Original Study

Hormonal State Comparison (Progesterone, Estradiol, and Leptin) of Body Fat and Body Mass Indices in Mexican Women as a Risk Factor for Neonatal Physiologic Condition

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A B S T R A C T

Study Objective: Describe the impact of teen pregnancy on later ovarian activity and metabolic hormones considering the concentration of current levels of ovarian steroids and leptin in a sample of Mexican females.
Design: Cross-sectional study in the maternity of the General Hospital of Atlacomulco and campus of the Autonomous University of the State of Mexico.
Participants: 71women between the ages of 18 and 24, and 160 neonates seen between March 2010 and June 2012.
Main Outcome Measures: The measurements obtained included anthropometric body composition (bioelectrical impedance), serum hormone quantification of ovarian steroids and leptin (immunoassays), and the Apgar scores, height, and weight in neonates. Statistical analysis included ANOVA, Student, and chi-square for $P < .05$.
Results: Adolescent mothers showed significantly lower concentrations of estradiol ($P = .001$) and progesterone ($P = .001$). However, higher levels of leptin in adolescent mothers were not statistically different compared with older mothers ($P = .84$). Also, leptin was correlated with all measures of adiposity. The mean birth weights ($P = .001$) and Apgar scores ($P = .001$) were lower in neonates of adolescent mothers than in neonates of adult mothers. There was no association between maternal age with the anthropometric variables studied.
Conclusions: Early reproduction represents a metabolic stress condition that modifies the long term ovarian activity and metabolic hormones, and impacts the morbidity-mortality of the mother and offspring in a later vital life cycle stage.
Key Words: Leptin, Adolescent pregnancy, Metabolic stress, Neonate

Introduction

Gestation is possibly the most important factor to define reproductive success in human females, and is one of the most decisive for natural selection. It represents the life stage with the highest energy and nutrient demand.[1,2] The energetic situation of women before pregnancy dictates the actual energy requirements necessary to meet the demands of gestation and lactation physiology (ie, fetal growth, maintenance and growth of maternal tissues, accumulation of adipose tissue, milk synthesis, and maintenance metabolism of mammary glands).[3] However, being young (≤19) during the first reproductive cycle (defined as pregnancy and lactation) adds additional costs associated with poor pregnancy, particularly those occurring 2 years after menarche. Authors have demonstrated that young women, particularly adolescent girls, show strong links between maternal and fetal competition towards growth and development.[4,5]

Compared to other hominids, human puberty is a long and particularly sensitive stage of the life cycle in which 2 physiologically important tasks must be completed: body growth and maturation of adult reproductive characteristics. During this stage, pregnancy could lead to a compromising metabolic situation, since scarce resources will be required simultaneously. This dilemma forces the body to make a change in energy allocation towards reproductive effort.[6]

Adolescent pregnancy is considered a health problem due to the increased incidence of maternal conditions, perinatal and neonatal, when compared with adult mothers, such as anemia, hypertensive status and gestational diabetes mellitus, eclampsia, a higher number of abortions, cesarean birth and prolonged labor, fetal growth restriction (FGR), low birth weight (LBW), low Apgar scores, undernourishment, prematurity, and perinatal death.[7,8]

Leptin is among hormones that have a major role in reproductive health. It is a hormone mainly secreted, but not exclusively, by adipose tissue and in women with normal weight it is essentially related with gluteofemoral fat.[9] Evidence supports the complex interrelationship between energy metabolism and female fertility because it exerts its actions essentially at 4 levels. The first is the

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central effect on the hypothalamus with a gonadotropin releasing hormone and the hypophysis, or the secretion of follicle-stimulating hormone and luteinizing hormone (LH).The second level is the peripheral effects in the ovary, endometrium, and reproductive tract. The third level is the direct effects on the development of the oocyte and the embryo and the fourth level is the effects during pregnancy to regulate oscillations of levels of LH and estradiol preparing the body for the metabolic demands of pregnancy.[10,11] In turn, the circulating leptin levels in vivo are modulated by a series of factors such as insulin and its more potent regulator, and its main secretagogue, nutrient availability, and triglycerides. In turn, the glucocorticoids (cortisol, androgens, testosterone, and growth hormone[9,12]) are jointly involved in glucose homeostasis, adipose tissue homeostasis, bone metabolism, food intake,[13] in regulating of the immune system[14] and in the growth hormone/insulin-like growth factor axis (GH/IGF-1).[15] They also have a direct role in steroidogenesis through the metabolic actions of insulin and IGF-I in the human cells of granulosa and theca.[16] These cells contribute to the increase in lipid peroxidation which occurs during adolescence and under the influence of increasing levels of estradiol, fatty acid storage in the gluteofemoral omega-3 type, which is critical in brain development.[17,18] This suggests that the scarcity of these fatty acids, and not of the adolescence status per se, may be associated with some cognitive deterioration in the progeny. It is imperative to consider that early motherhood is a physiologic event that also increases the demand of nutrients during adolescence, and that nutritional requirements seem to depend less on chronological age and more on whether growth continues or has ceased.[19]

