Hypothermia in Malnourished Jamaican Children

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Brooke, O. G. (1972). *Archives of Disease in Childhood*, 47, 525. **Hypothermia in malnourished Jamaican children.** An analysis was made of the 4-hourly temperature records of 137 malnourished Jamaican children, the consecutive admissions to a metabolic ward during a 3-year period. Mean rectal temperature of afebrile children during the first week in hospital was 0.52 °C lower than it was in the week before discharge. Hypothermia (rectal temperature <35 °C) occurred in 19.7% of the children. It was related to low weight and height but not to serum or whole body potassium, serum sodium, or seasonal variation in ambient temperature. The incidence of hypothermia in the survivors of this group of children was the same as it was in 42 children who died from severe malnutrition in the ward during the period 1960 to 1970. It is concluded that hypothermia is not an unfavourable prognostic sign in malnourished Jamaican children. Hypothermia was commoner in marasmus than it was in kwashiorkor. In 11 afebrile children with kwashiorkor, rapid loss of oedema was associated with a fall in mean rectal temperature, suggesting that the insulating properties of oedema fluid may protect against hypothermia in kwashiorkor.

Since the description by Trowell and Muwazi (1945) of hypothermia in malnourished children, there have been several publications on this subject from various parts of the African continent (Kahn, 1959; Morley, 1960; Lawless and Lawless, 1963; Brenton, Brown, and Wharton, 1967; Staff, 1968), and it has been stressed that malnourished African children with hypothermia have a poor prognosis. The cause of hypothermia in malnutrition remains in doubt, but Kahn (1959) suggested that it might be due to muscle hypotonia secondary to hypokalaemia, while Lawless and Lawless (1963) proposed that kwashiorkor was a cold injury syndrome.

Protein-calorie malnutrition is prevalent in Jamaica and both nutritional marasmus and kwashiorkor occur. This survey was undertaken for three main reasons: (1) to find the incidence of hypothermia in malnourished Jamaican children (hypothermia is known to be common here, though the climate of the lowland areas is very warm); (2) to see how hypothermia affects the prognosis of these malnourished children; and (3) to find how hypothermia is related to possible causative factors such as hypokalaemia.

Patients and Methods

Case notes were examined of 137 children who were admitted during 3 years (1965-67) to the Medical

Research Council's Tropical Metabolism Research Unit, University of the West Indies, Kingston, Jamaica. The diagnosis of kwashiorkor was made in 37 (27%), of marasmus in 67 (49%), and of 'marasmic-kwashiorkor' in 33 (24%). All children with kwashiorkor and marasmic-kwashiorkor had oedema. Children in the latter group were also less than 60% of their expected weight for age (50th centile, Boston Standard). Some details of the patients are given in Table I.

TABLE I
Clinical Details of 137 Malnourished Children

Total number of children	137
Male	94
Female	43
Mean age (mth)	10
Admission weight, % expected weight for age	54.6 (SD = 12.3)
Admission weight, % expected weight for height	70.5 (SD = 9.5)
Discharge weight, % expected weight for age	96.4 (SD = 5.2)

The rectal temperatures of all the children were taken 4-hourly, using low-reading clinical thermometers. The lowest temperature recorded during the first week of each child's admission was found from the temperature charts. The arithmetical mean of the 4-hourly temperature readings for the whole week

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was calculated and so was the mean temperature during the week preceding discharge from hospital.

Total body potassium was estimated using a 4 π whole body liquid scintillation counter (Garrow, 1965) in 80 of the children; serum sodium was estimated in 74, and serum potassium in 72 using flame photometry.

There were 9 deaths during this 3-year period. Necropsy showed bronchopneumonia in 5, aspiration of stomach contents in 1, and cerebral oedema of unknown cause in 1. One child had severe gastroenteritis and one died of unknown causes. On admission the children who died were, on average, 53% of their expected weight for age and 69% of their expected weight for height (Boston Standards).

In addition, the case notes of 42 out of the 44 children who died in the unit in the period 1960 to 1970 were reviewed. The notes of 2 children could not be traced. During part of this period, temperatures were taken in the axilla. However, low-reading thermometers were used and low temperatures were checked rectally. The mean age of these children was 12 months and they were, on average, 55% of their expected weight for age at the time of admission. 14 were classified as having kwashiorkor, 12 as having marasmic-kwashiorkor, and 16 as having marasmus.

Necropsies were done on all these children. The main clinical and pathological factors in their deaths were as follows: bronchopneumonia 26, gastroenteritis 7, septicaemia 3, liver failure 3, measles 1, purulent pericarditis 1, cerebral oedema 1, pulmonary fibrosis 1, congenital heart disease 1. There were no abnormal findings apart from severe malnutrition in 6 of the children.

