Original Research Article

Hour of Birth and Birth Assistance: From a Primate to a Medicalized Pattern?

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Objectives: Previous studies generally agree that in *Homo sapiens* births without medical intervention occur mostly at night, although with a less accentuated pattern than in other primate species. The present study has three main objectives: (a) to establish the hourly pattern of births in a modern medicalized population, (b) to explore the association between the hour of birth and maternal and fetal variables and mode of delivery, and (c) to evaluate the risk for medical intervention at different hours of the day.

Methods: The hourly distribution of 25,779 deliveries at the "La Paz" Madrid University Maternity Hospital (Spain) has been analyzed. Two different multivariate analyses have been used to evaluate, respectively, the relationships between maternal and fetal characteristics and the type of birth and hour of delivery.

Results: The increasing of unnecessary hospital interventions seems to have transformed the nocturnal pattern of birth into a diurnal one and may be contributing to the rise of preterm and low birth weight deliveries, reducing their probability of being breastfeed, and eliminating or transforming emotional and social support. Immigrant women present a higher frequency of the nocturnal pattern of delivery than their Spanish counterparts.

Conclusions: The predominant nocturnal pattern of birth seems to have disappeared in a Spanish highly medicalized population. However, the hallmark of primate nocturnal deliveries is evident when multiple births, malpresentation, Caesarean sections, and vaginal interventions are excluded. Possible consequences of diurnal birth include reduced infant–mother bonding, breast feeding, and later life reductions to health. Am. J. Hum. Biol. 24:14–21, 2012.

Birthing characteristics of modern *Homo sapiens* reflect multiple responses to different obstetric challenges derived from the adaptation of human reproductive biology to bipedalism, encephalization, and the combined consequences of both factors on presentation during labor. Human birth has evolved as a mosaic of characteristics (anatomical, physiological, and biocultural), retaining some primate features and incorporating new adaptations at different times of the evolutionary history of our lineage (Rosenberg and Trevathan 2002; Rosenberg, 1992; Trevathan, 1987). A predominant nocturnal pattern of delivery may be one of the ancestral characteristics of our species, shared with anthropoid radiation to which we belong (Ankel-Simons and Rasmussen, 2008; Kirk and Kay, 2004). Various reasons have been suggested to explain the advantage of nocturnal deliveries among diurnal species (lower activity of predators, group protection, better conditions for delivery, and better conditions for mother–infant bonding). Nonhuman and human primates share a maternal circadian mechanism, which regulates the nocturnal pattern of births (Backe, 1991; Honnebier and Nathanielsz, 1994; Kaiser and Halberg, 1962; Maleck, 1952). Contractions most frequently start in the middle of the night with a peak just after midnight (Backe, 1991). Recent research on the mechanisms underlying the timing of birth and regulation of the contractile machinery in the myometrium have shown that human parturition is normally the result of increased sensitivity to melatonin, which synergizes with oxytocine (Sharkey et al., 2009). The process is complex, showing peculiarities for different species of primates (Honnebier and Nathanielsz, 1994), and nonetheless, it provides the biological mechanism involved in the adaptive response associated with nocturnal pattern of births.

Information on hourly distribution of birth in primate populations—including our species—is relatively scarce. Previous publications (Kaiser and Halberg, 1962; Camargo and Ferrari, 2007; Charles, 1953; Honnebier and Nathanielsz, 1994; King, 1956; Trevathan, 1987) generally agree that in *Homo sapiens* births without medical intervention occur mostly at night, although with a less accentuated pattern than in other primate species. We have not advanced much in the knowledge of these aspects since Jolly (1972; p. 111) summarized the situation as follows: "Normal labor most commonly (...) ends between 1 and 7 a.m. Nocturnal labor is significantly shorter than diurnal labor. Differences are affected by parity as well as by normality." It has been suggested that in modern populations natural adaptation is blurred because of cultural factors (Martin, 2007) and that, at the same time, behaviors shaped by these cultural factors might be either adaptive, if they do in fact have a positive impact on mother–child viability and health (Martin, 2007; Trevathan, 1987), or maladaptative, if they surpass the limit of phenotypic plasticity allowed by our genes.

During the last 30 years, biosocial characteristics of childbearing women influencing birth outcomes have greatly changed in Western populations coinciding with increased rates of medicalization and intervention in pregnancy and delivery (EURO-PERISTAT, 2008).

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TABLE 1. Maternal, newborn, labor, and medical intervention indicators ("La Paz" University Maternity Hospital, Madrid, Spain, 1991, 2005 and 2007)

Characteristics		Categories	% (*n*/*N*)
Maternal	Age	<20 years	3.6 (912/25,486)
		20–29 years	40.3 (10,265/25,486)
		30–39 years	52.5 (13,386/25,486)
		>40 years	3.6 (923/25,486)
	Parity	Primiparous (vs. multiparous)	51.7 (13,072/25,264)
	Origin	Spanish mothers	66.0 (10,956 /16,589)
		Maghrebian mothers	4.7 (782/16,589)
		East European mothers	5.4 (903/16,589)
		Latin Americans mothers	22.3 (3,701/16,589)
		Chinese mothers	1.5 (247/16,589)
Newborn and labor	Sex	Male (vs. female)	105,4 13,104/12,430
	Maturity	Preterm (vs. full term)	7.1 (1,843/22,391)
	Weight	<2500 g	8.6 (2,194/25,506)
		2500–3999 g	86.9 (22,170/25,506)
		≥4000 gm	4.5 (1,142/25,506)
	Multiplicity	Multiple births (vs. singleton)	1.9 (500/25,779)
	Presentation	Malpresentation (Podalic and others vs. vertex)	4.0 (1,032/25,581)
Medical Interventions	Pain control	Epidural (vs. no pain control)	71.1 (12.888/18.134)
	Surgical intervention	Cesarean section (vs. vaginal)	21.2 (5,423/25,556)
	Vaginal deliveries	No intervention	27.0 (5,437/20.133)
		Episiotomy	55.6 (11,194/20.133)
		Instrumental	8.7 (1,767/20.133)
		Kristeller maneuver	8.6 (1,735/20.133)

