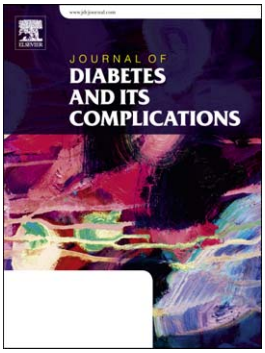

Participation in a National Lifestyle Change Program is Associated with Improved Diabetes Control Outcomes

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PII: S1056-8727(17)30470-1
DOI: doi: 10.1016/j.jdiacomp.2017.06.001
Reference: JDC 7039

To appear in: *Journal of Diabetes and Its Complications*

Received date: 3 April 2017
Revised date: 31 May 2017
Accepted date: 2 June 2017

Please cite this article as: Jackson, S.L., Staimez, L., Safo, S., Long, Q., Rhee, M.K., Cunningham, S.A., Olson, D.E., Tomolo, A.M., Ramakrishnan, U., Venkat Narayan, K.M. & Phillips, L.S., Participation in a National Lifestyle Change Program is Associated with Improved Diabetes Control Outcomes, *Journal of Diabetes and Its Complications* (2017), doi: 10.1016/j.jdiacomp.2017.06.001

Participation in a National Lifestyle Change Program is Associated with Improved Diabetes Control Outcomes

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Running head: Lifestyle Change and Diabetes Control Outcomes
Word count: 4,543 of 5000 allowed. Abstract 200. 3 Tables, 2 Figures.

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Funding: This work was supported in part by FDA award RO1FD003527 (L.S.P), VA award HSR&D IIR 07-138 (L.S.P, S.L.J.), NIH awards R21DK099716 (L.S.P., Q.L., S.S., L.R.S. and S.L.J.) DK066204 (L.S.P.), U01 DK091958 (L.S.P. and M.K.R.), U01 DK098246 (L.S.P. and D.E.O.), PCORI award ME-1303-5840 (Q.L. and S.S.) and a Cystic Fibrosis Foundation award PHILLI12A0 (L.S.P). It is also supported in part by the National Center for Advancing Translational Sciences of the National Institutes of Health under Award Number UL1TR000454. The sponsors had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; and preparation, review, or approval of the manuscript.

Disclosure statement: The authors declare that there is no duality of interest associated with this manuscript. With regard to potential conflicts of interest, within the past several years, Dr. Phillips has served on Scientific Advisory Boards for Boehringer Ingelheim and Janssen, and has or had research support from Merck, Amylin, Eli Lilly, Novo Nordisk, Sanofi, PhaseBio, Roche, Glaxo SmithKline, and the Cystic Fibrosis Foundation. In the past, he was a speaker for Novartis and Merck, but not for the last several years. Qi Long receives support from Cystic Fibrosis Foundation and American Heart Association and was a consultant for Eisai. Sandra Jackson previously received support from Amylin, and Venkat Narayan receives support from Novo Nordisk. These activities involve diabetes, but have nothing to do with this manuscript. Other authors have no potential conflicts of interest to declare.

Highlights Statement

- This research studied the largest clinical lifestyle change program in the United States, the Veteran's Health Administration's MOVE! program.
- Compared to eligible non-participants, participants in the program had significantly lower incidence of eye disease and renal disease, despite less medication intensification.
- Implementing lifestyle change programs in U.S. health systems may improve health among the growing patient population with diabetes.

Abstract

Aims: Clinical trials show lifestyle change programs are beneficial, yet large-scale, successful translation of these programs is scarce. We investigated the association between participation in the largest U.S. lifestyle change program, MOVE!, and diabetes control outcomes.

Methods: This longitudinal, retrospective cohort study used Veterans Health Administration databases of patients with diabetes who participated in MOVE! between 2005-2012, or met eligibility criteria (BMI $\geq$25 kg/m^2) but did not participate. Main outcomes were diabetic eye disease, renal disease, and medication intensification.

Results: There were 400,170 eligible patients with diabetes, including 87,366 (22%) MOVE! participants. Included patients were 96% male, 77% white, with mean age 58 years and BMI 34 kg/m^2. Controlling for baseline measurements and age, race, sex, BMI, and antidiabetes medications, MOVE! participants had lower body weight (-0.6 kg), random plasma glucose (-2.8 mg/dL), and HbA1c (-0.1%) at 12 months compared to nonparticipants (each $p<0.001$). In multivariable Cox models, MOVE! participants had lower incidence of eye disease (hazard ratio 0.80, 95% CI 0.75-0.84) and renal disease (HR 0.89, 95% CI 0.86-0.92) and reduced medication intensification (HR 0.84, 95% CI 0.82-0.87).

Conclusions: If able to overcome participation challenges, lifestyle change programs in U.S. health systems may improve health among the growing patient population with diabetes.

Keywords:

diabetes mellitus, diabetes complications, weight loss, weight reduction programs, veterans

Abbreviations:

CCI: Charlson Comorbidity Index

RPG: Random plasma glucose

SES: Socioeconomic status

VA: Veterans Health Administration

1. INTRODUCTION

The prevalence of type 2 diabetes has increased steadily in the United States between 1988 and 2012 [1]. Diabetes is a major cause of mortality and morbidity among adults, and is the leading cause of incident blindness and kidney failure [2]. In 2012, the total cost of diabetes was estimated at $245 billion, and projected healthcare expenditures attributable to prediabetes and diabetes are $3.5 trillion over the next decade [2, 3]. Segments of the U.S. population, such as racial and ethnic minorities, carry a disproportionate burden of morbidity and mortality from diabetes and its complications [2, 4].

