Efficacy of self monitoring of blood glucose in patients with newly diagnosed type 2 diabetes (ESMON study): randomised controlled trial

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ABSTRACT

Objectives To assess the effect of self monitoring of blood glucose concentrations on glycaemic control and psychological indices in patients with newly diagnosed type 2 diabetes mellitus.

Design Prospective randomised controlled trial of self monitoring versus no monitoring (control).

Setting Hospital diabetes clinics.

Participants 184 (111 men) people aged <70 with newly diagnosed type 2 diabetes referred to the participating diabetes clinics. Major exclusion criteria were secondary diabetes, insulin treatment, previous self monitoring of blood glucose.

Interventions Participants were randomised to self monitoring or no monitoring (control) groups for one year with follow-up at three monthly intervals. Both groups underwent an identical structured core education programme. The self monitoring group received additional education on monitoring.

Main outcome measures Between group differences in HbA1c, psychological indices, use of oral hypoglycaemic drugs, body mass index (BMI), and reported hypoglycaemia rates.

Results 96 patients (55 men) were randomised to monitoring and 88 (56 men) to control. There were no baseline differences in mean (SD) age (57.7 (11.0) in monitoring group v 60.9 (11.5) in control group) or HbA1c (8.8 (2.1)% v 8.6 (2.3)%, respectively). Those in the monitoring group had a higher baseline BMI (34 (7) v 32 (6.2)). There were no significant differences between groups at any time point (12 months values given) in HbA1c (6.9 (0.8)% v 6.9 (1.2)%, P=0.69; 95% confidence interval for difference −0.25% to 0.38%), BMI (33.1 (6.4) v 31.8 (6.0); adjusted for baseline BMI, P=0.32), use of oral hypoglycaemic drugs, or reported incidence of hypoglycaemia. Monitoring was associated with a 6% higher score on the depression subscale of the well-being questionnaire (P=0.01).

Conclusions In patients with newly diagnosed type 2 diabetes self monitoring of blood glucose concentration has no effect on glycaemic control but is associated with higher scores on a depression subscale.

Trial registration ISRCTN 49814766.
Analysis performed on intention to treat basis
Excluded from analysis (n=0)
Analysed (n=96)

Discontinued intervention (n=2; patients withdrew from study)
Received allocated intervention (n=96)

Allocated to self monitoring of blood glucose (n=96)
Allocated to control (n=88)

Assessed for eligibility (n=212)
Enrolment
Excluded (n=28): Did not meet inclusion criteria (n=11)
Refused to participate (n=17)
Randomisation
Allocated to self monitoring of blood glucose (n=96)
Received allocated intervention (n=96)

Lost to follow-up (n=0)
Discontinued intervention (n=2; patients withdrew from study)

Follow-up
Allocated to control (n=88)
Received allocated intervention (n=88)

Lost to follow-up (n=0)
Discontinued intervention (n=2; patients withdrew from study)

Analysis
Analysed (n=96)
Excluded from analysis (n=0)
Analysis performed on intention to treat basis

After an initial assessment visit, eligible patients were randomised into intervention (self monitoring of blood glucose) or control (no monitoring) groups with a randomly generated allocation code in consecutively numbered sealed envelopes. The study diabetes nurse at each hospital site performed the treatment allocation.

Patients in the self monitoring group were all provided with a single glucose monitor (Lifescan OneTouch Ultra; Johnson and Johnson, Milpitas, CA) and instructed in its use. They were asked to monitor four fasting and four postprandial capillary blood glucose measurements each week. They were advised on appropriate responses to high or low readings. Such advice included the need for dietary review or the suggestion of exercise (such as walking) in response to high readings. At each clinic visit, concordance with the self monitoring regimen was verified by downloading meter readings.

Patients in the no monitoring group [control] were asked not to acquire a meter or perform monitoring for the duration of the study.

Patients in both groups underwent an identical structured education programme involving diabetes nurse practitioners, dieticians, podiatrists, and medical staff. All patients were reviewed by the doctor, diabetes nurse practitioner, and dietician at three monthly intervals for one year. At each visit all aspects of diabetes care were reviewed including indices of glycaemic control (HbA1c for both groups and self monitoring results for the self monitoring group). Patients in the self monitoring group received ongoing advice and support in the appropriate interpretation of and response to their capillary glucose results.