Climate. Jamaica is a tropical island (latitude 18°N) and the lowland areas are hot. Minimum temperatures in February (the coolest month) rarely fall below 15 °C and are usually in the range of 17 to 18 °C. In summer minimum shade temperatures are around 21 °C and at maximum reach 34 °C. Relative humidity is generally in the range of 65 to 85%.

The metabolic ward of the unit is a large room containing 14 well-spaced cots. All windows are glazed and can be closed. The ward is not air-conditioned.

Results

Admissions 1965-67.

Mean temperatures and incidence of hypothermia. Table II shows the lowest rectal temperatures

TABLE II

Lowest Rectal Temperature During 1st Week of Hospital Treatment (137 Children)

Lowest Rectal Temperature	No. of Children
> 35.5 °C (96 °F)	76 (55.5%)
< 35.5 °C	61 (44.5%)
35.4 °C (95 °F) or less	27 (19.7%)
34.4 °C (94 °F) or less	8 (5.8%)

during the first week of hospital treatment. The lowest rectal temperature recorded was 33.7 °C. The mean rectal temperature of the children after recovery was 36.83 °C (SD = 0.12). This was 0.38 °C higher than the mean for the group during their first week of hospital treatment (36.45 °C, SD = 0.23), and 0.52 °C higher than the mean for the 98 children who were afebrile during their first week (36.31 °C, SD = 0.22). Both differences were highly significant ($P < 0.001$) when subjected to a 't' test applied to paired comparison.

The distribution of the lowest temperature readings among the three clinical varieties of malnutrition was examined. The results are shown in Table III. It can be seen that hypothermia was less often found in kwashiorkor than it was in marasmus and marasmic kwashiorkor, where wasting is more prominent. This difference could be due to the insulating properties of oedema fluid. Some children with kwashiorkor lose oedema rapidly when they are treated. 18 of the 37 children with kwashiorkor in this survey behaved in this way, and 11 of these had neither fever nor gastroenteritis. All these 11 children reached their lowest weight during their second week in hospital. Their mean rectal temperatures in the first and second weeks of hospital treatment were compared, and the results are shown in Table IV. The reduction in mean rectal temperature of 0.24 °C (0.5 °F) during the second week was found to be significant ($t = 3.9$, $P < 0.1$) when tested by a 't' test applied to paired comparison. In contrast, the 13 afebrile children with kwashiorkor who did not lose oedema rapidly, maintained their rectal temperatures during their

TABLE III

Distribution of Lowest Rectal Temperature Readings During 1st Week of Hospital Treatment in 3 Clinical Varieties of Malnutrition

Rectal Temperature	Kwashiorkor (37)	Marasmic-kwashiorkor (33)	Marasmus (67)
> 35.5 °C (96 °F)	28 (75%)	3 (10%)	10 (15%)
< 35.5 °C	8 (22%)	18 (54%)	35 (52%)
35 °C (95 °F) or less	1 (3%)	8 (24%)	18 (27%)
34.4 °C (94 °F) or less	0	4 (12%)	4 (6%)

second week in hospital. These results are also shown in Table IV.

Seasonal distribution of hypothermia. The seasonal distribution of the cases of severe hypothermia (temperature 35 °C or less) is shown in Table V. With the exception of January, the distribution was remarkably even throughout the year.

Hypothermia and the degree of malnutrition. Regressions relating rectal temperature to weight and height were calculated for all 137 children. Significant correlations were found and these are shown in Table VI. As might be expected, hypothermia becomes more common with increasing deficit of weight and height.

Hypothermia and electrolyte disturbances. Of the 72 children in whom serum potassium estimations were done on admission, 21 developed severe hypothermia (temperature 35 °C or less) in the first week. Mean serum potassium level in the hypothermic group was 4.4 mEq/l. (SD = 0.80), and in the remaining 51 children, it was 4.2 mEq/l. (SD = 1.08). These values do not differ significantly. Out of the 80 children who had total

body potassium estimations during their first three days in hospital, 10 became severely hypothermic. The mean total body potassium for this group was 37.5 mEq/kg (SD = 6.4), while for the remainder (20 children) it was 34.7 mEq/kg (SD = 7.5). Again there was no significant difference between these values. No correlation was found between the mean temperatures in the first week and serum or total body potassium levels.

Since hyponatraemia has been shown to be associated with poor prognosis (Garrow and Pike, 1967), serum sodium values were compared in children who became hypothermic (21) and those who did not (53). The mean for the hypothermic group was 132 mEq/l. (SD = 4.5), and for the remainder 134 mEq/l. (SD = 6.0). These values do not differ statistically.

