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Factors affecting human placenta and birth weights and vitality of newborns in a subtropical environment*

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ABSTRACT

Factors affecting birth and placenta weights and vitality of human newborns in Florida were evaluated in data sets of 1480 (data set I) and 788 cases (data set II). The latter set was a subset of the first, having fewer cases because of more rigid screening procedures. Screening deleted fetuses that were not alive at birth, or had extremely high or low values for any response variable; the latter were assumed to represent abnormal cases. Factors evaluated significantly affected the response variables in most cases, but not necessarily in both data sets. In data set II, month effects were detected on all variables except vitality at 5 min postpartum (Apgar score II). Placenta weights were 112 g lower in warm than in cool months. Vitality at 1 min postpartum (Apgar score I) was affected by month but not in a systematic manner. Males were 45 g heavier for placenta, 142 g for birth and 187 g for total weights. Ethnic group affected all responses except placenta weight. Parity effects were detected for all responses except placenta weight and Apgar score II; gestation length affected all responses except placenta weight. Placenta and birth weights were highly correlated with their sum (part-whole correlation), but not with each other; nor were weights correlated with Apgar scores. Apgar scores were highly correlated with each other. Knowledge of characteristics of response variables and the factors influencing them should contribute considerably to overall knowledge of factors affecting characteristics of human births.

INTRODUCTION

Birth weight of newborn is associated with well-being of infant and mother. Research and review by Pilotto *et al.* (1993) delineated factors affecting birth weight. Birth weights are heritable in mammals; estimates for maternal and non-maternal heritability are high (Wilcox, 1992). The placenta acts as an endocrine gland during pregnancy, and influences the time of parturition. Hippocrates stated in 460 BC that the fetus played a role in its own delivery (cited by Wilcox, 1980). Selye *et al.* (1934) suggested that the placenta was an endocrine organ with mammogenic effects, and this has been confirmed by many species (e.g. sheep, goats, rats, etc.).

In dairy cattle, at least, the genotype of the fetus influences the time of its birth, the subsequent milk yield of its mother, and her subsequent reproductive performance (Adkinson *et al.*, 1977; Thatcher *et al.*, 1980a,b, 1982; Moya *et al.*, 1989, 1991). Many of these effects are small, but they are real and measurable. Guilbault *et al.* (1985a,b) delineated periparturient endocrine changes of conceptus and maternal units and carryover effects postpartum. Birth weights were correlated with mean maternal concentrations of estrone (0.57), estradiol (0.59), and estrone sulfate (0.64).

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Functional responses of the conceptus (e.g. estrogens) and maternal units (e.g. progesterone) and prostaglandin $F_{2\alpha}$ metabolite (PGFM) were influenced by the genotype of the conceptus during the periparturient period. Within subject, PGFM concentrations were correlated with cervical (0.36) and uterine horn (0.32) diameters. Postpartum ovarian responsiveness and uterine involution were affected by fetal genotype.

A review by Thatcher *et al.* (1983) showed that heat stress in the last trimester of pregnancy in sheep causes a reduction in uterine blood flow, decreased placental weight, and a retardation of fetal growth. In the bovine, about 60% of fetal growth occurs during the last 90 days of pregnancy (280-day total gestation). In cows, placenta dry weights were found to be 7.4% heavier in males; parturitions in July and August (summer) had reduced total placenta dry tissue (Head *et al.*, 1993).

Many non-genetic factors affect birth weight. These include month or season of parturition, age and parity of mother, gestation length, sex of newborn, etc. (Wilcox and Roy, 1968; Collier *et al.*, 1980; Pilotto *et al.*, 1993).

Florida has a subtropical climate. Description of climate is shown in Table I. Florida does not have a true dry season; rainfall occurs every months but most (60 to 64%) falls in June through October. Mean temperatures are highest during these same months, averaging 26.0 and 26.4°C in North and North Central Florida.

MATERIAL AND METHODS

Single births for a 12-month period occurring at the University of Florida Teaching Hospital (Shands), Gainesville, FL, USA, were measured and recorded. As a teaching hospital, patients are accepted from throughout the state of Florida, and represent completely normal individuals as well as a large number of special cases. They represent a diverse sample of the population.

Dependent variables were birth and placenta weights (grams), the sum of birth and placenta weight, and Apgar scores postpartum. Apgar scores are measures of vitality of the newborn; Apgar I was recorded at 1 min after birth, and Apgar II at 5 min. Occasionally a later score was also recorded but these were not included in our analyses. Five items are included in Apgar scores, each scored as 0, 1, or 2. Measured are tone, heart rate, color, respiration, and crying. Thus the range in scores can be from 0 to 10, with 0 being dead and 10 very active.

