Improved cardiovascular health following a progressive walking and dietary intervention for type 2 diabetes

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Aim: To examine the impact of two different lifestyle programmes on cardiovascular health and glycaemic control among people with type 2 diabetes.

Methods: A two-phase 24-week randomized trial. During the first phase, participants were to increase daily steps using a pedometer. At week 12, participants were randomly allocated to either an enhanced lifestyle programme (ELP) targeting walking speed or a basic lifestyle programme (BLP) targeting total daily steps. Both programmes focused on increasing the intake of low glycaemic index foods but utilized different goal setting strategies. Clinical measurements were completed at baseline, week 12 and week 24. Principal outcomes were change in resting pulse rate (PR) and glycated haemoglobin A1c (A1c) between week 12 and week 24 compared between groups using analysis of covariance.

Results: Forty-one participants [mean ± s.d.: age = 56.5 ± 7.2 years, body mass index (BMI) = 32.7 ± 6.1 kg/m²] were randomized. After 12 weeks, we observed an increase in average total daily steps of 1562 (95% confidence interval: 303–2821, p = 0.02). Weight, BMI and systolic and diastolic blood pressure improved (p < 0.01 for all). No changes were observed for energy intake. At week 24, those in the ELP had a lower resting PR (71 ± 12 b.p.m.) compared with those in the BLP (78 ± 12 b.p.m.) (adjusted p = 0.03), while no group differences for total daily steps or glycaemic control were observed.

Conclusions: Improvements in cardiovascular health can be expected following a pedometer-based lifestyle modification programme that progresses from walking more to walking faster.

Keywords: Type 2 diabetes, walking, glycemic index, improved cardiovascular health

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A sound lifestyle approach to disease management for type 2 diabetes must include both diet and physical activity [1,2]. Briefly, the physical activity guidelines suggest that individuals with type 2 diabetes should accumulate at least 30 min of moderate-intensity physical activity on most days of the week. It is also recommended that consideration of both the quantity and the quality of carbohydrate, particularly the glycaemic index (GI) and glycaemic load (GL), will help contribute to achieving a variety of clinically relevant goals, including glycaemic control, lipid profile and healthy body weight [1,2].

We have previously reported that individuals with type 2 diabetes who walked approximately 10 000 steps/day had self-selected walking speeds that were...
slower, and therefore less intense, than those recommended to derive health benefit [3]. Additionally, individuals with type 2 diabetes enrolled in self-paced, pedometer-based lifestyle programmes show little, if any, significant improvement in physiological outcomes, despite increasing their walking by approximately 30 min/day [4–6]. This suggests that focusing on increasing the total number of steps/day with a pedometer may not be a sufficient activity recommendation to elicit improved clinical outcomes in this population. We tested this hypothesis in a pilot study and found that when people with type 2 diabetes are provided with targeted instruction on how to increase their walking speed for 30 min/day on 3 days/week, positive physiological outcomes can be attained [7].

Evidence from observational and controlled trials suggests that the consideration of both the quality and the quantity of dietary carbohydrate helps to achieve positive short-term and long-term glycaemic control [8–10] and improve traditional risk factors for cardiovascular disease [11–13]. However, there is a paucity of evidence describing effective, yet practical, approaches for improving the quality and quantity of dietary carbohydrate in combination with physical activity as a management strategy that is in agreement with at least part of the current clinical practice guidelines [1,2].

The purpose of this study was to compare markers of cardiovascular health and glycaemic control in people with type 2 diabetes who received either a basic lifestyle modification programme focusing on the quantity of daily physical activity and dietary carbohydrate vs. an enhanced lifestyle modification programme that emphasized both the quantity and the quality of physical activity and dietary carbohydrate after participating in a 12-week pedometer-based walking programme. We hypothesized that upon completion of our enhanced lifestyle programme (ELP), subjects would display a lower pulse rate (PR) (heart rate) and better glycaemic control compared with those who completed our basic lifestyle programme (BLP).

**Methods**

Participants with type 2 diabetes were recruited through a local advertising campaign (television and newspaper; figure 1). Eligibility criteria included the following: 40–70 years of age, not taking insulin, able to walk, not currently enrolled in another physical activity programme, no gastrointestinal disorders and previous attendance and completion of at least one regional diabetes education course. A history of significant cardiovascular disease at prescreening was considered a contraindication to study participation; those eligible but with higher cardiovascular risk [based on age, resting blood pressure and heart rate, waist circumference, body mass index (BMI), family history of cardiovascular disease and current medication use] were evaluated by a cardiologist (R. S. W.) before entering phase 2. All subjects participated in phase 2. The study protocol was approved by the Health Research Ethics Board at the University of Alberta.