Several authors (Astolfi et al., 1999; Joseph et al., 2003; Machado, 2006; Wilkinson et al., 1998) justify the need of extending medicalization of birth because of the rising rates in late maternal age, primiparity, and multiple pregnancies, which are associated with risky pregnancies and negative birth outcomes. In addition, the increasing proportion of deliveries by immigrant mothers—which in 2009 represent 20.9% of all births in Spain—might also affect the timing of birth. However, despite the changes in reproductive patterns and the contribution of foreign populations, there is wide agreement among experts that in Spain there are both an excessive medicalization in childbearing (EURO-PERISTAT, 2008) and an excessive incidence of a series of interventions in labor. These greatly surpass the World Health Organization guidelines (WHO, 1985, 2006), especially in comparison with most of the Western world.

Between 2005 and 2008, our group carried out research on the impact of migration on mother–infant health in Spain. Preliminary analyses carried out on secular changes and ethnic variability in reproductive patterns (Varea, 2009), in low birth weight, preterm deliveries, and weight for gestational age (Acevedo et al., 2010; Bernis, 2010; Varea, 2009), demonstrated ethnic differences in maternal and newborn characteristics. Spanish mothers were older, more often primiparous, and have higher rates of multiple births compared with immigrant mothers. Spanish babies have lower mean weight and higher frequency of low birth weight than migrants but similar rates of preterm births. They also differ in the use of prenatal care and in labor-related behaviors. Immigrants present less antenatal care and check-in at the maternity hospital at a more advanced stage of labor. The rate and type of intervention during labor also differ with immigrants receiving fewer epidural analgesias and more instrumental deliveries (Bernis, 2009). Significant differences were also found in breastfeeding rates according to mother's origin and the medical intervention used (Montero, 2009).

Tracking the hallmark of adaptive responses incorporated in the biology of contemporary populations (such as nocturnal patterns of birth) will be of value to medical science (Martin, 2007) to clarify whether the current excess in medical intervention might be affecting the biological responses to environmental changes, contributing, for example, to increasing number of "programed fetus," with health consequences later in life.

This study has three main objectives: (1) to establish the hourly pattern of births in Spain, (2) to explore the association between the hour of birth and maternal variables, fetal variables, and mode of delivery, and (3) to evaluate the risk for medical intervention at different hours of the day. In the light of our findings, we discuss possible consequences, which might affect essential aspects of biological plasticity.

MATERIALS AND METHODS

The analysis is based on 25,779 deliveries at the "La Paz" Madrid University Maternity Hospital during the years 1991, 2005, and 2007. Data from the Maternity Labor Registers were anonymously computerized. Data collection was approved by ethical committees from both the Maternity Hospital and Madrid Autonomous University; information was collected in agreement with the WHO Declaration of Helsinki ethical guidelines (World Medical Association, 2004).

Table 1 presents the maternal, newborn and labor characteristics collected from the Maternity Hospital Registers. Gestational age has been categorized in <37 (prematurity), 37–38 (early full-term), and ≥39 (normal full-term) weeks groups; maternal age in four groups (<20, 20–29, 30–39, and ≥40 years); and birth weight in three groups (<2,500, 2,500–3,999, and >4,000 g). Multiplicity expresses single or multiple gestations. The variable presentation includes the categories vertex presentation versus malpresentation (breech, transverse, or occipitoanterior presentations) deliveries. Mode of delivery includes Caesarean section and vaginal types of birth, the later including deliveries without intervention and deliveries with episiotomy, Kristeller maneuver (Kristeller

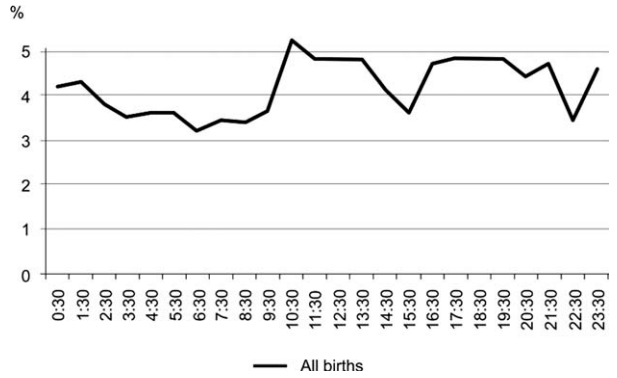

Fig. 1. Hourly distribution of births ("La Paz" University Maternity Hospital, Madrid, Spain, 1991, 2005, and 2007).

