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Original Research Article

Prevalence of Overweight and Cardiovascular Risk Factors in Rural and Urban Children from Central Asia: The Kazakhstan Health And Nutrition Examination Survey

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ABSTRACT Kazakhstan is undergoing a rapid modernization process, which carries the risk of an epidemic of obesity and cardiovascular disease. We enrolled a sample of about 50 children for every combination of gender, environment (urban vs. rural), ethnic group (Kazakh vs. Russian), and age group from 7 to 18 years, for a total of 4,808 children. Anthropometry and blood pressure were measured on all children while fasting blood cholesterol and glucose were measured only in 2,616 children aged $\geq$12 years. The prevalence of overweight and risk of overweight ranged from 2.8 (rural male Kazakhs) to 9.1% (urban male Russians). The prevalence of prehypertension and hypertension ranged from 8.3 (urban females) to 15.9% (rural females); that of hypercholesterolemia from 11.5 (male rural Russians) to 26.5% (female rural Kazakhs); and the overall prevalence of impaired fasting glucose was 0.1%. We conclude that overweight and cardiovascular risk factors are less prevalent in children living in Kazakhstan than in those living in Western countries. However, these figures are not negligible and suggest that preventive measures are needed to contain the epidemic of overweight and cardiovascular disease that will most likely accompany the modernization of Kazakhstan in the next years. Am. J. Hum. Biol. 19:809–820, 2007. © 2007 Wiley-Liss, Inc.

Kazakhstan, the major former Soviet republic of Central Asia, is undergoing a rapid modernization process, fuelled by urbanization (Unites States Agency International Development, 2005). The coexistence of people devoted to sheep breeding in rural villages and of people following a westernized way of living in urban centers offers a great opportunity to study the effects of modernization in Kazakhstan (Facchini and Fiori, 2001). Western countries are currently experiencing an epidemic of obesity and related disorders such as hypertension, hypercholesterolemia, and diabetes (World Health Organization, 2000). Urbanization has profound effects on the health of children, who experience both the advantages and disadvantages of the urban environment (Caballero, 2005; Gracey, 2003). Available data show that obesity is more common than undernutrition in Kazakh preschool children and adults (Facchini and Fiori, 2001; Kazakhstan Demographic and Health Survey, 1996, 2000). As far as the two main ethnic groups of Kazakhstan are concerned, Kazakhs appear to have lower frequency of obesity than Russians. Despite the availability of two demographic and health surveys of Kazakhstan and some data about preschool children (Facchini and Fiori, 2001; Kazakhstan Demographic and Health Survey, 1996, 2000), very little is known about Kazakh

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children aged 7–18 years. Moreover, the prevalence of cardiovascular risk factors in the general Kazakh population is unknown, even if data obtained on small samples show higher values of blood cholesterol in rural than in urban populations (Facchini and Fiori, 2001). Using data from the Kazakhstan health and nutrition examination survey (KHAN-ES), we estimated the prevalence of overweight and cardiovascular risk factors in Kazakh children.

METHODS

Study design

KHAN-ES is a cross-sectional study, whose primary aim is to evaluate the prevalence of overweight and cardiovascular risk factors in Kazakh and Russian children living in urban and rural areas of Kazakhstan. Male and female children of the two main ethnic groups of Kazakhstan, i.e. Kazakhs and Russians, were studied between 2002 and 2004. They were aged 7–18 years and resided either in Almaty or in Chilik. Almaty is the biggest city of Kazakhstan, numbering 1,200,000 inhabitants. Chilik is a village of about 20,000 inhabitants (including neighborhoods) located at 150 km North East from Almaty and very distant from urban centers. Because of the important economical role of Kazakhstan for the petroleum industry, Almaty has experienced an increasingly westernized lifestyle in the last years (Facchini and Fiori, 2001). On the contrary, Chilik is only marginally modernized and is not industrialized at all. In fact, most Chilik inhabitants are devoted to sheep breeding and agriculture and follow a traditional lifestyle. Because of this evidence and the fact that Chilik did not meet the demographic criterions of "urban area" defined by the United States Department of Agriculture (2005), we classified its environment as "rural." Almaty is made up of six urban districts, and at the time of the study had nearly 180,000 students aged 7–18 years, attending a total of 230 different schools. Only 20 schools of 3 different districts accepted to participate to KHAN-ES, so our Almaty sample is to be considered a convenience sample. In Chilik, there were about 5,000 students aged 7–18 years attending 15 different schools, 11 of which accepted to participate to KHAN-ES. We recruited about 50 children for every combination of gender (male vs. female), environment (Almaty vs. Chilik), ethnic group (Kazakh vs. Russian), and age group (7–18 years), for a total of 4,808 children. We selected a random sample of school classes for each year of age from 7 to 18 years and an equal number of Russian and Kazakh children of both sexes for each class. Exclusion criteria were chronic or acute disease, mental impairment, having a sibling already enrolled into the study, unknown ethnic origin, and different ethnic origin of parents. The overall participation rate was about 1.5% in Almaty and 50% in Chilik. The study was conducted in conformity with the declaration of Helsinki and the study protocol was approved by the Scientific Committee of the National Institute of Nutrition of Kazakhstan. The parents of the subjects or the subjects themselves if aged $\geq$18 years gave written informed consent to participate to the study.

Anthropometry

Weight and stature were measured following the *Anthropometric Standardization Reference Manual* (Lohman et al., 1988). Body mass index (BMI) was calculated as weight (kg)/(height)^2 (m^2). Z-scores and percentiles of weight, stature, and BMI were calculated from CDC 2000 US reference values (Ogden et al., 2002). Subjects with BMI $\geq$ 85th and BMI $<$ 95th percentile were classified as "at risk of overweight" and those with BMI $\geq$ 95th percentile as "overweight" (Bellizzi and Dietz, 1999; Dietz and Bellizzi, 1999).