Following telephone prescreening, potential participants attended an information meeting where the study was explained in detail, and interested participants gave their informed consent. As part of this meeting, participants were asked to walk at their self-selected ‘normal’ pace for 15 min on a 200-m indoor track while wearing a dual-biaxial accelerometer and pedometer (AMP 331; Dynastream, Cochrane, AB, Canada) to accurately assess their walking speed and walking cadence (steps/min). Those whose average walking pace exceeded 5.0 km/h were excluded from the study to avoid the potential that they would have to run rather than walk faster in the second phase of the study.

**Intervention**

The intervention consisted of two phases lasting a total of 24 weeks (figure 1). During weeks 1–12 (phase 1), all subjects participated in a pedometer-based walking programme adapted from Tudor-Locke et al. [4,14]. The goal for all participants over the 12 weeks was to increase their number of steps/day using a pedometer. Each participant set their own daily step goals, initially based on their baseline average steps/day. The average was calculated from three consecutive days including one weekend day [4]. From weeks 1–4, participants attended a weekly group meeting that included a supervised walking session. During weeks 5–12, walking sessions were held once weekly and attendance was optional. A resource manual and logbook were provided at the first meeting to facilitate goal setting and to record the total number of steps/day.

Prior to the second phase (week 12), participants were randomly assigned to either a BLP or an ELP. Random allocation was conducted using a random number generator within the Statistical Package for the Social Sciences (SPSS) v.15.0 (SPSS, Chicago, IL, USA). From weeks 13–16, all participants were asked to attend one weekly meeting within their assigned programme. Each meeting included a supervised walking session. From weeks 17–20, they were to attend two weekly booster sessions and during weeks 21–24 to attend one booster session within their assigned programme. Formal instruction was not provided after week 16, but
Fig. 1  Flow diagram for a 24-week lifestyle intervention. GI, glycaemic index.

general discussion was encouraged and a supervised walk was included at all booster sessions. All sessions were conducted by the same individual.

**Basic Lifestyle Programme**

The BLP followed the same goals for walking for weeks 1–12 (i.e. increase total daily steps) and incorporated a nutrition education component targeting the concepts of the GI. The nutrition education was integrated over weeks 13–16 with a slide presentation and print material from the Canadian Diabetes Association [15]. Complimentary material was incorporated in a resource manual designed specifically for this phase of the study. The dietary goal was to increase the number of low GI food choices on a daily basis.

**Enhanced Lifestyle Programme**

Participants in the ELP were asked to continue to walk the same number of steps/day that they walked during weeks 10–12 of phase 1. During weeks 13–16, participants were taught how to increase their baseline walking speed by 10% during a 30 minuets’ walk and were asked to incorporate this faster walking pace for 30 min/day on 3 days/week until the end of the
study. For example, if participants’ self-selected walking pace was 90 steps/min, they increased their pace to approximately 100 steps/min. Participants were asked to perform their faster walking in bouts lasting not less than 10 min. Participants in the ELP were given a second pedometer and a stopwatch to help them measure and monitor the number of steps they took and the time of their bouts of walking faster. They were also supplied with a resource manual to accompany this part of the programme, which included a set of small portable cards to record the number of faster steps immediately after they were performed. The nutritional element of the ELP focused on the concepts of GI and was delivered in the same manner as the BLP. Besides encouraging increased daily consumption of low GI foods, participants were also asked to exchange high GI foods with low GI foods (i.e. replace white or whole wheat bread with pumpernickel) on at least 3 days/week and to make at least two exchanges over the course of those days.

**Clinical Measures**

Anthropometric, behavioural and metabolic measures were assessed at baseline (time of recruitment to the study), 12 weeks (end of phase 1) and 24 weeks (end of phase 2). Resting PR and glycaemic control, measured by glycosylated haemoglobin A1c (A1c), were the main outcomes of interest. Resting PR and blood pressure were measured using a digital sphygmomanometer (Quick Response with Easycraft, Model UA-787; LifeSource™, Milpitas, CA, USA) and reported as the average of three consecutive measurements separated by 3–5 min. To establish the accuracy of the PR measurement, resting PR determined with the digital sphygmomanometer was directly compared with heart rate measured with a single-lead electrocardiograph (432000A; Hewlett Packard, McMinnville, OR, USA), at the same time in triplicate separated by 5 min of rest among a convenience sample of 10 healthy individuals. There was no significant difference between resting heart rate and PR using the two different methods (64 ± 7 vs. 63 ± 8 b.p.m. respectively). Body weight (Stand-on-Scale, Seca 776 Digital scale, Hannover, MD) and height (Heightronic™; QuickMedical Heightronic Digital Stadiometer, Northbend, WA, USA) along with waist and hip girth (non-stretch Teflon™ tape) were measured with participants wearing a standard hospital gown without shoes or stockings. Measurements were made in triplicate and averaged. Each participant was instructed on how to accurately record dietary intake using 3-day food records and how to use their pedometer (Digi-Walker SW-200, Yamax, Kyoto, Japan) and record their steps/day. Dietary data were analysed using FOOD PROCESSOR NUTRIENT ANALYSIS software v. 9.9.0 (ESHA Research, Salem, OR, USA). At 12 and 24 weeks, A1c (DCA 2000®; Bayer, Toronto, ON, Canada) was added to the measurements completed at baseline.