Table I - Climate of the State of Florida, USA[1].

Month	Rainfall		Mean temperature	
	North	North-Central	North	North-Central
	(cm)	(cm)	(°C)	(°C)
January	6.4	5.3	13.9	15.8
February	8.2	6.9	14.8	16.7
March	10.2	10.0	17.1	18.7
April	8.7	8.6	20.4	21.6
May	8.5	8.6	24.1	24.7
June	15.6	18.0	26.7	26.8
July	19.4	20.7	27.4	27.6
August	17.5	18.1	27.5	27.6
September	16.6	18.3	26.2	26.7
October	11.2	10.8	22.0	23.3
November	5.0	4.7	17.1	19.0
December	6.4	5.2	14.1	16.3
Total/mean	133.7	135.2	19.8	22.1

[1]Thirty year averages; from Dohrenwend (1978).

The total data set represented 2343 single births. Data were incomplete on many, and additional observations were lost after screening. After deleting incomplete records, data were screened further by deleting observations with gestation lengths of less than 35 and more than 43 weeks, birth weights < 500 g, and placenta weights < 150 g. These gestation lengths were selected because hospital policy was that births outside of this range were considered abnormal and required special care and attention. In many hospitals worldwide the lower boundary is 37 rather than 35 weeks. This data set was denoted data set I. Resulting were 1480 births. Data set I then was screened additionally to delete Apgar scores of 0 (dead births) and birth weights > 5500 g. Range in gestation lengths was widened to delete lengths of less than 19 or greater than 45 weeks. The resulting data were denoted data set II, which had 788 observations. Thus the two data sets represented a wide range (I) and a narrower range (II), with fewer abnormal situations.

Data were analyzed by the method of least squares analysis of variance, utilizing general linear model procedures (PROC GLM) of SAS (1985). Included in the mathematical model were class variables month, sex of infant, Rh factor, race, and their two and three factor interactions. The two ethnic groups were Caucasian and African American. Included as continuous independent variables were parity and gestation length, each to the third order of polynomial regression. None of the interactions among class variables were significant at $P < 0.20$, so these possible sources of variation were deleted from the models.

Likewise, the third order of the polynomial was not significant in any case, so the second order (quadratic) was used throughout in the final analyses.

RESULTS AND DISCUSSION

Overall means of the continuous independent variables (parity and gestation length) and the five response variables are in Table II for both data sets. Counts for both data sets for each class variable are in Table III. Least squares means of factors affecting the response variables are in Table IV and their corresponding probability levels in Table V.

Month effects

Effects were detected in data set II for every response except vitality at 5 min postpartum (Apgar II). A clear trend was evident in placenta weights in data set II. Gestations ending or approaching parturitions in hot months (June through November) clearly were associated with lower weights. Mean for June through November was 703 g; mean was 815 g for December through May. These trends were very close to those found in dairy cows in Florida by Collier *et al.* (1980).

Month of parturition effects were detected in data set II for birth ($P < 0.06$) and total weights ($P < 0.09$) but trends were not as clear. Highest mean birth weight for data set II was 3328 g in October, and lowest was 3060 g in May. Corresponding values for total weights were 4178 g (February) and 3849 g (July).

Apgar I scores were lowest (data set II) in February at 7.79, but the value was 7.94 for August, a hot month. The highest value was 8.63, for June. Reasons for statistically significant effects of month on vitality are not clear. Apgar II values (data set II) did not vary as widely as Apgar I values ($P < 0.233$), although as expected they clearly were higher than Apgar I values in both data sets.

Table II - Overall means of continuous independent and dependent variables.

Variable	Data set I[1]	Data set II[2]
Parity	2.1	2.1
Gestation length (d)	278.5	276.6
Placenta weight (g)	1291	741
Birth weight (g)	3297	3247
Total weight (g)	4588	3989
Apgar I	8.16	8.15
Apgar II	9.04	8.95

[1]N = 1480. [2]N = 788.

Sex effects

Males and females usually differed in weight (Table V). For data set II, male placenta, birth and total weights were higher (Table IV) by 6.4 and 3%, respectively. Apgar scores did not differ between sexes. Thus males were heavier than females with no difference detected in vitality.

Ethnic group effects

Ethnic group affected nearly every response. An exception was placenta weight (both data sets). This may be associated with size and weight of the mother at delivery. Specific reasons for ethnic differences are unknown. Differences in average economic status, dietary habits, and living conditions are known, and they may (or may not) be the underlying cause of ethnic effects, as well as true genetic differences between races.