Blood pressure

Systolic (SBP) and diastolic blood pressure (DBP) were measured following the US National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents (2004). Subjects with SBP and DBP $<$ 90th percentile for gender, age, and stature were classified as "normotensive," those with SBP or DBP between 90th and 95th percentile as "prehypertensive," and those with SBP or DBP $>$ 95th percentile as "hypertensive" (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004).

Blood cholesterol and glucose

Fasting blood glucose and cholesterol were measured by standard laboratory methods on all children aged $\geq$12 years (n = 2,616). Hypercholesterolemia was defined as a value of blood cholesterol $\geq$ 200 mg dl^{-1} (American Academy of Pediatrics, 1998); we also calculated the number of children with blood cholesterol $\geq$ 240 mg dl^{-1} (Expert Panel on Detection, Evaluation, and Treatment of High Blood

Cholesterol in Adults, 2001). Impaired fasting glucose was defined as a value of blood glucose $\geq$ 110 mg dl^{-1} and diabetes as a value $\geq$ 126 mg dl^{-1} (Silverstein et al., 2005).

Statistical analysis

Continuous variables were evaluated as medians and percentiles because of significant deviations from normality (Shapiro–Wilk test). Between-group comparisons of continuous variables were performed with Mann–Whitney *U*-test and those of categorical variables with Fisher's exact test or Pearson's χ^2 test. The Bonferroni–Keppel correction was applied to contingency tables when multiple comparisons were made. For the most common case, i.e., 8 goups with 12 comparisons, the critical value of alpha was set to 0.029. Log-linear models were applied to 2 × 2 × 2 × 2 tables to test for interactions, with variables coded as follows: (1) Effect (eff): BMI $\geq$ 85th percentile vs. BMI < 85th percentile for gender and age; hypertension or prehypertension vs. normal blood pressure; hypercholesterolemia vs. normal cholesterol; (2) Environment (env): urban vs. rural; (3) ethnic group (eth): Kazakh vs. Russian; (4) gender (gen): male vs. female. Statistical analysis was performed using SPSS 13 (SPSS, Chicago, IL) and StatXact 7 (Cytel, Cambridge, MA). To control for the effect of age on the relationships of interest, we used a logistic regression model with age coded first as continuous and then as discrete predictor.

RESULTS

Weight, height, and BMI

Table 1 gives the 10th, 50th, and 90th percentiles of height by living environment, gender, and ethnic group. Urban male Russians were generally taller than their rural peers, while no systematic trend was observed among Kazakhs. Except for urban Russians, male children were shorter than US children (median value between 25th and 35th percentile). Females were significantly taller in Almaty than in Chilik, with the median height of urban females corresponding to the 50th CDC 2000 percentile and that of rural females <50th percentile. Tables 2 and 3 give the 10th, 50th, and 90th percentiles of weight and BMI by living environment, gender, and ethnic group. As a general rule for BMI, medians were between the 35th and 50th CDC 2000 percentile in rural males and only sporadic differences were detected between urban and rural children.

TABLE 1. Height in cm (10th percentile–50th percentile or median–90th percentile) as a function of age class

	Urban								Rural							
	Males				Females				Males				Females			
	Kazakh		Russian		Kazakh		Russian		Kazakh		Russian		Kazakh		Russian	
Age	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th
7	123.0	116.3, 130.0	124.0	116.0, 129.6	122.0	113.2, 125.0	124.1	118.9, 128.8	117.8	111.2, 126.1	125.0	114.2, 134.0	118.9	113.5, 124.3	122.5	115.2, 129.9
8	126.3	121.0, 134.1	127.5	121.1, 136.0	126.7	119.5, 136.4	126.4	119.0, 137.0	121.5	115.0, 133.3	123.5	117.0, 131.8	122.8	116.9, 130.5	123.5	117.2, 130.2
9	132.5	122.8, 139.8	132.3	126.0, 140.9	132.5	123.6, 139.0	132.5	122.3, 142.1	130.2	124.0, 138.9	130.4	122.1, 137.8	126.0	120.0, 136.0	129.9	123.0, 138.1
10	137.0	130.0, 144.5	138.7	128.6, 148.7	136.0	127.6, 145.6	137.9	130.4, 146.6	134.5	127.0, 142.0	137.0	125.0, 148.0	133.0	126.0, 141.7	133.0	124.1, 143.8
11	142.1	133.6, 152.3	144.0	133.0, 153.0	142.5	131.3, 151.3	145.5	136.7, 153.6	140.0	131.4, 149.1	139.5	130.0, 151.3	140.0	129.2, 149.5	140.0	133.8, 151.5
12	146.0	139.6, 154.4	150.5	141.3, 162.7	153.9	139.5, 161.8	150.0	141.5, 162.6	146.0	134.9, 154.6	145.2	136.5, 153.1	145.4	135.9, 156.3	148.9	138.9, 159.8
13	152.1	144.2, 163.5	156.7	145.9, 169.0	155.5	146.1, 164.5	157.8	149.2, 167.0	149.4	142.4, 157.2	152.0	141.9, 166.6	154.0	142.7, 161.5	153.5	144.0, 167.5
14	162.0	146.5, 173.0	164.0	150.4, 178.2	160.5	151.2, 168.3	163.1	153.4, 172.8	158.5	144.2, 172.1	161.0	149.0, 171.0	155.4	149.0, 164.0	158.8	148.2, 165.3
15	167.0	154.0, 179.0	171.0	158.7, 179.6	161.7	155.0, 168.3	165.2	156.0, 171.5	166.4	152.3, 177.3	165.5	154.0, 176.6	158.0	150.9, 165.5	162.0	153.0, 170.0
16	170.4	163.6, 180.0	175.0	166.2, 186.5	165.0	156.0, 172.9	165.3	156.9, 173.6	170.0	162.2, 178.8	169.0	160.6, 178.9	161.0	150.5, 169.8	162.5	152.8, 171.0
17	173.1	165.6, 180.3	179.4	170.0, 186.0	165.5	157.1, 175.6	165.5	156.9, 172.8	171.1	162.9, 179.0	172.5	164.5, 181.5	160.5	154.0, 167.4	160.0	150.3, 170.5
18	177.0	170.5, 184.3	177.0	167.6, 190.6	162.5	156.1, 172.8	165.5	159.5, 173.6	174.0	166.4, 179.8	173.2	167.0, 185.0	158.5	148.5, 163.0	162.0	156.0, 167.1

