DEPARTMENT OF PHYSICAL EDUCATION
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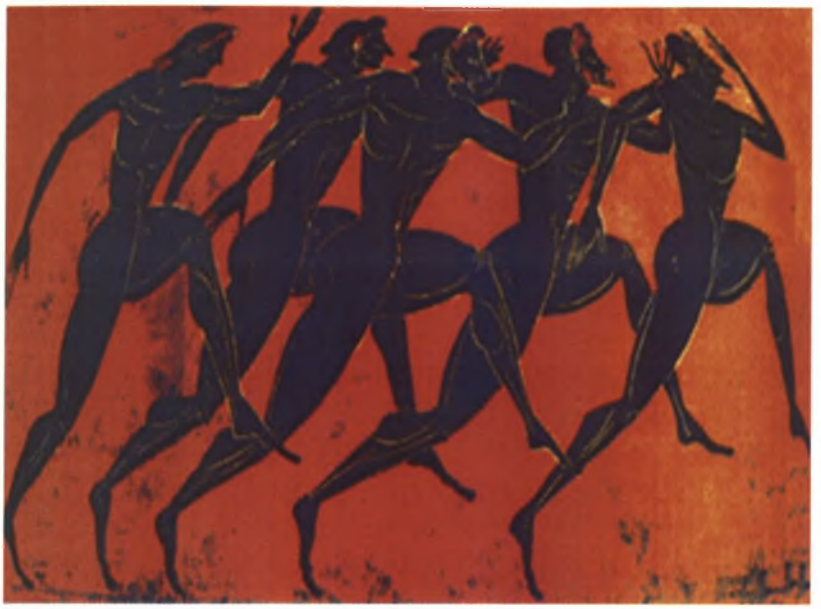

UNDERGRADUATE DISSERTATION

TITLE

IS INTRAUTERINE GROWTH INFLUENCED BY THE SEASON OF BIRTH?

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IS INTRAUTERINE GROWTH INFLUENCED BY THE SEASON OF BIRTH?

ABSTRACT

It has been established that retarded growth in utero [as assessed through birthweight (BW)] predicts the onset of many chronic diseases in adulthood and affects longevity. The objective of the present study was to examine the hypothesis that intrauterine growth is also influenced by the season of birth. To test our conjecture we used BW and Gestation Age (GA) data from the 'Birth and Death Registry' of Athens. The sample consisted of 516.874 infants (M: 266.579; F: 250.295) born from 1980 to 2005 in Greece. Males demonstrated greater BW, compared to females [3264.891gr vs. 3137.416gr]. Multivariate Analysis of Variance (MANOVA) detected significant effects of both gender and birth quarter on GA and BW. Males born in the first quarter of the year (Q1) demonstrated significantly greater BW and GA, compared to infants born in the other quarters of the year [Q1=3283.09gr, 38.56weeks; Q2=3256.91gr, 38.51weeks; Q3=3258.45gr, 38.48weeks; Q4=3261.11gr, 38.48weeks; ($p<0.001$)]. Results in females demonstrated a similar significant tendency [Q1=3155.63gr, 38.58weeks; Q2=3127.45gr, 38.52weeks; Q3=3132.17gr, 38.50weeks; Q4=3134.41gr, 38.50weeks; ($p<0.001$)]. A chi-square test was then conducted to find in which quarter of the year the lowest number of cases of Low Birth Weight (LBW) infants was observed and found that the lowest number of cases of LBW babies was observed for babies born in the first quarter of the year, and the highest in the third quarter [Q1=8981; Q2=9748; Q3=10894; Q4=10420; ($p<0.001$)]. According to these findings, babies (males & females) born in the first quarter of the year are significantly heavier, have longer gestation ages and have significantly less risk of being born with a LBW than babies born in the other quarters of the year.
It is concluded that the season of birth influences significantly BW and WG, possibly due to environmental - climatical conditions, the quality and quantity of nutrition received in utero and also the amount of bright sunshine the pregnant mother is exposed to.

