During the last decades, changes in diet and lifestyles have accelerated with industrialization, urbanization, economic development, and market globalization. This has had a significant impact on the health and nutritional status of populations (WHO, 2003). While standards of living have improved, food availability has expanded and become more diversified, and in general, access to health services has also increased. However, there have also been significant negative consequences in terms of inappropriate dietary habits, decreased physical activity, and increased tobacco use, and at the same time a corresponding increase in diet-related chronic diseases at the global level (WHO, 2003). Young people in Europe are currently facing rapid societal change and globalization, accompanied by health risks, such as decline in consumption of healthy food and physical activity and increase in alcohol use and starting smoking at early ages, all of which show an increasing trend by age (WHO, 2009a).

Childhood obesity and dental caries are among the chronic diseases with a growing global pandemic occurrence (Edelstein, 2006; Larson et al, 2007), afflicting both developed and developing countries (WHO, 2002). These two major public health problems are related to common lifestyle factors, such as unhealthy eating habits, skipping breakfast, and smoking among children (Bruno-Ambrosius et al,
2005; Fasting et al, 2008). These maladapted habits track into later life as predictors of increased risk of obesity (Viner et al, 2006) and higher rates of caries (Bruno-Ambrosius et al, 2005). Physical inactivity seems to act as a mediating agent between obesity and poor lifestyle factors. Children who are physically inactive are more likely to consume sweetened drinks and snacks and skip breakfast, and are therefore more likely to be obese (Craig et al, 2009; Nagel et al, 2009). However, the possible relationship between caries and physical activity has so far been neglected.

Another lifestyle factor that has developed unfavourably during recent years among adolescents is alcohol intake (Croezen et al, 2009). A few studies described the relationship between alcohol consumption and overweight in adolescents (Berkey et al, 2008; Croezen et al, 2009); it is interrelated with increased consumption of sugary products and negative attitudes towards dental health (Petersen et al, 2008). However, the relationship between alcohol use and dental health among adolescents is unknown.

There is growing interest in the association between children’s weight and dental caries (Macek et al, 2006; Pinto et al, 2007a; Willerhausen et al, 2007), but only one study has explored their common contributors in terms of dietary habits and TV-viewing among children (Cinar and Murtomaa, 2008). The aim of the present study was to assess any clustering between obesity, dental health, and lifestyle factors (dietary patterns, physical activity, smoking, and alcohol consumption) among adolescents.

**MATERIALS AND METHODS**

**Study population and method**

The present data are taken from an earlier study by Christensen et al (2010), which analyzed oral health of children under the Public Dental Health Service (PDHS) in Denmark. Cluster sampling, used for identification of participants, was explained in detail previously (Christensen et al, 2010). The clusters were Danish municipalities selected for the purpose of representing various geographical areas of the country and various degrees of urbanization. Eight municipalities were selected for the study. The mean concentration of fluoride in the drinking water varied from 0.1 to 0.2 ppm (parts per million) in the municipality with the lowest level, and 0.3 to 1.9 ppm in the municipality with the highest level. From eight municipalities (15-year-old population ranging from 84 to 2211 individuals), nearly 100 adolescents aged 15 years, stratified with respect to gender, were randomly selected. The sampling procedure, carried out by the government agency for civil registration numbers, is explained in Christensen et al (2010). Such a sample design was calculated to permit identification of differences between different socioeconomic groups. Data on caries experience, DMFT (decayed, missing and filled teeth in the permanent dentition), were obtained from nationally aggregated data collected in a database established and administered by the National Board of Health since 1972 (Helm, 1973). The criteria for caries agree with standards set by the World Health Organization for the presence of initial and manifest caries (WHO, 2003). In the present study, caries occurrence was recorded at the cavity level.

