Ability of the Higgins Nutrition Intervention Program to improve adolescent pregnancy outcome

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ABSTRACT

Objectives To determine the extent to which birth weight can be increased and the risk for adverse pregnancy outcome decreased when pregnant adolescents participated in the Higgins Nutrition Intervention Program; and to describe the dietary components of the program, including their variation as a function of diagnosed risk for adverse pregnancy outcome.

Design Retrospective cohort study involving review of medical charts.

Subjects/setting Developed as an adjunct to routine prenatal care, the Higgins Nutrition Intervention Program consists of an assessment of each pregnant adolescent's risk profile for adverse pregnancy outcomes and an individualized nutritional rehabilitation program based on that profile. The intervention group for this evaluation consisted of 1,203 pregnant adolescents who participated in the Higgins program at the Montreal Diet Dispensary between 1981 and 1991. The nonintervention group consisted of a randomly selected group of 1,203 pregnant adolescents known not to have participated in the program.

Outcomes measured Birth weight; rates of low birth weight, very low birth weight, preterm delivery, fetal growth retardation, perinatal morbidity and mortality; and maternal morbidity.

Statistical analysis Means and proportions were used to describe risk profiles and pregnancy outcomes in the two groups. Analysis of covariance and logistic regression were used to compare pregnancy outcomes while controlling for the effect of key confounding variables.

Results Results from multivariable analyses showed that infants in the intervention group weighed an average of 55 g more ($P<.05$) than infants in the nonintervention group; their low-birth-weight rate was 39% lower ($P<.001$) and their very-low-birth-weight rate was 56% lower ($P<.01$). Individually determined dietary prescriptions for the adolescents in the intervention group recommended increases in daily consumption averaging approximately 900 kcal energy and 52 g protein. The lowest daily increases (approximately 150 kcal energy and 2 g protein) were recommended to the group with no diagnosed risks; the greatest increases (approximately 1,300 kcal energy and 76 g protein) were recommended to the group with multiple risk conditions. Although none of the risk/intervention groups achieved their prescribed increases during intervention, increases in actual intake generally followed the pattern of the prescribed increases; that is, the greater the prescribed increase, the greater the actual increase.

Conclusions These results suggest that the Higgins Nutrition Intervention Program, in which nutrition intervention is individualized as a function of diagnosed risk, significantly improves the outcome of adolescent pregnancy. *J Am Diet Assoc. 1997;97:871-878.*

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Rates of adverse pregnancy outcome are high among adolescents: the low-birth-weight rate among their infants is almost twice that for infants born to older mothers, and rates of infant morbidity and mortality are also correspondingly higher (1-5).

Among adult women, prenatal nutrition is considered an important regulator of fetal growth (6), and maternal undernutrition is believed to result in reduced infant birth weight (2,7,8). Although less is known about the role prenatal nutrition plays in the outcome of adolescent pregnancy, there is reason to be concerned about this group. Adolescents are often considered to be nutritionally vulnerable; in addition, risk is believed to be further increased during periods of physiologic stress such as pregnancy (9). At least part of the reason for the increased risk during pregnancy appears to be related to the fact that pregnancies that occur within 3 to 4 years of menarche may superimpose the nutrition needs of the developing fetus on those of the mother's own linear growth (10-12).

This article provides information on the ability of the Higgins Nutrition Intervention Program to improve adolescent pregnancy outcome. A unique feature of the program is its approach to assessment and intervention in which dietary pre-

Table 1
The Higgins method for classification and treatment of risks for adverse outcome in adolescent pregnancy

Risk	Rehabilitation allowance
Undernutrition	
Usual protein intake as determined by a diet history done at the initial assessment lower than the 1958 National Research Council Recommended Dietary Allowance recommendation[a,b]	Additional daily protein allowance set equal to assessed deficit in usual intake; 10 kcal energy added for each gram of protein in rehabilitation allowance
Underweight	
More than 5% underweight[c]	Additional daily allowance of 20 g protein and 500 kcal energy for each additional weekly 0.5-kg weight gain desired. Maximum possible additional gain set at 1-kg per week[d]
Stress condition	
Poor outcome of prior pregnancy[e]; less than 12 months between birth of last child and conception; failure to gain 10 lb (4.5 kg) by 20th week of pregnancy; pernicious vomiting (hyperemesis gravidarum); serious emotional problems	Additional daily allowance of 10 to 20 g protein and 100 to 200 kcal energy for each stress condition. Maximum total daily rehabilitation allowance for multiple conditions set at 40 g protein and 400 kcal energy

