Contents available at ScienceDirect
Diabetes Research and Clinical Practice
journal homepage: www.elsevier.com/locate/diabres
International Diabetes Federation

Is the success of the SLIMMER diabetes prevention intervention modified by socioeconomic status? A randomised controlled trial

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ARTICLE INFO

Article history:
Received 5 December 2016
Received in revised form
11 April 2017
Accepted 4 May 2017
Available online 10 May 2017

Keywords:
Socioeconomic status
Type 2 diabetes mellitus
Prevention
Combined lifestyle intervention
Real-world setting

ABSTRACT

Aim: To explore the role of socioeconomic status (SES) in participation, programme attendance, programme acceptability, adherence to lifestyle guidelines, drop-out, and effectiveness in the SLIMMER diabetes prevention intervention.

Methods: SLIMMER was a randomised controlled intervention, carried out in a real-world setting, targeting 40- to 70-year-old adults at increased risk of developing type 2 diabetes ($n = 316$). The intervention group participated in a 10-month combined dietary and physical activity programme. Measurements were carried out at baseline, 12 months, and 18 months. Effectiveness was determined for fasting insulin, HbA1c, weight, BMI, waist circumference, and waist-to-height-ratio. Differences between the low SES (no, primary, or lower secondary school) and higher SES group were tested using logistic regression and ANCOVA.

Results: Fifty-two percent of the SLIMMER participants had a low SES. No differences in participation were observed between the low and higher SES group. The most important reason for non-participation in the low SES group was 'lack of interest' (32%), whereas in the higher SES group this was 'I already exercise enough' (31%). Attendance, acceptability, adherence, drop-out, and effectiveness after 12 months were similar in the low and higher SES group. After 18 months, the low SES group seemed to maintain slightly better effects for fasting insulin, HbA1c, and waist circumference.

Conclusions: The current study showed that participation, attendance, acceptability, adherence, drop-out, and effectiveness of the SLIMMER intervention were in general not modified by socioeconomic status. The SLIMMER intervention can contribute to health promotion for individuals in both low and higher socioeconomic groups.

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http://dx.doi.org/10.1016/j.diabres.2017.05.002
0168-8227/

1. Introduction

Type 2 diabetes mellitus is a major public health problem because of its associated co-morbidities [1] and premature mortality [2]. The prevalence of type 2 diabetes is especially high among individuals with low socioeconomic status (SES) [3]. Lifestyle interventions involving healthy diet and exercise promotion can be an effective way to prevent type 2 diabetes [4,5].

However, it is often argued that individuals with low SES are hard to reach for lifestyle interventions [6,7]. Moreover, if they do participate, they seem less likely to complete the intervention [8,9]. In contrast, low SES participants seem at least as successful as higher SES participants in attending intervention sessions and adhering to intervention goals [10–12]. Also, several studies have shown that the effectiveness of these lifestyle interventions may not depend on the socioeconomic position of the participants [13,14]. Apparently, SES can modify the success of an intervention, especially by selective participation and selective drop-out.

The aim of the current study is to explore the role of SES in willingness to participate, programme attendance, programme acceptability, adherence to lifestyle guidelines, drop-out, and effectiveness in the SLIMMER diabetes prevention intervention. SLIMMER investigated the effect of a 10-month combined dietary and physical activity intervention, according to general public health recommendations, in persons at increased risk of developing type 2 diabetes. SLIMMER was based on the evidence-based SLIM intervention (Study on Lifestyle intervention and Impaired glucose tolerance Maastricht) [9,15], which was translated to the Dutch public health and primary healthcare setting [16], pilot-tested [17], and thereafter implemented and evaluated on a large scale [18]. The SLIMMER study showed beneficial effects on anthropometry and glucose metabolism [19]. Studying the role of SES in different phases of the SLIMMER study – initial participation in the intervention study, active participation during the intervention programme, and completion of the intervention study – is valuable because it gives insight into critical phases and potential opportunities for improvement in order to successfully target low SES individuals with a lifestyle intervention.