Randomized clinical trials indicate that lifestyle change programs improve weight and glycemic control [5, 6], reduce medication use [7, 8], and may reduce microvascular complications [9]. However, the failure to translate research into practice and policy has prevented patients from benefiting fully from lifestyle change programs. The dissemination of effective interventions, particularly to those disproportionately burdened by diabetes and its complications, requires translation research in settings that reach subpopulations at highest risk of diabetes.

The Veteran's Health Administration (VA) is the largest integrated healthcare system in the U.S. In 2000, nearly 1 in 5 patients receiving care at the VA had diabetes [10], approximately twice the prevalence in the general adult population [2]. The VA's MOVE!® lifestyle change program has enrolled over 500,000 participants since 2005, and participation has been associated with modest weight loss [11] and reduced diabetes incidence [12]. Among patients with diabetes, we sought to understand the impact of participation in this healthcare-based lifestyle change program on diabetes management. Specifically, we examined the association between MOVE! participation and (a) incidence of diabetic eye disease and renal disease, (b) intensification of antidiabetes medications, and in secondary analyses of a subset of patients with available data, (c) change in glycemic control (hemoglobin A1c [HbA1c]), and random plasma glucose [RPG]). We hypothesized that the incidence of diabetic eye and renal diseases and the intensification of antidiabetes medications would decrease while glycemic control would increase.

2. SUBJECTS, MATERIALS AND METHODS

2.1 Databases

We used data from the VA's Corporate Data Warehouse, which contains national clinical and administrative data from 1999-present, including patient demographics, vital signs, diagnoses, procedures, and prescriptions. We accessed data through the Veterans Informatics and Computing Infrastructure (VINCI). This work was approved by the Emory University Institutional Review Board and the Atlanta VA Medical Center Research and Development Committee.

2.2 MOVE! Program

The MOVE! curriculum includes an orientation session and 10 core modules emphasizing improved nutrition, portion sizes, walking with a pedometer or physical activity modifications for wheelchair users, setting goals, and staying motivated. Implementation varies across VA facilities in terms of organization and delivery, although a study of best practices has emphasized the importance of using the standard MOVE! curriculum and offering a group-based format [13]. We defined participants as those who attended at least one session of the program.

2.3 Study Population

From nearly 10 million veterans receiving care between 2005-2012 (Fig. 1), we selected patients with yearly outpatient visits for at least 3 consecutive years, who were eligible to participate in MOVE! due to obesity (body mass index [BMI] $\geq$30 kg/m^2), or overweight (BMI $\geq$25). From these 4.5 million patients, we excluded those over age 70 because MOVE! is not targeted to individuals above this age, and we excluded veterans with contraindications. We restricted the sample to persons with diabetes at baseline, defined as use of the 250.xx ICD-9 code or prescription of a diabetes drug,[10, 14] and excluded veterans missing demographic data, leaving 400,170 eligible patients for this longitudinal, retrospective cohort study.

2.4 Measurements

Demographic characteristics: Available data included age, sex, race/ethnicity, and marital status. Race/ethnicity was defined as White, African American, and Other, the latter combining Hispanics, Asian/Pacific Islanders, and American Indians/Alaska Natives (each <2% of the study population). Socioeconomic status (SES) and disability were available through a variable termed "service-connected disability" that grades patient SES and disability jointly. Higher percentages indicate more severe disability and qualification for VA services; "no disability" (zero percent) indicates that a veteran has no disabilities related to military service but still qualifies for VA care based on low SES [15].

Weight-related illnesses and comorbidities: Illnesses were assessed using ICD-9 codes and procedure codes and were included in multivariable models. The Charlson Comorbidity Index (CCI) was also included, as an overall assessment of comorbidity burden.

Diabetes complications: Diabetic eye and renal disease were identified with ICD-9 codes, procedure codes, and CPT codes. Diabetic eye disease was defined by the presence of either (1) ICD-9 code 250.5x or 362.0x, as used previously for identification of diabetic eye disease [16]; or (2) diabetes (as above) along with codes for retinal edema, vitreous hemorrhage, retinal detachment, cranial nerve palsy, blindness, laser surgery, vitrectromy, retinal detachment repair, and/or enucleation. Sensitivity analyses were also conducted examining eye disease with inclusion of ICD-9 codes for glaucoma and cataracts, and procedure codes for glaucoma trabeculectomy and cataract extraction. Diabetic renal disease was defined as ICD-9 code 250.4x, or diabetes plus ICD-9 codes for kidney conditions, as used previously for identification of diabetic nephropathy [17], including proteinuria, kidney disease, acute renal failure, end-stage renal disease or uremia, or diabetes plus procedure codes or CPT codes for hemodialysis, peritoneal dialysis, or transplantation.

Diabetes Duration: This was defined as the number of years from first indication of diabetes to the patient's baseline visit. Duration of diabetes could not be obtained for 26% of patients, who appeared to have had diabetes prior to beginning care in the VA system. We conducted multiple imputation for the duration of diabetes variable, where the imputation model included age, BMI, and whether the participant

was prescribed a diabetes drug (insulin or no insulin, and oral medication or no oral medication). Twenty imputations were performed using a fully conditional specification (FCS) method on a log transformed duration variable to manage non-normality; results were combined using Rubin's rule [18].

Diabetes medications: Initiation of oral diabetes medications and insulin was assessed based on the date of the first recorded prescription. Medication intensification was defined as prescription of a new oral diabetes medication or initiation of insulin after baseline [19].

Laboratory Measures: Additional laboratory and clinical values (systolic blood pressure, RPG, and HbA1c) were available for a subset of patients, and were recorded as the most recent value within 12 months prior to baseline. Follow-up measures for RPG and HbA1c were recorded as average values captured within subsequent time windows (6 mo: 3-9 mo; 12 mo: 9-15 mo; 24 mo: 21-27 mo; 36 mo: 33-39 mo).

