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ORIGINAL ARTICLE

Body mass index and smoking: cross-sectional study of a representative sample of adolescents in Denmark

Mukesh Dhariwal · Mette Rasmussen · Bjørn E. Holstein

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Abstract
Objective To quantify the association between body mass index (BMI) and smoking (at all and daily smoking) stratified by gender, family social class, and ethnicity among adolescents aged between 13 and 15.
Methods The analyses were based on the Danish contribution to the international Health Behaviour in School-aged Children survey in 2002 with self-reported data on height, weight, and smoking behaviour. The study population comprised 3,072 students aged between 13 and 15 (1,512 boys and 1,560 girls). Logistic regression analysis was used to quantify the association.
Results Odds of at all smoking by BMI (per step) was 1.10 (95% CI 1.03–1.17) among boys but there was no association among girls (OR 0.98, 95% CI 0.93–1.04). No significant association was found for daily smoking and BMI. The association between at all smoking and BMI (per step) was significant among boys of middle social class (OR 1.13, 95% CI 1.03–1.24) and Danish ethnicity (OR 1.10, 95% CI 1.02–1.19).
Conclusion Significant association exists between smoking and BMI among boys of Danish ethnicity and middle family social class only.

M. Dhariwal (✉)
Department of Public Health, NHS Fife Windygages, Fife KY8 5RG, UK
e-mail: mukesh.dhariwal@nhs.net

M. Rasmussen · B. E. Holstein
Department of Social Epidemiology, National Institute of Public Health, University of South Denmark, Øster Farimagsgade 5-A, 1353 Copenhagen, Denmark

M. Rasmussen
e-mail: m.rasmussen@pubhealth.ku.dk

B. E. Holstein
e-mail: bho@niph.dk

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Introduction

Smoking and the behaviours that result in overweight (unhealthy diet and insufficient physical activity) are often established in adolescence from where they track into adulthood (Paul et al. 2008; Wang et al. 2008). Smoking may result in respiratory problems in adolescence and is a major risk factor for development of cardiovascular, respiratory, and cancer diseases in adults (The 2004 United States Surgeon General's Report 2004; World Health Organization 2007a, b). Overweight adolescents may face many immediate physical and psychological difficulties (Falkner et al. 2001) and major cardiovascular, respiratory, and gastrointestinal problems in adult life (Must and Strauss 1999). Therefore, in a life course perspective, adolescent smoking and overweight are of major public health importance.

Although the trends in prevalence over the last decades have differed, both smoking (Currie et al. 2004; Eaton et al. 2008) and overweight or obesity (Haug et al. 2009; Currie et al. 2004; Wang and Lobstein 2006) are prevalent in adolescents. There has been a rapid rise in childhood and adolescent overweight and obesity for the past few decades leading to an epidemic-like situation (Deckelbaum and Williams 2001; Wang and Lobstein 2006). On the contrary, the smoking prevalence among adolescents in the western world including Denmark has decreased over the years (Hublet et al. 2006; Nilsson et al. 2009; Rasmussen et al. 2008). The World Health Organization (WHO; 2007b) European ministerial conference on counteracting obesity estimated that by year 2010, approximately 15 million

children and adolescents (10% of the population) in the European region would be obese. It also observed that being overweight is the most common childhood disorder in Europe and approximately 20% children were overweight in 2004. The 2005/2006 Health Behaviour in School-aged Children (HBSC) survey (Currie et al. 2008) reveals that by 15 years of age more than 60% of adolescents had tried smoking, and 18% of adolescent population was a weekly smoker. Still, it is relatively unknown how these major problems associate in the same individuals.

Studies (Koval et al. 2008; Leatherdale et al. 2008; Potter et al. 2004) report that adolescents having weight concerns, take up smoking due to belief that smoking contributes to weight control. Leatherdale et al. (2008) argue that it is the perception of being overweight rather than the actual weight status, which is responsible for smoking initiation. They report that overweight/obese adolescents are at lower risk of smoking. A systematic review by Potter et al. (2004) reports conflicting evidence. They found some studies that reported positive association between body mass index (BMI)/body weight and smoking in either males or females, or both; some studies with no significant association, and some studies with inverse association. They also report that perception/concerns over being overweight are positively correlated with smoking. Koval et al. (2008) report that perception of being overweight among females and BMI for boys are important predictors for future smoking. Thus, the existing literature on the association between weight status and smoking among adolescents is contradictory and inconclusive. This evidence gap may hamper existing and future adolescent health policies, and therefore, there is a need for more research to synthesize the evidence. This paper aims to study the association between BMI and smoking in adolescents. Further, we aim to investigate whether the patterns of association vary by social class and ethnicity. This paper does not aim to explain the factors for adolescent smoking behaviour but focuses to quantify the association between BMI and smoking behaviour.