2. Materials and methods

2.1. Study design

SLIMMER was a randomised controlled intervention study, carried out in two middle-sized cities located in the eastern part of the Netherlands between 2011 and 2014. The intervention study was implemented in the public health and primary healthcare setting, involving local general practitioners (GPs) and practice nurses, dieticians, physiotherapists, and sports clubs. After baseline measurements, participants were randomly allocated to the intervention or the control group, using block randomisation on the GP level and stratification for gender. Participants were aware that they would be randomly allocated to an intervention or control group. The intervention group participated in an intensive lifestyle programme, and the control group received written information about a healthy lifestyle and usual healthcare as provided by their GPs and practice nurses. Participants joined the intervention study in three consecutive phases for logistical reasons. Participants were measured at baseline, at 12 months, and at 18 months (six months after the active intervention period ended). The study is registered with ClinicalTrials.gov (Identifier NCT02094911) and was approved by the Medical Ethics Committee of Wageningen University. All participants gave written informed consent before the start of the study. The design of the intervention study is described in detail elsewhere [18].

2.2. Study population

Participants were recruited via GPs and practice nurses from patient registration databases, using either a laboratory glucose test or the Dutch Diabetes Risk Test [20]. Persons were eligible to participate if they fulfilled the following criteria: (1) aged between 40 and 70 years at screening; (2) impaired fasting glucose (IFG; 6.1–6.9 mmol/l [14]) or an elevated/high risk of type 2 diabetes (a Diabetes Risk Test score of $\geq$7 points [15]); (3) willing and able to participate in the study for at least 1.5 years, and (4) able to speak and understand the Dutch language. Individuals with known diabetes or any severe cardiovascular or psychiatric disease were excluded. Eligible persons were invited for the SLIMMER study by their GP. In total, 590 persons met the study criteria, of whom 316 (54%) were willing to participate in the SLIMMER study. One participant was excluded from the current analyses because of missing data for SES.

2.3. Intervention programme

The intensive intervention programme lasted 10 months and consisted of a dietary and a physical activity (PA) component. Participants were supported to achieve a healthy diet according to the Dutch dietary guidelines [21] and an active lifestyle including moderate-intensity PA for at least 30 min a day at least five days a week. It was aimed to help participants to achieve 5–10% weight loss. A dietician provided participants with dietary advice during 5–8 individual consultations and one group session. Participants were encouraged to participate in weekly physical activity training sessions, which were provided in groups of SLIMMER participants and guided by a physiotherapist. The training sessions contained both aerobic and resistance training and were in line with the Dutch guidelines for physical activity and type 2 diabetes [22]. To guide participants in the process of maintaining lifestyle behaviour change, a maintenance programme was offered in the last phase of the intervention, consisting of sports clinics at local sports clubs, final interviews with dietician and physiotherapist, and a return visit three months after the active intervention ended [23]. Case management was provided by the practice nurse, who was the contact person for both participants and healthcare professionals.

2.4. Data collection and outcomes

Identical examinations were performed at baseline, at 12 months, and at 18 months. Participants filled in questionnaires, blood samples were taken by trained nurses, and anthropometric measurements were performed by trained research assistants according to standardised procedures. The measurement procedures are described in detail elsewhere [18]. Methods specifically for the current analyses are described below.

Socioeconomic status – Socioeconomic status was determined by highest completed educational level, ascertained by means of a questionnaire. Educational level was divided into two categories: low (no, primary, or lower secondary school) and middle/high (higher secondary education, pre-university education, intermediate vocational school, higher professional education, or university level).

Willingness to participate – In total, 316 of the 590 eligible and invited persons were willing to participate in the SLIMMER study. A short telephonic non-response survey was conducted by practice nurses if patients were not willing to participate, including questions regarding the main reason for non-participation and highest completed educational level. The reason for non-participation was known for 207 individuals (76%) and educational level for 96 individuals (35%) of the 274 non-responders. Missing data for non-responders could mostly be attributed to practice nurses' lack of time or to the fact that participants could not be reached.

Programme attendance – Attendance was defined as the total duration of the attended dietary consultations and presence at sports lessons, dietary group meeting, sports clinics, and return visit, as recorded by healthcare professionals during the intervention.

Programme acceptability – Participants' acceptability of the total SLIMMER intervention programme was assessed on a scale from 1–10 by means of a questionnaire.

