EFFECTS OF NURSING METHODS ON THE DEVELOPMENT OF INFANT HIP-BONES*

KUNIKAZU OOHASHI

Department of Public Health, Nagoya University School of Medicine
(Directors: Prof. Yahito Kotake and Assist. Prof. Hiroshi Mizuno)

Since Hippocrates first used the term "congenital dislocation of the hip", and described the conditions defined by that term, and suggested that intrauterine pressure and trauma at birth are possible causes, the existance of the disease has been recognized for many centuries.

After many failures in determining the etiology of the disease, Le Damany and other investigators attempted the application of Mendel's concept of heredity at the beginning of this century, but little attention was paid to the environmental factor sassociated with this disease.

Since Lorenz initiated the conservative treatment of this disease, its early diagnosis and treatment have gradually attracted the attention of physicians and numerous diagnostic and therapeutic methods have been utilized extensively by Hilgenreiner and Faber, etiological considerations were directed mainly to the prenatal period, as manifested by the term "primary congenital dysplasy", or to the delivery period, and the environmental factors of the post-natal period have been ignored. The environmental factors were taken into account by Klopfer as shown in his term "Wachstumreiz" or suggested by Bernbeck in the terms, environmental factors as well as congenital factors. The significance of the environmental factors was stressed furthermore by Badgeley using the term "acetabular dysplasia", and the etiological concept of the environmental factors has been advanced more in recent years.

Iino, Akabayashi, Imada and Tanaka introduced the hypothesis that there exist latent forms, between true dislocation and normal, and they investigated the environmental factors contributing to the development of these latent and true forms of dislocation. Also the multiple etiological factors associated with the disease have been studied by many recent investigators.

Of these, Mizuno and his associates have revealed the etiological mechanism of this disease, and have analysed the feature of the normal development of the hip joint in order to establish preventive measures for this disease. Their view is that retardation of the growth of the ilium is a final result, brought about by the interrelation of differences in sex, month age, physical growth and environmental factors. Moreover, Mizuno has stressed the importance of intensive preventive measures and nursing care based on the fact that infants under one year who have greater probability of dislocation were re-

Received for publication March 12, 1963.

* Thec ontents of this article were reported at the 16th Convention of the Japan Public Health Society, October 1960, Kobe.

cognized in the area over the rejecting limit-line at 5 per cent level on the regression line between the iliac and femur breadth.

The present author attempted statistical analysis of environmental factors in nursing which seem to cause differences in the development of hip-bones, and discussed the validity of Mizuno's preventive measures based on the present results.

MATERIAL AND METHOD

a) Materials

Of infants living in the area under a certain Health Center of Aichi Prefecture, the subjects for study were systematically selected according to month age, sex and birth season and were summoned to the Center for interview and physical examination during the period of one year from April, 1959 to March, 1960.

In this study, 1,355 subjects (681 males and 654 females) were examined, as shown in Table 1. They were measured for height and weight, and ventrodorsal roentgenograms of their hip were taken.

TABLE 1. Number of Infants by Sex and Month-Age

Sex→ / Month-Age ↓	Male	Female	Total
1	34	23	67
2	29	27	56
3	30	29	59
4	53	44	97
5	46	45	91
6	42	44	86
7	50	45	95
8	40	46	86
9	43	41	84
10	34	43	77
11	38	37	75
Total	439	434	873

b) Questionaire

At the same time, information regarding the environment of nursing was obtained from the guardians by interview. Knowledge of objective facts by the question-answer method is obtained with difficulty as has been pointed out repeatedly in the field of social science. Taking the above consideration into account, the author attempted to exclude incorrect information and to obtain correct information as much as possible. Items which could be most correctly replied were selected concerning the development of the hip. The items were previously tested on the mothers (or guardians) who attended the Health Center for clinical consultation of the infants, and the questionaires for each item and category were established after previous survey of their practical aspects.

Two persons took charge of the interview throughout the year.

The items of the questionaires were as follows.

1) Nutritional source: Sources of nutrition were classified into three groups of, (a) mother's milk, (b) mother's milk and artificial nutrition, and (c) artificial nutrition only. (b) and (c) were applied to those continuously fed for more than a month.

2) Vitamin D intake: Two groups were classified according to the source of Vitamin D supply. The first group consisted of those who were on diet supplemented by Vitamin D preparation for more than one month, and the second group of those who were on diet with no special supplementation of Vitamin D preparation or, if any, for less than one month.

3) Diaper: Discussions have previously been made on the appropriate time for changing swaddling to diaper in connection to dislocation of the hip. The author set up two categories for this item; the one defined as "appropriate" *i.e.* when swaddling was changed to diaper by 4 months of age, and the other as "delayed" when diaper was applied after 4 months of age.

4) Clothing: Three groups were classified under this item; as (a) heavy, (b) equal, and (c) light clothing compared with adults.

