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Screening risk factors for type 2 diabetes in overweight and obese adolescents in school settings of Hungary: A population-based study

Andrea Lukács [a,*], Emőke Kiss-Tóth [a,1,2], Ágnes Csordás [b,1,3], Péter Sasvári [c,1,4], László Barkai [a,d,1,5]

[a] Faculty of Health Care, University of Miskolc, Miskolc, Hungary
[b] Hungarian Association of Health Visitors, Budapest, Hungary
[c] Faculty of Mechanical Engineering and Informatics, University of Miskolc, Miskolc, Hungary
[d] Velkey László Center for Child Health, Miskolc, Hungary

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ABSTRACT

This population-based quantitative study explored the proportion of at-risk adolescents for development of type 2 diabetes (T2D) at school settings of Hungary. There were 3962 adolescents with BMIs over 85th percentile. School nurses completed a screening form to collect demographic data and risk factors for development of T2D (family history (accounted 83.3%), hypertension (75.0%), Acanthosis nigricans (37.1%), dyslipidemia (20.7%) and PCOS in females (9.6%). 512 students (262 males, 250 females) had at least two signs of conditions associated with insulin resistance and considered at-risk individuals. There was no gender difference regarding the risk factors for T2D, however, adolescents born preterm ($X^2_{(1)} = 4.292$, $p = 0.047$) and living in rural areas ($X^2_{(1)} = 5.520$, $p = 0.022$) were more likely to be at-risk. Gender difference was observed in hypertension, and boys were more afflicted with a higher T2D risk. Thirteen percent of adolescents are at-risk for development of T2D in later years. These population-based screening data highlight the need for public health approach. School settings may serve as suitable location where the screening and preventive protocol can be developed.

1. Introduction

Diabetes and its complications have been a public health dilemma for decades. The International Diabetes Federation (2015) predicts that by the year of 2040 there will be around 642 million people living with diabetes all around the world. Without appropriate action, this figure will rise. Most people suffer from type 2 diabetes (T2D), which accounts for 90–95% of all diabetes cases. The increasing rates of prediabetes and type 2 diabetes among adolescents and young adults have the potential to become a public health crisis if action is not taken to mitigate risk factors (Pinhas-Hamiel and Zeitler, 2005). Early identification of adolescents at risk presents an opportunity for early intervention to delay the onset of type 2 diabetes and possibly even the prevention of the disease altogether in school and health care personnel. Although, most children have type 1 diabetes (T1D), due to physical inactivity and the epidemic of obesity among children and adolescents (Krebs and Jacobson, 2003), prediabetes and diabetes are considered to be a growing public health concern. If this process intensifies, societies will face serious public health and economic problems (Reinehr, 2013). It is assumed that the prevalence of T2D in youths under 20 years of age will quadruple in 40 years (Imperatore et al., 2012; Pettitt et al., 2014). The emergence of

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* Corresponding author at: Faculty of Health Care, University of Miskolc, H-3515 Miskolc-Egyetemváros, B3-B4 Bld, Miskolc, Hungary.
E-mail addresses: lukacs.andrea@uni-miskolc.hu (A. Lukács), efkemci@uni-miskolc.hu (E. Kiss-Tóth), agnes.csordas@mave.hu (Á. Csordás), sasvari.peter@uni-miskolc.hu (P. Sasvári), barkail@t-online.hu (L. Barkai).
[1] Co-authors.
[2] Address: Faculty of Health Care, Univerity of Miskolc, 3515 Miskolc-Egyetemváros, Hungary.
[3] Address: Hungarian Association of Health Visitors, 1073 Budapest Akácfa u. 56. fsz. 4, Hungary.
[4] Address: Faculty of Mechanical Engineering and Informatics, University of Miskolc, 3515 Miskolc-Egyetemváros, Hungary.
[5] Address: Faculty of Health Care, Univerity of Miskolc, 3515 Miskolc-Egyetemváros, Hungary and 'Velkey László' Center for Child Health, 3526 Miskolc, Szentpéteri kapu 72-76, Hungary.

