General discussion

Childhood overweight and -obesity are a public health problem and its prevalence has increased worldwide over the past decades (1). Overweight and obesity are defined as abnormal or excessive fat accumulation that presents a risk to health (1). The childhood obesity prevalence has increased from 13.9% in 1999-2000 to 18.5% in 2015-2016, in the United States (2). In the Netherlands, between 1981 and 2015 the obesity prevalence fluctuated between 2.1% and 2.8%. However, the prevalence of overweight in children in the Netherlands increased from 10.1% to 21.1% during this same time period (3).

Children with overweight and obesity have a high risk of developing diseases during childhood and adulthood targeting almost every organ system (4, 5, 6, 7). For instance, it has been shown that for each one-half unit increase in BMI-z score, there is a 50% increase in the risk of metabolic syndrome for children with overweight (4). Furthermore, the relative risk of hypertension in children associated with childhood overweight ranges from 2.5 to 3.7 (4).

Since 2010 there is a Dutch clinical guideline on obesity for general practitioners in the Netherlands, which states that the general practitioner should play a role in signaling and treating obesity (8). To be able to do this, the general practitioner should recognize overweight and obesity in children, and the general practitioner should be able to discuss the weight status of a child during consultation, irrespective of the reason for encounter. Furthermore, giving advice about the treatment of obesity and knowledge on reasons for referral are other important roles of the general practitioner according to the guideline (8).

The first part of this thesis aimed to study the accuracy of self-reported weight and height, since these measures are needed to determine the weight status of a child. In part two, the associations between weight status and bone mineral density, and between weight status and the frequencies of musculoskeletal and respiratory consultations in general practice were studied. Lastly, part three described the effects of a multidisciplinary intervention program on cardiorespiratory fitness and blood pressure, and presented the differences in (in)activity between children with overweight and normal-weight.

In the current chapter, the key findings of this thesis are presented and discussed in comparison to other relevant studies. Finally, recommendations for clinical practice and future research will be addressed.

Key findings

In ***part one*** of this thesis, **Chapter 2,** we showed that in the age group 2–8 years, parents of children with underweight reported a significantly higher weight than the actual measured weight, whereas parents of children with overweight reported a significantly lower weight. In the age group 9–17 years, children with normal-weight- and-overweight reported a significantly lower weight than measured weight. Of all children who were classified as overweight by the GP (N=116), 17% was misclassified as normal-weight and

4% as underweight when self-reported measurements were used. Therefore, it can be concluded that general practitioners cannot fully rely on reported weight and height of parents and children.

In ***part two*** of this thesis the associations between childhood overweight and medical consequences are described. By means of a meta-analysis, moderate and high quality of evidence showed (**Chapter 3**) that children with overweight and -obesity have a significantly higher bone mineral density compared to normal-weight children. In **chapter 4**, using the DOERAK database, we showed that children with overweight consulted the general practice significantly more often during the 2-year follow up compared to normal-weight children (mean 7.3 (5.7) vs 6.7 (5.4), odds ratio (OR) 1.09; 95%CI 1.01-1.18). However, no differences were seen in the number of children with overweight and -normal-weight who consulted the general practice for a musculoskeletal complaint (OR 1.20; 95%CI 0.86 – 1.68). Moreover, no differences between children with normal-weight and children with overweight in the number of musculoskeletal consultations in general and musculoskeletal consultations of the upper- and lower extremities during two-year follow-up were found. In **chapter 5** we studied the association between children's weight status in the age group 2-18 years and respiratory consultations at the general practice. Overall, respiratory consultations were not more prevalent in children with underweight compared to normal-weight children (OR 0.87; 95%CI 0.64-1.10), and in children with overweight compared to normal-weight children (OR 1.33; 95%CI 0.99-1.77). Though, children aged 12-18 years with overweight had significantly more respiratory consultations (mean 1.87 (3.06) vs. 0.93 (1.54), OR 2.14; 95%CI 1.14-4.01), more asthma-like consultations (mean 0.48 (1.50) vs 0.20 (1.00), OR 3.94; 95%CI 1.20-12.88), and more respiratory allergy-related consultations (mean 0.78 (1.68) vs 0.31 (1.05), OR 3.14; 95%CI 1.25-7.86) than normal-weight children aged 12-18 years. However, in children aged 2-6, and 6-12 years old, no associations were found between weight status and respiratory complaints.