**Statistical Analysis**

Analyses for weeks 1–12 of this study were completed using analysis of variance with repeated measures. The independent variable for each statistical test was the intervention group, and the dependent variable(s) was the clinical and behavioural outcomes presented in table 2. From weeks 13–24, one-way analysis of covariance (ANCOVA) was conducted to compare the effect of the BLP vs. ELP on behavioural and clinical outcomes. The independent variable for the ANCOVA was the intervention group (BLP or ELP), and the dependent variables were the clinical and behavioural outcomes as presented in table 3. For each ANCOVA, the value observed at week 12 for each dependent variable was used as the covariate [16]. The week 12–dependent measures and the adjusted change scores have been reported (table 3). An intention-to-treat analysis was performed with the last observation carried forward for subjects with missing data at 24 weeks. Descriptive data are mean ± s.d. unless otherwise stated. A p-value of ≤0.05 was considered significant. Data were analysed with SPSS v.15.0 (SPSS).

**Results**

At baseline (week 0), participants (n = 44) were in their mid-50s (mean ± s.d. = 56.2 ± 7.2 years) and generally considered overweight to obese (BMI = 23.6–49.5 kg/m²) and 58% were female. The average time since diagnosis with type 2 diabetes was 56.5 ± 55.7 months for the entire group. At baseline, the preferred walking speed measured with an accelerometer was 4.2 ± 0.6 km/h with a cadence of 115 ± 9 steps/min. Medication use prior to randomization is listed in table 1. After the first 12 weeks (table 2), participants increased walking by 1562 steps/day (95% confidence interval: 302–2821, p = 0.02) with significant reductions in body weight, BMI and systolic and diastolic blood pressure (p < 0.01). No changes were observed for resting PR, waist or hip circumference, total energy or carbohydrate intake, daily average GI or daily total GL. At the end of phase 2 (table 3), those in the ELP had a lower resting PR (71 ± 12 b.p.m.) compared with the BLP (78 ± 12 b.p.m.; adjusted p = 0.03). No significant group differences were found for total daily steps or for any of the other variables assessed (table 3).
Table 1 Medication use according to group allocation (n = 41)

<table>
<thead>
<tr>
<th>Drug class</th>
<th>Group, n (%)</th>
<th>Enhanced</th>
<th>Basic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral diabetic agents*</td>
<td></td>
<td>13 (32)</td>
<td>17 (42)</td>
</tr>
<tr>
<td>Statin</td>
<td></td>
<td>10 (24)</td>
<td>8 (20)</td>
</tr>
<tr>
<td>Angiotensin-converting enzyme inhibitor</td>
<td></td>
<td>10 (24)</td>
<td>7 (17)</td>
</tr>
<tr>
<td>Diuretic</td>
<td></td>
<td>4 (10)</td>
<td>5 (12)</td>
</tr>
<tr>
<td>Angiotensin receptor blocker</td>
<td></td>
<td>5 (12)</td>
<td>3 (7)</td>
</tr>
<tr>
<td>Calcium channel blocker</td>
<td></td>
<td>2 (5)</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Beta-blocker</td>
<td></td>
<td>3 (7)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Cholesterol absorption inhibitor</td>
<td></td>
<td>1 (2)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Glycoside</td>
<td></td>
<td>1 (2)</td>
<td>0 (0)</td>
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</tbody>
</table>

*Includes all classes.

Of those in the ELP who returned their step logs, 36% of their daily steps were taken while walking faster. A total of 36 days of walking faster indicated 100% compliance for those in the ELP. Adherence to walk faster was completed on 78% of the total available number of opportunities (30 min/3 days/week × 12 weeks = 36 days) to increase walking speed (range 0–183%). Two participants exceeded 100% compliance: one recorded 63 days and the other recorded 39 days of walking faster (30 min/bout), and the later participant recorded walking faster twice daily for 30 min on 27 of the 39 days reported. Attendance at weekly group meetings for weeks 1–4 was 95, 93, 91 and 91% respectively. The average attendance for the four weekly programme sessions for weeks 13–24 were 100, 82, 63 and 75% for the BLP and 100, 77, 77 and 86% for the ELP.