According to the directives from the Danish health authorities, registration of data on oral health is mandatory by 15 years of age. In the present study, the number of reported clinical data was obtained from 76% of the study population. Information on socioeconomic and sociocultural factors, oral health, and related behaviour of the family was collected by postal questionnaires mailed to the 15-year-old adolescents and their parents. The questions to the parents were based on questionnaires used by the World Health Organization (Petersen, 1994) and the questions to the adolescents were based on a Swedish study on oral health behaviour and attitudes among teenagers (Ostberg, 2002). Information was collected on the parents’ socioeconomic status, the parents’ assessment on their children’s oral and general health, lifestyle habits including oral hygiene habits, and their children’s height and weight. Furthermore, data on the parents’ assessments of their own oral and general health, lifestyle habits, and height and weight were obtained. The adolescents’ questionnaires included their self-assessment of oral and general health, smoking habits, alcohol intake, exercise, and eating habits.

The parental questionnaire included the number of children in the family (ranging from 0 to 8), parental education (ranging from “7 years or less” to “12 years or more”), and total family annual income (ranging from “under 100,000 DKK” to “over 600,000 DKK”), scored as low = 0, moderate = 1, and high = 2 by using the 33rd percentile as the cut off. That is, low was defined as variable ≤ 33rd per-
The variable “number of children” was dichotomized according to mean (mean or above, i.e., ≥3 children = 1; below mean, i.e., 1 to 2 children = 2). A score of 1 indicates a “low” family context, whereas a score of 2 refers to a “moderate or high” family context, as low numbers of children indicate a better family context, namely better socio-economic status (Chittleborough et al, 2006; Cinar et al, 2008).

Sixty-eight percent of the parents and 66% of the adolescents completed and returned the questionnaires. Data on caries experience were merged with the questionnaire data for analysis by means of SPSS (Statistical Program for the Social Sciences). Figure 1 shows the sampling procedure and the participation rate.

**BMI-for-age [(weight in kilograms)/(height in meters)]** percentiles, developed and used as a growth and nutrition reference by the WHO, are dependent on gender- and age-specific weight-for-height charts for the ages 5 to 19 years (WHO, 2007). According to these charts, “non-obese”, “at risk for overweight”, and “overweight” were defined, respectively, as 5th percentile < BMI-for-age < 85th percentile, 85th percentile ≤ BMI-for-age < 95th percentile, and BMI-for-age ≥ 95th percentile (Macek et al,
Those who are underweight and at risk of underweight, defined as BMI-for-age ≤ 15th percentile (Levin et al, 2003), among Danish adolescents (11%, n=53) were extracted from further data analysis in order to compare non-obese and obese adolescents. The adolescents “at risk for overweight” and “overweight” were assigned to the “obese” group (Pinto et al, 2007b).

Statistical methods

Factor analysis can be used to hypothesize an underlying construct by the principal component analysis (PCA) approach; thus, it is used to find a few combinations of variables, called components or clusters, that adequately explain the overall observed variation, thereby reducing the complexity of the data. In the present study, factor analysis was applied to the variables by using PCA and Varimax rotation to analyze not the associations but the interrelationships (connection by sharing the common background factors), and common underlying dimensions among dental health, obesity, and lifestyle factors. These variables were classified into discriminative clusters (latent variables) for Danish adolescents based on factorial loadings, ranging from highest to lowest values. Loadings below 0.35 were extracted for ease of communication. The clusters are named based on the variable with highest loading. Factors were extracted according to meeting the Kaiser criterion of eigenvalue greater than 1.

Descriptive statistics, frequency distributions, the contingency coefficient for determining associations between variables, and binary logistic regression were applied. In addition, chi-square tests by cross-tabulation were applied to compare proportions, and the corresponding odds ratios were calculated. Statistical significance was set at p < 0.05.

RESULTS

Dental health and BMI measures

Adolescents’ mean DMFT was 2.03 [standard deviation (SD) = 3.01], made up of 0.57 (SD = 1.12) decayed mean and 1.45 (SD=1.91) filled teeth. Of the whole sample, 62% of adolescents experienced caries (DMFT > 0). Mean BMI was 21.30 (SD = 3.62), and 16% of the participants were classified as obese. No association appeared between obesity and DMFT (p > 0.05).