[a]Because at the time the Higgins method was formalized in 1963 the Canadian Dietary Standard (17) did not provide recommendations for females between the ages of 14 and 18, the 1958 National Research Council (NRC) figures for energy and protein (16) were adopted. They continue to be used at the present time. These recommendations are 2,600 kcal energy and 80 g protein daily for 14- to 15-year-olds and 2,400 kcal energy and 75 g protein daily for 16- to 18-year-olds. For 19-year-olds within 4 years of menarche at the time of conception, the NRC recommendations for 16- to 18-year-olds are used; for those more than 4 years beyond menarche, the 1948 Canadian recommendations (17) for adult women are used.
[b]The use of protein as a marker for the assessment of global nutrient adequacy in the Higgins method is based on the work of Jeans et al (14), which suggested that the level of protein intake is predictive of the level of other essential nutrients in the diet.
[c]Underweight was defined in comparison with desirable weights for adults prepared by the Metropolitan Life Insurance Company in 1959 (15).
[d]In 1972, the energy portion of this rehabilitation allowance was changed from 200 kcal to 500 kcal.
[e]Poor outcome of prior pregnancy includes infants with birth weight below 2,500 g, stillbirths, and spontaneous or therapeutic abortions.

scriptions are determined individually as a function of diagnosed risk.

METHODS AND PROCEDURES

Higgins Nutrition Intervention Program

Developed at the Montreal Diet Dispensary as an adjunct to routine prenatal care, the Higgins Nutrition Intervention Method of Assessment and Rehabilitation consists of an assessment of each pregnant adolescent's risk profile for adverse birth outcomes and an individualized nutritional rehabilitation program based on that profile. The Higgins Nutrition Intervention Program, which consists of the systematic application by trained dietitians of all components of the Higgins Method, has been described in detail elsewhere (13).

Briefly, the program consists of four steps: (a) assessment of the risks for the pregnancy (Table 1) (14,15); (b) determination of individual dietary prescriptions based on the combination of the normal requirements of pregnancy and rehabilitation allowances for diagnosed risks (Table 1); (c) teaching of food consumption patterns that meet individual dietary prescriptions while respecting preexisting food habits; and (d) follow-up and supervision by the same dietitian at 2-week intervals. Such an approach to assessment and intervention allows for differential compensation for the effects of varying levels of risk at the time of entry to the program.

When the Higgins Method is used with pregnant adolescents, the 1958 National Research Council Recommended Dietary Allowance figures for energy and protein (16) are used in establishing the normal nonpregnancy requirements as well as in assessing for potential undernutrition (Table 1). These figures were adopted when the Higgins Method was formalized in 1963, because at that time the Canadian Dietary Standard (17) did not provide recommendations for 14- to 18-year-old females. The National Research Council figures continue to be used at the present time.

Every adolescent participating in the Higgins program is provided with a supplement of milk, eggs, and a vitamin/mineral preparation for the remainder of pregnancy. Adolescents in greatest financial need may also be provided with other food as supplied by the local food bank. Cessation of smoking and abstinence from alcohol are encouraged. Referrals are made to appropriate agencies for further assistance and follow-up of nonnutrition problems.

Study Design

A review of medical charts was undertaken to determine differences in perinatal outcomes between two groups of infants born to adolescent mothers. The intervention group consisted of infants born at 15 Montreal area hospitals to adolescent mothers participating in the Higgins program at the Montreal Diet Dispensary between 1981 and 1991. The nonintervention group was selected at random from the cohort of all infants born to adolescent mothers at the same hospitals during the same period.

The nonintervention infants were selected as follows. Infants whose mothers had participated in the Higgins program were first eliminated from the listing of births for each hospital. Each listing was then stratified on the basis of year of delivery and maternal age. Nonintervention infants were selected at random from these stratified lists so that the study included the same number of intervention and nonintervention infants born at each hospital, each year, to mothers of the same age. This frequency matching was done to control for any differences in infant outcomes associated with differences in prenatal or obstetric care across hospitals, changes in obstetric management procedures over time, or maternal age.

The only exception to the matching procedure occurred at one tertiary-care hospital at which more than half of the adolescent mothers younger than the age of 17 years had participated in the Higgins program at the Montreal Diet Dispensary. Because matches were consequently not available for 13 of the infants in the intervention group born at this hospital, they were matched instead with infants born at a similar tertiary-care hospital located nearby. Support for the appropriateness of this matching substitution is provided by the almost identical average birth weights of the nonintervention infants delivered at the two hospitals.

All data used in the evaluation of the ability of the Higgins program to improve adolescent pregnancy outcome were abstracted from hospital medical charts; files maintained at the Montreal Diet Dispensary were used only to identify the intervention subjects. Random reabstraction and recoding of the data from the medical charts was done on an ongoing basis to monitor data abstraction and coding procedures used by the study archivists.

This study was approved by ethics committees of McGill University and the Faculty of Medicine, University of Sherbrooke.

Data Analysis

Means and proportions were used to describe risk profiles and pregnancy outcomes in the intervention and nonintervention groups. Multivariable analyses (analysis of covariance and logistic regression) (18,19) were undertaken to compare outcomes that are the primary target of the Higgins program (birth weight as well as rates of low birth weight, very low birth weight, preterm and very preterm delivery, and fetal growth retardation) while controlling for the effect of confounding variables. For other risk factors and outcome variables, *t* tests were used to assess differences in means and χ^2 tests to assess differences in proportions on a univariate level.

