DISCUSSION

Recent clinical studies have suggested a beneficial effect of vitamin D supplementation in pregnancy on fetal and neonatal growth. Vitamin D supplementation in pregnancy not only decreased the incidence of low birth weight babies (Brooke et al., 1980; Maxwell et al., 1981) but also produced a dose-dependent increase in fetal birth weight (Marya et al., 1981a). In another study, there was no significant difference between the mean birth weight in infants born to vitamin D supplemented & non-supplemented mothers. However, follow up revealed significantly greater weight and height of the babies of the supplemented group at nine months and twelve months age even though neither the mothers nor the babies received any vitamin D supplements postnatally (Brooke et al., 1981). In the present work the effects of vitamin D supplementation in pregnancy on the soft tissue growth and the skeletal growth of the rat pups have been investigated. Experimental studies have the obvious advantage over community nutritional studies since the dietary and environmental conditions can be rigidly controlled only in the former.

In this work, vitamin D has been administered to the pregnant rats on commercial diet containing adequate amounts of vitamin D (18,00 IU per Kg diet) as well as calcium (1%) and phosphorus (0.6%). Different groups of rats, received 3,000 IU (group AII), 7,500 IU (group AIII) or 15,000 IU (group AIV) of vitamin D₃ as a single intramuscular injection on 10-12th day of pregnancy. The dose of 3000 IU vitamin D
was roughly equivalent to the amount which was found by the author to produce best results in human pregnancy (Marya et al., 1981a). The body weight of the pups was studied at the ages d1, d10, d20 and d28. At d28, skeletal growth was studied by examination of dry weight, ash weight and ash weight over dry weight ratio in the tibia. Epiphyseal region of the tibia was also examined histologically. At d28, the pattern of soft tissue growth was studied in the liver, brain and gastrocnemius muscle. In these soft tissues, organ weight, protein content, RNA and DNA contents were estimated. In another series of experiments, vitamin D, in doses similar to those mentioned above, was administered in the mothers on the 3rd day of lactation instead of pregnancy. On 28th day of age the pups were examined for their body weight, skeletal and soft tissue growth by the methods described above. In the third series of experiments the pattern of soft tissue cellular growth in pups from supplemented and nonsupplemented groups was studied at d1, d10 and d20 age.

**EFFECTS OF VITAMIN D SUPPLEMENTATION DURING PREGNANCY ON THE NEONATAL GROWTH**

(A) **BODY WEIGHT**:

Administration of 3,000 IU (group AII) and 7,500 IU (group AIII) vitamin D during pregnancy resulted in birth of pups with slightly more weight than controls but the difference was statistically insignificant (Table II). However, by 10th day of age group AII and AIII pups became significantly heavier than control pups. At 28th day of age group AII &
A III pups were 24% and 31% respectively heavier than group A I pups indicating a dose related effect. The results are to some extent comparable to the clinical observation of Brooke et al. (1981), wherein although the birth weight and length of the babies in the supplemented group was not significantly different from controls, the babies of the supplemented mothers were significantly taller and heavier at 9 months and 1 year age.

Administration of a still larger dose i.e. 15,000 IU of vitamin D in pregnancy (group A IV) did not produce any beneficial effect on the neonatal growth of the pups. Even at birth these pups were slightly lighter than controls and at 28th day of age, the mean weight of the pups in group A IV was not significantly different from controls (Table II). These observations suggest that over and above the normal dietary intake of vitamin D, administration of a limited dose of the vitamin supplement in pregnancy produces a beneficial effect on the growth of the neonate. Higher doses may not only fail to promote neonatal growth (as observed in this study) but may even produce actual growth retardation. Administration of 20,000 IU of vitamin D per day during pregnancy has been reported to produce severe growth retardation in suckling pups (Ornoy et al., 1972).

(B) SKELETAL GROWTH:

In this work, estimation of plasma calcium levels in the pups (and their mothers) and histological study of the epiphyseal cartilage of the tibiae of the pups have been utilised to establish vitamin D status of the pups. Dry weight and ash weight of the tibia were used as indices of the skeletal growth in the pups.
It is important to know the vitamin D status of the pups in (control) group A I since, in the presence of hypovitaminosis D in this group, the significance of increase in weight of the pups in groups A II & A III would be different. Adequate vitamin D nutrition of the rats was assured by the vitamin D content (1,800 IU vitamin D/kg diet) of the commercial feed given to all the groups of rats including controls. Although many workers have used greater amounts (Boass et al., 1981a, Toverud et al., 1976), the recommended vitamin D content of rat feed is only 300 IU/kg diet (Porter, 1963; Hariharan, 1985). The calcium : phosphorus ratio of the rat feed (1.7:1) was also optimum for minimising the vitamin D requirement of the rats (Stewart, 1975).