Lifestyle factors

Most adolescents were likely to have breakfast every day (76%), but their daily consumption of fruit was lower (38%). More than half the adolescents reported getting physical exercise (66%), and no alcohol consumption was reported by 57%. Smoking was less frequent among these young people (10%). Adolescents who did not have breakfast every day were more likely to be smokers (19%, Odds Ratio (OR) = 2.79: Confidence Interval (CI): 95%:1.34-5.80) and to consume alcohol (71%, OR = 2.21: CI: 95%: 1.28-3.81) than were those who regularly ate breakfast (8%, 53% respectively), (p < 0.05). Those who were smokers were more likely to consume alcohol (80%, OR = 2.87: CI: 95% 1.28-6.40) but less likely to exercise (44%, OR = 0.88: CI: 95% 0.81-0.95) than nonsmokers (consumption of alcohol, 55%; exercise, 68%), (p < 0.05).

Socioeconomic factors

Socioeconomic characteristics of adolescents are shown in Table 1. Health measures, DMFT, and BMI were not associated with any of the socioeconomic variables (p > 0.005).

Clustering between DMFT and BMI

Principal component analysis revealed that DMFT and obesity were interrelated in Danish adolescents (Table 2). The relatively high loadings (maximum 1.0) on component one (“Health cluster”) by the variables “DMFT” (0.695), “BMI” (0.598), “daily fruit consumption” (0.411) and “nonsmoking” (0.428) may reveal that those having no dental caries were also not obese, nonsmokers, and daily fruit consumers. Component two, namely “lifestyle factors I cluster”, revealed that adolescents who had breakfast and ate fruit every day were more likely to less frequently consume alcohol.

DISCUSSION

The present data were obtained from eight different municipalities. Data regarding oral health were based on the Danish standardized recording system for oral health and were obtained from databases systematically stored and administered by
### Table 1  The socioeconomic characteristics of Danish adolescents with good health and favourable lifestyle

<table>
<thead>
<tr>
<th></th>
<th>Distribution among all adolescents</th>
<th>No dental caries</th>
<th>Non-obese</th>
<th>Daily breakfast</th>
<th>Daily fruit consumption</th>
<th>Non-smoking</th>
<th>No alcohol use</th>
<th>Regular exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Number of children</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥3 children</td>
<td>25</td>
<td>43</td>
<td>15</td>
<td>80</td>
<td>47*</td>
<td>91</td>
<td>43</td>
<td>72</td>
</tr>
<tr>
<td>1-2 child</td>
<td>75</td>
<td>36</td>
<td>16</td>
<td>75</td>
<td>34</td>
<td>90</td>
<td>33</td>
<td>64</td>
</tr>
<tr>
<td>Parental education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>12</td>
<td>31</td>
<td>82</td>
<td>74</td>
<td>33</td>
<td>82</td>
<td>54</td>
<td>59</td>
</tr>
<tr>
<td>Average</td>
<td>43</td>
<td>37</td>
<td>96</td>
<td>72</td>
<td>34</td>
<td>89</td>
<td>41</td>
<td>68</td>
</tr>
<tr>
<td>High</td>
<td>45</td>
<td>41</td>
<td>90</td>
<td>80</td>
<td>41</td>
<td>92</td>
<td>41</td>
<td>65</td>
</tr>
<tr>
<td>Family income</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>25</td>
<td>32</td>
<td>14</td>
<td>73</td>
<td>38</td>
<td>82*</td>
<td>51*</td>
<td>60</td>
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<tr>
<td>Average</td>
<td>29</td>
<td>38</td>
<td>18</td>
<td>75</td>
<td>34</td>
<td>96</td>
<td>47</td>
<td>65</td>
</tr>
<tr>
<td>High</td>
<td>46</td>
<td>42</td>
<td>15</td>
<td>78</td>
<td>39</td>
<td>90</td>
<td>35</td>
<td>69</td>
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<tr>
<td>Socioeconomic status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Low</td>
<td>35</td>
<td>36</td>
<td>14</td>
<td>69*</td>
<td>36*</td>
<td>83</td>
<td>53</td>
<td>58*</td>
</tr>
<tr>
<td>Average</td>
<td>44</td>
<td>39</td>
<td>18</td>
<td>70</td>
<td>29</td>
<td>91</td>
<td>47</td>
<td>57</td>
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<tr>
<td>High</td>
<td>21</td>
<td>39</td>
<td>15</td>
<td>82</td>
<td>44</td>
<td>90</td>
<td>41</td>
<td>71</td>
</tr>
</tbody>
</table>

