Despite the well-known positive health effects of physical activity, **lack of physical activity** is still a major public health concern. Too little physical activity increases the risk of many adverse health conditions and it is one of the two major risk factors for non-communicable diseases, i.e. coronary heart disease, some types of cancer and type 2 diabetes. However, only 44 percent of the Dutch adult population meets the physical activity guidelines. Especially, young adults are at risk as levels of physical activity tend to decrease during transition from adolescence into adulthood.

Given the large percentage of (young) adults not meeting the guidelines for physical activity, effective interventions to promote physical activity are needed. Novel approaches such as interventions that are delivered through smartphone apps are easily and consciously accessible. The high adoption rate of smartphones (97 percent among adults aged 20-29 years in the Netherlands) and the popularity of health and fitness apps and activity trackers suggest that young adults may appreciate and adopt app-based PA interventions. Therefore, the aim of this dissertation was to describe the stepwise development and the evaluation of the Active2Gether intervention, an app-based intervention targeting physical activity behaviors in young adults.

**Chapter 2** describes two content analyses, one focusing on the extent to which existing physical activity promoting apps were grounded in established health behavior theory, and the other focusing on the technical features included in physical activity apps. The results showed that available physical activity apps mainly use goals-setting, self-monitoring, and feedback on performance techniques, similar to the theoretical concepts most frequently used in other types of physical activity promotion interventions. Although apps clearly have the possibility to include theory-based behavior change techniques (BCTs), they often fail to use the full potential of possible BCTs as well as the technological possibilities. Very few apps dynamically adapt the content and feedback and link with external monitors.

To gain more insights in the preferences of smartphone features of young adults, focus group discussions (**Chapter 3**) were conducted. The aims of this study were to explore the use and appreciation of and the preferences for various features of a physical activity app among young adults. Results showed that young adults preferred an app that provides personalized and tailored feedback and that includes a coaching function. Preferably, physical activity promotion apps should include ranking features, a coaching feature to motivate users during the exercise and to provide feedback afterwards, and the possibility to set goals and to exercise according to a schedule. In addition, young adults preferred a website that accompanies the app to provide overviews of their results and progress. There appeared to be little need for a sharing feature to post results through social media.

**Chapter 3** also describes the results of a cross-sectional survey that aimed to explore if the specific BCTs (i.e. goal setting and goal reviewing, feedback and self-monitoring, and social support and social
Summary

Comparison (comparison) should be tailored to personal characteristics of the users, such as personality traits, level of self-efficacy and/or sport identity. The participants rated BCTs based on their experiences, wishes and/or requirements in a smartphone physical activity app. Ratings of various self-regulation BCTs were relatively high, in contrast to the ratings for BCTs addressing social support. Some BCTs were associated with personal traits and exercise self-efficacy.

The development of the Active2Gether intervention (Chapter 4) was guided by the program-planning model developed by Kreuter and colleagues. In the attempt to go beyond the state of the art of existing apps a computational model was combined with theory-based intervention input. Because a variety of data was collected and combined it was possible to provide dynamically tailored feedback. The result of the systematic development was a web-based android app that sends daily messages tailored to physical activity behavior determinants and that encourages and motivates users to be more physically active, i.e. to participate in sports and use active transport and the stairs more often. The app displays the weekly goal, Fitbit data (i.e. number of steps and stairs ascended) and it shows three graphs containing weekly steps data, coaching data, i.e. weekly minutes of sports, active transport or number of stairs ascended and the last graph compares the users’ activity data to other users.

The Active2Gether app was connected to a fitness tracker, the Fitbit One, that was used to (self-) monitor the participants’ physical activity behaviors. However, before using such a new device for research purposes it was important to know the validity of the Fitbit One among young adults. Chapter 4 describes the results of a validation study that compared Fitbit One measurements with ActiGraph GT3X+ in terms of assessing physical activity in different time intervals (i.e. minute, hour, day), to assess the construct validity of the Fitbit One for providing real-time physical activity feedback among young adults. The results indicated that the Fitbit One is relatively well-suited for providing real-time feedback on steps activity and for self-monitoring, but less suitable for assessing minutes of moderate-vigorous physical activity.

As part of the development of the Active2Gether intervention, the app-based intervention was evaluated with respect to its efficacy and its usability. The efficacy of the Active2Gether intervention was explored in a quasi-experimental trial in which the Active2Gether intervention was compared with a ‘light’ version of Active2Gether — without tailored feedback and coaching messages — and with the Fitbit app (Chapter 5). Furthermore, the Active2Gether intervention was evaluated with respect to its usability (i.e., adherence, interaction rates) and users’ appreciation (Chapter 5).

No evidence for significant superior intervention effects of Active2Gether on increased physical activity or more positive determinants of physical activity as compared to the ‘light’ version or Fitbit were found. The majority of the Active2Gether app users used the app at least several times per week, but was not satisfied with the app. In addition, a substantial number of participants experienced technical
problems. The evaluation study that was conducted differed substantially from the original protocol, especially regarding randomization and power. Thus, the results of this study should be interpreted with caution.

The second study (Chapter 5) aimed to evaluate the use (i.e., adherence, interaction rates) and the users’ appreciation of the Active2Gether app. In summary, significant differences were seen in duration of usage of the Fitbit in favor of the two Active2Gether apps. Furthermore, significant differences were seen with respect to the appreciation between the Fitbit app and the two Active2Gether apps; the Fitbit app scored higher in terms of ‘Satisfaction’, ‘User friendliness’, ‘Perceived effectiveness’ and ‘Professionality’.

This thesis shows that the development of a theory-based ‘artificial intelligent’ app is a complicated process and iterative process. The findings of the focus group discussions and the survey data indicate that young adults are interested in using apps to help them to increase their levels of physical activity. Preferably, physical activity apps should include tailored feedback, features that rank users’ performance and accomplishments as compared to peers, as well as goal setting, coaching and tailored feedback features. Although the Active2Gether intervention included all those features, the evaluation of the Active2Gether intervention did not provide evidence in favor of such tailored app-based intervention. Mobile - and artificial intelligence- technology and their possibilities are constantly and rapidly changing and evolving. Features that are possible today were not possible when the studies described in this thesis were started and conducted. The implications for intervention development aiming to systematically develop an app-based intervention based on relevant theories and evidence should consider applying approaches with shorter cycles of developing and testing, while involving the target population, stakeholders, professional app designers and companies and organizations that (aim to) spread and/or sell such apps to improve the uptake and impact of app-based interventions.