SUMMARY
Type 2 diabetes mellitus (T2DM) and cardiovascular diseases (CVD) are major health problems with an on-going rise in prevalence and incidence. Both diseases are related to each other and share common modifiable lifestyle risk factors such as overweight, smoking, low levels of physical activity and an unhealthy diet. Changing these risk factors can prevent or delay the onset of T2DM and CVD. Effective, cost-effective, safe and feasible interventions to improve lifestyle behaviours in at risk populations are needed in primary care. Whereas intensive lifestyle interventions in highly controlled settings have shown to lower the incidence of T2DM in individuals with impaired glucose metabolism, so far, randomised controlled trials evaluating the effectiveness of programmes targeting lifestyle behaviour in primary health care settings have not been able to reproduce these findings. A strict translation of efficacious interventions in controlled settings to ‘real life’ settings is not a realistic option, because both the available resources and training facilities in primary health care would be exceeded. We developed an innovative and feasible lifestyle intervention tailored to the available resources and infrastructure for national primary health care services in the Netherlands. In the Hoorn Prevention Study we implemented and evaluated this intervention. This thesis describes the background, process and various outcomes of the Hoorn Prevention Study.

Overweight, obesity, sedentary behaviour and prospective declines in physical activity

Earlier studies indicated that overweight, obesity and high levels of TV-viewing time could potentially be related to decreases in physical activity levels over time. Giving the importance of maintaining sufficient levels of physical activity to limit health risks, further understanding of the potentially modifiable factors preceding declines in physical activity is required. Chapter 2 describes the study in which we examined the associations of waist circumference and TV viewing time with prospective declines in physical activity levels, for men and women separately. For this study, data from the large Australian Diabetes, Obesity and Lifestyle Study (AusDiab) were used. The AusDiab is a nationally representative population-based cohort study with measures collected in 1999-2000 and 2004-2005. Our findings indicate that those with abdominal obesity at baseline had 50% higher odds of reducing their moderate-to-vigorous physical activity over five years (compared to those with a normal weight status). In addition, women, but not men, who
watched TV for more than 4 hours per day had a 50% higher risk of reducing their physical activity, independent of waist circumference. These results highlight the importance of prevention of (further) weight gain and promoting the adoption and maintenance of physical activity.

**Design**

The Hoorn Prevention Study, a randomised controlled trial, was designed to investigate the effectiveness of a lifestyle intervention aimed at changing lifestyle behaviours and reducing the estimated risk of developing T2DM or a fatal CVD in at-risk adults. The background and the methods of the Hoorn Prevention Study are presented in Chapter 3. The theory of planned behaviour (TPB) and the theory of self-regulation were used to guide the development of the lifestyle intervention because of their applicability and their superior reputation relative to other theories. The intervention consisted of a cognitive behaviour programme, which was based on an innovative combination of motivational interviewing and problem solving treatment. In a maximum of 6 individual counselling sessions followed by 3-monthly telephone sessions, trained practice nurses provided the intervention in several general practices. The main outcome measures were the estimated risk of developing T2DM and a fatal CVD, calculated according to the ARIC and the SCORE formulae, respectively. Secondary outcomes included lifestyle behaviour (diet, physical activity and smoking).

**Instrument development**

In order to justify the theoretical background of lifestyle intervention and to evaluate the impact of the intervention on determinants of behavioural change, we recognised the importance of measuring the TPB constructs that theoretically precede behavioural change (attitude, subjective norms, perceived behavioural control and intentions). However, validated questionnaires to assess those TPB constructs of physical activity, dietary behaviour and smoking in adults at risk of T2DM or CVD were not available. Therefore, we developed the Determinants of Lifestyle Behaviour Questionnaire (DLBQ). The development of this instrument and the analyses of its ability to assess the cognitive determinants of lifestyle behavioural change according to the TPB are described in Chapter 4. We proved that the DLBQ is a valid instrument for measuring these cognitive determinants and identified ‘key-determinants’ that seem to contribute to an increased intention to change.
Effectiveness

In Chapter 5 the effectiveness of the lifestyle intervention is described. Our primary outcome measures were the estimated nine-year risk of developing T2DM and the estimated ten-year risk of CVD mortality, assessed with the ARIC and SCORE formulae, respectively. Secondary outcomes included lifestyle behaviour (i.e. diet, physical activity and smoking). 536 (86%) of the 622 participants (age 43.5 years (SD 5.3)) completed the 6-month follow-up, and 502 (81%) completed the 12-month follow-up. The mean baseline estimated T2DM risk was 19% (SD 8.2) and the mean estimated CVD mortality risk was 4% (SD 3.0). We showed that after 6 and 12 months, the lifestyle intervention was not more effective than providing health brochures in improving the scores for T2DM and CVD risk or lifestyle behaviour. A median number of 2 counselling sessions were attended. In our per protocol analyses we showed that there were no noteworthy changes in the results if more sessions were attended.

