Anthropometric Indices of Adolescents who at Birth were Full-Term Long and/or Overweight for Gestational Age

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ABSTRACT: **Background:** Measurements of adolescents who at birth were large (long and/or heavy) for gestational age are scant.

Objectives: To determine the correlation between birth length and weight in female and male neonates born long and/or overweight for gestational age, with their height and weight at age 17.

Methods: We reviewed the records of the Rabin Medical Center for birth data of 96 full-term neonates born long and overweight for gestational age (FT-lo,ow), 33 full-term neonates born long but with normal weight for gestational age (FT-lo,nw), 148 full-term neonates born overweight but with normal length for gestational age (FT-nl,ow), and 401 full-term neonates born with normal birth length and weight (FT-nl,nw).

Results: Neonates of both genders born long and overweight at birth (FT-lo,ow) were taller and heavier at age 17 years than those born FT-nl,nw: females 167.8 ± 5.1 cm and 64.6 ± 10.3 kg vs. 162.6 ± 5.5 cm and 59.3 ± 11.1 kg ($P < 0.001$ for height and $P = 0.026$ for weight); and males 182.4 ± 8.1 cm and 80.6 ± 20.4 kg vs. 174.5 ± 6.2 cm and 67.4 ± 12.3 kg ($P < 0.001$). The correlations between birth length and height at age 17 for both genders were statistically significant ($P < 0.001$), as were those between birth weight and the weight and body mass index (BMI) at age 17 for both genders ($P < 0.001$). There was no correlation between birth length and weight or BMI at age 17.

Conclusions: Full-term neonates of both genders born large for gestational age become tall adolescents and weigh more at age 17 than children with a normal birth length and weight.

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KEY WORDS: adolescent height, adolescent weight, long neonates, overweight neonates, large for gestational age, adult height, adult weight

Adult height is determined by genetic and environmental factors. Most studies refer to birth weight as the measure of neonatal size, a criterion not accepted by pediatric endocrinologists who consider birth length an important developmental milestone. To clarify this issue Laron [1] and Laron and Mimouni [2] suggested new definitions for birth sizes.

Only a few studies have examined the relationship between length at birth and height and weight at adulthood [3-7], and none of them included females. In a previous study we showed that neonates born small for gestational age (short or underweight) are shorter and weigh less at age 17 years than neonates born with normal length and weight [8].

The aim of the present study was to determine whether being born long or overweight for gestational age is associated with tall stature and obesity at age 17 years, for both females and males.

SUBJECTS AND METHODS

The data of neonates' length, weight and week of birth were collected from the computerized data system of the Rabin Medical Center, Israel. The neonates were measured stretched in supine position by trained nurses in the neonatal ward, as described previously [9]. The inclusion criteria were:

- Full-term infants born between 1986 and 1990, with birth length and birth weight above the 95th percentile according to the growth curves of our population [10] – group 1
- Full-term infants, born in the same period, with birth weight above the 95th percentile and birth length between the 5th and 95th percentile according to the growth curves of our population [10] – Group 2
- Full-term infants, born in the same period, with birth length above the 95th percentile and birth weight between the 5th and 95th percentile according to the growth curves of our population [10] – Group 3
- Full-term infants, born in the same period, with both birth length and weight between the 5th and 95th percentile according to the growth curves of our population [10] – Group 4.

Exclusion criteria were prematurity, postmaturity and severe congenital malformations.

At age 17 years, prior to their induction into the Israel

Defense Forces, adolescents were measured at military recruitment centers as part of the required medical examination. These data were obtained from the computerized system of the IDF. Body height was measured to the nearest centimeter with the subject standing barefoot in a stretched position. Body weight was determined with the subject wearing underwear. Body mass index was calculated as body weight (in kilograms) divided by the square of the height (in meters).

STATISTICAL ANALYSIS

Size at birth and size at age 17 were compared among the four groups (FT-lo,ow/ FT-lo,nw/ FT-nl,ow/ FT-nl,nw) using ANOVA and Dunnett's T3 for multiple comparisons. The relationship between group and the distribution above and below the 90th percentile in height and weight according to the U.S. Centers for Disease Control growth charts was tested with the chi-square test. Partial correlation coefficients were calculated between birth length and height and BMI at age 17 controlled by weight, and between birth weight and weight and BMI at age 17 controlled by length. $P < 0.05$ was considered statistically significant. Statistical analyses were performed using SPSS version 17.0.