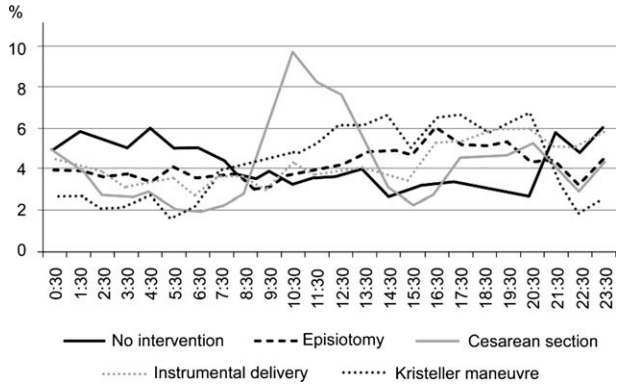

Fig. 2. Hourly distribution of cesarean section, vaginal non intervened deliveries and vaginal intervened deliveries ("La Paz" University Maternity Hospital, Madrid, Spain, 1991, 2005, and 2007).

maneuver consists of a gentle fundal pressure placed in the second stage of labor in order to accelerate the expulsion), and use of instrumental (forceps, vacuum, and spatulas). For 2005 and 2007, there is additional information on both pain control (deliveries with or without epidural anesthesia) and maternal country of origin (the contribution by foreign mothers to Spain's natality rate was not significant until 1996; hence, maternal origin rates were not accounted for in 1991, and analysis taking into account mother's origin have a small number of data). The hourly distribution of births was evaluated by comparing area of origin of the four most numerous communities: Latin American (Ecuador is the country contributing a higher number of immigrants), Eastern European, Maghrebians (99% of the mothers coming from Morocco), and Chinese mothers. The hour of birth has been categorized in eight periods of time: 01:30–03:30, 04:30–06:30, 07:30–09:30, 10:30–12:30, 13:30–15:30, 16:30–18:30, 19:30–21:30, and 22:30–24:30 h.

First, hourly distribution of all births is studied. Subsequently, the hourly distributions of births without intervention and with medical intervention (included Caesareans section) are compared. Multiple correspondence analysis (HOMALS) has been used to evaluate simultaneously the relationships among all variables. Finally, a multinomial logistic regression analysis has been carried out to evaluate the contribution of hourly birth pattern on the mode of delivery (only women with single deliveries in vertex presentation have been included).

The statistical treatment of data was performed with SPSS.17.

RESULTS

Hourly distribution of births

Figure 1 shows the hourly distribution of all births studied. A pattern of relative deficit of nocturnal births and two diurnal peaks is observed: the first in the morning and the second—longer and less marked—in the afternoon. Figure 2 compares the hourly distribution of births, differentiating birth without intervention from those born with medical intervention (Caesarean section, Kristeller maneuver, use of instruments, or episiotomy). Vaginal deliveries without intervention occur with greater frequency during nocturnal hours and birth with intervention accumulate during the day showing differences in timing and range according to the type of intervention. Accordingly, episiotomy mostly occurs between 13:30 and 20:30 h, whereas Kristeller maneuver presents a wider peak that ranges from 10:30 to 19:30 h. Instrumental births take place in the afternoon hours, between 15:30 and 20:30 h. Deliveries concluded by Caesarean section show both a marked decline during the night and within a conspicuous diurnal morning peak, between 10:30 and 12.30 h.

Relationships between the hourly distribution of birth and maternal, fetal, and labor characteristics

Multiple correspondence analysis (HOMALS) has been carried out to obtain a graphic summary of relationships among the categories of all variables. The model resulting explains 33% of total variance. Figure 3 shows the relationships among the categories of the different variables. The first dimension (D1) is mainly defined by the characteristics of medical intervention (epidural anesthesia and mode of delivery), and the second (D2) is mainly defined by fetal characteristics (birth weight and gestational age) and again by mode of delivery. Variability explained by dimensions D1 (17.5%) and D2 (15.5%) is independent. Two distinct subpopulations emerge from the graph. The first is formed by women receiving epidural analgesia, giving birth mainly in the day time, and presenting deliveries with interventions (episiotomy, Kristeller maneuver, and instrumental). These women are mainly primiparous Spanish and Eastern European. With characteristics opposite to this group, women not receiving epidural analgesia, having nonintervened vaginal deliveries, which occur mainly at night, are mainly multiparous migrants from China, Maghreb, or Latin America. Caesarean section is associated with both low birth weight, prematurity, and early full-term births ($<$ 37 and 37–38 weeks, respectively) as opposed to full-term vaginal deliveries ($\geq$39 weeks) and normal birth weight (2,500–3,999 g). In addition, Caesarean section is associated through D1 with multiparous Latin Americans and the diurnal birth period from 10:30 to 12:30 h, and through D2 with the diurnal birth period from 13:30 to 15:30 h and with primiparous Spanish and Eastern European women.

