

A cognitive-behavioural pedometer-based group intervention on physical activity and sedentary behaviour in individuals with type 2 diabetes

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Abstract

The purpose of this study was to investigate the benefits of a pedometer and a cognitive-behavioural group intervention for promoting physical activity (PA) in type 2 diabetes patients. We recruited 41 participants and randomized them into an intervention group (IG) ($n = 20$) and a control group (CG) ($n = 21$). The intervention consisted of five sessions within 12 weeks, a booster session after 22 weeks and a pedometer. Primary outcome was PA assessed by accelerometer (minutes per day) and pedometer (steps per day). Secondary outcomes were weight, body mass index, blood pressure, haemoglobin A1c and total cholesterol. After 12 weeks, the IG increased with more than 2000 steps day⁻¹ compared with the CG, whereas sedentary behaviour decreased more than 1 hour day⁻¹ in the IG and showed no change in the CG. There was no intervention effect on the accelerometer-based PA nor on health measurements. After 1 year, the increase in steps per day remained significant in the IG, but sedentary activity increased again to baseline levels. This pilot study showed that the combination of a 12-week cognitive-behavioural intervention and a pedometer has a significant short-term im-

pact on daily steps and sedentary behaviour but that the effects on total PA and long-term effects were limited.

Introduction

Despite the volume of evidence supporting the physical activity (PA) benefits in diabetes management [1], there is a dearth of interventions achieving change in PA behaviour in type 2 diabetes patients [2]. The majority of earlier studies investigating the effects of PA on type 2 diabetes has incorporated structured exercise programmes. These programmes showed favourable effects on glycaemic control, cardiovascular fitness, weight loss and hypertension [3]. Nevertheless, they were expensive and time-consuming [4], often targeting a highly motivated selected group [5], manifesting high dropout rates and a problematic long-term adherence [6]. In addition, type 2 diabetes patients are often not interested in joining such a time-demanding programme [7].

A recently observed shift has been away from structured programmes towards lifestyle interventions, which aim at increasing PA on a self-structured frequent basis [8]. Such programmes offer personal flexibility in scheduling and therefore reduce barriers such as lack of time, transport

or high costs [9]. Lifestyle and structured programmes are both similarly effective at increasing PA, cardiovascular fitness and decreasing blood pressure for sedentary healthy adults [8]. However, results from a randomized control trial that compared structured and lifestyle goals in a walking programme for type 2 diabetes patients showed that those who received lifestyle goals were more satisfied with the intervention and self-monitored their PA more often [10].

Only a few studies evaluated the effects of a lifestyle-based PA intervention in type 2 diabetes patients. Yamanouchi *et al.* conducted a clinical trial for type 2 diabetes patients to evaluate the effects of daily walking combined with diet versus diet alone. The PA intervention group (IG) was instructed to walk at least 10 000 steps day⁻¹, monitored by a pedometer. After 8 weeks of intervention, the PA IG increased their steps per day and walking was found to be a significant determinant of improved insulin sensitivity. However, no long-term results are available [11]. Araiza *et al.* tried to determine whether the recommendation to walk 10 000 steps day⁻¹ would result in increased PA. In contrast to the control group (CG), the IG increased to 10 000 steps day⁻¹ after 6 weeks but also in this study, no long-term results are available [12].

Tudor-Locke *et al.* [13] recently developed the First Step Program (FSP) that comprises four group meetings, followed by a 12-week adherence phase. The effects were analysed after 16 weeks of intervention and a 24-week follow-up. Relative to the CG, FSP participants increased their PA levels significantly after the intervention, but at follow-up, steps per day decreased (although they remained higher than baseline values). No significant changes emerged for glycaemia or cholesterol [14]. Kirk *et al.* investigated the effectiveness of PA counselling in type 2 diabetes patients. PA consultations were delivered at baseline and after 6 months, with follow-up phone calls. After 12 months, the IG had more favourable levels of self-reported PA, accelerometer counts, haemoglobin A1C (HbA1c), systolic blood pressure and cholesterol compared with the CG [15]. The Look-Ahead trial offered an intensive lifestyle intervention, including diet and PA

to type 2 diabetes patients. The IG significantly decreased in weight and HbA1c after 1 year compared with a CG [16]. Watanabe *et al.* developed a 4-month intervention for people with type 2 diabetes. The IG received an individual-based counselling programme and a pedometer. As a result, the IG engaged more in self-reported leisure time PA compared with a CG, but only short-term results were reported [17].

