Chapter 7

General Discussion
AIMS

This thesis aimed to explore the micro and macro level portion size food environment (part 1) and to develop and evaluate a weight-management intervention aimed at portion size (part 2). Specifically, the first part of this thesis focused on evaluating the current international serving size regulation in supermarkets of four high-income countries, with reference to non-alcoholic beverages (macro level, chapter 2), followed by an observational study in order to examine the in-home presence of factors associated with surplus portion size selection and intake (micro level, chapter 3). Second, a tool to increase portion size awareness was developed (chapter 4) and portion control strategies were identified (chapter 5). These elements were incorporated in the comprehensive intervention “PortionControl@HOME” that was evaluated by means of an RCT (chapter 6).

MAIN FINDINGS

There is a lack of adequate package and manufacturer recommended serving size guidance

In chapter 2, the package and manufacturer recommended serving size guidance for non-alcoholic beverages in four high-income countries (Australia, Canada, Netherlands and New Zealand) were compared. There was substantial variation in package sizes and in manufacturer recommended serving sizes of non-alcoholic beverages within and between the four high-income countries, especially for individual pack size drinks (e.g., containing an amount that is reasonable to consume in one sitting). Also, in Australia, the Netherlands, and New Zealand, no official guidelines specifying the amounts (gram or mL) for serving sizes on the food package were provided by national or governmental institutions. In Canada, guidelines were provided by the government; however, a wide variety in the presented Canadian serving sizes were still observed.
Factors associated with excess portion size selection and intake are frequently present in homes with overweight gatekeepers

In chapter 3, in-home factors influencing portion size selection and intake were identified. Overall, results showed that specific features associated with selecting and consuming large portions that had been identified in previous research, were frequently observed in real-life home environments. In the majority of households with overweight gatekeepers, a large number of processed snack foods were available and were stored in a way that may induce overconsumption. In addition, in most households large sized dinnerware was used. However, the results suggested that families with younger overweight gatekeepers used larger dinnerware (glasses, dessert bowls, mugs) compared to families with older overweight gatekeepers.

PortionControl@HOME, a theory-based intervention

The PortionControl@HOME intervention aimed to increase portion size awareness, to improve portion control behavior, improve skills to prepare meals of equal sized portions but with a lower energy density, and to stimulate individuals to shape a physical home food environment that supports adequate portion control behavior. The intervention was delivered using several formats, including an online interactive website, a DVD, an educational book including written assignments, a cooking class and a screening and feedback instrument developed to assist individuals to shape the physical home food environment. Behavioral change techniques including goal setting, action planning, coping planning and self-monitoring were included in the PortionControl@HOME intervention. Although these techniques have been widely used in previous weight loss interventions, the PortionControl@HOME intervention included several innovative aspects. First, the focus of the program was on ‘how much’ people consumed, not specifically on ‘what’. Also, no guideline on “good” (e.g., vegetables) or “bad” (e.g., chips) products was provided, though attention was paid to energy density (kcal/100 gram) and adequate portion sizes. Second, individuals were provided with several evidence-based behavioral strategies and behavioral change techniques to help them cope with the supersized environment and lower the amount of food selected and consumed. A third innovative aspect was that the intervention
included the so-called ‘home-screener’, helping individuals to shape a home food environment that would support adequate portion control behavior.

**PortionControl@HOME was effective in enhancing portion size awareness, increase the use of portion control strategies and short term weight-loss**

The studies described in chapters 4 and 5 provided preliminary evidence of two intervention elements regarding portion size awareness and the portion control strategies. The ‘PortionSize@warenessTool’ appeared to enhance people’s awareness about reference serving sizes and factors that may contribute to overeating in response to large portion sizes. The use of the evidence based strategies to control portion size selection and intake discriminated non-overweight from overweight and obese individuals, suggesting the first evidence of their validity. The overall PortionControl@HOME program was evaluated using an RCT design and was presented in chapter 6. The PortionControl@HOME program resulted in greater initial weight loss (-0.45 BMI points) than a non-intervention approach. Moreover, a mediation analysis indicated that the short-term intervention effect on weight loss was mediated by portion control behavior. However, once the intervention ceased, sustained effects on weight loss were no longer evident.

**Conclusions**

The main findings from this thesis can be summarized as follows. The macro and micro level portion size environment hinders the selection and consumption of adequate food portion sizes, and consequently do not favor controlling energy intake. However, a comprehensive educational portion control intervention resulted in greater portion size awareness, was successful at enhancing portion control behavior and had favorable effects on weight-loss directly after the intervention. Additional efforts or prolonged programs are needed to maintain the effectiveness.
REFLECTION ON THE MAIN FINDINGS

The studies conducted targeted different aspects of the portion size environment and portion size education. The results provided some important insights and concerns to reflect upon.

