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Effects of bodily development and nutritional status at birth on physical and mental development measured at age 18

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Abstract: Earlier the authors have proved strong effect of physical development and nutritional status, especially the IUGR of fetuses on perinatal mortality. This paper reports on a study carried out using the Maturity, Development, Nutritional status (MDN) system to investigate the influence of physical development and nutritional status at birth on later physical measurements and intellectual development. The data of 6,335 18-year old male conscripts for military duty were analyzed against their data at birth. The authors determined that, of the conscripts whose development and nutritional status at birth differed significantly from the norm, those rated as proportionally restricted at birth had the largest disadvantage in terms of physical measurements and mental abilitie In our earlier studies s. Only the group of those who were proportionally restricted at birth had significantly lower results for height (-5.3cm) and weight (-5.7kg), as well as lower school mark (In our earlier studies -0.3) and scores on IQ tests (-4.4).

Keywords: MDN System, Growth Restriction, Growth of Children, Intrauterine Development

1. Introduction

We consider it self-evident that, of the most important features measureable at the birth of a fetus, neither birth weight nor gestational age is enough in itself to determine bodily development, or maturity, with the necessary precision to estimate a newborn's chance of survival [1]. For this purpose, a method is required that can simultaneously take into account the newborn's sex, gestational age and the weight and length, using a country's own national newborn's standards.

It would be a serious error to attempt to use global development standards for newborns, since average birth weights (and most likely average birth lengths as well) differ considerably among nations. To mention just the extremes, the average birth weight for Papua New Guinea is 2400g, while in Norway it is 3600g. Considering racial differences, in the United States the average birth weight for Afro-Americans is 2800 g, for Caucasians 3200g, and for Native Americans 3600 g [2]. For this reason, we cannot approve of the still common practice of comparing infant mortality in two different nations, two different institutes, or even two sections of the same institute using groups categorized by weight (e.g., <1000 g, <1500 g, <2500 g, etc.).

Taking these factors into account, logically it would be necessary for each country to create its own national standards for birth weight and length based on a large amount of reliable data [3]. This should be determine separately for male and for female infants. The standards produced by Joubert were based on national data from Hungary for 680,497 single births We have prepared table format standards as well [4]. – We are aware that sometimes the measurement of length and the calculation of gestational age of newborns may not be too exact; however, the importance of this is tolerable when the database is so large.

Table 1. *Weight standards for the Hungarian male neonates born between 1990 and 1996.*

Zones	Percen-tiles	Gestational weeks												Percen-tiles
		20	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	
8														
	97	705	775	845	925	1019	1129	1269	1425	1615	1825	2055	2285	**97**
7														
	90	595	665	735	815	895	995	1119	1259	1435	1616	1828	2055	**90**
6														
	75	525	585	645	718	795	888	995	1128	1295	1475	1649	1845	**75**
5														
	50	455	501	555	621	705	781	881	1005	1155	1311	1481	1659	**50**
4														
	25	385	422	475	533	595	685	782	895	1015	1152	1305	1455	**25**
3														
	10	311	351	395	455	515	595	683	775	881	995	1123	1253	**10**
2														
	3	245	275	315	361	422	482	561	643	725	833	935	1051	**3**
1														

Table 1. *Continue*

Zones	Percen-tiles	Gestational weeks												Percen-tiles
		32	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	
8														
	97	2545	2787	3048	3325	3579	3819	4018	4193	4349	4495	4595	4627	**97**
7														
	90	2277	2508	2755	3008	3276	3525	3729	3909	4075	4195	4295	4328	**90**
6														
	75	2048	2259	2488	2725	2976	3238	3458	3655	3795	3895	3955	3979	**75**
5														
	50	1851	2045	2255	2475	2721	2949	3161	3349	3495	3608	3655	3671	**50**
4														
	25	1615	1805	2005	2211	2425	2663	2875	3055	3213	3305	3341	3352	**25**
3														
	10	1395	1561	1745	1935	2164	2395	2623	2805	2925	3005	3035	3021	**10**
2														
	3	1182	1323	1493	1671	1872	2105	2322	2524	2672	2754	2762	2735	**3**
1														

Table 2. *Length standards for the Hungarian male neonates born between 1990 and 1996.*