Methods

This study used data from the Danish contribution to the international HBSC survey in 2002. The HBSC is a WHO collaborative study, which has been conducted approximately every fourth year since 1983/1984 (Currie et al. 2009). The study is now conducted across Europe and North America (Currie et al. 2009) and the survey in 2002 included 37 countries (Currie et al. 2004).

The HBSC study includes students in three age groups, 11, 13, and 15 years (in Denmark equals to 5th, 7th, and 9th grades) from a random sample of schools in Denmark (except schools for children with learning disabilities). The data collection took place in the period February–April 2002. Out of 79 invited schools, 68 accepted to participate in the study. These 68 schools had 5,400 students in 297 classes. Of these, 4,981 students (92.2%) were present on the day of data collection, and 4,824 students (96.8% of students present) participated in the study. The participants completed the internationally standardized HBSC questionnaire about health, health behaviours, and socio-demographic situation (Roberts et al. 2009). The analyses in this study used data from 13- and 15-year-old students from grades 7 and 9, respectively. Of these 3,072 students (1,512 boys and 1,560 girls), 2,799 reported their height and weight and were included in the analyses (Due and Holstein 2002).

The following dependent variables are used in the analyses. Smoke at all: the HBSC 2002 questionnaire asked participants to rate their current smoking frequency and the options were daily, weekly, seldom, and never. This variable was derived by recoding into two categories: never smokers (including missing values) and daily, weekly or seldom smokers. Daily smoking: this variable was coded into two categories; daily smoking versus other forms of current smoking (weekly, seldom) and never smokers (including missing values). The main independent variable was BMI. The participants were asked to report their weight in kilograms without clothes and height in centimetres without shoes. BMI is calculated by formula weight (in kg)/(height in m^2). Students with missing values are not included in the analyses.

We used following covariates and stratifying variables to adjust the analyses. Gender: analyses were conducted separately for boys and girls as they often differ in their behaviour, peer relationship, and parental role model (Currie et al. 2008). Age group: the study population included participants from 13- and 15-year-olds. Ethnicity: participants were asked to report their country of birth, their parents' country of birth, and language spoken at home. We categorized Danish-speaking students born in Denmark by parents born in Denmark as Danish and all others as non-Danish. Family social class: this class was defined by the highest ranking parent, based on the coding of occupation of the father and mother in accordance with the standards of the Danish National Institute of Social Research. The categorization is similar to the one often used in UK; the Registrar General's social class classification from 1 (high) to 5 (low). This study added two extra categories: 6 (unclassifiable job) and 7 (economically inactive), i.e. living from transfer income. We recoded this information into high (1–2), middle (3–4), and low (5 and 7) and omitted group 6 as it is not possible to keep them under any category. Evenings out with friends per week: this is a measure of independence of adolescents and time spent

with friends out of parental control. The questionnaire asked the participants to indicate number of evenings they spend with their friends every week. From these, the students were grouped into three categories: no evenings/missing information, 1–3 evenings/week, and 4+ evenings/week. Mother, father, and best friend's smoking habit: the participants were asked if their mother, father, or best friend smokes everyday, sometimes, does not smoke, don't know, or they have never seen them smoking. Responses were grouped into two: smoke everyday or sometimes versus all others. Weekly alcohol consumption: the participants were asked to report type of alcoholic beverage they consume (beer, spirit, and wine) and frequency of consumption (weekly, monthly, seldom, and never). In the analyses, we combined this information into one variable: weekly alcohol consumption.