Inconsistencies in package sizes and manufacturer recommended serving sizes

Results from the international study outlined in chapter 2 suggest that current serving sizes as communicated by manufactures make it difficult for people to compare similar products on nutritional content. Moreover, recommended serving sizes as communicated by manufacturers were sometimes considered unrealistic amounts to consume (i.e., too small).

Recommended serving sizes as communicated by manufacturers, are not helpful to compare similar products on nutritional content

Across the four countries included in Chapter 2, different companies use different amounts (mL or g) to communicate the serving size and the related nutritional information for similar products. For example, four different serving sizes existed for orange juice: 100mL = 45 kcal; 150mL = 68 kcal; 200mL = 90 kcal; 250mL = 113 kcal. In addition, similar brands communicate different serving sizes for comparable products. For example, brand X displays a serving of 150mL = 100 kcal for grape juice but a serving of 200mL = 90 kcal for orange juice. This becomes problematic particularly when nutritional information is communicated per serving (e.g., 90 kcal per serving) without mentioning the exact size of the serving (e.g., 90 kcal per serving is 200 mL). Therefore, without further examination, a manufactured recommended serving size suggests that a glass of grape juice contains less calories than a glass of orange juice. However, when presenting a serving of grape juice per 200 mL (134 kcal), the opposite is insinuated. Therefore, the current serving size guidance is unclear and not helpful in making healthy choices [1, 2].
Recommended serving sizes as communicated by manufacturers reflect unrealistic amounts to consume

In addition to the numerous serving sizes and corresponding nutritional information that are communicated for similar products, unrealistic amounts per serving size can also be presented. The results of the study on non-alcohol beverages studied in chapter 2 showed that small servings (e.g., 90mL, 100mL, 118mL) were communicated to indicate one serving. However, presenting these servings and the related nutritional information will mislead the consumer about the caloric content of the amount they will actually consume. Another important problem is that the communicated serving size is not always in line with the package size (e.g., a package containing 4.5 servings). This makes it difficult for people to select and consume the recommended serving.

The regulation of recommended serving sizes

In the U.S., there has been greater attention paid to serving size regulations. The food and drug administration (FDA) has announced to make major changes in their guidance regarding nutrition labels on food and beverage packages [3]. While serving size communication is already mandatory in the U.S. and its government provides some guidance regarding servings, this guidance is based on the amount (edible portion) of food customarily consumed per eating occasion in the 1970s and the 1980s, and is based on Nationwide Food Consumption Surveys conducted by the U.S. Department of Agriculture [4]. Serving size recommendations are therefore based on eating habits and nutrition data before high-processed foods and large food portions were the standard. For example, the manufactured recommended serving size for pizza is 140g and is communicated on the package; however, one pizza weights at least 300g. Therefore, one of the proposed changes is to adjust the serving size information to reflect more recent sizes of the packages and portions sold, and consumer responses to these. In the Netherlands, it is voluntary to provide serving size information on food packages, yet there are no national guidelines regarding the serving size for foods and non-alcoholic beverages. Though there is a call for harmonization of portion information across Europe making serving size information more interpretable [5], the food industry is the major player in determining serving sizes and how these are displayed on the packages [6].
The regulation of package sizes

Alongside efforts to standardize serving size communication, the influence of the package size must not be ignored as this might be even more important for moderating energy intake than the communicated serving size [7]. In the Netherlands, the most common bulk pack-size for sugar sweetened beverages is 1.5 liter, which is double the amount of packages from thirty years ago [8]. The findings of chapter 2 in this thesis also support the role of large pack sizes of sugar sweetened beverages as a key factor in the obesity epidemic; of the included countries, the Netherlands had the smallest individual pack size drinks whereas New Zealand had the largest. This is interesting because of the countries included, the Netherlands had the lowest rates (11.8%) of obesity and New Zealand the highest (26.5%) [9]. It is recommended that in the future, enlargements of package sizes are prevented, particularly for high-processed, high-energy dense, nutrition low foods.

The regulation of portion sizes

In addition to the package and recommended serving sizes of products for sale in supermarkets, the portion sizes of food and beverages served in restaurants, fast-food outlets and cinemas are also important [10], although these settings were outside the scope of this thesis. Foods and beverages offered in these settings (e.g., soft drink, milkshakes, popcorn) are often available in a variety of sizes (e.g., Small, Medium, Large). Preliminary outcomes of a recently conducted study in the Netherlands aimed at determining the sizes of such products, revealed a wide variety of amounts available for each serving size. For example, a “small” milkshake varied from 210-490 mL, a “medium” milkshake was between 340-570mL and large varied from 440-660mL (unpublished study). These findings highlight that a “small” milkshake in one setting, is a “medium” or “large” one in another setting, and support the need for both advocacy and regulations regarding standardized package or portion sizes in these settings.
Portion control, a ‘healthy’ strategy in weight management?