Part three of this thesis consists of two chapters that focused on physical activity and the treatment of childhood obesity. In **chapter 6,** we demonstrated that a multidisciplinary intervention program for children with obesity in deprived areas resulted in a significant positive effect on cardiorespiratory fitness, but this effect was diluted one year after the intervention. Diastolic blood pressure percentiles were significantly higher at 52 weeks after intervention (β 0.20; 95%CI 0.08, 0.31). However, systolic blood pressure percentiles did not differ 52 weeks after the intervention, compared to baseline (β 0.08; 95%CI -0.06, 0.22). In **chapter 7**, a subsample (n=65) of the DOERAK database of children aged 4-18 years who wore an ActiGraph for one week was used. We showed that children with overweight spent significantly less time per day in sedentary behavior (β -1.65; 95%CI -3.12, -0.18), more time in light to moderate physical activity (β 1.48; 95%CI 0.07, 2.89), and more time in moderate to vigorous physical activity than normal-

weight children (β 0.45; 95%CI 0.02, 0.87). We found no significant difference between the number of normal-weight children and children with overweight meeting the WHO guidelines of 60 minutes of moderate to vigorous physical activity each day. Self-reported values of physical activity did not correlate well with objectively measured values.

Recognizing childhood overweight and obesity

This thesis showed that self-reported weight and height of children is not fully accurate, which is in line with what previous studies have found (9). Children with overweight (and their parents) underestimate their weight, and as a consequence, the general practitioner cannot only rely on self-reported weight and height of children. Therefore, general practitioners should measure the child him- or herself when the child visits the practice, to prevent misclassification of weight status from happening. This is in agreement with the Dutch clinical guideline on obesity, which recommends general practitioners to measure height and weight of each child they believe to be overweight or obese. However, this entails that general practitioners are able to recognize overweight and obesity in children. Unfortunately, research showed that although most general practitioners are able to identify children at the end of the spectrum (i.e. underweight or obese), many are not able to correctly identify the weight status of children who are at the category margins (10). This means that many children who are only slightly overweight and who do not bring up their weight for discussion themselves, will be missed by the general practitioner. This would be a missed opportunity to discuss the weight of the child and consequently give advice about a healthy lifestyle in order to prevent future obesity and morbidity. Besides the fact that general practitioners are not able to recognize all children with overweight, if recognized, general practitioners still find it difficult to start the conversation about weight if this is not the complaint the child consulted the general practitioner for (11). General practitioners seem to be reluctant to engage in weight-related discussions. This is primarily due to expected negative responses from parents, but also to a lack of time (11, 12, 13, 14).

One solution that may overcome the above described issues of not recognizing overweight and not starting the conversation about weight, is to improve the collaboration and communication between the Youth Health Care (JGZ), primary schools and general practices. In the Netherlands, the JGZ screens children on their health and development (15). They physically examine each child regularly from birth up to the age of four, once at the age of five and once at age eleven. During these examinations, children's weight and height are measured. The outcomes of these physical examinations are only issued to parents and not to the general practice of the child. If a child is overweight or obese, the JGZ has a treatment protocol which entails that the JGZ gives advice about a healthy lifestyle and that the JGZ has two follow-up appointments with the child (16). If after these advices, the child is still overweight or obese, the JGZ recommends the parents to

contact the general practice regarding the results of the examination. However it is still up to the parent to contact the general practice, and the question arises how often the parents actually contact the general practice in these cases.

If a better collaboration between JGZ and general practice is established, abnormal examination results and progress of children with overweight and obesity during follow-up at the JGZ would be communicated directly with the general practice. This way the general practitioner is aware of the weight problem and he or she can discuss the weight status when the child is coming for a next visit to the general practice. The general practitioner would also be up to date on the actions of the JGZ regarding the weight status, and can evaluate these actions with the child during consultations.

One major limitation of the JGZ screening program is that there are no routine examinations between ages 5-11, while this is a vulnerable period for children to become overweight or obese. It would be ideal if children of these ages were measured annually too so that children who are slightly overweight would be recognized, and general practitioners would be able to observe trends, such as (rapidly) increasing BMI. Especially since children with overweight who do not visit the general practice because they do not experience health problems would otherwise be missed. However, since there are 934.593 children between ages 5-11, implementing this extended screening program seems impossible due to the extra costs and extra workload that would be put both on the JGZ and on general practices (17).

