant differences in the percentages of sustained walking by other demographic characteristics.

Examining clinical variables, we found that only 65% of obese patients sustained walking versus 70% of those of normal weight and 71% of those who are overweight (p=.03). We found that pain was significantly associated with sustained walking, as only 63% of those patients who developed new pain walking at follow-up versus 68% of those with persistent pain at both time points, 71% of those with resolved pain, and 70% who never had pain (Table 2, p=.03). We did not observe a significant association between sustained walking and depressive symptoms.

Patients who experienced a myocardial infarction, cerebrovascular accident, amputation, or onset of renal dialysis were less likely to sustain walking (62%) than were those who did not (68%, p<.001). Patients who were not using antiglycemic

Table 1. Demographic Characteristics of TRIAD Participants by Baseline Walking Status

Sample characteristics (N=8,796)	Not walking at baseline (n=2,861)	Walking at baseline (n=5,935)	p value for difference
Demographics			
Age			<.0001
18–45 years (%)	7.6	9.1	
45–64 years (%)	46.5	51.0	
≥65 years (%)	46.0	40.0	
Race/ethnicity			<.0001
African American (%)	16.3	14.9	
Asian/Pacific Islander (%)	13.6	16.5	
Latino (%)	15.1	16.9	
White (%)	46.9	43.3	
Other (%)	8.1	8.5	
Female (%)	57.5	51.6	<.0001
BMI			<.0001
<25 (%)	14.9	16.8	
25–29 (%)	28.9	33.3	
≥30 (%)	56.2	50.0	
Education			.0022
<High school (%)	22.2	19.9	
High school graduate (%)	30.9	29.5	
Some college (%)	47.0	50.6	
Annual income			<.0001
<$15,000 (%)	26.7	22.1	
$15,000–$39,999 (%)	36.9	34.4	
$40,000–$74,999 (%)	23.4	27.2	
>$75,000 (%)	13.0	16.4	
Clinical characteristics			
BMI			<.0001
Normal weight (%)	14.9	16.8	
Overweight (%)	28.9	33.3	
Obese (%)	56.2	50.0	
Type of treatment			<.0001
Controlled with diet and physical activity (%)	7.9	7.8	
Oral medications only (%)	59.1	64.8	
Insulin only (%)	19.2	16.2	
Insulin and oral medications (%)	13.8	11.2	
Pain symptoms at baseline (%)	65.8	58.1	<.0001
Depressive symptoms at baseline (%)	24.0	14.5	<.0001
Major comorbidity at baseline (%)	13.6	9.3	<.0001
Neighborhood characteristics			
Neighborhood crime is a problem (%)	23.9	23.5	.59
Neighborhood trash and litter is a problem (%)	9.4	8.5	.29
Local access to recreational facilities is a problem (%)	15.7	11.5	<.0001
Neighborhood lighting at night is a problem (%)	9.7	8.1	.29

Table 2. Predicted Percentages of Sustained Walking at Follow-up among TRIAD Participants Walking at Least 20 minutes/day at Baseline