5) Movement restriction: Tying up both legs or putting the lower half of the body into cloth bags to restrict movemnt of the baby has been a long-standing custom in the region where the samples were obtained. This item was divided into two categories of whether or not the baby was restricted in movement according to this custom.

6) Sun-bath: This was classified into; one consisting of those who had chance of continuous exposure for more than one month and the other of those who did not.

7) Massage of legs: This consisted of those who had their legs massaged continuously for more than one month.

8) Sitting posture with flexio-abducted legs: Two groups were defined by this item; into one consisting of those who had such chance daily, as sitting on the mother's lap or playing with instruments while flexing and abducting, and the other with no such opportunity.

9) Exercise of legs: The infants were divided into those who received and those not.

10) Ventral posture in sleeping: These consisted of those who slept on their bellies, and those not.

c) Method of taking the ventrodorsal roentgenogram of the hip

Several parts of the hip-bone have already been measured and analysed in detail by many investigators at our department as indices of the interrelational development of the hip. Taking these analytical methods into account, the present author measured the following parts which are supposed to affect dislocation of the hip and to possess relatively stable variance. (c.f. Fig. 1)

1. T-T: The distance between the most lateral parts of ilia
2. S-S: The distance between the apexes of both acetabular roofs
3. Y-Y: The distance of Wollenberg's Y-Cartilage line
4. Z-Z: The distance between the most lateral margins of both Ischia

5. H–H: The distance between the Lingulae of both Femur-necks.

6. F–F: The distance between lateral margin of both Femur-metaphysis.

7. **a**: Horizontal distance of acetabulum.

8. **b**: Vertical distance of acetabulum.

9. **c**: Depth of acetabular roof.

10. $\angle\theta$: Inclination angle of acetabular roof.

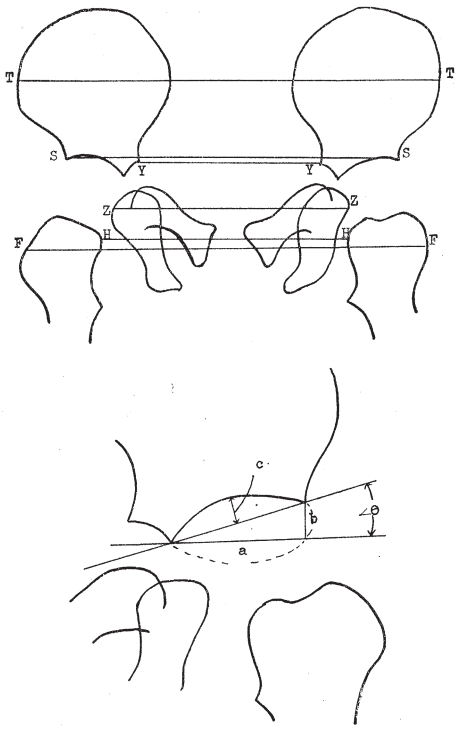

FIG. 1

d) 1) Method of statistical analysis

Analysis of variance by three factors (enviroment of nursing, sex, and month age) was applied.

2) Method of statistical calculation

The calculation of all the above obtained information was made with a Univac Digital Computer.

RESULTS

Number of samples, mean and standard deviatien of each variable are shown in Table 2, according to month age and sex.

These values shown were in close with those of previous studies by Mizuno and his associates.

It has been demonstrated by Mizuno and his associates that the measured values of the hip-bones were acertained to be normally distributed.

TABLE 2 a. Lay-out Table
Vertical distance of acetabulum (**b**)

Month-age	Mother's milk only		With artificial milk	
	Male	Female	Male	Female
1	10	13	13	10
2	15	18	13	16
3	12	18	15	15
4	20	18	18	13
5	13	18	14	16
6	17	19	18	18
7	20	23	16	21
8	18	20	20	19
9	18	22	17	23
10	20	26	18	23
11	22	23	20	24

The results of the present analysis of variance were as follows.

1. Differences in the nutritional environment

Five infants were sampled at random by sex and month age from two groups—of one group fed with mother's milk only and the other artificial by and measured values of the hip-bones were assembled in the experimental table for analysis.

Significant difference, of less than 5 per cent level, between the two groups was observed in the vertical distance of the acetabulum, namely, of the group of mother's milk was greater than of the other group: as shown in Table 2 b.

TABLE 2 b. Analysis of Variance
Vertical distance of acetabulum (b)

S.V.	S.S.	d.f.	M.S.	F	
Month-age (a)	427.41	11− 1=10	42.74	18.03	**
Sex (b)	54.56	2− 1= 1	54.56	23.02	**
Nutrition (c)	12.02	2− 1= 1	12.02	5.07	*
(a)×(b)	66.69	10× 1=10	6.67	2.81	
(a)×(c)	20.23	10× 1=10	2.02	0.85	
(b)×(c)	6.58	1× 1= 1	6.58	2.78	
Residuals	23.67	43−33=10	2.37		
Total	611.16	44− 1=43			

**: Significant difference at 1% level *: Significant difference at 5% level

Significant difference of less than 1 per cent level between both sexes and also between month ages showed the same tendency as in Morita's study on the development of the hip-bone. Rough evaluation of the difference between the two groups, between both sexes and month ages were hardly possible, since considerable crossing will result due to the small number of samples. However, differences were observed, namely, larger distance of acetabulum in females and in older infants than in males and younger infants.

