ABSTRACT
The aim was to investigate the effects of increased water or dairy intake on total intake of energy, nutrients, foods and dietary patterns in overweight adolescents in the Milk Components and Metabolic Syndrome (MoMS) study (n = 173). Participants were randomly assigned to consume 1l/d of skim milk, whey, casein or water for 12 weeks. A decrease in the dietary pattern called Convenience Food, identified by principal component analysis, was observed during the intervention both in the water and dairy groups. Total energy intake decreased by 990.9 kJ/d (236.8 kcal/d) in the water group but was unchanged in the dairy group during intervention. To conclude, an extra intake of fluid seems to favourably affect the rest of the diet by decreasing the intake of convenience foods, including sugar-sweetened beverages. A low energy drink, such as water, seems advantageous considering the total energy intake in these overweight adolescents. This study is registered at clinicaltrials.gov (NCT00785499).

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Introduction
Plain water should be promoted as the main source of fluid for children. This is the recommendation by the Committee on Nutrition of the European Society for Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) (Agostoni et al. 2011), and it is also the official recommendation in countries such as Denmark (Ministry of Food 2013). Water contains no energy but might contribute to a feeling of fullness (Van Walleghen et al. 2007). Water might therefore stabilise or reduce total energy intake by decreasing total energy density (DellaValle et al. 2005; Van Walleghen et al. 2007; Davy et al. 2008) and could potentially contribute to one’s ability to maintain or to lose weight (Dennis et al. 2010), as indicated in studies of adults. However, evidence is mostly based on studies of a single meal and evidence related to children is sparse.

The recommendation on water consumption from ESPGHAN continues by stating that plain water should be promoted instead of sugar-sweetened beverages (Agostoni et al. 2011). However, little is known about compensation in the rest of the diet when children in non-restricted settings increase their water consumption. The few studies that have investigated this compensation (Loughridge & Barratt 2005; Muckelbauer et al. 2009; Visscher et al. 2010) could not confirm the hypothesis. To our knowledge, no studies have analysed overall changes in dietary patterns when increasing water intake.

In previous studies water has been compared with different energy containing drinks such as dairy drinks (DellaValle et al. 2005). Dairy drinks might contribute with some health effects related to maintaining or losing weight other than the energy content (Merrilees et al. 2000; Baer et al. 2011) but this has not been settled yet. This led us to investigate the effects of increased intake of water and dairy drinks on the overall diet. Therefore, the aim of this paper was to investigate how the diet changed during water and dairy intervention in the Milk Components and Metabolic Syndrome (MoMS) intervention study with overweight Danish adolescents. To firmly investigate this we looked at different dietary levels such as energy-, nutrients-, foods- and dietary-pattern levels. The MoMS study comprised four intervention groups whose participants drank 1 l/d of either water, skim milk, whey or casein. This analysis is a secondary explorative analysis of the MoMS data, for which the intervention effects on body weight (BW) and...
biomarkers for metabolic syndrome were the main outcomes. Furthermore, the MoMS study provided an opportunity to compare the effects of water intake, with three different dairy drinks, on the diet.

In addition to the public health aspect of investigating a dietary intervention effect on dietary intake, this paper also contributes with a unique methodological approach. An increasing number of observational studies during the last two decades have improved our understanding of dietary complexity by reporting dietary patterns, most commonly by principal component analysis (PCA), instead of single-nutrient or food intake in adolescents (McNaughton et al. 2008; Cutler et al. 2009; Ambrosini et al. 2010; Yannakoulia et al. 2010; Oellingrath et al. 2010; Richter et al. 2012; Hearty & Gibney 2013; Rothausen et al. 2013). However, this paper is, as far as we know, the first to evaluate the effects of an intervention study in adolescents by identifying dietary patterns by PCA. This method has been used in an intervention only once in children, specifically in toddlers (Spence et al. 2013).