Data are distinguished by living environment, sex, and ethnic group.

TABLE 2. Weight in kg (10th percentile–50th percentile or median–90th percentile) as a function of age class

	Urban								Rural							
	Males				Females				Males				Females			
	Kazakh		Russian		Kazakh		Russian		Kazakh		Russian		Kazakh		Russian	
Age	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th
7	24.5	20.0, 28.0	24.5	20.0, 28.0	22.5	18.5, 27.0	23.5	20.0, 31.4	20.0	15.8, 23.9	23.0	17.9, 29.1	20.5	17.0, 24.0	22.3	18.6, 28.9
8	25.0	21.0, 31.6	25.0	20.8, 30.0	25.0	20.0, 29.0	25.0	20.0, 30.0	23.0	19.6, 27.0	23.0	19.0, 28.4	23.5	19.0, 27.1	23.0	19.0, 28.0
9	28.0	22.3, 35.4	28.0	24.0, 35.0	27.0	23.0, 34.2	28.0	22.0, 38.7	26.0	22.0, 33.5	25.8	22.0, 30.0	24.0	20.0, 32.0	26.0	20.0, 37.0
10	30.0	25.0, 38.0	32.5	24.0, 43.5	30.0	25.0, 35.0	31.3	24.5, 39.1	27.0	23.0, 34.0	29.0	24.0, 39.0	27.0	23.0, 36.0	26.5	23.6, 34.5
11	33.0	27.9, 42.2	34.0	28.1, 44.4	33.0	25.4, 40.2	34.0	26.0, 42.1	31.0	25.7, 37.7	33.5	25.8, 40.0	30.3	25.0, 37.9	31.0	26.0, 40.0
12	35.5	29.3, 46.7	38.5	31.2, 54.6	41.8	32.1, 52.7	36.0	30.0, 56.2	34.5	27.8, 44.0	35.0	29.5, 44.5	35.0	27.7, 45.3	38.0	29.8, 52.0
13	40.3	33.5, 57.0	43.3	33.5, 64.2	41.5	33.4, 55.2	43.0	34.6, 59.6	38.5	32.0, 45.2	40.0	31.8, 53.2	42.0	33.0, 55.0	42.0	34.0, 58.0
14	49.0	34.0, 58.3	50.0	35.5, 65.0	48.0	40.0, 56.8	51.0	36.7, 63.9	42.5	31.3, 57.2	47.0	38.0, 62.0	44.0	37.0, 53.5	48.0	36.0, 60.0
15	51.5	40.0, 63.0	56.0	41.3, 66.0	50.0	43.4, 58.0	53.5	44.3, 63.4	52.0	38.7, 63.8	53.0	42.0, 65.5	47.5	38.7, 55.3	50.0	41.0, 61.0
16	56.0	45.1, 66.8	60.0	51.1, 74.3	50.0	43.7, 58.1	53.8	45.9, 63.2	53.0	45.0, 61.8	57.0	46.0, 70.4	51.5	43.5, 67.8	53.0	44.0, 65.9
17	59.0	49.5, 70.0	64.5	53.4, 77.2	54.0	45.8, 65.4	55.0	48.0, 69.0	57.0	45.6, 64.1	58.8	53.0, 70.6	50.0	44.8, 63.2	52.0	43.6, 63.6
18	63.5	52.8, 78.5	65.0	50.1, 87.6	52.5	48.0, 64.2	54.0	44.8, 62.4	57.0	49.0, 67.0	62.5	54.0, 82.8	52.0	45.0, 55.0	54.0	45.0, 66.0

Data are distinguished by living environment, sex, and ethnic group.

TABLE 3. BMI in kg/m^2 (10th percentile–50th percentile or median–90th percentile) as a function of age class