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T2D during the past decades was paralleled by the increase in pediatric obesity. Currently, there is no cure for diabetes, but lifestyle modification can prevent or delay the onset of T2D (Schellenberg et al., 2013; Tuso, 2014). T2D usually develops slowly and often without any special symptoms over a longer time. Prevention plays a vital role in avoiding T2D, but initial screening in adolescents for the disease and its pre-stages has yet to be resolved. There are some factors associated with the risk of developing T2D in youth. The American Diabetes Association recommends testing the following groups: overweight, people with a family history of T2D in first- or second-degree relatives, high risk ethnic groups, and those with signs of insulin resistance or conditions associated with insulin resistance, including acanthosis nigricans, hypertension, dyslipidemia and polycystic ovary syndrome (PCOS) in females. If an individual's BMI is in the 85th percentile or higher and has any two risk factors, he or she is considered to be at high risk for developing T2D (ADA, 2015). Testing to detect prediabetes or diabetes should be considered in children and adolescents who are overweight or obese and who have two or more additional risk factors for diabetes as family history, Acanthosis nigricans, hypertension, dyslipidemia and polycystic ovary syndrome (ADA, 2015).

The principal aim of this study was to identify the prevalence of T2D risk factors in adolescent population (aged 12–19 years) in school settings with the assistance of school nurses, and to direct the high-risk individuals into the requisite health care they need. This study also investigated the gender differences in risk factors.

2. Material and methods

2.1. Procedure and sample

This is a population-based quantitative correlational design study. Hungary is covered by seven large regions. Taking into account the population distribution, in this simple random sampling two primary and four secondary schools were chosen from each region and 10 from the capital. All the students from all classes were surveyed from the selected institutes. Students with BMI at or above the 85th percentile were included in the sample.

School nurses working in school settings were asked to assist in the completion of a screening assessment all over Hungary. The health care experts can collaborate with physicians, school personnel, students and their parents or guardians and have access to the students' medical records. Together with the students' parents, they completed a form about adolescents studying at their schools and considered overweight and obese during the academic year 2013–2014. The information included gender, age, height, weight (calculated BMI percentile), birth weight and length (available in the medical records), residency (urban or rural), born preterm (before 36 weeks) or at term, and about risk factors for T2D as having first- or second-degree relatives with T2D (parents or siblings with diabetes), acanthosis nigricans, hypertension, dyslipidemia, and PCOS in females.

2.2. Data analysis

Descriptive statistics were presented in percentages for categorical variables and mean (standard deviation) for continuous variables. The relationship between categorical variables was examined with Pearson's chi-square test. *T*-test was used to compare the ages of males and females. F-test was applied to find the relationship between increased risk and age. Data were analyzed with the Statistical Package for Social Sciences (SPSS) 22.0 software. The significance level was set at p-values ≤ 0.05.

Ethical approval

The study was approved by the Borsod–Abaúj–Zemplén County Regional Science and Research Ethics Committee and the Hungarian Diabetes Association.

The management of the schools, where the nurses completed the screening forms, was contacted to obtain their permission to participate in this research study.

Before the completion of the form, parents were informed about the purpose of the study and written consent was obtained from them together with oral assent from the adolescent students.

3. Results

3.1. Adolescents with BMI > 85th percentile

A total of 3962 students, including 2037 males (14.19 ± 3.51 y/o) and 1925 females (14.03 ± 2.21 y/o) with BMI > 85th percentile were assessed for T2D risk factors. If students' BMIs were over the 85th percentile and had two risk factors, they were considered at-risk individuals for developing of T2D. There was no significant difference in age between males and females ($t = 1.706$; $n = 3962$, $p = 0.082$) (Table 1).

3.2. Adolescents at-risk for developing T2D

Out of the 3962 overweight and obese adolescents, 1358 students had one sign and 512 (13%; male = 262, female = 250) had at least two signs of insulin resistance or conditions associated with insulin resistance and considered high-risk individuals for developing T2D.

A high proportion (83.3%) of the at-risk adolescents had relatives with T2D. Hypertension affected 75.0%, Acanthosis nigricans 37.1%, dyslipidemia 20.7% and 9.6% (of the girls) had PCOS. Significantly more adolescent boys had hypertension than girls ($X^2_{(1)} = 5{,}513$, $p = 0.024$). There were no gender differences in other risk factors. The relation between hypertension and premature birth was significant ($X^2_{(1)} = 12{,}141$, $p = 0.001$) in boys ($X^2_{(1)} = 7{,}198$, $p = 0.009$) and girls ($X^2_{(1)} = 4{,}992$, $p = 0.032$) (Table 2).