Methods

Study design and participants

This paper is based on the MoMS intervention study, with 12–15 year-old adolescents (N= 203) with habitual milk and yogurt intake ≤ 250 ml/d and who were overweight, as defined by the International Obesity Task Force (age-and sex-adjusted BMI corresponding to overweight, as defined by the International Obesity) (Cole et al. 2000). The study was conducted at the Department of Nutrition, Exercise and Sports, University of Copenhagen. In the MoMS study, the participants were randomly assigned to one of four intervention groups: either 1 l/d of skim milk, whey, casein or water for 12 weeks. The nutritional composition of the test drinks have been published elsewhere (Arnberg et al. 2012), and all dairy drinks had the same protein content (3.5 g/100 g). Exclusion criteria were smoking, recent consumption of antibiotics and chronic diseases. The participants were recruited during the years 2008–2010 by sending a postal invitation to all adolescents living in the Copenhagen area who were born during the years 1995–1998, based on an extraction from the National Danish Civil Registration. The adolescents registered their diets before the intervention (week 0) and in the last week of intervention (week 12). Other measurements, such as anthropometry, blood samples, physical activity and blood pressure, were also carried out. In addition, few data from a small subsample of the participants were also collected 12 weeks prior to the intervention, but the dietary changes during the intervention period was the focus here. More details of this pre-test subsample and the MoMS study can be found in Arnberg et al. (Arnberg et al. 2012). This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects were approved by the Scientific Ethics Committees of the Capital Region of Denmark (H-A-2008–084) and registered at clinicaltrials.gov (NCT00785499). Informed written consent was obtained from all participants.

The mean intake of the test drinks as a percentage of the planned intake was 95% for water, 92% for skim milk, 91% for casein and 87% for whey, based on a compliance booklet or counting of leftovers, as earlier reported (Arnberg et al. 2012). All investigators and participants receiving a dairy product were blinded regarding the specific dairy product consumed. Blinding of water was not possible.

Dietary data

The participants were asked to consume 1 l/d of the test drink throughout the day and to eat their usual diet ad libitum during the entire study period. The dietary intake, excluding the test drink, will be referred to as the ‘background diet’. Dietary intake before the intervention and during the last days of the intervention was recorded for four consecutive days (preferably, one weekend day and three weekdays). For the diet record, a pre-coded food diary was completed each day. Portion sizes were estimated in household measures accompanied by a booklet with 12 series of food photographs. This method of diet recording has previously been validated (Trolle et al. 2011; Rothausen et al. 2012). Data were analysed at the individual level using the general intake estimation software system (GIES, version 1.000 d, developed at National Food Institute, Technical University of Denmark) and the Danish Food Composition Databank (version 7; Soborg; www.Foodcomp.dk). The selection of food groups and nutrients in this paper is based on Danish official dietary recommendations (Ministry of Food 2013) and current trends in human nutrition and obesity research. Food groups are named with a short, compressed description, such as ‘FatsAnimal’, ‘LowFatMilk’ or ‘SugaryDrink’. The estimated nutrient intake, including the test drink, was adjusted for compliance by multiplying with the proportion between the individual’s actual compliance and full compliance. Possible over- and under-reporters of energy intake were identified based on the Goldberg cutoff (Black 2000) and the Schofield equation (Alexander et al. 2004b) was used to estimate basal metabolic rate where a light activity level was assumed.
Anthropometry

Height was used as the mean of three measurements at a wall-mounted digital stadiometer, which made readings to the nearest 0.01 cm (235 Heightronic Digital Stadiometer, Quick Medical and Measurement Concepts). After an overnight fast and emptying the bladder, participants, wearing underwear and a T-shirt, were weighed to the nearest 0.1 kg on a digital scale (Tanita BWB600, Tanita). Weight gain was calculated in kg by subtracting weight before intervention from weight in the last week of intervention. BMI (kg/m²) was converted to z-scores (BAZ) using the software programme WHO AnthroPlus and the WHO growth reference (World Health Organization 2009).