	Urban								Rural							
	Males				Females				Males				Females			
	Kazakh		Russian		Kazakh		Russian		Kazakh		Russian		Kazakh		Russian	
Age	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th
7	16.0	14.0, 17.8	15.7	14.2, 17.2	15.3	13.4, 18.1	15.5	13.8, 21.2	14.3	12.7, 17.4	14.9	13.2, 16.6	14.3	12.6, 15.9	15.0	12.8, 17.4
8	15.7	14.0, 18.4	15.2	13.8, 17.3	15.4	13.6, 17.2	15.5	13.4, 18.3	15.4	14.0, 16.8	15.0	13.2, 17.8	15.0	13.6, 17.4	15.1	13.4, 16.8
9	15.9	14.4, 19.1	15.7	14.3, 18.8	15.7	14.0, 18.4	15.4	14.2, 19.9	15.4	14.2, 17.4	15.5	14.0, 17.6	14.8	13.2, 17.9	15.4	13.0, 20.0
10	16.5	14.6, 19.6	16.7	13.9, 22.5	16.1	14.2, 18.8	16.0	14.2, 19.9	15.4	14.0, 18.5	15.6	14.2, 18.9	15.5	13.8, 18.6	15.6	13.5, 17.4
11	16.3	14.6, 19.2	16.1	14.5, 19.6	16.4	14.0, 19.4	15.9	14.1, 18.8	15.8	14.2, 18.3	16.2	14.8, 18.7	16.0	14.1, 18.4	16.2	13.9, 19.5
12	16.5	14.7, 20.6	17.5	15.0, 21.0	17.5	15.3, 20.6	16.2	13.9, 21.8	16.6	14.9, 18.8	16.4	14.9, 20.5	16.6	14.2, 18.8	17.7	14.7, 22.3
13	17.1	15.6, 22.9	18.1	14.7, 23.9	17.6	15.0, 21.3	17.8	14.8, 22.9	17.1	14.9, 19.0	17.4	15.0, 21.2	17.9	15.6, 22.6	17.7	14.9, 23.5
14	17.9	15.6, 22.3	18.2	15.4, 22.3	18.3	15.9, 22.5	18.6	15.7, 23.5	16.8	14.5, 20.1	18.1	16.1, 22.2	18.5	15.8, 21.7	18.8	15.9, 22.8
15	18.2	15.7, 21.1	18.5	16.2, 21.9	18.7	16.7, 22.4	19.7	17.2, 22.3	18.8	16.4, 20.8	19.2	16.7, 22.0	19.0	15.3, 21.3	18.7	16.4, 22.9
16	19.4	16.4, 21.1	19.5	18.0, 22.1	18.7	16.0, 21.0	19.6	17.3, 22.8	18.4	16.3, 20.5	20.3	17.8, 24.3	19.7	17.8, 24.0	20.3	18.0, 24.4
17	19.4	16.9, 23.1	20.7	18.0, 24.1	19.7	16.9, 24.2	20.0	17.8, 24.5	19.0	17.0, 21.3	20.0	17.8, 22.1	19.9	17.5, 24.2	20.4	17.6, 24.4
18	19.7	17.5, 25.3	20.7	17.0, 25.5	20.3	18.3, 23.3	19.3	16.7, 22.6	19.1	17.0, 21.4	21.1	18.7, 25.0	20.4	18.5, 22.5	20.5	17.0, 23.9

Data are distinguished by living environment, sex, and ethnic group.

TABLE 4. Prevalence of risk of overweight and overweight in urban and rural children by gender and ethnic group (see text for details)

	Urban		Rural	
	Males	Females	Males	Females
Kazakhs at risk of overweight	6.80%	3.15%	2.33%	4.12%
Kazakhs overweight	0.85%	0.83%	0.50%	0.16%
Total at risk	7.65% (5.50–9.80)*,**	3.98% (2.42–5.54)	2.83% (1.50–4.15)	4.28% (2.67–5.89)
Total valid	$N = 588$	$N = 603$	$N = 602$	$N = 607$
Russians at risk of overweight	5.96%	5.28%	4.70%	4.98%
Russians overweight	3.14%	1.82%	1.01%	1.16%
Total at risk	9.10% (6.81–11.40)***	7.10% (5.05–9.14)	5.71% (3.85–7.58)	6.14% (4.22–8.05)
Total valid	$N = 604$	$N = 606$	$N = 595$	$N = 603$

*$P < 0.001$ as compared to male rural Kazakhs.
**$P < 0.01$ as compared to female urban Kazakhs.
***$P = 0.015$ as compared to male rural Kazakhs.

Overweight and risk of overweight

Table 4 gives the prevalence of overweight and risk of overweight by urban environment, gender, and ethnic group. Children overweight and at risk of overweight were pooled for further analyses because of the low number of overweight children. Among male Kazakhs, urban children were 2.8 times (95% CI 1.6–5.3, $P < 0.001$) more likely than rural children to be overweight or at risk of overweight; the same figure was 2.0 (95% CI 1.2–3.5, $P < 0.01$) for males vs. females among urban Kazakhs; and 2.0 (95% CI 1.1–4.0, $P = 0.015$) for Russians vs. Kazakhs among male rural children. Moreover, among male urban children, Russians were 3.8 times (95% CI 1.3–13.0, $P < 0.01$) more likely than Kazakhs to be overweight, even if the prevalence of risk of overweight and overweight together was similar (P = not significant). A log-linear and a logistic regression model were used to better study these relationships. The log-linear model was: $\lambda + \lambda^{\text{eff}} + \lambda^{\text{eff}\times\text{eth}} + \lambda^{\text{eff}\times\text{env}\times\text{gen}}$ (details not shown). In this model, eff × Kazakh was significantly different from eff × Russian ($P = 0.001$) and eff × urban × male was significantly different from eff × urban × female ($P < 0.01$). In other words, Russians were more frequently at risk of overweight or overweight than Kazakhs; males were more at risk than females in the urban environment; and urban males had the greatest overall risk. The predictors employed in the logistic model were eth (Russians as reference), env × gen (rural as reference for env and female for gen) and age as continuous variable. This analysis confirmed the results of log-linear model and showed that age did contribute to the outcome [odd ratio (OR) = 0.93 (95% CI from 0.90 to 0.97 for 1-year increase of age, $P = 0.001$]. Employing age as discrete predictor gave a similar result. It can be concluded that the risk of overweight was decreasing with age.