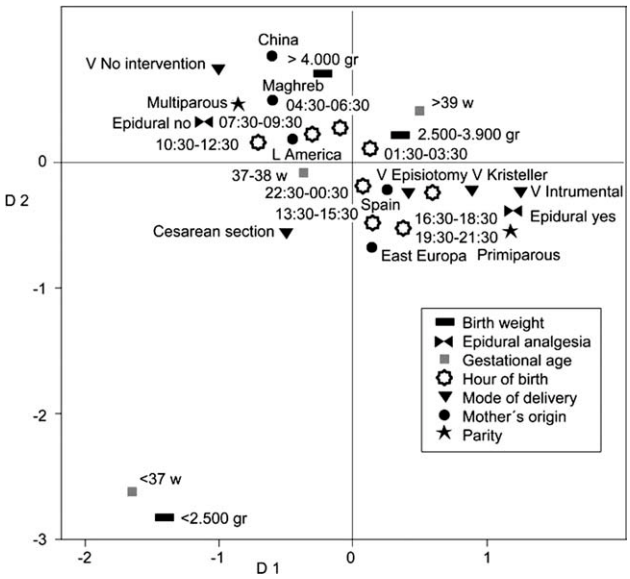

Fig. 3. Relationship between the categories of the analyzed variables¾hourly distribution of births, the maternal, fetal, and labor characteristics (V, vaginal) according to their punctuation in Dimensions 1 and 2 (Multiple Correspondence Analysis, HOMALS; "La Paz" University Maternity Hospital, Madrid, Spain, 1991, 2005, and 2007).

Effect of the hourly distribution of births, on the mode of delivery, after adjusting for mother and newborn characteristics and for the use of epidural anesthesia

Table 1 summarizes the multinomial logistic regression analysis, which is carried out to explain the contribution of the hourly birth pattern on the mode of delivery, after adjusting for maternal, fetal, and labor characteristics, and the use of epidural analgesia (all OR values and the 95% CIs and *P*-values for all variables are presented in the Table 2). Results from the multinomial logistic regression analysis complement those results shown by the HOMALS analysis. The model explains 24% of variability in the mode of delivery. The outcome in terms of mode of delivery was found to be significantly associated with all independent variables. The risk of having an intervention (episiotomy, instrumental delivery, Kristeller maneuver, or Caesarean section) was increased for those women delivering in the four diurnal periods established when compared with the reference nocturnal period, from 01:30 to 03:30 h. Women delivering in the nocturnal periods 22:30–00:30, 04:30–06:30, and 07:30–09:30 h do not present significant differences with respect to of intervention in comparison with the reference period. The risk of having a vaginal intervention (episiotomy, instrumental delivery, or Kristeller maneuver) is significantly increased for women receiving epidural anesthesia compared with those not receiving it, whereas that of having a Caesarean section was significantly decreased. These results reinforce the fact that the mode of delivery and its consequences are significantly associated with the hour of birth.

As for maternal characteristics, the risk of having all types of interventions is significantly increased in primiparous compared with multiparous women, and it is significantly increased with age of mother when compared with the reference group (<20 years). When compared with the Spanish, Latin American women are at a significant lower risk of having episiotomies, instrumental deliveries, or Kristeller maneuvers. However, no significant differences exist for Caesarean sections. In comparison with the Spanish mothers, the Chinese and Maghrebian mothers are at significant lower risk of having Caesarean sections, whereas no significant differences exist for vaginal interventions.

Finally, in respect to fetal characteristics, preterm births are at significant lower risk of being born with an episiotomy, an instrumental delivery or a Kristeller maneuver compared with the reference gestational age group (normal full-term, ≥39 weeks), whereas they are at significantly higher risk of being born after a Caesarean section. As for the birth weight, both macrosomic (more than 4,000 g) and low birth weight fetuses are at higher risk of being born by Caesarean section when compared with normal weight babies.

DISCUSSION

Considering all deliveries, our results show that the predominant nocturnal pattern of birth (from 1 to 7 a.m.) has disappeared in this Spanish population, one that is highly medicalized. We also find significant differences in the hourly pattern of deliveries, according to the mode of intervention in the delivery. Nonintervened births occur in the night hours, whereas those subject to intervention experience two diurnal peaks: (1) a morning peak for multiple births, breech presentations, preterm births prevail, and Caesarean sections; (2) an afternoon peak for those vaginal deliveries suffering other types of interventions. Concerning the hourly birth differences between primiparous (more frequent in day time) and multiparous women (more frequent in night time), our results mirror those of other authors (Charles, 1953; Trevathan, 1987). Migrant woman are more often multiparous, significantly less medicalized, and their hourly birth distribution keeps a more nocturnal pattern. These findings express a mixture of different cultural practices between Spanish and immigrants—the later tending toward younger age for the mother, bigger families, and language problems. Immigrant mothers attend less often to antenatal care and check into the maternity hospital at a more advanced stage of delivery, which in turn reduces the probability of having epidural anesthesia. There are also different medical practices for common delivery problems, for example, more Caesarean sections among Spanish and Latin American mothers and more deliveries with forceps among Chinese and Maghrebian mothers (Bernis, 2009).