The need for PA counselling and lifestyle interventions has also appeared in primary care. Earlier studies, investigating the effects of a general practitioner-based PA intervention for type 2 diabetes patients, showed mixed results. Di Loreto *et al.* [18] and Christian *et al.* [19] showed that a general practitioner-based intervention could increase PA. Stovitz *et al.* [20] concluded that advice and the use of a pedometer already results in more PA while Hillsdon *et al.* [21] argued that only advice without lifestyle counselling is ineffective. Van Sluijs *et al.* [22] found no effects after their general practitioner-based PA intervention.

The studies above indicate that lifestyle-based PA interventions show promising short-term results with regard to both acceptability and effectiveness, but data on long-term effectiveness and objective PA measurements are often lacking [23]. In addition, it is not clear whether a group programme (with cognitive-behavioural sessions on PA and a pedometer) is necessary or whether care as usual is sufficient to obtain changes in health and health behaviour. It seems that there is quite some variance in the success rate of the interventions and to our knowledge, none of these studies look into individual differences after the intervention.

This intervention links a strong theoretical comprehensive basis with pedometer use in order to achieve long-term objective results on PA in type 2 diabetes patients. The main purpose of this study is to (i) compare the effects of a cognitive-behavioural group intervention and a pedometer (IG) and minimum care as usual (CG) on objectively measured PA behaviour and (ii) determine whether the intervention had a sustained effect after 1 year. The hypothesis is that PA will increase more in the IG compared with the CG. As previous

studies only reported mean results over the total sample, it will also be reported how many participants in each group changed their behaviour. Furthermore, more favourable health measurements for the IG are expected, due to their increased PA.

Materials and methods

Sample and procedure

A sampling pool of potential participants was generated through a manual search of patient files located at the Endocrinology Department in a Belgian hospital (Saint-Augustinus hospital in Veurne). The inclusion criteria were as follows: (i) ≥ 6 months diagnosis of type 2 diabetes, (ii) aged between 35 and 75 years, (iii) treated for type 2 diabetes and (iv) no physical or medical PA limitations.

Of the total amount of 645 patients diagnosed with type 2 diabetes, a pool of 164 individuals was identified as eligible to participate according to the inclusion criteria. Fifty-one individuals responded positively to an invitation letter; 10 of them did not start the study (two persons had orthopaedic problems and eight persons found transportation to and participation in five group sessions too demanding). Finally 41 persons were included in the study (response rate = 25%). All of them signed an informed consent form and were assigned via stratified (gender and age) randomization to either the CG [$n = 21$ (6 women and 15 men, 61.3 years)] or the IG [$n = 20$ (7 women and 13 men, 61.3 years)]. Sealed envelopes were used and group allocation was concealed until the point of allocation. The Medical Ethic Committee of the University Hospital approved the study.

The CG received their usual care from their endocrinologist and received one single-group education on the effects of PA on diabetes care. The IG was offered a cognitive-behavioural group programme combined with a pedometer, which lasted for 12 weeks. All sessions took place at the Endocrinology Department. The intervention was given by two coaches, both possessing a Masters degree, one in Physical Education and Movement Sciences and another in Clinical Psychology.

Design and evaluation instruments

There were three assessment time points spread over a period of 12 months: baseline (T0), after the 12 weeks intervention (T1) and a follow-up 1 year after baseline (T2) (see Fig. 1). Assessments were the same for the IG and CG. At each time point, participants were contacted by telephone and an appointment was scheduled to complete measurements in their home. The week following the home visit, participants of both groups were asked to wear the PA monitors and to go to the hospital laboratory for blood samples.

Physical activity

The pedometer (Yamax DigiWalker SW200) and the accelerometer (Actigraph, model 7164) were worn for five consecutive days (including at least one weekend day) at the waist, above the right hipbone. All participants were trained in placement and use of the monitors and were asked to wear them during waking hours, removing only for water-based activities and sleeping. Both the pedometer and accelerometer are valid and reliable tools to objectively measure PA [24, 25]. The pedometer, which had a user viewable display, was used to count steps. The accelerometer was used to measure accelerations in the vertical plane and was set to measure activity counts in an epoch time of 1 min. The accelerometer had no display and activity data were reduced using a Microsoft Excel-based Macro (MAHUffe Analyser version 1.9.0.3) (www.mrc.epid.cam.ac.uk). Participants with at least 10 hours of recorded time and three complete days (including one weekend day) were included in the analyses. Non-wearing time was defined as 60 min or more of consecutive zero counts. The outcome variables were time spent at activities of different intensity [26]. Because more than 60% of the participants did not accumulate any time in vigorous intensity PA, a single variable was constructed by combining accumulated time in moderate-to-vigorous physical activity (MVPA) [27]. Total PA included light PA and MVPA. A cut-off of <100 counts min^{-1} defined sedentary time [27].