Statistical analysis

Data was analysed using 'STATA® version 10' software from Stata Corporation. Logistic regression analysis was used as the dependent variables (smoke at all and daily smoking) were dichotomous, and the independent variables/covariates were both continuous and categorical. As the survey was conducted in classes within schools, there were two possible levels of clustering causing data dependency: at school level and within a class. Results are reported after being adjusted for cluster effect by calculation of robust clustered standard errors. Crude and mutually adjusted odds ratios (ORs) with 95% confidence intervals (CIs) are reported for BMI (per step) versus smoke at all/daily smoking stratified by gender. A final model for each dependent variable was derived by using backwards, stepwise, and manual approach to logistic regression analysis. Full model was created initially, and then it was reduced manually, step by step, by removing the variable with highest p value until the model included only those variables with p values (Wald's chi-squared statistics) of 0.05 or less. An exception to this procedure was the BMI variable, as it was the main predictor variable. It was not removed in final models even if p value was higher than 0.05. Furthermore, we repeated the analyses stratified by family social class and ethnicity.

Results

Table 1 shows all the variables of interest used in the analyses stratified by gender. To show difference between boys and girls, Pearson's chi-squared p values are presented. There were fewer missing BMI values in girls in comparison to boys and boys had slightly higher average BMI (19.93 kg/m^2) as compared to girls (19.86 kg/m^2) but the difference was non-significant ($p = 0.53$). Girls were more likely to report peer smoking behaviour ($p < 0.01$) while more boys reported weekly alcohol consumption ($p < 0.01$). Girls were more likely to report 1–3 evenings out per week than boys were ($p = 0.02$).

Table 2 shows the OR (95% CI) for smoke at all and daily smoking per step increase in BMI, stratified by gender. There was significant crude association (OR 1.08, 95% CI 1.05–1.12) but non-significant association after adjustment with covariates (OR 1.01, 95% CI 0.97–1.07) as well as in final model (OR 1.03, 95% CI 0.99–1.08) between smoke at all and whole population (boys + girls). Among boys, the crude association between BMI and smoke at all was significant with OR 1.15 per step BMI (95% CI 1.09–1.21). BMI remained significantly associated with smoke at all after adjustment for other covariates (OR 1.09, 95% CI 1.02–1.17) and in the final model (OR 1.10, 95% CI 1.03–1.17). Among girls, the crude (OR 1.04, 95% CI 1.00–1.09) and mutually adjusted (OR 0.97, 95% CI 0.91–1.03) association between BMI (per step) and smoke at all was non-significant. Whole population and stratified analysis by gender showed non-significant association between daily smoking and BMI after adjustment with covariates and in final model. The interaction between BMI and family social class was significant neither among boys ($p = 0.25$) nor among girls ($p = 0.37$). Also, the interaction between BMI and ethnicity was significant neither among boys ($p = 0.10$) and nor among girls ($p = 0.16$).

Table 3 shows the OR (95% CI) for smoking behaviours by BMI (per step) stratified by gender and family social class and adjusted for all covariates. Among boys, there was a higher association between BMI (per step) and smoke at all in the middle family social class (OR 1.13, 95% CI 1.03–1.24) compared to lower (OR 1.05, 95% CI 0.92–1.20) and higher (OR 1.07, 95% CI 0.92–1.26) family social class, i.e. the association is significant only for the middle class. Among girls, an inverse but non-significant association between BMI (per step) and smoke at all was seen in all the family social classes. The association between daily smoking and BMI among boys and girls was non-significant in all the family social classes.

Table 4 shows analyses for smoking behaviours by BMI (per step) adjusted for covariates and using ethnicity and gender as stratification variables. A significant association between BMI (per step) and smoke at all was seen in Danish boys (OR 1.10, 95% CI 1.02–1.19) but not in non-Danish boys (OR 1.05, 95% CI 0.89–1.24). The association was non-significant for daily smoking among boys. Non-significant inverse association was found for smoking variables among girls of non-Danish ethnicity.