The hourly distribution of birth in primates and other mammals reflects significant circadian rhythms that are related to the best daily moments for maternal-infant viability, and delivery preferably happens in the nonactive hours so that both mother and neonate can be protected in a crucial moment for establishing mother–infant bonding (Honnebier and Nathanielsz, 1994; Jolly, 1972). For present-day human populations, the higher incidence of births during the night is well documented, preceded by a diurnal pattern of active labor initiation (Charles, 1953; Honnebier and Nathanielsz, 1994; Jolly, 1972; Malek, 1952; Shettles, 1960). Most of these results were published before the eighties and exclude multiple births, malpresentations, and medical interventions. However, because of the increasing medical intervention in current

TABLE 2. Results of the multinomial logistics regression analysis explaining the contribution of hourly birth pattern on the mode of delivery after adjusting for maternal, fetal, labor characteristics, and the use of epidural analgesia

	Mode of delivery											
	Vaginal episiotomy			Vaginal instrumental			Vaginal Kristeller			Cesarean section		
Maternal, newborn and labor characteristics		95% CI			95% CI			95% CI			95% CI	
	Exp (B)	Lower limit	Upper limit	Exp (B)	Lower limit	Upper limit	Exp (B)	Lower limit	Upper limit	Exp (B)	Lower limit	Upper limit
Maternal age (<20 years)												
20–29 years	1.209	0.936	1.561	1.892**	1.252	2.859	1.931*	1.230	3.030	2.027***	1.458	2.820
30–39 years	1.274	0.984	1.650	2.903***	1.917	4.395	2.550***	1.620	4.013	3.182***	2.284	4.434
>40 years	1.069	0.760	1.504	2.542**	1.421	4.548	2.966***	1.623	5.419	4.875***	3.266	7.277
Parity (Multiparous)												
Primiparous	4.034***	3.622	4.493	11.260***	9.450	13.417	9.292***	7.729	11.172	5.278***	4.660	5.978
Origin (Spain)												
China	0.825	0.584	1.164	1.827*	1.098	3.040	1.060	0.582	1.931	0.401***	0.243	0.660
E. Europe	0.874	0.707	1.081	1.030	0.751	1.411	0.854	0.599	1.218	0.779	0.601	1.010
Latin America	0.629***	0.559	0.706	0.755*	0.624	0.913	0.708**	0.576	0.870	0.967	0.848	1.103
Maghreb	0.804*	0.648	0.998	1.284	0.924	1.785	1.027	0.712	1.480	0.763*	0.589	0.989
Gestation length (>39 w)												
<37 w	0.694**	0.560	0.862	0.618*	0.416	0.917	0.434***	0.277	0.680	1.328*	1.057	1.668
37–38 w	0.872*	0.776	0.979	0.712**	0.586	0.864	0.802*	0.654	0.984	1.026	0.897	1.174
Birth weight (2,500–3,999 g)												
>4,000 g	1.018	0.811	1.276	1.196	0.849	1.684	1.077	0.729	1.590	2.155***	1.706	2.723
<2,500 g	1.138	0.913	1.419	0.644*	0.427	0.970	1.134	0.769	1.673	1.526***	1.207	1.930
Epidural analgesia (No)												
Yes	1.678***	1.510	1.864	5.595***	4.326	7.236	2.608***	2.099	3.240	0.975	0.865	1.099
Hour of birth (01:30–03:30 h)												
04:30–06:30 h	0.940	0.793	1.114	0.859	0.645	1.144	1.080	0.757	1.541	0.575***	0.459	0.721
07:30–09:30 h	1.008	0.847	1.199	1.222	0.923	1.619	2.555***	1.865	3.499	1.087	0.883	1.337
10:30–12:30 h	1.228*	1.031	1.462	1.960***	1.492	2.575	4.309***	3.177	5.844	3.007***	2.492	3.630
13:30–15:30 h	1.429***	1.200	1.702	1.265	0.951	1.683	3.234***	2.370	4.412	1.443**	1.172	1.776
16:30–18:30 h	1.674***	1.410	1.988	1.818***	1.402	2.359	2.945***	2.161	4.031	1.538***	1.253	1.888
19:30–21:30 h	1.389***	1.169	1.649	1.793***	1.385	2.321	2.380***	1.734	3.265	1.671***	1.368***	2.040
22:30–00:30 h	0.952	0.784	1.155	1.351*	1.010	1.807	1.098	.739	1.632	1.057	0.840	1.330

Reference category: Vaginal nonintervened delivery ("La Paz" University Maternity Hospital, Madrid, Spain). (For each characteristic, reference category is shown between brackets. Level of significance: *, <0.05; **, <0.000; ***, <0.000.)

populations (in our data only 30% of all deliveries occur without intervention), it is necessary to include all births and to analyze their variability according to the mode of delivery.

Natural selection shapes integrated reproductive strategies, coordinating physiological, anatomical, and behavioral mechanisms in the ecological context in which the species live. Circadian rhythms of birth are part of these mechanisms, determining that humans and other primates deliver preferentially during the night and early morning hours. During fetal life, circadian cycles of sleep–wakefulness are accommodated to maternal rhythms. In adults, a circadian rhythm of melatonin with high nocturnal and low diurnal levels is responsible for regulating the rhythm of sleep–wakefulness in the organism. In women, 24-h rhythms occur in biophysical variables, pregnancy-associated plasma hormones, and preparturient myometrial activity. The developing fetus receives information about the time of the day through the mother, making sure that the mature fetus will cooperate, so that parturition occurs at the most favorable time of the day (Backe, 1991; Honnebier and Nathanielsz, 1994). These are the reasons why nocturnal deliveries are shorter than diurnal ones (as much as 1.2 h, as found by Backe, 1991). It has even been suggested that labor induction with oxytocin should be done at night, when the uterine fibers are more sensitive to it (Honnebier and Natanieltz, 1994).