Hypertension

Figure 1 gives the relationship between blood pressure and age. As a general rule, DBP was higher in urban vs. rural males and SBP in rural vs. urban females, especially among adolescent Russians. This last difference increased after standardization of SBP and DBP on height (data not shown). Table 5 gives the frequency of prehypertension and hypertension in urban and rural children. Because there were no differences between ethnic groups (data not shown), the table was stratified by gender only. In Almaty, males were 1.7 (95% CI 1.3–2.3, $P < 0.001$) times more likely than females to have prehypertension or hypertension while the opposite was observed in Chilik (OR = 0.6, 95% CI 0.4–0.7, $P < 0.001$). Interestingly, while urban males were at higher risk than rural males (OR = 1.4, 95% CI 1.1–1.8, $P < 0.01$), urban females were at lower risk than rural females (OR = 0.5, 95% CI 0.4–0.7, $P < 0.001$). A log-linear and a logistic regression model were used to better study these relationships. The log-linear model was: $\lambda + \lambda^{\text{eff}} + \lambda^{\text{eff}\times\text{env}} + \lambda^{\text{eff}\times\text{env}\times\text{gen}}$ (details not shown). In this model, eff × urban was significantly different from eff × rural ($P = 0.001$) and eff × urban × male was significantly different from eff × urban × female ($P < 0.01$), whereas high BP × rural × M was significantly different from BP × rural × F and had an opposite sign ($P < 0.001$). In other words, rural females were more likely than urban females to be prehypertensive or hyper-

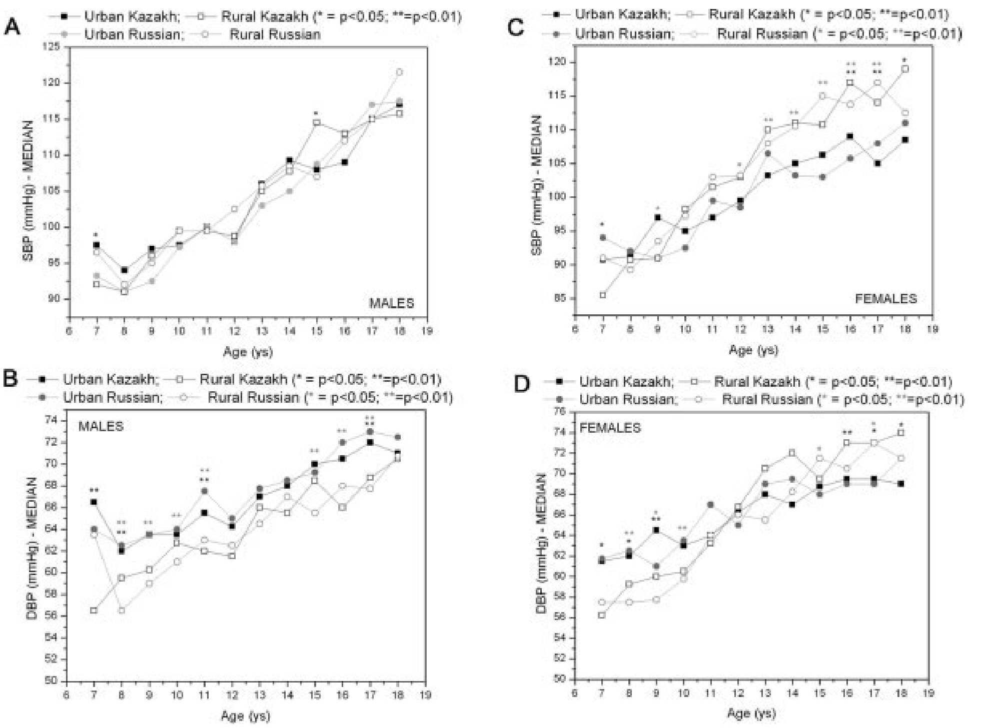

Fig. 1. SBP and DBP as a function of age. (A) SBP for males; (B) DBP for males; (C) SBP for females; (D) DBP for females. The significant differences refer to the origin area of the same ethnic Group (Mann-Whitney test).

TABLE 5. Prevalence of risk of prehypertension and hypertension in urban and rural children by gender (see text for details)

	Urban children		Rural children	
	Males	Females	Males	Females
Prehypertension	8.56% (6.97–10.15)	4.80% (3.59–6.00)	6.52% (5.12–7.91)	10.50% (8.77–12.22)
Hypertension	4.95% (3.72–6.18)	3.47% (2.44–4.51)	3.26% (2.25–4.26)	5.37% (4.10–6.64)
Total at risk	13.51%*,# (11.57–15.45)	8.27%## (6.72–9.82)	9.77%** (8.09–11.46)	15.87% (13.81–17.93)
Total valid	$N = 1{,}192$	$N = 1{,}209$	$N = 1{,}197$	$N = 1{,}210$

*$P < 0.001$ as compared to urban females.
**$P < 0.001$ as compared to rural females.
#$P < 0.01$ as compared to rural males.
##$P < 0.001$ as compared to rural females.

tensive, while for males there was an opposite trend. Altogether, the risk was however higher in rural area. The predictors employed in the logistic model were env (rural as reference), env × gen (rural as reference for env and female for gen) and age as continuous variable. This analysis confirmed the results of log-linear model and showed that age did contribute to the outcome [OR = 1.11 (95% CI 1.08–1.14 for 1-year increase of age, $P < 0.001$]. Employing age as discrete predictor gave a similar result. It can be concluded that the risk of hypertension was increasing with age.