An activity log was used to record date, the pedometer steps taken and the type and duration of

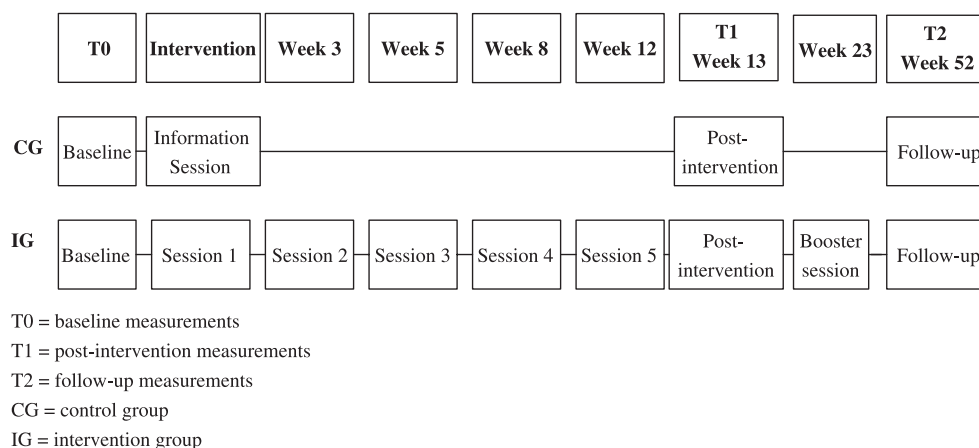


Fig. 1. Study design.

non-walking activities [28]. Participants were asked to complete the activity log at the end of each day for five consecutive days. Following established guidelines, participants were instructed to add 150 steps to their daily total for every minute engaged in biking and/or swimming [28].

Health measurements

Body weight and height were measured wearing light clothing and without shoes. Systolic and diastolic blood pressure was measured in seated position after 5 min of rest with an Omron 705IT. Glycaemic control was measured by means of HbA1c. The week after their home measurements were completed, all participants went to the laboratory of the hospital where non-fasting blood samples were taken (as part of their routine analyses).

At baseline, participants completed a self-administered background questionnaire with demographic information, medication use and diabetes-related questions.

Intervention

Both the CG and the IG received no specific advice concerning diet or glycaemic control. They were instructed to continue with the guidelines from their dietician and endocrinologist.

The IG followed a 12-week lifestyle intervention that consisted of five cognitive-behavioural group sessions of 90 min. The first three group meetings were given every 2 weeks in order to provide intense guidance to the participants. The last two sessions were delivered over an interval of 3 and 4 weeks between sessions, so that participants could autonomously adopt the learned principles in their daily life. Participants who were not able to participate in one or more sessions received a written summary.

The cognitive-behavioural intervention was based on cognitive-behavioural therapy [29], the Diabetes Prevention Program [30], the FSP [31] and Motivational Interviewing [32]. Within our framework, social support, self-monitoring and feedback (pedometer) are very important. The taxonomy of behaviour change techniques was also taken into account [33]. Table I gives an overview of the contents of the different sessions.

The group sessions started with a motivational interviewing phase. After this phase, commitment to a lifestyle change plan was strengthened: the coaches together with the participants developed an implementation plan in which the where, when and how of the planned behaviour changes would take place. The formulation of this plan was intended to make it easier for the participants to put the intended actions into practice.