Within the European model of birth attendance, that of Spain is considered to be highly interventionist (Aceituno, 2009; EURO-PERISTAT, 2008; Ministerio de Sanidad y Política Social, 2007). In the mid-1990s, coinciding with the rapid increase of migration into Spain, the extension of the epidural anaesthesia to all deliveries became an objective in the National Health Care System (EURO-PERISTAT, 2008; Ministerio de Sanidad y Política Social, 2007) and, at the same time, a liberalization of the Caesarean section occurred (González, 2009). In Spain, the rate of interventions varies among the different regions: the range for Caesarean is 13.1–28.7% and that for episiotomies 33–73.2% (Ministerio de Sanidad y Política Social, 2007).

Data on labor induction and elective Caesarean are not available for Spain. However, González (2009) estimated that in "La Paz" University Hospital—where our data have been collected—12% of all deliveries where induced and that 28.2% of Caesarean sections were either programmed or elective in 2007. The WHO (1985) recommends fewer than 15% Caesarean sections and fewer than 30% episiotomies. In our sample, 72% of women received epidural analgesia, and the rates for Caesarean section and episiotomy were 25 and 70%, respectively. The differences between WHO recommendations and the actual rates give an estimate of unnecessary interventions.

Prematurity and low birth weight have been increasing over the last three decades and present considerable fitness costs, reducing the chances to experience healthy development and increasing the risk of morbidity and mortality across the lifespan (Kramer, 2003). These costs have been interpreted as the expression of plasticity, resulting in permanent biological adjustments to environmental variability and stressful situations in uterus (fetal programing) (Hales and Baker, 2001). Our results rise two questions, which need further research: babies born preterm or with low birth weight after unnecessary medical interventions (induction and Caesarean section), do they experience the same physiological and metabolic adjustments as those spontaneously born low birth weight and preterm? or, do they experience the same adjustments as those born after needed medical intervention because of fetal distress? and, if so, will they develop postnatal adjustments similar to the stressed fetus?

The evolutionary significance of developmental plasticity has been widely discussed in the frame of life history theory (Bogin et al., 2007; Ellison, 2005; Frisancho, 2009; Gluckman et al., 2007; Kuzawa, 2007; Schell and Magnus, 2007; Worthman and Kuzawa, 2005). Whether such plasticity leads to pathological or adaptive responses remains a matter of debate? Longitudinal studies of preterm babies born after unnecessary medical intervention can give further light to these suggestions and to the understanding of the evolutionary significance of plasticity and its applications in public health. It has also been demonstrated that all children who are born preterm, with low birth weight or by Caesarean section are at increased risk of missing maternal breastfeeding (Merten et al., 2007; Montero, 2009) and all the known benefits associated with it, including those leading to better biological outcomes later in life (Haines and Kintner, 2008).

Nocturnal labors are the result of an ancient evolutionary adaptive pattern, which benefits the physiological needs of the mothers and babies, as deliveries are shorter, mother infant bonding is improved and are at a significant lower risk of intervention. Intervened deliveries are more expensive, Caesarean section is more life threatening and seems related to increasing preterm and low birth weight babies (Häger et al., 2004; Althabe and Belizán, 2006; Liu et al., 2007; Lumbiganon et al., 2010; Murta et al., 2006; Norman et al., 2009). The benefits of nocturnal labor together with the evolutionary adaptive pattern are often rendered ineffective by unnecessary hospital policies and procedures. Increased hospital interventions might be affecting various biocultural aspects of birth, transforming the predominant nocturnal pattern into a diurnal one, contributing to the increasing rate of preterm and low birth weight deliveries (which in turn reduces the probability of being breast fed), and eliminating or limiting traditional emotional and social support, all of which are essential aspects of biological adaptations.

A clear understanding of the interaction between behavior and biology is essential to make decisions to redefine and improve the application of protocols affecting the health of women and their descendants (Stuart-Macadam and Dettwyler, 1995). A big gap between national guidelines and their practical application exits in most countries, despite the fact that they are based on the best available scientific knowledge (Chaillet et al., 2007; Festin et al., 2003; Ministerio de Sanidad y Política Social, 2007; SEGO, 2005). Nonmedical factors have been suggested as causing the widespread and continuing rise in labor intervention, mainly related to behavior and attitudes, regarding maternal characteristics, physician practice patterns, maternal choice, and legal pressures (Malin and Gissler, 2009). It is not easy to overcome the existing barriers for implementing the guidelines, especially those related to women's motivations, the nature of the medical explanations provided, the management of maternal requests for medical interventions, and the physicians' perceptions

(Chaillet et al., 2007; Festin et al., 2003). We suggest that a thorough understanding of the evolutionary basis of human pregnancy and delivery will result in a change for the better of behaviors and attitudes.

CONCLUSIONS

1. The predominant nocturnal pattern of birth seems to have disappeared in a current Spanish highly medicalized population. However, the hallmark of primate nocturnal deliveries is evident when multiple births, malpresentations, Caesarean sections, and vaginal interventions are excluded. This conclusion could be probably being extended to other populations with similar western reproductive patterns and similar rates of obstetric intervention.
2. Increased hospital interventions affect several biocultural aspects of birth, transforming the predominant nocturnal pattern into a diurnal one, contributing to the increasing rate of preterm and low birth weight deliveries (which in turn reduce the probability of being breast fed), and eliminating or transforming traditional emotional and social support. On the basis of these facts, we suggest that the rate of nocturnal deliveries might be used as a positive indicator of perinatal health.
3. The benefits of nocturnal labor together with the evolutionary adaptive pattern are often rendered ineffective by unnecessary hospital policies and procedures.
4. An evolutionary approach to pregnancy and birth is recommended in the curricula of professional health, and in the natural science programs at Secondary schools: it will be very useful for the comprehension of human adaptation, essential for decision making, and very helpful in changing motivations and attitudes among both professionals and women.