In the other parts of the hip-bones there was seen no significant difference, but in examining the totals of the measured values of individual factors, the group of artificial nutrition was superior to the other group in the development of the upper structures of the hip-bone.

Differences seen between the sexes and month ages were in close agreement with the studies of Mizuno and his associates.

The problems in accuracy concerning artificial nutrition shoud be discussed. The first is the quantity of artificial nutrition added to mother's milk in the area where the samples were obtained. In this area artificial nutrition is not always associated with lack of mother's milk, but the group fed with mother's milk can be supposed to be short of the necessity compared with the group fed with artificial nutrition. The second is the grouping, as the group of artificial nutrition included not only infants who were fed completely with artificial nutrition but also those who were continuously fed artificial by for at least, namely the periods of artificial nutrition varied in continum. In this study the number of samples was limited and therefore it is not possible to

demonstrate accurately the possible effects of nutrition on the development of the hip-bones.

A further study must be made with statistically sufficient samples.

2. Vitamin D intake

Seven infants were sampled at random accoring to sex, month age, into group—one with Vitamin D supplementation and the other without—but the number of the former of each month age was so small that the month age was divided into four categories, *i.e.* 4–5, 6–7, 8–9, and 10–11 months.

A significant difference at less than 5 per cent level between the two groups was observed in the iliac bredth H-H and c. The variance ratios of the tow groups, month ages and sexes regarding interraction of these three factors on T-T is as shown in Table 3 b.

TABLE 3 a. Lay-out Table
The distance between the most lateral parts of ilia. (T-T)

Month-age	Vitamin D suppl.		No Vitamin D suppl.	
	Male	Female	Male	Female
4- 5	55	36	56	30
6- 7	86	66	79	53
8- 9	89	80	73	68
10–11	79	84	84	88

TABLE 3 b. Analysis of Variance
The distance between the most lateral parts of ilia. (T-T)

S.V.	S.S.	d.f.	M.S.	F	
Month-age (a)	3625.25	4− 1= 3	1208.41	188.27	**
Sex (b)	576.00	2− 1= 1	576.00	89.74	**
Vitamin D (c)	121.00	2− 1= 1	121.00	18.85	*
(a)×(b)	528.50	3× 1= 3	176.10	27.44	*
(a)×(c)	201.50	3× 1= 3	67.17	10.47	*
(b)×(c)	6.25	1× 1= 1	6.25	0.97	
Residuals	19.25	15−12= 3	6.42		
Total	5077.75	16− 1=15			

The group with Vitamin D supplementation was observed to be larger in the T-T than in those with non-supplementation, and a significant difference at below 5 per cent level was observed in the interaction between group and month age. It thus seems that the younger the month age the larger the effect of Vitamin D supplementation.

A significant difference at below 1 per cent level was observed in sex and month age, suggesting that T-T is larger in males than in females and gradual development of T-T was seen with month ages. Furthermore although there was no significant difference seen in other parts of the upper structure of the pelvis, such as S-S, Y-Y, the same tendency was observed.

This differences marked similarity with previous data obtained by Mizuno

and his associates.

The depth of the acetabular roof in the group with Vitamin D supplementation was observed to be significantly deeper than in those with non-supplementation.

The variance ratios were as shown in Table 4-b.

TABLE 4 a. Lay-out Table
Depth of acetabular roof (**c**)

Month-age	Vitamin D Suppl.		No Vitamin D Suppl.	
	Male	Female	Male	Female
4- 5	13	13	15	8
6- 7	20	21	20	15
8- 9	18	24	15	16
10-11	15	18	17	19

TABLE 4 b. Analysis of Variance
Depth of acetabular roof (**c**)

S.V.	S.S.	d.f.	M.S.	F	
Month-age (a)	111.19	4− 1= 3	37.07	21.42	*
Sex (b)	0.06	2− 1= 1	0.06	0.03	
Vitamin D (c)	18.06	2− 1= 1	18.06	10.44	*
(a)×(b)	34.69	3× 1= 3	11.56	6.68	
(a)×(c)	25.69	3× 1= 3	8.56	4.95	
(b)×(c)	22.57	1× 1= 1	22.57	13.05	*
Residuals	5.18	15−12= 3	1.73		
Total	217.44	16− 1=15			

The above figures appear to suggest that Vitamin D supplementation promotes the development of the hip-bone in early infancy, and the finding that Vitamin D supplementation is more effective in early infancy than later, is of great interest, but the skewness in sampling should be considered carefully, for the same reason as in the experiment on nutrition, and further studies are needed.

3. Restriction of lower extremities

There still remains the custom for newborns to be placed baskets with their feet pushed into a narrow sack or tied with a cord.