All variables listed in Table 2 were initially evaluated as potential confounding variables in the multivariable analyses. Because the effect of parity and previous poor obstetrical outcome (a risk for which there is a rehabilitation allowance in the Higgins Method) cannot be studied independently, their combined effect was estimated using previous obstetrical history as a three-level variable (ie, no previous outcome, poor previous outcome, good previous outcome).

The assumption of equality of regression slopes in the two groups (ie, parallelism) was violated for three variables retained in the final analyses (socioeconomic status as measured by income quintile assigned to area of residence [20] at the time of delivery, pregravid weight, previous obstetrical history). This was not surprising; the Higgins program is designed to prevent full expression of the impact of such risk factors. Because of the violation of the assumption of parallelism, the following adjustment procedure was used for these variables: the impact of each variable was estimated using data from the nonintervention group alone, and these estimates were then used to adjust for the effect of differing distributions of the variables in the intervention and nonintervention groups.

In attempting to identify the model that best described the relationship between pregravid weight and birth weight, visual inspection of the data indicated that the relationship was different below and above 50 kg. For this reason, as well as because 50 kg was one of two cutoff points used by the Committee to Study the Prevention of Low Birthweight (2) to define "low" pregravid weight, different linear models were used for pregravid weights below and above 50 kg. The improved fit of this "piecewise" linear model over that of a quadratic curvilinear model was demonstrated by its lower mean square error.

Classical analysis of covariance and logistic regression techniques were used to adjust for the impact of the differing distributions of the other confounding variables retained in the final analyses (sex of infant, maternal smoking, involvement of a social worker, and location of prenatal care). Location of prenatal care was coded as a two-level variable: hospital-affiliated clinic or private practice office. Because of the universal medical coverage system in Quebec, the choice between these two types of location for prenatal care is not influenced by financial considerations.

Table 2
Maternal health risk profile

Maternal characteristics	Intervention group (n=1,203)	Nonintervention group (n=1,203)
Age at delivery[a] (y)	17.7±1.3	17.7±1.2
Age at menarche[a] (y)	12.5±3.6	12.7±4.2
Parity[a]	0.1±0.4	0.1±0.3
Primiparas (%)	89	91
Gravity[a]	1.4±0.7	1.3±0.6***
Primigravas (%)	71	78***
Poor obstetrical history[b] (%)	7	6
Maternal height[a] (cm)	161±9	162±7***
Pregravid weight[a] (kg)	55±9	56±10
Low pregravid weight (<50 kg) (%)	32	27
Urinogenital infections (%)	15	12***
Underlying medical conditions[c] (%)	5	5
Smoked during pregnancy (%)	35	43***
Nonwhite (%)	38	22***
Unmarried (%)	82	76***
Income quintile of residence at time of delivery[a,d]	4.3±1.1	4.0±1.2***
Social assistance as source of income (%)	20	10***
Low education for age[e] (%)	5	2***
Alcohol or drug use noted (%)	7	6
Followed-up by a social worker (%)	45	31***
Followed-up as a clinic patient (%)	74	77*
Overall social risk score[a,f]	3.0±1.2	2.5±1.2***

[a]Mean±standard deviation.
[b]Any of the following: spontaneous abortion, fetal death, low birth-weight infant.
[c]Conditions known to affect perinatal outcomes: hypertension, renal disease, asthma, preexisting diabetes.
[d]Income quintile was calculated using the postal code assigned to the address given by the mother as her residence at the time of delivery. Quintile 1 is the highest income quintile; quintile 5 is the lowest.
[e]The adolescent was noted to have low education for age when the difference between her age and the number of years of schooling completed was 8 or greater. One would normally obtain a value of six or seven for persons who have not repeated any grades and have not already left school.
[f]The overall social risk score was calculated as the unweighted sum of the individual risks in the table. In calculating this score, income quintiles 4 and 5 were assigned a score of 1; quintiles 1, 2, and 3 were assigned scores of 0.
*Significant difference between groups, $P \leq .05$.
***Significant difference between groups, $P \leq .001$.

Two sets of subgroup analyses were performed. The first set compared outcomes for the intervention and nonintervention groups separately for infants born to adolescents with pregravid weights below and above 50 kg. The second set compared intervention and nonintervention outcomes separately for infants born to mothers aged 17 years or younger and those born to mothers aged 18 to 19 years.