Hypothermia and fever. 39 (28%) of the 137 children had a rectal temperature of 37.7 °C (100 °F) or more at some time during their first week in hospital. Of these, 21 also had temperatures below 35.5 °C (96 °F) in the same period and 8 had readings of 35 °C (95 °F) or less, showing a remarkable variation in body temperature.

TABLE IV

Comparison of Mean Rectal Temperature in 1st and 2nd Weeks of Hospital Treatment in Children with Rapid Loss of Oedema and in Those with Slow Loss

	No. of Children	Mean Weight (kg)		Mean Rectal Temperature (°C)	
		1st Week	2nd Week	1st Week	2nd Week
Rapid loss of oedema	11	6.52 (SD = 1.93)	5.97 (SD = 1.70)	36.65 (SD = 1.42)	36.41 (SD = 1.15)
Slow loss of oedema	13	6.09 (SD = 2.04)	6.12 (SD = 1.96)	36.58 (SD = 1.38)	36.60 (SD = 1.51)

TABLE V

Seasonal Distribution of Severe Hypothermia (Rectal Temperature <35 °C) During 3 Years

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5	2	2	2	3	2	1	2	1	3	2	2

TABLE VI

Relation Between Rectal Temperature and Weight and Height Deficit During 1st Week of Hospital Treatment

Lowest temp. in 1st week <i>vs</i> weight (% expected weight for age)	$r = +0.47, t = 6.2, P < 0.001$
Lowest temp. in 1st week <i>vs</i> weight (% expected weight for height)	$r = +0.33, t = 4.1, P < 0.001$
Lowest temp. in 1st week <i>vs</i> height (% expected height for age)	$r = +0.31, t = 3.8, P < 0.01$
Mean temp. in 1st week <i>vs</i> weight (% expected weight for age)	$r = +0.35, t = 4.3, P < 0.001$
Mean temp. in 1st week <i>vs</i> weight (% expected weight for height)	$r = +0.36, t = 4.4, P < 0.001$
Mean temp. in 1st week <i>vs</i> height (% expected height for age)	$r = +0.33, t = 4.1, P < 0.001$

Mortality. 9 of the 137 children died in hospital, a mortality of 6.5%. Of the 61 children who had rectal temperatures of less than 35.5 °C at some time during the first week, 5 (8.2%) died; of these 5, 4 had temperature readings of 35 °C or less in the same period. This represents a death rate of 14.8% in the group of 27 children with severe hypothermia—more than twice that of the whole group. 3 of the 5 children had pneumonia. The other 2 had no evident infection.

Deaths 1960–70. Since the number of deaths in the 1965–67 survey was small, the study was extended to include 42 children who died in the period 1960–70. The chief causes of death have been summarized above. Thermoregulatory research was not in progress during much of this period, but there was awareness of hypothermia as a complication of severe malnutrition and it is emphasized that temperatures were taken 4-hourly in all children, using low-reading thermometers. Low temperatures were checked rectally during the period in which axillary temperatures were taken as standard (1960–64). For these reasons it is felt that it is valid to compare the incidence of hypothermia in these 42 children with that in the surviving children of the 1965–67 survey. This comparison is shown in Table VII, where it is seen that figures

TABLE VII

Lowest Rectal Temperatures Recorded Before Death in 42 Children Who Died from Malnutrition, Compared with Those Found in 1st Week of Hospital Treatment in 128 Survivors

Lowest Rectal Temperature	No. of Children	
	Dead	Surviving
> 35.5 °C (96 °F)	30 (71.4%)	68 (53.1%)
< 35.5 °C	12 (28.6%)	60 (46.9%)
35.0 °C (95 °F) or less	7 (16.7%)	23 (18.0%)
34.4 °C (94 °F) or less	2 (4.8%)	6 (4.7%)

for temperature readings of 35 °C and below bear a striking similarity in both groups. Since it has been shown (Table III) that children with kwashiorkor developed hypothermia less often than those with marasmus, it was important to establish that the distribution of marasmus and kwashiorkor was similar between the two groups. Table VIII shows the distribution figures. A χ^2 test was made, and showed no statistical difference in the distribution of marasmus, marasmic-kwashiorkor, and kwashiorkor among these groups ($\chi^2 = 1.45$, $P > 0.10$). Of the 12

TABLE VIII

Comparison of Distribution of 3 Clinical Varieties of Malnutrition Among Survivors and Children Who Died

	Survivors	Dead
Kwashiorkor	35	14
Marasmic-kwashiorkor	32	12
Marasmus	61	16
Total	128	42

children who died, 8 who had developed temperatures of 35.5 °C or less, had severe bronchopneumonia (confirmed at necropsy by gross and histological examination). 2 had liver failure, and 1 died of unknown causes. In the group as a whole, pneumonia was cited as the main cause of death in 25 of the 38 children. Thus the incidence of pulmonary infection was higher in those children who had low temperatures.