Table I. *Content of the intervention*

Session	Session content	Behavioural/cognitive and self-regulation strategies
Session 1	<ul style="list-style-type: none"> • Welcome • Increasing knowledge of the benefits of PA • Increasing awareness of the risk of a sedentary lifestyle 	<ul style="list-style-type: none"> • Information • Consciousness raising • Modelling and social support • Motivational readiness • Mastery experience
Session 2	<ul style="list-style-type: none"> • Experiences with pedometers and goal setting (skills) • Monitoring sedentary activities/substituting alternatives • Increasing awareness of PA opportunities • Time management (skills) • Increasing self-efficacy to set up an action plan • Listing personal benefits and barriers of PA and sedentary behaviour (changing attitudes) 	<ul style="list-style-type: none"> • Self-monitoring • Activity reminders • Mastery experience • Reinforcement • Modelling and social support • Counter-conditioning • Coaching in realistic and measurable goal setting • Discussion action plan Discussion of benefits of and barriers to increase PA and decrease sedentary behaviour—decisional balance
Session 3	<ul style="list-style-type: none"> • Increasing self-efficacy to: <ul style="list-style-type: none"> – overcome barriers, – dealing with negative thoughts, – change habits 	<ul style="list-style-type: none"> • Recognizing and resolving ambivalence • Discussion of problem-solving approach to address behaviours • Cognitive restructuring • Identifying discrepancies between behaviour and goals • Reattribution training Planning coping responses • Counter-conditioning
Session 4	<ul style="list-style-type: none"> • Relapse prevention (skills) • Increasing self-efficacy to manage high-risk situations and stress • Increasing self-efficacy to set up an action plan 	<ul style="list-style-type: none"> • Discussing about relapse prevention and problem-solving barriers to PA • Planning coping responses • Counter-conditioning • Coaching in realistic and measurable goal setting • Feedback
Session 5	<ul style="list-style-type: none"> • Social cues • Increasing self-efficacy to set up a long-term action plan and goal achievement 	<ul style="list-style-type: none"> • Identification of supports for maintenance of health behaviour changes • Setting goals using support • Enlisting support • Reinforcement and feedback • Coaching in realistic and measurable goal setting
Booster session	<ul style="list-style-type: none"> • Social cues • Increasing self-efficacy to set up a long-term action plan and goal achievement • Relapse prevention (skills) 	<ul style="list-style-type: none"> • Reinforcement and feedback • Coaching in realistic and measurable goal setting (using support) • Discussing about relapse prevention and problem-solving future barriers to PA • Planning coping responses

In addition to the session, the participants from the IG received a pedometer and a pedometer diary during the intervention as motivational tools. They were asked to wear the pedometer and to record their PA type and duration and number of steps at

the end of each day. In this way they could set their own step goals in the context of their daily routine [34]. The pedometer is proven to be a novel and highly useful motivator, a direct source of feedback and memory prompt and reminder to be physical

active [35]. The pedometer diary was used to track progress and to encourage discussion in the group sessions. Results of the baseline pedometer measurements were used to motivate the patients to increase their PA. At each session, participants and coaches reviewed progress and set new goals together. At the end of the last session, the entire process was reviewed, emphasizing participant achievements and planning for continued PA engagement without further support from the coaches. After the intervention there was no further motivational contact until they were invited to a booster session after 6 months. In this session, the progress of the participants was discussed and the topics of social support and relapse prevention were recalled.

The CG only received their usual care from their endocrinologist and a single education session about type 2 diabetes and PA, which was the same as the first session of the IG. They received only information on the benefits of PA and the risks of sedentary behaviour and were not motivated to increase their PA (received no pedometer during the intervention).

Data treatment and statistical analyses

Data were analysed using SPSS15 for Windows and were expressed as mean \pm SD, unless otherwise stated. A P -value of 0.05 was considered statistically significant and a P -value of 0.1 a trend towards significance. Significance levels of 0.1 and 0.001 are also added in the tables. Baseline differences between the IG and the CG were examined using independent samples' t -tests. Differences in demographics between groups were evaluated by χ^2 . A repeated-measures analysis of variance was used to examine changes between groups in PA and health measurements. Data were analysed using intention-to-treat. Data of the participants who dropped out were included in analyses; missing data for Weeks 13 and 52 were substituted by their baseline scores.

Based on intervention effects on number of steps per day in previous research [14], *a priori* power analysis was conducted. This analysis showed that to power the study at 0.80 given the 0.05 level of

significance, a sample size of minimum 20 participants was needed for each sample separately.

Results

Sample characteristics and dropout

Baseline descriptive statistics for the 41 participants are shown in Table II. The only difference between both groups was perceived health status; more participants in the CG perceived their health status as weak ($\chi^2 = 5.8, P = 0.02$).

Dropout at T1 was 9.7% (two persons in each group). At T2, the average dropout was 12.2% (one more participant from the IG lost interest). Statistical analysis showed no significant differences in PA, gender, body mass index (BMI) and age between dropouts and those who completed the programme.

About 75% of the IG achieved adequate compliance to the intervention (attending at least three of the five sessions). There were no differences in outcome variables between those with adequate compliance and the remaining 25% of participants.

