Research Journal of Medical Sciences 5 (4): 176-183, 2011
ISSN: 1815-9346

The Adipokines Resistin and Visfatin in Overnourished and Obese Adolescentsld of a Population at High Risk to Develop Diabetes Mellitus Type 2

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Abstract: Obesity in adolescents often remains in adult life and poses obese young males and females to the risk of suffering DM in future or even develop the metabolic syndrome early in life. Prevalence of diabetes mellitus type 2 is frequent in Thailand in particular in the Northeast of the country. The aim of this investigation was to search for early indications of future insulin resistance of overnourished and obese male and female high school students residing in northeastern Thailand. Eighty one male and 219 female high school students with a median age of 15 had been recruited for a cross sectional study. The nutritional status was defined by BMI values adjusted to the IOTF standard. Besides BMI also biceps and triceps skin fold measurements had been taken, in addition to the determination of triglycerides, fasting plasma glucose, insulin HOMA-IR and the adipokines resistin and visfatin. For evaluating the results non-parametric statistics had been applied and a univariate as well multivariate regressions had been conducted. Anthropometric variables, triglycerides, insulin, HOMA-IR and resistin were found to be elevated in the groups of overnourished and obese adolescents. Visfatin did not statistically differ between groups of the different nutritional status but together with sex, skin folds, triglycerides and HOMA-IR contributed significantly to the variation of the BMI selected as dependent variable while resistin did not correlate significantly with BMI. The nutritional status determines the resistin and visfatin blood levels only marginally in a group of overnourished and obese adolescents belonging to a population of high risk to develop diabetes mellitus type 2. The correlation of visfatin to BMI might be an early discrete metabolic reaction to a looming insulin resistance while resistin elevation in overnutrition and obesity might be a more direct indicator towards a further development of diabetes mellitus type 2.

Key words: Metabolic syndrome, insulin resistance, overnourished, recruited, triglycerides, triceps

INTRODUCTION

Chronic diseases now take the lead in challenging health delivery systems also outside highly industrialized countries (WHO, 2005). One of the leading problems is the occurrence of the metabolic syndrome including Diabetes Mellitus type 2 (DM). A major risk factor for the development of DM is overnutrition and obesity. Thailand is no exception to the rule in that obesity, indicated by a BMI of ≥25 was found to account for 34.3% for women and 22.4% for men assessed by a national health survey (Aekplakorn and Mo-Suwan, 2009). Over nutrition is not confined to the urban sector only but also found frequently in the rural areas. Based on the assumed population size of Thailand for 2004 the prevalence of DM accounted for 7.4% for women and 6% for males while the proportion for Impaired Fasting Glucose (IFG) was 10.4% for women and 14.7% for males (Aekplakorn *et al*., 2007). Obesity in adolescents often remains in adult life as well and will pose obese young males and females not only to the risk of suffering DM in future but even develop the metabolic syndrome early in life as pointed out by a recent review about the role of adipocytokines as predictors of the metabolic syndrome (Korner *et al*., 2007a, b). Adipokines are known to be secreted among others by the visceral fat tissue and research in the function of these substances is mounting since they could play a role in the development of insulin resistance and DM. This study attempteded to measure the adipokines resistin and visfatin together with a selection of anthropometric variables, triglycerides, insulin and the Homeostasis Model assessment for Insulin Resistance (HOMA-IR) in the serum of overnourished and obese adolescents in Thailand. The two adipokines had been of interest because resistin might be connected to a possible increase in insulin resistance while visfatin is considered to have a contrary effect (Antuna-Puente *et al*., 2008). The results of the investigation might be suitable to formulate a working hypothesis for future investigation intending to establish early signs of risk for the development of DM in groups of overnourished and obese adolescents.

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MATERIALS AND METHODS

Selection of participants: From altogether 18 high schools of the Mahasarakham province, Northeast Thailand, 5 of them had been randomly selected and from those 5 schools 300 high school students voluntarily participated in the study. Obviously overnourished and obese students were encouraged to participate in the study although every student who expressively wanted to be included into the study was taken. A physical examination was conducted and all of the selected students were obviously healthy. Informed consent was obtained from the students and their parents before launching the study. The research protocol was approved by the ethical committee of the Mahasarakham University.