Ω Distribution of each category of a socioeconomic measure by favourable health and lifestyle variables is given in each row. The percentage of an unfavourable lifestyle factor plus that of its corresponding healthy lifestyle factor = 100% (e.g., 43% no dental caries means 57% dental caries, yielding 100%). *P < 0.05

### Table 2  Factor analysis for assessing lifestyle clusters of DMFT (no dental caries experience vs caries experience) and BMI (nonobese vs obese) among Danish adolescents by Varimax rotated solution

<table>
<thead>
<tr>
<th></th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Health</td>
<td>Lifestyle factors I</td>
<td>Lifestyle factors II</td>
</tr>
<tr>
<td>DMFT</td>
<td>0.695</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>BMI</td>
<td>0.538</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Daily breakfast</td>
<td>*</td>
<td>0.561</td>
<td>*</td>
</tr>
<tr>
<td>Daily fruit consumption</td>
<td>0.411</td>
<td>0.452</td>
<td>0.387</td>
</tr>
<tr>
<td>Non-smoking</td>
<td>0.428</td>
<td>*</td>
<td>0.494</td>
</tr>
<tr>
<td>No alcohol consumption</td>
<td>*</td>
<td>0.800</td>
<td>*</td>
</tr>
<tr>
<td>Regular physical exercise</td>
<td>*</td>
<td>*</td>
<td>0.863</td>
</tr>
</tbody>
</table>

The clusters in the study group, in total, accounted for 51.8% of the total variance (composed of component 1: 18.2%, component 2: 17.1% and component 3: 16.2%). † All lifestyle variables (daily breakfast and fruit consumption, smoking, alcohol use, physical exercise) classified as favourable (1) and unfavourable (0) along with health measures (no dental caries experience = 1, non-obese = 1). *Loadings below 0.35 extracted for ease of communication. The clusters are named based on the variable with highest loading.

Danish health authorities (Helm, 1973). The recording system is based upon a relatively simple coding method and standardized criteria for clinical registration that provides information on the DMF-T index. Hausen et al (2001) have suggested that data collected from public health records are not substantially inferior to those obtained from examinations by trained examiners. Consequently, the underlying data were considered of acceptable reliability.
Clinical data were available for 76% of the study population. Missing clinical data from 25% of the study population may have caused some selection bias; however, the most likely reason for the missing data is the extended intervals of dental examination to more than one year for children and adolescents with no caries incidence for years. Consequently, no data were available on these “dentally healthy” children during the study period. This may indicate that the mean figures for caries in the present results are too pessimistic. On the other hand, analysis of caries experience in the group whose parents did not respond to the questionnaire showed somewhat higher levels of caries experience than in the children of the respondents.

The response rate among parents and adolescents were 68% and 66%, respectively, which is considered satisfactory. However, questions on weight and height may be sensitive and fewer persons replied to these specific questions. The results of this study may therefore not be fully representative of the Danish adolescent population in general; nevertheless, a tendency can be shown.