INTRODUCTION

The season of birth and birth weight are two topics that have concerned the scientific community over past generations. Many years ago children who were born preterm or underweight had very little chance of surviving due to the fact that there were no incubators or medicine available. Neither were there qualified doctors with the necessary knowledge to keep the new born babies alive. However, in the 21st century due to medical advancements the chances of these babies surviving and living a reasonable life have greatly increased. Not only does the medical profession have the required equipment, drugs and experience in dealing with very light newborns but also future mothers have been educated in the correct diet and exercise when pregnant so endeavouring to give birth to a healthy baby. Birth weight is of great importance to scientists because of its implications to one's health in childhood and later on in adulthood. There are of course, many factors affecting birth weight, but is the season of birth one of them? The season of birth has always played a significant role in the survival of new born babies due to the forces of nature. Famine, floods, heat and cold are just a few of nature's way of incorporating the survival of the fittest. The healthiest survive but the weakest babies do not have the strength to survive. But does the season of birth actually contribute to the weight of new born babies? Although a lot of research has been done on the topic of birth weight in general not much has been done on whether the season of birth affects birth weight. In Greece, in particular, no such research has been done until now. It is a problem which affects people from many walks of life and many countries at different times of the year and in order to consider the significance of the seasons of year, we must take note of the 'Father of Medicine - Hippocrates'

'Whoever wishes to investigate medicine properly should proceed thus: in the first place to consider the seasons of the year, and what effects each of them produces for they are not at all alike, but differ much from themselves in regard to their changes' (Hippocrates-translated W. H. Jones 1923).

LITERATURE REVIEW

In order to discuss the importance of season of birth and birth weight in relation to health later in life it is of vital significance to mention a number of factors concerning the early neonatal birth, failure of foetal growth during pregnancy and the impact of birth weight on medical outcomes during childhood and adulthood. In this review the following areas will be discussed:

1. Birth weight & preterm birth
2. Eye & ear disorders
3. Cardio respiratory effects
4. Catch up growth & Long term implications
5. Academic success & Cognitive abilities
6. Psychological problems due to low birth weight & season of birth
7. Season of birth & birth weigh

1. Birth weight & preterm birth

Extremely low birth weight (ELBW) is considered to be <1000gr, very low birth weight (VLBW) is considered to be <1500gr (Hack et al., 2004), low birth weight (LBW) <2500gr whereas normal birth weight (NBW) is >2499gr. Estimating smallness in relation to family norm could be more informative rather than using the 'small for gestational age' (SGA) (pathologically small at birth) (Basso et al., 2005). They showed that VLBW babies classified by SGA criterion are more likely to be born to small or smoking mothers. Black women, smokers and maternal malnutrition are just a few of the many prenatal factors leading to foetal growth restriction and reduced birth weight.

According to published information (Little, Brocard, Elliott, & Steer, 2005), the major factors causing early neonatal death are preterm birth and the failure of foetal growth. Therefore, prolonging the duration of pregnancy, if possible, could be one solution to this problem. Children with congenital heart disease have significantly lower birth weight but due to the paediatric cardiology and the development of cardiac surgery many of these diseases can be corrected. Although operations lead to a better life the infants are in danger due to their age and weight so any kind of surgical treatment is a risk. It is also known that foetal under nutrition is a coronary risk factor.

2. Eye & ear disorders

One of the leading causes of morbidity in VLBW babies is retinopathy of prematurity (eye disorder) especially infants born with a weight less than 1000grams. This is a multifactorial vasoproliferative retinal disorder which when severe is associated with hyperglycaemia and candida sepsis so requiring the need for laser surgery (Mittal, Dhanireddy, & Higgins, 1998).

Children born in spring have a higher risk of acute otitis media (AOM) (ear disorder) than children born in autumn. However, those born in summer and autumn are more likely to have recurrent AOM (rAOM) (five or more episodes of AOM since birth) probably due to the risk of being reinfected in late autumn and winter (Homoe, Christensen, & Bretlau, 2005).