Anthropometry: Weight and height measurements were taken to assess the nutritional status. The body weight of each individual dressed in light clothing was measured using a carefully calibrated beam balance (Detecto®). Height measurements were taken by means of a vertical measuring rod. From these measurements, the conventional Body Mass Index (BMI) in kilogram divided by height in square meters was calculated for each student. Actual BMI measurements were adjusted to the International Obesity Taskforce (IOTF) standard (Cole *et al*., 2000) in order to allocate the adolescents to three categories of the nutritional status i.e., being normal nourished, overnourished or obese. Standard techniques were applied in measuring of triceps and biceps skin fold thickness. Three measurements were taken for each individual and the average of the measurements are given in the results.

Laboratory determinations: From the adolescents investigated, about 10 mL venous blood was taken in the morning after an overnight fast. Blood drawing was performed by nurses and medical technology staff of the Mahasarakham provincial hospital. All of the blood samples were immediately processed in dividing them into aliquots and storing them at -80°C until further determination. For triglycerides determinations a commercially available test kit was used obtained from Siemens Healthcare Diagnostic Inc. An enzymatic test was applied for measuring plasma glucose levels using a test kit from Dade Behring Inc. Serum insulin was assessed using a commercially available radioimmunoassay test from Linco Research, Inc. utilizing ^{125}I-labeled human insulin and a human insulin antiserum (Morgan and Lazarow, 1963). The Homeostasis Model Assessment for Insulin Resistant (HOMA-IR) was applied using the formula fasting insulin (mU L^{-1})×fasting glucose (mmol L^{-1}) divided by 22.5 (Matthews *et al*., 1985; Wallace *et al*., 2004). A commercially available radioimmunoassay test was used to determine serum resistin levels (LINCO Research, Inc, St., Charles, Missouri, USA), assay sensitivity was 0.16 ng mL^{-1} and inter-assay and intra-assay coefficients of variation were 7 and 4%, respectively and for the determination of visfatin also a commercially available radioimmunoassay test was used (Phoenix Peptides, Karlsruhe, Germany). Assay sensitivity was 1.85 ng mL^{-1} and inter-assay and intra-assay coefficients of variation were 10 and 5%, respectively.

Statistical analysis: Statistical analysis was done by using the Minitab statistical computer program (Minitab Release 12.2). Differences in the proportion of from males vs. females had been tested by using the conventional Chi-square test, for continuous data the median and achieved 95% Confidence Interval (C.I.) was computed. For assessing differences among categories the Kruskal-Wallis test had been performed and the p-value adjusted for ties are displayed together with the z-value for the median of a given variable according to the nutritional category. To determine the percent of variation (R^2 (adj.)) of the response variable BMI due to the predictor variables a multivariate regression model was computed and for giving an impression to what extend a single predictor variable contributes to the variation of BMI the R^2(adj.) values of univariate regressions had been added to the last column.

RESULTS AND DISCUSSION

Basic information: Altogether 300 adolescent high school students from schools at the Mahasarakham province of the northeast of Thailand participated in the study. Over 70% of them had been females (Table 1).

Table 1: Proportion of high school students according to sex, nutritional status and fasting plasma glucose levels

Variables	N	Percent
Sex		
Male	81	27.0
Female	219	73.0
Nutritional status*		
Normal	77	25.7
Overweight	125	41.6
Obese	98	32.7
Male**		
Normal	12	14.8
Overweight	33	40.7
Obese	36	44.4
Female**		
Normal	65	29.7
Overweight	92	42.0
Obese	62	28.3
IFG***		
Normal	292	97.3
IFG	5	1.7
DM	3	1.0

*Age adjusted BMI according to IOTF standard: Normal nutritional status BMI (kg m^{-2}) <25; overnutrition BMI ≥25 to <30; obese BMI ≥30 (Cole *et al*., 2000); **Chi-square test boys vs. girls: p = 0.007; ***IFG Impaired Fasting Glucose; (6.1-6.9 mmol L^{-1}); DM Diabetes mellitus (≥7.0 mmol L^{-1}) (WHO, 2006)

