

Research: Care Delivery

Changes in physical activity among adults with diabetes: a longitudinal cohort study of inactive patients with Type 2 diabetes who become physically active

S. Palakodeti¹, C. S. Uratsu², J. A. Schmitt¹ and R. W. Grant²

¹Department of Medicine, Kaiser Permanente Northern California, San Francisco and ²Division of Research, Kaiser Permanente Northern California, Oakland, NC, USA

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Abstract

Aims To identify the predictors and clinical effects among inactive patients with diabetes who become physically active, in the setting of a large integrated health system.

Methods We studied adults with Type 2 diabetes with at least two clinic visits between December 2011 and November 2012 who reported being inactive at their first visit. The mean (\pm SD) interval between their first and last visit was 6.2 (\pm 2.3) months. We analysed self-reported moderate-to-vigorous physical activity data collected using a structured intake form during routine clinical care.

Results The study cohort ($N = 6853$) had a mean age of 60.2 years; 51.4% were women and 53.6% were non-white. Nearly two-thirds (62.5%, $n = 4280$) reported remaining physically inactive, while 16.0% reported achieving the recommended moderate-to-vigorous physical activity levels (≥ 150 min/week) by the last visit of the study period. Female gender (odds ratio 0.77, 95% CI 0.67, 0.88), obesity (BMI 30–34.9 kg/m²: odds ratio 0.76, 95% CI 0.60, 0.97; BMI ≥ 35 kg/m²: odds ratio 0.55, 95% CI 0.42, 0.70), chronic kidney disease (odds ratio 0.78, 95% CI 0.65, 0.94) and depression (odds ratio 0.77, 95% CI 0.62, 0.96) were each independently associated with not achieving the recommended moderate-to-vigorous physical activity level, while physician referral to lifestyle education was a positive predictor (odds ratio 1.40, 95% CI 1.09, 1.85). Controlling for baseline differences, patients achieving the recommended moderate-to-vigorous physical activity target lost 1.0 kg more weight compared with patients remaining inactive ($P < 0.001$).

Conclusions Patients with diabetes in a real-world clinical setting lost weight after becoming physically active; however, nearly two-thirds of patients remained inactive. Novel interventions to address physical inactivity in primary care should address barriers faced by older patients with medically complex disease.

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Introduction

The prevalence of Type 2 diabetes, obesity and physical inactivity continues to increase, contributing significantly to morbidity, mortality and healthcare expenditure [1,2]. A sedentary lifestyle among patients with Type 2 diabetes increases the risk of diabetes-related complications, coronary disease and all-cause mortality [3–6]. Conversely, regular physical activity can improve blood glucose control, blood pressure and quality of life, while lowering harmful chole-

sterol levels and decreasing cardiovascular events and mortality [7–11]. Given the benefit of regular physical activity among patients with diabetes, the American Diabetes Association and American College of Sports Medicine both recommend at least 150 min per week of moderate-to-vigorous physical activity (MVPA), which is defined as reaching ~40–60% of maximum aerobic capacity (equivalent to a brisk walk) [7]. Unfortunately, cross-sectional data from US national surveys indicate that < 10% of American adults achieve this level of MVPA and more than one-third engage in no physical activity at all [12,13]. A similar survey from 12 European nations found that less than half of adults report being sufficiently active, and, in many cases, the proportion of physically active adults was closer to one quarter of the population [14].

Correspondence to: Sandeep Palakodeti. E-mail: sandeep.palakodeti@kp.org
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What's new?

- This is the first large-scale longitudinal assessment of exercise changes among inactive patients with Type 2 diabetes that is paired with clinically relevant end-points.
- Previous analyses of exercise habits have typically been derived from cross-sectional survey data or less representative clinical trial participants.

Patients with Type 2 diabetes have frequent contact with healthcare systems. Typical patients have four or more outpatient visits per year, with the majority of these visits being to primary care providers [15,16]. Interventions within primary care settings to improve physical activity have the potential, therefore, to address a significant national health problem. A systematic review that included six randomized trials found only modest benefits from primary care-initiated exercise referral schemes, leading the authors to conclude that significant barriers exist to wider adoption of exercise programmes [17]. Further insight into the epidemiology and clinical consequences of becoming physically active among sedentary patients with Type 2 diabetes may therefore help guide new strategies to address physical activity in this high-risk population.