Effect of the interventions on patient outcomes

Effect of the intervention on PA

There was a significant interaction effect ($P < 0.05$) in steps per day from T0 to T1 (Table III). The IG increased their steps per day by 2502, in contrast with the CG where there was almost no change (an increase with 324 steps day⁻¹). Between T1 and T2, both groups decreased significantly in steps per day ($P < 0.01$) with a decrease of 1577 steps day⁻¹ for the IG and 1188 steps day⁻¹ for the CG. When comparing T0 and T2, there was a trend towards a significant interaction effect ($P < 0.1$): an increase in steps per day for the IG (925 steps day⁻¹) and a decrease for the CG (864 steps day⁻¹).

In Fig. 2, the difference in steps per day between T0 and T1 is plotted for each individual participant. All but three participants in the IG increased in steps per day while in the CG about 50% of the patients decreased. Only 9.5% of the CG increased minimum 2000 steps day⁻¹ after the intervention, whereas 40% in the IG.

Table II. Descriptive characteristics

Demographic	Total (N = 41)	CG (N = 21)	IG (N = 20)	χ^2
Gender				0.2
Male	28	15	13	
Female	13	6	7	
Age classes (years)				0.0
35–54	6	3	3	
55–75	35	18	17	
Civil state				0.0
Married	31	16	15	
Single	10	5	5	
Level of education				1.6
Low	12	8	4	
High	29	13	16	
Smoking				0.2
Non-smoker	7	3	4	
Smoker	34	18	16	
Duration diabetes (years)				0.0
1–5	16	8	8	
>5	25	13	12	
Health problems				3
None	21	8	13	
Problems	20	13	7	
Health status				5.8*
Good	17	5	12	
Average or weak	22	15	7	
PA	Average \pm SD	Average \pm SD	Average \pm SD	
	Total	CG	IG	
Pedometer				
Steps per day	6135 \pm 3865	5214 \pm 3352	7099 \pm 4208	1.6
Accelerometer (min day ⁻¹)				
Total PA	239 \pm 86	223 \pm 84	255 \pm 87	1.2
Light PA	208 \pm 80	200 \pm 81	216 \pm 80	0.6
MVPA	31 \pm 33	23 \pm 29	39 \pm 35	1.5
Sedentary behaviour	1195 \pm 91	1206 \pm 94	1183 \pm 90	0.8
Health measurements	Average \pm SD	Average \pm SD	Average \pm SD	T
	Total	CG	IG	
Weight (kg)	88.1 \pm 16.5	92.6 \pm 16.6	83.5 \pm 15.5	1.8
BMI (kg m ⁻²)	30.2 \pm 4.7	31.5 \pm 5.0	29.0 \pm 4.2	1.8
Age (years)	61.3 \pm 6.5	61.3 \pm 6.9	61.3 \pm 6.3	0.4
Diastolic blood pressure (mmHg)	83.5 \pm 10.4	82.6 \pm 11.0	84.4 \pm 9.9	0.6
Systolic blood pressure (mmHg)	151.8 \pm 23.2	148.6 \pm 21.0	155.1 \pm 25.3	0.9
HbA1c (%)	7.7 \pm 1.2	8.0 \pm 1.3	7.5 \pm 1.1	1.4
Total cholesterol (mg dl ⁻¹)	188.1 \pm 33.7	184.4 \pm 33.1	192.0 \pm 34.7	0.7

* $P \leq 0.05$.

Total PA analyses (measured with the accelerometer) revealed no interaction effects, only time effects between T0 and T1 ($P < 0.001$). Both groups significantly increased in total PA: 37 min

day⁻¹ for the CG and 46 min day⁻¹ for the IG. Between T1 and T2, an interaction effect was found ($P < 0.05$): the IG decreased more in their total PA than the CG.

