

## An Internet-based diabetes self-care intervention tailored to self-efficacy

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### Abstract

The main objective of this study was to assess whether self-efficacy (SE) could function as a moderator of the effect of a tailored Internet-based intervention aimed at increasing self-reported diabetes self-care behaviours. In a two-group, 1-month interval pre-test–post-test randomized controlled trial, participants ( $N = 64$ ) were assigned at random to either a group that received an intervention on the area of self-care (blood glucose monitoring, diet management or physical activity) for which the reported SE was lowest (LSE group) or to a group that received an intervention on area of self-care for which the reported SE was highest (HSE group). Improvements in self-care were observed for both groups, but the HSE group improved more. Self-care also increased for those areas that the intervention did not target. Furthermore, SE levels decreased from baseline to follow-up. This study suggests that SE can function as a moderator in a behavioural intervention for diabetes self-care, and hence that initial level of SE provides relevant information for tailoring such interventions.

### Introduction

Diabetes can lead to secondary complications like blindness, leg amputation, renal failure and cardio-

vascular diseases, and is one of the leading causes of death in many countries [1]. Improved glycaemic control through lifestyle changes can reduce long-term diabetes complications [2, 3] or even prevent Type 2 diabetes in high-risk groups [4–7]. Managing diabetes is a complex task of balancing diet, physical activity and for many, insulin, with the aid of blood glucose monitoring. Besides the educational needs this entails, maintaining such lifestyle changes over time is challenging [5, 8].

Gary et al. [9] concluded in their meta-analysis of 18 educational and behavioural interventions for Type 2 diabetes that such interventions have provided modest improvements in glycaemic control and should be refined further. They also found a possible publication bias, i.e. fewer published studies with non-significant or negative findings than could be expected, meaning that diabetes education interventions may in actual practice produce even more modest effects than suggested by the literature. Norris et al. [10] found in their meta-analysis of 31 randomized controlled trials of self-care education for adults with Type 2 diabetes that GHb levels decreased immediately after intervention, but that this benefit declines over time. Therefore, there is a need for tools that can support and encourage long-term changes as well as facilitate information retrieval and interaction with peers and health care personnel [11].

The potential for supporting health through information and communication technology (ICT) is increasingly recognized. Accumulating evidence shows that diabetes education delivered via ICT contributes to reduction of HbA1c levels [12–14]. In Norway, where the present trial was conducted, access to and use of ICT is substantial [15].

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Especially attractive is ICT's ability to support interventions tailored to the individual [16, 17]. Studies have shown that tailored health messages are in general better remembered and perceived as more personally relevant, compared with non-tailored educational material [16, 18]. Thus, ehealth tools can combine the reach of mass education approaches with the efficacy of individualized interventions.

It is generally recommended that health behaviour interventions should be based on theory. In a review of behavioural interventions for adolescents with Type 1 diabetes, it was concluded that theory-based interventions had the highest effect sizes (0.47) [19]. The concept of self-efficacy (SE) stems from social cognitive theory [20] and refers to the degree to which an individual perceives that he or she can perform a particular behaviour [21].

SE level has been found to predict better glucose control mediated by better self-care, both in young adults with Type 1 diabetes [22] and in adults with Type 2 [23–26]. Through several studies of the related concept 'perceived competence', Williams et al. [27, 28] found that increasing autonomy and perceived competence lead to greater motivation for diabetes self-care and thus better glucose control.

Senecal et al. [29] examined SE and dietary self-care within the context of social cognitive theory, and concluded that interventions should aim to increase SE. There are, however, differing views. Peyrot [30] stated that 'attempts to induce behavior change by increasing SE are likely to represent a waste of time and effort', as 'self-efficacy, while generally regarded as an important proximal outcome, is unrelated to behaviour change resulting from education. Behaviour change produces self-efficacy rather than vice versa' (p. 71). An SE belief is thought to be largely based upon experience with the behaviour in the past. Interventions aimed at increasing SE can therefore aid in pointing out past successful behaviour (e.g. through monitoring with feedback), modelling successful behaviour (e.g. through peer networks or videos) and by encouraging and/or facilitating actual success in performing the target behaviour [21].