Adherence to lifestyle guidelines – Adherence to a healthy diet was assessed by the Dutch Healthy Diet index (DHD-index) [24,25]. The original DHD-index consists of 10 components, of which two were not measured in the SLIMMER study (sodium intake and acidic drinks and foods). For the remaining eight components (physical activity, vegetables, fruit, fibre, fish, saturated fatty acids, transfatty acids, and alcohol), participants could score between 0 and 10 points, resulting in a total maximum score of 80 points (meaning complete adherence). Dietary intake was assessed by a validated Food Frequency Questionnaire (FFQ) [26,27] and calculated with the 2011 Dutch food composition table [28]. Adherence to the physical activity guidelines was assessed by determining which participants were moderately physical active for at least 30 min at least five times a week. Physical activity was measured using the validated Short QUestionnaire to ASsess Health-enhancing physical activity (SQUASH) [29,30].

Drop-out – It was preferred to choose an indicator for drop-out that was applicable to both the intervention and the control group. Therefore, drop-out was defined as not attending measurements of the intervention study. As fasting insulin and body mass index (BMI) were the two most important study outcomes, participants were considered drop-outs at 12 months or at 18 months if data on fasting insulin or BMI were missing at the respective time point [19].

Effectiveness – Effectiveness was assessed by changes in blood markers and anthropometric measures, including fasting insulin, HbA1c, weight, BMI, waist circumference, and waist-to-height ratio. Blood samples were taken after at least 10 h of fasting. For fasting serum insulin, all blood samples were analysed within one run after 18 months. BMI was calculated as the ratio of weight and height squared (kg/m^2). Waist circumference was measured midway between the lowest rib and the iliac crest. Waist-to-height-ratio was calculated as the ratio of waist circumference and height.

Other socio-demographics – Data on age, gender, ethnicity, job status, marital status, smoking, and medication use were collected by participant questionnaires, using standardised questions according to national health surveillance in the Netherlands [31] and earlier research [32].

2.5. Statistical analyses

Data were analysed with IBM SPSS Statistics version 22. Non-normally distributed variables were natural log transformed (BMI, fasting insulin). Significance level was set to 0.05. For interaction terms specifically, a p-value of 0.20 was considered relevant [33]. Continuous variables are presented as mean ± SD and categorical variables as percentages.

Socio-demographic baseline characteristics were compared between participants with low and higher SES with Chi-Square tests and independent samples t-tests. Because of differences in age and gender distribution between the SES groups, baseline characteristics for anthropometric measures, blood markers, and lifestyle guidelines were compared with either ANCOVA or logistic regression, adjusted for age and gender.

Willingness to participate was compared between individuals with low and higher SES using logistic regression, adjusted for age and gender. Attendance, acceptability, adherence, and drop-out were compared between SES groups with either logistic regression or ANCOVA, adjusted for age, gender, and recruitment phase. Attendance, acceptability, and adherence were determined for the treatment group only. Effectiveness of the intervention programme was compared between SES groups using an ANCOVA model, adjusted for baseline value, age, gender, and recruitment phase, and for medication use if applicable. An interaction term was included in the ANCOVA model to test whether the association between treatment and outcome measures differed between SES groups. For analyses regarding effectiveness after 12 and 18 months, only data of participants who did not drop out earlier were used (12 months: $n = 275$; 18 months: $n = 240$). Analyses were performed according to the intention-to-treat principle, i.e. participants were analysed in the groups to which they were randomised. Stratified analyses were conducted for gender.

3. Results

3.1. Willingness to participate

No differences in willingness to participate were observed between the low and higher SES group (Table 1). However, reasons for non-participation differed between the groups. The most important reason for non-participation in the low SES group was 'lack of interest' (32%), whereas in the higher SES group this was 'I already exercise enough' (31%). Other frequently mentioned reasons for non-participation in both groups were 'lack of time' and 'it is of no importance to me' (Table 1).

The baseline characteristics of persons who participated in the SLIMMER study, by SES, are described in Table 2. SES did not differ between the intervention and the control group (54% vs. 51% with low SES, respectively). Compared to participants with higher SES, participants with low SES were more often female (60% vs. 37%), slightly older (62 ± 6 years vs. 60 ± 6 years), had less often a fulltime job (15% vs. 40%) and more often no paid job (30% vs. 11%), and had higher HbA1c levels at baseline (41 ± 4 mmol/mol vs. 39 ± 4 mmol/mol). These differences between low and higher SES participants were similar in the intervention and the control group (Supplemental file 1).