Therefore, other solutions to get a better grip on the group of children in this age-range, in regards to recognizing overweight and obesity, have to be proposed. Formerly, children aged 8 years were also included in the JGZ program for routine examination. Since the Dutch government has recently become more active in fighting childhood obesity (i.e. the National Prevention Agreement), perhaps it is a possibility to re-introduce the measurement of 8 year old children (total of 188.580 children) by the JGZ screening program (17). However, the extra costs of this measurement could be a barrier for implementation. Furthermore, primary schools could play a more pronounced role in recognizing overweight and obesity during a children's life, especially since teachers see children from ages 4-11 almost daily. Not only could they recognize overweight and obesity at an early stage, primary schools also play a role in teaching children about healthy lifestyles. Thus, collaboration between general practice, JGZ and primary schools to recognize and attack childhood overweight and obesity at an early stage is crucial. With this collaboration, childhood overweight would be recognized at an earlier stage and early intervention could be initiated when weight management efforts may be more likely to be successful. All three parties can collectively play a role in trying to prevent childhood obesity progress into adult obesity, and prevent childhood overweight to turn into childhood obesity. However, the willingness of schools to have an additional signaling role should be investigated.

Other important parties in this collaboration are the government and townships. They should initiate this collaboration by bringing all parties together and they should be the leading party and make sure the collaboration is well organized. The government should also take other actions to fight childhood obesity such as promoting healthy foods and physical activity, creating healthy environments, etc.. The role of the government in these actions will be discussed later on in this discussion. Health insurance companies should also get involved in this collaboration, since prevention of childhood obesity is also of interest for them, because in it the end it would lead to lower medical costs.

The above proposed collaboration between all these parties would be very useful to attack childhood obesity, however some barriers are to overcome in order to implement this collaboration. First of all, the government should make clear rules and regulations about this collaboration so that everyone is involved. They should delegate that all townships organize meetings with the local JGZ, general practices and schools to explain and carry out this new collaboration. Moreover, the collaboration between all parties cannot be established without better communication between JGZ, general practices and schools. The development of one electronic medical record in which all information from JGZ and general practice can be safely shared or a way to safely exchange data is an important next step that should be facilitated by the government taking into account legal barriers.

Musculoskeletal complaints

This thesis showed that children with overweight and obesity do not consult the general practitioner more often for musculoskeletal complaints than children of normal-weight. We also showed that there is no association between weight status and musculoskeletal complaints of the lower- or upper extremities in particular. Our findings are not in line with what was expected from previous studies, which showed that childhood overweight and obesity was associated with musculoskeletal complaints, injuries and fractures (18, 19). Our finding, that we found no association between weight status and complaints of the lower extremities, was also unexpected since several studies have found more complaints of the lower extremities in children with overweight than in children of normal-weight (18, 19, 20, 21). Moreover, some of the theories about why children with overweight have more complaints of lower extremities are well substantiated. A few of these proposed theories are 1) obesity changes the biomechanical alignment and function of the joints, 2) being overweight or obese puts a greater load on bones and joints, and 3) changes in gait and balance are common in overweight and obese people (21, 22, 23, 24).

The discrepancy between previous literature and the findings in this thesis could however be due to the fact that previous literature mainly based their findings on questionnaires in open populations, rather than from medical files (18, 20). It could therefore

be suggested that the complaints reported in these questionnaires by children with overweight and obesity are only temporarily present and/or not severe, or at least not relevant enough, to consult the general practitioner. Another explanation may be that children with overweight at the age of eight, which was the average age of the children in our cohort, do not experience more musculoskeletal complaints (yet) than normal-weight children. However, when we compared the older children with overweight to older normal-weight children in our cohort, still no differences were found in musculoskeletal consultations. Though, the average age of the children included in the studies that did find an association between being overweight and having musculoskeletal complaints was higher (mean age 10.5-17.8 years) than our cohort (mean 8 years) (18, 20). Perhaps these children have been exposed to excess weight for a longer period of time and therefore experience more musculoskeletal complaints.

We also found no association between weight status and complaints of the upper extremities such as pain or injury of the shoulder or arm. A large study by Adams et al. including 913.178 children aged 2-18, using data from medical files, found similar results as us regarding the association between weight status and complaints of the upper extremities (19). This may be explained by the fact that the joints in the upper extremities are not exposed to the extra load from the excess weight compared to the lower extremities, and therefore are not more prone to injuries than normal-weight children.

One association that has frequently been shown to exist is the association between obesity and osteoarthritis in adults (25). Moreover, it has already been shown that children with morbid obesity show early signs of osteoarthritis (26). The children in our cohort however, were younger than the children in the study by Widhalm et al. (26). It is also known that injury risk in overweight, obese and extremely obese children increases in a linear fashion (19). Moreover, a recent study by Kelly et al. about the association between BMI and primary health care use in childhood showed that children with obesity had significantly higher rates of appointments at the general practice than normal-weight children, while this difference was not found in children with overweight compared to normal-weight children (27). The children in our cohort were not in the range of morbid obesity (only 3% was obese), which may explain why no association was found between overweight and musculoskeletal complaints in our cohort.