Zones	Percen-tiles	Gestational weeks												Percen-tiles
		20	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	
8														
	97	36,9	39,1	41,1	42,9	44,6	46,2	47,6	49,1	50,5	51,6	52,7	53,6	**97**
7														
	90	34,1	36,2	38,3	40,2	41,9	43,5	44,9	46,5	47,8	49,1	50,3	51,3	**90**
6														
	75	31,8	33,9	35,8	37,7	39,4	40,9	42,5	43,9	45,3	46,6	47,9	49,1	**75**
5														
	50	29,5	31,4	33,3	35,1	36,9	38,6	40,1	41,6	42,9	44,3	45,7	46,9	**50**
4														
	25	27,1	29,1	30,8	32,7	34,3	36,1	37,6	39,1	40,7	42,1	43,5	44,7	**25**
3														
	10	24,4	26,5	28,3	30,2	31,9	33,5	35,1	36,7	38,3	39,9	41,3	42,7	**10**
2														
	3	21,6	23,4	25,2	27,2	28,9	30,7	32,3	33,9	35,4	36,9	38,5	40,1	**3**
1														

Table 2. *Continue*

Zones	Percen-tiles	Gestational weeks												Percen-tiles
		32	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	
8														
	97	54,5	55,3	56,2	56,9	57,5	58,1	58,5	58,8	59,1	59,2	59,3	59,4	**97**
7														
	90	52,3	53,3	54,2	54,9	55,7	56,4	56,9	57,4	57,6	57,8	57,9	57,9	**90**
6														
	75	50,2	51,3	52,3	53,1	53,8	54,5	55,1	55,4	55,6	55,8	55,9	55,9	**75**
5														
	50	48,1	49,3	50,4	51,3	52,1	52,7	53,2	53,5	53,7	53,9	53,9	54,1	**50**
4														
	25	46,1	47,2	48,4	49,5	50,3	50,9	51,4	51,8	52,1	52,2	52,2	52,3	**25**
3														
	10	44,1	45,4	46,5	47,8	48,6	49,3	49,9	50,2	50,4	50,4	50,5	50,5	**10**
2														
	3	41,8	43,2	44,8	46,1	47,1	47,8	48,2	48,6	48,8	48,9	48,9	49,1	**3**
1														

Table 3. *Weight standards for the Hungarian female neonates born between 1990 and 1996.*

Zones	Percen-tiles	Gestational weeks												Percen-tiles
		20	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	
8														
	97	675	725	801	895	995	1118	1269	1438	1638	1845	2055	2295	**97**
7														
	90	595	635	689	765	849	965	1096	1245	1417	1605	1796	2005	**90**
6														
	75	529	555	601	668	755	855	968	1097	1255	1425	1615	1805	**75**
5														
	50	461	479	521	582	655	749	852	967	1101	1255	1425	1602	**50**
4														
	25	395	415	451	501	573	651	751	855	975	1105	1245	1402	**25**
3														
	10	335	352	382	425	481	562	643	735	843	953	1072	1201	**10**
2														
	3	282	295	323	355	405	465	531	614	702	791	885	1003	**3**
1														

Table 3. *Continue*

Zones	Percen-tiles	Gestational weeks												Percen-tiles
		32	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	
8														
	97	2545	2775	3015	3239	3466	3669	3855	4025	4176	4315	4368	4355	**97**
7														
	90	2235	2455	2685	2917	3155	3375	3568	3747	3898	4005	4055	4049	**90**
6														
	75	2018	2225	2438	2655	2885	3098	3296	3475	3619	3725	3775	3798	**75**
5														
	50	1803	1998	2201	2402	2617	2835	3035	3202	3329	3415	3475	3497	**50**
4														
	25	1581	1765	1952	2145	2355	2565	2773	2945	3075	3161	3202	3205	**25**
3														
	10	1355	1525	1701	1891	2103	2325	2525	2703	2835	2912	2943	2951	**10**
2														
	3	1132	1283	1455	1645	1845	2052	2255	2455	2614	2701	2725	2732	**3**
1														

Table 4. *Length standards for the Hungarian female neonates born between 1990 and 1996.*