Rh factor effects

Rh scores apparently had little effect on the response variables. For the five variables in each data

Table III - Distribution of data.

Variable	Data set I[1]	Data set II
Month		
1	130	78
2	125	65
3	113	61
4	104	61
5	99	46
6	123	63
7	101	58
8	135	71
9	121	58
10	140	82
11	125	62
12	164	83
Sex		
M	777	426
F	703	362
Rh		
+	1314	709
–	166	79
Ethnic group		
1	789	429
2	691	359
Total	1480	788

[1]See text for description of data sets.

Table IV - Least square mean for effects associated with birth and placenta weights and vitality.

Factor	Placenta weight		Birth weight		Total weight[2]		Apgar I		Apgar II	
	Data set I[1]	Data set II	Data set I	Data set II	Data set I	Data set II	Data set I	Data set II	Data set I	Data set II
Month										
1	1264[3]	823	3327	3270	4591	4093	8.02	8.03	9.19	9.05
2	1386	859	3283	3320	4669	4178	7.99	7.79	9.12	8.77
3	1309	760	3267	3243	4576	4003	8.03	8.00	8.89	8.66
4	1287	791	3359	3271	4646	4062	8.41	8.30	8.96	8.79
5	1476	832	3217	3060	4693	3891	8.39	8.45	9.09	9.00
6	1353	768	3349	3319	4702	4086	8.34	8.63	8.98	9.09
7	1288	719	3241	3130	4529	3849	8.42	8.38	9.15	9.01
8	1359	738	3418	3326	4777	4064	7.76	7.94	8.82	8.75
9	1318	650	3292	3313	4609	3963	8.29	8.40	9.16	9.03
10	1257	689	3322	3328	4578	4017	8.29	8.27	9.07	9.07
11	1276	652	3331	3308	4607	3961	8.40	8.33	8.12	8.99
12	1340	849	3291	3251	4638	4106	8.34	8.59	9.02	9.00
Sex										
M	1327	783	3367	3333	4693	4116	8.19	8.17	9.02	8.88
F	1326	738	3250	3191	4576	3929	8.26	8.34	9.08	8.89
Ethnic group										
1	1310	770	3365	3321	4075	4092	8.33	8.36	9.20	9.09
2	1344	751	3251	3203	4594	3954	8.11	8.16	8.91	8.79
Rh										
+	1269	732	3312	3255	4581	3987	8.25	8.24	9.05	8.95
–	1384	789	3304	3269	4688	4058	8.20	8.28	9.06	8.93

[1]Data set I, N = 1480; data set II, a subset of data set I, N = 788; see text for screening criteria. All weights are in grams.
[2]Total weight is sum of placenta and birth weights.
[3]See Table V for probability levels associated with each effect.

Table V - Probability levels for classes and continuous independent variables from least squares analyses of variance of data sets I (N = 1480) and II (N = 788).

Effect	Placenta weight		Birth weight		Total weight		Apgar I		Apgar II	
	I[3]	II[3]	I	II	I	II	I	II	I	II
Month[1]	0.426	0.005	0.127	0.059	0.613	0.094	0.004	0.019	0.184	0.233
Sex[1]	0.995	0.077	< 0.001	< 0.001	0.007	< 0.001	0.395	0.116	0.265	0.143
Ethnic group[1]	0.389	0.470	< 0.001	< 0.001	0.072	0.001	0.008	0.079	< 0.001	< 0.001
Rh[1]	0.034	0.181	0.832	0.809	0.116	0.311	0.176	0.818	0.905	0.882
Parity, Linear[2]	0.816	0.443	< 0.001	0.001	0.015	< 0.001	0.427	0.586	0.319	0.776
Parity, Quadratic[2]	0.598	0.119	0.125	0.159	0.697	0.037	0.200	0.022	0.993	0.204
Gestation Length, Linear[2]	0.913	0.147	< 0.001	< 0.001	< 0.001	< 0.001	0.811	< 0.001	0.149	< 0.001
Gestation length Quadratic[2]	< 0.001	0.637	< 0.001	< 0.001	0.961	0.023	0.005	< 0.001	0.001	< 0.001

[1]Class variables; probability levels based on partial sums of squares (SAS Type III).
[2]Continuous independent variables; probability levels based on sequential sums of squares (SAS Type I).