The effects of custom were examined in this experiment. Because of the scarcity of subjects examined, two were sampled at random according to the sexes and month ages of five categories, *i.e.* 1–2, 3–4, 5–6, 7–8, and 9–10 months.

Results obtained showing significance were as follows:

The vertical distance of the acetabulum was found to be larger in

1) infants with restriction than in those without.

The depth of the acetabular roof was found to be shallower in

2) infants with restriction than in those without.

3) The inclination angle of the acetabulum was found to be larger in in-

fants with restriction than in those without.

These differences were found to be significant at below 1 per cent level in 1) and 3) below 5 per cent in 2). Variance ratios of the group were as shown in Table 5 b, 6 b, 7 b respectively.

TABLE 5 a. Lay-out Table
Vertical distance of acetabulum (**b**)

Month-age	No restriction		Restricted	
	Male	Female	Male	Female
1- 2	3	6	4	6
3- 4	9	10	5	5
5- 6	11	9	7	6
7- 8	9	9	7	6
9-10	6	7	7	9

TABLE 5 b. Analysis of Variance
Vertical distance of acetabulum (**b**)

S.V.	S.S.	d.f.	M.S.	F	
Month-age (a)	29.20	5− 1= 4	7.30	24.33	**
Sex (b)	1.25	2− 1= 1	1.25	4.17	
Restriction-movement (c)	14.45	2− 1= 1	14.45	48.16	**
(a)×(b)	10.00	4× 1= 4	2.50	8.33	*
(a)×(c)	26.80	4× 1= 4	6.70	22.33	**
(b)×(c)	0.05	1× 1= 1	0.05	0.17	
Residuals	1.20	19−15= 4	0.30		
Total	82.95	20− 1=19			

TABLE 6 a. Lay-out Table
Depth of acetabular roof (**c**)

Month-age	No restriction		Restricted	
	Male	Female	Male	Female
1- 2	2	2	3	2
3- 4	6	2	7	2
5- 6	5	6	5	6
7- 8	6	6	10	10
9-10	8	6	7	8

TABLE 6 b. Analysis of Variance
Depth of acetabular roof (**c**)

S.V.	S.S.	d.f.	M.S.	F	
Month-age (a)	85.70	5− 1= 4	21.43	31.52	**
Sex (b)	4.05	2− 1= 1	4.05	5.96	
Restriction-movement (c)	6.05	2− 1= 1	6.05	8.90	*
(a)×(b)	17.70	4× 1= 4	4.43	6.52	*
(a)×(c)	10.70	4× 1= 4	2.68	3.94	
(b)×(c)	0.05	1× 1= 1	0.05	0.07	
Residuals	2.70	19−15= 4	0.68		
Total	126.95	20− 1=19			

TABLE 7 a. Lay-out Table
Inclination angle of acetabular roof ($\angle\theta$)

Month-age	No restriction		Restricted	
	Male	Female	Male	Female
1- 2	12	17	12	21
3- 4	22	21	11	13
5- 6	21	17	14	13
7- 8	15	15	11	12
9-10	10	13	12	19

TABLE 7 b. Analysis of Variance
Inclination angle of acetabular roof ($\angle\theta$)

S.V.	S.S.	d.f.	M.S.	F	
Month-age (a)	40.70	5− 1= 4	10.18	26.79	**
Sex (b)	22.05	2− 1= 1	22.05	58.04	**
Restriction-movement (c)	31.25	2− 1= 1	31.25	82.25	**
(a)×(b)	58.70	4× 1= 4	14.68	38.64	**
(a)×(c)	21.50	4× 1= 4	30.38	79.96	**
(b)×(c)	11.25	1× 1= 1	11.25	29.61	**
Residuals	1.50	19−15= 4	0.38		
Total	286.95	20− 1=19			

A significant difference in the vertical distance of the acetabulum was observed also according to but in sex. In previous studies differences were observed in both month age and sex. This discordance might have arisen presumably from the small sample-size in the present study. Further-more, significant differences were observed in the interraction between group and month age and in the interraction between sex and month age, though the differences suggested that the younger the infant the larger the effect of the restriction. The difference due to sex was revealed to be larger in early infancy, but requires further study.

The depth of the acetabular roof was found to be shallower in the group with restriction than in those without, and a gradual development with month was observed at a significance level of below 1 per cent.

Furthermore, a significant difference was observed in the interaction between sex and month age, and though there was no significant difference seen by sex, this may be due to the larger variance due to the small sample size.

Regarding the inclination angle of the acetabulum, a similar tendency was observed in the vertical distance of the acetabulum. This is reasonable as the difference in vertical distance of the acetabulum was observed and the difference in horizontal distance of acetabulum was not. Another significant difference of the inclination angle of the acetabulum was observed in month age, sex, interaction between sex and month age, that between group and month age, and that between sex and group. The difference seen with month and sex was in marked accord with the previous data obtained by Morita, namely, that the angle was larger in females than in males and a gradual decrease

with month age was noted.

