Lessened decline in physical activity and impairment of older adults with diabetes with telemedicine and pedometer use: results from the IDEATel study

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Abstract

Objective: to examine the effects of the Informatics for Diabetes Education and Telemedicine (IDEATel) telemedicine intervention and pedometer use on physical activity (PA) and impairment in older adults with diabetes.
Design: randomised clinical trial.

Subjects: ethnically diverse medically underserved Medicare beneficiaries with diabetes (n= 1,650).

Methods: participants received home videovisits with a diabetes educator every 4–6 weeks or usual care. All received a pedometer. Annual measurements included hemoglobin A1c, Comprehensive Assessment and Referral Evaluation Activities of Daily Living, Diabetes Self-Care Activities, Charlson Comorbidity Index, Luben Social Support and pedometer use. Mixed model analyses were performed using random effects to adjust for clustering within primary care physicians.

Results: in the telemedicine group compared with the usual care group, the rate of decline in PA (P= 0.0128) and physical impairment (PI) (P= 0.0370) was significantly less over time. Significant mean endpoint differences were observed for PA (P= 0.0035). Pedometer use was significantly associated with PA (P= 0.0006) and PI (P< 0.0001). Baseline characteristics associated with greater PA included having fewer comorbid conditions (P= 0.0054), less depression (P< 0.0001), more social networking (P< 0.0001), lower BMI (P< 0.0001), male gender (P< 0.0001) and lower hemoglobin A1c level (P= 0.0045). Similar predictors were observed for PI, except duration of diabetes also predicted increased impairment (P< 0.0001). Significant indirect effects were observed through use of the pedometer on reduced decline in PA (P= 0.0024, 0.0013) and PI (P= 0.0024, P< 0.0001).

Conclusions: this telemedicine intervention reduced rates of decline in PA and impairment in older adults with diabetes. Pedometers may be a helpful inexpensive adjunct to diabetes initiatives delivered remotely with emerging technologies. ClinicalTrials.gov identifier NCT 00271739.

Keywords: diabetes, telemedicine, physical activity, physical impairment, elderly

Introduction

Sedentary behaviour is common in older adults with diabetes and is associated with high levels of functional impairment [1]. Regular physical activity (PA) is associated with reduced disability among older adults with diabetes, and can contribute to reductions in hemoglobin A1c and improvements in cardiovascular risk factors [2]. Education or counselling can increase PA levels [3]. In older adults at risk of hospital readmission, initiation of an exercise programme with nurse home visits and telephone follow-up decreased emergency readmissions and improved quality of life [3]. This exercise programme included walking, but a majority of the study sample did not have diabetes [3]. Walking confers health benefits and is accessible to diverse populations. Educational interventions to promote PA and walking as part of diabetes self-management have met with mixed success [4–7].

Use of pedometers has been investigated as a tool to promote walking to achieve recommended PA goals [8]. Short-term results of pedometer-based interventions for adults with diabetes demonstrate improvement in PA [7, 9, 10]; however, longer-term findings indicate lack of persistence of these beneficial changes [11]. Studies of pedometer-based interventions employed structured schedules of face-to-face or telephone visits without opportunity for interaction between clinicians and participants between measurement visits. Telemedicine can facilitate more frequent interactions, particularly with older adults living in underserved areas who have limited access to diabetes education and care. The effectiveness of an interactive telemedicine-based intervention with use of pedometers on PA and physical impairment (PI) in older adults with diabetes has not been previously described.

The Informatics for Diabetes Education and Telemedicine (IDEATel) project randomised older adults with diabetes to receive usual care from their primary care providers (PCPs) or usual care augmented by a telemedicine intervention that involved home videovisits every 4–6 weeks with a diabetes educator [12]. We previously reported improved hemoglobin A1c, blood pressure and low-density lipoprotein (LDL)-cholesterol levels in intervention subjects after 5 years of participation [13]. In this report, we examine the effect of the IDEATel intervention on PA and PI over 5 years, and the influence of pedometer use on improvement in PA and PI.

Methods

Participants

Participants were Medicare beneficiaries with diabetes living in federally designated underserved areas (see [13] for CONSORT diagram). Urban subjects, recruited in NYC, were primarily Hispanic or African American. Rural subjects, recruited from PCP practices in upstate NY, were primarily White. The intervention used bilingual educators at Columbia University, NYC for urban subjects and educators at SUNY Upstate Medical University in Syracuse NY for rural subjects.

