SMGroup

SM Journal of Public Health and Epidemiology

Article Information

Received date: Aug 11, 2016
Accepted date: Aug 12, 2016
Published date: Aug 16, 2016

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Editorial

The Evolution of Neonatal Head Circumference

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Until recently, biologists thought evolution was too slow a process to be observed in a human lifetime. Today, from studies of the adaptation of mammals and birds to an urban environment, we are learning that spectacular transformations of species may be fast and that non genetic factors have been previously underestimated. To offer a typical example of rapid transformations related to modified lifestyles, let us mention that the studies looking at plasma melatonin concentrations among black birds suggest the powerful effects of artificial light on urbanized animals [1].

In such a scientific context, there are reasons to consider the particularities of Homo sapiens. Some fast transformations are already conspicuous and well documented. This is the case of height, an easily measured trait. We'll focus on the possible evolution of a less visible trait, namely the encephalization quotient (i.e. the ratio between actual brain mass and predicted brain mass for an animal of a given size). The routine evaluation of head circumference at birth (in relation to birth weight and gestational age) may provide some clues about a possible evolution of this human trait. It has been confirmed that head circumference is a valuable index of brain weight in the newborn [2]. We'll consider three aspects of modern lifestyles that may significantly influence the evolution of head circumference at birth: cesarean section, nutritional factors and environmental pollutants.

Cesarean Section

It is commonly accepted that, from the time our ancestor separated from the other members of the chimpanzee family, there has been a tendency towards a gradual increase of brain volume. An upright posture appears as the prerequisite for brain development. We can carry heavy heights on our head when we are upright: mammals walking on all fours cannot do the same. Until recently, it was commonly accepted that, for obstetrical reasons, the development of the human brain has reached the limits of what is possible. There has been an evolutionary conflict in our species, because the pelvis adapted to the upright posture must be narrow enough to allow the legs to be close together under the spine, which facilitates transfer of forces from legs to spine when running: the faster our ancestors could run, the more likely they were to survive. Limits of head size have been reached when, at term, the smaller diameter of the fetal head (which is not exactly a sphere) became roughly the same as the larger diameter of the mother's pelvis (which is not exactly a cone).

At a time when the cesarean section has become an easy, fast, safe and therefore widespread operation, more and more human beings are not born by the vaginal route. A tendency towards an increased head circumference at birth is plausible, since the "evolutionary bottleneck" has suddenly disappeared [3].

Nutritional Factors

In the early 1990s, we conducted a hospital and parity matched comparison study [4]. Four-hundred and ninety-nine pregnant women, attending selected clinics, before 29 weeks gestation, were offered a 20-min nutritional advice session. They were encouraged to increase the intake of oily sea fish and reduce intake of food rich in transfatty acid. For each woman interviewed a corresponding control was established. The objective was to know if, in the context of a British non-teaching hospital, one short session of nutritional counseling, focusing on the quality of lipids consumed, can have measurable effects in the perinatal period. Before the 1990s, the effects of fish oil supplementation had been occasionally evaluated, but not the effects of fish consumption and other perinatal criteria than head circumference had been taken into account.

In our preliminary study, the routine measure of head circumference provided the only statistically significant difference between the two groups. The mean head circumference (cm) was 34.65 versus 34.45 ($P = <0.05$. 95% CI 0.01- 0.39). There was a tendency towards an increased head circumference for gestational age (mm/wks): 876.5 versus 872.8. Mean birth weight, gestational age at birth, birth weight for gestational age and rates of caesarean sections were not significantly different. Let us mention that, in the study group, there was no eclampsia and no preeclamptic toxaemia recorded in the register, while, in the control group, there was one eclampsia with convulsions and two severe preeclamptic toxaemia.

OPEN ACCESS
ISSN: 2473-0661

In another British hospital, our study was replicated and enlarged [5]. The 3:2 randomisation was chosen to maximize the researchers' time for interviewing in clinic. Among the birth size outcomes, the estimated effect on mean head circumference (cm) was highly significant: it was 34.54 in the intervention group (n=1607); in the control group (n-1078), it was 34.32 (P<0,001). Differences in mean body length (cm) were also significant: 51.77 versus 51.50 (P= 0.03). There were no significant differences in terms of birth weight, length of gestation and rates of caesarean sections.

These results suggest the need for further studies about neonatal head circumference in relation to such factors as the comparative availability of land food and sea food.

Environmental Pollutants

The concepts of "timing of exposure" and "windows of susceptibility" are considered essential in studies evaluating the possible effects of environmental pollutants. There is an accumulation of reasons to focus on fetal life, and to consider, in particular, the issue of brain development. Once more, neonatal head circumference appears as an essential available criterion.

Among the neurotoxic pollutants introduced via the digestive tracts, a great importance should be given today to acrylamide. We had to wait until 2002 to learn that acrylamide is formed in a wide variety of carbohydrate-containing foods during frying or baking at high temperatures [6]. It has been confirmed since that time that there are significant amounts of acrylamide in commonly consumed foods such as fried potatoes, potato chips, biscuits, breakfast cereals and coffee. Developmental toxicity of acrylamide has been confirmed by studies in rodents exposed in utero. A prospective European mother-child study examined the associations between prenatal exposure to acrylamide and birth outcomes, including head circumference [7]. Hemoglobin (Hb) adducts of acrylamide and its metabolite glycidamide were measured in cord blood (reflecting cumulated exposure in the last months of pregnancy) from 1,101 singleton pregnant women recruited in Denmark, England, Greece, Norway, and Spain during 2006-2010. Maternal diet was estimated through food-frequency questionnaires. Both acrylamide and glycidamide Hb adducts were associated with a statistically significant reduction in head circumference: the estimated difference for infants in the highest versus lowest quartile of acrylamide Hb adduct levels, after adjusting for gestational age and country, was -0.33 cm (95% CI: -0.61, -0.06). The difference in birth weight (-132g) was also statistically significant (95% CI: -207, -56). An anthropometry at birth study involving 1471 mother-child pairs showed a negative correlation between dietary acrylamide in pregnancy and birthweight and birth length, but did not provide data about head circumference [8].

Development toxicity of airborne pollutants should also inspire a generation of studies focusing on brain development. Because placentation in our species is hemochorial, a particular importance should be given to studies of the effects of transplacental transfer of nanoparticles smaller than 100 nanometers (such as those emitted by Diesel engines).

What We Should Keep in Mind

To detect the most significant transformations of our species in relation to changing lifestyles, we must keep in mind that a huge encephalization quotient is the main characteristic of Homo sapiens. This is why neonatal head circumference, as an available but underused index of brain weight, is an irreplaceable criterion.

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