Zones	Percen-tiles	Gestational weeks												Percen-tiles
		20	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	
8														
	97	37,5	39,3	41,3	43,1	44,8	46,4	47,9	49,3	50,5	51,7	52,7	53,5	**97**
7														
	90	34,8	36,5	38,5	40,2	41,8	43,5	45,2	46,7	48,1	49,2	50,3	51,3	**90**
6														
	75	32,1	33,9	35,6	37,3	39,1	40,8	42,5	43,9	45,4	46,8	47,9	49,1	**75**
5														
	50	28,8	30,8	32,9	34,7	36,5	38,1	39,6	41,1	42,6	43,9	45,3	46,5	**50**
4														
	25	26,1	28,1	30,1	32,1	33,9	35,8	37,5	39,1	40,4	41,9	43,2	44,4	**25**
3														
	10	23,1	25,3	27,2	29,3	31,3	33,1	34,9	36,6	38,1	39,6	41,1	42,4	**10**
2														
	3	20,1	22,1	24,1	26,1	28,1	30,1	31,9	33,7	35,3	36,8	38,3	39,8	**3**
1														

Table 4. *Continue*

Zones	Percen-tiles	Gestational weeks												Percen-tiles
		32	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	
8														
	97	54,5	55,2	55,9	56,5	57,1	57,5	57,8	58,1	58,3	58,4	58,5	58,6	**97**
7														
	90	52,2	53,1	53,7	54,4	55,1	55,6	56,1	56,4	56,6	56,8	56,9	56,9	**90**
6														
	75	50,1	51,1	51,9	52,7	53,3	53,9	54,4	54,7	54,9	55,2	55,3	55,4	**75**
5														
	50	47,7	48,7	49,7	50,5	51,3	51,9	52,4	52,9	53,2	53,4	53,5	53,5	**50**
4														
	25	45,7	46,9	47,9	48,9	49,7	50,3	50,8	51,1	51,3	51,5	51,6	51,6	**25**
3														
	10	43,8	44,9	46,2	47,2	47,9	48,5	49,1	49,4	49,6	49,8	49,9	49,9	**10**
2														
	3	41,2	42,6	43,9	45,2	46,2	46,8	47,4	47,7	47,9	48,1	48,2	48,3	**3**
1														

Such standards for neonates are currently in use [5-7], but they alone are not enough, since each of them permits judgment on the basis of development of either weight or length. If we wish to take the newborn's nutritional status into account, classifying an infant on this basis as well, then nutritional status needs to be combined simultaneously with the infant's position on the weight and length standards. For this, *Berkő's* MDN (Maturity, Development, Nutritional status) system and matrix [8-11] are necessary.

In the 64-cell MDN matrix, the 8 rows indicate the 8 recognized zones of the weight standard (the 1st zone for below the 3rd percentile, the 2nd zone for the 3rd to 10th percentile, … the 8th zone for above the 97th percentile). The 8 columns give the zones for the length standard.

As soon as we determine the neonate's sex and gestational age, measure its weight and length, and find its position on the weight and length standards using a software program, then within a minute we can locate the appropriate cell in the MDN matrix. In the center of the matrix (the four central cells, labelled sector AA) are those newborns with totally average development and nutritional status. In the lower left corner are the proportionally restricted (PR), whose weight and length are below the 10th percentile, while in the upper right corner are proportionally overdeveloped (POD) infants, above the 90th percentile in weight and length. In the triangle in the upper left area of the matrix are those infants who are extremely overnourished (EON) or moderately overnourished (MON) in relation to their length, while the lower right-hand triangle contains infants who, in relation to their length, are extremely or moderately undernourished (EUN, MUN, respectively), or disproportionally restricted (EDPR, MDPR, respectively). In Figure 1 and in the following figures, the MDN matrices display data from the newborn population of Hungary between 1997 and 2003.

In our earlier studies (9-11), carried out with data on nearly 700,000 Hungarian newborns, we showed that the intrauterine, neonatal and perinatal mortality rates for neonates into the most characteristic sectors differed greatly. While the "total perinatal mortality" (intrauterine + 0-28 days neonatal mortality) rate was only 8‰ in the absolute average (AA) sector, in the PR sector it was 34‰ (but in the extreme PR cell it was 65‰!), in the POD sector 11‰, in the ON red sectors 19‰, and in UN (or DPR) green sectors

28‰ (but in the extreme UN, or EDPR sector it was 442‰!).