Study design

Subjects were randomised within PCP practices to the telemedicine group or usual care. Details of the study design have been previously described [12]. Telemedicine subjects received a home telemedicine unit to videoconference with a diabetes educator every 4–6 weeks for self-management
education, review of transmitted home blood glucose and blood pressure measurements and individualised goal-setting. Subjects were enrolled between 2000 and 2002, with participation from 2000 to 2007.

In 2004, pedometers were distributed to all participants with written instructions for use. The PCPs could set goals with their patients as they deemed appropriate. Subjects were asked to discuss with their PCP recommended goals for the safe use of their pedometers. In the telemedicine arm, educators also discussed proper use of pedometers and set goals if appropriate. The initial goal was to wear the pedometer. Subsequently, common goals were to increase steps by 10% or to maintain the number of steps. Participants were encouraged to write down their daily steps and report them during the video visits. For participants who were able to use the pedometer, nurses asked about pedometer use at each televisit.

**Annual assessments and evaluation data collection**

All participants had annual assessments by personnel who were blinded to intervention status and were not involved in supporting the intervention. Assessments included physical measurements (height, weight, blood pressure), laboratory measurements (hemoglobin, A1c, lipid panel, urine microalbumin:creatinine) and completion of questionnaires which included the Diabetes Self-Care Activities for Assessment of PA (DSC-PA) [14], the Comprehensive Assessment and Referral Evaluation (CARE) Activities of Daily Living scale (ADL) for assessment of PI [15], the CARE Depression instrument [16], the Charlson Comorbidity Index [17], the Lubben Social Support instrument [18], SF-12 and self-report of pedometer use (yes/no). Responses to the DSC-PA and CARE ADL were used to calculate scores assessing PA and PI, respectively. Those scores constituted the outcome variables of our analyses. The DSC-PA contained two items: ‘On how many of the last 7 days did you participate in at least 30 min of PA, and ‘On how many of the last seven days did you participate in a specific exercise session other than what you do around the house or as part of your work?’ Possible and observed values ranged from 0 to 7, with a high score indicative of higher levels of PA.

The CARE ADL, the measure of PI, was developed using large probability samples from the USA and UK and has been used in numerous studies, including the Systolic Hypertension in the Elderly Project (SHEP) [19]. It has been used to assess elderly individuals in several community settings and among different ethnic/race groups [20]. Cronbach’s alphas for the development samples were 0.95 and 0.84 in the SHEP study. The Cronbach’s alpha for this sample ranged from 0.93 to 0.95 across administrations. The theoretical range was from 0 to 29, and the observed from 0 to 28, with a high score indicative of more impairment. Convergent validity coefficients ranged from 0.66 to 0.70. The concurrent and predictive validity of the scale for institutional planning, morbidity and death was good, e.g.

**Analysis**

Longitudinal mixed fixed and random effects models were used to examine the direct effects of the intervention on PA, PI and self-reported pedometer use. Repeated measures mixed-model path analyses were performed to examine the indirect, longitudinal effects of the intervention on PA and PI through pedometer use. Random effects were included to model the design features of subjects nested within PCPs, using SAS Proc Mixed. In the models predicting PA and PI, pedometer use was treated as a time-varying covariate. Baseline values were used for other covariates included in the analyses. Time was centred in order to reduce collinearity in the analyses involving interaction terms. Examination of the distributions of the outcomes for skewness and kurtosis indicated that they were normally distributed and no transformations were necessary. The covariance matrix was examined and the pattern selected based on best fit, tested using Akaike’s Information Function. The compound symmetry covariance structure provided the best fit. The analyses were as follows:

(i) Mixed model regression analyses were performed, examining the effects of the intervention and pedometer use on PA and PI for both the primary and sensitivity analyses. Models without the covariates in Tables S1 and S2 (Supplementary data are available in *Age and Ageing* online) were used to examine the effects of the intervention on PA and PI. Models with the covariates in Tables S1 and S2 (Supplementary data are available in *Age and Ageing* online) were used to examine the effects of pedometer use on PA and PI. Unadjusted and adjusted means are shown in Table S3 (Supplementary data are available in *Age and Ageing* online).