Although our study on musculoskeletal complaints in children with overweight and obesity did not find an association between the two, the published literature does give indication that there is an association (18, 19, 20, 21, 22, 23, 24). Based on published literature, general practitioners should be aware of the consequences of childhood obesity, and more importantly, should make their young patients and their parents aware of the potential consequences, even when they are not apparent yet.

Respiratory complaints

Since the prevalence of both asthma and obesity have increased over the past decades, researchers have increasingly investigated the (causal) relationship between these two diseases (28). According to this thesis, children with overweight aged 12-18 years had significantly more respiratory-, asthma-like, and respiratory allergy related consultations than normal-weight peers. In children aged 2-6, and 6-12 years old, no association was found between weight status and respiratory complaints. This may be explained by the suggestion that the relationship between obesity and asthma might be dose-dependent, since the children aged 12-18 years could have been exposed to obesity for a longer period of time (29).

No conclusions could be drawn about the causal relationship between obesity and asthma, since we did not have data starting at birth, and therefore did not know which disease started first. There are, however, other convincing studies showing that childhood obesity increases the risk of asthma (30, 31, 32, 33). Besides the finding that obesity increases the risk of asthma, it has also been found that obesity is associated with worse asthma-related health outcomes (34, 35). A large study in adults showed a 10% increase in asthma prevalence per unit of increase in BMI in men, and a 7% increase in prevalence per unit increase in BMI in women, which strengthens the suggestion that the relationship between obesity and asthma is dose-dependent (29, 35).

A recent review including 21.130 children suggested that the association between asthma and obesity may be inverse, meaning that asthma may lead to obesity (36). The authors showed that children with physician-diagnosed asthma had a 66% higher risk of incident obesity than those without asthma (36). The association between asthma and obesity may be caused by different factors, such as biological and lifestyle factors. Some hypothesized pathways underlying both asthma and obesity are systemic inflammation, adipokine dysregulation and shared genetics (37). The association may also partially be explained by lifestyle factors, i.e. asthmatic children have lower levels of physical activity and less sleep than healthy children, both of which can lead to obesity (38). Furthermore, asthma medication use (inhalation corticosteroid) also increases the risk of obesity (36). However, the association between asthma and obesity cannot be fully explained by medication use only (36).

Regardless of whether asthma causes obesity, or obesity causes asthma, the two often coexist. This has consequences for the treatment of asthma in children with overweight and obesity, since it is known that children with overweight and obesity require increased amounts of B-agonists and higher oral steroid use (39). Therefore, weight reduction in children with overweight and obesity with asthma may improve asthma related symptoms and may improve response to medication. A Cochrane review including a total of 197 adults showed that weight loss may be beneficial for improving asthma control in adults with overweight and obesity. However, all included studies were

of high risk of bias (40). Another review found that all 15 included studies showed an improvement of at least one asthma outcome variable after weight loss in adults (41). Though research in children on the effects of weight loss on asthma symptoms is limited, a small randomized controlled trial by Jensen et al. including 28 children showed that weight loss in children with obese improved the static lung function and asthma control (42). Moreover, a recently published cohort study including 507.496 children that compared asthma incidence among children with overweight and obesity found that 10% of clinically diagnosed asthma among all children in the population could be prevented with weight reduction (43).

Even though the evidence is still limited, it does suggest that weight loss leads to improved asthma symptoms and decreased exacerbations in children- and adults with overweight, and can even decrease asthma incidence in children. Therefore, more research should be done to provide stronger evidence on the effectiveness of weight loss on asthma symptoms in children and adults. Though, with this limited evidence, the GP can already discuss weight loss when a child with overweight or obesity with asthma consults him or her, not only to improve asthma, but also for general health reasons. Up to now, no guidelines are available on how to integrate weight loss into asthma treatment. If future research confirms that weight loss is an effective intervention to improve asthma symptoms and reduce the need for asthma medication and may improve the response to medication, weight loss should be implemented as part of the treatment of asthma in asthma guidelines, both for children and adults. By doing so, patients will be treated as a whole and better health outcomes may be reached.

