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The effect of maternal malnutrition on physical growth of Wistar rats

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The study was conducted to find out the effect of maternal malnutrition during the first and third trimesters of pregnancy on body weight and length of the offsprings up to adult life. Thirty Wistar strain female rats were randomly divided into 3 groups and were allowed to become pregnant. Forty percent restriction of food intake was done during the first trimester in test I group and during the third trimester in test II group while one group ,the control group, was given food *ad libitum* throughout pregnancy. The offsprings of all three groups were allowed to take food *ad libitum*. Mean birth weight, mean weaning weight, mean weaning length and mean adult length of test II group were significantly lower ($p<0.0001$) than those of the control group (4.56g *vs* 5.46g, 19.57 g *vs* 23.84 g, 14.45 mm *vs* 16.08 mm and 39.78 mm *vs* 41.15 mm respectively). However, mean birth weight (5.4 g), mean weaning weight (24.78 g), mean weaning length (16.08 mm) and mean adult length (40.82 mm) of test I group were more or less similar to those of control group but mean adult weight of test I group (263.04 g) was significantly greater ($p<0.004$) than that of the control group (237.65 g). From this study, it was found that maternal malnutrition during third trimester can cause defective physical growth of off-spring.

INTRODUCTION

It has been reported that maternal malnutrition affected the fetal growth and development [1, 2]. In rats, a 50 % overall reduction of food intake or a decrease in protein content of 5 to 6 % from early pregnancy or throughout the pregnancy caused 20 to 30 % reduction in birth weight of offspring [3]. However, Nailsmith (1969) and Rippel *et al*. (1965) showed that in rats and pigs, moderate protein deprivation had no effect on the weight of the off-spring [4,5]. Studies by Polani (1974) indicated that about 40% birth weight variation was due to genetic factors and about 60% was due to the fetal environment such as maternal health and nutrition [6]. According to Hytten (1979), the belief widely held by nutritionists, that the fetus is vulnerable to maternal dietary inadequacy in pregnancy may be mistaken [7]. The widespread changes in the maternal homeostasis of nutrients makes it easier for the placenta to compete with maternal tissues for supplies. Essential nutrients are acquired by the fetus via active fetus-directed transport so that in extreme conditions the fetus will acquire nutrients at the expense of the mother [7]. However, Girard *et al.* (1979) pointed out that low fetal birth weight occurred following fasting during late pregnancy in rats (17.5 to 21.5 days) [8]. Seller (1987) brought to light the effect of maternal nutrition on different embryonic stages in rats. He divided prenatal development into 3 distinct phases: pre-implantation, implantation and post-implantation. He stated that alteration in nutrition does not usually affect the early pre-implantation phase but markedly affect on later two phases [9]. It was also reported that food restriction during the third trimester gives rise to low birth weight pups; and the dams which were food restricted for the first two trimesters but re-fed during third trimester showed that in every parameter, they were comparable with control [10].

Barker's discovery in 1984 that low birth weight linked to cardiovascular disease in adulthood had led to a discovery of fetal programming. Under-nutrition during the fetus's first trimester makes obesity more likely in adulthood, perhaps because the appetite control centre in brain is programmed to over-eat and fetus undernourished later in gestation may develop fewer fat cells. That makes it harder to become fat after birth [11].

Therefore, the present study was aimed to find out the effect of maternal malnutrition during first and third trimesters of pregnancy on body weight and length (growth) of the off-springs up to adult life.

MATERIALS AND METHODS

Study design

It was a randomized experimental trial design.

Materials

Wistar rats from laboratory Animal Services Division , DMR(LM) were used.

Method

Thirty pairs of Wistar rats were randomly divided into three groups. One group was used as control. Out of 10 female rats used, eight female rats became pregnant and completed the study. They were fed diet *ad libitum*.

In another group (Test I group), out of 10 female rats, 7 became pregnant and completed the study. These pregnant rats were restricted in food intake (40% restriction) during the first week of pregnancy but later re-fed *ad libitum*.