3.3. Factors correlating with increased risk for developing T2D

The F-test revealed that there was a relationship between age and risk ($F_{(1,3960)} = 27{,}212$; $p < 0.001$). As students get older, the risk of T2D increases. Premature birth ($X^2_{(1,3896)} = 4{,}292$, $p = 0.047$) and living in a rural environment ($X^2_{(1,3960)} = 5{,}520$, $p = 0.022$) also increase the risk of developing the disease. The rate between the urban and rural location in the high risk versus not at-risk groups was 0.46 and 0.36.

4. Discussion

In our study, overweight and obese adolescent students were assessed for increased risk for developing T2D. The screening criteria were based on the ADA specifications. Generally, T2D is not diagnosed as long as the symptoms are not present. Prevention or delay of the onset of diabetes is more important to the individual and the family than the diagnosis of the disease. With a longer duration of the disease, the chance of developing diabetes-related complications is increased (Pinhas-Hamiel and Zeitler, 2007). There is evidence that T2D can be prevented or delayed. Lifestyle modification, including weight loss, healthy eating habits and increasing physical activity, should be the first step to prevent or delay T2D (ADA, 2015). The most appropriate place for prevention programs could be the educational institutions where the students

Table 1
Gender characteristics of adolescents with BMIs over 85th percentile.

	Males	Females	Gender comparison	Sig.
Sample size	2037	1925		
Age (years, mean ± SD)	14.29 (±2.19)	14.18 (±2.21)	t = 1.615	N/S
Rural/urban	0.38	0.37	$X^2_{(1)} = 0.179$	N/S
Born preterm (%)	9.5	9.5	$X^2_{(1)} = 0.001$	N/S
First- or second-degree relatives with T2D (%)	33.5	35.3	$X^2_{(1)} = 1.308$	N/S
Acanthosis nigrican (%)	6.8	6.8	$X^2_{(1)} = 0.002$	N/S
Hypertension (%)	18.1	12.8	$X^2_{(1)} = 20.917$	p < 0.001
Dyslipidemia (%)	3.4	3.2	$X^2_{(1)} = 0.138$	N/S
PCOS (%)	–	1.7	–	–
At-risk for T2D (%)	12.9	13.0	$X^2_{(1)} = 0.017$	N/S

PCOS – polycystic ovary syndrome, t – *t*-test, X^2 – Chi-square test, Sig. – significance.

Table 2
Gender characteristics of adolescents at high risk for developing T2D.

	Males	Females
Sample size	262	250
Age (years, mean ± SD)	14.95 (±2.00)	14.46 (±1.95)
Rural/urban	0.43	0.49
Born preterm (%)	12.0	12.1
First- or second-degree relatives with T2D (%)	82.2	84.4
Acanthosis nigrican (%)	35.5	38.8
Hypertension (%)	79.4*	70.4
Dyslipidemia (%)	20.6	20.8
Polycystic ovary syndrome (%)	–	9.6

* $X^2_{(1)} = 5{,}513$, $p < 0.05$.

spend most of their time. All the schools in Hungary offer dining option for the students and compulsory physical education classes. Encouraging the students to exercise regularly and having normal body weight is important for every child, but more so for individuals at-risk. Exercise makes the body's muscle cells more sensitive to insulin; a sedentary lifestyle is a risk factor and obesity is considered to be the prominent risk factor for developing T2D as it leads to insulin resistance. Overweight and obese individuals are more likely to be prediabetic (Li et al., 2009). Relying also on Reinehr's study (2005), it is becoming increasingly clear that overweight and obese children should be screened for T2D.

In the present study, students in 85th percentile and above of BMIs were examined. Thirteen percent of the investigated students had at least two signs of T2D or prediabetes. This high proportion indicates that adolescents are a high risk population, so the screening of this population is a public health issue, as previously indicated by D'Adamo and Caprio (2011).