Hypercholesterolemia

Table 6 gives the 10th, 50th, and 90th percentiles of blood cholesterol levels by environment, gender, and ethnic group. Medians and 90th percentiles were similar for gender and ethnic groups within urban areas, even if

TABLE 6. Total cholesterol in mg/dl (10th percentile–50th percentile or median–90th percentile) as a function of age class

	Urban								Rural							
	Males				Females				Males				Females			
	Kazakh		Russian		Kazakh		Russian		Kazakh		Russian		Kazakh		Russian	
Age	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th
12	194.4	117.8, 216.2	174.4	122.7, 222.4	149.7	108.0, 207.7	174.1	121.5, 224.3	177.9	137.7, 236.7	174.1	142.0, 208.5	187.6	133.1, 253.4	176.0	143.1, 206.2
13	160.1	111.0, 220.5	166.3	123.9, 208.1	157.0	115.8, 206.9	155.1	118.1, 202.7	185.7	136.6, 230.9	177.9	154.3, 197.7	185.7	149.3, 266.1	170.2	150.9, 197.3
14	148.1	116.0, 205.8	161.7	123.9, 216.6	155.1	116.2, 201.5	171.0	122.7, 214.3	177.9	131.5, 232.1	177.9	139.3, 208.9	185.7	150.9, 232.1	177.9	154.7, 216.6
15	156.3	119.9, 206.2	152.4	112.0, 200.4	160.1	123.4, 221.2	167.5	127.7, 217.4	177.9	144.7, 232.1	177.9	143.1, 199.6	166.3	143.1, 229.4	185.2	150.9, 228.2
16	143.9	114.6, 215.4	156.7	105.0, 194.2	155.1	121.8, 206.6	162.5	123.7, 220.5	177.9	140.8, 215.8	177.9	150.9, 204.2	177.9	145.5, 242.9	170.2	139.3, 202.7
17	158.6	120.1, 216.2	158.6	115.1, 201.5	157.8	119.8, 220.5	162.5	125.6, 210.0	181.8	135.0, 229.8	177.9	150.9, 208.9	177.9	140.8, 242.9	170.6	147.0, 208.1
18	156.3	116.8, 215.1	151.6	115.6, 234.0	153.2	111.5, 205.8	146.6	130.5, 188.8	185.7	152.8, 241.8	177.9	154.7, 196.1	197.3	135.4, 242.9	166.3	150.9, 194.2

Data are distinguished by living environment, sex, and ethnic group.

Russian females tended to have greater values of cholesterol than Kazakh females. In rural areas, however, Kazakh males and females had greater 90th percentile values than their Russian counterparts. Rural males and females had higher cholesterol values than urban peers ($P < 0.01$; Mann–Whitney test). Table 7 gives the prevalence of hypercholesterolemia in urban and rural children at cut-points of 200 and 240 mg dl^{-1} and for pooled subjects. In rural areas, male Kazakhs were nearly two times more likely (OR = 1.9; 95% CI 1.3–3.0, $P < 0.01$) than male Russians to have hypercholesterolemia and the same was observed for females (OR = 1.8; 95% CI 1.1–2.8, $P < 0.01$). The contribution of children with cholesterol $\geq$ 240 mg dl^{-1} to this risk was not negligible. Lastly, rural Kazakh females had an increased risk of hypercholesterolemia as compared with their urban peers [OR = 1.58 (1.09–2.29), $P = 0.018$. A log-linear and a logistic regression model were used to better study these relationships. The log-linear model was: $\lambda + \lambda^{\text{eff}} + \lambda^{\text{eff}\times\text{eth}} + \lambda^{\text{eff}\times\text{env}} + \lambda^{\text{eff}\times\text{env}\times\text{eth}}$ (details not shown). In this model, eff $\times$ Kazakh was significantly different from eff $\times$ Russian ($P = 0.01$) and the main effect of gender was of borderline significance ($P = 0.057$). Moreover, eff $\times$ urban $\times$ Kazakh and eff $\times$ rural $\times$ Russian were significantly different but with opposite signs ($P = 0.02$ for both interactions). In other words, Kazakhs were more likely than Russians to have hypercholesterolemia; rural Kazakhs were more at risk than urban Kazakhs, while for Russians it was just the opposite. Logistic regression analysis confirmed the results of the log-linear model and showed that age did contribute to the outcome [OR = 0.92 (95% CI 0.86–0.97 for 1-year increase of age, $P < 0.01$]. Employing age as discrete predictor gave a similar result. It can be concluded that the risk of hypercholesterolemia was decreasing with age.

Impaired fasting glucose

Table 8 gives the 10th, 50th, and 90th percentiles of blood glucose levels stratified by environment, gender, and ethnic group. Medians and percentiles were similar for gender and ethnic group within urban areas, even if Kazakh females had generally higher values of glucose than Russian females. On the contrary, in rural areas, Kazakhs tended to have higher 90th percentiles than Russians, and Kazakh females had higher levels of glucose

TABLE 7. Prevalence of risk of hypercholesterolemia in urban and rural children by gender and ethnic group (see text for details)

	Urban children		Rural children	
	Males	Females	Males	Females
Kazakhs $\geq$ 200 (mg dl^{-1})	17.35%	17.02%	17.02%	17.77%
Kazakhs $\geq$ 240 (mg dL^{-1})	2.21%	1.52%	5.47%	8.73%
Total at risk	19.56% (15.19–23.92)	18.54% (14.34–22.74)	22.49%* (17.98–27.00)	26.51%**,# (21.76–31.25)
Total valid	$N = 317$	$N = 329$	$N = 329$	$N = 332$
Russians $\geq$ 200 (mg dL^{-1})	13.15%	19.39%	10.22%	11.55%
Russians $\geq$ 240 (mg dL^{-1})	1.53%	1.21%	1.24%	2.43%
Total at risk	14.68% (10.84–18.51)	20.60% (16.24–24.97)	11.46% (7.98–14.93)	13.98% (10.23–17.73)
Total valid	$N = 327$	$N = 330$	$N = 323$	$N = 329$

*$P < 0.01$ as compared to male rural Russians.
**$P < 0.01$ as compared to female rural Russians.
#$P = 0.018$ as compared to female urban Kazakhs.

than Russian females. Only 3 out of 2,616 subjects (0.11%) had impaired fasting glucose and none had diabetes.