Treatment

Obesity is a complex disease. Some predisposing factors for obesity are genetics, prenatal factors (such as an overweight mother during pregnancy), parent feeding behaviors (i.e. restriction, food prompting and pressuring), increased sedentary behavior, decreased physical activity, increased caloric sweeteners (i.e. sweetened beverages, snacks), decreased child nighttime sleep duration, increased parent BMI, and chronic stress (44, 45, 46, 47). Since obesity is such a complex disease, the Dutch clinical guideline on obesity states that multidisciplinary intervention programs are the first choice of treatment for obesity (8).

The health outcomes of the intervention program Kids4Fit presented in chapter 6 in this thesis showed that during the intervention period beneficial health effects are reached, such as better cardiorespiratory fitness. However, one year after the intervention, the positive effects of the program have diluted. Three Cochrane reviews have investigated the effect of diet, physical activity and behavioral interventions for the treatment of overweight or obesity in children up to 6 years of age, children aged 6 to 12 years and adolescents aged 12 to 17 years (48, 49, 50). These reviews found that multidisciplinary

intervention programs may be beneficial for children with overweight and obesity in all age categories, but the evidence is mostly of low quality due to limited confidence on how the studies were performed, inconsistent results between studies, and the low number of included children in some studies (48, 49, 50). Furthermore, long-term follow-up after the interventions was rarely performed, while it is known that maintenance of weight-loss after an intervention is the main challenge. Therefore, it is important to investigate which maintenance interventions are successful for long-term weight loss. A review on maintenance interventions in children with overweight or obesity by van der Heijden et al. showed a favorable effect of maintenance interventions with stable BMI-z scores in the maintenance intervention patients, compared to a slight increase in BMI-z scores in control patients (51). They also showed that 'face-to-face' interventions were more effective than 'on distance' interventions, and that continuous motivation was the strongest predictor for weight maintenance (51). Though, these conclusions should be handled with care, since the studies included in this review had considerable clinical and methodological heterogeneity, with limitations in the quality of the studies such as small sample sizes and risk of bias (51). Another study in children with obesity found a positive effect of motivational interviewing on BMI and on obesity-related behavior outcomes (52). Therefore, to maintain long-term weight loss, booster sessions with face-to-face contact and motivational interviewing should play a role in multidisciplinary intervention programs for children with overweight and obesity. However, since the literature for this group of patients is still scarce and mainly of low quality, further research should focus on the most appropriate forms of post-intervention maintenance in order to ensure intervention benefits are sustained over the longer term.

Since multidisciplinary intervention programs are the preferred non-invasive treatment for obesity, and the obesity prevalence is still rising, the minister of medical care and the state secretary of public health of the Netherlands announced that certified multidisciplinary intervention programs will be included in the basic health insurance package of adults from January 2019 (53). This means that adults with obesity can be referred to intervention programs by the general practice, and the health insurance covers the costs. This decision to include intervention programs for adults with obesity in the basic health insurance package is a step in the right direction to attack the obesity epidemic. However, this policy change only affects obese adults, but should also be introduced for children. Furthermore, since it is known that childhood obesity increases the risk of staying obese in adulthood, and since prevention is better than cure, the focus should be on preventing obesity in children in the first place (1).

Prevention

We live in an obesogenic environment that promotes unhealthy eating habits and unhealthy lifestyle and by doing so, this contributes to the development of overweight and

obesity in children and adults. An important point of discussion is who takes responsibility for the increase and treatment of obesity. Is it the individual consumer who decides what lifestyle to adapt, or is it the general practice, the food industry or the government who should take responsibility? In my opinion, since obesity is so complex, many different disciplines need to work together to prevent the obesity epidemic to rise even further and this is not something the general practitioner can solve by him- or herself. I believe the food industry and the government should take further actions to fight the obesity epidemic, just like the concerted actions that are initiated to curb the smoking prevalence especially among adolescents (i.e. increasing the price of cigarettes, making smoking prohibited in most public places, etc.) and alcohol consumption (i.e. increasing the legal drinking age to 18). Recently, in November 2018, the Dutch government and secretary of state presented a 'National Prevention Agreement' which focuses on reducing smoking, alcohol consumption and overweight prevalence (54). The three pillars for reducing overweight are: 1) promoting healthy foods, 2) increasing physical activity, and 3) improving a healthy environment and healthcare (54). These pillars will be further discussed and referred to below.