BMI: Body mass index (BMI) was assessed using clinically recorded weight and height, after excluding implausible values of weight <75 or >700lb or height <48 or >84 in. (approximately 0.1%) [20]. Height was taken as the average if multiple measures were available. Weight was recorded as the patient's baseline weight and follow-up weights as averages within subsequent time windows, as above.

VA Care: Distance to the nearest VA facility offering MOVE! was calculated for each patient, based on distance between the geographic midpoint of the patient's zipcode and the coordinates of the nearest VA facility offering MOVE!. Each patient's average number of primary care visits per year and total number of years with recorded VA visits were also calculated to assess frequency and span of interaction with the VA system.

Smoking: Patients were classified as "Current Smoker", "Former Smoker", or "Never / Lifetime Non-Smoker," as previously described and validated [21].

2.5 Statistical Analysis

Least square means were produced through linear models to calculate average body weight, RPG, and HbA1c among participants compared to non-participants, controlling for baseline value, BMI, age, gender, race/ethnicity, and baseline antidiabetes medications.

For regression, we conducted stepwise model selection, assessing model fit based on the Akaike information criterion (AIC). After verifying model assumptions, including the proportional hazards assumption, Cox proportional hazards models were used to estimate hazard ratios for each of the following outcomes: (i) diabetic eye disease (among those without eye disease at baseline), (ii) diabetic renal disease (among those without renal disease at baseline), and (iii) medication intensification. All years of available data for each patient were included (maximum 2005-2012) and patients were censored at the time of event (eye disease, renal disease, or medication intensification, respectively, for each of the three Cox models) or at the time of each patient's last visit during this time period (for patients who did not have an event). Robust sandwich covariance matrix estimates were used to adjust for clustering at the clinic level [22]. Models were further adjusted for a propensity score that reflected likelihood of participating in MOVE!. Propensity scores were used to reduce bias by creating a score for each individual, defined as the conditional probability of participating in MOVE! given the individual's covariate values. Additional analyses were performed to examine the association between participation and incidence of diabetes outcomes among subgroups likely to have differing risk (sex, race, age, BMI, diabetes duration, and diabetes medication use).

Baseline was assigned as a veteran's first MOVE! visit for participants and as the first visit at which weight was recorded after January 1, 2005 (the initial year of MOVE! roll-out) for non-participants. Sensitivity analyses were adjusted for baseline year as a categorical variable to allow for potential differences in management across years. We also performed sensitivity analyses examining those who met the VA criteria for "intense and sustained" participation (attending $\geq$ 8 sessions within 6 months), which is a level of participation that has been previously associated with greater weight loss [23]. All analyses were conducted using SAS® statistical software (version 9.2; SAS Institute, Cary, NC).

3. RESULTS

3.1 Baseline Characteristics

In this MOVE!-eligible population with diabetes, patients had frequent (median 4 visits per year) and sustained (median 10 years) care in the VA system. MOVE! participants were more likely than nonparticipants to be female, African American, and obese (Table 1). Participants were more likely than nonparticipants to have eye disease or renal disease at baseline, and were also more likely to be taking oral antidiabetes medications or insulin. All differences between participants and nonparticipants were statistically significant ($p<0.001$).

3.2 Change in Weight, RPG, and HbA1c

MOVE! participation was associated with slightly greater change in mean body weight (-0.6 kg), RPG (-2.8 mg/dL), and HbA1c (-0.1%) at 12 months (Table 2A, all $p<0.001$) compared to nonparticipation after adjusting for age, gender, race/ethnicity and for baseline values (of weight, RPG, and HbA1c, respectively), and use of oral antidiabetes medications, and insulin. Observed differences became smaller between 12 to 36 months, but remained significant. Participants who met VA criteria for "intense and sustained" participation (9.5% of participants) had larger reductions in weight (-2.1 kg), RPG (-7.8 mg/dL), and HbA1c (-0.3%) compared to nonparticipants at 12 months (Table 2B, all $p<0.001$).

3.3 Incidence of Diabetes Complications

Median follow-up time after baseline was 69 months (range 1-95). The incidence of diabetic eye disease was 52 per 1000 person-years and incidence of renal disease was 30 per 1000 person-years (among those without such diagnoses at baseline). Consistent with previous studies, being African American was associated with increased incidence of eye disease, as was having a prescription for oral antidiabetes medications or insulin at baseline. Incident renal disease was associated with being African American, having diagnosed hypertension, and using insulin at baseline.

In multivariable models, MOVE! participation was associated with lower incidence of eye disease (HR 0.80, 95% CI 0.75-0.84) and renal disease (HR 0.89, 0.86-0.92) (Table 3) across the entire follow up period. We conducted sensitivity analyses adjusting for baseline HbA1c and systolic blood pressure, measures available for a subset of patients (Appendix Table 1). The inverse associations between MOVE! participation and diabetes complications remained significant after these adjustments. Stratified results across baseline participant characteristics (demographics, BMI, diabetes duration, and use of medication) continued to show an association between MOVE! participation and reduced eye disease and renal disease (Fig. 2A, 2B).

3.4 Initiation and Intensification of Diabetes Medications

Medication intensification occurred at a rate of 157 new medications per 1000 person-years of observation over the entire follow up period. As expected, patients who already had a prescription for insulin at baseline were much less likely to have a new medication added (HR 0.29, 0.28-0.30) compared to patients who did not (Table 3). However, even after adjustment for baseline medication, MOVE! participation was associated with reduced medication intensification (HR 0.82, 0.80-0.84) (Table 3).