Definitions of infant outcomes evaluated in these analyses are as follows: (a) low-birth-weight infants have a birth weight of less than 2,500 g, (b) very-low-birth-weight infants have a birth weight of less than 1,500 g, (c) preterm deliveries occur at a gestational age of less than 37 completed weeks of gestation, (d) very preterm deliveries occur at a gestational age of less than 34 completed weeks of gestation, and (e) fetal growth retardation is present if the ratio of the observed birth weight to mean birth weight for gestational age as reported in intrau-

Table 3
Maternal progression of pregnancy

Variable	Intervention group (n=1,203)	Nonintervention group (n=1,203)
Length of gestation[a] (wk)	39.2±2.1	39.0±2.6*
Cesarean delivery (%)	14	12
Gestational weight gain[a] (kg)	15.2±6.0	14.9±6.1
Maternal morbidity[b] (%)	7	6
Pregnancy-induced hypertension (%)	7	5
Gestational diabetes (%)	2	2
Bleeding[c] (%)	3	3
Premature rupture of membranes (%)	4	5

[a]Mean±standard deviation.
[b]Any of pregnancy-induced hypertension, gestational diabetes, bleeding, or premature rupture of membranes.
[c]Includes placenta previa, abruptio placentae, and other antepartum bleeding.
*Significant difference between groups, $P \leq .05$.

Table 4
Descriptive data on neonatal outcomes

Outcome	Intervention group (n=1,203)	Nonintervention group (n=1,203)
Birth weight[a] (g)	3,214±545	3,168±602
Length[a] (cm)	50.3±3.2	50.0±3.1
Head circumference[a] (cm)	34.0±2.0	34.1±1.8
Males (%)	53	53
Low birth weight[b] (%)	6.7	9.9
Very low birth weight[b] (%)	1.3	2.6
Preterm[b] (%)	8.2	12.8
Very preterm[b] (%)	2.3	5.1
Fetal growth retardation[b] (%)	2.8	3.2
Perinatal mortality (per 1,000)	6	7
Neonatal intensive care (%)	5	7*
Days in neonatal intensive care[a]	10±20	19±33
Apgar score—1 min[a]	7.8±1.8	7.8±1.7
Apgar score—5 min[a]	9.0±1.4	9.0±1.1
Infant morbidity[c] (%)	4.3	5.3
Asphyxia (%)	1.7	1.7
Fractures/paralysis (%)	0.5	0.6
Respiratory distress syndrome (%)	1.2	2.2*
Malformations (%)	0.7	0.8

[a]Mean±standard deviation.
[b]Definitions appear in Data Analysis section.
[c]Any of asphyxia, fractures/paralysis, respiratory distress syndrome.
*Significant difference between groups, $P \leq .05$.

terine growth standards from the same city as our study (21) is less than 0.75 (22).

Odds ratios less than unity indicate a reduced risk of adverse outcome among the intervention infants. For example, an odds ratio of 0.5 means that the odds of the intervention infants experiencing a given adverse outcome is one half that of the nonintervention infants. Data were analyzed using the Statistical Analysis System (version 6.03, 1987, SAS Institute, Cary, NC).

RESULTS

A total of 1,314 adolescents were enrolled in the Higgins program between 1981 and 1991. Of these, 8 delivered twins, 28 delivered outside the Montreal metropolitan area, and the hospital charts of 75 (distributed more or less evenly across study hospitals) could not be traced at the time of data abstraction. After the exclusion of these 113 subjects, the intervention group thus consisted of 1,203 adolescent mothers who had delivered at 15 Montreal area hospitals. They were frequency matched according to hospital of delivery, year of delivery, and age with 1,203 adolescent mothers known not to have been enrolled in the Higgins program.

Characteristics of the Study Groups

Descriptive data on characteristics of the study groups are presented in Table 2. Age at delivery averaged 17.7 years in both groups. There was a similar proportion of primiparas in the two groups, but the intervention group included a significantly lower proportion of primigravas, which suggests a larger number of interrupted pregnancies in the intervention group. Maternal height averaged 1 cm lower and pregravid weight 1 kg lower in the intervention group. A slightly higher proportion of adolescents in the intervention group had a pregravid weight of less than 50 kg. The intervention group contained a significantly higher proportion of adolescents who had experienced urinogenital infections during pregnancy. A significantly lower proportion in the intervention group were noted, in their hospital charts near the time of delivery, to be smokers.

More adolescents in the intervention group were nonwhite, were unmarried, had completed a low number of years of schooling for their age, lived in areas of the city classified as lower income (20), were followed-up by a social worker, and reported social assistance as their source of income. Alcohol or drug use was noted somewhat more frequently in the charts of adolescents in the intervention group; this difference was not statistically significant. Seventy-four percent of the adolescents in the intervention group and 77% of the adolescents in the nonintervention group received prenatal care in hospital-affiliated clinics.

Overall social risk scores, calculated as the unweighted sum of the individual social risk factors presented in Table 2, were significantly higher for the intervention group (3.0 vs 2.5, $P<.001$). This was not unexpected. The Higgins program was specifically created to help compensate for the effect of risk factors for adverse pregnancy outcome frequently observed among socially and economically disadvantaged groups. Many local agencies working with pregnant adolescents routinely refer those at highest risk to the program.

Maternal Progression of Pregnancy

Data on maternal progression of pregnancy are presented in Table 3. Duration of pregnancy was 0.2 weeks longer ($P \leq .05$) and gestational weight gain was 0.3 kg higher (not statistically significant) in the intervention group. Pregnancy-associated morbidity was slightly more frequent in the intervention group as were cesarean deliveries; neither of these latter differences achieved statistical significance.

