Extended abstract

Effect of intrauterine development and nutritional status on perinatal, intrauterine and neonatal mortality

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At least 50-60% of 3 million of intrauterine and near 4 million deaths that occur worldwide every year are associated with low birth weight, caused by intrauterine growth restriction, preterm delivery, and genetic abnormalities. Fetal growth restriction is the second leading cause of perinatal morbidity and mortality.

The authors study to what extent bodily development and nutritional status influence the viability, or perinatal mortality of foetuses and neonates. In the present study the authors describe their novel method, the MDN system (MDN: Maturity, Development, Nutritional status) and its application:

1./ to determine the nutritional status of a neonate on the basis of its gestational age, length and weight development considered simultaneously; - 2./ to differentiate the most viable and the most endangered neonates on the basis of their development and nutritional status; - 3./ to demonstrate the influence of a neonate's nutritional status by the gestational age on its perinatal mortality.

Method – the MDN system

The authors have developed a new method, the MDN system (MDN*:* Maturity, Development, Nutritional status) to determine the weight and length standard positions of neonates in relation to reference standards on the basis of their gestational ages, birth weights and lengths. The system contains a chessboard-like matrix (MDN-matrix) comprising 64 cells arranged in eight horizontal lines of the most common zones of weight percentile standards and eight vertical columns of the length percentile standards. Depending upon its weight and length, each neonate can be positioned in one of the cells of the MDN-matrix. The matrix allows differentiating major neonate groups with significantly different developmental and nutritional statuses.

The determination of weight and length standard positions

The weight and length development of a newborn is determined on the basis of its sex, gestational age, body mass and length at birth. To do this however, sex-specific national weight and length standards of reference value are needed. In Hungary, K. Joubert prepared such standards on the basis of the birth data of babies born in this country between 1990 and 1996 (799 688 neonates). As is the case with other commonly known standards, Joubert's standards apply 7 percentile curves (percentiles 3, 10, 25, 50, 75, 90 and 97) to divide the entire weight and length ranges into 8 weight zones and 8 length zones. The field under percentile curve 3 makes zone 1; zone 2 is made by the area between percentile curves 3 and 10, while the area above percentile curve 97 gives zone 8.

By using tabulated formats of standards or a software designed specifically for the purpose, knowing the gestational age one can easily determine the weight zone (W) and length zone (L) of newborn baby on the basis of its weight and length at birth. Any neonate can be described with the letters (W and L) and numbers (1-8) of its weight and length zones. For example, if the birth weight of a newborn is in weight zone 6, that is between weight percentile curves 75 and 90, and its length is in length zone 2, that is between percentile curves 3 and 10, then the standard positions of this baby are W6, L2.

Description of the nutritional status

The simplest way to describe the nutritional status of a person at any age is to give the person's height and body mass. The nutritional status (N) of a newborn is defined by the weight development and length development according to the gestational age.

The authors prepared a matrix comprising eight horizontal lines for the weight standard zones and eight columns for the length standard zones, which seems a useful tool to determine the nutritional status of neonates. This 64 cell matrix is referred to as the MDN matrix *(Figure.1)*. Any newborn can be positioned in this matrix, no matter what weight or length zone it belongs to. Each cell is identified by the letter and number of the weight zone and those of length zone in the intersection of which the cell is located in the matrix.

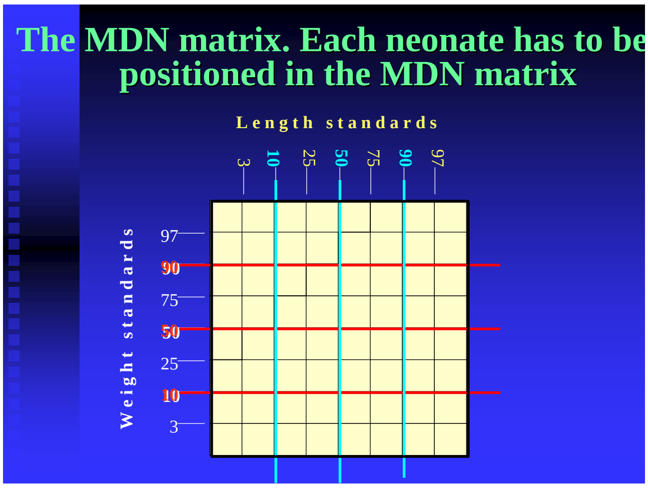

Figure 1 *MDN matrix for the simultaneous representation of weight and length standard positions of neonates.- It contains eight horizontal lines for the weight standard zones and eight columns for the length standard zones.*

In order to describe nutritional status (N) of a neonate, one has to know its weight standard position (weight zone number = W) and length standard position (length zone number = L). The calculation of the nutritional index, or nourishment status: N = W – L. In case the number of the weight zone is higher than that of the length zone, then N will be a positive number, which means that the baby is born with a relative overweight (overnourished). When N is a negative number, the baby is relatively underweight for its length.