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LITERATURE CITED

Aceituno L. 2009. Tasa de partos instrumentales en España. Prog Obstet Ginecol 52:609–615.

Acevedo P, Bernis C, Varea C, Montero P. 2010. Gestación y maternidad de las mujeres de Madrid: comparación entre madres inmigrantes y españolas. Trabajos de Antropología 30:23–30.

Althabe F, Belizán JF. 2006. Caesarean section: the paradox. Lancet 368:1516–1523.

Ankel-Simons F, Rasmussen DT. 2008. Diurnality, Nocturnality, and the Evolution of Primate Visual Systems. Yearb Phys Anthropol 51:100–117.

Astolfi P, Ulizzi L, Zonta LA. 1999. Selective cost of delayed childbearing. Hum Reprod 19:490–503.

Backe BA. 1991. Circadian variation in the observed duration of labor. Possible causes and implications. Acta Obstet Gynecol Scand 70:465–468.

Bernis C. 2009. Determinantes biológicos y sociales del embarazo y el parto: estado nutricional, género y origen. In: Bernis C, López R, Montero P, editors. Determinantes biológicos, psicológicos y sociales de la maternidad en el S XXI. Mitos y realidades. Madrid: Ediciones de la Universidad Autónoma de Madrid. p 79–124.

Bernis C. 2010. Factores causales de la reducción del peso al nacer en España 1980–2007: cambios en la viabilidad fetal, en la distribución de la edad gestacional y en la dinámica del crecimiento intrauterino. Trabajos de Antropología 31:233–247.

Bogin B, Varela Silva I, Rios L. 2007. Life history trade-offs in human growth: adaptation or pathology? Am J Hum Biol 19:631–642.

Camargo CC, Ferrari SF. 2007. Observations of day time births in two groups of red-handed howlers (*Alouatta bezbul*) on an island in the Tucuri reservoir in eastern Brazilian Amazonia. Am J Primatol 69:1075–1079.

Chaillet N, Dube E, Dugas M, Francoeur D, Dube J, Gagnon S, Poitras L, Dumont A. 2007. Identifying barriers and facilitators towards implementing guidelines to reduce caesarean section rates in Quebec. Bull World Health Organization (Geneva) 85:733–820.

Charles E. 1953. The hour of birth. A study of the distribution of times of onset of labour and of deliveries through 24 h period. Br J Prev Soc Med 7:43–59.

Ellison PT. 2005. Evolutionary perspectives on the fetal Origins Hypothesis. Am J Hum Biol 17:113–118.

EURO-PERISTAT. 2008. European Perinatal Health Report. EURO-PERISTAT Project in collaboration with SCP, EUROCAT & EURONEOSTAT; Available at: www/europeristat.com.

Festin MR, Lumbiganon P, Tolosa JE, Finney KA, Ba-Thike K, Chipato T, Gaitán H, Xu L, Limpongsanurak S, Mittal S, Peedicayil A, Pramono N, Purwar M, Shenoy S, Daly S. 2003. International survey on variations in practice of the management of the third stage of labour. Bull World Health Organization (Geneva) 81:286–291

Frisancho R. 2009. Developmental adaptation: where we go from here? Am J Hum Biol 21:694–703.

Gluckman PD, Hanson MA, Beedle AS. 2007. Early life events and their consequences for later disease: a life history and evolutionary perspective. Am J Hum Biol 19:1–19.

González A. 2009. Riesgos del embarazo y del parto. In: Bernis C, López R, Montero P, editors. Determinantes biológicos, psicológicos y sociales de la maternidad en el S XXI. Mitos y realidades. Madrid: Ediciones de la Universidad Autónoma de Madrid. p 297–317.

Häger RM, Daltveit AK, Hofoss D, Nilsen ST, Kolaas T, Øian P, Henriksen T. 2004. Complications of cesarean deliveries: rates and risk factors. Am J Obstet Gynecol 190:428–434.

Haines MR, Kintner HJ. 2008. Can breast feeding help you in later life? Evidence from German military heights in the early 20th century. Econ Hum Biol 6:420–430.

Hales CN, Barker DJ. 2001. The thrifty fenotype hipothesis. Br Med Bull 60:5–20.

Honnebier MB, Nathanielsz PW. 1994. Primate parturition and the role of maternal circadian system. Eur J Obstet Gynecol Reprod Biol 55:193–203.

Kirk EC, Kay RF. 2004. The evolution of high visual acuity in the Anthropoidea. In: Ross CF, Kay RF, editors. Anthropoid origins: new visions. New York: Kluwer Academic/Plenum. p 539–602.

Kramer MS. 2003. The epidemiology of adverse pregnancy outcomes: an overview. J Nutr 133:1592S–1596S.

Jolly A. 1972. Hour of births in primates and man. Folia Primatol 18: 108–121.

Joseph KS, Young DC, Dodds L, O'Connell CM, Allen VM, Chandra S, Allen AC. 2003. Changes in maternal characteristics and obstetric practice and recent increases in primary cesarean delivery. Obstet Gynecol 102:791–800.