Neonatal Outcomes

Descriptive data on neonatal outcomes are presented in Table 4. Rates of low birth weight, very low birth weight, preterm delivery, very preterm delivery, and fetal growth retardation were all lower in the intervention group. (No univariate tests of the statistical significance of differences in the rates of these key outcome variables were performed, however, because of the unequal distribution of risk factors for their occurrence in the intervention and nonintervention groups [Table 2]. Results of the multivariable analyses are presented in Table 5.)

As can also be seen from Table 4, there were significantly fewer admissions to neonatal intensive care ($P \leq .05$) among the intervention infants. In addition, the 60 infants (5%) in the intervention group admitted for intensive care had stays averaging 9 days less (not significant) than the 84 infants (7%) in the nonintervention group who received intensive care. Less infant morbidity occurred in the intervention group; this finding was accounted for by a significantly lower rate of respiratory distress syndrome ($P \leq .05$).

Results of the multivariable analyses are presented in Table 5. All variables listed in Table 2 were initially considered as potential confounding variables for these analyses. The following variables, which were associated with exposure and independently associated with outcome, were adjusted for as confounding variables (23): infant sex, pregravid weight, previous obstetrical history, socioeconomic status as measured by income quintile of residence at time of delivery, smoking, involvement of a social worker, and location of prenatal care. Odds ratios for perinatal mortality are also presented in Table 5; because of the small number of deaths, these ratios have not been adjusted for the effect of confounding variables.

Table 5 shows that after adjusting for the effects of confounding variables, the birth weight of the intervention infants averaged 55 g higher ($P \leq .05$) than that of the nonintervention infants. The intervention infants had rates of low birth weight that were 39% lower ($P \leq .001$) and of very low birth weight that were 56% lower ($P \leq .01$) than those of the nonintervention infants. The preterm delivery rate was 41% lower ($P \leq .001$), and the very preterm delivery rate 47% lower ($P \leq .001$) in the intervention group. Rates of fetal growth retardation and of perinatal mortality were also lower in the intervention group, but the differences did not achieve statistical significance.

The magnitude of the risk reduction associated with the intervention was similar for subgroups defined on the basis of prepregnancy weight and maternal age. For all adverse outcomes, the confidence limits around the odds ratios for the subgroup with maternal pregravid weights less than 50 kg (30% of the total group) included the values of the odds ratios for the subgroup with maternal pregravid weights of 50 kg or greater. In addition, with the exception of low birth weight and preterm delivery, for which the impact of the intervention appeared somewhat greater for infants born to the adolescents aged 18 to 19 years (64% of the total group), the confidence limits around the odds ratios for the subgroup of infants born to the younger adolescents included the values of the estimated odds ratios for the subgroup of infants born to the older adolescents. Three of the odds ratios presented in Table 5 were greater than 1; none were statistically significant and none had been suggested by previous knowledge.

Variables such as maternal height, urinogenital infections, race, education, and marital status have been reported as risk factors for adverse pregnancy outcome; all were unequally distributed in the intervention and nonintervention groups of our study. Because, however, these variables were not associated with exposure and independently associated with outcome—the criteria for confounding variables (23)—they were not retained in the multivariable analyses.

Smoking status has been adjusted for in the analyses presented in Table 5, despite the fact that the lower rate of smoking recorded in the hospital charts of the intervention group near the time of delivery may have been at least partially due to the fact that all pregnant women enrolled in the Higgins program are encouraged to stop smoking.

Table 5
Impact of the Higgins Nutrition Intervention Program on adolescent pregnancy outcome[a]

Risk categories	Birth weight of nonintervention infants (g)[c]	Birth weight difference (g)	Adjusted birth weight difference[bc] (g)	LBW[a] Odds ratio	LBW[a] CL	VLBW[a] Odds ratio	VLBW[a] CL	Preterm delivery[b] Odds ratio	Preterm delivery[b] CL	Very preterm delivery[b] Odds ratio	Very preterm delivery[b] CL	FGR[b] Odds ratio	FGR[b] CL	Perinatal mortality Odds ratio	Perinatal mortality CL
Overall	3,168±603	46	55±24[f]	0.61	0.45,0.82	0.44	0.23,0.82	0.59	0.45,0.78	0.53	0.35,0.81	0.95	0.66,1.34	0.88	0.33,2.36
Pregravid weight <50 kg[d]	3,036±537	104	105±40	0.61	0.38,0.98	0.71	0.21,2.40	0.63	0.38,1.06	0.60	0.25,1.47	0.73	0.41,1.30	0.84	0.09,8.07
Pregravid weight ≥50 kg	3,216±618	33	54±28	0.55	0.37,0.81	0.37	0.18,0.77	0.57	0.41,0.80	0.52	0.32,0.84	1.07	0.67,1.72	0.93	0.32,2.68
13-17 y old[e]	3,147±651	40	44±43	0.80	0.51,1.25	0.51	0.21,1.19	0.86	0.57,1.30	0.57	0.30,1.09	0.84	0.49,1.43	0.63	0.16,2.41
18-19 y old	3,180±574	50	61±28	0.50	0.34,0.75	0.38	0.15,0.97	0.45	0.31,0.66	0.49	0.28,0.87	1.09	0.66,1.79	1.29	0.32,5.25