Due to very rapid rate of growth (8-10 fold increase in body weight during the first 28 days of life), the neonatal period seems to be very sensitive to maternal deficiency of vitamin D. Whereas several weeks of vitamin D deprivation is required to produce rickets in adult rats, even short term vitamin D deprivation in pregnant rats results in all the features of rickets in 20-25 days old pups (Boass et al., 1981a). Therefore, in the absence of facilities for the estimation of plasma levels of vitamin D or its metabolites, histological study of the epiphyseal cartilage becomes a useful tool to assess the vitamin D status of the pups. It may be added that, till recently, the study of the epiphyseal cartilage in the young rat was a well recognized method for the bioassay of vitamin D (Fourman and Royer, 1968).
In the control group, histological study of epiphyseal cartilage of the upper end of tibia (Fig. 4), revealed a normal columnar arrangement of the hypertrophic cell layer and an even line of ossification. Thus the characteristic skeletal features of hypovitaminosis D i.e. irregular arrangement of the hypertrophic cell layer, and uneven line of ossification or wide osteoid borders (Holtrop et al., 1982) were not seen in the control groups. Similarly in the pups of supplemented group A II, A III & A IV, the characteristic feature of vitamin D intoxication i.e. wide osteoid borders on the trabeculae alongwith normal looking epiphysseal cartilage (Follis, 1955) were not seen (Fig. 5-7). Plasma calcium levels in the mothers and their pups at d 28 were also essentially similar in all the groups (Table VII). From these observations, it may be concluded that neither the control pups were vitamin D deficient nor were the supplemented groups of pups hypervitaminotic.

Another evidence of normal vitamin D status of the pups in group A I was the fact that ash weight/dry bone weight ratio of the pups in this group was not less than that in group A IV, that is, pups whose mothers were administered a large dose (15,000 IU) of vitamin D in pregnancy (Table VI). In hypovitaminosis D, bone weight, ash weight and ash/bone weight ratio tend to decrease. For example, the content of ash as a per cent of dry limb bone was reported to decrease from 44.9% in normal controls to 17.7% in vitamin D deficient adult animals (Steenbock, 1924). In another study in 19 days old pups of vitamin D deficient mothers, the ash weight as per cent of bone weight was
significantly reduced to 33.8% as compared to 36.2% in the pups from vitamin D replete mothers (Boass et al., 1981a).

In group A II and A III pups (whose mothers received 3,000 IU and 7,500 IU vitamin D in pregnancy, respectively) the tibial dry weight (75.15 mg±2.22 and 81.56 mg±1.87 respectively) was significantly more than that in group A I (63.45 mg ±1.97). The ash weight of the tibia in pups of vitamin D administered mothers was also significantly more than in controls (Table VI). However estimation of ash as a percent of the total dry weight of the tibia did not reveal any significant difference between controls and group A II or group A III. These results indicate greater osteogenesis in pups whose mothers received 3,000 IU or 7500 IU vitamin D in pregnancy.

Bone weight over total body weight ratio (mg/g) was determined to study the relative effect of vitamin D administration on skeletal and soft tissue growth. In groups A II and A III, the ratio was not significantly different from that of controls (Table VI) indicating that in groups II and III pups the skeletal tissue showed improvement in growth in proportion to the total body growth.

Improved osteogenesis in pups whose mothers, during pregnancy, received vitamin D over and above the normal requirement has not been reported before. However, there is one report in which administration of 1,25(OH₂)D₃ has been shown to increase the bone mass in normal adult rat (Larson et al., 1977). Some
other evidences also suggest that vitamin D₃ may be involved in the bone formation. In cultured rat osteosarcoma cells, 1,25 (OH₂) D₃ stimulates the synthesis of osteocalcin in a dose-dependent manner (Price, 1984). In another study, long term administration of 24,25(OH₂) D₃ produced marked and dose dependent increase in bone volume without leading to any hypercalcemia (Nakamura et al., 1988).