Statistical analysis

Energy, nutrients and dietary pattern scores were presented as mean intake, while intake of food groups were not normally distributed and were presented as medians. Dietary patterns were displayed by PCA, including all the food group variables (g/kg BW) from before and during intervention together in long format (intake before and during intervention for each participant constituted two different rows in the data matrix) using MATLAB R2010b and PLS Toolbox, version 7.3.1. PCA is a data-driven method, which reveals latent patterns in multifactorial data, such as dietary patterns in the whole diet. These dietary patterns are identified from the inter-correlation between food group variables. Based on the PCA an individual dietary score value for each dietary pattern was assigned to each participant before and during the intervention. The score value is a measure of the participant’s adherence to a dietary pattern at a particular time point. Before the PCA the data were centred and scaled to unit variance (auto-scaling). The naming of the latent dietary patterns was based on food groups with the highest loadings within each principal component. The number of principal components was selected based on a clear change in the scree plot (Cattell RB 1966). Orthomax rotation was tried but not used, since it did not significantly alter the interpretation of the dietary patterns.

Changes in diet during the intervention were evaluated by one-way ANOVA on paired differences of intake during intervention minus intake before intervention at the levels of energy, nutrients, foods and dietary pattern score values. The same method was used to test changes over time according to sex, age and BMI. The use of paired differences eliminates the need for adjusting for confounding factors because each child was compared only with her/himself. At the energy and nutrient levels, the analyses were repeated, including the contribution from test drinks. Post hoc pairwise comparisons of the different intervention groups were executed and adjusted for multiple testing using the single-step method (Hothorn et al. 2008). Intervention groups were investigated, both as four subgroups (skim milk, casein, whey and water) and as two groups with and without an energy contribution (dairy group/water group), pooling the skim milk, casein and whey subgroups. The statistical programming environment R version 3.0.2 (www.r-project.org) was used in the analysis of dietary changes. All p values were evaluated at a 5% significance level. The power calculation for the MoMS study has previously been reported (Arnberg et al. 2012).

Results

Characterisation of participants

Two hundred and three participants were enrolled in the MoMS project, but 10 participants withdrew before the start of the intervention. Dietary records, both before and during intervention, were available from 173 participants and are included in this paper. Characteristics of these participants are presented in Table 1, which shows a higher weight gain in the dairy group compared to the water group during the

| Table 1. Characteristics of participants with complete diet data divided into intervention groups. |
|---|---|---|---|---|
| | Water group | Dairy group | p* |
| | Mean | SD | n | Mean | SD | n |
| Age, y | 13.2 | 0.7 | 50 | 13.2 | 0.7 | 123 | 0.88 |
| Weight, kg | 66.9 | 8.5 | 50 | 66.8 | 10.0 | 123 | 0.63 |
| Height, cm | 162.9 | 7.6 | 49 | 163.1 | 7.9 | 123 | 0.95 |
| BMI z-scorebd | 1.8 (38% obese) | 0.5 | 49 | 1.8(28% obese) | 0.5 | 123 | 0.55 |
| Weight gain, kg | 1.6 | 2.0 | 50 | 2.7 | 2.1 | 123 | <0.001 |
| Girls | 64% | | 50 | 60% | | 123 | 0.71 |

*Significant differences between the water and dairy groups were tested by the Mann Whitney U test for continuous variables, and by chi-squared test for categorical variables.

aAt the examination before intervention.
dObese defined as BMI z-score > 2.
intervention. The differences in weight gain have previously been reported (Arnberg et al. 2012).

Characterisation of diet and change in diet according to intervention group

For the most part, changes in the water and dairy groups (but not those in the dairy subgroups) during the intervention are reported. Additional analyses of changes within each of the three dairy subgroups and a descriptive overview of all diet variables have been placed in the online supplemental data (Tables S1A & S1B).

Energy

The total energy intake for the 173 participants was 7997 ± 2384 kJ/d (1911 ± 570 kcal/d) before intervention (week 0) and 6663 ± 2290 kJ/d (1592 ± 547 kcal/d) during intervention (week + 12), excluding the test drink. For comparison, energy intake 12 weeks prior to the intervention in a small random pre-test subgroup of 32 participants was 7278 ± 2538 kJ/d (1739 ± 607 kcal/d). Energy intake, excluding the test drink, was lower during intervention than before, both in the water group (p = 0.01) and dairy group (p < 0.0001). However, when dividing the dairy group into subgroups, this was significant only for skim milk (p = 0.0007) and whey (p = 0.0001) but not casein (p = 0.16). When including the energy contribution from test drinks, the lower energy intake during intervention compared to that before intervention was significant only for the water group (p = 0.007) but not for the dairy group (p = 0.88) (Figure 1A, B). The energy intake in the water group decreased on averages 990.9 kJ/d (236.8 kcal/d) during intervention.