Figure 2. demonstrates the nutritional statuses (N value) of neonates in each cell of the 64-cell of the MDN Table. The N value, representing nutritional status as rated according to the Table, can range from +7 to –7. Obviously, exteremely overnourished neonates are positioned in the cell marked +7, while extremely undernourished ones will be positioned in the cell marked –7. In an ideal case, a neonate is positioned in the weight zone and length zone having identical numbers when its N value = 0. Neonates with N = 0, N = +1 or +2 and those with N = -1 or -2 are regarded as being normally (or proportionally) nourished.

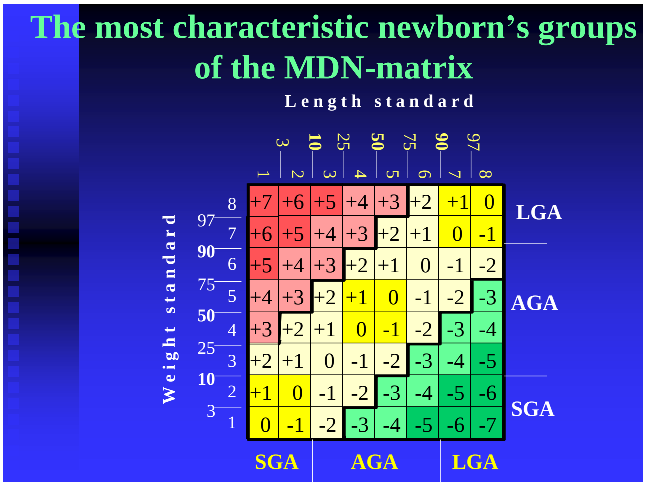

Figure 2 *The weight and length standard positions (W and L) and N values (W-L) of neonates with different nutritional statuses in the MDN matrix.*

Classification of neonates according to the degree of nourishment

Figure 3. demonstrates the most typical groups of newborns according to their nourishment. This figure also demonstrates the incidence rates of neonates with specific development and nutritional status in the neonate population born between 1997 and 2003 (680 947 newborn babies as recorded by the Hungarian Statistical Office).

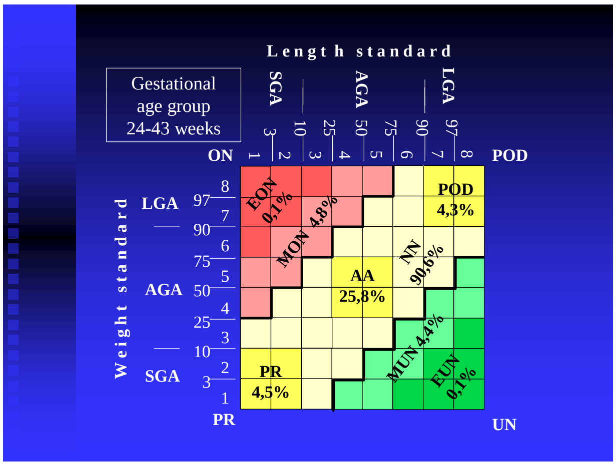

Figure 3. *The classification (and percentage distribution) of Hungarian neonates born between 1997 and 2003 by bodily development and nourishment. Abbreviations: NN (normally nourished), AA (absolute average), PR (proportionally retarded), POD (proportionally overdeveloped), MUN (moderately undernourished), EUN (extremely undernourished), MON (moderately overnourished), EON (extremely overnourished)*

Results

By processing the birth data of the entire neonate population, gestational age 24-43 weeks, born in the years from 1997 to 2003 in Hungary, the authors studied the perinatal mortality rate of the neonates in each cell of the MDN matrix. The four cells in the centre of the table represent the neonates considered an absolute average (AA) or etalon group on the basis of their weight and length. Perinatal mortality (PM) rates printed in boldface type indicate the values, which are at least twice as high as in any of the four cells in the centre of the table.