[a]Key: LBW=low birth weight; VLBW=very low birth weight; FGR=fetal growth retardation; CL=95% confidence limits.
[b]Adjusted for infant sex, pregravid weight, previous obstetrical history, income quintile of residence at time of delivery, smoking, involvement of a social worker, and location of prenatal care; because the matching on year and hospital of delivery was not maintained when infants were divided on the basis of maternal pregravid weight, they were included as covariates in these multivariable analyses.
[c]Mean±standard error of the mean.
[d]383 adolescents in the intervention group and 321 in the nonintervention group had pregravid weights <50 kg; 820 in the intervention group and 882 in the nonintervention group had pregravid weights ≥50 kg.
[e]434 adolescents in the intervention group and 430 in the nonintervention group were 13 to 17 years of age; 769 in the intervention group and 773 in the nonintervention group were 18 to 19 years of age. The slight difference in the numbers of intervention and nonintervention adolescents in each of the age groups is related to the fact that in a few instances the closest age match for a 17-year-old intervention adolescent who was about to turn 18 was an adolescent a few weeks older, who had already turned 18.

Table 6
Maternal and infant characteristics as a function of maternal risk[a]

Maternal characteristics	No diagnosed risks (n=149)	Undernourished (n=333)	Underweight (n=43)	Stress (n=184)	Multiple conditions (n=494[b])	Overall (n=1,203)
Age at delivery[c] (y)	17.4±1.4	17.5±1.4	17.7±1.2	17.8±1.2	17.9±1.1	17.7±1.3
Pregravid weight[c] (kg)	59.4±10.7	56.5±8.0	48.1±5.2	56.7±8.5	56.2±8.2	54.9±8.9
Length of gestation[c] (wk)	39.2±2.5	39.3±1.9	39.0±2.9	39.2±2.3	39.2±1.8	39.2±2.1
Week of gestation intervention began[c]	20.1±7.0	22.9±7.5	21.0±6.5	19.3±6.8	21.0±2.1	21.2±7.2
Weight gain before intervention[c] (kg)	7.2±5.0	7.7±5.0	7.2±4.6	3.6±5.5	4.1±5.2	5.5±5.4
Weight gain during intervention[c] (kg)	9.6±5.2	8.3±5.4	8.9±4.3	10.0±5.3	8.2±5.0	8.6±5.2
Total weight gain[cd] (kg)	17.2±5.3	16.0±4.8	16.2±4.3	13.6±6.2	12.3±5.6	14.2±5.7
Infant birth weight[c] (g)	3,257±629	3,292±510	3,176±691	3,203±554	3,157±501	3,214±545
Low birth weight[e] (%)	6.7	3.6	11.6	6.6	8.3	6.7

[a]Risk categories are defined in Table 1.
[b]Multiple conditions include two or more of the following risks: undernutrition, underweight, or stress.
[c]Mean±standard deviation.
[d]Sum of weight gain before intervention and weight gain during intervention does not equal total weight gain in all risk/intervention groups. A small number of subjects who could not report their pregravid weight were included only in the calculation of weight gain during intervention.
[e]Low-birth-weight infants have a birth weight of less than 2,500 g.

Variability in Risk and Associated Variability in Dietary Prescriptions

Given the positive impact of the Higgins program on adolescent pregnancy outcome, data are now presented on its dietary component. These data are drawn largely from the diet histories conducted, and the dietary changes counseled, by the treating dietitians at each program visit of the adolescents in the intervention group (13). In reviewing these data, note that energy and protein levels of the dietary prescriptions vary as a function of the level of diagnosed risk: adolescents with the lowest level of risk received dietary prescriptions for the smallest increases in dietary consumption during intervention, whereas those with the highest level of risk received prescriptions for the greatest increases in consumption.

Only 12% of the adolescents (149 of 1,203) participating in the Higgins program had none of the risks for adverse pregnancy outcome evaluated using the Higgins Method (Table 6), 47% had a single risk (either undernutrition, underweight, or stress), and 41% had multiple risks. Energy intake (Table 7), as estimated from the diet history taken at the initial assessment visit, averaged approximately 2,300 kcal/day for the total intervention group; protein intake averaged 73 g/day. The lowest intakes were reported by adolescents in the undernourished and multiple conditions groups (groups in which a low protein intake at initial assessment resulted in the diagnosis of undernutrition as a risk for adverse pregnancy outcome). Unexpectedly, the highest levels of energy and protein consumption before intervention were reported by the small group of adolescents with underweight as their only diagnosed risk.