Discussion

The main finding from this study was that after 24 weeks, adults with type 2 diabetes had a lower resting PR after completing a 24-week lifestyle modification programme that first asked them to increase the number of steps/day and then to walk faster on 3 days/week for 30 min/day compared with those who were asked to target their total number of steps/day without walking faster.

Our results are consistent with the conclusions of meta-analytic data [17–19] in that physical activity of higher intensity may facilitate improved cardiovascular outcomes (i.e. cardiorespiratory fitness) for individuals with type 2 diabetes. Compared with a recent longer term study targeting walking speed in this population [20], we had a very low rate of attrition in the ELP, which we believe is related to the progressive approach to walking intensity that we provided over the 24 weeks. Thus, the ELP used in this study provides an acceptable vehicle to promote behaviour modification and improve cardiovascular health in the context of a straightforward and practical pedometer-based walking programme that targets walking speed.

Previous pedometer-based studies in this population have resulted in modest changes in common markers of cardiovascular health [4,5]. In this regard, it is noteworthy that over the first 12 weeks of this study, when participants were increasing only their steps/day, there was a reduction in average systolic and diastolic blood pressures. Furthermore, our results suggest that increasing the speed of at least one third of total daily steps leads to a reduction in resting PR and that a pedometer and a stopwatch can aid in attaining lifestyle management goals. Over and above the reduction in blood pressure in the first 12 weeks of the study, the reduction in resting PR among those in the ELP has clinical significance because there is now considerably strong evidence indicating that a reduction in resting heart rate is associated with reductions in cardiovascular disease–related morbidity and mortality, irrespective of changes in blood pressure [21–25]. Interestingly, however, a concomitant reduction in blood pressure as is often experienced with exercise training [26], but not always found [27], was not shown in the current study. Because many individuals with type 2 diabetes have numerous subclinical cardiac and vascular
in resting PR was observed in the ELP, but not in the BLP, underlines the importance of the intensity of physical activity in order to attain physiological benefit in this population. Nonetheless, our results are encouraging because individuals with type 2 diabetes are at substantially greater risk for cardiovascular morbidity and mortality [31], and any improvement in cardiovascular health is an important step towards reducing the cardiovascular complications commonly found in this population.

Although there was a reduction in resting PR in the ELP, we observed no significant change in A1c between the treatment groups. This could be because of a number of factors: first, the average A1c observed prior to the intervention was low and suggests that this group was well controlled. This may have reduced the potential for A1c to be further reduced through any changes in diet and physical activity. Second, the sample size was too small to detect a reduction in A1c. This study used a statistical power calculation based on resting PR/resting heart rate because participants in our pilot study showed improved cardiorespiratory fitness [7] and a reduction in resting heart rate (−5.3 ± 2.2 b.p.m., p < 0.05; unpublished data). Lastly, because both groups were provided nutrition and physical activity training, the potential for observed differences between them may have been relinquished.

Despite the new evidence presented, the results of this study must be interpreted with limitations in mind. Free-living individuals with type 2 diabetes typically accumulate ~6500 steps/day [14], suggesting that at baseline, this group of participants could be considered ‘moderately’ to ‘highly’ active and this may, in part, help explain their good glycaemic control at baseline and as a consequence limiting the generalizability of these results to other less well-controlled and less physically active patients with type 2 diabetes. Second, it is plausible that the oral antihyperglycaemic agents and cardiovascular-related medications (e.g. beta-blockers) taken by subjects in this study may have had some impact on the outcomes measured. However, our participant pool was randomized at week 12, and participants did not report having made any significant changes in medication use during the course of the trial. Thus, we believe that pharmacological therapy had little impact on the study outcomes.

In summary, this study demonstrates that a programme for individuals with type 2 diabetes who targets an increase in the total number of steps for 12 weeks and then walking speed for 30 min/3 days/week for an additional 12 weeks leads to cardiovascular improvements. Acknowledging that there was no difference between the groups, the nutrition education component targeting
the GI may have helped all participants improve their dietary intake even though they were generally eating well at the beginning of the study. This approach to a lifestyle modification programme that combines physical activity and nutrition is effective in generating both behaviour change and physiological improvements to reduce the risk of diabetic complications.

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References