It must be also perceived that the most favourable values of perinatal mortality are out of the absolute average area. All of this is in relationship with the tendency observed in the matrix: in the zone between –2 and +2 perinatal mortality diminishes toward the zones of hingher weights except giant babies, of course.

Identification of the most endangered neonates with the MDN matrix on the basis of their bodily development and nutritional status

Relying on the birth data of neonates born between 1997 and 2003, the authors find perinatal mortality rate to be 8,9$^{o}/_{oo}$ in Hungary in that period of time. For comparison, this rate in the absolute average group, which is necessary to determine for comparative studies, was 7$^{o}/_{oo}$ in the same period of time. The highlighted sectors of the MDN Table in Figure 4. and Figure 5. represent the most endangered groups of fetuses and neonates.

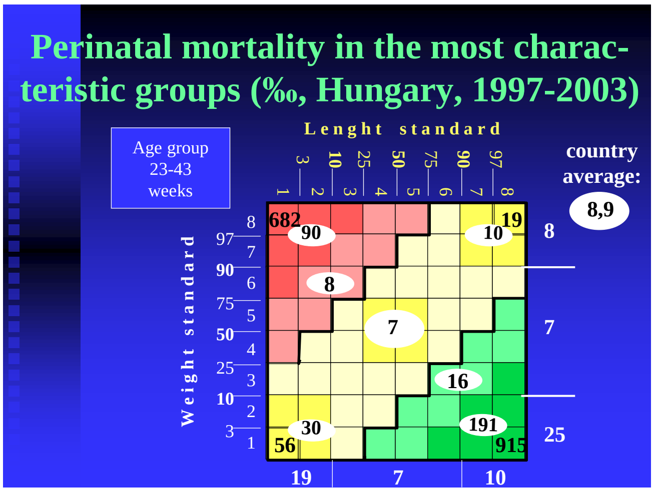

Figure 4 *Perinatal mortality rates (‰) of the entire Hungarian neonate population (gestational age 24-43 weeks) born between 1997 and 2003, as represented by the cells of the MDN matrix.*

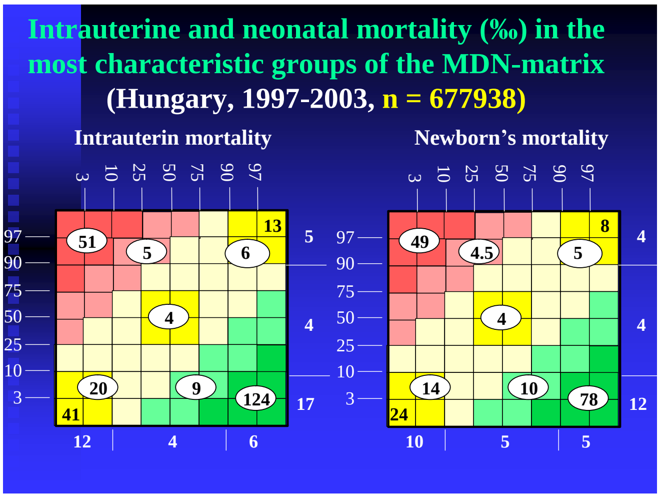

Figure 5. *Intrauterine and neonatal mortality rates (‰) in Hungary (1997 – 2003). The tendencies are very similar.*

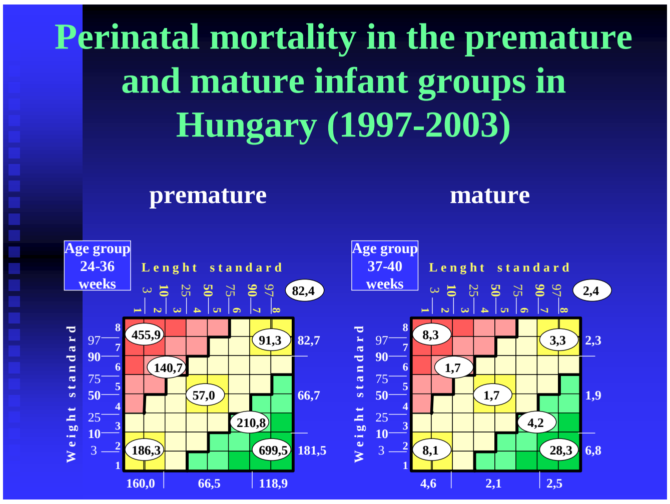

Figure 6. *Perinatal mortality rates of premature and mature groups (‰) in Hungary (1997 – 2003). The tendencies are very similar.*