Oral antidiabetes medication initiation occurred more frequently (141 per 1000 person-years) than insulin initiation (60 per 1000 person-years). MOVE! participation was more strongly associated with lower oral antidiabetes medication intensification (HR 0.81, 0.78-0.85) than insulin initiation (HR 0.95, 0.92-0.98) (Appendix Table 2). The association between MOVE! participation and reduced medication intensification remained significant across subgroups stratified by participant characteristics (Fig. 2C).

4. DISCUSSION

Participation in a lifestyle change program implemented within a national health care system was associated with significant health benefits for U.S. veterans with diabetes. Participants in the MOVE! program had 20% lower incidence of diabetic eye disease, 11% lower incidence of renal disease, and 18%

lower medication intensification compared to patients who did not participate. These health benefits were apparent even after adjustment for baseline demographic and clinical risk factors, emphasizing the independent associations between MOVE! participation, diabetes control and the prevention of diabetes complications. Expanding on results from randomized controlled clinical trials, results from this healthcare system translation suggest that lifestyle change programs can be clinically relevant and effective in real-world settings, among a relatively high-risk population.

Our study is consistent with findings in randomized trials, which suggest that lifestyle change programs can improve diabetes control. The Look AHEAD trial showed lower medication usage among lifestyle change program participants with diabetes, as well as reductions in weight, HbA1c concentrations, and incidence of chronic kidney disease [7, 24]. The China Da Qing Diabetes Prevention Outcomes study found that lifestyle intervention was associated with a lower incidence of severe retinopathy (HR 0.53, 0.29-0.99) but not nephropathy (HR 1.05, 0.16-7.05) [25], and reduced cardiovascular mortality [26]. Although there are few trials of lifestyle change in diabetes patients with microvascular endpoints, one review has linked weight loss in chronic kidney disease patients with improved renal function, including decreased proteinuria and increased GFR [9].

Our study also supports prior work that has demonstrated short-term improvements in weight and glucose control with lifestyle change among patients with diabetes [5, 6]. For example, a small-scale healthcare system-based randomized trial among obese persons with diabetes found that lifestyle change reduced weight (-3.0 kg at 12 months) and HbA1c levels, although impact on HbA1c was modest and not statistically significant at 12 months (-0.2%, p=.45) [8]. These metabolic changes were comparable to what we observed in "intense and sustained" MOVE! participants (weight loss -2.1 kg, HbA1c -0.3% over 12 months, all $p<0.001$ compared to nonparticipants).

Health care system factors may affect lifestyle change program participation and diabetes-related outcomes. For example, the TRIAD study found that out-of-pocket costs tended to reduce patient participation in diabetes education programs [27]. Low participation is a key challenge of the MOVE! program, although the VA eliminated copayments for health education in 2008 in order to promote

participation in MOVE!. Efforts to improve diabetes management should consider both payment structures and processes of care; implementation of a multifactorial diabetes management program, including provision of diabetes education with no copayments, dissemination of clinical guidelines, and development of clinical reminders to improve processes of care, has been associated with decreased HbA1c (-0.6%) [28].

In addition to low participation rates, another challenge of the MOVE! program is the difficulty of achieving and sustaining weight loss, particularly among participants with diabetes, as has been found in other studies [29]. We observed modest differences in weight, RPG, and HbA1c between participants and nonparticipants, and these differences were attenuated over time. Prior research has suggested that participants in lifestyle change programs who have diabetes accomplish less weight loss and maintenance of losses over time compared to those without diabetes [30]. Difficulties among patients with diabetes in adhering to dietary and exercise regimens have been noted previously [31]. Weight loss may also be more difficult among persons with diabetes due to the weight gain associated with some antidiabetes medications and insulin, the risk of hypoglycemia with weight loss (particularly if medications are not adjusted proactively), and the mental and emotional effects of previous failed weight loss attempts [32, 33]. Despite these potential challenges, patients in this study experienced health benefits.

The strengths of our study include the examination of a lifestyle change program within a national healthcare setting, and a study population large enough to examine development of diabetes complications. However, there were limitations. First, the observational nature of the data confers the possibility of residual confounding and selection bias. For example, participants were generally in poorer health than nonparticipants, and were more likely to have eye disease or renal disease at baseline. To reduce potential bias, analyses utilized electronic health record data to adjust for differences in known clinical risk factors, together with a propensity score to adjust for the likelihood of participation in MOVE! based on demographic and clinical indicators. Second, some veterans receive care outside of the VA, and some diagnoses and medications may not be recorded in VA databases. To minimize this potential source of misclassification, we restricted analyses to veterans receiving at least 3 continuous

years of outpatient care in the VA, to focus on patients who had consistent contact with the VA system. Third, deaths were not captured in VA databases, and could not be accounted for in analyses. Fourth, we were not able to account for changes in dosage in our examination of medication intensification. However, our definition of medication intensification as 'initiation of a new medication' is consistent with prior work [19]. Fifth, non-participants exhibited weight loss over time, potentially reflecting the longitudinal initiation of medication in this sample of diabetes patients. Nevertheless, more weight loss was reported in MOVE! participants compared to non-participants. Sixth, the VA population is predominantly male, which may limit generalizability. Lastly, analysis of different features of the intervention (participation in sessions on diet, physical activity, etc.) was beyond the scope of this study, but we did find that health outcomes were improved progressively with more intensive lifestyle change participation (intense vs. low/medium participation vs. non-participation, as shown in Table 2b).

In conclusion, this study demonstrates that participation of patients with diabetes in a healthcare system-based lifestyle change program was associated with reduced incidence of diabetes complications. In addition, participation was associated with improved weight, blood pressure, and HbA1c levels despite reduced intensification of diabetes medications. Broad implementation of lifestyle change programs within large healthcare systems might have widespread beneficial effects on the growing population of people with diabetes.