Like total body weight, dry bone weight and ash weight in group A IV pups (whose mothers received 15,000 IU of vitamin D₃ in pregnancy) were not significantly different from controls (Table VI). Ash weight/dry bone weight ratio and bone weight/total body weight ratio were also similar to those in controls. Thus only a limited dose of vitamin supplement in pregnancy is helpful in the promotion of skeletal growth of the offspring. Administration of massive doses of vitamin D during pregnancy may even impair osteogenesis in the fetus (Ornoy et al., 1968, 1969). Ornoy et al. (1968) estimated ash weight as a per cent of wet bone weight, in the bones of fetuses whose mothers received 40,000 IU vitamin D₂ per day. The value was 15% as compared to 25% in normal and 28% in those whose mothers received 4,000 IU vitamin D per day in pregnancy.
The well known target organs for vitamin D include the bone, intestinal mucosa and the kidney. However reports of nuclear receptor sites for $1,25(\text{OH})_2\text{D}_3$ in a number of other tissues like the skeletal muscle, heart, brain, skin etc. (Reichel et al., 1989) suggest a wide spread action of vitamin D. These reports seem to support the belief of Steenbock and Herting (1955) that vitamin D may have an effect on tissue organic metabolism, of which improvement in growth is one of the manifestations.

In this work, three soft tissues namely the liver, brain and gastrocnemius muscle were investigated. In each case the tissue weight was significantly more in group A III pups than in group A I (controls), indicating the contribution of the soft tissues to the increase in total body weight. In group A III, the weight of gastrocnemius muscle, liver and brain was 35%, 20% and 10% respectively more than in controls (Table III-V).

In the liver a dose-effect relationship was observed. The hepatic weight, protein content, RNA content and DNA content were found to be progressively greater in groups A II and A III as compared to group A I, but the difference was statistically significant in group A III only. protein/DNA ratio (cell size) and RNA/DNA ratio (protein synthetic capacity) were significantly increased in group A II as well as in group A III. However in these two indices, no significant difference could be observed between groups A II and A III (Table III).
In the gastrocnemius muscle, on the other hand, the tissue weight, and all the indices of cellular growth investigated were significantly greater in groups AII and A III than in controls. Moreover there was no significant difference between groups A II and A III (Table IV).

In the brain, vitamin D administration produced a significant increase in tissue weight, protein content, RNA content and RNA/DNA ratio only. Like the skeletal muscle, these indices also showed almost maximum response in group A II and no further improvement in the indices of growth of the brain was observed in group A III (Table V).

Administration of a still higher dose of vitamin D₃ i.e. 15,000 IU in pregnancy failed to produce the beneficial effects in growth of the liver & skeletal muscle observed with lower doses of vitamin D (Table III, IV).

From the observations on soft tissue growth summarised above, it is obvious that the skeletal muscle showed the maximum response whereas the brain, the least. Besides environmental factors, the tissue growth and development is regulated by a genetic control. In various malnutrition and overfeeding experiments the brain showed relatively lesser variation in growth than the skeletal muscle (Rosso, 1977; Winick & Noble 1967). Vitamin D mediated growth variation in the three tissues could also be due to a difference in the population of receptors for 1,25(OH)₂D₃. It has been estimated that about 60% of the amount of vitamin D or its metabolites injected accumulates in the muscle and the skeleton (De Luca, 1977).
From the results discussed so far it may be concluded that when the female rats were on diet containing 1.8 IU vitamin D/g diet, administration of 3,000 IU or 7,500 IU of vitamin D₃ during pregnancy significantly increased the neonatal growth. Both the skeleton and the soft tissues participated in the accelerated growth. In postulating the mechanisms involved in accelerating the growth processes in the pups, one has to keep in mind the fact that the increase in total body weight of the pups reached a significant level only after 10 days of postnatal life. Therefore vitamin D administration in pregnancy might have increased the neonatal growth by:-

(i) improving the lactational performance of the mother and/or,
(ii) anabolic action on the fetal & neonatal tissues.