Dietary prescriptions recommended increases in consumption averaging approximately 900 kcal energy and 52 g protein per day for the intervention portion of pregnancy (Table 7). The lowest daily increases, averaging approximately 150 kcal energy and 2 g protein, were recommended to the group with no diagnosed risks. The greatest daily increases, averaging approximately 1,300 kcal energy and 76 g protein, were recommended to the group with multiple risk conditions.

Actual increases in consumption during intervention averaged 366 kcal energy and 23 g protein daily, or 40% to 45% of the prescribed increases. These increases were not evenly distributed, however, across risk/intervention groups. Two of the five groups (no diagnosed risks, stress) reported little change in intake during intervention; the group with underweight as their only diagnosed risk reported decreases averaging slightly more than 200 kcal energy per day. In contrast, two groups (undernourished and multiple conditions) reported increases that averaged approximately 500 kcal energy and 30 g protein per day. One must ask whether the greater increases in these latter groups were related to the fact that their prescriptions recommended substantially greater daily increases in consumption than those received by the other groups. (The undernourished and multiple risk conditions groups received prescriptions recommending daily increases of 1,000 to 1,300 kcal energy per day; those in the other risk/intervention groups received prescriptions for increases averaging less than 400 kcal/day.)

Milk intake (Table 7), as determined at the initial assessment interview, averaged 461 mL/day. Although there was variation between groups in both the initial levels of intake and the increases made during intervention, these were generally complementary. As a result, daily consumption during intervention averaged more than 900 mL in all risk/intervention groups.

Data on gestational weight gain as taken from the nutrition intervention charts are presented in Table 6. Total weight gains presented here are about 1 kg lower than those in Table 3 (which were taken from the hospital charts and used in the multivariable analyses presented in Table 5). The 1-kg difference is believed to be at least partially related to the following circumstances: last prenatal weights tended to be recorded in the nutrition intervention charts about 2 weeks before delivery, whereas those in the hospital charts were often taken very close to delivery.

The group with multiple risk conditions had received dietary prescriptions recommending the greatest increases in dietary consumption during intervention (Table 7). Although their weight gain during intervention was similar to the intervention gain by the other risk/intervention groups (Table 6), their total gestational gain was the lowest of all risk/intervention groups. Infants in this risk/intervention group had the lowest average birth weight (3,157 g) and the second highest low-birth-weight rate (8.3%).

Infants born to adolescent mothers with underweight as their only diagnosed risk for adverse pregnancy outcome had the highest low-birth-weight rate (11.6%) of the five risk/intervention groups. The most favorable outcomes were observed in the group with undernutrition as their only risk (birth weight averaged 3,292 g; low birth weight rate was 3.6%).

Table 7
Energy, protein, and milk intake as a function of maternal risk profile[a]

Variable	No diagnosed risks (n=149)	Undernourished (n=333)	Underweight (n=43)	Stress (n=184)	Multiple conditions (n=494)	Overall (n=1,203)
Energy intake at initial assessment[b] (kcal)	2,709±637	2,120±522	2,855±705	2,675±667	2,075±467	2,285±618
Recommended increase in energy intake[bc] (kcal)	+150±655	+998±617	+315±731	+371±641	+1,282±572	+892±755
Actual increase in energy intake[bd] (kcal)	−37±570	+488±556	−207±790	+51±623	+562±541	+366±626
% of recommended increase in energy consumed	0	49	0	14	44	41
Protein intake at initial assessment[b] (g)	94±25	65±19	96±21	90±24	64±18	73±24
Recommended increase in protein intake[bc] (g)	+2±26	+58±32	+13±22	+26±27	+76±32	+52±40
Actual increase in protein intake[bd] (g)	+5±23	+29±22	0±21	+8±23	+30±21	+23±24
% of recommended increase in protein consumed	250	50	0	31	39	44
Milk intake at initial assessment[b] (mL)	742±471	366±263	741±438	621±427	353±279	461±371
Recommended increase in milk intake[bc] (mL)	+259±471	+631±265	+254±441	+379±410	+647±279	+539±370
Actual increase in milk intake[bd] (mL)	+219±441	+534±323	+191±383	+306±416	+545±309	+456±374

[a]As defined in Table 1.
[b]Mean±standard deviation.
[c]All recommendations for increases are for the intervention portion of pregnancy.
[d]Calculated as a weighted average of the difference between the reported intake at each follow-up visit and the reported intake at the initial assessment visit; each difference weighted according to the number of weeks since the previous reported intake.

DISCUSSION

The goal of Higgins Nutrition Intervention Program is to treat pregnant women identified at risk for adverse pregnancy outcomes so as to prevent the actual occurrence of those adverse outcomes. The effectiveness of this intervention has been shown for adult women with both singleton and twin pregnancies (24,25). The results of our study demonstrate that the Higgins program also improves the outcome of adolescent pregnancy. Rates of low birth weight, very low birth weight, and preterm delivery were significantly lower (39% to 56%) among infants whose mothers had participated in the program.