3. Cardio respiratory effects

Chronic lung disease occurs frequently in more immature neonates with an association of a high incidence of adverse neurodevelopment (Yeo, 1997). This could be due to lack of control maintaining maternal factors including height, age, race, weight, smoking which could influence birth weight (Edwards, Osman, Godden, Campbell, & Douglas, 2003). In the cohort conducted by C.A Edwards in 2001, 381 subjects whose ages were between 45-50 years were tested for lung function. They found a significant linear trend between birth weight and current forced expiratory volume in 1 second and forced vital capacity. It is a well known factor that lung development is greatly influenced by foetal growth and duration of gestation (Barker

et al., 1991). Anything retarding weight gain of foetus can retard the growth of the airways so adversely affecting adult lung function. It is also agreed that an adverse environment in uterus resulting in negative foetal growth could have an effect on lung function at mean age 47 years (Barker et al., 1991). It was also found that the number of people who had a wheeze aged 26 years fell with the increase of birth weight (Shaheen, Sterne, Montgomery, & Azima, 1999). The respiratory health of ELBW subjects was examined and (Halvorsen et al., 2004) found a history of asthma and the need for asthma inhalers. The pulmonary tests which were carried out showed reduced airflow and increased airway resistance and bronchial hyper responsiveness to metacholine (Halvorsen et al., 2004).

Higher systolic blood pressure is strongly associated with babies with VLBW. It is a known fact that this affects females in particular, later on in life. Blood pressure was examined and the findings showed a higher mean systolic blood pressure for VLBW especially in females (Hack et al., 2005). Doyle et al came to the same conclusion after examining 145 VLBW subjects who were 18 years old and over. They found a higher mean systolic and diastolic blood pressure and the subjects had an ambulatory systolic blood pressure above the 95th percentile (Doyle, Faber, Callanan, & Morley, 2003)

4. Catch up growth & Long term implications

Even though mortality remains high in VLBW infants many do survive but do they overcome their serious conditions and lead to a normal life? The number of surgical interventions is significantly higher in VLBW children during childhood and although early treatment is preferred these premature infants have a worse survival rate than normal birth weight children. Assuming these babies survive to school age we should consider the catch up growth. It has been said that this could be associated with metabolic and cardiovascular risk later in life and may influence adult growth attainment and also have long term implications in one's health when the patient becomes an adult. There are also significant differences between males and females. Females usually catch up in growth by the time they reach twenty but males tend to be slightly shorter and lighter and also have higher rates of re-hospitalization than females.

Low birth weight also increases the risk of cardiovascular disease, insulin resistance and the development of type 2 diabetes which is amplified if followed by rapid postnatal catch up growth (Ozanne & Nicholas Hales, 2005). It is also suggested that hypertension in adulthood is associated with accelerated growth in childhood in low birth weight babies. Paradoxically, people with low birth weight are more likely to be affected by the adverse effects of obesity. Research carried out by (Hack et al., 2003) showed the difference between males and females with VLBW with regard to their catch up growth. Although they had similar rates of intrauterine and neonatal growth failure the girls caught up and showed no significant difference from their NBW controls in height, weight or body mass index (BMI). In fact at 20 years of age 21% were overweight and 15% were obese. The men, however, were significantly smaller in height, weight or BMI. It was discovered that at age 23 years ELBW males and females had significantly lower height, weight and head circumference (Saigal et al.,

2005). The same was reported by (Rogers et al., 2005). Other researchers found that their subjects had a significantly lower height (Halvorsen et al., 2004). As weight gain causes risks for disease later on, it is suggested that the timing of weight gain is crucial (Cole, 2004). It is believed that early weight gain is not as important as weight gain in adolescence.

5. Academic success & Cognitive abilities

Maureen Hack using information from studies from Australia, Canada, USA, Great Britain and other European countries reminds us that with few exceptions adults who were born underweight have poorer educational success (Hack et al., 2002). They often had to have special assistance at schools academically. The same conclusion was also formed by (Lefebvre, Mazurier, & Tessier, 2005). The young adults also have poorer physical and cognitive abilities. Problems like cerebral palsy, visual and hearing difficulties and asthma were more prevalent.

Under-nourishment in uterus could cause various problems in middle age including mental illness, diabetes, atherosclerosis, hypertension and cardiovascular disease (Barbier, 1998). A 10% rate of neurosensory impairment was found in VLBW subjects (Hack et al., 2002). 7% had severly reduced sight and 8% a lack of hearing (Ericson & Kallen, 1998). ELBW subjects according to Lefebvre et al and Hack et al reported overall rates of neurosensory impairment of 12% (Ericson et al., 1999; Lefebvre et al., 2005; Hack et al., 2004). Saigal et al found 37% of the subjects examined had an impairment of their vision. ELBW subjects had weaker hand-grip measurements and problems with coordination (Saigal et al., 2005). A poorer physical activity level was reported by (Rogers at al., 2005) and they found their subjects also had difficulty in maintaining rhythm.