3.2. Programme attendance

There were no differences in attendance between participants with low and with higher SES (Table 3). During the intervention programme, the low and higher SES group attended a similar number of physical activity lessons (38 ± 22 vs. 37 ± 20) and individual consultations with the dietician (204 ± 53 vs. 208 ± 36 min). Neither was attendance at the group meeting with the dietician significantly different between the low and the higher SES group (66% vs. 68%). During the maintenance programme, there were no differences in number of sports clinics attended (2.1 ± 1.8 vs. 2.5 ± 2.0) and attendance at the return visit (55% vs. 61%). The return visit was, however, significantly less often attended by males with a low SES than males with a higher SES (35% vs. 62%; $p = 0.01$) (Supplemental file 2).

3.3. Programme acceptability

The total SLIMMER intervention programme was not differently scored by low and higher SES participants (8.2 ± 1.1 vs. 8.0 ± 1.1) (Table 3).

3.4. Adherence to lifestyle guidelines

After 12 months, when adjusted for age, gender and recruitment phase, intervention participants with a higher SES complied better with the Dutch guidelines for a healthy diet than intervention participants with low SES (DHD-index scores: 61.1 ± 9.7 vs. 63.4 ± 7.7; $p = 0.04$). When the analysis was additionally adjusted for baseline values of the DHD-index scores, this difference was no longer statistically significant ($p = 0.15$). Adherence to the guidelines for a healthy diet at 18 months and adherence to the physical activity guideline at both 12 and 18 months were not significantly different between the low and higher SES groups (Table 3).

3.5. Drop-out

Drop-out did not differ significantly between the SES groups at 12 and at 18 months (Table 4). However, when the data were stratified for treatment group, drop-out was relatively high among low SES participants compared with higher SES participants at 18 months in the intervention group specifically (28% versus 17%; $p = 0.11$).

3.6. Effectiveness

Effectiveness of the intervention after 12 months was not modified by SES for fasting insulin, weight, BMI, waist circumference, and waist-to-height ratio (Table 5). Only for HbA1c was the intervention effect among participants with low SES slightly better compared to the higher SES group directly after the intervention ($p = 0.07$). After 18 months, the

Table 1 – Participation and reasons for non-participation by socioeconomic status.[a]

	Low SES	Middle/high SES	p[b]
Participation			0.98
Non-responder[c]	50 (52)	46 (48)	
Responder	165 (52)	150 (48)	
Main reason for non-participation			0.003
Lack of time	13 (26)	8 (18)	
Lack of interest	16 (32)	6 (13)	
'I already exercise enough'	2 (4)	14 (31)	
'It is of no importance to me'	8 (16)	7 (16)	
Not being able due to illness or handicap	5 (10)	1 (2)	
Other reasons	6 (12)	9 (20)	

[a] Values are expressed as n (%).
[b] p-value is adjusted for age and gender.
[c] Total number of non-responders was 274. Education data were available for only 96 non-responders. Reason for non-participation was known for 95 of these non-responders.

Table 2 – Baseline characteristics of SLIMMER participants ($n = 315$) by socioeconomic status.[a]

	Low SES ($n = 165$)	Middle/high SES ($n = 150$)	p
Treatment group			0.68
Intervention group	83 (50)	72 (48)	
Control group	82 (50)	78 (52)	
Socio-demographics			
Gender			<0.001
Male	66 (40)	95 (63)	
Female	99 (60)	55 (37)	
Age (years)	62.0 ± 6.3	59.6 ± 6.4	0.001
Ethnicity			0.37
Dutch	143 (87)	137 (91)	
Western non-Dutch	17 (10)	9 (6)	
Non-western non-Dutch	5 (3)	4 (3)	
Employment status			<0.001
Retired	58 (35)	43 (29)	
No paid job	50 (30)	16 (11)	
Part-time job (<32 h/week)	32 (19)	31 (21)	
Fulltime job (≥32 h/week)	25 (15)	60 (40)	
Educational level			
No education	7 (4)	–	
Lowest education (primary)	24 (15)	–	
Low education (lower secondary)	134 (81)	–	
Middle education	–	75 (50)	
High education	–	75 (50)	
Smoking status			0.99
Current	31 (19)	29 (19)	
Former	96 (58)	87 (58)	
Never	38 (23)	34 (23)	
Anthropometric measurements[b,c]			
Weight (kg)	87.4 ± 17.2	90.7 ± 15.9	0.74
BMI (kg/m^2)	30.5 ± 5.0	29.9 ± 4.4	0.29[d]
Waist circumference (cm), total	104.7 ± 13.4	104.9 ± 12.2	0.28
Male	109.8 ± 12.3	107.7 ± 10.9	
Female	101.5 ± 13.0	99.9 ± 12.8	
Waist-to-height ratio	0.620 ± 0.072	0.603 ± 0.067	0.10
Blood markers[c]			
Fasting insulin (pmol/l)	87.3 ± 46.5	88.5 ± 68.2	0.52[d]
HbA1c (mmol/mol)	41 ± 4	39 ± 4	0.007
Lifestyle guidelines[c]			
Adherence healthy diet (score 0–80)[b]	58.3 ± 9.4	59.5 ± 9.5	0.15
Adherence physical activity (n (%))	139 (84)	115 (77)	0.53