Table 1 Description of the study population by the applied variables

Variable	Boys (n = 1,512)	Girls (n = 1,560)	Total (n = 3,072)	p value[a]
BMI				
Average (SD)	19.93 (2.79)	19.86 (2.97)	19.90 (2.88)	0.53
Missing cases	150 (9.9%)	123 (7.9%)	273 (8.9%)	
Smoke at all				
Yes	275 (18.2%)	303 (19.4%)	578 (18.8%)	0.38
No	1,237 (81.8%)	1,257 (80.6%)	2,494 (81.2%)	
Daily smoking				
Yes	120 (7.9%)	139 (8.9%)	259 (8.4%)	0.33
No	1,392 (92.1%)	1,421 (93.1%)	2,813 (91.6%)	
Age group				
13 years	807 (53.4%)	812 (52.5%)	1,619 (52.7%)	0.46
15 years	705 (46.6%)	748 (47.5%)	1,453 (47.3%)	
Weekly alcohol consumption				
Yes	443 (29.3%)	345 (22.1%)	788 (25.7%)	0.00
No	1,069 (70.7%)	1,215 (77.9%)	2,284 (74.3%)	
Mother smokes				
Yes	550 (36.4%)	583 (37.4%)	1,133 (36.9%)	0.57
No	962 (63.6%)	977 (62.6%)	1,939 (63.1%)	
Father smokes				
Yes	595 (39.3%)	638 (40.9%)	1,233 (40.1%)	0.38
No	917 (60.7%)	922 (59.1%)	1,839 (59.9%)	
Best friend smokes				
Yes	372 (24.6%)	461 (29.6%)	833 (27.1%)	0.00
No	1,140 (75.4%)	1,099 (70.4%)	2,239 (72.9%)	
Evenings out with friends/week				
No evenings	336 (22.2%)	295 (18.9%)	631 (20.5%)	0.02
1–3 evenings	782 (51.7%)	903 (57.9%)	1,685 (54.9%)	0.00
4+ evenings	394 (26.1%)	362 (23.2%)	756 (24.6%)	0.07
Ethnicity				
Danish	1,236 (81.8%)	1,288 (82.6%)	2,524 (82.1%)	0.55
Non-Danish	276 (18.2%)	272 (17.4%)	548 (17.9%)	0.55
Family social class				
Higher	356 (23.5%)	337 (21.6%)	693 (22.6%)	0.20
Middle	737 (48.7%)	799 (51.2%)	1,536 (50.0%)	0.17
Lower	260 (17.2%)	291 (18.6%)	551 (17.9%)	0.29
Unclassifiable/missing	159 (10.6%)	133 (8.5%)	292 (9.5%)	

[a] p value of difference between boys and girls

Discussion

Univariate analyses show that the odds of at all smoking increases by 15 and 4% for boys and girls, respectively, per step increase in BMI. Since the year 2000, International Obesity Task Force (IOTF) has defined cut-off values for being overweight and obese among adolescents according to age and gender, based on adult BMI cut-off values for being overweight and obese (Cole et al. 2000). The difference between optimal BMI and overweight/obese is 5–10 points according to these cut-off values. Thus, the odds of being a smoker for overweight/obese boys is between 75 and 150% higher in comparison to normal weight adolescents, while for girls it is between 20 and 40% higher. BMI remained significantly associated with at all smoking among boys even after mutual adjustment for other covariates, and the increase in odds per step BMI was 9%. Mutual adjustment for other covariates made BMI insignificant among girls for smoke at all. The increase in odds per step BMI, for daily smoking variable, was 15 and

Table 2 OR (95% CI) for smoke at all and daily smoking by BMI (per step) stratified by gender

Gender	Crude OR (95% CI)	Mutually adjusted OR (95% CI)[a]	Final model OR (95% CI)
Smoke at all			
Boys + Girls	1.08 (1.05–1.12)	1.01 (0.97–1.07)	1.03 (0.99–1.08)[b]
Boys	1.15 (1.09–1.21)	1.09 (1.02–1.17)	1.10 (1.03–1.17)[b]
Girls	1.04 (1.00–1.09)	0.97 (0.91–1.03)	0.98 (0.93–1.04)[c]
Daily smoking			
Boys + Girls	1.10 (1.05–1.14)	1.02 (0.96–1.08)	1.01 (0.96–1.08)[d]
Boys	1.15 (1.07–1.22)	1.03 (0.93–1.14)	1.03 (0.94–1.13)[e]
Girls	1.06 (1.01–1.12)	1.00 (0.94–1.08)	0.99 (0.93–1.06)[f]