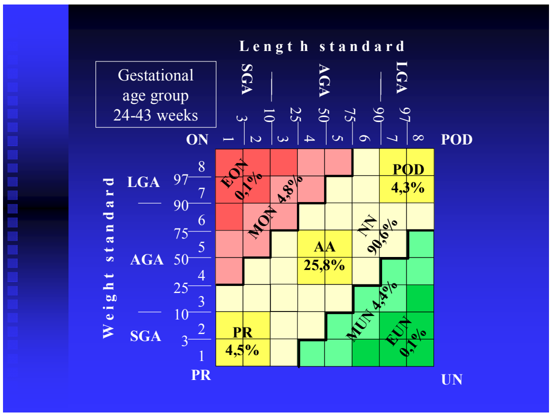

Figure 1. MDN matrix showing the most characteristic groups of newborns based on bodily development and nutritional status, with the percentage distribution for Hungarian neonates

Several studies have reported negative effects on the health of adults from development deviating from the average at birth [12-17]. In this paper, we introduce the effects of (intrauterinally formed) bodily development and nutritional status at birth on physical development and mental abilities later in life, at age 18.

2. Method

In this study we analyze data from a representative national sample taken in 1998 of more than 8000 young men, aged 18, during a conscription examination. Of these, official birth data was available for 6335. It is a real and the only representative sample database of the Hungarian population. The parameters measured at age 18 were height, weight, averaged marks from school and Raven's Progressive Matrix values [16,17]. Based on their birth data, the subjects were placed in the MDN matrix. Next, their weight and height averages were calculated for each of the most characteristic groups of the MDN matrix. This was also performed for the averaged school marks for each group (using results from the most recent school year completed) and Raven test scores. Based on Raven's Standard Progressive Matrix, which is a so-called culture-free test that measures reasoning and problem-solving abilities [18], average IQ values were obtained. Average group values for the four groups in the corners of the MDN matrix were compared with those for the central absolute average group. The significance-values of differences were calculated with the help of a *two sample t-test*. In the figures, values that differ significantly are shown in blue.

3. Results

There appears to be a clear correlation between physical parameters at age 18 and bodily development and nutritional status at birth.

The average height of the 6445 male conscripts at age 18 was 175.5 cm. As can be seen in Figure 2, those placed in the absolute average (AA) sector based on their data at birth had an average height of 176.1 cm, while those in the proportionally overdeveloped (POD) group at birth had an average height of 180.2 cm. The shortest group was those who were proportionally restricted (PR) at birth, with an average height of 170.8 cm. The difference with the AA group was highly significant (p>3.291) for both the POD (p=7.184) and PR groups (p=13.910).

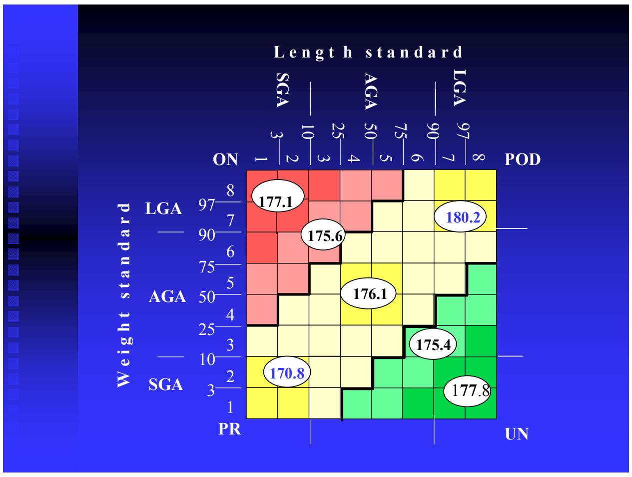

Figure 2. Average values for height (cm) in the main sectors of the MDN matrix

The same tendency may be found for weight at age 18, as shown in Figure 3. The average weight of the AA group was 68.7 kg, for the POD group it was 75.3 kg (p=4.948), and for the PR group only 63.0 kg (p=8.881). Once again, a highly significant difference (p>3,291) was found between the AA group and the other two groups.