6. Psychological problems due to low birth weight & season of birth

Hack et al using the Achenbach parent child report (a report assessing behavioural and emotional problems which parent and child fill in) observed that VLBW females had more internalising problems i.e. depression, anxiety and withdrawal symptoms. Parents of VLBW men reported that their sons tended to be inattentive (Hack et al., 2004). Again, using the Achenbach report (Grunau, Whitfield, & Fay, 2004) stated that parents of ELBW subjects reported significant differences in social competence thought and attention problems and were more withdrawn than NBW subjects. (Hack et al., 2004) suggest that some of the reasons for VLBW subjects developing psychopathology are intellectual disability (Richards et al., 2001; van Os, Jones, Lewis, Wadsworth, & Murray, 1997) poor physical health (Cohen et al., 1998) and neurological problems (Pine, Shaffer, & Schonfeld, 1993; Sigurdsson, Van Os, & Fombonne, 2002). These adults have difficulties in concentrating, are hyperactive (Botting, Powls, Cooke, & Marlow, 1997; Saigal, Pinelli, Hoult, Kim, & Boyle, 2003; Whitaker et al., 1997) are shy and withdrawn (Nadeau, Boivin, Tessier, Lefebvre, & Robaey, 2001), have poor social skills (Hoy et al., 1992) and are anxious and depressed (Botting et al., 1997; Saigal et al., 2003). It was suggested that ELBW confers general vulnerability to psychopathology so it's not surprising that women in

adulthood experience an increase in internalising symptoms (Szatmari et al., 1993). Maureen Hack et al points out that although VLBW children have lower IQ and experience learning problems, they are less likely to take risks and become delinquent which is a paradox in itself. They also state that this could be due to increased parental monitoring and maybe social isolation. They came to the conclusion that an increased awareness of the likelihood of psychological problems in adulthood implementing guidance and early intervention could help to prevent or alleviate the problem.

The lightest babies are born in May, the season of spring (McGrath et al., 2005). In their abstract (Rock, Greenberg, & Hallmayer, 2005) point out that deliberate self harm (DSH) has a significant season of birth peaking in spring. They also state that most studies show that suicide peaks in spring (northern & southern hemisphere). Subjects are more likely to commit suicide close to their birthday (Barraclough & Shepherd, 1976; Shaffer, 1974). It is suggested that utero or neo - natal infection may be involved (Hall & Peckham, 1997). Children born in October (spring in Australia) are in their second trimester in May – July which is winter in Australia when there is a high risk of respiratory infections. Subjects who are in uterus in the high risk flu months were more likely to contemplate suicide when they are post pubertal than those who are in utero in other seasons (Hope-Simpson, 1981; Joiner, Pfaff, Acres, & Johnson, 2002). Subjects born in spring have lower levels of serotonin (Chotai & Adolfsson, 2002; Chotai & Asberg, 1999).

7. Season of birth & birth weight

It is widely accepted that birth weight and growth in utero predicts the onset of many chronic diseases in adulthood and affects longevity.
There is, however, another major factor associated with health later in life which will be examined in this study is that the hypothesis that intrauterine growth is also influenced by the season of birth which in turn affects health later on.
Research was carried out by (Vaiserman, Collinson, Koshel, Belaja, & Voitenko, 2002) for the examination that longevity is associated with the season of birth. Their findings showed that there is a relationship between the month of birth and age of death showing that the age of death was lowest for those born in April – July and highest for those born at the beginning and end of the year. Other findings have demonstrated that the birth weight differs greatly when comparing months – those born in October were the heaviest and those born in May, the lightest (McGrath et al., 2005). These results suggest that pre-natal and early post natal seasonal factors affect longevity. The relationship between fluctuating asymmetry (deviations in developmental stability) and the season of birth was examined by (Benderlioglu & Nelson, 2004) . They also found that the month of birth affects adult health and developmental disorders including neurological and psychiatric disorders suggesting that those born during the winter and spring are at risk for asymmetric development. Subjects born in January and February ran the risk of adult glioma and meningioma (cancerous tumours) (Brenner et al., 2004). Much research has proved that births in January – March are associated with schizophrenia. (Brenner et al., 2004; Mortensen et al., 1999; Rezaul, Persaud, Takei, & Treasure, 1996).