The IDF Medical Corps and the Rabin Medical Center institutional review boards (Helsinki Committee) approved this study.

RESULTS

We collected data of 1128 neonates (580 females and 548 males) from Rabin Medical Center records. Data for the subjects at age 17 years were available for only 678 (368 females and 310 males), which comprised 60.1% of the neonates.

These 678 subjects for whom birth data were available were categorized into four groups as follows: Group 1 – 96 neonates (41 females and 55 males), group 2 – 148 neonates (60 females and 88 males), group 3 – 33 neonates (19 females and 14 males), and group 4 – 401 neonates (190 females and 211 males). The birth length and weight of the four groups are shown in Table 1.

Females and males in groups 1 and 3 were significantly longer than those in group 4.

Females and males in groups 1 and 2 were significantly heavier than those in groups 3 and 4 ($P < 0.001$ for both genders). Females and males in group 3 were heavier than those in group 4 ($P = 0.039$ for females and $P = 0.004$ for males).

IDF = Israel Defense Forces
FT-lo,ow = full-term long and overweight for gestational age
FT-lo,nw = full-term long with normal birth weight
FT-nl,ow = full-term overweight for gestational age, with normal birth length
FT-nl,nw = full-term with normal length and normal weight for gestational age
BMI = body mass index

Table 1. Comparison of the mean (± SD) length and weight at birth between full-term neonates born long and overweight (FT-lo,ow), neonates born long with normal weight for gestational age (FT-lo,nw), neonates born overweight with normal length for gestational age (FT-nl,ow), and neonates born with normal length and weight for gestational age (FT-nl,nw)

	Group 1	Group 2	Group 3	Group 4
	FT-lo,ow	FT-lo,nw	FT-nl,ow	FT-nl,nw
Females	**n=41**	**n=19**	**n=60**	**n=190**
Length (cm) (± SD)*	52.9 (± 0.9)	53.4 (± 1)	50.9 (± 0.8)	49.2 (± 1.3)
Weight (g) (± SD)**	4249 (± 270)	3515 (± 331)	4162 (± 162)	3278 (± 297)
Males	**n=55**	**n=14**	**n=88**	**n=211**
Length (cm) (± SD)*	54.0 (± 0.7)	55.1 (± 1.3)	51.6 (± 1.1)	49.7 (± 1.2)
Weight (g) (± SD)**	4436 (± 217)	3699.7 (± 268)	4330 (± 211)	3379 (± 303)

*Group 1 and 2 vs. groups 3 and 4 ($P < 0.001$)
**Group 1 and 3 vs. groups 2 and 4 ($P < 0.001$)

Table 2. Comparison of the mean (± SD) height, weight and body mass index at age 17 of full-term females and males

	Group 1	Group 2	Group 3	Group 4
	FT-lo,ow	FT-lo,nw	FT-nl,ow	FT-nl,nw
Females	**n=41**	**n=19**	**n=60**	**n=190**
Height (cm)*	167.7(± 5.1)	168.3(± 6.2)	164.6(± 5.4)	162.6(± 5.5)
Weight (kg)**	64.6(± 10.3)	62.8(± 16.4)	65.4(± 11.3)	59.3(± 11.1)
BMI	23.0(± 3.8)	22.1(± 4.8)	24.1(± 3.7)	22.4(± 4.2)
Males	**n=55**	**n=14**	**n=88**	**n=211**
Height (cm)#	182.4(± 8.1)	178.1(± 5.6)	176.7(± 6.7)	174.5(± 6.2)
Weight (kg)##	80.6(± 20.4)	64.9(± 10.2)	77.1(± 15.4)	67.4(± 12.3)
BMI§	24.1(± 4.9)	20.4(± 2.8)	24.7(± 4.8)	22.1(± 3.9)

*Group 4 vs. groups 1 and 2 ($P < 0.001$)
**Group 4 vs. group 1 ($P = 0.026$), group 4 vs. group 2 ($P = 0.002$)
#Group 1 vs. groups 3 and 4 ($P < 0.001$)
##Group 1 vs. groups 2 and 4 ($P < 0.001$)
§Group 1 vs. group 2 ($P = 0.005$), group 1 vs. group 4 ($P = 0.05$)