Since the 14th century, dieting has appeared in history indicating “a prescribed course of food, restricted in kind or limited in quantity, (esp. for medical or penal reasons; regimen)” [11]. In the past, a diet was common for people in prison, during periods of fasting or when sick. Dieting to lose weight however became common in the 19th century and onwards [12]. Yet today, numerous diets have dominated the weight loss market, accompanied by thousands of weight loss products (pills, shakes) promising a quick and easy weight loss [13]. Weight loss by excessive reduction in the calorie intake (less than 1200 kcal/day) occurs most often very quickly after starting the diet. However, after a while, the body’s basal metabolic rate slows down, making the body utilize its energy more efficiently. In addition, lean body mass (e.g., muscles) and not body-fat starts to breakdown [14]. Excessive dieting is also associated with unbeneﬁcial physical and psychological consequences [15]. As a result of very low caloric intake, deﬁcits in cognitive performance and inactiveness occur, making it very hard to continue the diet. Once people give up and return to their “normal” diet, they quickly regain weight. Therefore, such forms of dieting have not been effective for the maintenance of weight-loss. Moreover, most of the people who have lost weight quickly, regain weight within five years and 25% of people have gained even more weight than when started [16]. In addition to the ineffective results on weight loss, dieting is associated with negative side effects as depression, anxiety and an increased risk of eating disorders. Despite the lack of effectiveness of most dietary approaches in the treatment of obesity, dieting remains popular [16] and many people prefer the short-term “quick fix”. Although the ongoing popularity of dieting, there has been a shift away from such diets as more overweight individuals prefer evidence based programs over commercial weight-loss plans in recent years [17]. This approach is focused on helping people make behavioral changes towards a healthy lifestyle and healthy energy intake (≥1200 calories/day) [13] rather than eliminating foods or going on very low caloric intakes. Moreover, this approach focuses on improving eating habits and utilizing behavioral change techniques to help individuals shape their dietary behavior. The PortionControl@HOME intervention was developed in-line with these healthy weight loss standards. Therefore, PortionControl@HOME may be indicated as a healthy weight-loss approach and can be a healthy substitute for crash diets. In addition, the program included a module that supported the individual in changing the home food environment, making the
individual aware of the influence of the environment on energy intake and provided the individual with strategies to deal with the food environment, acknowledging the importance of individuals’ surroundings on energy intake. The applicability as substitute for ‘popular’ diets was also found in the study described in chapter 6 as the intervention group significantly used less of the additional approaches during the intervention period.

**Portion control: an ‘effective’ strategy in weight management?**

The results of chapter 4 provided evidence for the effectiveness of the PortionSize@awarenessTool to increase portion size awareness. Chapter 5 showed that the ‘from the literature extracted’ portion control strategies were more commonly used among non-overweight participants than overweight and obese adults. Moreover, the portion control strategies were evaluated as applicable and useful. Though these outcomes provided no insight in the effectiveness of the strategies on weight management, they were important requirements for the potential of portion control in weight loss. The results of the RCT revealed that between baseline and the 3-month follow-up measurement, the mean BMI of the intervention group decreased by 0.42 BMI point more than the control group. This decrease was larger (-0.45 BMI point) when outliers (n=3) were excluded and results were corrected for dieting behavior and baseline characteristics. Translating these results to actual weight, equated to a difference of approximately one kilogram between the intervention and the control group. Looking only at the descriptive statistics of the weight loss in both groups, the control group lost approximately 1 BMI point and the intervention group 2 BMI points (although these outcomes probably reflect an unreliable estimation of the results as only participants that completed the follow-up measure were included). A decrease of 2 BMI points results in an average weight loss of six kilograms within three months. For a hypothetical participant in the intervention group with a weight of 100 kg at baseline, this reflects a weight loss of 6%. Descriptive data reveal that compared to the baseline measures, participants in the intervention group lost 3.3 kg after six months and 2.2 kg after 12 months. These weight losses reflect a mean a weight loss of 3.3% after six months and 2.4% after 12 months for the hypothetical participant; and suggest that individuals started gaining weight again as soon as the intervention finished.
Compared to healthy weight loss standards\(^1\) [18], the weight loss after three months fulfilled the standards though the percentages after six and 12 months were rather small. Moreover, the PortionControl@HOME effects at 12 months follow-up (-2.2 kg) were smaller than the pooled weight loss at 12 months (-2.8 kg (95% confidence interval -3.6 to -2.1)) that was observed in a recent meta-analysis [19] of 37 weight management interventions of 3-12 months duration.