Promoting healthy foods

The food industry is responsible for commercials about sugary beverages, snacks and sweets. In the US, children view 15 television food advertisements per day on average, and 98% of these commercials viewed by children aged 2-11 years promote products high in fat, sugar and/or sodium (55). In these commercials, positive emotions are often evoked by making an association with sports, and by associating food with fun and good times, and being hip or cool (56). Research has shown that there is a direct causal link between food advertising and greater snack consumption and that over-consumption of sugar is a major contributor to obesity (57, 58). Not only commercials, but also the abundance of sugary snacks offered at the cash registry of every supermarket and gas station seduce people to buy unhealthy food. Research showed that by reducing unhealthy food advertisement exposure of children to zero, 14%-33% of children with obesity in the USA might not have been obese (59). The Dutch government is in the position to make rules and regulations about food advertisement, such as putting restrictions on the amount and type of commercials during children's television programs. Even though the National Prevention Agreement does not make a statement on restrictions on the amount and type of commercials during children's television programs, it does state that the use of licensed media characters aimed at children under the age of 13 must be limited (54). It also states that during sport events, no food commercials should be aimed at children under the age of 13, unless they are about healthy foods. These new rules seem to be small steps to the right direction to attack childhood obesity, although rules and regulations on TV-advertisement are lagging behind.

Besides the excessive advertising of unhealthy foods, the healthy food choices are often more expensive than the unhealthy foods, making it more expensive for people to eat healthy (60). Moreover, in the Netherlands the price for unhealthy food (ice cream, sugar, candy) have dropped the past year, while the prices of healthy products (milk, eggs, fruit, nuts) have increased (61). The WHO has composed fiscal policies for diet and the prevention of non-communicable diseases and it proposes that "as appropriate to national context, countries consider the use of economic tools that are justified by evidence, and may include taxes and subsidies, to improve access to healthy dietary choices and create incentives for behaviors associated with improved health outcomes and discourage the consumption of less healthy options" (62). It has been shown that putting a tax on sugary drinks that increases prices by 20% can lead to a reduction in consumption by 20%, thus preventing obesity (63). Furthermore, in the UK, the USA and New Zealand, fruits and vegetable subsidies that reduces prices by 10-30% are effective in increasing fruit and vegetable consumption (62, 64). It seems logical to think that these measures would also be effective in The Netherlands. However, rather than providing subsidies on fruit and vegetables, the cabinet decided to increase the tax rate on these products from 6% to 9% in 2019 (65). On the other hand, much attention in the National Prevention Agreement has been given to promote healthy diets. It states that, among other things, consumers must be tempted to buy healthy foods, employers in supermarkets will be educated on healthy eating to better advice their customers who have questions regarding healthy foods, and sports clubs and hospitals must provide healthier foods (54). However, based on what has been shown in previous research, it may have been more effective if the government introduced tax on sugary drinks and other products high in fat and sugar, and subsidies on fruits and vegetables (62, 63, 64).

Besides the role of the government, other parties should take part in promoting healthy foods as well. First off, schools are in a great position to teach children about healthy foods and drinks. An example of schools where this is already successfully carried out are the 'Lekker Fit' schools in Rotterdam (66). At these schools a healthy lifestyle is promoted by, for instance, having children engage in physical activity three set times during the school day, and by stimulating the children to eat healthy treats and to drink water (66). General practices are also in the position to give advices about healthy foods to children and parents. Physician assistants working in general practices can educate children with overweight and their parents on healthy foods. Another possibility is to include a dietician in the general practice who is easily accessible for children with overweight or obesity and their parents. This would especially be beneficial in areas where obesity is more prevalent. Furthermore, multidisciplinary intervention programs to treat childhood obesity, such as Kids4Fit which was discussed in chapter 6 of this thesis, should involve a dietician to educate children and their parents about a healthy diet.

Physical activity

The second pillar in the National Prevention Agreement is the increase of physical activity. Besides the changes in the food industry over the past years, there has also been a change in the lifestyle of people. Children (and adults) are more sedentary, screen time has increased and time spent on physical activity has decreased (67, 68). Research conducted in 2007-2012, showed that children spent on average about 2,2-2,5 hours per day on screen time (67, 69, 70, 71). Of children aged 4-11 years, 55.5%, and only 31% of children aged 12-17 years, meet the guideline of 60 minutes of moderate to vigorous physical activity (MVPA) per day (72). In line with that, Chapter 7 of this thesis investigated the physical activity behavior in children with normal-weight and-overweight and studied if children met the WHO guidelines of 60 minutes of MVPA per day (1). The findings of that study showed that there is no difference in level of physical activity between children with normal-weight and children with overweight, and of the normal-weight children, only 20% - 33% met the MVPA guidelines and for children with overweight this ranged from 24% - 45%. Because of the increased inactivity in children, children are not developing motor coordination, or motor competence. It is known that motor competence is positively associated with physical activity, cardiorespiratory endurance, and perceived motor competence, while it is inversely correlated with weight status (73, 74, 75). Furthermore, motor competence is an important predictor for physical activity in childhood and adolescence, and it is a step toward lifelong commitment to physical activity (76). Since motor competence is inversely associated with weight status and positively associated with health related fitness and a lifelong commitment to physical activity, it is important that children at a young age are already put in the position to develop these movement skills (74).