Interventions that address multiple risk behaviours may have carry-over effects across the behaviours, but can also lead to the individual feeling overwhelmed [31, 32]. It has been suggested that the best way to go about facilitating better self-care of diabetes is to choose one or two specific behaviours for intervention or to intervene in a stepwise fashion [33]. Peyrot and Rubin [33] found that those with the worst initial self-care showed the greatest improvements, and suggests that educators should help patients to identify the areas of self-care most amenable to change. Several different and often opposing criteria for choosing target behaviours have been suggested, such as starting with the factor associated with the most reduced life expectancy or the area the user him- or herself is most interested in changing [31].

Peyrot [34] points out that at present we know that most behavioural diabetes interventions work, but we do not know much about the critical mechanisms, and that testing a theory is not the same as basing an intervention on those principles alone. A general distinction can be made between a factor playing mediating versus moderating roles [35]. If education influences self-care and self-care in turn influences blood glucose level, self-care has the role of a mediating factor. Moderating factors operate differently, as for example when education/self-care/behaviour links are stronger for certain types of people than for others. If this were true for men versus women, for example, gender would be considered a moderating factor. However, a variable such as SE may in the same intervention function as both a mediator and a moderator.

In the diabetes education arena, there is substantial uncertainty about which factors mediate and which factors moderate education's effects on self-care. This is largely because the existing literature has been generated mostly in cross-sectional studies or pre-test, post-test longitudinal designs. Strict examination of mediating and moderating effects requires study designs with at least three waves of data collection.

Furthermore, causal hypothesis regarding theoretical mechanisms should as far as possible be singled out for manipulation and tested using true

experimental designs, with randomization to experimental and control (comparison) conditions.

This study builds on the considerations discussed above, to test whether SE mediates and/or moderates the effect of an educational intervention on diabetes self-care behaviours. It was hypothesized that ICT-delivered, tailored diabetes self-care education would be more effective among people with low SE than with high SE (a moderating effect). The outcome measure for this hypothesis was self-care behaviour. It was also hypothesized that regardless of initial SE level, education would increase SE (a mediating effect). The outcome measure for this hypothesis was change in SE. Both hypotheses were tested in a single design.

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## Method

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### Design

The study used a two-group randomized control trial design. Participants were assigned by randomization to either a treatment group receiving an online intervention on the area of self-care for which they rated themselves as having the lowest SE (LSE group) or a treatment group receiving an online intervention on the area of self-care for which they rated themselves as having the highest SE (HSE group).

Study measurements were made using questionnaires delivered online when logging on to the Internet site at baseline, and again after using the intervention for 1 month. The main outcome measure was self-reported self-care behaviour. A secondary outcome measure was SE.

### Participants

The participants were Norwegians between 17 and 67 years of age, recruited through Internet advertising. Inclusion criteria were (i) diagnosis of Type 1 or Type 2 diabetes and (ii) having access to the Internet. There were no exclusion criteria. The study protocol was approved by the Regional Ethics Committee for health region NORD (REK-NORD) before contact was made with participants.

### The intervention

The intervention was delivered via an Internet site to which the participants logged on with their own user name and password. When the participants first logged on to the Web site, they were presented with information about the study. After having consented to participate, they were presented the baseline questionnaire, and could only start using the intervention after having completed the questionnaire.

The intervention was tailored to level of SE. Participants received intervention exclusively on that aspect of self-care (blood glucose monitoring, diet care, physical activity) with the lowest self-rated SE (LSE group) or the highest self-rated SE (HSE group).

The interventions consisted of several components derived mainly from social cognitive theory [20] that aimed to increase the performance of self-care. Behaviour exercises that included monitoring and graphic feedback were the most centrally placed component at the Web site. Information on health risks and benefits, self-care, overcoming barriers to lifestyle change and diabetes in general were delivered online via articles and a reference compendium. Quizzes with feedback were used to facilitate interactive learning. Videos of peers interviewed about overcoming barriers to self-care were available (peer modelling). Videos of lectures from health personnel on the specific area of self-care were also available for download.

Each intervention theme focused on one specific target behaviour. For general diabetes control, this was measuring blood glucose levels, for diet it was reading nutrition labels and for exercise it was engaging in a minimum of 30 min of activity each day.