Three main explanations for the short duration of intervention effects were proposed. First, a minority of the individuals completed the coping planning and self-monitoring assignments, which were considered important strategies to help people change behavior [20, 21]. Second, the duration of the intervention (3 months) may not have been sufficient to achieve adequate and sustained weight loss [18], especially since the study population included mainly obese individuals (65%). This group may need a longer period and probably greater supervision to acquire weight loss maintenance. Moreover, it is likely that this group performed non-portion control behaviors for a relatively long time by which these behaviors became automated. Presumably, a longer period is needed to break these non-portion control habits or replace such strong habits with healthier, portion control behaviors. A third explanation for the temporary effect on BMI change might be related to the relatively small presence of relapse prevention strategies in the program [22].

Although the intervention did not achieve sustained weight loss, it is important to note that the improvements in self-reported portion control behavior were maintained over the 12 months. Some explanations might be given for this seemingly contradictory finding. First it is possible that individuals still used the portion control strategies at the long term (at six and twelve month follow-up), but less often or less strict as compared to during the intervention period (thus between baseline and three month follow-up). Possibly, sporadically or low-intensive use of the strategies may not be sufficient to generate weight loss or weight-maintenance. Second, people might have started to compensate for the reduced energy intake that was accomplished by the intervention with other behaviors before or afterwards. For example, people might exercise less (e.g., I eat small portions today so I can skip the gym) or might adjust the frequency of consumption (e.g., instead of consuming 2 portions of 100

\(^1\)Weight loss standards indicating health benefits of a weight loss of 5% of the initial body weight after three months and 10% of the initial body weight after 6 months [18]
gram, consume 4 portions of 60 gram a week) that result in a net increase of the total amount per week) [23]. Third, prior to the six and 12-month follow-up measures (long-term), the summer and Christmas holidays had just finished. It is plausible that individuals abandoned the use of the portion control strategies during holidays, while after these periods – and thus during the measurements – they were back on track using the portion control strategies. Finally, reporting bias can be occurred as portion control behavior was assessed with a self-report measure [24].

**Portion Control in the wider context of obesity prevention**

This thesis provided preliminary evidence that portion control behaviour might be beneficial for weight-management, and showed that the PortionControl@HOME intervention had favorable effects on weight-loss directly after the intervention. However, this thesis also showed that the current portion size food environment is not favourable for making portion control food choices and that the weight-loss effects of the PortionControl@HOME intervention were not sustained. In the wider context of obesity prevention, these findings highlighted issues regarding individual, corporate or governmental responsibilities with respect to healthy eating and will be outlined below.

**Individual responsibility (Individual based interventions)**

In the past decades, public health interventions aimed at improving diet and reducing obesity have largely focused on the individual, and such approaches have predominantly focused on educating people to eat more healthy. This approach is based on the assumption that human beings are rational creatures that make statements, decisions, judgments, and behave based on reasoned thinking and can change their unhealthy eating behavior deliberately. Yet, people do not always act in a reasonable or deliberated way and are influenced by many environmental factors influencing eating behavior (i.e., promotions) without necessarily being aware of such influences on food choices [25]. It can therefore be questioned if it is justifiable to think that losing weight can be achieved by individual-focused interventions only without
illuminating the influences of the food environment, corporate behavior or weak or counterproductive government regulation.

Although individual’s actions are not always deliberate and people act upon the environment they live in, it is not fully justified to say that overweight and obese individuals are ‘vulnerable victims’ who overeat in response to the food abundance environment. Though some studies suggest that overconsumption is a response to powerful environmental triggers [25], others show that also decision-making deficits, low self-control, little self-regulatory skills or a high impulsiveness are associated with the inability to control food intake or being (at risk for being) overweight [26]. For example, individuals having the ability to inhibit short-term rewards (e.g., nice food) because long-term consequences are harmful (e.g., gaining weight), are more successful in weight management [27]. Moreover, self-regulation capacity may weaken the effect of the food-rich environment on food intake [28]. In addition, so-called eating appropriate standards (defined as “shared practices and expectations regarding what is the appropriate or normal course of action in a specific eating situation”) guiding what, how much, when and where to eat have also been indicated as crucial in appropriate energy intakes in food abundant environments [29]. The studies presented in this thesis also indicated the impact of individual’s capacity to control food intake. We found that weight loss was mediated by portion control behavior, a means of self-regulating food intake. In addition, healthy weight individuals used these strategies more often as compared to overweight and obese individuals. This provides some evidence to support the notion that people can increase their capacity to cope with the supersized food environment by strengthen their self-regulating techniques. Moreover, it illustrates the importance of increasing behavioral capacities in weight loss interventions.