The estimated proportion of under-reporters was 34% before and 55% during the intervention (including the test drink), respectively, and the estimated proportion of over-reporters was 1%, both before and during the intervention (including the test drink). However, all possible under- and over-reporters were included in all analyses in this paper, as excluding over-reporters did not change the overall results, and excluding under-reporters would seriously affect the power.

Nutrients

During intervention, the percentages of total energy (E%) from fat (p = 0.19), protein (p = 0.70) and carbohydrates (p = 0.52) did not change from the background

Figure 1. Intake of energy and macronutrients before and during intervention divided into water or dairy groups. (A) Mean intake of energy in the water group, (B) Mean intake of energy in the dairy group, (C) Mean intake of macronutrients in the water group, (D) Mean intake of macronutrients in the dairy group. Significant differences between values before and during intervention are indicated with asterisks (p < 0.001***, < 0.01**, < 0.05*), based on ANOVA followed by post hoc pairwise comparisons. If no asterisks are present, the difference was not significant.
diet in the water and dairy groups (Figure 1C,D). When including the test drink, the fat E% decreased ($p<0.0001$), while protein E% increased ($p<0.0001$) in the dairy group, but it remained unchanged for the water group, both for fat E% ($p = 0.24$) and protein E% ($p = 0.91$). The carbohydrate E%, including the test drink, did not change ($p = 0.57$) in the water and dairy groups.

**Foods**

Some foods were eaten by only a small proportion of the participants during the registration periods, which gave skewed distributions of the intake. Therefore, the percentages of the adolescents who ate the different food groups are shown in Table 2, which also includes descriptions of the different groups. A general trend of a recorded lower intake of foods per kg BW during intervention than that before intervention (Figure 2A, B) was observed. The intake of Vegetable, FatsAnimal, LowFatMilk and SugaryDrink was significantly lower, both in the dairy and water groups during intervention, while BreakfastCerealsNoAddSugar, Meat, FatsVegetable, Cheese, FruitNutSnack and FastFood were significantly lower during intervention only in the dairy group but not in the smaller water group. E.g. the decrease in SugaryDrink was on average 0.9 l/week. When divided into the four intervention subgroups, the casein group differed from the other groups by having no significant change in food groups during intervention; additionally, the overall decrease in SugaryDrink was significant only for the skim milk group ($p=0.0005$) (supplemental Table S1B).

**Dietary patterns**

Three dietary patterns appeared by PCA. Based on the loading plots, these patterns are labelled Convenience Food, Fast Food and Health-Conscious Food (Figure 3). Convenience Food explained 11% of the variation in food intake and was characterised by the highest intake of foods such as FastFood, SugaryDrink, SweatsCake and Meat. The Fast Food pattern explained 9% of the variation in food intake and was characterised by the highest intake of the food groups FastFood and Cheese, while the Health-Conscious Food pattern explained 7% of variation in food intake and was characterised by the highest intake of WheatBreadWholegrain, Fruit, BreakfastCerealsNoAddSugar and LowFatMilk, and a low intake of WheatBreadNoWholegrain. Together, these patterns described 27% of the total variation in the participants' background diet. The Convenience Food pattern was the only dietary pattern showing a significant change during intervention. The change was seen for both the water group ($p = 0.0004$) and the dairy group ($p < 0.0001$), while no significant change in the Fast Food ($p = 0.81$) and the Health-Conscious Food ($p = 0.27$) patterns was seen (Figure 2C, D). The participants had a mean score at the Convenience Food pattern that was higher before intervention than during