The superposition of a pregnancy during this vital stage, in which adolescents have higher energy and nutritional requirements, leads to a situation where the needs of both the mother and the fetus cannot be adequately and simultaneously satisfied. Therefore, there is a higher risk that the pregnant adolescent and her fetus will compete for available nutrients. This competition leads to metabolic stress for both the mother and her progeny due to a deficit in the energetic intake or energetic reserves.[20] Epidemiologic studies have established a relationship between reduced growth in early life (eg, pregnancy, lactation, infancy, and early childhood) with multiple endocrine dysfunctions in adulthood mainly related to glucose tolerance, insulin resistance,[21,22] hypertension and vascular damage, resistance to growth hormones, and others associated with the metabolic syndrome.[23,24] "The programming of fetal life" hypothesis is commonly used to explain the development of these alterations in the long-term. This hypothesis proposes that intra-uterine undernourishment triggers endocrine adaptations during critical or sensitive periods of the development, and causes permanent changes in morphology, physiology, and metabolism. Also, this could become harmful during periods of abundant nutrition, which is called "developmental plasticity as cause of adult disease".[25]

Therefore our prediction is that the adolescent mothers have a conflict in energetic allocation, and that having not reached its full development of body condition will result in lower fatty deposits (long chain polyunsaturated) in breast and gluteofemoral fat which can impact hormonal status, weight, and neonatal physiologic condition. In the present study we quantified hormonal status (progesterone, estradiol, and leptin), nutritional status (ie, weight, body mass, and percentage fat mass) of women (adolescents and adult) and the physiologic condition of neonates (ie, birth weight, birth length, and Apgar scores at 1 and 5 minutes).

Materials and Methods

Seventy-one females (aged 18-24 years) living in Atlacomulco in the State of Mexico were enrolled in this study in 2010 and 2011. Most of the participants were students at the Atlacomulco campus of the Autonomus University of the State of Mexico or employees (general and administrative assistants) at the general hospital in the same geographic region. The women participating in the study signed a consent form after they were informed of the objectives, benefits, and requirements of the research. The study protocol was approved by the ethics committee of the Municipal Hospital following the ethical principles for medical research in humans.

The female participants were divided into 4 groups based on their current age and their age at the time of their first full-term birth: (A) 24 nulligravid adolescents (ages 18-19); (B) 23 nulligravid young adults (ages 20-24); (C) 12 with adolescent primiparity (ages 20-24 but with a full-term pregnancy before age 18); and (D) 12 with young adult primiparity (ages 20-24 with a full-term pregnancy at age 18 or older). The selection criteria for the participants were as follows: regular menstrual cycles with an average duration of 28 $\pm$ 7 days; absence of any gynecologic, endocrine, or chronic-degenerative condition (eg, diabetes, hypo/hyperthyroidism); more than 6 months since the last pregnancy or lactation; no use of steroid-based contraceptives; clinically healthy with a normal weight for their height, and acceptable nutritional status based on their body mass index. The classifications proposed by the World Health Organization (WHO) and the Mexican Official Standard NOM-174-SSA1-1998 were used as a reference. As proposed by the United Nations Development Program in Mexico, to minimize bias, all selected participants were residents of the mixed municipality (rural, urban, and semi-urban) of Atlacomulco in the State of Mexico. The participants were medium-marginalized as graded by the National Population Commission[26] and were from the low-middle socioeconomic stratum according to the Mexican National Institute of Statistics, Geography, and Informatics and the National Survey of Income and Expenditure of Households.[27] As a population, they were very representative of a large portion of Mexican society. The women included in the study did not belong to any local ethnic group, had an average educational level of 10.5 years, and an average monthly income of twice the minimum salary, which is defined as the equivalent of US$4.80 per day by the National Commission of Minimum Salaries in Mexico.