Corporate or governmental responsibilities (e.g., environmental interventions)

Although individual self-regulation capacity is important to control food intake, it cannot eliminate the impact of the food abundant environment totally [28]. Therefore creating healthier food environments that stimulate healthier eating behaviors have become more important in recent years. Although many forces contribute to obesity and poor diet, food industry behaviors such as promoting large portions have raised calls for government
regulation and started a path for action (e.g., Bloomberg’s call for a soda-ban). In response to public protest (e.g., nanny state) and such calls for government intervention, the food industry pledged to adopt so-called self-regulatory initiatives. These voluntary actions typically involve promises of the companies to follow self-generated rules and standards (e.g., use food-labeling, the introduction of smaller food portions) to create healthier products and food environments [30]. However, numerous exceptions and ambiguities in industry self-regulatory pledges may provide still more benefit to the industry than real health benefits to consumers [31]. Therefore it is questioned if industry self-regulation is enough to counter the obesity epidemic.

Environmental interventions conducted by the government can steer the provision of healthier food offer (e.g., regulation regarding the availability of small food portions, adequate serving size labelling). Based on governmental regulations toward tobacco and alcohol, three regulatory strategies could be used to mobilize against obesity; 1) controlling the conditions of sale through direct restrictions or limits (e.g., restricting large servings; e.g., Bloomberg’s soda ban); 2) raising prices through taxes (taxing larger food packages and portions instead of using a ‘value-for-money’ principle or 3) regulating marketing and advertising (banning or limiting marketing and advertising of large food portions) [32].

*Environmental interventions and freedom of choice*

Though it is emphasized that the obesity epidemic will not be reversed without government leadership and regulation [33, 34], opponents of governmental intervening indicate that such interference infringes individual’s need for autonomy [35]. According to this perspective, people know themselves what is best and are responsible for their own choices and behavior. Therefore, intervening by the government, for example banning large portion sizes or taxing larger servings, reduces freedom of choice and personal responsibility. Advocates of governmental interference however, state that the idea that consumers have a total freedom of choice is closer to fiction than reality as individuals are confronted with an assortment of food and available choices, offered and created by an external party [36]. In addition, consumers like to believe that they have the freedom to choose whatever they want (if I want to have a large portion, I can have a large portion). Consequently, resistance is evoked if
people feel that someone is taking that idea away (figure 1). However, that the food-industry ‘decide’ what is on the market, has not been recognized as infringing on freedom of choice [25]. The debate about individual responsibility versus governmental regulation illustrate that there is a tension between “paternalistic” macro-level, probably most effective interventions and individual based interventions that support freedom of choice, but generally have limited impact on weight reduction. An alternative approach to this dilemma is nudging [37].

Figure 1. Resistance against the proposed governmental soda-ban

The potential of nudging

A potential solution that balances educational and governmental interventions, affects behavior and may steer people’s choices in welfare promoting directions is nudging. This technique is defined as “any aspect of the choice architecture that alters people’s behavior in a predictable way without forbidding any options or significantly changing their economic incentives” [37]. Nudging can help individuals to select the healthy choice, without eliminating their freedom of choice. However, rather than steering deliberated decisions, nudging mainly operates through the automatic, affective system of behavior. In other words, nudges are small changes in the food environment that may steer mindless choices [38], even amongst individuals low in self-control who make impulsive decisions [39]. For example, providing information that the majority of consumers chose the healthiest option, but without explicitly
stating that this was the healthiest food option (so-called social proof heuristics\(^2\)), may stimulate a majority of individuals that are low in self-control to choose the healthy, less palatable food above the tempting, unhealthy food [39]. In the portion control area, a nudge would also involve placing appropriate pack sizes in a cafeteria or supermarket at eye level, while putting the larger portions in harder to reach places, or making the appropriate rather than the larger portions the default option in fast-food outlets [37]. Using such nudges, a choice environment is created that steer people to make behavioral choices that are in the best interests of their personal well-being and public good. Because this may support individuals to choose the healthy option, but does not eliminate the unhealthier choice, nudging may provide a balance between educational interventions and governmental regulations (Figure 2).