| Food group                  | Description                                             | Before intervention % ($n = 173$) | During intervention % ($n = 173$) |
|-----------------------------|---------------------------------------------------------|----------------------------------|----------------------------------|
| Fruit                       | Fruit and berries, fresh, cooked, frozen, preserved     | 82                               | 79                               |
| Vegetable                   | All vegetables eaten raw/cooked alone or in a dish      | 100                              | 100                              |
| BreakfastCerealsAddSugar    | Sugar puffs, sugary cereals                             | 12                               | 14                               |
| BreakfastCerealsNoAddSugar  | Oat meal, muesli, cornflakes, porridge                  | 54                               | 50                               |
| WheatBreadWholegrain        | Graniy bread, crisp bread                               | 70                               | 63                               |
| WheatBreadNoWholegrain      | White bread/bun, biscuits                               | 88                               | 88                               |
| RyeBread                    | Rye bread with and without seeds                        | 77                               | 65                               |
| PastaRice                   | Pasta, rice                                            | 81                               | 73                               |
| Potato                      | Potatoes, boiled, baked, mashed or prepared in potato salad | 49                               | 47                               |
| Fish                        | All fish and fish products eaten as sandwich spread or in a dish | 62                               | 66                               |
| Meat                        | All meat and meat products eaten as sandwich spread or in a dish, except poultry and fish | 98                               | 99                               |
| Poultry                     | All poultry and poultry products eaten as sandwich spread or in a dish | 77                               | 77                               |
| Egg                         | All egg and egg products eaten as sandwich spread or in a dish | 94                               | 93                               |
| FatsAnimal                  | Butter, spreadable butter, sauce made from butter       | 87                               | 77                               |
| FatsVegetable               | Oil, margarine, mayonnaise, remoulade, ketchup, low-fat sauce | 74                               | 63                               |
| Cheese                      | All cheese and cheese products eaten as sandwich spread or in a dish | 96                               | 90                               |
| HighFatMilk                 | Whole milk, cream, sour cream                           | 12                               | 13                               |
| LowFatMilk                  | Skimm milk, semi-skim milk, buttermilk, yogurt          | 87                               | 80                               |
| FruitNutSnack               | Cereal bar, nuts, almonds, dried fruit and fruit spread, jam, honey, peanut butter, seeds, peanuts | 64                               | 56                               |
| Chips                       | Chips, popcorn                                          | 38                               | 33                               |
| SweatsCake                  | Ice cream, candy, soufflé, Danish pastry, cookies, cream cake, pancake, cream puff, light/not light | 97                               | 92                               |
| SugaryDrink                 | Soda, juice, lemonade light/not light, cider            | 95                               | 88                               |
| FastFood                    | Fried potato, French fries, hotdog, pizza, burger, spring rolls | 75                               | 70                               |
intervention. This was also true for all intervention subgroups (supplemental table S1B).

The changes in dietary patterns, energy intake and SugaryDrink, as an example from the food level, did not differ between genders, ages and degree of overweight (data not shown).

**Discussion**

The background diet before and during a dietary intervention with water or dairy test drinks was investigated for overweight adolescents at four dietary levels: energy, macronutrients, foods and dietary patterns. Comparing the diet before and during intervention showed several changes in the background diet. A decrease in the Convenience Food dietary pattern during the intervention was observed, both in the water and dairy groups together with a general trend of lower intake at the individual food-group level, which was significant for Vegetable, FatsAnimal, LowFatMilk and SugaryDrink. This was also reflected in a lower energy intake from the background diet during intervention. These findings are especially interesting in relation to the current recommendation about drinking water to improve health.

**Dietary intake**

The energy distribution between macronutrients, both in intake before and during intervention, was within the recommended range (Carbohydrates: 50–60E%; Fat: 25–35E% and Protein: 10–20E% (Alexander et al. 2004a, 2004c, 2004d)). At the foods level, the adolescents ate less fruit and vegetables but, on average, more sugar-sweetened beverages than recommended (Ministry of Food 2013). Similar trends are seen in other Danish surveys (Hoppe et al. 2009; Pedersen et al. 2010). The dietary pattern Convenience Food identified here is, to some degree, comparable with the dietary pattern Processed, which was identified in a Danish national survey of 11–14 year-old adolescents (Rothausen et al. 2013). They also identify a Health-Conscious pattern,
Figure 3. Dietary patterns based on both diet registrations before and during intervention. (A) PCA loading plot of Convenience Food and Fast Food patterns. (B) PCA loading plot of Convenience Food and Health-Conscious Food patterns. PCA based on intake of foods (g/kg BW/day) before and during intervention.
which seems to have only a few similarities with our Health-Conscious Food pattern (Rothausen et al. 2013). The dissimilarities might be related to different selection of food groups and a higher proportion of girls in the MoMS study. A distinct Fast Food pattern appears only in the MoMS study, but not in the national survey (Rothausen et al. 2013); this might be because this study covers a selected group of overweight adolescents. A distinct Fast Food pattern has earlier been reported in a study of Brazilian obese adolescents (Dishchekenian et al. 2011), but also in a national survey of Danish adults (Knudsen et al. 2014).