We used an identical treatment algorithm for dietary and pharmacological management of glycaemia for both groups based on HbA1c targets (figure 1). Blood concentrations of HbA1c, lipids, and electrolytes were measured at or before each clinic and results were discussed with patients in the context of the treatment targets. Measurement of HbA1c was performed in the local hospital laboratory with a diabetes control and complications trial (DCCT) aligned HbA1c assay. All laboratories participated in HbA1c external quality assurance, which was satisfactory for the duration of the study. All other laboratory tests were also performed in the local hospital laboratory, where staff were blinded to treatment allocation.

At each three monthly visit patients completed a questionnaire survey incorporating the diabetes treatment satisfaction questionnaire, a modified version of the diabetes attitude scale, and the well-being questionnaire. The diabetes attitude scale included three of the seven subscales: seriousness of type 2 diabetes, blood glucose control and its implications, and impact of diabetes on patients’ lives. The well-being questionnaire incorporated four subscales (depression, anxiety, energy, and positive wellbeing) and a total score of general wellbeing.

The study was powered to detect a 1% (1 unit) difference in HbA1c (2 SD) between the groups at the 0.05 level (two tailed t test) with a power in excess of 90%. (A 50% reduction in this standard deviation—that is, a narrowing of the HbA1c distribution width as HbA1c values converge on treatment targets—would detect a difference of 0.5% in HbA1c with the above power.) We used Mplus univariate independent t tests for statistical analysis and checked the results against non-latent growth models with time variant and time invariant covariates. We used three predetermined time invariant predictors: sex, age, monitoring status (that is, control or monitoring, with monitoring further broken down into two subgroups: patients who complied with the suggested monitoring regimen and patients who did not comply with the suggested monitoring regimen). Compliance was defined as a monitoring frequency of >80% of that requested. In addition, we introduced the number of medications being taken for the control of HbA1c, as a time varying covariate. The analysis was performed on an intention to treat basis, with missing data imputed through the use of full information maximum likelihood. Psychological indices were examined by analysis of covariance with the measurement models held invariant across time. Differences between groups in use of oral...
Table 2 | Mean(SD) HbA1c in patients with newly diagnosed diabetes according to self monitoring or no monitoring (control) of blood glucose

<table>
<thead>
<tr>
<th>Time (months)</th>
<th>Monitoring</th>
<th>Control</th>
<th>P value</th>
<th>Mean difference (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8.8 (2.1)</td>
<td>8.6 (2.3)</td>
<td>0.68</td>
<td>-0.33 (-0.77 to 0.11)</td>
</tr>
<tr>
<td>3</td>
<td>7.2 (1.1)</td>
<td>7.1 (1.2)</td>
<td>0.50</td>
<td>0.18 (-0.47 to 0.23)</td>
</tr>
<tr>
<td>6</td>
<td>7.0 (0.9)</td>
<td>7.0 (1.1)</td>
<td>0.82</td>
<td>0.04 (-0.27 to 0.35)</td>
</tr>
<tr>
<td>9</td>
<td>6.9 (0.8)</td>
<td>7.1 (1.4)</td>
<td>0.30</td>
<td>0.19 (-0.16 to 0.54)</td>
</tr>
<tr>
<td>12</td>
<td>6.9 (0.8)</td>
<td>6.9 (1.2)</td>
<td>0.69</td>
<td>0.07 (-0.25 to 0.38)</td>
</tr>
</tbody>
</table>

DISCUSSION

Self monitoring of blood glucose concentrations might contribute in two ways to the management of type 2 diabetes: by improving glycaemic control or by improving the patients’ experience of diabetes. In this cohort of patients with newly diagnosed type 2 diabetes we were unable to identify any significant effect of self monitoring over one year on HbA1c, BMI, use of oral hypoglycaemic drugs, or reported incidence of hypoglycaemia. Furthermore, monitoring was associated with a 6% higher score on the well-being depression subscale.