Figure 2. Examples of education, regulation and nudging in the context of portion control

METHODOLOGICAL ISSUES

The studies presented in this thesis used a variety of methodologies. An advantage of all the studies described was that they were conducted in a real life setting, enhancing their ecological validity. Moreover, the studies described in this thesis addressed different areas of portion size research, such as a cross-sectional exploration of the portion size environment,

\(^2\)Simple and quick decision rules that steer the tendency to adopt the option preferred by others, but that save self-control recourses.
questionnaire studies determining individual usage and evaluation of portion control strategies and a randomized controlled trial to investigate the effect of a weight-management intervention on portion control behavior and body mass index. However, these studies have several limitations and the results and conclusions should be interpreted in the light of these issues. Therefore, considerations regarding participants, study design and measures are discussed in this section.

Participants

Except for the studies in part one (chapter 2 and 3), participants were mainly female and native Dutch. Therefore the ability to generalize findings to non-Dutch groups or the overall Dutch population is limited [40]. It would be useful to determine the effects of the studies for men, non-Dutch participants or in more general populations. Another limitation regarding the generalizability is that only ‘healthy’ overweight and obese individuals were included to determine the effect of the PortionControl@HOME intervention. Therefore effects for normal weight individuals to mitigate weight gain or for specific patient groups (e.g., diabetes) patients are unknown. Moreover, all individuals in the studies participated voluntary and were probably motivated to participate in educational portion size interventions or to lose weight; therefore, selection bias was likely.

Another important consideration is that the RCT of the PortionControl@HOME intervention was associated with a larger drop-out (31.3%) than anticipated when designing the trial (10%). The results indicated that participants in the intervention group were more likely to drop out, especially after completing the intervention program. Two contradicting reasons and consequences might be taken into account. On the one hand these participants might refused to participate in follow-up measurements because they did not lose weight, which might result in an overestimation of the weight-loss outcomes. On the other hand, these participants might be successful in losing weight but quitted as no more incentives were left, which might result in an underestimation of the effects. Larger drop-out must be taken into account in the sample size analysis of future studies that include PortionControl@HOME. Moreover, strategies need to be included to keep intervention group participants in the study after they have completed the intervention program, but not the follow-up measures.
It is important to note that throughout the different studies, variation existed in the weight status of participants. In chapter 3 and chapter 6 only overweight and obese gatekeepers were included, whereas in the studies described in chapters 4 and 5 also non-overweight individuals participated. When comparing the results from the different chapters, it is important to take these differences into account.

**Design**

*Cross-sectional design*

Insight into the portion size food environment described in chapter 2 and 3 was gained with cross-sectional data, which does not allow causation to be determined. Moreover, given the highly dynamic and changeable nature of the food environment, measurements at a single point in time may not provide a true representation. The home food environment described in chapter 3, for instance, may depend substantially on whether gatekeepers have just done their groceries. The macro level portion size environment is likely to be less dynamic than the portion control home environment, however it is still likely to change over the time as new products or packages become available or others are excluded from the assortment. Therefore, cross-sectional data reflects only an observation of one point in time [41].

*Randomized Controlled Trials, the golden standard?*

A strength was that the PortionControl@HOME intervention was evaluated using an RCT design using intention to treat principles. RCTs are considered to be the gold standard for determining the effectiveness of interventions. However, as emphasized in chapter 6, it has been questioned whether a standard RCT design is the most appropriate for assessing weight-loss or lifestyle interventions that include a usual care comparison. ‘New’ designs in which RCTs are nested within cohort studies (RCT nested in a cohort design) have been recently suggested to be more suitable in the evaluation of such interventions [42]. In this design, a large observational cohort of participants with the condition of interest (e.g., overweight) is recruited and their outcomes are measured regularly. When entering the cohort, participants consent to provide observational data, but also consent that they may be approached for new
interventions. When starting a new RCT, information of the cohort is used select the group of eligible participants (e.g., that fulfil the inclusion criteria). Of this sub-cohort, a random selection is offered with the intervention whereas the participants that were not random selected will function as control group (e.g., those who receive usual care). Consent to participate in the new intervention is sought only from those who are offered the intervention, and not to the participants in the control group. This design addressed some of the problems associated with regular RCT designs for evaluating educational interventions in which blinding of the condition is impossible. In future studies it is important to keep considering the best methods to examine the effect of behavioural interventions to provide the best evidence.