Table 2: Median and 95% achieved Confidence Interval (CI) of age and anthropometric variables of 300 high school students including 81 males and 219 females of different nutritional status according to the IOTF criteria

	Total		Boys		Girls	
Variables	Median (95% CI)	p-value* (z-value)	Median (95% CI)	p-value* (z-value)	Median (95% CI)	p-value* (z-value)
Age (years)	-	0.000	-	0.341	-	0.000
Normal	16	(6.440)	14	(1.230)	16	(6.050)
	(16-17)	-	(14-16)	-	(16-17)	-
Overnutrition	15	(-2.130)	14	(0.250)	15	(-2.740)
	(14-15)	-	(13-15)	-	(14-15)	-
Obese	14	(-3.760)	14	(-1.120)	14	(-3.140)
	(14-15)	-	(14.15)	-	(14-15)	-
Weight (kg)	-	0.000	-	0.000	-	0.000
Normal	54.6	(-10.680)	59.9	-3.790	53.8	(-9.940)
	(53.1-26.2)	-	(55.9-66.9)	-	(51.5-55.5)	-
Overnutrition	64.5	(-2.670)	66.4	-3.840	63.6	(-0.530)
	(62.9-65.7)	-	(61.3-72.2)	-	(62.6-65.4)	-
Obese	83.3	(12.750)	86.2	6.510	82.5	(10.670)
	(81.1-85.0)	-	(81.9-91.5)	-	(80.4-84.1)	-
Height (m)	-	0.000	-	0.477	-	0.010
Normal	1.57	(-1.460)	1.66	(-0.010)	1.57	(-0.460)
	(1.56-159.0)	-	(1.58-1.68)	-	(1.55-1.58)	-
Overnutrition	1.57	(22.480)	1.63	(-1.140)	1.56	(-2.240)
	(1.56-1.59)	-	(1.61-1.66)	-	(1.55-1.58)	-
Obese	1.60	(3.970)	1.65	(1.130)	1.59	(2.920)
	(1.59-1.63)	-	(1.63-1.69)	-	(1.57-1.60)	-
BMI (kg m^{-2})**	-	0.000	-	0.000	-	0.000
Normal	21.9	(-12.390)	22.3	(-4.960)	21.8	(-11.260)
	(21.3-22.5)	-	(21.5-23.6)	-	(21.1-22.4)	-
Overnutrition	25.8	(-2.080)	25.3	(-4.060)	26.2	(0.070)
	(25.6-26.2)	-	(24.3-25.8)	-	(25.6-26.4)	-
Obese	31.4	(13.730)	31.4	(7.560)	31.6	(11.340)
	(30.9-33.2)	-	(30.1-33.4)	-	(30.8-33.3)	-
Biceps skin fold (mm)	-	0.000	-	0.000	-	0.000
Normal	12.4	(-7.880)	8.8	(-4.510)	14.1	-7.110
	(10.9-14.7)	-	(4.7-10.6)	-	(11.8-15.6)	-
Overnutrition	17.0	(-1.940)	13.8	(-2.750)	18.1	-0.460
	(15.1-18.3)	-	(11.9-16.1)	-	(16.2-19.4)	-
Obese	23.7	(9.380)	22.3	5.950	24.8	7.710
	(22.6-25.4)	-	(20.1-25.6)	-	(23.0-26.9)	-
Triceps skin fold (mm)-	0.000	-	0.000	-	0.000	
Normal	13.8	(-10.140)	11.8	(-4.720)	14.2	(-9.180)
	(12.6-15.2)	-	(7.2-14.5)	-	(13.2-16.6)	-
Overnutrition	22.3	(-0.800)	18.5	(-3.210)	23.3	(1.270)
	(20.5-23.4)	-	(16.8-21.0)	-	(22.0-25.2)	-
Obese	29.4	(10.280)	31.8	(6.550)	29.2	(7.910)
	(28.0-30.6)	-	(27.5-33.5)	-	(27.6-30.0)	-

*Kruskal-Wallis test; **Based on actual measurements of weight and height

According to age adjusted BMI as recommended by the IOTF (Cole *et al*., 2000) over 40% of the students had been overnourished and over 30% obese while the rest of about 25% of the participants were classified as normal nourished. The nutritional status differed between males and females in that a higher proportion of males had been obese hence the proportion of normal nourished females exceeded those of males. Most of the study participants had been fasting blood glucose levels termed to be normoglycaemia (WHO, 2006), five students had Impaired Fasting Glucose (IFG) levels and three students were found with fasting plasma glucose levels indicative for diabetes mellitus.