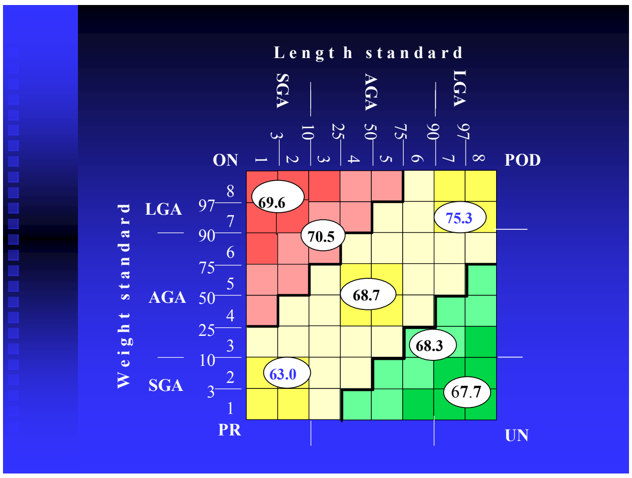

Figure 3. Average values for weight (kg) in the main sectors of the MDN matrix

We also succeeded in showing that bodily development and nutrition at birth has a fundamental influence on the mental abilities tested at age 18.

While the IQ points of those placed in the AA group at birth had an average value of 90.1 when tested at age 18, the average IQ for the PR group was only 85.7 (p=5.250) (Figure 4.).

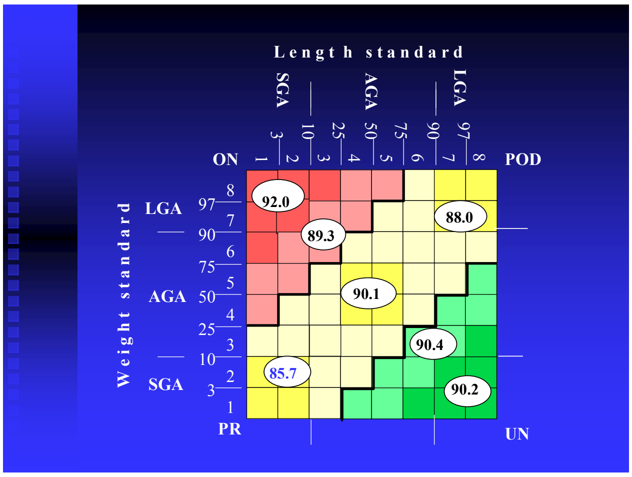

Figure 4. *Average IQ score in the main sectors of the MDN matrix*

The intellectual abilities based on IQ values measured at age 18, depend not only on the individual's biological status l, but also on the family's socioeconomic status, but the significant values between the different developmental groups show clearly the effect of the biological status of newborns

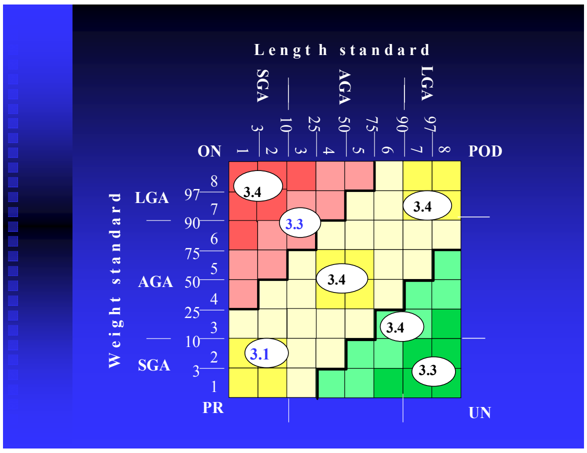

Figure 5. *Average school marks in the mainsectors of the MDN matrix*

We also investigated the relationship with average school marks for the final year completed (Figure 5). The AA group was 3.4 out of a perfect 5.0. The other groups of matrix had same results, but the proportionally restricted group's school mark average was only 3.1. The difference was highly significant (p>3.291).

4. Discussion

Many obstetricians and neonatologists speak about the IUGR as if it would be an uniform disease. This is a mistake. The proportional (symmetric) and disproportional (asymmetric) growth restrictions are characteristically different entities. All the two types of restriction cause higher intrauterine and newborn mortality, but probably, only the proportional IUGR has consequences in adult age (12-16).