Along with obesity, a family history of diabetes is associated with T2D. Knowledge about this hereditary (likely multigenic) factor may provide the earliest screening tool to identify individuals at increased risk. Hariri et al. (2006) found the positive family history a more sensitive indicator of the presence of diabetes than obesity, which is a well-established risk. Hypertension was the other factor that has a high prevalence in youth, especially in boys. More boys had high blood pressure than girls, which was congruent with Dasgupta's longitudinal cohort study (2006) that suggests sex hormones have different effects on blood pressure levels. Hypertension is an important precursor not only of T2D but also of cardiovascular diseases. It is evident that high blood pressure is associated with obesity. Since family history is a non-modifiable risk factor, obesity and hypertension can be prevented with lifestyle modifications. Acantosis nigricans is also a perceptible risk factor for hyper insulinemia and insulin resistance, which affects both genders, but this skin disorder can result in obesity or endocrine disorder (Hu and Stampfer, 2005; Copeland et al., 2006; Guran et al., 2008). Weight loss contributes to reversing the dermatological process by reducing both insulin resistance and compensatory hyperinsulinemia (Hermanns-Lê et al., 2004).

There is some evidence that low birth weight is associated with T2D (Eriksson et al., 2003; Burke et al., 2004; Whincup et al., 2008), but there are limited studies evaluating premature birth status. We found that preterm birth (before 36 weeks of gestation) was also a risk factor for T2D. Although the main objective of our study was different, we consider this result meaningful since it confirms the Helsinki Birth Cohort Study (Kajanti et al., 2010). In our study, premature birth was specifically associated with hypertension. This finding suggests that preterm infants are more likely to have high blood pressure later in life (even in adolescence) than those born full term (de Jong et al., 2012; Vohr et al., 2010). Another interesting result of our study is the rural dominance among students at-risk. The rate of the at-risk group living in rural settings is higher than their not at-risk counterparts (0.46 vs. 0.36). Some studies have also observed a disproportion in the prevalence of T2D between urban and rural communities, with more rural residents having T2D (O'Connor and Wellenius, 2012; Hwang et al., 2012; Zabetian et al., 2012). Zabetian et al. (2012) and Hwang et al. (2012) in their meta-analysis found that prevalence of diabetes is high and rapidly rising among rural population, especially in low and middle income countries. Supposed factors are pre-existing rural health disparities, including lack of financial resources and primary care providers, but further investigation is required to identify the diabetes risk factors that are specific to rural inhabitants.

There are some limitations of this study. The risk factors for developing T2D were screened only in overweight and obese students; nevertheless, the disease can occur in normal weight individuals, although, the probability is substantially lower (ADA, 2010). The other limitation is the lack of feedback. We have no information about the real sample size of students diagnosed with T2D or its pre-stages. It was a school-based screening and the school nurses' duties were to perform the screening procedure and refer at-risk individuals to primary care for a diabetes test. It is not possible to implement a diabetes test (fasting plasma glucose test or/and 2-h oral glucose tolerance test) within the school health care system. There is no pressure on parents and it depends on their collaboration, whether they take the child to the diabetes test or not. The strengths of this study include a large sample size with females and males in equal proportions. This study was novel in its examination of adolescents. Most previous studies have evaluated adults and there are limited data available about the at-risk adolescent population.

5. Conclusion

A high proportion (13%) of overweight adolescents is at high risk for the development T2D, highlighting need for a public health approach. School settings can serve as the most suitable location

where a screening and preventive protocol can be developed. Screening at-risk adolescents in a non-clinical setting by school nurses seems to be an easy and cost-effective. Another benefit of screening in a school setting is that total population can be approached and the screening results can be provided to the individuals and their parents. School nurses can follow up the students for years during their education; and they have the knowledge to promote prevention of modifiable risk factors of diabetes. They are in a position to influence students, their parents, to collaborate with health care providers and school management, and argue for healthy school environments and facilities as well as effective health prevention programs.

Manuscript contribution

A Lukács, E Kiss-Tóth and L Barkai conceived the study design. A Lukács, E Kiss-Tóth and A Csordás collected the data. A Lukács, P Sasvári and L Barkai analyzed the data. A Lukács and L Barkai drafted the article, and all authors were involved in critical revisions and approved the final version.

The authors have no conflicts of interest to declare.

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