Measures

Food environmental data

In the studies to gain insight in the portion food environment, data were collected through observations by the researchers. Moreover, the international data on package and manufactured serving sizes were obtained using a similar smart-phone application in all countries. Therefore, it was less likely that bias occurred. Nevertheless not the full spectrum of the food environment regarding food portions was measured. In chapter 2, only insight into the package and serving size of non-alcoholic beverages was taken into account. In chapter 3, only insight into three domains (processed snack-food availability; in-home salience of snack foods; size of dinnerware) of the home food environment of overweight and obese individuals was gained. This limits the generalizability of the results regarding the portion food environment as more factors within the physical portion size environment are important, such as the availability and accessibility of other unhealthy foods and beverages (i.e. ice-cream) or the availability of super-sized processed-food packages especially. Moreover, in addition to the physical food environment, also the economical, socio-cultural and political environment regarding portion size is of interest [43]. For example, the amount of money the family has to spend on food or what rules or values families have regarding the amount of food purchased and consumed may influence portion control behavior [44].
Portion Control Behavior

Chapters 5 and 6 investigated individuals’ portion control behavior. To examine the use of the portion control behavior, a new measure especially for this purpose was developed. Although pre-tested, the questionnaire was not validated against existing, related questionnaires or actual behavior. This raised doubts about the degree to which self-reported portion control behavior reflects actual behavior. Moreover, because the portion control behavior was determined by self-reported data, bias could be occurred because of participants’ memory, interpretation and social desirability that can occur when using self-reported exposure measures [24]. Finally, the use of the portion control strategies included in the PortionControl@HOME intervention were ascertained almost literally in the questionnaires used in the RCT. Consequently, one could argue that the control group could have been contaminated with the portion control strategies, which may partly explain why the control group also lost weight. Therefore, the results of chapter 6 provide a fairly conservative test of the intervention effect.

Body Mass Index

The partly subjectively measured body mass index used in the RCT may be biased by social desirability. Self-reported body mass index has been associated with underreporting of actual weight, which in turn may be associated with an overestimation of weight loss in this study [45]. However, it was assumed that both the control and intervention group would underreport their weight to the same extent. Although partly self-reported data on weight were used, this research extended most previous studies by evaluating the applicability and effectiveness of a portion size intervention on weight status. Previous studies have assessed the impact of portion size on energy intake, satiation and hunger [46-48]. To the best of our knowledge, the study described in chapter six is one of the first portion size studies that use body mass index as the primary outcome measure.
IMPLICATIONS OF THE STUDY FINDINGS

The studies presented in this thesis were to explore the portion size food environment and to develop and evaluate the PortionControl@HOME intervention. A number of implications for future policy, practice and research arise from the results and will be discussed below.

Implications for policy and practice

Regulate and standardize manufacturer serving sizes

Future public policies for preventing further obesity may require significant changes in the current regulation in addition to well-recognized population wide education [49]. Therefore, we recommend that serving sizes displayed on packages should be regulated more strictly. In doing so, serving size regulations, preferable set by the government, are needed to provide unambiguous recommendations of the amount that is normally consumed in one sitting. Providing adequate serving size information is important to provide clear health communication to the consumer. If this is not regulated, no serving size information should be displayed and nutrition labelling should only be per 100 mL, which is already mandatory in many countries.

Improved use of theoretical behavior change techniques

The alignment with important theoretical behavior change techniques is advisable. During the PortionControl@HOME intervention, participants were stimulated to monitor their successes during the intervention period; this strategy should play a more prominent role in future use of the PortionControl@HOME program. Also the use of other technologies such as smartphone applications could be used to offer the intervention or to enhance the intervention usage [50]. For example, the Home-Screener could be developed as a smartphone application to maximize feasibility.
*Incorporate portion control and focus on the home food environment in weight-counseling*

At the individual level, dieticians, weight consultants or other health professionals supporting people in weight management, could pay attention to the home environment as part of their treatment. They could help individuals in setting up their home environment in such a way to facilitate adequate portion size selection and intake (i.e., stockpile tempting snacks invisibly or use specialized equipment such as a small bowl when consuming a dessert). Findings from this thesis suggest that ‘portion control’ might be an effective strategy to achieve adequate portion size selection, intake, and initial weight loss. Important implications are that the (components of) PortionControl@HOME could easily be integrated as part of existing weight-management consults and programs. Because of the online nature of the PortionSize@warenessTool, this intervention element could be implemented and scaled throughout the Netherlands. Ongoing refinements of the intervention are needed to induce a stronger intervention effect on weight-loss over a prolonged period.

**Implications for future research**

Important next steps in further research are comprehensive, long term monitoring of the portion size food environment and additional and extended research on the PortionControl@HOME intervention. Suggestions are provided below.

*Monitoring of the portion food environment*

To determine the changes in package-size, portion size and the manufactured recommended serving size, monitoring of the products, corporate pledges and governmental regulations are needed to determine the change of the food environment over the common years. Already, first steps to monitor the food environment have been made by establishing the Global Food Monitoring Group in 2011. This initiative currently consists of 31 countries and seeks to monitor and report the nutritional composition of processed foods available in different countries, including data on the package and portion size [51]. The first study presented in this thesis was in cooperation with this group. However, only cross-sectional insight in the portion food environment was revealed. In order to monitor progress and changes regarding
portion sizes at macro environmental level, it is advisable to systematically monitor the available package, serving and portion sizes within and across countries over time. Alongside the monitoring of actual package, serving and portion sizes, it is of importance to progress on government and private sector policies regarding food portions. In doing so, the interaction between new policies, commitments and the actual presence of package, serving and portion sizes can be determined [52].