Predictor variable	Percent that sustained walking behavior at follow-up	*p* value for group comparison
Demographics		
Age		.048
18–44 years	72.9	
45–64 years	69.7	
≥65 years	63.3	
Gender		.11
Male (%)	69.3	
Female (%)	65.9	
Race/ethnicity		.77
White (%)	66.7	
African American (%)	67.6	
Latino (%)	65.3	
Asian/Pacific Islander (%)	70.1	
Other (%)	69.8	
Education		.36
<High school (%)	68.4	
High school graduate (%)	69.2	
Some college (%)	66.3	
Annual income		.51
<$15,000 (%)	67.2	
Between $15,000 and $40,000 (%)	69.2	
Between $40,000 and $75,000 (%)	67.4	
>$75,000 (%)	65.2	
Clinical characteristics		
BMI		.03
Normal weight	69.6	
Overweight	70.5	
Obese	64.9	
Type of treatment		.03
Controlled with diet and physical activity (%)	72.3	
Oral medications only (%)	68.6	
Insulin only (%)	63.8	
Insulin and oral medications (%)	63.9	
Pain		.03
New pain since baseline (%)	62.9	
Persistent pain (%)	67.5	
Pain resolved since baseline (%)	71.0	
Never in pain (%)	70.3	
Depressive symptoms		.31
New depressive symptoms since baseline (%)	59.9	
Persistent depressive symptoms (%)	65.2	
Depressive symptoms improved since baseline (%)	70.3	
Never had depressive symptoms (%)	67.9	
Major new comorbidity since baseline		.048
Yes (%)	62.0	
No (%)	68.1	
Neighborhood characteristics		
Local crime		.07
Problem (%)	64.7	
Not a problem (%)	68.5	
Local trash and litter		.62
Problem (%)	69.2	
Not a problem (%)	67.5	
Access to recreational facilities		.60
Problem (%)	69.5	
Not a problem (%)	67.3	
Lighting at night		.22
Problem (%)	72.7	
Not a problem (%)	67.1	

Model adjusted for comorbidities at baseline, employment status at both baseline and follow-up, and mean monthly temperature at both baseline and follow-up.

medications for their diabetes were more likely to sustain walking (72%) than were those using oral medications only (69%) or insulin (64%, p=.03). We found no associations between the likelihood of sustained walking and perceptions of neighborhood problems with crime, trash and litter, access to recreational facilities, or lighting at night (Table 2).

DISCUSSION

Our study is the first analysis of factors associated with sustained walking within a cohort of managed care patients with diabetes and adds several key findings to the literature. We found that clinical factors such as obesity and symptoms of pain were associated with a moderately lower likelihood of sustained walking, as was age ≥65 years, use of antiglycemic medications, and the development of a major new comorbidity. We did not find an association between self-reported neighborhood variables and the likelihood of sustained walking.

Approximately 65–70% of participants in our study sustained walking over several years, more than have been observed in the majority of walking intervention trials,[26] but similar to populations of community-dwelling individuals who are walking on their own.[5] Our analytic sample was drawn from participants in the second and third waves of a longitudinal study and, therefore, represented a somewhat select, motivated, and active group compared to the overall population. However, a substantial minority of TRIAD participants did not sustain walking, and identifying preventable or treatable reasons why relatively motivated patients may stop walking is clinically important. Sustained physical activity is important for this population, as it leads to reductions in visceral fat that may in turn be associated with a lower risk of adverse cardiovascular outcomes.[7–9]

The identified relationship between pain and sustained walking is particularly noteworthy. Other investigators have shown that over 50% of patients with diabetes report pain that interferes with usual exercise regimens.[27] We found that patients with new pain since baseline were particularly unlikely to sustain walking, which supports the importance of regular screening for pain among active individuals with diabetes. This is crucial because clinicians may not be aware of the presence or severity of symptoms.[28] Almost a quarter of patients with chronic pain do not inform their providers,[29] and many of these people choose to self-manage their pain, using suboptimal strategies.[30] Appropriate pain treatment, using analgesic and nonanalgesic modalities with stepped-up therapy as needed may improve quality of life and promote continued physical activity among patients with diabetes.

Obesity has been previously linked with inactivity in cross-sectional studies among populations with diabetes,[25,31] but our longitudinal findings show that obese patients who are actively walking are less likely to sustain that behavior than are patients of normal weight or those who are overweight. There are several possible explanations for our findings, such as potential lower self-efficacy for physical activity among the obese,[32] or physiologic limitations, such as higher oxygen consumption by obese individuals at a given activity level compared with individuals of normal weight.[33] Efforts to prevent overweight individuals from gaining weight and ultimately progressing to obesity may help them remain active.