Age and anthropometric variables: Median values with 95% CI for some anthropometric measurements are shown in Table 2 for the overall group of high school students and separately for boys and girls categorized as normal, overnourished and obese according to the IOTF standard. The observation that obese students with the median age of 14 years are significantly younger than students categorized as normal nourished is due to the fact that a significant trend to be obese at a younger age was found for females but not for males. Weight, individual BMI, biceps and triceps skin fold measurements values increased significantly from a normal nutritional status to obesity. Obese female students were slightly but significantly taller than their normal nourished counterparts, an observation which was not noticed for males.

Laboratory determinations: The medians of triglycerides and plasma glucose determinations increased statistically significantly from a normal nutritional status to obesity for females and the overall group but not for male students

Table 3: Median and 95% achieved Confidence Interval (CI) of triglycerides, glucose, insulin HOMA-IR, resistin and visvatin determinations of 300 high school students including 81 males and 219 females of different nutritional status according to the IOTF criteria

	Total		Male		Female	
Variables	Median (95% CI)	p-value* (z-value)	Median (95% CI)	p-value* (z-value)	Median (95% CI)	p-value* (z-value)
Triglycerides (mmol L^{-1})	-	0.000	-	0.401	-	0.000
Normal	0.802	(-4.500)	0.921	(-0.780)	0.780	(-4.640)
	(0.704-0.916)	-	(0.522-1.253)	-	(0.679-0.870)	-
Overnutrition	0.972	(-0.430)	1.04	(-0.770)	0.966	(0.020)
	(0.905-1.096)	-	(0.791-1.192)	-	(0.870-1.106)	-
Obese	1.339	(4.640)	1.124	(1.320)	1.407	(4.680)
	(1.094-1.448)	-	(0.997-1.404)	-	(1.188-1.575)	-
Glucose (mmol L^{-1})	-	0.000	-	0.282	-	0.000
Normal	4.61	(-4.610)	4.66	(-1.560)	4.61	(-4.090)
	(4.56-4.67)	-	(4.52-4.97)	-	(4.51-4.67)	-
Overnutrition	4.83	(1.490)	4.94	(0.240)	4.83	(1.650)
	(4.78-4.94)	-	(4.78-5.00)	-	(4.67-4.94)	-
Obese	4.86	(2.730)	4.89	(0.880)	4.83	(2.340)
	(4.72-4.94)	-	(4.71-5.02)	-	(4.72-4.94)	-
Insulin (mU L^{-1})	-	0.000	-	0.000	-	0.000
Normal	1.53	(-7.890)	1.58	-3.430	1.42	(-7.030)
	(1.34-1.62)	-	(1.54-1.79)	-	(1.24-1.62)	-
Overnutrition	1.99	(0.450)	2.15	-0.700	1.94	(1.050)
	(1.84-2.31)	-	(1.72-2.62)	-	(1.80-2.36)	-
Obese	2.67	(6.870)	2.46	3.150	2.79	(5.980)
	(2.54-3.13)	-	(2.30-3.08)	-	(2.61-3.33)	-
HOMA-IR	-	0.000	-	0.000	-	0.000
Normal	0.31	(-8.160)	0.32	(-3.520)	0.29	(-7.240)
	(0.27-0.34)	-	(0.29-0.39)	-	(0.25-0.34)	-
Overnutrition	0.43	(0.490)	0.46	(-0.450)	0.41	(0.960)
	(0.39-0.48)	-	(0.37-0.59)	-	(0.37-0.48)	-
Obese	0.60	(7.090)	0.54	(2.960)	0.61	(6.290)
	(0.55-0.66)	-	(0.50-0.64)	-	(0.57-0.70)	-
Resistin (ng mL^{-1})	-	0.002	-	0.000	-	0.008
Normal	16.09	(-3.230)	14.75	-3.520	16.23	(-3.090)
	(15.27-17.17)	-	(10.64-23.12)	-	(15.61-17.62)	-
Overnutrition	19.27	(0.230)	18.07	-0.450	20.07	(1.350)
	(18.08-20.79)	-	(13.15-19.56)	-	(18.52-23.42)	-
Obese	23.05	(2.770)	23.68	2.960	22.86	(1.650)
	(21.19-24.61)	-	(19.64-31.23)	-	(19.06-25.28)	-
Visfatin (ng mL^{-1})**	-	0.412	-	0.600	-	0.296
Normal	38.04	(-0.610)	28.30	(-1.010)	39.43	(-0.420)
	(34.31-41.03)	-	(12.64-50.44)	-	35.01-41.50	-
Overnutrition	41.64	(-0.710)	42.65	(0.320)	41.56	(-1.010)
	(31.96-46.07)	-	(25.16-50.58)	-	32.03-46.33	-
Obese	45.73	(1.330)	38.21	(0.410)	49.86	(1.540)
	(31.89-54.97)	-	(19.81-60.30)	-	32.33-57.45	-