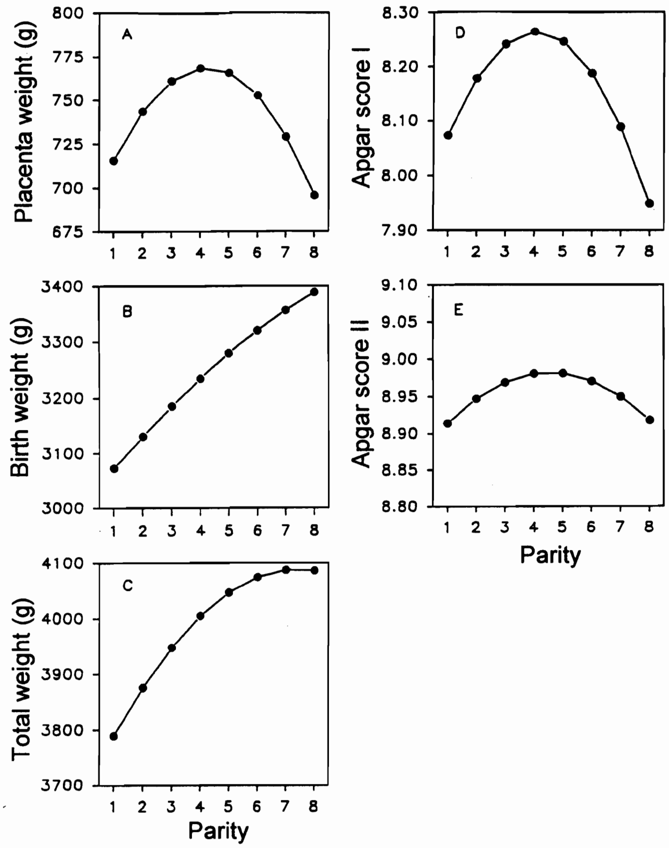

Figure 1 - Data set II, parity effects: a. placenta weight; b. birth weight; c. total weight; d. Apgar score I; e. Apgar score II.

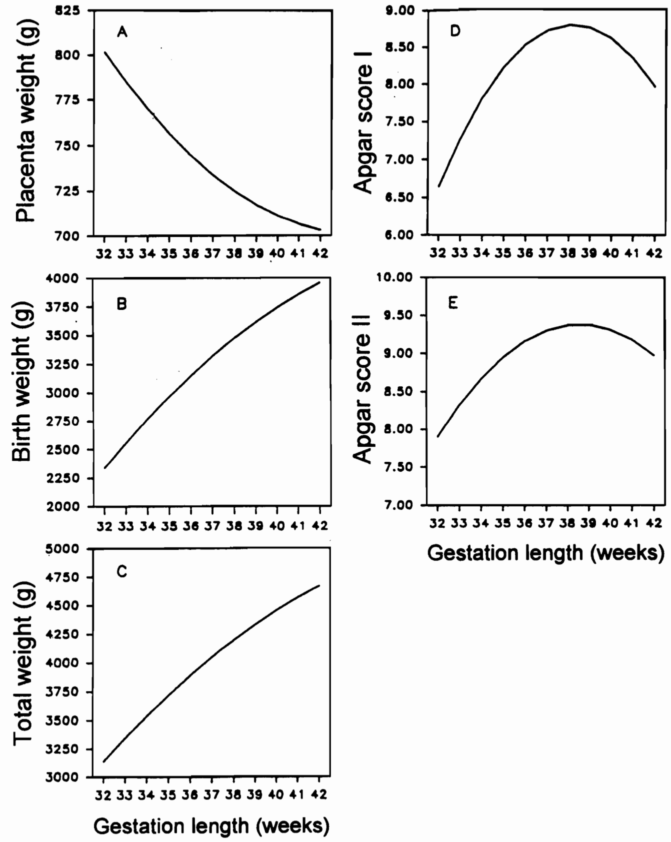

Figure 2 - Data set II, gestation length effects: a. placenta weight; b. birth weight; c. total weight; d. Apgar score I; e. Apgar score II.

set, the difference between Rh + and – was significant ($P < 0.034$) only for placenta weight, in data set I. Nor did a consistent pattern appear in the other nine estimates.

Parity

Effects were detected on most response variables. Although curvilinearity was not detected in every case, the quadratic curves were plotted for each data set II. Although there were several births of parity 9 and higher, curves were truncated at parity 8 (Figure 1).

Placenta weights seemed to increase (not significantly) until parity 4, and then declined (Figure 1A). Increase was only about 45 g from parities 1 to 4, with a subsequent decrease at parity 8 of about 65 g. Birth and total weights increased about 300 g from parity 1 to 8 (Figures 1B and 1C).