Little is currently known about longitudinal exercise patterns among patients with diabetes in the primary care setting. Within our care system, self-reported exercise data are collected by medical assistants as part of routine clinical care using a standardized intake form during each outpatient clinic visit. We used this unique large-scale clinical data collection as an opportunity to identify a 12-month longitudinal cohort of patients with Type 2 diabetes who reported no physical activity when asked at their first visit of the study period. Among these physically inactive patients, we examined baseline characteristics and subsequent clinical changes, comparing patients who remained inactive with those patients who adopted increased physical activity levels. We hypothesized that inactive patients who became physically active would have fewer concurrent comorbidities and would achieve measurable health benefits over the short term.

Methods**Setting**

The present study was conducted among adult primary care practices in Kaiser Permanente Northern California, an integrated care system serving over 3.4 million members. As part of routine care, medical assistants are trained to ask patients two questions: 'How many days per week do you engage in MVPA?' and 'On average, how many minutes per day do you exercise at this level?'. These data are combined to calculate patients' weekly MVPA in minutes and entered

into the electronic medical record for the physician to review during the visit.

Study design

We defined an observational, longitudinal cohort of adult members with Type 2 diabetes who had at least two visits to their primary care provider between 1 December 2011 and 30 November 2012 and who reported < 10 min/week MVPA when asked at the first visit ('inactive at baseline'). Additional study cohort eligibility criteria included age 18–75 years and continuous plan membership during the study period. We excluded patients who switched medical centre affiliations, who were hospitalized or pregnant, or who had certain comorbidities that may restrict exercise capacity (e.g. end-stage renal or liver failure, lower extremity amputation, dementia or new diagnosis of cancer other than skin cancer). Independent variables included demographic characteristics (sex, age, race/ethnicity and neighbourhood income and education levels) and clinical characteristics (baseline HbA_{1c} and BMI; comorbid conditions including cerebrovascular disease, chronic obstructive pulmonary disease/asthma, chronic kidney disease and depression; and current diabetic and antidepressant medication use).

Demographic and clinical data were obtained from the Kaiser Permanente Northern California clinical data repository. The neighbourhood median level of income and percentage of the population with a bachelor's degree education was identified using 2012 census data by census block group. We used a validated text search program to identify lifestyle-related documentation in physician progress notes [18]. Referrals for lifestyle-related counselling were captured using our system's electronic referral system and/or registered attendance in lifestyle-related classes. We grouped together all lifestyle referrals related to weight management, exercise, nutrition or other healthy behaviour counselling and educational services. No specific exercise-based intervention was made on a consistent basis; rather, the best strategy to increase physical activity was determined between the patient and their physician, health coach or class discussions.

The present study was conducted and funded as part of the Natural Experiments for Translation in Diabetes (NEXT-D) Study, a network of academic, community, industry, and policy partners collaborating to advance the methods and practice of natural experimental research and to identify and prioritize the best policies for preventing and controlling diabetes. The institutional review board of the Kaiser Foundation Research Institute approved the study protocol.

Statistical analysis

Analyses focused on patients with Type 2 diabetes who reported no physical activity at baseline. Patients were

stratified into three categories based on their self-reported exercise level at subsequent visits: no increase in physical activity; some increase in physical activity (at least 10 min/week but < 150 min/week); and achieving the recommended threshold of ≥ 150 min/week. For univariate analyses, patients in different exercise change categories were compared using chi-squared tests or ANOVA as indicated.

We created logistic regression models to identify the independent predictors of becoming physically active. Two separate models were used to compare: 1) patients remaining inactive vs. those achieving any degree of activity and 2) patients achieving less than the recommended vs. those achieving equal to or above the recommended threshold of MVPA. We also created separate linear regression models to estimate changes in weight and in HbA_{1c} levels, based on level of physical activity achieved after controlling for baseline demographic and clinical differences. Changes from baseline were calculated using patients remaining inactive as the referent group. We used SAS version 9.3 (SAS Institute, Cary, NC, USA) for all analyses.

Results

Study cohort and changes in physical activity

The present cohort of patients with Type 2 diabetes who reported being inactive (< 10 min MVPA/week) at baseline had a mean age of 60.7 years; 52.9% were women and 52.4% were of non-white race/ethnicity (Table 1). The mean (\pm SD) time between first and last visits was 6.2 (\pm 2.3) months. Among those patients inactive at the first 'index' visit, 62.5% remained inactive, while 37.6% achieved some level of physical activity when asked at their last visit, including 1096 (16%) patients who reported exercising at or beyond the recommended threshold of 150 min of MVPA/week.