[a] Values are expressed as n (%) or mean ± SD.
[b] Data are missing for 1 participant with low SES.
[c] p-value is adjusted for age and gender.
[d] Log-transformed data were used.

improvements in HbA1c were still larger in the low SES group ($p = 0.03$). In addition, at that time, effectiveness on fasting insulin ($p = 0.14$) and waist circumference ($p = 0.16$) seemed somewhat better among the low SES group than among the higher SES group.

Analyses stratified for gender showed that the effectiveness of the intervention was similar for low and higher SES female participants. However, among male participants, some differences in effectiveness were observed (Supplemental file 2). An interaction between SES and treatment for changes in HbA1c was observed at 12 months ($p = 0.02$) and at 18 months ($p = 0.12$), where the low SES men achieved relatively greater improvements in HbA1c than the higher SES men. In addition, at 18 months, somewhat better improvements were achieved for weight ($p = 0.18$) and BMI ($p = 0.16$).

4. Discussion

The current study assessed the impact of socioeconomic status on willingness to participate, programme attendance, programme acceptability, adherence to lifestyle guidelines, drop-out, and effectiveness in the SLIMMER diabetes

Table 3 – Programme attendance, programme acceptability, and guideline adherence by socioeconomic status.[a]

	n	Low SES	*n*	Middle/high SES	p^b	p^c
Attendance	83		72			
Number of physical activity lessons		38 ± 22		37 ± 20	0.99	
Individual consultations dietician (min)		204 ± 53		208 ± 36	0.21	
Group meeting dietician (*n* (%))		55 (66)		49 (68)	0.53	
Return visit (*n* (%))		46 (55)		44 (61)	0.11	
Number of sports clinics		2.1 ± 1.8		2.5 ± 2.0	0.17	
Acceptability (score 1–10)	74	8.2 ± 1.1	67	8.0 ± 1.1	0.23	
Adherence healthy diet (score 0–80)						
At 12 months	75	61.1 ± 9.7	67	63.4 ± 7.7	0.04	0.15
At 18 months	66	61.5 ± 8.7	65	62.7 ± 8.2	0.30	0.71
Adherence physical activity (*n* (%))						
At 12 months	76	64 (84)	68	56 (82)	0.39	0.34
At 18 months	67	61 (91)	65	53 (82)	0.77	0.61

[a] Determined for participants of the intervention group only. Values are expressed as *n* (%) or mean ± SD.
[b] *p*-value is adjusted for age, gender, and recruitment phase.
[c] *p*-value is adjusted for age, gender, recruitment phase, and baseline adherence.

Table 4 – Drop-out by socioeconomic status.[a]

	n	Low SES	*n*	Middle/high SES	p^b
Drop-outs at 12 months, total	165	18 (11)	150	22 (15)	0.36
Intervention group		9 (11)		7 (10)	0.92
Control group		9 (11)		15 (19)	0.25
Drop-outs at 18 months, total	165	37 (22)	150	31 (21)	0.38
Intervention group		23 (28)		12 (17)	0.11
Control group		14 (17)		19 (24)	0.57

[a] Values are expressed as *n* (%).
[b] *p*-value is adjusted for age, gender, and recruitment phase.