[a] Adjusted for age, sex, mother, father, and best friend's smoking habit, family social class, evenings out with friends per week, and weekly alcohol consumption

[b] Adjusted for father and best friend's smoking habit, evenings out with friends per week, and weekly alcohol consumption

[c] Adjusted for mother and best friend's smoking habit, evenings out with friends per week, and weekly alcohol consumption

[d] Adjusted for age, mother, father, and best friend's smoking habit, evenings out with friends per week, and weekly alcohol consumption

[e] Adjusted for age, father and best friend's smoking habit, evenings out with friends per week, and weekly alcohol consumption

[f] Adjusted for age, mother and best friend's smoking habit, evenings out with friends per week, and weekly alcohol consumption

Table 3 OR (95% CI) for smoking behaviour by BMI (per step) stratified by gender and family social class

Smoking behaviour	Family social class		
	Lower	Middle	Higher
Smoke at all			
Boys	1.05 (0.92–1.20)	1.13 (1.03–1.24)	1.07 (0.92–1.26)
Girls	0.91 (0.81–1.03)	0.97 (0.89–1.06)	0.98 (0.83–1.16)
Daily smoking			
Boys	0.93 (0.73–1.20)	1.05 (0.93–1.20)	1.11 (0.84–1.41)
Girls	0.98 (0.85–1.12)	1.00 (0.91–1.10)	1.13 (0.90–1.41)

Adjusted for age, ethnicity, mother, father, and best friend's smoking habit, evenings out with friends per week, and weekly alcohol consumption

Table 4 OR (95% CI) for smoking behaviours versus BMI (per step) stratified by gender and ethnicity

Smoking behaviour	Ethnicity	
	Danish	Non-Danish
Smoke at all		
Boys	1.10 (1.02–1.19)	1.05 (0.89–1.24)
Girls	0.98 (0.91–1.05)	0.91 (0.80–1.04)
Daily smoking		
Boys	1.04 (0.94–1.16)	0.97 (0.69–1.38)
Girls	1.03 (0.94–1.13)	0.97 (0.86–1.09)

Adjusted for age, family social class, mother, father, and best friend's smoking habit, evenings out with friends per week, and weekly alcohol consumption

6% for boys and girls, respectively, making overweight and obese adolescents at higher odds than normal weight adolescents. However, mutual adjustment for other covariates showed that BMI is not significantly associated with daily smoking. These findings are in direct contrast to the study by Leatherdale et al. (2008) who documented that increase in BMI lead to decreased susceptibility of being a smoker. However, our findings are similar to the literature review by Potter et al. (2004) over studies concerning body weight, weight concerns, and smoking in adolescents. Here inconsistent positive or no association between BMI and smoking/daily smoking was found. The popular notion that smoking helps in controlling weight might be responsible for taking up smoking in overweight and obese individuals to control their weight. Smoking cessation causes weight gain (Kawada 2004) and it might be possible that once started to reduce weight, overweight and obese adolescents continue to smoke for the fear of gaining more weight once they stop smoking. Adolescents with higher BMI often suffer from low self-esteem, poor body image, and lack of social skills (Falkner et al. 2001) and to cope up, they may indulge in smoking behaviours.

Adolescents of lower social class and Danish background tend to indulge in higher smoking behaviours (Clarkin et al. 2008; Unger et al. 2007). There is also higher prevalence of overweight/obesity in adolescents from black ethnic and lower family social class backgrounds (Gordon-Larsen et al. 2003; Lioret et al. 2009; Wang and Zhang 2006). To corroborate these findings, we

conducted data analyses to evaluate whether the association between BMI and smoke at all/daily smoking differed according to social class and ethnicity. Among boys, the association between BMI and smoke at all was significant in middle social class. There was a significant association between BMI and smoke at all in Danish adolescent boys. These findings suggest that factors like weight concerns, peer pressure, peer or parental role modelling, or parental control could be higher in overweight/obese Danish boys of middle social class compelling them to indulge in smoking behaviour. However, we did not find any statistically significant difference between Danish boys of different family social classes with respect to parental and best friend's smoking and evenings out with friends per week. We are aware of many residual factors like enforcement of restriction policies and availability of cigarettes that might influence smoking among adolescents and were not measured in our analysis and could undermine the association. Additionally, studies (John et al. 2005; Xu et al. 2007) indicate that there is 'dose–effect' relationship, i.e. association between number of cigarettes smoked daily/weekly and obesity, and it would have been interesting to see such an association, but we lacked the relevant data. Furthermore, studies (Epstein et al. 2002; Morton et al. 2006) report that polymorphisms in dopamine receptor and transporter genes are associated with current smoking and obesity and could be the explanatory factor for such an association among adolescents.