Predictors of inactive patients becoming active

In multivariate models, female gender [odds ratio (OR) 0.77, 95% CI 0.67–0.88], obesity (BMI 30–34.9 kg/m²: OR 0.76, 95% CI 0.60–0.97), BMI ≥ 35 kg/m² (OR 0.55, 95% CI 0.42–0.70), presence of comorbid chronic kidney disease (OR 0.78, 95% CI 0.65–0.94), or depression (OR 0.77, 95% CI 0.62–0.96) were each independently associated with a decreased likelihood of achieving the recommended threshold of 150 min/week of MVPA during the follow-up period. We also analysed our data using a lower exercise threshold to compare patients remaining inactive with patients reporting any physical activity (MVPA ≥ 10 min/week) and found similar results, with the exception that female gender and comorbid chronic kidney disease were no longer statistically significant (Table 2).

Documentation of lifestyle assessment or counselling in physician progress notes was similar among patients who remained inactive vs. patients who became physically active (31.4 vs 34.1%; $P = 0.17$). Physician referral to lifestyle education was relatively uncommon (7.3% among patients who achieved the recommended threshold of MVPA vs. 5.0% among patients remaining inactive; $P = 0.006$) but was independently predictive of patients achieving some level of MVPA (OR 1.40, 95% CI 1.13–1.75) and for achieving recommended threshold of MVPA (OR 1.42, 95% CI 1.09–1.85).

Impact of becoming physically active on short-term clinical outcomes

Patients with Type 2 diabetes achieving the recommended levels of MVPA lost significantly more weight than those not achieving the recommended levels (loss of 1.1 vs 0.1 kg) between visits. This relative difference in weight loss (1.0 kg) was significant ($P < 0.001$; Table 3) after adjustment for baseline patient demographic and clinical differences. Although not quite reaching statistical significance, HbA_{1c} levels among patients with baseline HbA_{1c} ≥ 53 mmol/mol (7%; $n = 1175$) improved by 0.18% among patients achieving recommended physical activity levels relative to patients remaining inactive ($P = 0.09$ after controlling for baseline patient differences; Table 3).

Discussion

We analysed a 'real world' longitudinal cohort of adults with Type 2 diabetes attending primary care practices within a large and diverse care system that routinely collected patient exercise data. We found that patients with Type 2 diabetes who reported no physical activity at baseline had a high likelihood of remaining inactive over the follow-up period. Female gender, obesity, concurrent chronic kidney disease and depression were each independently associated with remaining inactive, while referral to lifestyle counselling, although uncommon overall, was associated with increased subsequent physical activity. Other factors such as baseline HbA_{1c} level, prescribed medications and documented lifestyle assessment or counselling in physician progress notes were not predictive of becoming physically active.

Because documented referral to lifestyle education classes was relatively uncommon in both groups (although higher in the group that became physically active), we infer that the majority of patients who became physically active did so for other reasons (e.g. healthcare provider counselling, the influence of family or friends, or the patients' own determination to become more physically active). Lifestyle education and referral by primary care providers has previously been found to have only a modest impact on exercise, suggesting that more

Table 1 Baseline patient characteristics by level of moderate-to-vigorous physical activity achieved