Acknowledgements

The authors gratefully acknowledge the contributions of Ms. Christine Jasien, at the Atlanta VA Medical Center, as well as Dr. Kathleen McGinnis and her colleagues at the Veterans Aging Cohort Study Team (funding source: NIAAA 5U10AA013566 and 1U24AA020794), who shared their expertise with VA data and informed the present work.

Sandra Jackson conducted data analyses and drafted the manuscript, including literature search, production of figures, data interpretation, and writing. Lisa Staimez contributed interpretation of the data and substantial manuscript revisions. Lawrence Phillips provided guidance and input across all stages of study planning, analysis, and manuscript development and revisions. Qi Long and Sandra Safo provided statistical expertise for analyses and edited the manuscript. Mary Rhee, Darin Olson, Anne Tomolo, Solveig Cunningham, Usha Ramakrishnan, and K.M. Venkat Narayan contributed conceptually to study planning and edited manuscript revisions. Sandra Jackson and Lawrence Phillips had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. There was no medical writer or editor.

Drs. Phillips, Rhee, Olson, and Tomolo receive support from the VA, and Dr. Jackson and Dr. Safo conducted analyses using VA resources and data. This work is not intended to reflect the official opinion of the VA or the U.S. government.

Funding

This work was supported in part by FDA [award RO1FD003527 for L.S.P], VA [award HSR&D IIR 07-138 for L.S.P and S.L.J.], NIH [awards R21DK099716 for L.S.P., Q.L., S.S., L.R.S. and S.L.J.; DK066204 for L.S.P.; U01 DK091958 for L.S.P. and M.K.R., U01 DK098246 for L.S.P. and D.E.O.], PCORI [award ME-1303-5840 for Q.L. and S.S.] and a Cystic Fibrosis Foundation award [PHILLI12A0 for L.S.P]. It is also supported in part by the National Center for Advancing Translational Sciences of the

National Institutes of Health under Award Number UL1TR000454. The sponsors had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; and preparation, review, or approval of the manuscript.

Conflictions of Interest

The authors declare that there is no duality of interest associated with this manuscript. With regard to potential conflicts of interest, within the past several years, Dr. Phillips has served on Scientific Advisory Boards for Boehringer Ingelheim and Janssen, and has or had research support from Merck, Amylin, Eli Lilly, Novo Nordisk, Sanofi, PhaseBio, Roche, Glaxo SmithKline, and the Cystic Fibrosis Foundation. In the past, he was a speaker for Novartis and Merck, but not for the last several years. Qi Long receives support from Cystic Fibrosis Foundation and American Heart Association and was a consultant for Eisai. Sandra Jackson previously received support from Amylin, and Venkat Narayan receives support from Novo Nordisk. These activities involve diabetes, but have nothing to do with this manuscript. Other authors have no potential conflicts of interest to declare.

Appendices

Appendix Table 1. Incidence of diabetes complications and medication adjustment, further adjusting for baseline HbA1c and systolic blood pressure, among subsets with laboratory measurements available

	Eye Disease		**Renal Disease**		**Medication intensification**	
	N=215,960		N=248,265		N=269,442	
	HR	CI	HR	CI	HR	CI
MOVE! Participation	0.84	0.79-0.89	0.92	0.88-0.96	0.89	0.87-0.92
Baseline HbA1c	1.16	1.15-1.16	1.05	1.04-1.06	1.18	1.18-1.19
Baseline Systolic BP	1.01	1.00-1.01	1.01	1.01-1.01	1.00	1.00-1.00

Models identical to Table 3, but including addition adjustment of HbA1c, and restricted to patients with available data for laboratory measures. Models also controlled for Charlson Comorbidity Index, smoking status, coronary artery disease, COPD, osteoarthritis, mental health conditions (depression and psychoses), distance from a patient's zipcode to a facility offering MOVE!, marital status, number of primary care visits per year, diabetes duration in years, and years of care in the VA system. Other factors considered for inclusion in analysis but omitted through AIC model selection included heart failure, PTSD, alcohol abuse, and drug abuse. Models were adjusted for clustering by clinic, and included propensity scores to adjust for likelihood of MOVE! participation. Hazard ratios reflect 1-unit change for continuous variables.

Appendix Table 2. Intensification of Oral Antidiabetes Medication and Insulin

	Initiation of oral medication		**Initiation of insulin**	
	N=116,675		N=303,729	
	HR	CI	HR	CI
MOVE! Participation	0.81	0.78-0.85	0.95	0.92-0.98

Models also controlled for Charlson Comorbidity Index, smoking status, coronary artery disease, COPD, osteoarthritis, mental health conditions (depression and psychoses), distance from a patient's zipcode to a facility offering MOVE!, marital status, number of primary care visits per year, diabetes duration in years, and years of care in the VA system. Other factors considered for inclusion in analysis but omitted through AIC model selection included heart failure, PTSD, alcohol abuse, and drug abuse. Models were adjusted for clustering by clinic, and included propensity scores to adjust for likelihood of MOVE! participation. Hazard ratios reflect 1-unit change for continuous variables.