Kaiser IH, Halberg F. 1962. Circadian periodic aspects of birth. Ann N Y Acad Sci 98:1056–1068.

King PD. 1956. Increased frequency of births in the morning hours. Science 123:985–956.

Kramer MS. 2003. The epidemiology of adverse pregnancy outcomes: an overview. J Nutr 133:1592S–1596S.

Kuzawa CW. 2007. Developmental origins of life history: growth productivity and reproduction. Am J Hum Biol 19:654–661.

Liu S, Liston RM, Joseph KS, Heaman M, Sauve R, Kramer MS. 2007. Maternal mortality and severe morbidity associated with low-risk planned cesarean delivery versus planned vaginal delivery at term. CMAJ 176:455–460.

Lumbiganon P, Laopaiboon M, Gulmezoglu AM, Souza JP, Taneepanichskul S, Ruyan P, Attygalle DE, Shrestha N, Mori R, Nguyen DH, Hoang TB, Rathavy T, Chuyun K, Cheang K, Festin M, Udomprasertgul V, Germar MJV, Yanqiu G, Roy M, Carroli G, Ba-Thike K, Filatova E, Villar J. 2010. Method of delivery and pregnancy outcomes in Asia: the WHO global survey on maternal and perinatal health 2007-08. Lancet 375:490–499.

Machado CJ. 2006. Impact of maternal age on birth outcomes: a population study of primiparous Brazilian women in the city of San Paulo. J Biosoc Sci 38:523–535.

Malek J. 1952. The manifestation of biological rhythms in delivery. Gynaecologia 133:365–372

Malin M, Gissler M. 2009. Maternal care and birth outcomes among ethnic minority women in Finland. BMC Public Health 9:84–93.

Martin RD. 2007. The evolution of human reproduction: a primatological perspective. Yearb Phys Anthropol 50:59–84.

Merten S, Wyss C, Ackerman-Liebrich U. 2007. Cesarean sections and brestfeeding initiation among migrants in Swizerland. Int J Public Health 52:210–222.

Ministerio de Sanidad y Política Social. 2007. Estrategia de atención al parto normal en el sistema nacional de salud. Madrid: Ministerio de Sanidad y Política Social.

Montero P. 2009. La alimentación del recién nacido: condiciones biosociales y culturales. In: Bernis C, López R, Montero P, editors. Determinantes biológicos, psicológicos y sociales de la maternidad en el S XXI. Mitos y realidades. Madrid: Ediciones de la Universidad Autónoma de Madrid. p 125–146.

Norman JE, Morris C, Chalmers J. 2009. The effect of changing patterns of obstetric care in Scotland (1980–2004) on rates of preterm birth and its neonatal consequences: perinatal database study. PLoS Med 6:e1000153. doi:10.1371/journal.pmed.1000153 [Published: September 22, 2009.]

Murta EF, Freire GC, Fabri DC, Fabri RH. 2006. Could elective cesarean sections influence the birth weight of full-term infants? Sao Paulo Med J 124:313–315.

Rosenberg KR. 1992. The evolution of modern human childbirth. Am J Phys Anthropol 35:89–124.

Rosenberg KR, Trevathan W. 2002. Birth, obstetrics and human evolution. BJOG 109:1199–1206.

Schell LM, Magnus PD. 2007. Is there an elephant in the room? Adressing rival approaches to the interpretation of growth perturbations and small size. Am J Hum Biol 19:606–614.

SEGO. 2005. Recomendaciones para la Organización de un Servicio de Obstetricia y Ginecología. Madrid: Sociedad Española de Obstetricia y Ginecología.

Sharkey JT, Puttaramu R, Word RA, Olcese J. 2009. Melatonin synergizes with oxytocin to enhance contractility of human myometrial smooth muscle cells. J Clin Endocrinol Metab 2:421–442.

Shettles LS. 1960. Hourly variation in onset of labor and rupture of membranes. Am J Obstet Gynecol 79:177–179.

Stuart-Macadam P, Dettwyler KA, editors. 1995. Breastfeeding: biocultural perspectives. New York: Aldine de Gruyter.

Trevathan WR. 1987. Human birth. An Evolutionary Perspective. New York: Aldine de Gruyter.

Varea C. 2009. El debate sobre un nuevo patrón reproductor en España y la contribución del colectivo de mujeres inmigrantes. In: Bernis C, López R, Montero P, editors. Determinantes biológicos, psicológicos y sociales de la maternidad en el S XXI. Mitos y realidades. Madrid: Ediciones de la Universidad Autónoma de Madrid. p 171–198.

WHO. 1985. Appropriate technology for birth. Lancet 2:436–437.

WHO. 2006. Pregnancy, childbirth, postpartum and newborn care: a guide for essential practice,2nd ed. Geneva: World Health Organization.

Wilkinson C, McIlwaine G, Boulton-Jones C, Cole S. 1998. Is a rising caesarean sectionrate inevitable? Br J Obstet Gynaecol 105:45–52.

World Medical Association. 2004. Declaration of Helsinki. Ethical Principles for Medical Research Involving Human Subjects; Available at: http://ohsr.od.nih.gov/guidelines/helsinki.html.

Worthman CM, Kuzawa J. 2005. Life history and the early origins of health differentials. Am J Hum Biol 17:95–112.