In the other group (Test II group), out of 10 female rats, 5 became pregnant and completed the study. These pregnant rats were given food *ad libitum* and restricted in food intake (40% restriction) during last week of pregnancy. Litter size, birth weight, weaning weight, weaning length (snout to rump length) and weekly changes in weight and length were recorded up to adult life.

To all groups, clean cages and autoclaved bedding were provided twice a week and autoclaved DMR rat diet and tap water were provided daily. The room temperature was kept at 19 ± 2° C.

Data analysis

Means of all parameters were compared by the student 't' test and the differences were considered as significant at $p < 0.05$.

RESULTS

Figure 1 shows comparison of mean maternal body weight changes during pregnancy among Test I, Test II and Control groups. Weight reduction was found to coincide with food restriction period.

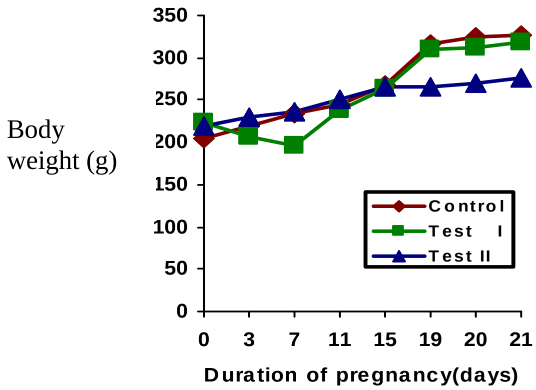

Figure 1. Maternal body weight changes during pregnancy

Mean birth weight, mean weaning weight, mean weaning length and mean adult length of off-springs of Test II group were significantly lower ($p < 0.0001$) than those of control group but mean adult weight of off-springs of Test I group was significantly greater ($p < 0.004$) than that of control group(Table 1).

Table 1. Comparison of mean litter size, mean birth weight, mean weaning weight, mean weaning length, mean adult weight and mean adult length of off-springs of Test I, Test II and Control groups.

No		Control	Test I	Test II
1	No. of pregnant rats	8	7	5
2	Litter size	13.50 ± 2.98	10.86 ± 3.93	15.00 ± 3.16
3	No. of off-springs	95	68	60
4	Birth weight (gm)	5.40 ± 0.38	5.46 ± 0.59	4.56 ± 0.24*
5	Weaning weight (gm)	23.84 ± 2.99	24.78 ± 8.85	19.57 ± 4.20*
6	Weaning length (mm)	16.08 ± 1.17	16.08 ± 1.85	14.45 ± 1.62*
7	Adult weight (gm)	237.65 ± 49.86	263.04 ± 56.17**	236.95 ± 43.96
8	Adult length (mm)	41.15 ± 2.05	40.82 ± 2.04	39.78 ± 1.62*

** significant difference when compared with the control ($p < 0.0001$)*
*** significant difference when compared with the control ($p < 0.004$)*

Figure 2 shows comparison of changes in mean body weight of the off-springs of Test I and Test II groups with that of the Control groups. The off-springs of Test II group have lower weight gain.

Figure 3 shows comparison of changes in mean body length of the off-springs of Test I and Test II groups with that of the Control groups. The off-springs of Test II group have also lower mean body length changes than those of other groups.

DISCUSSION

Regarding maternal body weight changes during pregnancy, Wistar rats given DMR stock diet *ad libitum* showed a slight increase in body weight during the first two weeks (0 to 14 days) and a marked increase in body weight during the third week (15 to 21 days). This was in accord with Beaton's report (1954) [12] as well as Hla Hla Aye's findings [10]. Those pregnant rats during 40% overall reduction in food intake were found to be associated with marked reduction in body weight.