### Measures

Background information collected included age, gender, highest educational attainment, type of diabetes, years with diabetes, use of insulin, weight and height and latest HbA1c value, a measure of glycosylated haemoglobin reflecting blood glucose control over the last months.

The Summary of Diabetes Self-Care Activities (SDSCA) measure [36] was used for assessing diabetes self-care behaviours. The SDSCA contains items about dietary behaviour, exercise, glucose monitoring, foot care and smoking. Only the first three scales were used in this study. Several of these items have been used previously in two large Norwegian health surveys. The SDSCA has a high inter-item correlation as well as moderate test-re-test reliability and has been validated against other measures of diet and exercise [36].

The perceived competence scales (PCS) were used for assessing SE. The perceived competence for glucose monitoring scale consists of four items representing the degree to which a person feels he or she can manage daily aspects of glucose monitoring. Responses are given on a scale from 0 (not at all) to 6 (to a great extent). Internal consistency for the scale has been good in previous studies, with Cronbach's alphas ranging from 0.83 to 0.93. Confirmatory factor analyses have also found the four items to load on a single latent factor [28]. The scale has furthermore been found to have good predictive validity for both behaviour and glycaemic control [27, 28]. The perceived competence for maintaining a healthy diet and the perceived competence for regular physical exercise were correspondingly measured with four items each [37].

User evaluation was assessed through the two items 'Would you recommend this site to a friend with diabetes?' and 'How useful was this site?' Users were also asked to rate the most and least useful components. Data on use of the site were gathered through Web logging. The following assumptions were made in order to estimate the number of accesses at different components and time spent there: an access to a component had to last at least 1 min to be coded, and if no activity was detected in a 15-min period, the next onset of activity was coded as a new visit.

### Statistical analyses

Main effects of intervention on self-care were analyzed by repeated measures analysis of covariance (ANCOVA). Gender and baseline level of SE were entered as covariates. Other baseline characteristics

were not significant covariates and were excluded from the analysis to increase statistical power. For analyses of changes in SE, intervention theme and baseline level of self-care were entered as covariates.

Differences between means were tested with between-subjects analysis of variance. Differences between proportions were tested by chi-square. Effect sizes are reported as partial eta squared for ANCOVA. All reported confidence intervals (CIs) are 95%.