Based on the results of the examination, we consider it proven that the intrauterine development leading to bodily development and nutritional status at birth has a significant effect not only on neonatal mortality rates (1st to 28th day), but also on the height and weight, and intellectual power of surviving children. Naturally, the mental abilities based on IQ values and on school mark average measured at age 18, depend not only the biological status of the individual, but also on the socioeconomic status the family, but the significant values between the different developmental groups have shown well the effect of the biological status of the newborns.

5. Conclusions

These results also demonstrate that growth restriction of intrauterine physical development, leading to measurements at birth deviating from the normal has a highly significant effect on physical development and mental abilities measured as a young adult, and that this effect is most negative in the case of *proportionally restricted* neonates.

This study and its results once again confirm that the MDN system that we have created is highly suitable for application in cases where the categorization and comparison of distinctive groups of neonates is desired, and also for investigating their development later in life.

References

[1] WHO. Public health aspects of low birth weight. *WHO Technical Report,* Series 1961, No. 217, Geneva

[2] Meredith H. Body weight at birth of viable human infants: a worldwide comparative treatise. *Hum Biol* 1970, 42:217-264.

[3] Wilcox A, Russel I. Why small black infants have a lower mortality rate than small white infants: The case for population-specific standards for birth weight. *J Pediatrics* 1990,116:7-16.

[4] Joubert K. Standards of birth weight and length based on liveborn data in Hungary, 1990-1996. *J Hungarian Gynecol* 2000, 63:155-163 (In Hungarian with English summary).

[5] Lubchenco LO, Hausmann C, Dressler M, Boy E. Intrauterine growth as estimated from liveborn birth weight data at 24-42 weeks of gestation. *Pediatrics* 1963, 32:793-799.

[6] Battaglia FC, Lubchenco LO. A practical classification of newborn infants by weight and gestation age. *Pediatrics* 1967, 71:159-170.

[7] Bakketeig, LS. Current growth standards, definitons, diagnosis and classification on fetal growth retardation. *Eur J Clin Nutr. 1998,* 52 (suppl 1), pp. 1-4.

[8] Berkő, P. Study of the incidence, causes and consequences of retardation with the MDN system (*PhD Thesis) Hungarian Academy of Science, Budapest, 1992.*

[9] Berkő P, Joubert K. The effect of intruterine development and nutritional status on intrauterine and neonatal mortality. *Orv. Hetil*, 2006, 147 (29), pp. 1369-1375 (In Hungarian with English summary).

[10] Berkő P, Joubert K. The effect of intrauterine development and nutritional status on perinatal mortality. *J Matern Fetal Neonatal Med* 2009, 22 (7), pp. 552-559.

[11] Berkő P, Joubert K. The Effect of Intrauterine Development and Nutritional Status on Perinatal, Intrauterine and Neonatal Mortality: The MDN System. In: Ezechi, O.C., Pettersson, KO. *Perinatal Mortality*, InTech, Zagreb 2012, pp. 11-27.

[12] Barker DJP, Gluckman PD, Goldfrey KM, Harding J, Owens JA, Robinson JS. Fetal nutrition and adult disease. *Lancet* 1993, 341:938-941.

[13] Henriksen T. Foetal nutrition, foetal growth restriction and health later in life. *Acta Pediatr (*Suppl) 1999, 88 (429):4-8.

[14] Osmond C, Barker DJ. Fetal, infant, and childhood growth are predictors of coronary heart disease, diabetes, and hypertension in adult men and women. *Environ Health Perspect* 2000, 108 (suppl 3):545-553.

[15] Goldfrey KM, Barker DJP. Fetal nutrition and adult disease *Am J Clin Nutr* 2000, 71:1344-1352.

[16] Joubert K, Gyenis G. Prenatal effects of intra-uterine growth retardation on adult height of conscripts from Hungary – HOMO. *J Comparative Human Biol.* 2003, 54:104-112.

[17] Gyenis G, Joubert K, Klein S, Klein B. Relationship among body height, socio-economic factors and mental abilities in Hungarian conscripts. *Anthrop Közl.* 2004, 45:165-172.

[18] Raven J, Raven JC, Court JH. *Manual for Raven's Progressive Matrices and Vocabulary Scales:* Section 3, Standard Progressive Matrices – Oxford Psychologists Press 1998, Ltd. 106.