In the other parts measured, a significant difference between the two groups was observed, as the same tendency as seen in nutrition, that namely, the upper structures of the pelvis were smaller in the group with restriction than in those without. On the contrary, such a tendency was hardly observed in the parts measured at the head of femur.

4. Sitting posture with flexio-abducted legs

Three infants were sampled at random by sex and month age from two groups—the one with the custom of sitting with flexio-abducted legs and the other not—and measurements of the hip-bones were callected to a table for analysis. The results obtained with significance were as follows.

1) S–S was observed significantly, at below 5 per cent level, to be larger in infants with the custom than in those without.

2) Vertical level distance of acetabulum was observed significatly, at below 1 per cent, to be smaller in infants with the custom than in those without.

The variance ratios of the above indicated factors were as shown in Table 8 b, 9 b.

In the other factors, S–S, a significant difference was revealed at below 5 per cent level by sex, and at below 1 per cent by month age, namely S–S was larger in males than in females and a gradual development with month ages was observed. This result also was in close accord with a previous study by Kuroda.

TABLE 8 a. Lay-out Table
Distance between the apexes of both acetabular roof (S–S)

Month-age	No floxure abduction		Flexure abducted	
	Male	Female	Male	Female
6	67	54	63	49
7	63	62	61	64
8	73	65	61	60
9	71	67	61	65
10	73	65	75	65
11	75	78	69	82

TABLE 8 b. Analysis of Variance
Distance between the apexes of both acetabular roof (S–S)

S.V.	S.S.	d.f.	M.S.	F	
Month-age (a)	743.84	6− 1= 5	148.77	24.59	**
Sex (b)	53.94	2− 1= 1	53.94	8.92	*
Flexure abduction (c)	60.14	2− 1= 1	60.14	9.94	*
(a)×(b)	294.56	5× 1= 5	58.91	9.74	*
(a)×(c)	70.36	5× 1= 5	14.06	2.32	
(b)×(c)	28.26	1× 1= 1	28.26	4.67	
Residuals	30.24	23−18= 5	6.05		
Total	1281.34	24− 1=23			

TABLE 9 a. Lay-out Table
Vertical distance of acetabulum (**b**)

Month-age	No flexure abduction		Flexure abducted	
	Male	Female	Male	Female
6	17	15	14	13
7	17	18	16	17
8	15	16	12	16
9	16	16	13	18
10	15	18	12	18
11	15	20	12	17

TABLE 9 b. Analysis of Variance
Vertical distance of acetabulum (**b**)

S.V.	S.S.	d.f.	M.S.	F	
Month-age (a)	14.33	6− 1= 5	2.87	2.87	
Sex (b)	32.66	2− 1= 1	32.66	32.66	**
Flexure abduction (c)	16.66	2− 1= 1	16.66	16.66	**
(a)×(b)	28.34	5× 1= 5	5.67	5.67	*
(a)×(c)	4.34	5× 1= 5	0.87	0.87	
(b)×(c)	6.01	1× 1= 1	6.01	6.01	
Residuals	4.99	23−18= 5	1.00		
Total	107.33	24− 1=23			

In the other factors, namely vertical distance of acetabulum, a significant difference at below 1 per cent level by sex and below 5 per cent by the interaction between month age and sex was revealed, namely the vertical distance of the acetabulum was larger in females than in males and the difference in development of the vertical distance by sex was revealed more extensively in later infancy than in early infancy. The variance ratios of the above factors were as follows.

DISCUSSION

Since the dawn of this century investigations on the origin of congenital dislocation of the hip have been attended by great success. Most investigators were influenced by heredity factors and have supported the theory of primary congenital malformation as the origin of the disease, as shown by the term "Primary Congenital Dysplasia", but Weissman and Badgeley lately, have stressed the role of post-natal environmental factors. On the other hand, Bernbeck has supported both standpoints.

In Japan, Mizuno *et al.* presented in 1950 the results of studies on the development of the hip in infancy, from the relative view point of growth. He pointed out the existence of possible erroneous diagnosis of the disease, when a scheme of the normal hip was prepared and compared with suspected hips by X-ray photographs. Since then he has asserted the need of a statistical diagnosis of the disease measuring the relative situation of the hip-joint, or the pelvis and femur, and the post-natal environmental factors have received

much studied extensively, though only on the environments of diseased infants.

Due to advances in health administration programs in Japan after the Warld War II, the wide application of early diagnosis of the disease by mass examination with X-rays has contributed much to early discovery of dislocation in infancy, and operative treatment for the disease has become less frequent. This rapid advance in the campaign against dislocation of the hip has stimulated investigators on a study of the normal development of the hip in childhood.

Summarizing and analysing the results obtained so far by several investigators, it can be said that:

I. The hip-joint in infancy develops rapidly, with the lower bones growing more rapidly than the upper.

For example, the growth of F-F compared with T-T in infants between the ages of 1 and 11 months, was found to alter the ratio from 105 to 90 as revealed by Kuroda's study. Namely, F-F is larger than T-T on the average at birth but the latter grows more rapidly than the former as the month-age advances.