Such reductions are comparable to, if not somewhat greater than, those achieved with the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC); a meta-analysis (26) estimates that providing WIC benefits to pregnant women reduces rates of low birth weight by 25% and rates of very low birth weight by 44%. The 56% reduction in rates of very low birth weight among adolescents participating in the Higgins program has particular importance. The majority of infants in this birth-weight range are cared for in neonatal intensive care units where costs are high (27-29).

The present study is not the first to observe an association between nutrition and preterm delivery. Gosselink et al (30) found that women with premature delivery accompanied by premature rupture of the amniotic sac membranes were significantly less likely than full-term controls to have improved their diets during pregnancy. In a clinical trial of the impact of calcium supplementation on adolescent pregnancy outcome, Villar and Repke (31) found significantly lower rates of prematurity and low birth weight among infants in the calcium supplementation group.

The adolescents who participated in the Higgins program had significantly better pregnancy outcomes than the nonintervention group, but their gestational weight gain averaged only 0.3 kg higher. This nonsignificant finding is consistent with an Institute of Medicine report (32) that an increase in maternal weight gain that could explain the increase in infant birth weight has been observed in only the minority of nutrition intervention programs operating in developed countries of the world.

The results presented here also suggest that recommending relatively large increases in dietary consumption to some of the adolescents participating in the Higgins program did not result in excessive gestational weight gain. The risk/intervention group that received dietary prescriptions for the greatest increases in dietary intake had the greatest level of initial risk for adverse pregnancy outcome (the group with multiple risk conditions). Their weight gain during intervention was the second lowest of any group; their total gestational gain was at the lower end of the recommended range.

A higher than average proportion of infants (5 of 43, 11.6%) born to adolescents in the group with underweight as their only diagnosed risk were low birth weight. One possible explanation for this rate relates to the fact that these underweight adolescents had reported the highest energy and protein intakes at the time of initial assessment. To the extent that these high levels were due to overreporting of consumption, there would have been a corresponding failure to diagnose and treat undernutrition as a risk factor for adverse pregnancy outcomes such as low birth weight. Support for the plausibility of overreporting by this underweight group is provided by Yellowless et al (33) who found that underweight adolescents tend to overestimate the size of food items more than average-weight adolescents. Another possible explanation for the 11.6% rate of low birth-weight observed in this group relates to the small number of infants involved: if 2 more of these 43 infants had been low birth weight, the rate would have been 16%; 2 less would correspond to a rate of 7%.

Even though the infants born to the group with multiple risk conditions had good outcomes given their level of initial risk, they did have the lowest average birth weight and the second highest rate of low birth weight of the five risk/intervention groups. Their adolescent mothers had the greatest absolute increases in consumption during the course of intervention, but nonetheless consumed on average only 44% of the recommended additional energy and only 39% of the recommended additional protein. Maternal weight gain was also the lowest of any group, mainly because of a low gain before intervention. Although the rate of low birth weight for infants in this highest risk group who participated in the Higgins program was lower than that of the nonintervention infants (see Table 5), we must ask whether it could have been further reduced if their mothers had entered the intervention program earlier than at 21 weeks of gestation (Table 6).

The lowest rate of low birth weight (3.6%) was observed in the group with undernutrition as their only risk, and not, as one might expect, in the group with no diagnosed risks. Unlike underweight or stress, undernutrition as a risk factor for adverse pregnancy outcome can only be identified if usual dietary intake patterns are assessed carefully. When they received individualized nutrition intervention, the adolescent mothers with this risk condition gave birth to infants with the highest average birth weight and the lowest proportion of low birth weight of any risk/intervention group. Prenatal identification and treatment of undernourished adolescents may be a particularly effective means of improving adolescent pregnancy outcome.

The Higgins program has multiple intervention components, and we believe the impact of each component should be interpreted only in the context of the total program. Nonetheless, in terms of levels of dietary intake, we point out that the treated adolescents were encouraged to increase their consumption by an average of approximately 900 kcal energy and 52 g protein per day. We do not know whether the reduction in rates of adverse adolescent pregnancy outcome achieved with the program would have been obtained if different levels of dietary prescriptions had been used. This may be particularly true for adolescents who had the highest levels of diagnosed risk at the time of initial assessment and who consequently received prescriptions for the greatest increases in daily consumption.

APPLICATIONS

The Committee to Study the Prevention of Low Birthweight has recommended that research be undertaken that includes "evaluation of certain well-defined combinations of prenatal care interventions designed to meet the widely varied needs and risks among pregnant women" (2, p 15). This has been done with the Higgins Nutrition Intervention Program. Given that the program has now been demonstrated to be an approach that reduces the rate of adverse pregnancy outcome when used with adolescents, we recommend that care for pregnant adolescents include a well-defined nutrition intervention program such as this one. The intervention should be individualized, and the intensity of its dietary component should be determined as a function of diagnosed risk. Identifying and treating undernutrition may be a particularly important way of improving the outcome of adolescent pregnancy. ■

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