EFFECT OF VITAMIN D SUPPLEMENTATION IN PREGNANCY ON LACTATIONAL PERFORMANCE

Since the increase in body weight of the pups in groups A II and A III reached significant level at d 10 onwards (Table II), the increased lactational performance could be one of the mechanisms of increased neonatal growth. Mammary gland seems to be one of the target organs, for vitamin D metabolites. In autoradiograms of mammary gland of rats on 6th day of lactation, after injection of tritiated 1,25(OH)₂D₃, a nuclear concentration of radioactivity was observed in alveolar and duct cells (Narbiatz et al., 1981). The role of vitamin D in lactational performance has also been demonstrated indirectly by the severe growth retardation in rat pups following maternal vitamin D deficiency (Boass, et al., 1981a;
Brommage and Neuman, 1981; Halloran and De Luca, 1980a). The rat pups appeared normal at birth but stopped growing at one week of age. The results have been attributed to a severe reduction in milk secretion (Brommage and De Luca, 1984a,b).

These workers have attributed the decrease in milk production to hypocalcemia since food consumption and milk secretion were increased by self selection of high calcium diet (Brommage and De Luca, 1984c). In this work the milk output could not be measured since accurate measurements of milk secretion require the use of radioactive isotopes of water and potassium (Brommage & De Luca, 1984b). However, estimation of food intake and body weight of the mothers during lactation can be used to assess the lactational performance, indirectly. Food intake of the mothers was estimated in the lactating rats on d 14-16. In groups A II and A III the mean daily food intake was 54.81g + 1.69 & 55.16g + 2.01 respectively. These values were significantly greater (p<0.05) than that of the control group A I (49.25 + 1.40). Inspite of this, all the three groups of mothers i.e. group A I, A II and A III had similar amount of weight during the 4 weeks of lactation (Table I). These results indicate greater lactational performance of rats in groups A II and A III than in group A I.

It may be pointed out that even in the control mothers the food intake was markedly greater than in non-pregnant rats of similar body weight. During lactational period, food intake increases to a level about 4 times that of the non-lactating rats. The increased appetite appears to be related to the suckling-
induced stimuli as well as the metabolic drain of milk production (Toverud & Boass, 1979).

From these results it may be concluded that improvement in lactational performance was at least one of the mechanisms by which vitamin D administration in pregnancy increased the neonatal growth. To explore the possibility of an anabolic action of vitamin D on the fetal and neonatal tissues, group B, C and D studies were conducted.

If vitamin D administration in pregnancy increased the neonatal growth merely by increasing the lactational performance, administration of similar doses of vitamin D in early lactation may be expected to be equally effective in increasing the neonatal growth. In group B studies, such a possibility has been explored.

**EFFECTS OF VITAMIN D SUPPLEMENTATION IN LACTATION**

In group B studies, mothers were administered vitamin D₃ on the 3rd day of lactation. Thus groups B II, B III, and B IV received 3,000 IU, 7500 IU and 15,000 IU of vitamin D₃ as a single intramuscular injection. At d 1 and d 10, mean body weights of the pups were similar in all the groups including group B I. However at d 21 and d 28, group B II and B III pups were significantly heavier than control (group B I) pups (Table IX). The increase in the total body weight was also reflected in the increased weight of the soft tissues (skeletal muscle, liver and brain) as well as in the tibia (Table X-XIII).
Therefore, vitamin D administration in early lactation also seems to increase the lactational performance as well as neonatal growth. In an earlier study, Djojosoebagio & Turner (1964) observed greater milk yield and greater body weight of suckling pups on administration of vitamin D$_2$ in lactation.

Superficially the results of group A and group B studies seem to be similar and therefore the increased neonatal growth observed in both the studies may be attributed to better lactational performance. However, a close scrutiny of the data reveals certain important differences between the two groups. One important difference was that administration of similar doses of vitamin D produced greater improvement in neonatal growth in group A than in group B. In groups A II and A III, the weight of the pups at d 28 was 24% and 31% more than the controls. In groups B II and B III, the weight of the pups at d 28 was only 16% more than control. These results could be explained if it is assumed that vitamin D is more effective in increasing the lactational performance when administered in pregnancy than in lactation. Although there is no direct evidence to support this view, such a possibility is suggested by the fact that mammary tissue normally undergoes hyperplasia in pregnancy and receptor sites for 1,25(OH)$_2$D$_3$ have been reported in not only lactating and non-lactating mammary tissue (Reinhardt & Conrad, 1980) but also in anterior pituitary cells involved in secretion of growth hormone (Haussler et al., 1982) thyroxine (Sar et al., 1980) and prolactin (Wark and Tashjian, 1982). Moreover, human breast tumour cells in tissue culture have been shown to respond to addition of vitamin D metabolites in the medium by greater DNA synthesis (Freake et al., 1981). Iwasaki et al. (1983)
observed a dose dependent biphasic response to 1,25(OH)₂D₃ in mammary tissue culture. Low concentrations of the metabolite caused significant inhibition of growth.