*Kruskal-Wallis test; **Visfatin determinations from 291 students including 80 males and 211 females

(Table 3). The median values for insulin HOMA-IR and resistin increased significantly from being normal nourished to be obese for male and female students likewise. This was not the case for the adipokine visfatin in that median values did not differ significantly between different nutritional statuses instead broad variation of individual visfatin blood levels indicated by confidence intervals overlapping for different categories of the nutritional status had been determined.

Multi and univariate regressions: A multivariate regression indicates that age, sex, skin folds, triglycerides and visfatin statistically significantly control the variation of BMI for 68.5% while glucose and resistin values don't correlate statistically significantly within the model to the BMI (Table 4). A p-value of 0.059 for HOMA-IR should be taken as an indication that this variable almost fits statistically significantly into the multivariate model. The R^2(adj.) values for univariate regressions of the given independent variables to the dependent variable BMI indicate that in contrast to the results of the multivariate regression all of the tested variables (except sex) statistically significantly contribute to the variation of BMI. Triceps skin folds correlate with about 60% to the variation of BMI followed by the biceps skin folds with almost 40%. The contribution of triglycerides to the variation of BMI is comparably small with almost 10% in comparison to the skin folds measurements. The correlation of glucose, insulin and HOMA-IR resistin and visfatin with BMI according to the univariate tests is rather weak especially for resistin and visfatin with 1 and 2.5%, respectively. Differences between males and females had been observed when calculating a multivariate regression separately to gender and age

Table 4: Multivariate regression with BMI as respondent variable and age, sex anthropometric variables, triglyceride, fasting plasma glucose, insulin, HOMA-IR, resisting, visfatin as independent variables and R^2 (adj) from univariate regression with BMI as dependent and each of the independent variables*

Independent variables*	Coefficient	SD	T	p-value	R^2 (adj) univariate regression (%)
Age	0.133700	0.101400	1.32	0.189	2.6**
Sex***	-1.389600	0.364100	-3.82	0.000**	-
Biceps skin fold	0.153880	0.027350	5.63	0.000**	39.3**
Triceps skin fold	0.326339	0.025010	13.05	0.000**	57.1**
Triglycerides	1.187400	0.223600	5.31	0.000**	9.1**
Glucose	0.468800	0.383000	1.22	0.222	2.8**
Insulin	1.051100	0.492200	2.14	0.034**	5.6**
HOMA-IR	-3.392000	1.791000	-1.89	0.059	3.4**
Resistin	0.002954	0.009335	0.32	0.752	1.0**
Visfatin	0.002665	0.001169	2.28	0.023**	2.5**

*Multivariate regression included 291 students; p = 0.000; R^2 (adj) 68.5%; F = 64.07; **Statistically significant correlation; ***Multivariate regression for males resulted in a significantly correlation of age to BMI and no correlation of visfatin to BMI while for females age was not significantly correlated to BMI but visfatin was