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Table 1. Baseline characteristics of U.S. veterans with diabetes who were eligible for MOVE!, a lifestyle change program, 2005-2012

	All	Non-Participants	Participants
	N=400,170	N=312,804	N=87,366
Age at baseline (years)	58.4 ± 7.7	58.5 ± 7.7	58.3 ± 7.7
Sex			
Male	95.9%	96.7%	92.8%
Female	4.2%	3.3%	7.2%
Race			
White	77.1%	78.4%	72.8%
African American	18.3%	17.1%	22.9%
Other	4.5%	4.6%	4.34%
Weight (kg)	233.1±45.8	228.2±42.9	250.4±51.2
BMI at baseline (kg/m^2)	34.0 ± 6.2	33.1 ± 5.6	37.3 ± 6.8
25-29.9	28.5%	33.3%	11.3%
30-34.9	35.4%	36.7%	30.5%
35.0-39.9	21.2%	19.1%	28.7%
≥40	15.0%	10.9%	29.5%
Eye disease	16.9%	14.6%%	25.1%
Renal disease	6.6%	4.9%	12.7%
Oral diabetes Medication	69.3%	66.7%	78.9%
Insulin	22.0%	19.2%	32.3%
HbA1c (%)[a]	7.5±1.7	7.5±1.8	7.6±1.6
RPG (mg/dL)[b]	156.1±70.0	157.3±71.2	152.7 ±65.9
Systolic Blood Pressure (mm Hg)[c]	134.3±17.2	135.1±17.6	131.4±15.4
Diabetes Duration (months)[d]	37.6 ± 30.23	34.6 ± 26.6	48 .2± 39.0
Charlson Comorbidity Index			
0 Point	72.1%	76.5%	56.5%
1 Point	17.7%	15.4%	25.6%
2+ Points	10.3%	8.1%	18.0%
Hypertension	80.5%	78.3%	88.4%
Dyslipidemia	70.1%	67.0%	81.0%
Mental health conditions			
Depression	25.2%	20.4%	42.5%
Psychoses	21.5%	17.2%	37.0%
PTSD	12.0%	9.2%	22.2%
Smoking Status			
Current Smoker	30.0%	30.9%	26.8%
Former Smoker	37.5%	37.3%	38.5%
Lifetime Non-smoker	32.5%	31.9%	34.7%
Rx for weight loss medication	22.0%	21.7%	23.0%

Married	62.2%	63.5%	57.5%
No Disability	49.1%	51.3%	41.5%
No. Primary Care Visits per Year	4.3 ± 2.6	4.1 ± 2.4	5.0 ± 2.9
No. Years with a Visit Recorded in VA Databases	9.9 ± 3.3	9.8 ± 3.4	10.0 ± 3.2
Average Distance to MOVE! Clinic	43.6 ± 32.7	44.5 ± 32.9	40.8 ± 32.1

[a] For baseline HbA1c, N=274,474 for all, N=200,209 for nonparticipants, and N=74,265 for participants.

[b] For baseline RPG, N=319,964 for all, N=238,054 for nonparticipants, and N=81,910 for participants.

[c] For baseline systolic blood pressure, N=397,136 for all, N=311,224 for nonparticipants, and 85,912 for participants.

[d] For duration of diabetes (in months), N=391,463 for all, N=305,958 for nonparticipants, and N=85,505 for participants.

±values are means ±SD. All associations between patient characteristics and MOVE! participation were significant ($p < 0.001$), according to chi-squared tests (categorical variables) and ANOVA (continuous variables).

Table 2. Metabolic characteristics in U.S. veterans after baseline, stratified by MOVE! participation, 2005-2012.

Table 2a: Participants vs. Non-participants				
	6 Months	12 Months	24 Months	36 Months
Weight (kg)				
Non-participants	105.84	105.49	104.84	103.83
Participants	105.38	104.91	104.25	103.54
Difference	*0.46*	*0.58*	*0.59*	*0.29*
RPG (mg/dL)				
Non-participants	148.28	148.56	148.46	149.28
Participants	145.33	145.76	146.83	148.48
Difference	*2.95*	*2.80*	*1.63*	*0.80*
HbA1c (%)				
Non-participants	7.45	7.53	7.54	7.62
Participants	7.38	7.43	7.50	7.57
Difference	*0.07*	*0.10*	*0.04*	*0.05*
Table 2b: "Intense and Sustained" vs. "Non-participants				
	6 Months	12 Months	24 Months	36 Months
Weight (kg)				
Non-participants	105.85	105.49	104.84	103.83
Less Active	105.58	105.10	104.40	103.67
Intense and Sustained	103.81	103.44	102.96	102.48
Difference (Intense vs. Non)	*2.04*	*2.05*	*1.88*	*1.35*
RPG (mg/dL)				

Non-participants	148.31	148.59	148.48	149.29
Less Active	146.08	146.33	147.26	148.84
Intense and Sustained	138.76	140.83	143.12	145.34
Difference (Intense vs. Non)	*9.55*	*7.76*	*5.36*	*3.95*
HbA1c (%)				
Non-participants	7.45	7.53	7.54	7.62
Less Active	7.41	7.45	7.52	7.58
Intense and Sustained	7.16	7.28	7.39	7.43
Difference (Intense vs. Non)	*0.29*	*0.25*	*0.15*	*0.19*