Apgar I scores increased about 0.2 units from parity 1 to 4 and then declined by about 0.3 to parity 8 (Figures 1D). Apgar II scores changed only slightly (not significant) (Figure 1E).

Gestation length

Changes in response variables are shown in Figure 2 for lengths of 32 to 42 weeks, for data set II. A very slight decline (not significant) in placenta weights was observed; the change was about 100 g. Birth and total weights increased in curvilinear fashion, about 1625 and 1525 g, respectively. Birth weight was most affected by gestation length, in variables studied by Pilotto *et al.* (1993).

Apgar scores changed in curvilinear fashion; both were maximum at 38 weeks, with very slight declines thereafter. Increase in Apgar I was 2.45 units with a subsequent decrease of 1.32 units. Correspondingly Apgar II scores increased by 1.47 units and then decreased by 1.07 units. Thus maximum vitality was observed at 38 weeks.

Correlations among responses

Simple and partial correlations are shown in Table VI for each data set. Partial correlations were obtained from a mathematical model which included all

Table VI - Simple and partial correlations between response variables, data sets I and II.

Response variable	Placenta weight	Birth weight	Total weight	Apgar score I	Apgar score II
Simple correlations[1]					
Placenta weight	1	-0.004	0.718	-0.040	0.030
Birth weight	-0.044	1	0.625	0.023	0.024
Total weight	0.506	0.839	1	-0.017	0.039
Apgar score I	-0.052	0.136	0.089	1	0.703
Apgar score II	-0.041	0.110	0.073	0.719	1
Partial correlations[2]					
Placenta weight	1	-0.009	0.559	-0.037	-0.023
Birth weight	-0.028	1	0.791	0.008	-0.044
Total weight	0.588	0.7921	1	-0.016	-0.050
Apgar score I	-0.039	0.015	-0.012	1	0.681
Apgar score II	-0.025	-0.034	-0.043	0.684	1

[1]Correlations above diagonal based on data set I; below diagonal on data set II; values >0.06 significant at $P < 0.05$.
[2]Variation in each response adjusted for effects included in the mathematical model (see text). For data set I at $P < 0.05$; 0.07 for data set II.

of the independent variables; all were ignored to estimate simple correlations.

With simple correlations, placenta and birth weights were highly correlated with total weight (0.778 and 0.625, data set I; 0.506 and 0.839; data set II). These are part-whole correlations. They were essentially uncorrelated to each other (-0.004 and -0.044), nor were weights highly correlated with Apgar scores (12 correlations averaged 0.032), although some of those correlations were statistically significant. Apgar scores were highly correlated with each other. Partial correlations were very similar to simple correlations with no noteworthy exceptions.

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RESUMO

Os fatores que afetam o peso de nascimento e da placenta e a vitalidade de recém-nascidos humanos na Flórida foram avaliados em bancos de dados de 1480 (conjunto de dados I) e 788 (conjunto de dados II) casos. Este último conjunto foi uma subdivisão do primeiro, tendo menos casos devido a procedimentos de seleção mais rígidos. Estes procedimentos excluíram natimortos ou fetos com valores muito elevados ou baixos em qualquer variável de resposta, sendo que estes últimos foram então considerados como casos anormais. Os fatores avaliados afetaram significativamente as variáveis de resposta na maioria dos casos, mas não necessariamente em ambos os conjuntos de dados. No conjunto de dados II, efeitos do mês do parto foram detectados em todas as variáveis exceto vitalidade aos 5 min pós-parto (valor II de Apgar). O peso da placenta foi 112 g menor nos meses quentes do que nos meses frios. A vitalidade em 1 min pós-parto (valor I de Apgar) foi afetada pelo mês mas não de modo sistemático. Os recém-nascidos do sexo masculino tiveram pesos 45 g maiores para placenta, para peso corporal (142 g) e para peso total (187 g). O grupo étnico afetou todas as respostas, exceto o peso placentário. Efeitos da paridade foram detectados para todas as respostas, exceto peso placentário e valor II de Apgar; a duração da gestação afetou todas as respostas, exceto o peso placentário. Os pesos placentário e do recém-nascido correlacionaram-se intensamente com sua soma (correlação de parte com o todo), mas não um com o outro nem com os valores de Apgar. Estes correlacionaram-se intensamente um com o outro. O conhecimento das características das variáveis de resposta e dos fatores que as influenciam deve contribuir consideravelmente para o conhecimento geral dos fatores que afetam as características dos nascimentos humanos.

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