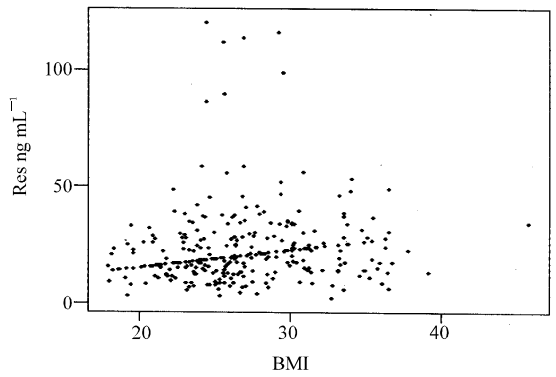

Fig. 1: Regression resistin versus BMI

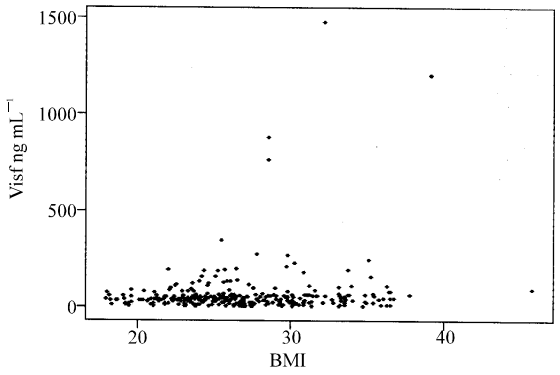

Fig. 2: Regression visfatin versus BMI

significantly correlated with BMI but not visfatin for males while for females' age was not significantly correlated with BMI but visfatin contributed significantly to the variation of BMI. Tables for these calculations are omitted.

Figure 1 shows a plot of individual resistin-versus BMI values (y = 12.27+0.41) and Fig. 2 Visfatin-versus BMI values (y = -63.72+4.79). Resistin values scatter randomly over BMI ranges while visfatin values remain in a close range along increasing BMI measurements.

This study did not intend to estimate the prevalence of overweight and obesity of high school students in Thailand but intended to describe the relationship of some variables of recent interest in connection with overnutrition and obesity in adolescents derived from a population being of high risk to develop DM. For evaluating variables with continues data nonparametric tests had been applied. This is justified by the findings that especially the variables derived from laboratory determinations don't follow a normal distribution. The proportion of males to females in this survey is 1:2.7. Differences between genders reported here might be accounted for this uneven distribution.

A foregoing survey conducted among adults in Northeast Thailand, the same area where the high school students for this study had been recruited, detected a rather high proportion of middle aged adults with high triglyceride levels with 30% individuals over 200 mg dL^{-1} triglycerides but only 7% study participants with total cholesterol levels over 251 mg dL^{-1} (Chaisiri *et al*., 1998). The researchers concluded, based on a rather low over all LDL-HDL ratio below 5 that the lipid pattern of the population under study is more prone to develop DM instead of cardio vascular diseases. This assumption was supported by a consecutive investigation in the same area. From a random sample taken from the above mentioned adult population 18.1% had an impaired glucose tolerance and 11.9% DM diagnosed by an oral glucose loading test (Chaisiri *et al*., 1997). Recently over 8% of urban and rural females in Northeast Thailand were found to have DM (Aekplakorn *et al*., 2007).

As observed for the adult population of the above mentioned study, triglyceride levels of adolescent girls investigated in this survey differ between the overnourished and the obese group but that was not true for male students however, for both sexes triglycerides concentrations determined positively and significantly the variation of BMI and might be taken as a hint that over nourishment and obesity of Thai adolescents might be a

risk factor for the development of diabetes mellitus even in case triglyceride values as measured here are still in a range considered to be normal. In addition the medians of skin fold thickness, glucose, insulin, HOMA-IR and resistin are significantly elevated in overnutrition and obesity in this cross sectional study.