In our experiment, mean litter sizes of Control group, Test I group and Test II group were not significantly different. Mean birth weight of pups born from Test II group [The pregnant dams who were given restricted food intake during the last week (15 – 21 days)] was significantly lower ($p < 0.0001$) than that of the control group. However mean birth weight of pups born from Test I group [The pregnant dams who were given restricted food intake during the first week (1 – 7 days)] was comparable to that of the control group. This finding was also in accord with those of Seller's report [9] and Hla Hla Aye's findings]10]. These findings may be explained by the facts suggested by Seller (1987) [9]. He stated that in the pre-implantation period the embryo acquired nutrients by diffusion and maternal nutrition does not affect the embryo development. In post-implantation period, nutrients exchange occurred across the placenta membrane and alteration of maternal nutrition could have marked effects on the fetus.

Most of the studies on the effect of maternal nutrition on the off-springs put emphasis only on the birth weight and their exploration did not extend to adult life. In our study, the effects of maternal nutrition on the off-springs were observed up to adult life and also extended to the next generation. In the study of growth, changes in both body weight and snout to rump length were main parameters to be considered. In this study, changes in both body weight and snout to rump length up to adult life of the pups of group II were lower than those of the control group. This indicates the fact that maternal malnutrition during third trimester can affect not only the birth weight but also growth of pups in later life. Although adult weight of

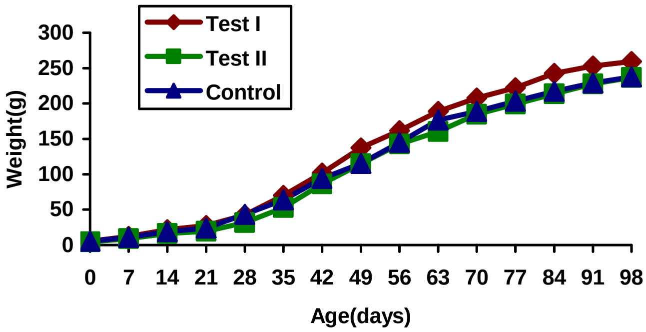

Figure 2. Comparison of changes in mean body weight of the off -springs of Test I and Test II groups with that of the Control groups

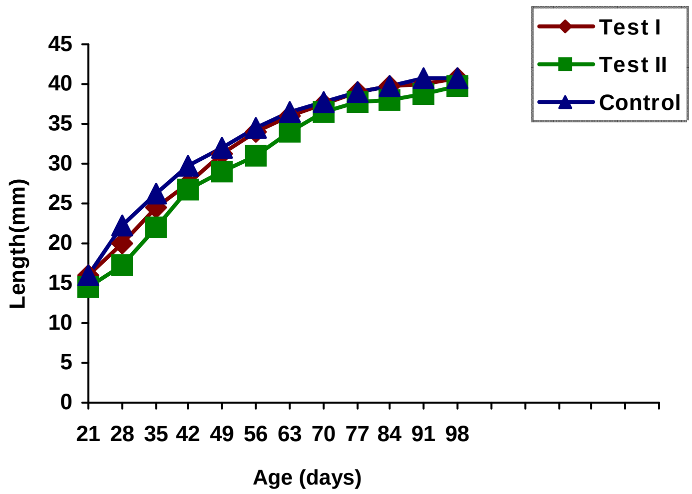

Figure 3. Comparison of changes in mean body length of the off-springs of Test I and Test II groups with that of the control groups

pups is not significantly lower than that of the control group, adult length was still significantly lower than that of control group. However, changes in both body weight and snout to rump length up to adult life of the pups of group I were more or less comparable to those of the control group although adult weight of the pups of group I was significantly greater ($p<0.004$) than that of the control group. These findings were in accord with the concept of "fetal programming" suggesting that as pregnancy progress, each month in the womb shapes health for life. As mentioned above, under-nutrition during the fetus's first trimester makes obesity more likely in adulthood, perhaps because the appetite control centre in brain is programmed to over-eat and fetus undernourished later in gestation may develop fewer fat cells [11]. That makes it harder to become fat after birth. From this study, it was found that maternal malnutrition during third trimester could cause defective physical growth of off-spring.

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