Compensation in background diet during intervention

The water group showed a decrease in total energy intake during intervention and thereby indicates a long-term reducing effect of water consumption on energy intake, which supports results from acute test meals in adults (Van Walleghen et al. 2007; Davy et al. 2008). Moreover, there was no significant change in total energy intake in the dairy group (including the contribution from test drinks) between the two dietary recording periods, which could be interpreted as sufficient compensation in background diet for the energy content in the test drink. This finding is supported by two studies that investigated a long-term intervention with dairy products (Merrilees et al. 2000; Lappe et al. 2004), but which was contradicted by two short-term meal studies that showed a stable energy intake from the background diet and thereby an increase in total energy intake when including the contribution from sugary test drinks (Rolls et al. 1990; Flood et al. 2006). This could indicate a satiating effect of a protein-rich milk drink rather than a sugary drink. However, one study that tested both milk and sugar-sweetened beverage intake found an increase in total energy intake for both types of test drinks (Maersk et al. 2012). Moreover, protein content in the test drink does not explain the decrease in energy intake in the water group, which only contributes with an extra volume. Finally, the findings related to energy intake are challenged by the degree of under-reporting discussed later.

Data on foods and dietary pattern levels provide more information about the changes in the background diet. The Convenience Food intake decreased, including, for example, the food group SugaryDrink in both the dairy and water groups. This is in contrast to other intervention studies that have investigated the effects of increased water intake in children, which found unchanged intake or purchase of sugar-sweetened beverages (Loughridge & Barratt 2005; Muckelbauer et al. 2009; Visscher et al. 2010). However, our results support the assumption used in the ESPGHAN and official Danish recommendation (Agostoni et al. 2011; Ministry of Food 2013): increased water intake decreases the intake of sugar-sweetened beverages. The decrease in SugaryDrink was considerable, on average 0.9 l/week which roughly can be estimated to a possible decrease in BW of 2 kg/y based on an energy requirement of 9.4 kcal/g of weight gain in fat tissue (WHO et al. 2007). Dividing the dairy group into skim milk, casein and whey subgroups showed that only the skim milk group significantly decreased SugaryDrink, which might be because of reduced power due to relatively small groups. The Convenience Food pattern is not only characterised by SugaryDrink but rather by a range of different food groups, such as FastFood, SweetsCake, FatsAnimal, FatsVegetable and Meat, at approximately the same levels of loadings in the PCA. These other foods probably also contributed to the significant decrease in this pattern during the intervention. A noteworthy change in the background diet is the decrease in FastFood during the intervention, which also contributed to the decrease in the Convenience Food pattern, though this change was significant only in the overall dairy group possibly because of its larger sample size.

Change in dietary patterns during intervention

Only a few other studies have looked at dietary patterns in adolescence over time, and they were observational studies that had a follow-up period of several years (Mikkila et al. 2005; Cutler et al. 2009; Oellingrath et al. 2011). Moreover, these studies compared dietary patterns based on separate PCAs for each time point and not dietary scores from different time-points in the same PCA as we do, which is an attempt to ensure that score values from the different time-points are compared precisely on the same dietary pattern. We have only found one intervention study that has taken advantage of the PCA method to evaluate the effects of a dietary intervention (Spence et al. 2013). Yet, both the intervention and the age group differ considerably from the MoMS study. However, a firm investigation of the background diet at multiple levels, including dietary patterns, seems advantageous compared to the assumption of no change or similar changes for all intervention groups, e.g. only looking at energy intake. More insight into possible changes at the level of foods or dietary patterns during a dietary intervention study would increase our understanding of possible biological effects which might be due to, for example, less sugar-sweetened beverages rather than more water. Moreover, this insight would probably be valuable in decisions on optimal
future community interventions, such as promoting water intake instead of prohibiting sugar-sweetened beverages.