Table 5 – Effectiveness at 12/18 months by socioeconomic status: changes in blood markers and anthropometric measures.[a]

	Low SES		Middle/high SES		p^b
At 12 months	INT (*n* = 74)	CON (*n* = 73)	INT (*n* = 65)	CON (*n* = 63)	
Fasting insulin (pmol/l)[c,d]	−9.52	0.82	−9.96	−0.52	0.78
HbA1c (mmol/mol)[c]	−1.85 ± 2.09	−0.58 ± 2.87	−1.46 ± 2.50	−0.92 ± 1.96	0.07
Weight (kg)	−3.07 ± 5.55	−0.62 ± 3.25	−2.99 ± 4.31	0.15 ± 3.88	0.87
BMI (kg/m^2)[d]	−1.06	−0.20	−0.94	0.04	0.99
Waist circumference (cm)	−5.89 ± 6.17	−1.88 ± 4.24	−4.68 ± 4.53	−0.86 ± 4.79	0.76
Waist-to-height-ratio	−0.034 ± 0.037	−0.011 ± 0.025	−0.026 ± 0.026	−0.004 ± 0.028	0.81
At 18 months	INT (*n* = 60)	CON (*n* = 66)	INT (*n* = 58)	CON (*n* = 56)	
Fasting insulin (pmol/l)[c,d]	−18.54	−6.70	−15.73	−10.56	0.14
HbA1c (mmol/mol)[c]	−2.03 ± 2.38	0.06 ± 6.39	−1.67 ± 2.25	−1.43 ± 2.11	0.03[e]
Weight (kg)	−3.30 ± 5.78	−0.56 ± 3.26	−2.46 ± 4.31	−0.09 ± 4.07	0.37
BMI (kg/m^2)[d]	−1.16	−0.21	−0.78	−0.03	0.28
Waist circumference (cm)	−5.15 ± 6.77	−1.30 ± 4.48	−3.61 ± 5.35	−1.21 ± 6.30	0.16
Waist-to-height-ratio	−0.029 ± 0.040	−0.006 ± 0.027	−0.019 ± 0.031	−0.005 ± 0.037	0.20

[a] Values are expressed mean ± SD.
[b] *p*-value for interaction between treatment group and SES in ANCOVA test, adjusted for respective baseline variable, age, gender, and recruitment phase.
[c] Adjusted for diabetes medication at 12 months or at 18 months.
[d] Log-transformed data were used. Data were back-transformed; hence SD cannot be presented.
[e] There was one extreme outlier in the low SES control group. Excluding this participant from the analysis resulted in a *p*-value for interaction of 0.08.

prevention intervention. Persons with low SES were as likely as persons with higher SES to participate in the SLIMMER study, to attend the intervention programme, and to complete the SLIMMER study. Adherence to the lifestyle guidelines and effectiveness of the intervention after 12 months were also mostly independent of SES. At 18 months, after 6 months of follow-up, the low SES participants seemed to maintain some effects better than the higher SES participants.

It has been hypothesised that individuals with low SES are less likely to participate in lifestyle programmes than individuals with higher SES [6,7]. In the SLIMMER study, there was no difference in SES between responders and non-responders. Also, the percentage of participants with low SES in the SLIMMER study was relatively high (52%) compared with the general Dutch population between 45 and 75 years old in 2012 (38%) [34], Apparently, the SLIMMER study was successful in reaching individuals with low SES. However, among non-responders, differences were observed in reasons for non-participation between the SES groups. Whereas the higher SES non-responders were more likely to report that they already exercised enough, the low SES non-responders were more likely to express a lack of interest in participating. It could be speculated that a different approach is necessary to motivate low and higher SES groups to participate in lifestyle programmes. Unfortunately, it is not known what motivated the current SLIMMER participants.

Once they were participating in the SLIMMER study, low SES participants attended the programme as well as the higher SES participants and showed similar adherence to the lifestyle guidelines; this is in line with earlier findings [10–12]. Furthermore, SLIMMER was also successful in retaining low SES as well as higher SES participants until the end of the intervention study, as drop-out rates were not different between SES groups. This is surprising, as comparable studies observed that individuals with low SES were less likely to complete an intervention study [8,9] and its follow-up measurements [35]. One of these studies is SLIM [9,15], which formed the basis of the SLIMMER study. In the SLIMMER study, the SLIM intervention was translated from an experimental setting to a primary care setting [16]. The finding that SES groups did not differ in drop-out in the SLIMMER study whereas they did differ in SLIM may suggest that the intervention is more successful in retaining low SES participants in a real-world setting than in an experimental setting. However, it should be noted that the SLIM programme had an average duration of 4.2 years with measurements up to 10 years after baseline [35], whereas the SLIMMER programme had a duration of 10 months with measurements up to 18 months after baseline. It could be that a longer period of follow-up is needed to observe differences between socioeconomic groups. It would be interesting to study the impact of SES in the SLIMMER study after a longer period of follow-up.