Strengths of study

We investigated the role of self monitoring in a cohort of patients with newly diagnosed type 2 diabetes, all of whom were therefore new to monitoring. We randomised a high proportion of eligible participants (86.7%), suggesting that the cohort was representative of newly presenting patients in the community. The drop-out rate was low (2.2%) and concordance with the monitoring regimen in the intervention group was high. We used a structured drug treatment algorithm based on HbA1c targets for both groups. The core diabetes educational programme was identical to that administered under standard care, although education on monitoring was provided to those randomised to the monitoring group only. The starting HbA1c was high (8.8% and 8.6% in self monitoring and control groups, respectively) and both groups attained a satisfactory HbA1c level of 6.9%. We therefore think that the results of this study have general applicability.

Comparison with other studies

Previous studies on the efficacy of self monitoring have varied in design and have included non-randomised trials (both prospective and retrospective) and randomised controlled trials.1-5 The range of designs used in these studies reflects the difficulty of isolating the effect of a single home intervention in a condition in which hypoglycaemic drugs were assessed by Pearson’s χ² test.

RESULTS

Of 212 consecutive participants approached between January 2003 and July 2005, 195 were recruited and 184 (86.7% of those approached) proceeded to randomisation (96 to self monitoring) (fig 2). Four participants (two in each group) failed to complete the study.

There was no significant difference in baseline HbA1c, age, or sex between the groups, although participants in the self monitoring group had a higher baseline body mass index (BMI) (mean (SD) 34 (7) v 32 (6.2), table 1).

Of the 96 participants in the self monitoring group, 63 carried out more than 80% of the requested blood glucose monitoring (that is, four fasting and four postprandial readings a week).

Outcome measures

Although HbA1c fell within each group, there were no significant differences between the groups at any time point, with mean (SD) values at 12 months of 6.9 (0.8)% v 6.9 (1.2)% for the self monitoring versus control groups (table 2). The 95% confidence interval for the difference at 12 months in HbA1c, between groups was −0.25% to 0.38%.

The measures of depression and anxiety were scored on a 100 point scale with the measure at the final time point regressed on to the baseline measure, monitoring status, and sex. All models provided an adequate description of the data. Participants in the self monitoring group were more depressed, scoring 6 points higher (that is, 6%) on the depression subscale of the well-being questionnaire at 12 months (P=0.01), and there was a trend towards increased anxiety (table 3). There were no significant (0.05 level) differences between groups on any of the other subscales, in the mean scores on treatment satisfaction, or on any of the diabetes attitude subscales. There were no differences between groups in the incidence of reported hypoglycaemia at any time points or in use of oral hypoglycaemic drugs (tables 4 and 5). Although there was a difference in BMI between groups at randomisation, after correction for the baseline value there were no significant differences at subsequent time points (table 6).

Comparison with other studies

Previous studies on the efficacy of self monitoring have varied in design and have included non-randomised trials (both prospective and retrospective) and randomised controlled trials.7-19 The range of designs used in these studies reflects the difficulty of isolating the effect of a single home intervention in a condition in which
in the control group suggested that pre-existing management had been suboptimal and that management administered under the study protocol differed from usual care. Furthermore the ASIA study had a high drop-out rate (48% in the self monitoring group, 40% in the control), which limits the general applicability of the findings. In contrast, the well designed DIGEM trial of 453 patients found no benefit of self monitoring (with or without structured education) in patients with established and well controlled type 2 diabetes, although the mean starting HbA1c was low (7.5%), which would have reduced the sensitivity for detecting an effect of monitoring.

An important difference between these randomised controlled trials and the present study is that our study included a rigorous treatment algorithm for the management of glycaemic control based on the target HbA1c. The success of this algorithm is shown by the reduction in mean HbA1c in both groups to the satisfactory level of 6.9% at 12 months. The use of an effective and uniformly applied treatment regimen possibly minimises any potential benefit conferred by monitoring.

All studies to date, however, have included people with established diabetes, and it is unclear to what extent results could be extrapolated to newly presenting patients. Recruitment protocols in such studies generally excluded those who were already actively monitoring or who had recently monitored. This introduced a potential selection bias by excluding patients who had found monitoring beneficial, and by including patients who may have had previous experience of monitoring but rejected it as unhelpful. The effect of any such bias would be to underestimate the benefit of self monitoring. We removed any such potential bias by recruiting only those patients with a new diagnosis of diabetes and who had not previously performed self monitoring.