Relation between dietary findings and health

The health outcomes investigated in the MoMS study have been reported previously (Arnberg et al. 2012, 2013; Larnkjaer et al. 2013) and show an increased BAZ in all dairy subgroups but no change in the water group after intervention compared to before intervention (Arnberg et al. 2012). The increased BAZ in the dairy group was unexpected, as there was no change in total energy intake during the intervention. However, this might be due to an under-reporting of dietary intake; the under-reporting would possibly be amplified from first to second recording (Goris et al. 2001). Thus, under-reporting seems to be a possible limitation in all intervention groups, as BAZ did not change in the water group despite a decrease in the reported energy intake, or it may take a longer intervention period before an effect on BAZ can be observed in the water group. The rate of under-reporting is higher for adolescents and for overweight individuals than it is for younger children and for normal-weight individuals; this is probably the explanation for the relatively high proportion of under-reporters in this study compared to that in other studies (Burrows et al. 2010). In a recent review, the proportion of under-reporters using similar dietary records was 19–41% (Burrows et al. 2010) compared to 34 and 55% before and during intervention, respectively, in this study. Moreover, there is a risk of overestimating the proportion of under-reporters in a group of overweight/obese individuals due to lower metabolic activity in adipose tissue, thereby resulting in an overestimation of the basal metabolic rate (Black 2000). However, the version of the Schofield equation, both including weight and height, used in this study has been recommended to minimise this overestimation in obese individuals (Rodriguez et al. 2002).

No disadvantages of additional water intake in relation to BW and risk of metabolic syndrome were shown in the MoMS study, and the advantages of additional dairy intake are unclear (Arnberg et al. 2012, 2013; Larnkjaer et al. 2013). This again supports the recommendation of drinking water to maintain a healthy lifestyle in this study population. However, possible additional useful effects of milk intake on metabolic risk markers should continue to be investigated, including studies with smaller amounts of milk more comparable to official recommendations. Moreover, milk is an important contribution to a healthy Danish diet for adolescents to support bone health (Merrilees et al. 2000; Pedersen et al. 2010) and perhaps to decrease SugaryDrink, as indicated in the present study.

Strengths and limitations

The main strength of this study is the examination of multiple levels of the background diet. Especially, the inclusion of the whole dietary approach of well measured foods and dietary patterns increases the interpretation in relation to food-based recommendations. Moreover, the investigation was designed with no restriction of diet apart from the extra intake of the test drink each day for 12 weeks. This imitates how dietary changes may be adapted into usual life and supports free-living behaviour, which increases the interpretation of results in relation to public health.

The main limitation in this study is the possible under-reporting of dietary intake. There was an increase in under-reporting from the first to the second dietary record period, which has also been seen in other studies (Goris et al. 2001). Moreover, the under-reporting might be differentiated and, unfortunately, most pronounced for potentially unhealthy snack-related foods (Lafay et al. 2000) such as SugaryDrink. However, the degree of under-reporting does not differ between intervention groups, whereby the comparison of results between the intervention groups is likely to be relevant. However, the smaller sample size in the water group compared to the dairy group might explain some of the different findings in the two groups. A limitation related to PCA is the unavoidable subjective decisions incorporated into the definition of content and into the number of food groups even though it is a data-driven method. However, in this study, the investigation of the other dietary levels (energy, nutrients and food groups) supports the findings based on the dietary patterns. Finally, the participants were all overweight with a low habitual intake of milk, which could influence the generalisability to other groups of adolescents.

Conclusion

Consumption of extra fluid seems to have a favourable influence on the rest of the diet, as a decrease in a Convenience Food pattern was observed, including a decreased intake of the food group SugaryDrink during both water and dairy interventions. The choice of a beverage with low energy content, such as water, seems advantageous when considering the total energy intake in these overweight adolescents. These findings support the recommendation stating that plain water should be promoted as the main source of fluid for children, who should thereby reduce the intake of sugar-sweetened beverages.
beverages. This conclusion is strengthened by the multiple dietary levels included, which also cover dietary patterns identified by PCA.

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