Clusterization of overweight, hypertension, and hypercholesterolemia

Table 9 gives the prevalence of prehypertension and hypertension, hypercholesterolemia, and both, in urban and rural children on the basis of weight status. In the full sample (n = 4,808), children at risk of overweight and overweight had nearly three times the risk of hypertension of normal weight-children in both urban (OR = 2.9, 95% CI 1.9–4.2, $P <$ 0.001) and rural areas (OR = 3.2, 95% CI 2.1–5.0, $P <$ 0. 001). In the subsample of children aged 12 years and over, who underwent blood measurements (n = 2,616), urban subjects at risk of overweight or overweight were 2.7 times more likely (95% CI 1.6–4.4, $P < 0.001$) to have hypercholesterolemia than normal-weight children. Finally, the risk of prehypertension or hypertension together with hypercholesterolemia was 4.2 times higher (95% CI 2.1–7.8, $P <$ 0. 001) in children at risk of overweight or overweight.

DISCUSSION

Using data from KHAN-ES, we evaluated the prevalence of overweight and cardiovascular risk factors in a large sample of Kazakh children. To our knowledge, this is the first study of this kind performed in a rapidly modernizing ex-Soviet Republic of Central Asia.

Overweight

The prevalence of overweight and risk of overweight in our sample ranged from 2.8 (rural male Kazakhs) to 9.1% (urban male Russians). These estimates are substantially lower than those reported for most Western countries; for instance, in 2003/4, 17.1% of US children and adolescents were overweight (Ogden et al., 2006). Interestingly, overweight and risk of overweight were more frequent among Russians than among Kazakhs and male urban children were at greater risk than their rural peers. This is in contrast with the finding that in Western countries, where overweight is presently more frequent among rural than among urban children (Caballero, 2005; Gracey, 2003; McMurray et al., 1999; Tognarelli et al., 2004). However, before 1980, urban areas were at greater risk of overweight than rural areas (Dietz and Gortmaker, 1984; Malina, 1993) and the same phenomenon is currently observed for some developing countries (Jackson et al., 2003; Pena Reyes et al., 2003). An anthropometric study of Kazakh children aged 4.0–4.9 years is available but it was performed in the 90s and gives no data about overweight (Dangour et al., 2003). In a group of Kazakh women aged 15–49 years, the prevalence of obesity (BMI $\geq$ 30 kg m^{-2}) was 17.6% in the urban area and 15.6% in the rural area (Facchini and Fiori, 2001; KDHS, 1996). The prevalence of overweight detected by KHAN-ES for school-aged children is lower and fits well with the estimate of 4.3% given by De Onis and Blosser (2000) for Kazakh pre-school overweight children. In Uzbekistan, the prevalence of overweight is 6.7% in males and 7.8% in females aged 15–19 years (Mishra et al., 2006). In Iran, the prevalence of overweight in male children aged 6–18 years is 17.1% in urban areas and 14.2% in rural areas (Lafta and Kadhim, 2005). The prevalence of risk of overweight in children is 7.7% in China, 9.0% in Russia, and <10% in Lithuania

TABLE 8. Blood glucose in mg/dl (10th percentile–50th percentile or median–90th percentile) as a function of age class

	Urban								Rural							
	Males				Females				Males				Females			
	Kazakh		Russian		Kazakh		Russian		Kazakh		Russian		Kazakh		Russian	
Age	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th	50th	10th, 90th
12	81.5	58.1, 99.5	74.0	57.9, 85.9	72.2	63.0, 96.8	70.2	60.1, 91.1	70.2	54.0, 79.2	72.0	61.6, 85.1	69.3	63.7, 91.1	68.4	56.7, 86.4
13	73.3	59.0, 96.3	74.9	59.4, 90.0	75.1	59.4, 90.5	73.8	56.1, 89.8	72.0	61.2, 90.0	70.2	57.6, 86.4	70.2	57.6, 86.4	66.6	54.0, 84.6
14	83.0	62.2, 98.6	79.4	62.4, 93.1	74.2	59.0, 97.9	72.5	62.5, 90.7	70.2	57.6, 83.7	72.0	61.0, 86.6	70.2	64.8, 88.2	72.0	64.8, 82.4
15	74.5	60.0, 90.2	71.8	59.5, 89.5	79.0	59.5, 95.2	71.3	57.4, 90.2	68.4	61.2, 88.6	73.8	55.8, 88.2	72.0	61.2, 90.0	70.2	61.2, 86.4
16	72.2	57.1, 89.5	75.2	58.2, 90.2	74.9	64.6, 92.7	72	61.0, 90.0	72.0	54.0, 84.6	72.0	58.0, 82.1	71.1	58.7, 89.5	68.4	54.6, 82.8
17	77.2	57.4, 91.8	73.8	55.5, 89.6	74.5	65.9, 90.3	77.4	61.0, 92.5	72.0	54.0, 90.0	72.0	57.6, 81.0	72.0	57.6, 90.0	71.1	57.8, 89.5
18	72.7	62.5, 92.0	74.5	56.8, 90.2	72.2	57.4, 90.0	78.8	58.7, 86.4	68.4	65.7, 89.1	72.0	62.3, 79.2	72.0	63.0, 86.4	68.4	57.6, 73.1

Data are distinguished by living environment, sex, and ethnic group.

(Lissau, 2004; Wang et al., 2002). So, our estimates of prevalence of overweight are in agreement with those available in the literature.