Studies have been done on people being born in the hungry season in Africa July – December. The mothers are at their lightest and are lacking in nutrition so foetal undernutrition is considered to be the major cause of the impairment of development. Young adults born in the hungry season in rural Gambia, West Africa were studied by (Simondon et al., 2004). The most plausible potential cause for light babies was foetal under nutrition. They suggested that maternal malnutrition could have negative long – lasting effects on the immune status of the foetus including a risk of infectious diseases among adults. Nutritionally mediated intrauterine growth retardation could have deleterious effects later on in life and may permanently impair the development of immune function (Coltey, Jotereau, & Le Douarin, 1987). Risk of death from infectious diseases and chronic diseases in post - pubertic subjects is programmed in early life events (Moore et al., 1999). Their research on three rural Gambian villages found that month of birth and adult death were connected. 49 cases were born in July-December which is the nutritionally debilitating hungry season. Even pregnant women are expected to work so creating a negative energy balance and weight loss resulting in lower birth weight.

Other studies have shown that birth weight influenced by season is modified by ethnicity especially in black people who tend to produce lower birth weight babies anyway particularly in the summer and autumn. Black babies born in the winter and spring had higher birth weights than those born in the summer and autumn (van Hanswijck de Jonge, Waller, & Stettler, 2003). They suggested this variation could be based on maternal food intake, basal metabolic rate (BMR) and weight as they all change according to seasons. Food intake is higher in energy and carbohydrates during the autumn than the summer (de Castro, 1991). BMR rises in the winter and falls in the summer (Kashiwazaki, 1990) and body weight and fat are lower in the summer (Kashiwazaki, 1990; Wells, 2000). Birth weight could be affected by the seasonal variation in vitamin C has also been suggested (Mathews, Yudkin, & Neil, 1999) Once again, the study done by (Murray et al., 2000) on babies born in Northern Ireland showed that infants born in late spring or early summer were lighter than those born in winter which could be the result of exposure to low temperatures during gestation. Fluctuations in seasons can have an impact on maternal nutrition both nutritionally and on energy expenditure so affecting the baby's birth weight (Lawlor, 2004). Exposure to the cold during mid – gestation could compromise placental blood flow resulting in LBW subjects in spring (Lawlor, Leon, & Davey Smith, 2005; Murray et al., 2000) Other factors influencing birth weight are prenatal sunshine (Tustin, Gross, & Hayne, 2004), insulin – like growth factor (Holdaway, Mason, Gibbs, Rajasoorya, & Hopkins, 1991) and not forgetting vitamin D (DeLuca & Zierold, 1998). In winter and autumn, mothers tend to stay indoors and are in contact with smokers and use central heating (Waldie, Poulton, Kirk, & Silva, 2000).

The Aims of this Study

Based on the available literature it becomes clear that there is a dearth of published information in Greece regarding season of birth and newborn babies. Therefore, the objective of the present study is to examine the hypothesis that intrauterine growth is influenced by the season of birth.

Methods

Collection of data

To test our conjecture we used data from the 'Birth and Death Registry' of Athens upon request. The data contained accurate date of birth, birth weight and weeks of gestation. The sample consisted of 516.874 infants (M: 553.656; F: 527.519) and was supplied by electronic means (Microsoft Office Excel).

Statistical analyses

The sample was processed and the data was statistically analysed with the help of the SPSS programme. In the first stage statistics of males and females were used to find the mean and standard error for both birth weight and weeks of gestation. Then, taking into account the date of birth of each infant the sample was divided into 4 groups: the four seasons of the year and this was compared using the Multivariate Analysis of Variance (MANOVA) method. The first group comprised of the cases born in the first quarter, the second group comprised of those born in the second quarter (April, May, June), the third group of those born in the third quarter (July, August, September) and the fourth group of those born in the fourth quarter (October, November, December). The data was then processed with the descriptive statistics in order to find the mean & standard deviation for the birth weight and weeks of gestation separately for each trimester. We then went on to examine the frequency and the Percent (%) for the babies with low birth weight. A chi-square test was conducted to observe in which trimester most low birth weight infants were born and in which trimester the least number of low birth weight babies were born.