Table III. PA and health measurements

Measurements	T0	T1	T2	T0-T1-T2		T0-T1		T1-T2		T0-T2	
				F time × group	F time	F time × group	F time	F time × group	F time × group	F time × group	
Steps day ⁻¹				2.6(*)	5.9**	5.1*	8.5**	0.2	8.3**	2.8(*)	0.1
CG	5214 ± 3352	5538 ± 3877	4350 ± 3214								
IG	7099 ± 4208	9601 ± 5002	8024 ± 5331								
Total group	6135 ± 3865	7520 ± 4861	6142 ± 4703								
Min day ⁻¹ total active				1.4	9.8***	0.2	17.4***	3.3*	9.0**	1.2	0.9
CG	223 ± 84	260 ± 104	246 ± 109								
IG	255 ± 87	301 ± 106	253 ± 99								
Total group	239 ± 86	281 ± 106	250 ± 103								
Min day ⁻¹ light active				1.1	10.6***	0.1	19.9***	2.7(*)	7.1**	1.1	2.4(*)
CG	200 ± 81	236 ± 95	225 ± 107								
IG	216 ± 80	256 ± 93	221 ± 89								
Total group	208 ± 80	246 ± 94	223 ± 97								
Min day ⁻¹ MVPA				0.5	2.2(*)	0.4	1.0	1.3	4.1*	0.2	1.8(*)
CG	23 ± 29	24 ± 29	20 ± 24								
IG	39 ± 35	44 ± 38	32 ± 34								
Total group	31 ± 33	35 ± 35	26 ± 30								
Min day ⁻¹ inactive				4.6**	12.3***	4.6*	20.9***	9.9**	15.9***	0.7	0.3
CG	1206 ± 94	1180 ± 104	1191 ± 111								
IG	1183 ± 90	1111 ± 118	1187 ± 99								
Total group	1195 ± 91	1145 ± 115	1189 ± 104								
Kg (mean ± SD)				0.4	1.7	0.4	0.7	0.5	2.9*	0.2	3.4*
CG	92.6 ± 16.6	92.6 ± 15.8	94.9 ± 18.7								
IG	83.5 ± 15.5	83.9 ± 16.2	84.9 ± 17.9								
Total group	88.1 ± 16.5	88.4 ± 16.4	90.0 ± 18.8								
BMI (kg h ⁻¹)				1.0	3.0**	0.3	0.7	1.6	5.6*	0.1	3.0*
CG	31.5 ± 5.0	31.5 ± 4.7	32.6 ± 5.2								
IG	29.0 ± 4.2	29.1 ± 4.4	29.4 ± 4.9								
Total group	30.2 ± 4.7	30.3 ± 4.7	31.0 ± 5.3								
HbA1c (%)				1.0	3.4**	0.1	5.7*	2.0(*)	4.1*	0.8	1.6
CG	8.0 ± 1.3	7.9 ± 1.3	8.0 ± 1.3								
IG	7.5 ± 1.1	7.3 ± 1.1	7.9 ± 1.2								
Total group	7.7 ± 1.2	7.6 ± 1.2	7.9 ± 1.2								
Systolic blood pressure (mmHg)				0.3	1.5	0.2	1.6	0.5	0.4	0.1	2.8(*)
CG	148.6 ± 21.0	143.9 ± 20.4	144.2 ± 22.6								

Table III. Continued

Measurements	T0	T1	T2	T0-T1-T2		T0-T1		T1-T2		T0-T2	
				F time	× group	F time	× group	F time	× group	F time	× group
IG	155.2 ± 25.3	153.0 ± 20.2	148.8 ± 18.8								
Total group	151.8 ± 23.2	148.3 ± 20.6	146.4 ± 20.7								
Diastolic blood pressure (mmHg)				0.6	7.3***	0.1	3.3*	1.2	9.8**	0.6	14.9***
CG	82.6 ± 11.0	80.2 ± 9.2	70.0 ± 23.3								
IG	84.4 ± 9.9	80.9 ± 10.7	75.9 ± 9.8								
Total group	83.5 ± 10.4	80.6 ± 9.8	72.9 ± 18.0								
Cholesterol (mg dl ⁻¹)				1.3	0.2	0.1	0.3	1.6	0.2	2.6(*)	0.1
CG	184.4 ± 33.1	183.6 ± 39.2	192.3 ± 40.4								
IG	192.0 ± 34.7	190.3 ± 38.4	186.5 ± 35.1								
Total group	188.1 ± 33.7	186.9 ± 38.4	189.5 ± 37.5								

T0 = baseline measurements, T1 = post-intervention measurements and T2 = follow-up measurements.

(*) $P < 0.1$, * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

Sedentary behaviour showed an interaction effect between T0 and T1 ($P < 0.05$) and T1 and T2 ($P < 0.001$). The IG decreased significantly after 3 months, but on the long term they increased again to their baseline levels. In the CG no significant changes were found.