Both screen time and physical (in)activity are modifiable behaviors that may be tackled in childhood obesity prevention efforts. Similar as with promoting healthy foods, increasing physical activity and teaching about the importance of physical activity can also be carried out by many different parties, such as schools, general practices and the JGZ. These different parties should be adequately informed about the importance of physical activity at a young age, so that they can better educate parents and children about this. Educating parents and children about the importance of physical activity would then hopefully lead to better involvement in physical activity. A great example of where physical activity is integrated in daily school life is Finland. After every 45 minutes of class time, children get 15 minutes of playtime outside (77). In comparison to other European countries the Finnish children spend the least time in class, and have the least amount of homework, and they still are at the top of the Programme for International Student Assessment (PISA) list each year (77, 78). Therefore, primary schools in the Netherlands should spend more time on physical activity as well. In The Netherlands, there is a guideline on movement education for primary schools (79). Even though there

is no lawful norm on the amount of time that has to be spent on movement education by schools, the guideline does state that children in primary schools are advised to get 2 x 45 minutes of movement education per week (79). The previous cabinet in the Netherlands even stated that there should be at least 3 hours per week of movement education in primary schools. However, according to a recent report (2017) by the Mulier Institute for sport research, children in primary schools are only physically active for 89 minutes per week (80). Thus, to increase levels of physical activity, to improve motor competence, and to improve weight status, primary schools should be imposed to meet the requirement of (at least) 3 hours of physical activity per week. The National Prevention Agreement makes a few statements on how to increase levels of physical activity in children and adults: 1) sport providers will be locally supported to offer sports which are more suitable for inactive children and adults, and to make sure that attending these sports leads to structural physical activity; 2) it will be stimulated to bike to school and work; 3) extra attention will be given on how to improve the development of motor skills in children and extra attention will be given to children with motor development problems (54). If these three measures are executed, the levels of physical activity throughout the Dutch population will hopefully increase.

Role of parents in stimulating physical activity

Parents are essential in determining the amount of screen time and physical activity of their children. Parents are the ones that can put restrictions on the amount of time children spend on their tablet, phones, and watching television. Moreover, reducing parents' own screen time can lead to a decreased child screen time (81). It has also been found that children whose parents encourage and support their child's physical activity are more likely to have higher levels of physical activity. Also parents' physical activity was positively associated with children's' levels of physical activity (81). This highlights the importance of involving parents in multidisciplinary intervention programs, as has been done in the Kids4Fit intervention (Chapter 6). Educating (future) parents in the role they play in their children's activity life as stated above should be emphasized during interventions. The JGZ and the general practices can also play a role in giving information to parents about physical activity during consultations of children with overweight or obesity.

Improving healthy environment

Lastly, pillar three of the National Prevention Agreement is about creating healthy schools, and a healthy environment and healthcare (54). It states that in 2020, 25% of all schools should be a 'healthy school', which entails extra education on obesity, having a healthy environment, healthy food choices etc. They also state that schools should have a healthy playground at school, and that children daycares should have a

pedagogical professional who is trained in nutrition, physical activity, playtime outside and socio-emotional development of children. Healthy townships and districts are also promoted in the National Prevention Agreement, especially since the environment has a strong influence on the behavior and health of children and adults (54). It has been shown that low levels of green space, no access to a garden and no access to a run-down area are associated with childhood overweight and obesity (82). Furthermore, poor neighborhood conditions increased the probability of overweight or obesity significantly (82). Therefore, improving these conditions are crucial in the fight of obesity and the government should play a central role in this.

I believe that all the actions described in the National Prevention Agreement on promoting healthy food, increasing physical activity, and improving healthy schools and a healthy environment would lead to a more healthy lifestyle of parents and children now, and in the future and would lead to a decrease of the obesity prevalence. (54). However, many different parties are involved in taking these actions which makes it very complex. Moreover, implementing all these actions throughout the country will cost a lot of money and will take a lot of time. Therefore, whether the National Prevention Agreement will indeed deliver positive results on lifestyle changes is still to be expected.