Cost-effectiveness

An economic evaluation was conducted alongside the randomised controlled trial in order to assess the cost-effectiveness and cost-utility of the lifestyle intervention as provided in the Hoorn Prevention study. This was done because information about the trade-off between costs and benefits of lifestyle interventions can help policy makers to decide whether it is efficient to implement and reimburse them. The economic evaluation was done from a societal perspective, with a time horizon of two years, and is presented in Chapter 6. The results indicate that also after two years, no significant differences between the intervention and control group were found on clinical parameters, 9-year risk for developing T2DM and 10-year risk for CVD mortality; nor were there significant between-group differences in quality adjusted life years (QALYs) gained. Thus, the lifestyle program offered by practice nurses was no more effective in reducing these risks than general health brochures. However, the intervention resulted in small cost savings. A high probability of cost-utility was found at all ceiling ratios. Nevertheless, due to methodological uncertainty it is currently not advised to implement the intervention in Dutch general practices.
**Process evaluation**

Next to evaluating clinical results of an intervention programme with regard to its effectiveness, it can be as valuable to evaluate the programme’s translatability and feasibility as well as its limitations.

Thus, in Chapter 7 we aimed to explore a) why the lifestyle intervention was not more effective than providing health brochures only, and b) the effects of the intervention on intermediate determinants of behavioural change. For this purpose we carried out a systematic evaluation of the intervention’s reach, effectiveness on intermediate determinants, adoption, implementation and maintenance (RE-AIM).

The results indicate that the recruitment strategy was feasible and the number of included individuals provided us with adequate statistical power to detect potential relevant differences in outcomes between groups. The motivational interviewing and problem solving treatment skills of practice nurses who provided the intervention were moderate to good. 78% of participants were satisfied with the counselling sessions. Nevertheless, the amount of attended sessions was low, and almost no effects on determinants of behavioural change were seen.

**Beyond health outcomes**

Economic evaluation studies such as described in Chapter 7 generally focus on health outcomes, as these outcomes are considered most relevant to health care decision making. On the other hand, health promotion activities have broader outcomes that go beyond health. Hence, the concern has been raised that economic evaluation studies neglect relevant outcomes of health promotion. The various broader outcomes of health promotion, however, are not well defined. In Chapter 8 we describe a study in which we aimed to provide insights into the types and nature of the ‘beyond health outcomes’ in the Hoorn Prevention Study.

A combination of in-depth interviews and focus groups were conducted with 52 participants randomised to the intervention group. The identified beyond health outcomes included outcomes of behaviour change, such as increased body satisfaction or stress reduction; and outcomes experienced more directly from participation in the intervention, such as increased awareness and increased goal-setting skills. The interviews revealed that the broader social environment of participants may benefit from the intervention as well. The results of this study contribute to the evidence on beyond health outcomes of health promotion and highlight the need for further debate about the incorporation of these outcomes in economic evaluation studies.
General discussion
In Chapter 9, finally, some of the issues that have been raised in Chapter 2 to 8 are linked to each other, some new issues are discussed, and recommendations for clinical practice and future research are given. The absence of an intervention effect in the Hoorn Prevention Study should, in our eyes, not be sought in shortcomings of methodological nature, but might have a more contextual reason: the intervention was designed to focus on changing individual level determinants in order to change lifestyle behaviours without addressing the physical, social-cultural or socio-economic environment of participants. It is argued that the wide range of influences on individuals and behaviours should not only be addressed in single-level interventions that simply focus on the individual (or a distinct social and/or environmental aspect), but rather in multi-level intervention approaches that integrate individual, community, organisational, and/or societal systems. It remains to be determined whether such multilevel intervention approaches will be effective in improving lifestyle behaviours of at-risk adults.

Conclusions
This study is the first to report on the effects of a lifestyle intervention specifically aimed to reduce the risk of developing T2DM and CVD mortality in a ‘real life’ primary care setting. We showed that our recruitment strategy was adequate and resulted in a reasonably high reach of the target population and the practice nurses were competent and confident in providing the cognitive behavioural programme. Nevertheless, this innovative, theory based intervention did not sort the expected effects and was not cost-effective. Hence, it is currently not advised to implement the intervention in Dutch general practices.