Effect of the intervention on health measures

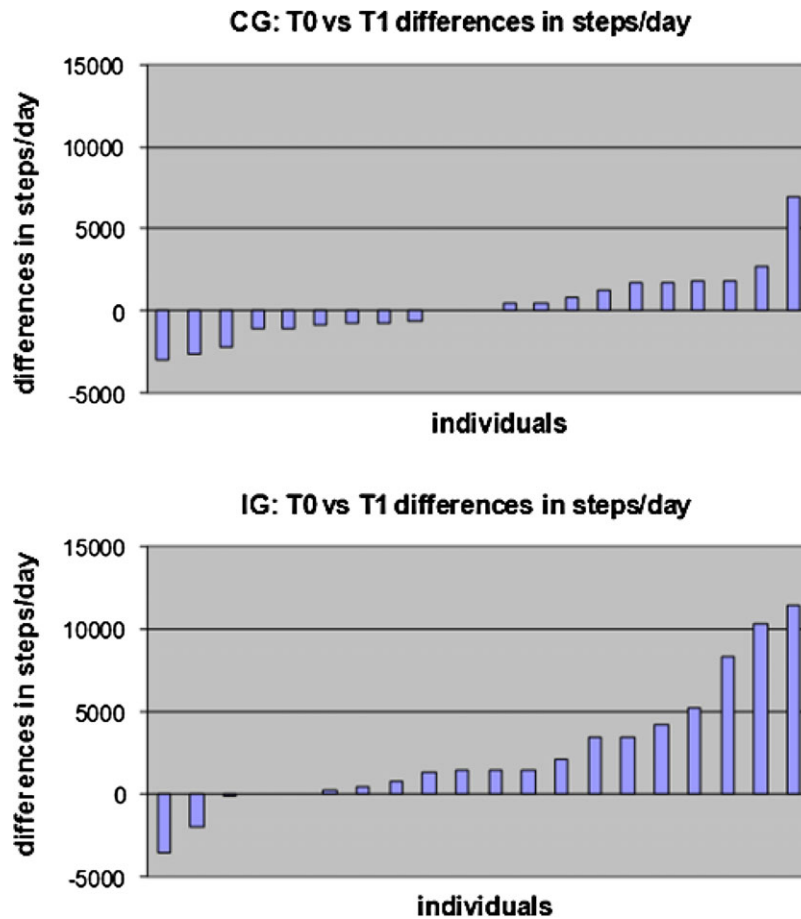
There were no significant interaction effects on BMI, weight, blood pressure, cholesterol and HbA1c between T0, T1 and T2 (Table III).

There was a significant decrease in HbA1c in both groups comparing T0 and T1 ($P < 0.05$) and again an increase at T2 to baseline levels ($P < 0.05$). There was also a trend towards a significant interaction effect ($P < 0.1$) comparing the results at T1 and at T2: the IG increased more in HbA1c than the CG.

Discussion

It was hypothesized that the IG would have a more active lifestyle than the CG. This was confirmed for self-reported steps per day measured by the pedometer and objectively measured sedentary behaviour by the accelerometer but not for objectively measured total PA.

The most obvious effects were found in steps per day. Both groups had an increase after 3 months; however, this increase was much more pronounced for the IG. Unfortunately, after 1 year there was again a decrease for both groups. This deterioration over time is typically observed in intervention studies and is probably a result of reduced contact [36]. However, when comparing baseline and 1-year follow-up, the IG still showed an increase of nearly 1000 steps day⁻¹, whereas the CG showed a decrease of almost the same magnitude. The average increase in steps per day of the IG was 2502. Forty percent of the participants had an increase of minimum 2000 steps day⁻¹, which is very hopeful, as several intervention studies have shown that an increase of 2000–2500 steps day⁻¹ can improve important health outcomes [36]. After the intervention, average steps per day of the IG was 9601, which is rather



T0 = baseline measurements
 T1 = post-intervention measurements
 T2 = follow-up measurements
 CG = control group
 IG = intervention group

Fig. 2. Differences in steps per day.

high, considering the fact that we worked with elderly overweight type 2 diabetes patients. However, this is lower than the average reported by Araiza *et al.* [12] possibly because their participants were given the directive to accumulate at least 10 000 steps day⁻¹. In our study, however, the participants could set their own goals, considering their own baseline level.

The second aim of the study was to observe the number of participants that changed favourably in both groups. When we looked at each individual, we found that all but three participants in the IG increased their steps per day, while in the CG steps per day decreased in half of the individuals. This shows that averaging data induce loss of insight as to individual outcome, and individual levels should

also be considered when drawing conclusions from an intervention.

These exploratory mean and individual level findings on steps per day demonstrate the possible utility of our six cognitive-behavioural sessions, in combination with the use of a pedometer on the short term, with a population known to have little interest in, and a high dropout rate from structured programmes [3].