(ii) A path analysis was performed using SAS Proc Mixed and Proc Glimmix in order to determine the indirect (mediating) effects of pedometer use on PA and PI. These models do not include the covariates listed in Tables S1 and S2 (Supplementary data are available in *Age and Ageing* online).

Although recent evidence from Monte Carlo studies support simple joint significance tests of the mediation path coefficients [23, 24], also examined were two other formal tests of mediation effects [25, 26]. These formulas, although typically applied to single level path analyses, are appropriate for multilevel analyses with random effects such as those used here to provide estimates of the path coefficients [27].
The primary analyses consisted of up to six waves of data (median = 4) through February, 2007 (baseline plus five annual follow-ups). In the primary analyses, pedometer use was coded as ‘not used’ for waves prior to the receipt of the pedometer. The sensitivity analyses used baseline outcome data from the year prior to receipt of the pedometer and up to three waves of follow-up data through June, 2007.

Results

Baseline characteristics of the participants are shown in Table 1. There are no significant baseline differences according to intervention status; however, higher mean scores on PI at baseline were observed for the telemedicine group than for the usual care group (P= 0.07). A majority of participants were 65–80 years old at enrolment, 63% were female and most were obese (mean BMI 32 kg/m²). Approximately half of participants were White. More than two-thirds of the participants had diabetes for more than 5 years. Co-morbidities and depression scores were similar in both groups at baseline, as were the Lubben Social Network scores. At baseline participants in both groups reported following an exercise programme 2.9 days/week (2.9 Usual Care; 2.8 Telemedicine).

Physical activity

In the primary analysis, membership in the telemedicine group was associated with a lower rate of decline in PA over time (P= 0.0128, Figure 1) as well as a significantly higher (P= 0.003) endpoint activity level [estimated mean (standard error) for usual care of 2.09 (0.09), and telemedicine of 2.47 (0.09) of possible scores of 0–7 with higher scores indicative of greater PA]. The usual care group declined by almost one point from baseline to final follow-up (0.83) on the 7-point activity scale over time, although the telemedicine group declined by about one half of a point (0.49) for a difference of 0.34 (CI = 0.02, 0.66). PA was significantly associated with the use of the pedometer (P = 0.0006; Table S1, Supplementary data are available in Age and Ageing online). Baseline characteristics that were associated with increased PA were having fewer

Table 1. Baseline characteristics of participants (percentages or mean ± standard deviation)