Kuroda concluded the relative growth of hip-joints, after analysing the correlation coefficients and the regression lines obtained from several parts of the hips, that the iliac breadth and other horizontal distances of the ilium grow relatively more rapidly than the distance between both femurs. The pelvic formation also showed many changes during the one year after birth, and it was not so easy to decide on only one normal shape of the hip, without consideration of sex and month age and thus very dangerous to attempt diagnose of dislocations of the hip based on such a single shape. Further-more Matsumoto made follow-up observations, by X-ray photos and reported that the inferior acetabulum at birth grow more rapidly than the superior acetabulum as if attempting to catch up with the superior in size. His study was certainly unique but contained statistical error.

An attempt was thus made to reexamine his data. The infants were divided into three groups; superior, the average and inferior, according to the ratio of the horizontal distance of the acetabulum at six months of age to that at birth. The analysis of variance was then applied to the measurements of the hips at birth and the results showed that the superior group were inferior in development of (**a**) at birth. Mizuno observed a similar tendency in the development of the entire acetabulum.

The above revealed are summarized below.

1) The hip-bones of the infant during the one year after birth show amazing development, with a relative pattern in the growth of each part. Therefore, a single index or pattern of the diseased hip can not be established.

2) There is a trend for hip-bones of inferior growth at birth to grow more rapidly, especially the acetabulum.

II. Why does this disease occur more frequently in females?

This fact and its etiology were previously studied by H. Mizuno and his associates appling the analysis of regression line from the relative view point

of growth, and also by the method of analysis of variance, and the author's discussion on this shows the horizontal distance of the acetabulum in the sampled infants of ages, 1 and 11 months.

Sex differences in development of hip-bone are shown in the following parts.

T-T	male>female
S-S	male>female
Y-Y	no significant difference
Z-Z	no significant difference
H-H	no significant difference
F-F	no significant difference
a	male>female
d	male<female
c	male>female

The results obtained from the above can be concluded to be as follows.

1) Significant sex differences are observed in the horizontal development of the upper structures of the pelvis, but not in the lower structures. This may lead to a hypothesis that poor growth of the upper structures affects the development of the acetabulum and that the frequency of dislocation of the hip in females is due to it.

2) The bony parts of the acetabulum in females are poor in horizontal development but greater in vertical development, resulting in the inclination angle of the acetabulum to be larger in females.

3) Sex differences in the relative situation between the acetabulum and head of the femur are observed in the distance from the outer margin of the upper femoral metaphysis in females is situated relatively outwards compared with males. And the relative vertical situation between the acetabulum and the femoral head in females is closer than in males.

It is well to note that the relative vertical situation between the upper margins of the obturator foramen and the femoral head grows in closer correlation with month age, and shows no difference according to.

III. The environmetal factors of nursing care affecting the development of the hip-bones.

According to Nomura, greater growth in pelvic breadth is seen rather than in the pelvic height of infants under better nursing environment and this tendency is more so in females.

IV. Infants born in the warm season show greater development of the hip than those born in the cold. The following parts show significant differences in development by the analysis of variance.

The results of the present study will be discussed in the following.

1) Nutrition

Significant difference in the development of hip-bones was not seen between the two groups of infants—one nourished only with mother's milk and

the other with supplemental artificial nourishment excepting the height of the acetabulum. The height of the acetablum (**b**) was greater in the group fed with mother's milk than in the other group, though the development of the pelvic breadth showed a reverse tendency, *i.e.*, inferior in the group fed with mother's milk than in the other group. This different development may be due to the nutritional condition of the area surveyed. More infants short of milk were believed to be in the group fed with mother's milk due to the complex factors of economy and intelligence than in the other group. In other words, the differences were supposed to come from the deficiency of milk and not from the supplementation of calcium or other artificial nutriments. However, more accurate studies are needed to eliminate the skewness due to the grouping method, supposed to exist in this survey.

Many authorities have discussed the relation of nutritional status to dislocation of the hip. They suggested that insufficient nourishment works adversely on the horizontal development of the upper structures of the hip and consequently produce a steep acetabulum so that the probability of dislocation will increase, and the cause of frequent occurance of the disease in females should be considered.

This suggests that instruction in correct feeding after birth is one of the most important preventive measures in this disesse.

2) Vitamin D intake

As in the above (1), Vitamin D deficient infants were supposed to exist in this area, and infants fed with additional V.D. were defined as a group with sufficient V.D. intake. These infants were found to be better not only in the development of the upper strucutres of pelvis and the acetabulum but also in F–F, namely, the development of the eatire hip-bone.

However, this trend must be considered with prudence, since infants grouped in the supplimental V.D. intake were extraordinarly small in sample size compared with the nutritional survey, and the skewness influenced by economical and intelligent factors was supposed to be larger, though the grouping was made more accurately.

This large skewness has to be taken into acount, and further study is required.