Hypertension

The prevalence of prehypertension and hypertension was influenced by gender, living environment, and weight status, but not by ethnic group, with estimates ranging from 8.3% (urban females) to 15.9% (rural females). These estimates are lower than those available in the literature for Western populations (Sorof et al., 2004). While urban male children were at greater risk of prehypertension and hypertension than rural male children, the opposite was observed for females. As a further confirmation of this finding, rural females showed higher values of blood pressure also after correction for stature. Even if unexpected, this finding may be very important and we are planning further analyses of potential risk factors to explain this association. As expected (Sorof et al., 2004), subjects overweight or at risk of overweight were more likely to be prehypertensive or hypertensive than those with normal weight (23.9% vs. 9.9% and 30.7% vs. 11.9% for urban and rural children, respectively). The prevalence of hypertension in Kazakhstan is presently unknown except for little groups (Fiori et al., 2000b). A study performed in Kyrgyzstan gives however a prevalence of high blood pressure of about 8% for rural children aged 15–19 years (Young et al., 2005). Unfortunately, data from Uzbekistan are not directly comparable with ours because of a different cut-point for hypertension (Mishra et al., 2006). However, comparisons with other countries can be made. Hypertension is common in children from Pakistan (Jafar et al., 2005) but less common in rural communities of Iran (5.2–8.7%) and Estonia (6.0–11%) (Grunberg and Thetloff, 1998; Kelishadi et al., 2006).

Hypercholesterolemia

In the subjects aged ≥12 years, the prevalence of hypercholesterolemia ranged from 11.5% (male rural Russians) to 26.5% (female rural Kazakhs). Importantly, about 9% of rural Kazakh females and 5% of rural Kazakh males had values of cholesterol ≥ 240 mg dl^{-1}. As a rule, rural children tended to have higher cholesterol values than urban children; in rural areas, Kazakh females had higher values of cholesterol than Russian

TABLE 9. Prevalence of prehypertension and hypertension, hypercholesterolemia, and both in urban and rural children by overweight status

Environment	BMI status	Prehypertension or hypertension [blood pressure (n = 4,808)]	Hypercholesterolemia [Cholesterol (n = 2,616)]	Prehypertension or hypertension and hypercholesterolemia (n = 2,616). High
Urban	Not overweight or at risk of overweight	9.89% (8.65–11.13)	17.26% (15.15–19.38)	
Urban	Overweight or at risk of overweight	23.95%* (17.46–30.43)	36.0%# (25.14–46.86)	
Rural	Not overweight or at risk of overweight	11.95% (10.62–13.28)	18.70% (16.54–20.87)	
Rural	Overweight or at risk of overweight	30.70%** (22.23–39.17)	17.74% (8.23–27.25)	
Urban and rural	Not overweight or at risk of overweight			2.62% (2.35–3.70)
Urban and rural	Overweight or at risk of overweight			10.22%## (5.15–15.29)

*$P < 0.001$ as compared to not at risk of overweight children.
**$P < 0.001$ as compared to not at risk of overweight children.
#$P < 0.001$ as compared to urban not at risk of overweight children.
##$P < 0.001$ as compared to not at risk of overweight children.

females while no difference was found in urban areas. In the Central Asia High Population Project (Facchini and Fiori, 2001; Fiori et al., 2000a), we found that rural Kazakhs have higher cholesterol values than rural Kazakhs, Uigurs, and Kirghizs. A prevalence of hypercholesterolemia similar to ours was reported in children from Iran (12%–21%, Azizi et al., 2001) and Estonia (11%–24%, Grunberg and Thetloff, 1998) but a lower prevalence was reported for Siberian children (5%, Denisova et al., 1998).

Impaired fasting glucose

The prevalence of impaired fasting glucose was 0.1% and none of the children had diabetes. This estimate is substantially lower than that reported for most Western countries; for instance, in the US this figure is presently around 2% (Silverstein et al., 2005).

Clusterization of risk factors

Even if children at risk of overweight and overweight were generally at greater risk of hypertension, a greater risk of hypercholesterolemia was observed only for urban children. Not unexpectedly, children at risk of overweight and overweight were at greater risk of concomitant hypertension and hypercholesterolemia. Further studies are needed to explain the role of age in determining the risk of overweight and hypercholesterolemia and hypertension.

Study limitations

Even if KHAN-ES is the first study to investigate the contribution of the living environment, gender, and ethnic group to overweight and selected cardiovascular risk factors in children living in Kazakhstan, it has some limitations. The main limitation is that Almaty and Chilik are not representative of all urban and rural areas of Kazakhstan. Thus, our results cannot be extended to the overall population of Kazakhstan; they may also not apply to other ethnic groups besides Kazakhs and Russians, which nonetheless represent about 80% of ethnic groups in Kazakhstan. Another potential limitation is that the reference values employed for BMI, blood pressure, cholesterol, and blood glucose were developed in the US population (Iughetti et al., 2000). The US population is currently undergoing an epidemic of obesity so that the employed reference values of BMI may have artificially increased with a possible underestimation of the prevalence of overweight in our children (Flegal et al., 2001). Moreover, we did not collect blood sample in children aged less than 12 years. Thus, our conclusions about hypercholesterolemia and impaired fasting glucose apply only to children aged from 12 to 18 years.

CONCLUSION

In conclusion, while overweight risk and cardiovascular risk factors are presently less prevalent in children living in Kazakhstan than those living in Western countries, their estimates are not negligible and suggest that preventive measures are needed to contain the likely epidemics of overweight and cardiovascular risk factors that could accompany the modernization of Kazakhstan in the next years. Some of the differences found between environments, ethnic groups, and gender are probably explained by anthropological, nutritional, and socio-economical factors and further work is in progress to define the contribution of these factors to the state of health of Kazakh children.

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