<table>
<thead>
<tr>
<th>Treatment group</th>
<th>Usual care (n = 813)</th>
<th>Telemedicine (n = 837)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at randomisation (years), Mean (SD)</td>
<td>70.9 (6.78)</td>
<td>70.8 (6.49)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female (%)</td>
<td>62.1</td>
<td>63.6</td>
</tr>
<tr>
<td>Race/Ethnicity (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White, non-Hispanic</td>
<td>50.9</td>
<td>48.3</td>
</tr>
<tr>
<td>Black, non-Hispanic</td>
<td>14.3</td>
<td>15.2</td>
</tr>
<tr>
<td>Hispanic</td>
<td>34.6</td>
<td>35.8</td>
</tr>
<tr>
<td>Other</td>
<td>0.2</td>
<td>0.7</td>
</tr>
<tr>
<td>Marital status (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married/living with significant other</td>
<td>41.1</td>
<td>41.3</td>
</tr>
<tr>
<td>Single, never married</td>
<td>10.1</td>
<td>12.8</td>
</tr>
<tr>
<td>Separated/divorced</td>
<td>18.1</td>
<td>16.5</td>
</tr>
<tr>
<td>Widowed</td>
<td>30.6</td>
<td>29.3</td>
</tr>
<tr>
<td>Data missing</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Lives alone?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>36.8</td>
<td>38.0</td>
</tr>
<tr>
<td>Education (years), Mean (SD)</td>
<td>9.9 (4.13)</td>
<td>9.7 (4.12)</td>
</tr>
<tr>
<td>Duration of diabetes (years), Mean (SD)</td>
<td>10.9 (9.08)</td>
<td>11.2 (9.61)</td>
</tr>
<tr>
<td>Currently smokes cigarettes (%)</td>
<td>9.2</td>
<td>8.7</td>
</tr>
<tr>
<td>PA (Number of days/week followed exercise program), Mean (SD)</td>
<td>2.9 (2.30)</td>
<td>2.8 (2.33)</td>
</tr>
<tr>
<td>PI (CARE ADL Imp), Mean (SD)</td>
<td>5.9 (6.44)</td>
<td>6.5 (6.56)</td>
</tr>
<tr>
<td>Charlson Comorbidity Index, Mean (SD)</td>
<td>2.9 (1.77)</td>
<td>2.9 (2.00)</td>
</tr>
<tr>
<td>General health, Mean (SD)</td>
<td>4.0 (1.88)</td>
<td>4.1 (1.81)</td>
</tr>
<tr>
<td>CARE: Depression, Mean (SD)</td>
<td>5.8 (4.84)</td>
<td>5.5 (4.77)</td>
</tr>
<tr>
<td>Lubben Social Network, Mean (SD)</td>
<td>20.9 (7.77)</td>
<td>20.7 (8.06)</td>
</tr>
<tr>
<td>Body mass index (kg/m²), Mean (SD)</td>
<td>31.7 (6.86)</td>
<td>32.0 (6.65)</td>
</tr>
<tr>
<td>Hemoglobin Alc (%), Mean (SD)</td>
<td>7.4 (1.59)</td>
<td>7.4 (1.48)</td>
</tr>
<tr>
<td>Systolic blood pressure (mm Hg), Mean (SD)</td>
<td>142.5 (23.65)</td>
<td>142.8 (24.21)</td>
</tr>
<tr>
<td>Diastolic blood pressure (mm Hg), Mean (SD)</td>
<td>71.0 (10.44)</td>
<td>71.6 (11.28)</td>
</tr>
<tr>
<td>Total cholesterol (mg/dl), Mean (SD)</td>
<td>184.8 (38.52)</td>
<td>182.8 (38.43)</td>
</tr>
<tr>
<td>HDL cholesterol (mg/dl), Mean (SD)</td>
<td>47.5 (13.48)</td>
<td>47.5 (14.59)</td>
</tr>
<tr>
<td>LDL cholesterol (mg/dl), Mean (SD)</td>
<td>108.0 (35.84)</td>
<td>106.5 (34.79)</td>
</tr>
<tr>
<td>Urine microalbumin (mg/creatinine (G), Mean (SD)</td>
<td>169.9 (601.22)</td>
<td>148.9 (491.13)</td>
</tr>
<tr>
<td>Log Transformed Urine microalbumin (mg)</td>
<td>3.3 (1.61)</td>
<td>3.3 (1.60)</td>
</tr>
</tbody>
</table>
Baseline characteristics that were associated with lower PI (increased ADL impairment) were having more comorbid conditions ($P < 0.0001$), being more depressed ($P < 0.0001$), having less social networking ($P < 0.0001$), having a higher BMI ($P < 0.0001$), longer duration of diabetes ($P < 0.0001$) and being female ($P = 0.0382$). The results of the sensitivity analyses were consistent with the primary analyses with two exceptions, being female and diastolic blood pressure. PI was significantly associated with lower diastolic blood pressure at baseline ($P = 0.0072$).

Path analyses examining the mediating effects of pedometer use

Results of mixed-model path analyses shows a mediation effect of the intervention on PA and PI through pedometer use (Figure 2). The intervention had both a direct effect on PA ($P = 0.0440$) as well as an indirect effect through increased use of the pedometer ($P = 0.0024; P = 0.0013$). The intervention also had an indirect effect through increased pedometer use on PI ($P = 0.0024; P < 0.0001$), indicating a partial mediating effect.

Discussion

The current study demonstrated a persistent PA benefit associated with the IDEATel telemedicine intervention in older adults with diabetes. In the intervention, educators used home televisits every 4–6 weeks with goal-setting to encourage lifestyle change. Although there has been much heterogeneity and variation in the mode and locus of delivery of previous PA interventions in older adults with diabetes, our findings demonstrate that home televisits can assist this population to improve PA and reduce ADL decline. The use of telemedicine, telephone interventions and the internet may help improve delivery to underserved populations, but it remains to be determined which mode of delivery is the most effective and efficient for older adults. This report is unique in that the intervention successfully utilised home telemedicine in an underserved, ethnically diverse population of older adults with diabetes. There was high participant and PCP satisfaction with this intervention [28, 29].