Conflicting results had been obtained in this investigation by determining the median of resistin within categories for BMI adjusted to the IOTF standard (Cole *et al*., 2000) and the results of the multivariate regression model. Elevated resistin levels were observed in overnutrition and obesity compared with a normal nutritional status but resistin didn't significantly contribute to the variation of BMI in the multivariate assessment and to only 1% in the univarate regression. The contradictory results are due to the random scattering of resitin values along an increasing BMI range. Scattering of values around a BMI of 20 are more due to lower resistin values in comparison to a higher BMI range where values of quite some high resistin concentration are observed (Fig. 1). Increasing categories of the nutritional status indicated by BMI result in significant differences between medians of resistin according to categories but don't fit a linear regression significantly in a multivariate model. According to Aeberli *et al*. (2009) dietary intake is not associated with resistin and further investigations needed to find out whether the distribution pattern of resistin against BMI is due to an insufficient relation of the resistin to dietary intake.

Elevated concentration of triglycerides over normal nourished individuals might indicate a further risk to develop DM. While animal experiences hints towards reduced insulin sensitivity in connection with elevated resistin levels (Banerjee *et al*., 2004), the results of investigation with humans are contradictory. An investigation undertaken with German children and adults suggests that resistin is not the main link between obesity and insulin resistance (Gerber *et al*., 2005). For Thai adults it was found that plasma resistin levels increased in obesity and for individuals with DM (Chanchay *et al*., 2006). It might be hypothesized that elevated concentration of resistin in overnourished and obese individuals might be indicative of a thread to develop insulin resistance in future.

Contrary to resistin the concentration of visfatin is not elevated above a normal nutritional status in overnourished and obese students but the variable significantly contributes to the variation of BMI values in the multivariate regression however only marginally. Figure 2 shows a plot scatter graph of visfatin values against BM explains the seemingly conflicting results. With the exception of only some outlayer values the variation visfatin concentration along increasing BMI values remain in a rather narrow range with only a marginal slope of the regression line. It has been pointed out by Antuna-Puente *et al*. (2008) that the main functions of visfatin do not involve metabolism which might explain the distribution pattern of visfatin versus BMI in this study. Contrary to the results of this investigation it was found in a study with 40 healthy children and 83 obese children from Austria that visfatin was markedly elevated in obese children (Haider *et al*., 2006). The vast difference in the nutritional status between the controls and the obesity group having a mean BMI of 18.9 and 31.8, respectively might explain the difference in outcome between this communication and the investigation of Haider *at al*. (2006). A similar wide difference between the normal and obese adolescents existed in a study from China (Jin *et al*., 2008) and Turkey (Davutoglu *et al*., 2009). Also for these two studies significant differences for visfatin levels were found when comparing a control group with obese individuals. Visfatin levels in the fasting state are only 10% compared to insulin levels (Antuna-Puente *et al*., 2008) and methods for the determination of visfatin are not yet well established and not standardized which might explain the high number of publications with conflicting results (Nusken *et al*., 2007; Korner *et al*., 2007b). Nevertheless visfatin was found also in this study to be correlated to the nutritional status indicated by the variation of BMI values over the whole group of study participants. Research results obtained from DM patients so far seem to hint towards increased visfatin levels and a progressive beta cell deterioration (Lopez-Bermejo *et al*., 2006). HOMA-IR and insulin values determined in this study are not indicative for beta cell dysfunction or insulin resistance yet although, increased median values are found in overnourished and obese adolescents for both variables and for plasma glucose for girls.

CONCLUSION

From the results obtained from the Thai adolescents it might be hypothetically concluded based on the insulin-mimetic properties resulting in a glucose lowering effect that although the metabolic functions of visfatin in obesity and diabetes is not yet fully established but based on the findings that visfatin is secreted by visceral fat (Sethi and Vidal-Puig, 2005; Fukuhara *et al*., 2005), this adipokine might be an early discrete metabolic reaction to a looming insulin resistance in obese adolescents while resistin elevation might be a more direct and obvious indicator towards further insulin resistance. To verify these assumptions appropriate cohort studies had to be conducted.

ACKNOWLEDGEMENTS

Researchers would like to thank the students and school administrators for their participation in the study as well as the Mahasarakham provincial health officers and the assistant medical scientists of the Mahasarakham Hospital. We are especially grateful to Prof. Dr. Rangsun Tungtrongchitr for his supervision of the laboratory investigation of visfatin and resistin. Last but not the least, we also thanks the Dean of the Faculty of Public Health of the Mahasrakham University, Prof Somjit for his continuous encouragement while conducting the project.

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