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## Results

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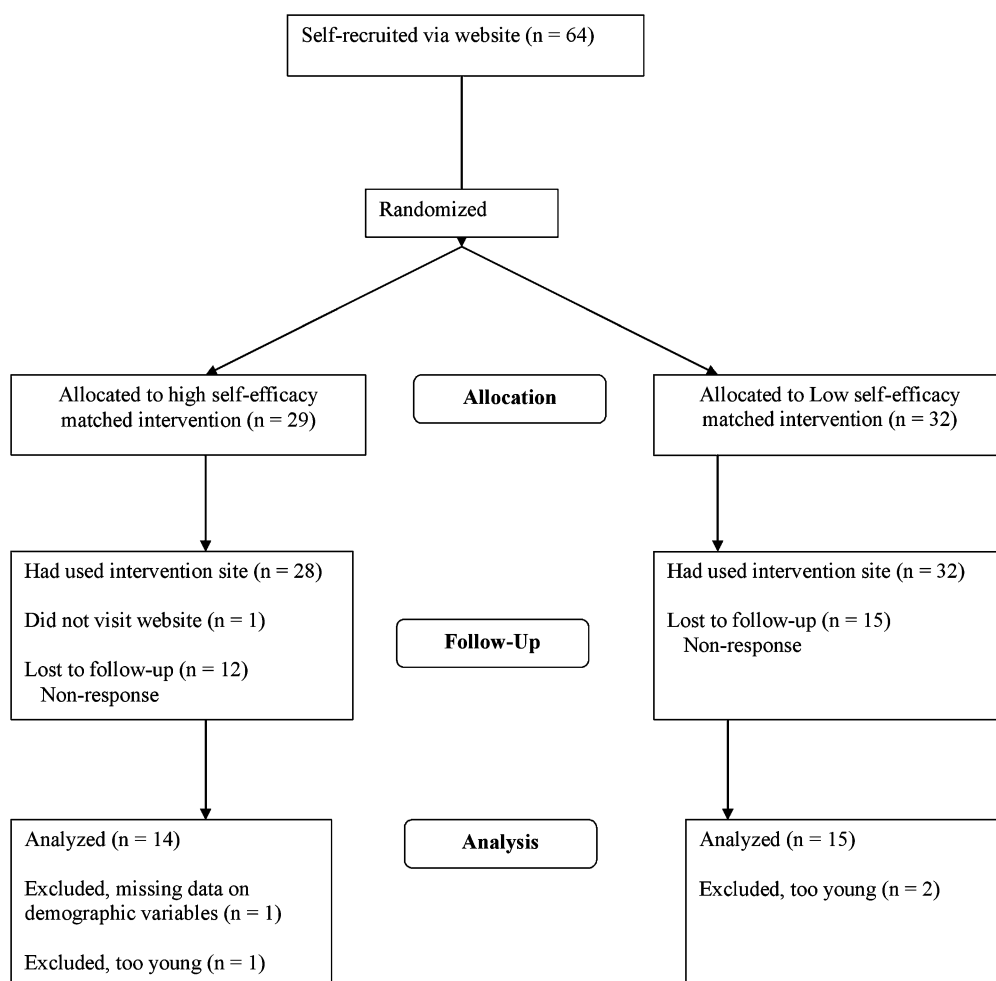
Sixty-four participants volunteered for the trial. Of these, three were excluded because they were younger than 17 years, and 1 did not visit the trial Web site. Characteristics of the remaining 60 participants are described in Table I, and a participant flow chart is given in Fig. 1. There were no significant baseline differences between the LSE and HSE groups on the baseline level of overall SE, self-care or demographic characteristics. Thirty-three (52%) of the 63 participants who completed baseline measures returned the 1-month post-assessment questionnaire. There were no significant differences between those who responded at post-assessment and those who had dropped out on baseline SE level ( $F_{(1,58)} = 1.69, P = .20$ ) or self-care ( $F_{(1,58)} = 0.45, P = .51$ ). The non-responders had however visited the site fewer times ( $F_{(1,58)} = 8.24, P = .006$ ).

A post hoc power analysis showed that with the 29 participants available at follow-up, the statistical power is .52 to detect a main effect of the intervention at a medium effect size ( $f^2 = .10$ ) with ANCOVA at an alpha level of .05. Hence, this trial does not have adequate power to reject an effect of the intervention.

In order to assess measurement validity, data on the eight items of the SDSCA from this and a second trial (total  $N = 83$ ) were entered into a second-order confirmatory factor analysis with the items loading onto latent variables representing their respective subscales, and the three subscales loading onto a total self-care latent variable. This model fitted the data well ( $\chi^2 = 21.3, df = 20, P = .38$ ,

**Table I.** Demographic characteristics of the sample

Variable	Low SE-matched group, <i>n</i> = 32 (95% CI)	High SE-matched group, <i>n</i> = 28 (95% CI)	Tests for difference
Baseline self-care (SDSCA total)	25.7 (21.9–29.5)	30.4 (26.7–34.2)	$F = 3.28, P = .08$
Baseline SE (PC total)	47.9 (42.5–53.3)	53.1 (48.9–57.2)	$F = 2.33, P = .13$
Age (years)	37.3 (33.2–41.4)	42.9 (38.0–47.9)	$F = 2.96, P = .09$
Women (%)	63	50	$\chi^2 = 0.95, P = .33$
12 years or less of education (%)	11	8	$\chi^2 = 0.23, P = .63$
Type 1 diabetes (%)	72	50	$\chi^2 = 3.02, P = .08$
Insulin use (%)	78	71	$\chi^2 = 0.36, P = .55$
Baseline HbA1c	7.7 (7.1–8.4)	7.2 (6.6–7.8)	$F = 1.38, P = .25$

**Fig. 1.** Participant flow chart.

RMSEA = .028,  $P = .61$ , GFI = .94) confirming the construct validity of the SDSCA. Concurrent validity was assessed through the association between the SDSCA total latent variable and HbA1c ( $\beta = -.12$ ,  $P = .33$ ). Although this relation was not significant, it was in the expected direction, i.e. fewer self-care behaviours were related to worse blood glucose control (higher HbA1c value).