The interest in the interrelation between obesity and poor dental health has been growing. In line with earlier studies (Cinar and Murtomaa, 2008; Cinar and Murtomaa, 2010), the clustering of these two health parameters among Danish adolescents, not necessarily implying an association between them, may provide further evidence that DMFT and obesity are connected by sharing some common underlying lifestyle factors, and both refer to a common parameter, namely health. Overnutrition is a type of malnutrition, and defined as “a chronic condition where intake of food is in excess of dietary energy requirements by over-consumption of energy-dense, nutrient-poor foods and leisure-time activities” (WHO, 2009b). The intake of unhealthy food (eg, soft drinks, snacking) is increased in a diet where the healthy dietary habits such as daily consumption of fruit and regularly eating breakfast are reduced (Utter et al, 2007a; Verzeletti et al, 2009). Such an unhealthy diet among adolescents is directly related to smoking (Giannakopoulos et al, 2009); both of which may contribute to obesity (Biliboni et al, 2009; Cinar and Murtomaa, 2010; Utter et al, 2007b) and dental caries (Bruno-Ambrosius et al, 2005; Cinar and Murtomaa, 2008). This is in line with the present findings that Danish adolescents who were more likely to smoke and less frequently consume fruit were more likely to become overweight and experience dental caries.

The present study found that smoking was associated with irregular breakfast consumption, alcohol consumption, and inadequate physical exercise, which agrees with previous studies (Frazier et al, 2000; Paavola et al, 2004). That may indicate that smoking may have a mediating effect between unhealthy dietary habits, irregular physical activity, and alcohol use. This needs further attention regarding the separate clustering of smoking and physical exercise as one lifestyle cluster, and alcohol consumption as another group in the present study. The interrelation between smoking and physical activity among Danish adolescents may reveal the socially networked structure of physical activity and smoking. Surprisingly, the social networks formed by adolescents involved in sports activities may provide increased opportunities for peer support of cigarette use, since the young athletes view cigarettes as a symbol of victory (Frazier et al, 2000). Conversely, other authors have found that physical activity has a protective effect against smoking (Charilaou et al, 2009) and a promoting impact on healthy eating (Kelder et al, 1994), which was found in the present study as the clustering of regular physical activity, nonsmoking, and fruit consumption.

The separate clustering of alcohol consumption along with regular breakfast and fruit consumption may highlight the significance of parental modeling. Regular breakfast consumption is a health enhancing behaviour learned by parental modeling; the adolescents whose parents skip breakfast are more likely to have infrequent breakfasts themselves (Keski-Rahkonen et al, 2003). Fruit consumption is related to family eating habits, as found previously among Turkish and Finnish preadolescents (Cinar and Murtomaa, 2008) and Danish adolescents (Krolner et al, 2009); hence, it is a behaviour learned in the family. Parental drinking is also a role model for adolescents and has been found to be a prototype that can be transmitted to adolescents (Gerrard et al, 1999). Regular alcohol intake is a common custom in families in Denmark (Bloomfield et al, 2008). Danish adolescents may thus model their parents for not only for breakfast and alcohol consumption, but also for consumption of fruit.

It is noteworthy that the findings of the present study for healthy dietary habits (daily breakfast and fruit consumption, 76% and 38%, resp), no alcohol use (57%), and nonsmoking (90%), resemble those of the HBSC (WHO Health Behaviour Survey for School-aged Children) (64%, 38%, 68%, 85%) which
follows an increasing pattern starting from the age of 11 years (WHO, 2008). Danish adolescents in the present study engage in either health enhancing or health detrimental behaviours, as already found earlier (Donovan, 1993; Aas et al, 1995), lead to improvement or endangerment of their health. Therefore, it is important that health professionals and health educators combine their efforts to promote the message of healthy eating, anti-smoking and anti-alcoholic beverages. The dental team, with its regular and periodic recall of adolescents, has a unique opportunity to promote healthy eating and anti-tobacco messages.

CONCLUSION

It may be concluded that, based on the findings of this and earlier studies, obesity and dental caries share common lifestyle factors among adolescents, regardless of nationality and different health-care systems. Thus, it seems that dental health is becoming a global health concern, and further multinational and cultural studies are needed. Improvement of dental health and general well-being of adolescents requires active collaboration between dental and general health-care providers and the implementation of health promotion strategies targeting management of both obesity and dental caries for young persons by using a holistic approach.

ACKNOWLEDGMENTS

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