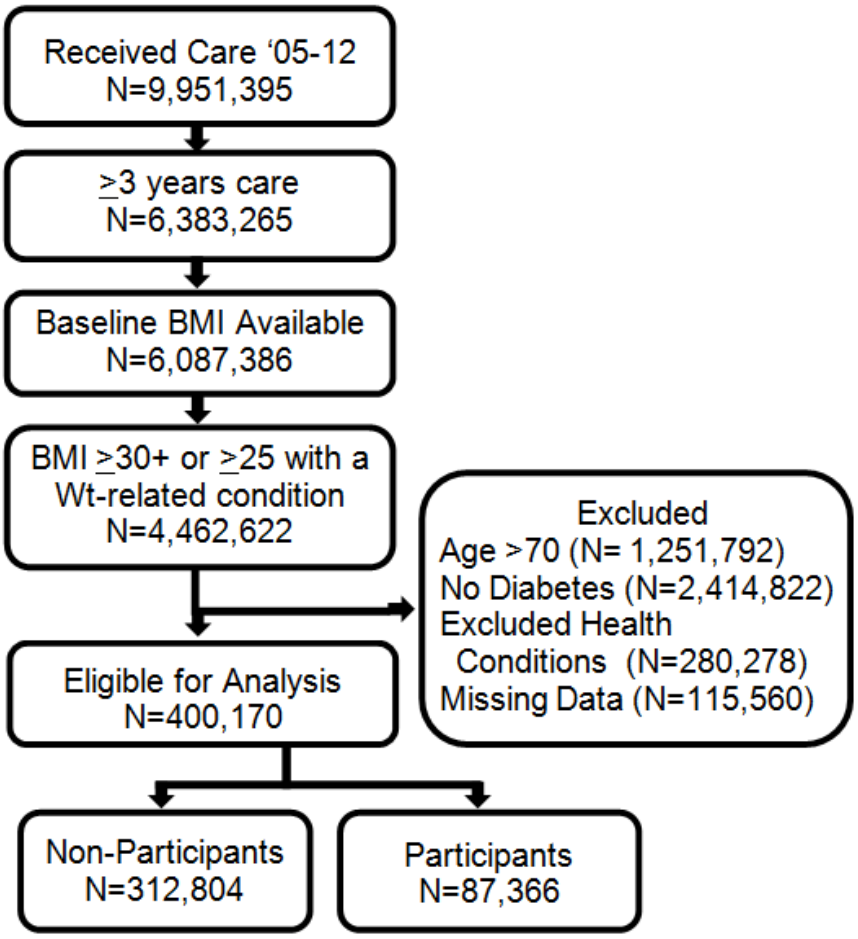
Adjusted means controlled for baseline value, baseline BMI, baseline age, gender, race/ethnicity, and baseline medication status (oral antidiabetes medications and/or insulin). For weight, N=15,885 at 6 months, 317,129 at 12 months, 280,996 at 24 months, and 242,766 at 36 months. For RPG, N=227,144 at 6 months, 230,508 at 12 months, 204,690 at 24 months, 177,611 at 36 months. For HbA1c, N=187,810 at 6 months, 190,126 at 12 months, 167,636 at 24 months, and 144,876 at 36 months. All differences were significant between participants and nonparticipants ($p<.001$) in Table 2a, and across participation levels (non-participation, less active participation, and intense and sustained participation) in Table 2b ($p<.001$).

Table 3. Incidence of Diabetes Complications and Medication Intensification in U.S. Veterans, 2005-2012.

	Eye Disease		Renal Disease		Medication intensification	
	N=324,419		N=365,265		N=391,464	
	HR	CI	HR	CI	HR	CI
MOVE! Participation	0.80	0.75-0.84	0.89	0.86-0.92	0.82	0.80-0.84
Age at baseline	1.01	1.00-1.01	1.03	1.03-1.03	0.99	0.99-0.99
Female	0.82	0.77-0.87	0.78	0.72-0.85	0.84	0.82-0.87
Race (ref=White)						
African American	1.18	1.11-1.27	1.44	1.38-1.50	0.97	0.95-0.99
Other	1.12	1.03-1.20	1.01	0.95-1.08	0.96	0.92-0.99
BMI at baseline	0.99	0.99-1.00	1.02	1.01-1.02	1.00	1.00-1.00
Baseline kidney disease	1.12	1.08-1.16	-	-	0.88	0.85-0.90
Baseline eye disease	-	-	1.29	1.25-1.33	0.98	0.97-1.00
Insulin at baseline	2.01	1.95-2.08	1.60	1.56-1.64	0.29	0.28-0.30
Oral Antidiabetes Rx at baseline	1.18	1.15-1.21	1.05	1.02-1.07	0.80	0.78-0.82
Diabetes Duration (in years)	1.04	1.03-1.04	1.04	1.03-1.04	1.00	0.99-1.00
Rx for weight loss	1.28	1.24-1.31	1.32	1.28-1.36	2.50	2.42-2.58
Hypertension (ICD-9)	1.05	1.02-1.07	1.40	1.36-1.44	0.98	0.96-0.99
Dyslipidemia (ICD-9)	0.92	0.89-0.94	1.03	1.00-1.06	0.95	0.94-0.96
Disability (ref=none)						
0-20%	1.04	1.01-1.07	0.84	0.81-0.87	0.96	0.94-0.98
30-60%	1.08	1.04-1.11	0.86	0.83-0.89	1.00	0.98-1.02
70-100%	1.24	1.20-1.29	1.10	1.07-1.14	1.07	1.05-1.09

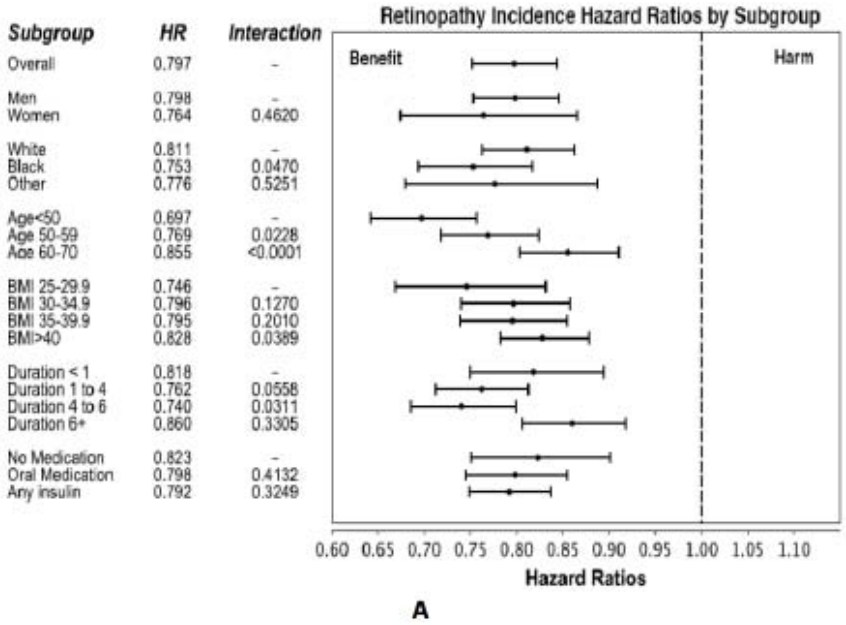
Models also controlled for Charlson Comorbidity Index, smoking status, coronary artery disease, COPD, osteoarthritis, mental health conditions (depression and psychoses), distance from a patient's zipcode to a facility offering MOVE!, marital status, number of primary care visits per year, and years of care in the VA system. Service connected disability is a percentage reflecting both patient SES and patient disability, often used to determine eligibility for VA care. Higher percentages indicate more sever disability and qualification for VA services; zero percent indicates that a veteran has no disabilities but is still qualified for VA care based on low SES. Other factors considered for inclusion in analysis but omitted through AIC model selection included heart failure, PTSD, alcohol abuse, and drug abuse. Models were adjusted for clustering by clinic, and included propensity scores to adjust for likelihood of MOVE! participation. Hazard ratios reflect 1-unit change for continuous variables.