HEIGHT AND WEIGHT AT AGE 17

The body sizes at age 17 years of the four groups are presented in Table 2. Our findings show that females in group 1 were significantly higher and heavier at age 17 than females in group 4 ($P < 0.001$ for height and $P = 0.026$ for weight). Females in group 1 became taller at age 17 than females in group 2 ($P = 0.021$). There was no significant difference in BMI or weight at age 17 between groups 1 and 2 or between groups 3 and 4.

Males in group 1 were significantly taller and heavier at age 17 than males in group 4 ($P < 0.001$). Males in group 1 became taller at age 17 than males in group 2 ($P < 0.001$). Our findings show that males in groups 1 and 2 became heavier at age 17 than males in groups 3 and 4 ($P < 0.005$). Males in

groups 1 and 2 had higher BMI at age 17 than those in group 4 ($P = 0.051$ and < 0.001 respectively).

Using partial correlation coefficient after adjustment for birth weight and birth length respectively, we found a significant correlation between birth length and height at age 17 for both genders ($r = 0.29$, $P < 0.001$). We also found significant correlations between birth weight and weight at age 17 for females ($r = 0.22$, $P < 0.001$) and for males ($r = 0.21$, $P < 0.001$). The correlations between birth weight and BMI at age 17 were $r = 0.21$ ($P < 0.001$) for females and $r = 0.22$ ($P < 0.001$) for males.

The correlations between birth length and BMI at age 17, and between birth weight and height at age 17 were not statistically significant for both genders.

To further evaluate the findings, we examined for each gender the fractions above the 90th percentile in height and weight according to the CDC growth charts. In group 1, 24.4% of females and 30.9% of males were above the 90th percentile for height at age 17 compared to 10% of females and 10.2% of males in group 2 and 7.4% of females and 2.4% of males in group 4. In group 1, 17.1% of females and 27.3% of males were above the 90th percentile for weight at age 17 compared to 18.3% of females and 21.6% of males in group 2 and 7.9% of females and 5.7% of males in group 4.

DISCUSSION

Adult height and weight are determined by genetic, intrauterine and postnatal environmental factors. In this study we showed that neonates, both females and males, born long and overweight for gestational age tend to be taller and heavier as adolescents than neonates born with adequate length and weight.

Our results for the Israeli male population are similar to those of Rasmussen and Johansson [5] who, in a study from Sweden, found a direct association between length and weight at birth and the height and percentage of overweight males at age 18 years. Our results are also in accordance with those of Eide et al. from Norway [3], Tuvemo et al. from Sweden [7], and Haeffner et al. from Brazil [4], who found an association between being born long and being overweight in adulthood. However, our study is unique because it includes both genders, whereas all the above cited studies included males only. We also showed that birth length has a stronger effect on adult height than birth weight, as did Haeffner et al. [4] and Sorensen and co-authors from Denmark [6].

In another study from Israel [11], which included both females and males, a linear correlation between birth weight and weight at age 17 was found, but that study did not include birth length. A recent cohort study from Brazil [12] found a linear correlation between length at age 2 years and height of females at age 19. Whereas height at age 17 for females can be considered adult height, this may not be true for all males, some of whom may not have finished their pubertal growth.

There are a few limitations to our study. We were able to follow only 60% of the neonates. The main reasons are that in Israel, Orthodox females and ultra-Orthodox Jewish males, as well as Arabs of both genders, are exempted from military service and therefore were not measured at age 17. Nonetheless, we assume that this did not significantly affect our results. Additional reasons for some dropout between birth and 17 years were emigration, severe chronic or psychiatric disease that required hospitalization, and death from any cause. We could not evaluate the influence of parents' height and weight since our study was retrospective and the records in the neonatology department and the records in the recruitment centers do not include these data.

CDC = Centers for Disease Control

CONCLUSIONS

Birth length and weight are not only markers for intrauterine growth but are also predictors of adult height and weight. Long and/or overweight neonates tend to become tall and overweight adolescents. This is the first study to show these relationships for females.

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