Several diabetes medications can lead to weight gain, particularly insulin and thiazolidinediones (TZDs).[34] Well-meaning clinicians may inadvertently contribute to their patients' obesity through their choice of drug therapy. Regimens with less potential for weight gain, such as the use of metformin in combination with TZD therapy (as opposed to TZD monotherapy), decrease the potential for obesity. Whereas aggressive glycemic control is a primary concern in the treatment of patients with diabetes, thoughtful prescribing patterns along with diet and exercise will help to prevent weight gain and thereby may facilitate continued walking over the long-term.

Our finding that patients who sustain a new comorbidity are less likely to sustain walking is not surprising. The development of a major comorbid event such as a myocardial infarction can be associated with the onset or progression of disability, limiting the capacity for physical activity, which in turn increases the risk for future comorbid events. Intensive treatment with multiple drugs to achieve tight control of blood pressure and glucose levels and reduce low-density lipoprotein (LDL) cholesterol significantly reduces macrovascular complications of diabetes such as myocardial infarctions and cerebrovascular accidents.[34–36] Unfortunately, these goals have proven difficult to achieve in real-life settings.[37] Our findings support the importance of finding viable ways to increase the use of multiple drugs to treat patients with diabetes.

Among the demographic variables we examined, only age was associated with sustained walking with patients aged 65 years and over the least likely to keep walking. This was not surprising, as any characteristics of age related to inactivity, such as falls or the fear of falling, will only increase during a longitudinal study. Several evidence-based interventions involving physical activity for older adults that address these types of barriers are being actively translated to "real-world" community settings.[38–40]

We did not find statistical evidence to support our hypothesis that patients with diabetes who have preexisting depressive symptoms or develop new depressive symptoms would be less likely to sustain walking. Major depression has been associated in cross-sectional analyses with higher rates of physical inactivity among patients with diabetes,[41,42] but the relationship between depression and physical inactivity is likely bidirectional.[43] Excluding nonwalkers from the study cohort may, therefore, have contributed to a weaker link between depression and physical activity than has been seen in earlier cross-sectional analyses. In addition, we had relatively few patients with depressive symptoms in the overall study cohort and we may have lacked power to detect a difference in sustained walking behavior.

We found no evidence to support an association of "activity-friendly" neighborhood characteristics such as adequate lighting and minimal litter with sustained walking. As with depressive symptoms, we had limited power to identify differences in walking behavior related to these variables. Because we only examined patients already walking at baseline, our results do not reflect whether adverse neighborhood conditions are negatively associated with the initiation of walking.

Our study has several limitations. First, we classified patients as walkers or nonwalkers from self-reported minutes walked per day at 2 points in time, and thus actual activity may have been misreported. However, this is unlikely to have produced a directional bias, as the predictors of sustained walking we identified are unlikely to be associated with the likelihood of overreporting or underreporting walking activity. Second, follow-up measures of pain and depression were collected at the same time as the measure of sustained walking, so we can report associations but are unable to determine causality. Third, we lacked data on physical activities other than walking, so participants could have substituted other moderate-intensity activities rather than discontinuing physical activity altogether. Finally, we were unable to identify those patients who walked at least 150 minutes/week but did not walk every day, may not have captured all participants who were walking regularly at baseline, and were unable to distinguish between walking for exercise and walking for lifestyle-related activities.

Our analysis is one of the first to examine sustained walking behavior in a large sample of patients with diabetes. We found that patients with diabetes were somewhat less likely to sustain walking when they were experiencing symptoms of pain. Obesity, the development of new comorbidities, and advanced age were also associated with a moderately lower likelihood of sustained walking. We did not identify associations between depressive symptoms or neighborhood characteristics and sustained walking, but this may have been because of the study limitations. Whereas controlled intervention studies are needed, our findings suggest that treating pain and preventing obesity and macrovascular events may be associated with higher rates of sustained walking among patients with diabetes.

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Conflict of Interest: *None disclosed.*

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