	Moderate-to-vigorous physical activity level			P
	No increase: 62.5%, n = 4280	Some increase: 21.6%, n = 1477	Recommended level: 16.0%, n = 1096	
Patient demographics				
Female, n (%)	2262 (52.9)	779 (52.7)	481 (43.9)	< 0.001
Mean (sd) age, years	60.7 (9.98)	59.73 (10.22)	58.87 (10.45)	< 0.001
Age group, n (%)				
30–39 years	103 (2.4)	52 (3.5)	36 (3.3)	
40–49 years	466 (10.9)	173 (11.7)	130 (11.9)	
50–59 years	1142 (26.7)	423 (28.6)	323 (29.5)	
60–69 years	1641 (38.3)	551 (37.3)	424 (38.7)	
70–75 years	898 (21.0)	269 (18.2)	168 (15.3)	
Race/ethnicity, n (%)				
White	2039 (47.6)	682 (46.2)	461 (42.1)	< 0.001
Black	426 (10.0)	142 (9.6)	99 (9.0)	
Asian	624 (14.6)	304 (20.6)	226 (20.6)	
Hispanic	964 (22.5)	268 (18.1)	240 (21.9)	
Other	227 (5.3)	81 (5.5)	70 (6.4)	
Income, n (%)				
< \$40k	897 (22.4)	246 (18.0)	212 (20.8)	< 0.001
\$40k to < \$75k	2321 (57.9)	789 (57.6)	558 (54.7)	
≥ \$75k	793 (19.8)	335 (24.5)	250 (24.5)	
Education: Bachelor degree, n (%)				
< 10%	1088 (27.1)	305 (22.3)	248 (24.3)	< 0.001
10–19%	1470 (36.6)	473 (34.5)	345 (33.8)	
20–29%	1003 (25.0)	400 (29.2)	279 (27.4)	
≥ 30%	450 (11.2)	192 (14.0)	148 (14.5)	
Clinical characteristics				
Mean (sd) HbA _{1c} mmol/mol	59.8 (17.1)	59.7 (16.4)	60.3 (18.6)	0.63
%				
HbA_{1c} concentration, n (%)				
< 53 mmol/mol (7%)	1717 (41.2)	573 (40.0)	431 (40.7)	0.22
53–62.8 mmol/mol (7–7.9%)	1186 (28.5)	463 (32.3)	315 (29.7)	
63.9–73.8 mmol/mol (8–8.9%)	573 (13.8)	181 (12.6)	144 (13.6)	
≥ 74.9 mmol/mol (9%)	690 (16.6)	216 (15.1)	169 (16.0)	
Mean (sd) BMI, kg/m ²	34.42 (7.76)	33.36 (7.50)	32.29 (6.96)	< 0.001
BMI, n (%)				
19–24.9 kg/m ²	333 (7.8)	156 (10.6)	138 (12.7)	< 0.001
25–29.9 kg/m ²	1018 (23.9)	393 (26.8)	312 (28.6)	
30–34.99 kg/m ²	1158 (27.2)	398 (27.1)	321 (29.4)	
≥ 35 kg/m ²	1745 (41.0)	520 (35.4)	319 (29.3)	
Comorbidities, n (%)				
Cerebrovascular disease	849 (19.8)	239 (16.2)	177 (16.1)	0.001
Chronic obstructive pulmonary disease /asthma	680 (15.9)	210 (14.2)	115 (10.5)	< 0.001
Chronic kidney disease	985 (23.0)	302 (20.4)	179 (16.3)	< 0.001
Depression	745 (17.4)	212 (14.4)	120 (10.9)	< 0.001
Medications, n (%)				
Diabetic	3728 (87.1)	1269 (85.9)	927 (84.6)	0.075
Antidepressant	1278 (29.7)	388 (26.3)	231 (21.1)	< 0.001
Exercise-related documentation in physician progress note, n (%)	1,346 (31.4)	490 (33.2)	374 (34.1)	0.165
Lifestyle-related referral, n (%)	215 (5.0)	94 (6.4)	80 (7.3)	0.006

Recommended moderate-to-vigorous physical activity: ≥ 150 min/week.

Some increase in moderate-to-vigorous physical activity: moderate-to-vigorous physical activity of < 150 min/week.

Income and education measures represent neighbourhood prevalence based on 2010 Census tract data and patient residence.

intensive or innovative approaches may be necessary to address this epidemic of sedentary behaviour [17].

We compared changes in weight and HbA_{1c} levels among patients who did achieve some level of activity with those remaining physically inactive. Over an average of only 6 months between visits, patients with diabetes who

achieved the recommended MVPA threshold had significantly greater weight loss (1.0 kg more) and some indication of improved HbA_{1c} levels (0.18% lower, although not reaching statistical significance) compared with patients with diabetes who remained inactive. These results underscore both the difficulty in achieving behaviour change and the

Table 2 Independent predictors of becoming physically active among inactive patients

	Moderate-to-vigorous physical activity/week: < 10 vs. ≥ 10 min		Moderate-to-vigorous physical activity/week: < 150 vs. ≥ 150 min	
		<i>P</i>		<i>P</i>
Gender: female	0.93	0.16	0.77	< 0.001
Race/ethnicity				
White	1 (referent)		1 (referent)	
Black	1.001	0.99	0.99	0.97
Asian	1.18	0.04	1.07	0.51
Hispanic	0.88	0.07	1.07	0.46
BMI				
1–24.9 kg/m ²	1 (ref)		1 (ref)	
25–29.9 kg/m ²	0.85	0.09	0.80	0.07
30–34.9 kg/m ²	0.77	0.01	0.76	0.03
≥ 35 kg/m ²	0.62	< 0.001	0.55	< 0.001
HbA _{1c} at baseline				
< 7.0	1 (referent)		1 (referent)	
7–7.9	1.13	0.05	1.01	0.95
8–8.9	0.97	0.67	0.99	0.93
≥ 9.0	0.92	0.30	0.93	0.48
Chronic kidney disease	0.88	0.07	0.78	0.01
Depression	0.82	0.01	0.77	0.02
Referred to lifestyle education class	1.40	0.002	1.42	0.01

benefits of physical activity in patients with Type 2 diabetes. It is possible that greater weight loss may have been achieved if patients had adopted dietary changes rather than increasing physical activity, although there is evidence that even modest weight loss attributable to increased exercise is often accompanied by increased muscle mass, which may have beneficial metabolic effects [19].