Implications for the general practice

The role for the general practitioner in the signaling and treatment of obesity has been stated in the clinical guideline on obesity, but is now mainly demand-driven. This makes it hard since there are only 4.6, 2.9 and 2.7 consultation per year at the general practitioner for children aged 0-4, 4-12, and 12-16 years respectively (83, 84). Only this small amount of children who visit the general practice for any type of complaint are exposed to the possibility that the general practitioner brings up their weight (8). Moreover, it is even questionable how many general practitioners bring up weight problems during consultations, since it has been shown that only 53.8% of the general practitioners agreed that they should discuss weight, even if the obese patient has another reason for the consultation (14). It has also been found that weight problems were less frequently discussed by younger general practitioners (14). Therefore, (future) general practitioners should be educated on different communication techniques and ways to start the conversation about weight.

With the previously mentioned collaboration between general practices, JGZ and schools, general practices would be better aware of which children in their practice are overweight or obese which would make it easier to reach out to these children and discuss their weight status during consultations. General practices can, together with the JGZ and schools, discuss topics like diet, screen-time, and physical activity, which are all mentioned in the obesity guideline. General practices can also refer to a dietician to help

the child and parent with a healthy diet, or they can include a dietician in their general practice to make it easier to access.

If a child already has an obese weight status, the general practice can refer to a multidisciplinary intervention program such as Kids4Fit. It is important for general practices to be aware of the available intervention programs in their area, so it is easier to refer the children with obesity. The general practitioner or physician assistant should stay in contact with the children with obesity and their parents during the intervention to check the progress every 3 months, as stated in the obesity guideline (8). It would also be recommended to follow-up the child after the intervention, so that children do not regain their weight.

Lastly, from this thesis we know that children with overweight and obesity consult the general practice more often in general and more for respiratory symptoms. From other literature we know that obesity is associated with comorbidities in every organ system. Therefore, if a child with overweight or obesity consults the general practice, the general practitioner should approach the child as a whole, rather than just the one complaint, and make both the child and parents aware of the different health consequences associated with overweight and obesity.

It is, however, important to keep in mind that the general practitioner cannot stop the childhood obesity epidemic in their consultations rooms (85). Schools, families, and especially the government should take their combined responsibilities in fighting the obesity epidemic. All disciplines should work together to aim for the best results.

Future research

There are some important suggestions for future research as a results of the studies presented in this thesis. To begin with it would be interesting to investigate the barriers and facilitators of a collaboration between the JGZ, schools and general practices. Hereafter, a pilot study could research the effects of such a collaboration on overweight and obesity prevalence. If this collaboration proves to be successful, it should be implemented throughout the country.

Furthermore, more research should be done to investigate how to improve the role of the general practice in the obesity epidemic, especially since the majority (83%) of the general practitioners in the Netherlands agreed that weight management of their patients is part of their responsibility (14). Wageningen University has performed a pilot study on a minimal intervention strategy (MIS) to treat adults with overweight and obesity in the general practice (86). It is a hands-on method, with flowcharts describing different steps in the treatment process, which helps the general practitioner to find out if the patient is motivated, and it helps the general practitioner to set up a treatment plan and to evaluate the progress (86). Both the general practitioners and the patients who worked with the MIS were enthusiastic about the method. It would be interesting to

perform a similar pilot study on a MIS for the treatment of children with overweight or obesity. The MIS could also involve the role of a physician assistant and of a dietician in the general practice, so that there is a multidisciplinary approach.

To get a better understanding of the effects of childhood overweight or obesity on physical (and mental) complaints in general practice, general practitioners should be more consequent in reporting weight status in the medical files. By improving this reporting, future research can better investigate the effects of overweight and obesity, but also of weight loss, on different health outcomes such as musculoskeletal complaints in children with overweight and obesity of all ages. Furthermore, more research should be done to investigate the effects of weight loss on asthma, in order to optimize the treatment for children with overweight and obesity with asthma. If weight loss in children with overweight and obesity proves to be effective in reducing asthma symptoms, weight loss strategies can be added to the clinical guideline on asthma in children.

The long-term effects of multidisciplinary intervention programs on the health outcomes of children should be further investigated, since as of today, mainly the short term effects are studied. It is however, interesting and important to know what happens with the health outcomes after the intervention is completed. Furthermore, it would be helpful to investigate which measures (i.e. booster sessions) would be effective to maintain the health effects of intervention programs for children with overweight and obesity after the intervention has finished.

Lastly, it will be very important to see what the effects of the National Prevention Agreement will be throughout the next few years on the incidence and severity of overweight and obesity rates in the Netherlands. It does seem like a good start has been made, although I wonder whether the plans are effective enough.

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