Discussion

Hypothermia is a frequent accompaniment of infantile malnutrition in Jamaica, a factor that has been overlooked in previous descriptions of the symptoms of protein-calorie malnutrition in this country (Garrow, Picou, and Waterlow, 1962; Garrow, 1966; Garrow and Pike, 1967). It is more common in those forms of malnutrition that are characterized by wasting than it is in children with 'classical' kwashiorkor in which weight loss is less marked. This makes it unlikely that the oedema of kwashiorkor is a symptom of cold injury, as suggested by Lawless and Lawless (1963).

With the exception of January, a cool month but not the coolest, the distribution of cases of hypothermia is remarkably even throughout the year, indicating that seasonal variation in ambient temperature is not an important factor in the pathogenesis. Much more important is the degree of weight deficit, as shown by the significant relation between low weight and height and lowered body temperature. This confirms the findings of Brenton *et al.* (1967), and may reflect a reduced metabolic capacity for heat production in heat-losing environments, as suggested by Kerpel-Fronius, Varga, and Kun (1954). It may also reflect a reduction in thermal insulation, and in this respect the data shown in Table IV are relevant. Rapid loss of oedema in children with kwashiorkor is often an early sign of recovery, and these 11 children should be metabolically more capable of maintaining their body temperatures during their second

week in hospital than during their first. That they are not implies that the thermal insulation of generalized oedema may be of importance in preventing a fall in body temperature. These findings are at variance with the comments of Jelliffe (1968), who ascribes hypothermia in kwashiorkor to, among other factors, the 'water cooling' effect of generalized oedema.

Hypothermia sometimes occurs during hypoglycaemia (Kerpel-Fronius *et al.*, 1954; Staff, 1968; Wharton, 1970; Brooke, 1972). No hypoglycaemia was recorded in relation to hypothermia in this survey, but this may only mean that hypoglycaemia was not looked for. The association which may occur between these two symptoms supports the theory that hypothermia may be related to deficient energy reserves, and so does the observation that body temperature rises markedly when hypothermic malnourished children are given a high calorie feed (Brooke, 1972). However, there must be other factors involved, since this survey has shown that both hypothermia and fever may occur within a short space of time, long before definite evidence of nutritional improvement has occurred.

The suggestion by Kahn (1959) that hypokalaemia might be the cause of hypothermia in malnourished children was not supported by the findings of this survey. No relation was found between serum or whole body potassium levels and hypothermia or reduced mean body temperature.

The Jamaican experience of hypothermia in malnutrition contrasts with the African. In Jamaican infants rectal temperatures of less than 35.5 °C (96 °F) are common, occurring in nearly half the admissions, and there is little indication that hypothermia is a sign of poor prognosis. There was an increased mortality in the children who had temperatures of 35 °C or less in the 1965-67 series, but the numbers were small and the finding was not confirmed when the records of the 42 dead children were examined. In these children the incidence of hypothermia was similar to the incidence in the survivors of the 1965-67 series, and the only factor to emerge having a possible bearing on prognosis was a higher incidence of pneumonia among the dead children who had been hypothermic. In Africa on the other hand, even mild degrees of hypothermia have a sinister significance and workers in Uganda state that most children die who have temperatures of less than 35.6 °C (Staff, 1968). Kahn (1959) also commented on the poor prognosis of hypothermic children with kwashiorkor. The reasons for these differences are not clear, but two possible factors are the older age group of the

malnourished African children and the higher incidence of kwashiorkor in Africa. Older children less readily become hypothermic than infants, so those who do are likely to be more severely ill. Furthermore, since hypothermia is commoner in marasmic babies than in those with kwashiorkor, the African child with kwashiorkor who develops hypothermia may well be more severely malnourished, and so more likely to die, than his Jamaican counterpart.

Though the outlook for malnourished Jamaican children who develop hypothermia is apparently no worse than for those who do not, it must not be assumed that hypothermia is in itself a benign condition, and its recognition and treatment are of great importance. The harmful effects of hypothermia are well known (Cooper, 1968), and animal studies have shown that death of starved baby pigs can be postponed by raising the ambient temperature (Morrill, 1952). Thus it is recommended that the rectal temperatures of newly admitted malnourished children be taken at no more than 4-hour intervals using low-reading thermometers, and that if hypothermia develops it should receive prompt attention. Even in the absence of hypoglycaemia, we have found that a feed invariably increases the body temperature of these hypothermic children and many who have developed hypothermia have been unwilling feeders in the previous 12- to 24-hour period. For this reason as much reliance is placed on frequent feeding, by nasogastric tube if necessary, as it is on physical rewarming, and it is our policy to attempt to establish a high calorie intake as early as possible in the course of the child's admission.

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