Results

The mean and standard error for birth weight (in grams) and gestation age (in weeks) of males and females are shown in **Table 1.** Although the males are heavier at birth than the females they have a smaller gestation age. In order to establish whether there is a statistical difference in these means, a MANOVA was conducted showing that there was no overall significant difference.

Table 1: The mean and standard error for birth weight (in grams) and gestation age (in weeks) of males and females.

Estimates

Dependent Variable	Gender	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Birth weight (grams)	Males	3264.891	1.049	3262.834	3266.948
	Females	3137.416	1.083	3135.293	3139.540
Gestation Age (weeks)	Males	38.508	.003	38.501	38.514
	Females	38.525	.003	38.518	38.531

Table 2 shows the mean weight for each quarter of birth of males, females and for the entire sample as a whole. The mean gestation age (in weeks) can also be seen for each quarter of birth of males, females and for the entire sample as a whole. MANOVA detected significant ($p<0.001$) effects of both gender and quarter on gestation age and birth weight ($p<0.001$). However, there was no interaction between gender and birth quarter on their effects on gestation age and birth weight.

Table 2: The mean birth weight and the mean gestation age (in weeks) for each quarter of birth of males –females and for the entire sample as a whole.

Descriptive Statistics

	Gender	Birth quarter (1 to 4)	Mean	Std. Deviation	N
Birth weight (grams)	Males	1	3283.09*	553.274	63511
		2	3256.91	558.654	63917
		3	3258.45	547.869	72358
		4	3261.11	555.069	66793
		Total	3264.62	553.656	266579
	Females	1	3155.63*	518.966	59144
		2	3127.45	532.764	59430
		3	3132.17	528.027	68345
		4	3134.41	529.537	63376
		Total	3137.16	527.519	250295
	Total	1	3221.63*	540.766	122655
		2	3194.54	550.147	123347
		3	3197.11	542.008	140703
		4	3199.43	546.468	130169
		Total	3202.90	544.892	516874
Gestation Age (weeks)	Males	1	38.56*	1.665	63511
		2	38.51	1.750	63917
		3	38.48	1.674	72358
		4	38.48	1.688	66793
		Total	38.51	1.694	266579
	Females	1	38.58*	1.601	59144
		2	38.52	1.762	59430
		3	38.50	1.659	68345
		4	38.50	1.672	63376
		Total	38.52	1.674	250295
	Total	1	38.57*	1.634	122655
		2	38.52	1.755	123347
		3	38.49	1.667	140703
		4	38.49	1.680	130169
		Total	38.51	1.684	516874

`* Denotes statistical significance at P < .001

A significant finding concerning Low Birth Weight (< 2500gr) is observed in **Table 3.** A total of 40.043 infants were born with low birth weight giving a prevalence of low birth weight of 7.7%.

Table 3: Percent and frequency of normal and low birth weight babies

Low Birth Weight

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal Birth Weight	476831	92.3	92.3	92.3
	Low Birth Weight	40043	7.7	7.7	100.0
	Total	516874	100.0	100.0	

A chi-square test was conducted **Table 4** showing that the lowest number of cases (8.981 total) of low birth weight babies was observed for babies born in the first quarter of the year and the highest in the third quarter.

Table 4 & 5: The lowest and highest number of cases of low birth weight babies.

Birth quarter (1 to 4)

	Observed N	Expected N	Residual
1	8981	10010.8	-1029.8
2	9748	10010.8	-262.8
3	10894	10010.8	883.3
4	10420	10010.8	409.3
Total	40043		

Table 5 shows the second table from the chi-square test. This difference in quarters is statistically significant at $p< 0.001$.

Table 5

Test Statistics

	Birth quarter (1 to 4)
Chi-Square[a]	207.481
df	3
Asymp. Sig.	.000

a. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 10010.8.