The mostly endangered groups of fetuses and neonates (Perinatal Mortality)

1. **Undernourished (UN) group.** They are those who were born with insufficient weight and often show the syndrome of classic **disproportional restriction.** The perinatal mortality rate is rather high, $21^{o}/_{oo}$ in the large group of undernourished neonates. The group comprises the moderately undernourished subgroup with a PM rate of merely $16^{o}/_{oo.}$ The cells creating the triangle of **extremely undernourished** neonates in the UN corner of the table has a conspicuously high, $191^{o}/_{oo}$ PM rate. The MDN-matrix clearly shows that disproportional restriction, which causes a high mortality rate, can be found not only among the neonates under weight percentile 10, but also among those over weight percentile 10, as two thirds of the studied cases show.

2. **Overnourished (ON) group.** PM rate is $10^{o}/_{oo}$ in the **overnourished group.** This group includes the moderately overnourished subgroup where PM rate is only $8^{o}/_{oo}$. PM rate is $90^{o}/_{oo}$ in the triangle of the **extremely overnourished** group in the ON corner of the MDN Table.

3. **Proportionally restricted (PR) group. Proportionally restricted babies** are positioned in the four bottom left cells (in the PR corner) giving the field bordered by weight percentile 10 and length percentile 10. PM rate in this group is $30^{o}/_{oo}$. However, the smallest disproportionally retarded neonates, being under percentile 3 by both weight and length, have an even higher, $56^{o}/_{oo,}$ PM rate.

4. It should not be forgotten, however, about the group of extremely **proportionally overdeveloped or** giant babies positioned in the POD corner of the table being both their weight and length in the 8^{th} percentile zone. They are also highly endangered as is shown by the 19‰ PM rate of this cell.

5. **SGA group by weight. PM rate in the weight group under the 10^{th} percentile** (heterogeneous SGA by length and nutritional status) is $25^{o}/_{oo}$ (that in AGA group is $7^{o}/_{oo).}$

Discussion

Relying on the empirical fact that the degree of nourishment and the status of development have a high influence on the life prospects of neonates, the authors developed a method, the MDN system including an MDN-matrix to study and qualify the nutritional status at birth.

The MDN system can be applied when gestational age, birth weight and length are known and when reliable weight and length standards are available for reference.

The MDN system with an integrated MDN-matrix where maturity (gestational age), development (weight and length standard positions) and nutritional status are considered simultaneously allows the identification the most endangered neonate groups on the basis of bodily development and nutritional status. Having processed the data of almost half a million Hungarian neonates, the authors describe the most endangered groups of this population.

The MDN system offers a novel method to identify and differentiate proportionally restricted, disproportionally restricted and mixed retarded newborns below the 10^{th} weight percentile, as well as disproportionally restricted ones over the 10^{th} weight percentile.

Using the MDN system the authors have investigated 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 abilities. Only the group of those who were proportionally restricted at birth had significantly lower results for height, weight, and BMI as well as lower scores on IQ tests and lower average marks from school.

Using this novel method, it was found that 48% of those with the lowest weight and at the same time the lowest height at age 18 ranked as proportionally retarded at birth. Based on our data, we recommend that the physical development of those children identified at birth as being proportionally retarded on the MDN-matrix, as well as those ranked next to them, be carefully monitored, since children in potential need of growth hormone therapy from the age of 4 belong primarily to this group.

The MDN system as a method can be applied in any country. Preferably, the development of neonates born in the studied country has to be determined first according to country-specific (or preferably race-specific) weight and length percentile standards. Then, each neonate will be rated by and positioned in its nation-specific MDN-matrix. The morbidity and mortality rates of different national neonate groups having equivalent positions in their national MDN-matrices can be compared with this method. This also makes possible the compareison of neonatal morbidity and mortality data of countries, even if average birth weights are sidnificantly different. The MDN system offers a tool to make more accurate and more reliable national and international comparative studies.

Most important basis studies of authors

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).

Berkő, P. A study of the incidence, causes and consequences of retardation with the MDN system (*PhD Thesis) Scientific Academy, Budapest, 1992.*

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.

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.

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

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.

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.

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