The effects on sedentary behaviour were also consistent with our hypothesis: sedentary behaviour decreased by 72 min day⁻¹ after 3 months for the IG, compared with 26 min day⁻¹ for the CG. Earlier studies showed that sedentary behaviour is positively associated with coronary heart disease risk factors, obesity and development of the metabolic syndrome [37]. Moreover, it has been suggested that interventions should seek to decrease sedentary behaviour [38]. Unfortunately, over the long term, sedentary behaviour increased again for both groups to baseline levels. This is in contrast with the review of Dunn *et al.* [39], showing long-term effects of lifestyle interventions on reducing sedentary behaviour.

However, the accelerometer data did not support the intervention effects on PA. Both groups increased in accelerometer-derived total PA after 3 months. The IG increased 11 min day⁻¹ more than the CG, but this result was too small to reveal a statistically significant difference between both groups. The discrepancy between effects on objectively measured PA by the accelerometers and the self-reported steps per day measured by a pedometer is notable. However, it emerged from the group sessions that more than 40% of the participants chose the home exercise bike as PA tool and this kind of PA is not measured by the accelerometer, whereas the participants were instructed to add steps for every minute they engaged in non-ambulatory activities [28]. Secondly, it must be noticed that the *a priori* power analyses for this study were calculated only on steps per day and it seemed that for accelerometer data our sample is underpowered. So further investigation is needed with a larger sample size and data where non-ambulatory activities are imputed.

In contrast to the hypothesis, there were no effects of the intervention on most health measures. There was a significant short-term decrease only in HbA1c in both groups, however, followed by a significant increase to baseline levels over the long term. The lack of effect on health measures may be logical as the behavioural effects were not entirely maintained over the long term. Conversely, in the Look-Ahead trial, important changes in health measurements were observed, but this intervention focused on diet and PA, whereas we only focused on PA [16].

The present study has some limitations. First of all, the sample was small. It was a pilot study with some exploratory positive findings but it could be possible that more significant interaction effects could be detected with a larger sample. A second weakness is that the pedometer and the accelerometer have limitations as research tools because of their inability to provide information related to non-ambulatory activity [40]. Thirdly, it must be acknowledged that the trial is not blinded. Clearly blinding to group allocation could not be maintained post-recruitment as with most behavioural interventions. The psychologist who did the measurements and lead the group sessions also did the statistical analyses, however, in an anonymous way. Fourthly, with the current design one could not know if the intervention effects were due to only the pedometer or the pedometer plus the group sessions. It would have been better if a pedometer-only group was used next to the CG and the IG (pedometer plus group sessions). A last no cost or sustainability assessment of the intervention was done.

The strengths of this study include (i) data on both the short- and long-term, (ii) the use of objective measurements of PA, (iii) the fact that there was nearly no dropout in the data, (iv) the detailed socio-demographic, medical and behavioural data obtained, (v) the compliance with the study protocol and (vi) the well attended group meetings.

Conclusion

The cognitive-behavioural programme and pedometer succeeded in elevating the steps per day and decreasing sedentary behaviour in sedentary type 2

diabetes patients over the short term. Future studies are needed to understand how to maintain these exploratory short-term findings and a larger sample is needed. A follow-up by phone may be a promising strategy to obtain long-lasting results [41]. From another recently conducted intervention study in type 2 diabetes patients, it emerged that increases in PA were mediated by coping with relapse, self-efficacy towards PA barriers and social norm, support and modelling from family (K. De Greef, D. Van Dyck, B. Deforche, J. Ruijs, C. Tudor-Locke, J-M. Kaufman, I. De Bourdeaudhuij, in preparation). It might be important to target these identified mediators of PA change in future follow-up calls in type 2 diabetes patients. Moreover, the programme and the pedometer were appealing to the target audience and rather easy to deliver compared with structured interventions. There were no effects on long-term health parameters, so further research is needed to determine levels of PA needed to obtain important health benefits.

Practice implications

The present findings can be relevant to all people of the multidisciplinary diabetes team. First of all, it can be concluded that more attention must be given to the topic of PA at the endocrinology department. Because PA is one of the three cornerstones of diabetes management, patients need to receive more information and motivation regarding PA than they receive now. More specifically, it can be emphasized that a cognitive-behavioural approach and a pedometer are promising to work with in this population. However, continued support for a longer time than 3 months is probably necessary to elicit long-term behavioural and health effects.

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We confirm all patient/personal identifiers have been removed or disguised so the patient/person(s) described are not identifiable and cannot be identified through the details of the story.

Conflict of interest statement

None declared.

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