### Main outcome

Mean unadjusted scores for self-care at baseline and at 1 month after intervention can be seen in Table II. There was a significant overall main effect of the intervention on self-care,  $F_{(1,25)} = 5.56$ ,  $P = .026$ ,  $\eta_p^2 = .18$ . The change in self-care from baseline to 1 month after intervention is shown in Fig. 2. The interaction between time and group was not significant,  $F_{(1,25)} = 2.31$ ,  $P = .14$ ,  $\eta_p^2 = .09$ , although the HSE group improved more than did the LSE group. A significant interaction between change in self-care and baseline SE was found,  $F_{(1,25)} = 4.67$ ,

$P = .040$ ,  $\eta_p^2 = .16$ , with lower baseline SE being related to greater improvements in self-care. This relationship can be seen in Fig. 3. A significant interaction between time and gender was observed,  $F_{(1,25)} = 4.78$ ,  $P = .038$ ,  $\eta_p^2 = .16$ , with men having greater improvements in self-care than women.

A non-significant tendency towards decreases in SE from baseline to post-intervention was observed,  $F_{(1,25)} = 2.02$ ,  $P = .17$ ,  $\eta_p^2 = .08$ . There were no significant interactions between change in SE and study group,  $F_{(1,25)} = 0.70$ ,  $P = .41$ ,  $\eta_p^2 = .03$ , nor with baseline level of self-care,  $F_{(1,25)} = 0.35$ ,  $P = .56$ ,  $\eta_p^2 = .01$ . There was, however, a near-significant interaction between changes in SE and intervention theme,  $F_{(1,25)} = 3.81$ ,  $P = .06$ ,  $\eta_p^2 = .13$ , with those receiving the diet intervention tending to lower their SE more.

### User evaluation

The mean score on perceived usefulness was 3.6 ( $CI_{95\%} = 3.1-4.1$ ), which corresponds to a slightly

**Table II.** Mean scores on SE and self-care before and after intervention per theme and per intervention group

Intervention	Group	Mean SE before (SD)	Mean SE after (SD)	Mean SC before (SD)	Mean SC after (SD)
Blood glucose monitoring	Low SE ( $n = 3$ )	16.67 (7.51)	20.67 (3.06)	10.67 (4.93)	10.67 (4.93)
	High SE ( $n = 9$ )	20.22 (4.21)	19.44 (4.69)	10.22 (5.72)	11.56 (4.64)
	Men ( $n = 4$ )	21.00 (2.83)	21.75 (2.06)	13.50 (0.58)	13.50 (0.58)
	Women ( $n = 8$ )	18.50 (5.88)	18.75 (4.80)	8.75 (5.97)	10.25 (5.26)
	Total for theme ( $n = 12$ )	19.33 (5.07)	19.75 (4.25)	10.33 (5.31)	11.33 (4.50)
Diet	Low SE ( $n = 8$ )	13.75 (3.85)	12.25 (4.43)	8.63 (4.41)	10.88 (4.29)
	High SE ( $n = 4$ )	19.25 (3.77)	15.00 (2.00)	12.50 (6.76)	15.50 (5.69)
	Men ( $n = 5$ )	15.20 (4.09)	13.40 (2.97)	10.80 (7.79)	14.80 (4.92)
	Women ( $n = 7$ )	15.86 (5.15)	13.00 (4.73)	9.29 (3.25)	10.71 (4.79)
	Total for theme ( $n = 12$ )	15.58 (4.54)	13.17 (3.93)	9.92 (5.33)	12.42 (5.07)
Exercise	Low SE ( $n = 4$ )	17.50 (10.50)	17.50 (8.54)	7.25 (3.10)	6.75 (4.99)
	High SE ( $n = 1$ )	24.00	24.00	6.00	8.00
	Men ( $n = 2$ )	24.00	24.00	7.50 (2.12)	11.00 (4.24)
	Women ( $n = 3$ )	15.33 (11.72)	15.33 (9.02)	6.67 (3.51)	4.33 (1.53)
	Total for theme ( $n = 5$ )	18.80 (9.55)	18.80 (7.95)	7.00 (2.74)	7.00 (4.36)
Across all	Low SE ( $n = 15$ )	52.20 (13.19)	49.73 (14.18)	29.47 (9.49)	30.60 (8.92)
	High SE ( $n = 14$ )	52.07 (10.66)	49.93 (10.83)	27.64 (8.55)	32.07 (7.50)
	Men ( $n = 11$ )	52.63 (11.07)	51.45 (9.93)	31.90 (9.52)	37.36 (5.00)
	Women ( $n = 18$ )	51.83 (12.56)	48.83 (13.95)	26.56 (8.16)	27.61 (7.52)
	Total ( $n = 29$ )	52.14 (11.82)	49.83 (12.45)	28.59 (8.94)	31.31 (8.15)