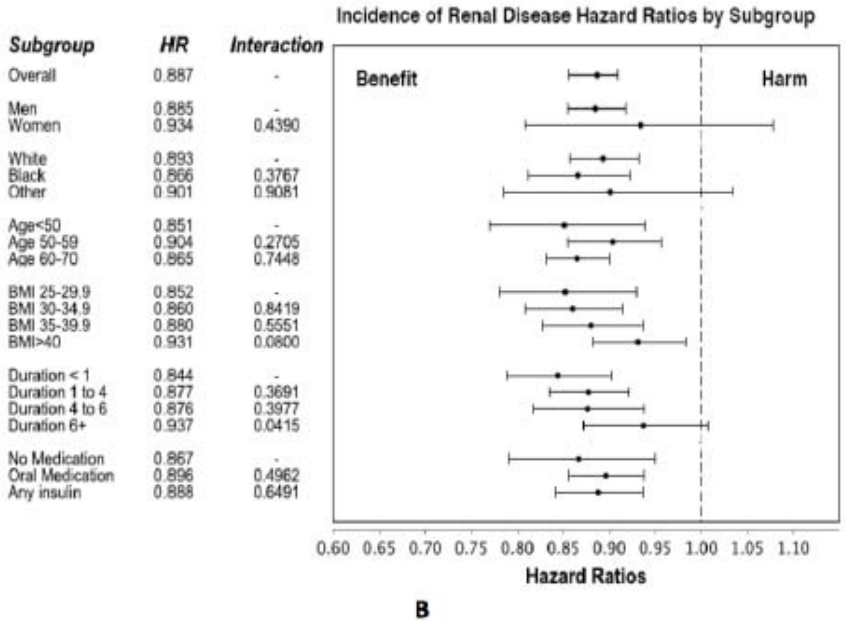
Figure 1. Study Population, 2005-2012

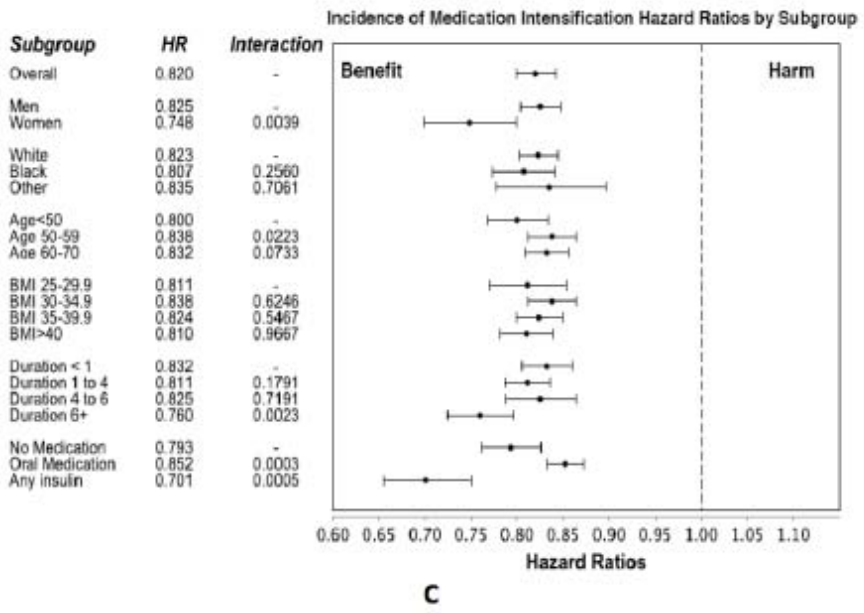


Weight-related health conditions included diabetes, hypertension, dyslipidemia, sleep apnea, or osteoarthritis. Excluded health conditions, consistent with a prior study of MOVE, included diagnoses of sepsis, pregnancy, cancer other than skin cancer, neurodegenerative disease, HIV, or anorexia, or receipt of hospice or nursing home care.

Figure 2. Association between MOVE! Participation and Incidence of Diabetes Complications and Medication Intensification in U.S. Veterans, by Subgroup, 2005-2012







Cox proportional hazards models included all covariates in Table 3. Wald p-values for interaction terms are shown, for subgroups: sex, race, age category (years), BMI category (kg/m2), duration of diabetes at baseline (years), and diabetes medication status at baseline. Hazard ratios less than 1 (to the left of the dashed axis) indicate that MOVE! participation was associated with reduced incidence of diabetes complications. Significant p-values indicate possible heterogeneity of effects across subgroups.