*Study the interaction between the portion size environments and individual behavior*

As indicated previously in this chapter, it is suggested to regulate portion sizes or to use nudging strategies to improve the portion-size environment. However, it is of importance to monitor the effects of these efforts on individual purchase and eating behaviors. With such studies, preliminary insights in the effectiveness of public health approaches can be determined. Possible real-life settings for studying changes in portion sizes are worksite-cafeterias [53], cinemas [54] and restaurants [55]. Another setting in which certain strategies could be studied is the virtual supermarket [56]. This is a three-dimensional software application, which was designed based on a real supermarket. Though a virtual surrounding can never replace studies in a real-life setting, it has a great potential to gain insight in the effect of portion size regulations and nudges and consumer behavior. In addition to the effects on individual purchase and eating behaviors, effects on weight and health-status need to be studied using more comprehensive and long-term research.

*Study the effect of an extended version of PortionControl@HOME intervention*

Based on the findings presented in chapter 6, it is advisable to build upon the current program and perform additional research to evaluate the effects of an extended PortionControl@HOME program. The extended PortionControl@HOME intervention period needs to prolong its duration and include relapse prevention strategies (Figure 3). Below, suggestions for future research are outlined.
Prolong and intensify the intervention period

A prolonged, continued PortionControl@HOME program is advisable. The intervention materials could be used as the foundation for a larger, more comprehensive program. One possibility is that in addition to the cooking class, also other elements of the intervention are targeted in group-sessions or interpersonal counseling with weight-coaches or other suitable professionals. Over these sessions, the content of the overall intervention could be addressed and repeated. Moreover, these sessions could help people to define well written goals and plans, help them focus on their plans and tackle their barriers to perform adequate portion control behavior. Such face-to-face self-regulation approaches have the potential to increase weight reduction [57]. Another recommendation is to include physical activity promotions in the intervention as a combination of a behavioural nutrition and physical activity components have been suggested to be more effective than a behavioural nutrition intervention only [58].
Include relapse prevention strategies

In the studied PortionControl@HOME intervention, limited relapse prevention strategies were included and the booster sessions were ineffective at keeping individuals on track. Although several strategies for relapse prevention can be emphasized, important strategies are to strengthen participants’ coping capacity and self-efficacy. Increasing coping capacity, needs to rely not only on paying attention to “when and how to cope”, but also on developing missing requirements (e.g., skills or knowledge to cope) or address other factors (e.g., motivation to cope) that interfere with adequate portion control behavior [22]. Enhancement of self-efficacy might be desired to increase participants’ feeling of ownership of successful portion control behavior and willingness to persist when barriers arise. In addition to the prevention of relapse, strategies to cope with a relapse could be incorporated when offering interventions [59]. Another important target in relapse prevention strategies is enhancing autonomous motivation to fulfill the portion control behavior due to its association with long-term weight loss [60, 61]. For example, by using motivational interviewing, which is defined as “a client–centered, directive method for enhancing intrinsic motivation to change by exploring and resolving ambivalence” [62]. Moreover, social-context events that conduce toward feelings of competence during action (e.g., positive performance feedback) can facilitate motivation and can promote the internalization of health behavior so that it is more likely to be maintained term weight loss [61]. These insights support the application of self-determination theory in the intervention to target the problem of weight maintenance [63] and also reinforce the inclusion of intrapersonal coaching as part of the more comprehensive PortionControl@HOME intervention.

GENERAL CONCLUSIONS

Portion control is a favorable, healthy approach in weight-management at the individual level. The intervention PortionControl@HOME is a promising strategy in weight-loss and is advisable to be embedded in weight-management therapy or public health efforts. However, improvement of the program is needed to strengthen and prolong its effects on weight-loss. In doing so, increasing the intervention period and including relapse prevention strategies
seems most promising. Nevertheless, the current food environment is not supportive for choosing adequate portion sizes and must be targeted as well. Therefore, complementary to educational approaches, environmental interventions (i.e., both regulations and nudges) aimed at portion size are needed in order to help consumers to make the ‘portion controlled choice’, the easiest choice. In order to curb obesity levels national or globally, larger food environmental, system-based changes are required. Without such efforts, individual level approaches will not provide the solution to the obesity epidemic.
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