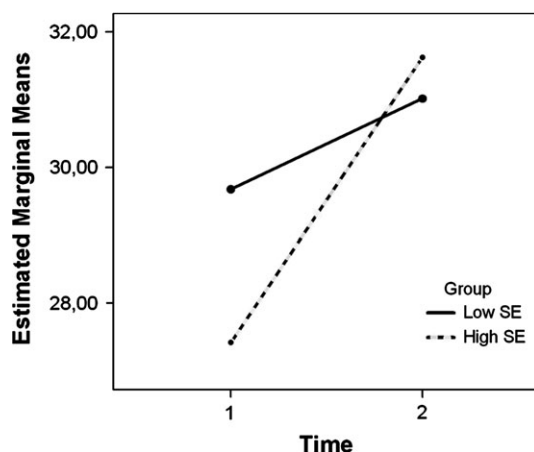


Fig. 2. Change in self-care (SDSCA total) from baseline to 1 month after intervention per group.

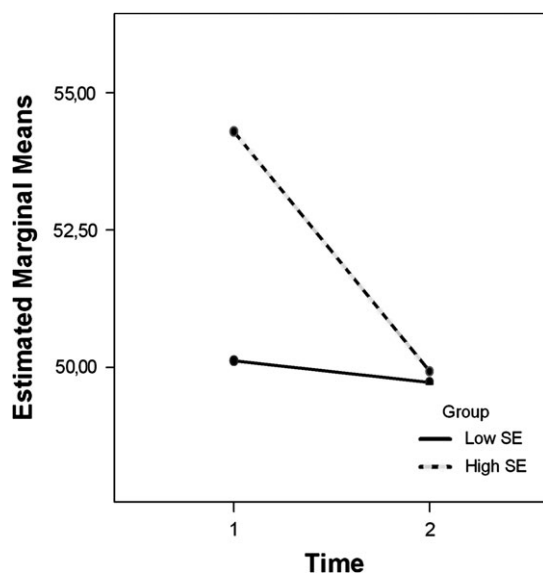


Fig. 3. Change in SE (PC total) per group.

positive attitude. There was no difference in perceived usefulness between the two groups,  $F_{(1,27)} = 0.29$ ,  $P = .60$ , but women ( $M = 3.9$ ) perceived the site as more useful than men ( $M = 3.0$ ),  $F_{(1,27)} = 3.6$ ,  $P = .067$ . The reference compendium was rated as the most useful intervention compo-

nent by 13 of 28 users, while all components besides the quizzes were nominated as least useful by equal proportions of users. Four of 28 (14%) users would recommend the site to a friend.

Use of the site was greatest during the first days, and declined rapidly thereafter. The mean time spent on the site was 45.2 min ( $CI_{95\%} = 37.1-53.3$ ), and the mean number of visits was 5.9 ( $CI_{95\%} = 3.9-8.0$ ). The checkbox for the targeted daily self-care behaviour was accessed most often, while only 4 of 28 users had downloaded any videos. There was no significant correlation between total time spent at the site and improvement in self-care,  $r = .10$ ,  $P = .60$ , nor between time spent at the site and perceived usefulness,  $r = -.04$ ,  $P = .83$ .

## Discussion

Changes in diabetes self-care from pre- to post-intervention were observed. The HSE group improved slightly more than the LSE group. Furthermore, baseline SE level was found to interact significantly with changes in self-care, with those having the lowest SE showing the greatest improvements. Although the direction of the relationship between baseline SE and improvements in self-care is ambiguous, the findings support the hypothesis that SE is a moderator of the effect of educational interventions on diabetes self-care behaviours.