3) Movement restriction of the legs

The stimuli from moving the legs have been supposed to be an important factor, accelerating the development of the hip-bones.

The author had the opportunity to investigate the above supposition, since the custom of restricting movement of the legs still remains in the area surveyed.

The development of the acetabulum in infants with restricted movement of the legs was inhibited remarkably.

Mizuno and his associates recognized that the development of the acetabulum has closest relationship to breadth of the upper structures of the hip-bone, and showed that the horizontal development of the upper structures indirect by controls the development of the acetabulum. The results obtained

by the present survey showed small variance ratios, and accordingly no significant differences in the upper structures. This suggests that rigid restriction of movement of the legs inhibits specifically the development of the acetabulm though the other environmental factors may be favorable to development of the hip-bones.

Unless the active of the hip-joints is practiced, this tendency to not only deformation of the head of femur but also inhibition of development of the acetabulum will result.

Furthermore, this may support the recent trend in therapy for dislocation where advocation has been placed on mobile treatment, and warns of the possible restriction of movement by therapy which may disturb the normal development of the hip-joints (when the infant has been misdiagnosed as dislocation or suspected).

The observation of the $\angle\theta$ in Table 7 b suggests that there is more significant difference between groups as restiction of the legs in the younger group and in the male group in the interraction between month age and group, and sex and group. Further discussion of the above interraction factors shoule await more accurate studies.

4) *Sitting posture with flaxio-abducted legs*

Contrary to restriction of movement of the legs, free movement of the legs stimulates development of the hip-joints. Mizuno insisted on the validity of sitting posture withflexio-abducted legs in the normal development of the hip-bones, whereas the strong thrusting shock of the head of the head of the femur against the acetabuluma. Increases the risk ofdislocation. The result obtained in the present study where the group with the habit of sitting with flexio-abducted legs showed better horizontal development of the upper structure of the hip-bones, showing the significant difference especially in S-S and Y-Y, supports the above view.

In the group with this habit of sitting, the relative situation of the acetabulum against the head of the femur was on the outer side, and moreover as the vertical distance of acetabulum is small, the roof covered the head more efficiently. At any rate, it is evident that the development of the hip-joint is more marked in the group with this habit of sitting than in others.

The result due to the sitting posture is less influenced by other factors such as economic and intelligent states than the results of Vitamin D supplementation and nutritional environment.

5. *Other environmental factors of sursing care*

Significant differences between groups were not observed in the other 6 items.

This may be due partly to the failure in grouping or partly because the samples subjected for the study were beyond the limit of experimental control.

CONCLUSION

This survey was made to investigate the influences of the nursing environment on the development of the hip-bones. The sampled infants (681 males

and 654 females) were selected from an area under the control of a Health Center in Aichi Prefecture during one year from Apr., 1959. Questionaires consisting of 10 items concerning the nursing environment, which were supposed to affect the development of the hip-bones, were selected, and the data obtained were statistically analysed.

Significant differences in development of the hip-bones are influenced by particular nursing environments, found in this survey to be as follows.

1) Nutritional environment

The vertical distance of the acetabulum was found to be greater in infants nourished with mother's milk than in those fed artificially with beast supplemented.

2) Vitamin D and hip development

The development of the iliac breadth. the distance of both linguets of the medial edge of the upper femoral metaphysis, the depth of the acetabular roof were found to be greater in infants given supplementary Vitamin D.

3) Restriction of the movement of legs

The development of the inclination angle of the acetabulam was found to be suppressed in the vertical distance of the acetabulum more, and the depth of the acetabular roof was shallower in the infants with restricted movement of their legs for up to 6 months after birth than in those with no restriction of movement of the legs.

4) Sitting with frequent oppotunities to development with the legs foexio-abducted showed greater of S–S and Y–Y distance, and smaller vertical distance of the acetabulum than in those not.

Significant defferences in development of the hip-bones seen according to month age and sex were in marked accordance with the previous data obtained by Mizuno and his associates.

The above described results suggest that the development of the hip-joints of infants in the first year of life is inhibited indirectly by deficiency of milk and Vitamin D and directly by restriction of the lower extremities, and promoted by abundant experiance of sitting with the legs flexio-abdueted.

In other variables of measurements, differences were not significant. Consequently it appears that sufficient intake of milk and Vitamin D is one of the important factors promoting directly the development of the hip-bones in the horizontal direction, and indirectly that of the acetabulum. In these infants the femoral head of femur is situated relatively along the inner side.

The early diagnosis of congenital dislocation of the hip by mass survey has recently been practiced on a large scale in Japan.

And it is important that accurate diagnosis be made, and the results of this present study should be applied for this purpose.

Analysis of variance—applied in this study for the statistical analysis—had limitations. Furthermore it is difficuly to design experiments for selected factors independent of the human community, because development of the hip-joint is controled by multiple-factors after birth. One way to solve this

problem in further studies would be the application of multiple analysis such as factor analysis and another ecological observation applied to each district part of community diagnosis.