We identified an association between pedometer use and PA and PI. Several short-term clinical trials studied pedometer-based interventions in adults with diabetes with disappointing results [7, 10]. A more recent randomised clinical trial of a pedometer-based education programme for older adults with impaired glucose tolerance demonstrated improvement in step counts, self-reported walking and total moderate-vigorous PA up to 12 months following the intervention [30]. The current study stands in contrast to these in that it established associations between pedometer use and long-term PA behaviour in older adults with diabetes. There is scant literature that includes pedometer-based interventions for individuals with diabetes with PI as an outcome. Our study makes an important...
contribution in that it revealed a specific association between pedometer use and preserved functional status in a large sample of older individuals with diabetes.

In the current investigation, goal-setting with educators during home televisits to increase PA as well as pedometer use were part of a larger telemedicine intervention that was designed to improve comprehensive diabetes management [12, 13]. Although the main study findings examining the effects of telemedicine on physical activities and function are based on the original randomised design, several limitations related to the analyses of pedometer use are acknowledged. Pedometers were introduced into the project after subjects had been enrolled for 2–4 years and were distributed to all participants. Unlike the telemedicine intervention, pedometer use was self-selected rather than randomised. Thus, causal inference was restricted to examination of the potential mediating effect of pedometer use on activity and impairment. Another limitation is that few participants provided data on step counts, precluding meaningful analyses of the intensity of pedometer use. PA behaviour was based on participant recall of PA during the seven days (Diabetes Self-Care Activities instrument) rather than daily diaries or accelerometer recordings, which may have affected the accuracy of PA measurement. Finally, measurement of pedometer use was crude (based on the self-reported yes/no question, ‘Have you used the pedometer?’). Longitudinal benefits of telemedicine on PA, and pedometer use on PA and PI will need to be confirmed in future clinical trials where pedometers are the principal intervention using standardised protocols.

In conclusion, in the context of a declining trajectory in PA and PI associated with older individuals with diabetes, regularly scheduled home televisits with a diabetes educator, including individualised goal-setting, was significantly associated with lessened decline. Pedometer use played a significant mediating role in the reductions of PA and PI in the IDEATel telemedicine program for comprehensive diabetes management. Pedometers may be an inexpensive adjunct to educational and support initiatives delivered remotely to underserved older adults. These findings warrant confirmation through future research.

**Key Points**

- In older adults with diabetes, a telemedicine intervention can significantly lessen the rate of decline in PA and PI over 5 years, with significant 5-year differences for PA.
- Greater PA was associated with fewer comorbid conditions, less depression, more social networking, lower BMI, male gender and lower hemoglobin A1c at baseline.
- Indirect effects were observed through use of pedometers on reduced decline in PA and PI.
References

The predictive ability of self-rated health on ischaemic heart disease and all-cause mortality in elderly women and men: the Nord-Trøndelag Health Study (HUNT)

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Abstract

Background: the aim of this study was to assess the predictive ability of self-rated health (SRH) on ischaemic heart disease (IHD) and all-cause mortality in elderly women and men.

Methods: a total of 5,808 participants aged ≥70 years with no diagnosed atherosclerotic diseases at baseline in the Nord-Trøndelag Health Study (HUNT 2, 1995–97) were followed for 10 years. Participants provided data on psychosocial, behavioural and biomedical factors. The association between SRH and mortality was assessed using Cox proportional hazard model.

Results: the SRH below good was reported by 50% of the women and 35% of the men. For SRH below good, the mortality from IHD was 1.62 (1.14–2.29) in women and 1.23 (0.91–6.67) in men. The corresponding adjusted hazard risk ratio for all-cause mortality was 1.59 (1.38–1.83) in women and 1.43 (1.26–1.63) in men.

Conclusions: poor SRH predicted mortality in elderly people. For older women, the predictive value of poor SRH was higher than that of men, and this was true independent of age, marital status, diabetes, any limiting long-standing illness and selected biomedical, behavioural and psychosocial factors. These results are in contrast to most studies on the SRH–mortality association in elderly people. Further theoretical and empirical studies are needed to identify the particular factors that should be taken into account when elderly women and men rate their own health.

Keywords: self-rated health, elderly people, gender differences, ischaemic heart disease mortality, all-cause mortality