While more self-efficacious people tend to have a higher level of self-care, it could be that the room for improvement is less, i.e. a ceiling effect. Peyrot and Rubin [33] found that those who initially had the worst self-care improved the most over an educational intervention.

SE did not improve in either study group. Rather, there was a tendency for SE to decrease from baseline to 1 month after assessment. SE, therefore, does not seem to be a working mechanism in this self-care intervention even though the intervention had the secondary aim to increase SE.

Hence, it was found that the intervention improved self-care behaviours while at the same time slightly decreasing SE. Together, the findings from this study support the inference that SE has

a moderating rather than mediating effect on improvements in diabetes self-care [30, 35]. This is consistent with previous studies pointing out the great predictive potential of SE for behaviour in general, and self-care especially [38]. The study is, however, not consistent with claims that SE is the main mediator between educational interventions and behavioural outcome, as this intervention was aimed at increasing SE for the low-SE group, failed at that but still led to improvements in behaviour for the high-SE group.

A limitation of this study is that the improvement cannot be attributed strongly to the intervention because of lack of a no-intervention control group. The improved self-care might be a result of repeated measurement in itself or the attention effect of intervention of any kind.

The observation that SE decreased slightly over the study period could have been partly a consequence of participants' increasing awareness of their actual performance level, causing them to adjust their estimate of SE to a level more in tune with actual behaviour. However, this speculation cannot be confirmed with the present data. If change in SE level is seen as a manipulation check, it would seem that the intervention design was faulty, or possibly that the exposure to the intervention was too low. The latter explanation is supported by the observation that the peer modelling element of the intervention, which is thought to be an important element in improving SE, was not used at all by most participants.

Alternatively, if behaviour causes increases in SE rather than vice versa, it would be reasonable to expect SE changes to appear later than 1 month after intervention. But no long-term follow-up was conducted that could have detected this. Such follow-up was considered, but rejected since the drop out rate during the intervention was substantial. This also means that there is no information available on whether the changes in self-care were sustained over time or whether they improved glycaemic control.

While the self-reported usefulness of the intervention was moderate, few of the remaining users reported that they would recommend the site to

a friend. Internet-based interventions allow direct assessment of actual use. In this study, most users spent little time on the site. Although no significant correlation between use and effect was found in this study, it seems reasonable that interventions such as this rely heavily upon a certain level of use to have any influence on cognition or behaviour. Increasing the attractiveness and perceived usefulness of sites intended for diabetes self-care improvement is therefore an important future aim.

Possible improvements of this intervention could be allowing the users to set their own specific behavioural goals and monitor progress towards these, including the forming of implementation intentions, i.e. specifying when, how and where to perform chosen behaviours [39]. Furthermore, Internet-based interventions should exploit the possibilities for providing social support, for example via a chat room [40]. For some users, social support may have an additional rewarding function that increases use of the total intervention.

Men tended to have both higher baseline SE levels and higher self-care scores and showed a larger intervention effect than did women. Gender, therefore, may be a moderator of the effectiveness of diabetes self-care interventions. This does not seem unreasonable, in that women have greater difficulty controlling their blood glucose levels than do men [41, 42]. Consequently, women could perceive less correspondence between self-care behaviours and blood glucose control outcome, possibly starting a downwards spiral of lower SE and lower levels of self-care behaviours.

The greatest limitation of the study with regard to its internal validity is the low sample size. Low statistical power due to unexpectedly high drop out limits greatly the level of confidence in all inferences that might be drawn from this study's results. Thus, the power problem also limits the generalizability of the study.

Still, this study provides some indications that SE and gender predict for whom the interventions led to improvements. Thus, gender differences and the initial level of SE should be taken into account when developing future interventions aimed at increasing diabetes self-care. This study found



support for the general hypothesis that SE can function as a moderator of the relation between educational interventions and self-care, although not in the expected direction since tailoring according to area of the highest, not the lowest, SE was found to be effective.

The main implication of this study for diabetes educators and behavioural counsellors more generally is that initial level of SE provides relevant information for tailoring behavioural intervention for diabetes self-care to the individual. Perhaps more specifically, that one should not necessarily address the biggest challenge first. Targeting the behaviour for which the individual has the highest initial SE may not only lead to further improvement of that behaviour, but also have carry-over effects on other behaviours.

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