Discussion

The aims of the present study were to examine the hypothesis that intrauterine growth is influenced by the season of birth. The main finding shows that, in both males and females, birth weight and gestation ages for infants born in the first quarter of the year were significantly greater compared to infants born in the remaining quarters. Babies born in the third quarter of the year demonstrated the lowest birth weight and gestation ages. We further found that the lowest number of cases of LBW babies was observed for babies born in the first quarter of the year and the highest in the third quarter of the year and with a prevalence of 7.7%. The following factors may have influence the present findings:

1. Environmental conditions
2. Climate
3. Quality and quantity of nutrition received in utero
4. Bright sunshine

1. Environmental conditions

There are many environmental conditions adversely affecting intrauterine growth. Some researchers believe that there is a connection between air levels of sulphur dioxide and carbon monoxide and LBW (Ricciardi & Guastadisegni, 2003). The pregnant mother whose first trimester is during the winter months is exposed to many major air pollutants both indoor (ventilation, heating, cooking, environmental smoke) and outdoor (traffic, industrial sites, dry cleaners, petrol stations) and women who are pregnant during the winter stay indoors so are in contact with these pollutants. This can impair the intrauterine growth and development and cause LBW (Bobak, 2000; Kogan, 1995; Palmer, 1993).
Another group of researchers are also of the opinion that exposure to air pollution during pregnancy may interfere with weight gain during pregnancy (Gouveia, Bremner, & Novaes, 2004). In the Czech Republic a study was carried out on exposure to air pollution during pregnancy and it was found that exposure to air pollution especially in the first trimester caused LBW (Dejmek, Selevan, Benes, Solansky, & Sram, 1999).
Air pollution, especially in the first trimester adversely affects the placenta and foetus. A recent study in Sao Paulo showed that although improvements in maternal education and health services have been made, the rates of LBW have hardly changed. Sao Paulo is notorious for its high levels of pollution (Gouveia et al., 2004). Winter is also the season of respiratory infections and are high risk flu months (Godfrey et al., 1996). All these negative environmental conditions in the first months of gestation are causal of low birth weight babies being born in the summer months (third quarter of the year).

2. Climate

Another reason for babies born underweight in late spring and early summer is low winter temperatures which cause intrauterine growth retardation. One reason for this

is low winter temperatures during mid-gestation (Murray et al., 2000) which is why women who are pregnant during winter should keep themselves warm. Environmental temperature and birth weight are associated in humans and non-human animal species and adverse effects are evident for chronic cold stress (Wells, 2002). Infants born during late spring and summer are lighter than those born in the other seasons (Murray et al., 2000).

3. Quality and quantity of nutrition received in utero

In Africa children are born underweight during the hungry season as the mothers are at their lightest and are lacking in nutrition so causing foetal undernutrition. Also pregnant women are expected to work causing a negative energy balance and weight loss resulting in lighter babies. Birth weight is also affected by the seasonal variation of vitamin C & D. Food intake is higher in energy and carbohydrates during autumn (de Castro, 1991). A high intake of carbohydrates in early pregnancy is detrimental to birth weight so mothers pregnant in autumn will produce lighter babies in late spring and summer (Godfrey, Robinson, Barker, Osmond, & Cox, 1996).

4. Bright sunshine

Another factor which plays an important role in determining seasonal variation in birth weight is the amount of bright sunshine the pregnant mother is exposed to (Tustin et al., 2004). Maternal exposure to sunshine during the first trimester of gestation increases length and weight at birth. High levels of sunshine during the first months of pregnancy alter hormones that are involved in growth and may increase the level of insulin – like growth factor (Tustin et al., 2004). Therefore mothers who are pregnant during spring and summer will produce heavier babies in winter. Mothers who are pregnant in winter will not be exposed to many hours of bright sunshine so producing lighter babies in summer.

Conclusions – Recommendations for future studies

It is concluded that among the many factors causal of LBW, the season of birth influences significantly intrauterine growth and gestation age, possibly due to the areas discussed. According to our findings we came to the conclusion that babies (males & females) born in the first quarter of the year are significantly heavier, have longer gestation ages and have significantly less risk of being born with a LBW than babies born in the other quarters of the year. Future studies are needed to establish to what extent the season of birth is a determinant of LBW. It is a well known fact that Low Birth Weight is one of the major causes of infant mortality in both developed and non developed countries. It is a factor contributing to 9 million infant deaths annually. The prevention of LBW is very important from the public health perspective. The hypothesis that different geographical areas in Greece influence birth weight merits investigation and will be examined in further research.

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