Anecdotal and other evidence suggests that some patients consider monitoring uncomfortable, intrusive, and unpleasant. An interesting finding of our study was that monitoring was associated with a 6% higher score on a depression subscale and a trend towards increased anxiety, although satisfaction with treatment was unchanged. This supports the results of Franciosi et

### Table 4 | Number of patients who reported hypoglycaemia (total number of hypoglycaemia episodes reported) according to self monitoring and no monitoring (control) of blood glucose

<table>
<thead>
<tr>
<th>Time (months)</th>
<th>Monitoring</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1 (3)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>3</td>
<td>5 (10)</td>
<td>2 (8)</td>
</tr>
<tr>
<td>6</td>
<td>3 (5)</td>
<td>4 (8)</td>
</tr>
<tr>
<td>9</td>
<td>5 (9)</td>
<td>1 (6)</td>
</tr>
<tr>
<td>12</td>
<td>4 (4)</td>
<td>6 (14)</td>
</tr>
</tbody>
</table>

### Table 5 | Use of oral hypoglycaemic drugs in patients with newly diagnosed diabetes according to self monitoring or no monitoring (control) of blood glucose

<table>
<thead>
<tr>
<th></th>
<th>Monitoring</th>
<th>Control</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>At baseline†</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No drugs</td>
<td>86</td>
<td>78</td>
<td>0.67</td>
</tr>
<tr>
<td>1 drug</td>
<td>8</td>
<td>7</td>
<td>0.91</td>
</tr>
<tr>
<td>2 drugs</td>
<td>0</td>
<td>2</td>
<td>0.14</td>
</tr>
<tr>
<td><strong>At 12 months‡</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No drugs</td>
<td>34</td>
<td>29</td>
<td>0.95</td>
</tr>
<tr>
<td>1 drug</td>
<td>44</td>
<td>40</td>
<td>0.62</td>
</tr>
<tr>
<td>2 drugs</td>
<td>11</td>
<td>6</td>
<td>0.36</td>
</tr>
</tbody>
</table>

*Pearson’s χ² cross tabulation between monitoring and control by number of drugs. †Data missing for two patients in monitoring group and one in control group. ‡Data missing for seven in monitoring group and 13 in control group.
Self monitoring of blood glucose concentration in type 2 diabetes is widely advocated as an adjunct to achieving good glycaemic control

Randomised trials on self monitoring have given conflicting results, have been limited to patients with established diabetes, and have rarely considered quality of life

WHAT THIS STUDY ADDS

Self monitoring of blood glucose in patients with newly diagnosed type 2 diabetes did not result in improved glycaemic control but was associated with a 6% higher score on a depression index

Table 6 | Body mass index (mean* (SD) and predicted overall mean) at 3, 6, 9, and 12 months adjusted for baseline value in self monitoring or no monitoring (control) groups

<table>
<thead>
<tr>
<th>Time (months)</th>
<th>Monitoring</th>
<th>Control</th>
<th>P value</th>
<th>Predicted overall mean (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>34.0 (7.0)</td>
<td>32 (6.2)</td>
<td>0.04</td>
<td>—</td>
</tr>
<tr>
<td>3</td>
<td>33.0 (6.5)</td>
<td>31.5 (6.1)</td>
<td>0.56</td>
<td>31.83 to 32.93 (32.38)</td>
</tr>
<tr>
<td>6</td>
<td>33 (6.3)</td>
<td>31.4 (6.1)</td>
<td>0.75</td>
<td>31.71 to 32.86 (32.28)</td>
</tr>
<tr>
<td>9</td>
<td>33.1 (6.3)</td>
<td>31.7 (6.1)</td>
<td>0.49</td>
<td>31.99 to 33.19 (32.59)</td>
</tr>
<tr>
<td>12</td>
<td>33.1 (6.4)</td>
<td>31.8 (6.0)</td>
<td>0.32</td>
<td>32.09 to 33.29 (32.69)</td>
</tr>
</tbody>
</table>

*Raw score standard deviations.
†Confidence interval based on overall predicted mean score.

Competing interests: None declared.

Ethical approval: University of Ulster ethics committee.

Provenance and peer review: Not commissioned; externally peer reviewed.


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