Certain differences in the indices of cellular growth between group A and group B, however, suggest that some additional mechanism was also involved in promoting greater neonatal growth in pups of groups A II and A III. In groups BII and B III the tissue weights and DNA contents of the liver, gastrocnemius muscle and brain were significantly more than in group B I (Tables X-XII) indicating cellular hyperplasia in the supplemented groups. In over-feeding experiments similar cellular hyperplasia and increased weight of the pups have been reported by Winick and Noble (1967). Thus the study of the indices of cellular growth again support the view that in groups B II and B III, the pups gained more weight than group B I due to better lactational performance. On the other hand the increase in soft tissue growth in groups A II and A III was due to not only cellular hyperplasia but also a significant increase in protein synthetic capacity leading to cellular hypertrophy as well (Tables III-V). Thus vitamin D administration in pregnancy promoted neonatal growth not only by increasing lactational performance but also by some other anabolic action which produced greater protein synthesis. Such an anabolic action might have occurred during the neonatal period or during the intrauterine life. To clarify this point 1000 IU and 500 IU of vitamin D₃ were administered intramuscularly at d 10 to half the number of pups in each litter while the other half acted as controls (Group D studies). All the pups suckled their mother who did not receive any vitamin D supplement in
pregnancy or lactation. At d 28 no significant difference could be detected between the weights of the supplemented and non-supplemented groups of pups (Table XXIII). These results suggest that the anabolic effect is produced only when additional quantities of vitamin D reach the pups during intrauterine life.

The possibility of a fundamental role of vitamin D in intrauterine growth and development is suggested by the reports of receptor sites for 1,25(OH)\textsubscript{2}D\textsubscript{3} in many fetal tissues such as placenta, bone, skin, kidney and yolk sac (Haussler, 1986). The placenta can not only transport vitamin D and its metabolites to the fetus (Hadded et al., 1971; Ross et al., 1979) but also is the only non-renal tissue capable of converting 25(OH)D\textsubscript{3} to 1,25(OH)\textsubscript{2}D\textsubscript{3} (Tanaka et al., 1978). However it may be argued that if the anabolic action of vitamin D on the tissues begins to operate during intrauterine life, why the greater birth weights were not observed in group A II and A III pups? In this regard it may be pertinent to point out that in pregnant women administration of vitamin D resulted in babies with greater birth weight (Marya et al., 1981a, 1988) but in the rats the beneficial effect was observed only after 10 days of postnatal life. Probably the difference lies in the extent to which the fetus completes its growth at birth. The mean weight of a rat pups is about 2% of the adult weight whereas a human newborn weighs about 5% of the adult value. More important differences have been reported between these two species regarding the pattern of cellular growth during interauterine and in early postnatal life. According to
Winick et al. (1972) the cellular growth is characterised by three consecutive and somewhat overlapping phases. During the first phase an organ grows exclusively by increasing its cell number. This is reflected by linear increase in DNA content of the organ without change in protein/DNA ratio. During the second phase, rate of cell division falls and cell size begins to increase. Finally in the third phase the cell division ceases and the organ growth becomes a function of increase in cell size (protein/DNA ratio). In human fetus rapid increase in DNA content of liver, gastrocnemius muscle, kidney and heart can be observed during the first 25 weeks of gestation, after which the proliferative phase slows down. In these organs the protein/DNA ratio begins to increase rapidly during the last 10 weeks of intrauterine life (Widdowson et al., 1972). In the rat, on the other hand, the proliferative phase extends not only throughout intrauterine life but also to the first month of postnatal life (Winick and Noble, 1965). The only exceptions are the brain where the proliferative phase is mostly completed by 20th postnatal day and the liver where it extends up to 48th postnatal day (Winick et al., 1972). Thus the pattern of cellular growth in the perinatal period is such that alterations in growth processes set into motion during intrauterine life are likely to manifest postnatally. The study of the effects of vitamin D administration in pregnancy on the phases of cellular growth studied during the first month of life provide further evidence of intrauterine anabolic action of vitamin D.
EFFECTS OF VITAMIN D SUPPLEMENTATION DURING PREGNANCY ON THE INDICES OF CELLULAR GROWTH AT BIRTH AND IN FIRST MONTH OF LIFE