Grateful acknowledgement is made to Prof. Y. Kotake and Assist. Prof. H. Mizuno for their constant interest and guidance in this study. Also the auther is deeply indebted to Dr. H. Nakao and other colleagues.

REFERENCE

1. BERNBECK, G. A.: *Kinderorthopaedie.* Stuttgart: Thieme, 1954.
2. LE DAMANY: *Z. Orthop.* **21**: 129, 1908.
3. FABER, A.: *Untersuchungen uber die aetiologie und Pathogenese der angeborenen Hueftverrenkung.* Leipzig, Thieme, 1938.
4. FUERMAIER, A.: *Z. Orthop.* **79**: 469, 1950.
5. GLAUNER, R.: *Roentgendianostik des Hueftgelenks.* Stuttgart: Thieme, 1956.
6. HILGENREINER, H.: *Z. Orthop.* **60**: 9, 1934; **63**: 344, 1934.
7. IDELBERGER, K.: *Die Erbpathologie der sogenannten angeborenen Hueftverrenkung.* Muenchen u. Berlin: Urbans Schwarz. 1951; *Z. Orthop.* **82**, 571, 1952.
8. KLOPFER, F.: *Zur Problematik der Sofortbehandlung bei angeborener Hueftgelendskysplasie.* **79**: 1, 1949.
9. LORENZ, A.: *Die sog. angeborene Hueftverrenkung.* Stuttgart, Enke, 1920.
10. MITTELMEIER, H.: *Arch. Orthop. u. Unfall-Chir.* **52**, 465, 1961.
11. HART, V. L.: *J. Bone and joint Surg.* **24**, 753, 1942.
12. LEVEUF, J.: *J. Bone and joint Surg.* **29**: 149, 1947.
13. LORENZ, A.: *Am. J. Orthop. Surg.* **2**: 219, 1905.
14. RECORD, R. G.: *Brit. J. prev. soc. Med.* **12**: 8, 1958.
15. BADGELEY, C. E.: *J. Bone and joint Surg.* **25**: 503, 1943; **31-A**: 341, 1949.
16. AKABAYASHI, J.: *J. Jap. Orthop. Surg. Soc.* **32**: 9, 1658 (Japanese).
17. IMADA, H.: *J. Jap. Orthop. Surg. Soc.* **32**: 255, 1958 (Japanese).
18. INNO, S.: *Nippon Ijishinshi* **70**: 533, 1953. (Japanese)
19. UJIIE, K.: *J. Jap. Othop. Surg. Soc.* **30**: 41, 1956.
20. OSAWA, M.: *J. Jap. Orthop. Surg. Soc.* **35**: 106, 1961 (Japanese).
21. SASAKI, F.: *J. Jap. Orthop. Surg. Soc.* **34**: 1505, 1961 (Japanese).
22. SARUWATARI, .: *J. Jap. Orthop. Surg. Soc.* **6**: 219, 1931 (Japanese).
23. SUDO, K.: *J. Jap. Orthop. Surg. Soc.* **35**: 43, 1961 (Japanese).
24. TSUCHIYA, K.: *J. Jap. Orthop. Surg. Soc.* **33**: 864, 1960 (Japanese).
25. NAGURA, S.: *Congental Dislocation of the hip.* Tokyo: Nippon Ishyo, 1948 (Japanese).
26. HAMADA, H.: *J. Jap. Orthop. Surg. Soc.* **7**: 219, 1929 (Japanese).
27. MATSUMOTO, A.: *Central J. Jap. Orthop. and Traumatic Surg.* **3**: 987, 1960 (Japanese).
28. WATANABE, S.: *J. Nagoya med. Ass.* **71**: 502, 1960 (Japanese).
29. FISHER, R. A.: *The Design of Experiments,* Edinburgh and London: Oliver and Boyd, 1935.
30. FISHER, R. A.: *Statistical Method for Research Workers,* 10th ed., Edinburgh and London: Oliver and Boyd, 1948.
31. COCHRAN, W. G. AND COX, G. M.: *Experimental Designs,* 2nd ed., New York: John Wiley, 1957.

32. GOULDEN, C. H.: *Methods of Statistical Analysis*, 2nd ed., New York: John Wiley, 1952.
33. MIZUNO, H.: *Koshyueisei*, **21**: 38, 1957 (Japanese).
34. MIZUNO, H.: *Koshyueisei*, **21**: 47, 1657 (Japanese).
35. MIZUNO, H.: *Nippon-Rinshyo*, **16**: 125, 1958 (Japanese).
36. MIZUNO, H.: *Gakkohokenkenkyu*, **4–2**: 1, 1957 (Japanese).
37. TACHINO, M.: *Nagoyaigaku*, **68**: 833, 1954 (Japanese).
38. KURODA, T.: *Nagoyaigaku*, **80**: 1341, 1959 (Japanese).
39. MORITA, J.: *Nagoyaigaku*, **80**: 1395, 1959 (Japanese).