As HBSC is a cross-sectional study, any causality cannot be determined. Although the response rate was quite high, there is still a risk of selection bias caused by the non-participants and the students with missing data. Overweight/obese adolescents report more physical complaints and have higher absence in schools due to sickness (Fonseca et al. 2009; Geier et al. 2007). Thus, it is likely that many overweight and obese adolescents were absent during the day of data collection. A similar risk of selection bias is possible for adolescents who indulge in smoking. Another limitation of the school-based study is that school dropouts, who are actually at higher risk of risk behaviour, were not included in the study. School dropout is, however, very limited in Denmark. The HBSC questionnaire in Denmark is essentially administered in Danish language, so the schools for non-Danish students where medium of instruction is not Danish, were not part of the study. This could create obvious sampling bias and also limits the interpretation of ethnicity-based results.

The HBSC questionnaire is a widely applied and a standardized one based on a range of validity studies (Roberts et al. 2007). Still, there is a risk of information bias in our analyses. There is no consensus regarding the validity of self-reported height and weight and consequently BMI. There are many studies (Brener et al. 2003; Sherry et al. 2007) worldwide to ascertain the validity of self-reported height and weight, and most of them report that children tend to underestimate their weight and overestimate their height, thus, underestimating BMI in the process. In this survey, 273 (8.9%) participants did not to report their height and/or weight. This could be a major limiting factor in the power of the study as it might be possible that non-responders were different from responders. However, we conducted analyses on missing cases of BMI (data not shown) and did not find statistically significant difference in this group. Besides, 8% smokers did not report their height and/or weight, which is again a limiting factor that may affect the findings.

In general, self-reported smoking prevalence is considered a good indicator of the actual smoking status among adolescents (Dolcini et al. 2003; Kentala et al. 2004). Yet, some students may not provide valid answers and may underreport the frequency of smoking. Family social class was determined by the usage of self-report data on parental occupation and studies report that it is a good measure of parental occupation (Currie et al. 2008; Pueyo et al. 2007; Lien et al. 2001). Still, approximately 10% of respondents either did not provide the information or provided unclassifiable information. If missing/unclassifiable responses were not equally distributed among socio-economic groups, this may affect the findings. In our analyses (data not shown), the association between BMI and smoke at all was higher among boys and girls with such responses than those with valid responses. Therefore, the results related to family social class must be interpreted cautiously. Inclusion of weekly and occasional smokers in the second category might dilute the associations between BMI and daily smoking.

The HBSC study is a population-based and nationally representative survey that has the strength of allowing for more generalization than would have been possible from a clinic-based sample. It is a routine procedure to assure the respondents about anonymity and non-availability of data to parents and teachers prior to administration of questionnaire. In addition, honesty of participants is promoted during the administration of the questionnaires. Despite being a self-reported questionnaire, it carries high internal and external validity. Many variables concerning risk behaviour were validated several times by focus group interviews and full-scale pilot test studies in the classroom settings, and any problem identified was adjusted to minimize information bias. It is also notable that smoking and alcohol use among adolescents in Denmark is not perceived as a sensitive issue, so one can rely on honesty of self-reported risk behaviour (Due and Holstein 2002). Use of dichotomous-dependent variables would seem a crude measure, but in fact, it reduces bias due to reporting errors.

This study adds to the growing evidence in favour of increased risk behaviour among overweight and obese adolescents. There is need for population-based cohort studies in adolescent population to clarify if there is causality between BMI and smoking. Research is needed to provide biochemical evidence related to overweight/obesity and higher smoking tendency. In terms of perspectives for prevention, this study highlights the importance and relevance of coordinating preventive programmes aimed at smoking and obesity.

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Conflict of interest statement None.

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