In this series of experiments 7,500 IU vitamin D was administered to the rats on 10-12th day of pregnancy (group C II) and the pups were sacrificed at d 1, d 10 and d 20 and indices of cellular growth studied in the liver and brain. In group C II pups on d 1, neither total body weight nor liver weight was significantly different from control group C I. However, even at this stage the brain weight was significantly more in group C II than in group C I. On d 10, besides total body weight, both weights of the liver and brain were significantly more in the supplemented group (Tables XV-XX). Comparison of the weights of the liver and brain at d 1 and d 28 in the control group reveals an interesting feature of their perinatal growth. At d 1 and weight of the liver (162 mg) was 10% of the weight at d 28 (1.63 g). On the other hand, weight of the brain at d 1 (220 mg) was 18% of the weight at d 28. In other words, compared to the liver a larger percentage of total growth of the brain occurs in intrauterine life. Therefore the anabolic effect of vitamin D, if it occurs during gestation, is more likely to manifest at birth in the brain rather than the liver.

In the control pups, the pattern of cellular growth in the liver during the first 28 postnatal days was characterised by a marked increase in DNA content till d 20 followed by a marked increase in protein/DNA ratio during d 20-28 (Fig. 8). Thus the control pups showed the usual pattern of cellular...
proliferation and subsequent cellular hypertrophy. Comparison of this pattern with that of group C II pups (Fig. 8) shows that vitamin D administration did not alter the basic pattern of cellular growth in the liver. It accentuated the phase of cellular hyperplasia during the first 20 days and extended it till d 28. In addition, it produced a large increase in protein synthetic capacity so that the protein/DNA ratio on d 28 was significantly greater in the supplemented group.

In the brain (Fig. 9) the pattern of cellular growth in group C II was essentially similar to that of group C I except that all the indices of cellular growth were slightly greater in the former. Some of these indices were significantly greater in group C II even at birth (weight & protein content) while others (RNA content and RNA/DNA ratio) were found to be greater only at d 28.

From the observations on the pattern of cellular growth during the neonatal period described above, it may be concluded that additional amount of vitamin D made available to the pregnant rat modified the fetal tissue growth so as to promote both cellular hyperplasia and hypertrophy but the results manifested chiefly during the neonatal period when these processes reached their peak rate in the rat. However it remains to be explained how vitamin D could alter the rate of cellular proliferation and protein synthesis.

The role of Ca++ in regulation of cellular proliferation and differentiation has been demonstrated recently by many workers.
Whitfield et al. (1980) observed blockade of DNA synthesis in regenerating liver cells after parathyroidectomy which could be reversed by calcium supplementation. In mouse epidermal cells the rate of cellular proliferation and differentiation could be modified by altering Ca$^{++}$ concentration in the medium (Henning et al., 1980). In view of these reports and the fact that 1,25\((OH)_2\)D$_3$ stimulates synthesis of calcium binding protein in many tissues other than intestinal mucosa (Mayer et al., 1984; Clemens et al., 1985), it has been recently proposed that vitamin D, by regulating intracellular calcium ion concentration may be involved in regulation of cellular proliferation and differentiation (Haussler et al., 1985). In view of the key role of calcium in many exocrine functions including secretion of milk (Smith et al., 1982; Bhattacharjee et al., 1987), the improved lactational performance in vitamin D supplemented mothers can also be explained on similar basis as acceleration of soft tissue and skeletal growth. Moreover many studies (Eckl et al., 1987; Boynton et al., 1977) have demonstrated maximum cellular proliferation at a particular Ca$^{++}$ concentration. Both lower and higher Ca$^{++}$ concentrations decreased the rate of cellular proliferation. Therefore, it is not difficult to understand why administration of 15,000 IU of vitamin D in pregnancy or lactation failed to promote the neonatal growth.

To conclude, the results of this study have demonstrated that in the rats on normal intakes of vitamin D, calcium and phosphorus, administration of a limited supplement of vitamin D during pregnancy produced a beneficial effect on the fetal and
neonatal growth. The increase in growth involved both the skeletal and soft tissues. The accelerated neonatal growth was partly due to an improvement in the lactational performance of the mothers. In addition certain evidences suggest an anabolic action of vitamin D on the offspring which began during gestation and extended into neonatal period.