Physical inactivity is a major modifiable risk factor for subsequent diabetes-related morbidity and mortality. Our results are consistent with the Behavioral Risk Factor Surveillance System, a US cross-sectional telephone survey [12], but add new insight into longitudinal patterns of change among unselected patients attending primary care practices. Our study adds new information to the epidemiology of

physical inactivity among typical patients with Type 2 diabetes in that it represents the first large-scale longitudinal assessment of exercise changes measured as part of routine care. The factors associated with remaining physically inactive identified in our analysis highlight the importance of developing educational and outreach programmes directed at older, more complex patients with Type 2 diabetes typically seen in the primary care setting.

The US Preventive Services Task Force recently concluded that substantially increasing physical activity requires medium-intensity and high-intensity counselling interventions [20]. Strategies such as implementing a multidisciplinary team, including behavioural health coaches, engaging family members and social support structures, and targeted goal-setting have shown promise in smaller-scale trials [21–23]. Efforts are now needed to translate these tools more broadly to patients within healthcare systems. Our analysis suggests that collection of patient-reported exercise data as part of routine care has the potential to identify physically inactive high-risk patients and could be used to tailor interventions for groups of patients at high-risk based on baseline characteristics. Engaging various payers, insurers and administrators in developing and promoting more effective physical activity programmes by using effective systems represents a promising avenue for addressing physical inactivity, and could be considered as a reimbursable intervention for this high-risk population.

The present results must be considered in the context of the study design. Firstly, self-reported exercise is less reliable than use of accelerometers or other electronic monitors; however, such monitors are impractical for measuring exercise patterns in a large general primary care population over the course of a year and therefore self-report was ideally suited for our research question. Moreover, while there may be a tendency to over-report exercise levels, we focused on patients who reported no physical activity and thus this social desirability bias is less likely to have influenced our study. Secondly, our patient population was limited to patients receiving care within an integrated healthcare system; however, patient demographic and socio-economic factors within our system are similar to those of the area population, except at the extremes of the income distribution [24], indicating that our results are probably generalizable to many other patient

Table 3 Change in weight and HbA_{1c} among patients who became physically active relative to patients remaining physically inactive

	Weight change, kg (<i>n</i> = 6642)	<i>P</i>	HbA _{1c} change (<i>n</i> = 1822)	<i>P</i>	HbA _{1c} change [Baseline HbA _{1c} ≥ 53 mmol/mol (7%)]	<i>P</i>
Moderate-to-vigorous physical activity level at follow-up						
0–149 min/week	–0.13	0.32	0.06%	0.39	0.02%	0.84
≥ 150 min/week	–1.07	< .001	–0.08%	0.32	–0.18%	0.09

Patients remaining physically inactive were the referent group. Values were adjusted for baseline patient differences.

A total of 1822 patients in the cohort had two HbA_{1c} measurements during the study period, including 1175 patients who had HbA_{1c} ≥ 53 mmol/mol at baseline.

populations. Finally, because this was an observational study, we could not infer causality. Our results provide a description of the short-term epidemiology of physical inactivity among primary care patients with diabetes and can be used to inform future health system interventions to increase physical activity in this population. Future work with a longer-term cohort is needed to examine the persistence of exercise behaviour change and durability of clinical improvements.

Patients with diabetes who adopt lifestyle changes, including regular exercise, have a significantly reduced cardiovascular risk in the first year after diagnosis [25]. Over the longer term, there is a dose-dependent association between exercise and reduced macrovascular complications and mortality risk [25–29]. Despite these benefits, engaging patients with medically complex diabetes in continued physical activity has proven to be difficult. The present study shows that, while the majority of inactive patients with diabetes in the usual care setting remain inactive, a sizeable minority of patients do increase physical activity over time with salutatory health effects, even over the short term. These findings may help provide a real-world picture of physical activity over time and also underscore the need for developing more effective tools within care systems to improve exercise-related health outcomes.

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Competing interests

None declared.

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