Our findings that effectiveness after 12 months – directly after the end of the intervention programme – was in general not modified by SES is in line with results from the Finnish Diabetes Prevention Study, where, after one year, effectiveness regarding several clinical markers and diabetes incidence was mostly independent of educational attainment [14]. Remarkably, after 18 months – after a period of follow-up – effectiveness for some outcomes in the SLIMMER study seemed better among the low SES group than among the higher SES group. However, it should be realised that drop-out at 18 months was relatively high compared with drop-out at 12 months in the low SES intervention group. It could be that a selective group, possibly consisting of the more successful participants, was willing to participate in the follow-up measurements, resulting in biased results.

Although the success of the SLIMMER study was in general not modified by SES, the current study could not exclude the possibility that some socioeconomic differences may be present in men or women only. Analyses stratified for gender showed some differences for programme attendance and effectiveness among men in particular. To our knowledge, little is known about the impact of gender on socioeconomic differences in lifestyle interventions. This impact should be further explored in future studies.

A strength of this study is that the intervention was carried out in a real-world setting and involved professionals from local healthcare. The study therefore shows the actual effect of the intervention in the Dutch healthcare setting, rather than its potential in a more controlled setting. Another strength is that this study investigated differences between low and higher SES groups in multiple stages of the intervention: from initial participation in the intervention study, through active participation during the intervention programme, to completing the intervention study.

A limitation of this study is that it lacked some data to conduct these analyses optimally. For analyses regarding participation, educational level was missing for a large number of non-responders; therefore, the analysis could be subject to selection bias. Furthermore, reasons for participation and drop-out were not known. Additionally, the sample size may not have been sufficient for the stratified analyses for gender or treatment group. With a larger sample size, differences within the low SES group could have been studied, for example comparing the low vs. the least educated or comparing ethnic groups. Another limitation is that SES was determined by educational level only. It would be interesting to study other indicators of socioeconomic status, like employment, income, or neighbourhood socioeconomic characteristics, as different SES indicators are not interchangeable and can influence health outcomes differently, through different causal pathways [36,37]. In the current study, it was not possible to study these SES indicators because of the high number of retired participants, the small differences in neighbourhood deprivation in the two middle-sized cities where the study was carried out [38], and the fact that participants' income was unknown.

In conclusion, this study showed that participation, programme attendance, programme acceptability, adherence to lifestyle guidelines, drop-out, and effectiveness of the SLIMMER diabetes prevention intervention were in general not modified by socioeconomic status. In Dutch primary healthcare, the SLIMMER study was able to reach the low SES group as effectively as the higher SES group from the beginning to the end of the intervention study, resulting in at least similar health benefits. The SLIMMER intervention can therefore contribute to health promotion of individuals in both low and higher socioeconomic groups. Future studies should give insight into possible differences between low and higher

SES groups after a longer period of follow-up. In addition, attention should be paid to the influence of gender in relation to socioeconomic differences and differences between specific subgroups within the low SES group.

Conflict of interest

The authors declare that they have no conflict of interest.

Funding

This work was supported by the Netherlands Organization for Health Research and Development ZonMw (87600048, 20400.7003), the Dutch Diabetes Research Foundation (2011.15.1462) and LekkerLangLeven (cooperation between the Dutch Diabetes Research Foundation, the Dutch Kidney Foundation, and the Dutch Heart Foundation) (2009.20.021). These study sponsors had no role in the design; collection, analysis, and interpretation of data; writing the report; and the decision to submit the report for publication.

Authors' contributions

GD, AHN, SCJ, JtB, GJH, and EJMF contributed to the development of the SLIMMER study. GD collected the data. AJB conducted the analyses for the current study and drafted the manuscript. GD and EJMF helped to interpret the results and to revise the manuscript. AHN, SCJ, JtB, and GJH were involved in reviewing and improving the manuscript. All authors read and approved the final manuscript.

Acknowledgements

We thank all the participants and healthcare professionals who were involved in the SLIMMER study. We also thank the local steering committees of Apeldoorn and Doetinchem (Community health service, municipality, health insurer, regional supporting organisation for primary care (ROS), general practitioners, physiotherapists, and dieticians) for facilitating implementation of the study.

Appendix A. Supplementary materials

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.diabres.2017.05.002.

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