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Motor skills of mild-malnourished compared with normal preschool Senegalese children

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The relationship between motor skills and mild protein-energy malnutrition was studied in a rural Senegalese setting. Eighty-eight children in good health, aged between 3 and 5 years were examined on 3 occasions in the course of one year, and their physical performance and motor skills evaluated. Regular progress in their abilities was observed over the year. Nevertheless, 3/4 of them portrayed mild somatic deficiencies. After dividing the children into 4 nutritional groups according to their height-for-age and weight-for-height deficiencies,it was found that normal and thin children, scored higher in the various tests than did children who were underheight, or both underheight and underweight.

Insufficient muscular mass available for exercise seemed to be the principle factor limiting the performance of these mildly undernourished children. However, other hypotheses should be mentioned: reduction in the children's habitual physical activity, and the neuro-motor consequences resulting from former, severe malnutrition.

These observations show that even slight degree malnutrition can affect a child's ability to perform physical work and, thus, hinder his future development and learning.

Key Words: Protein-energy malnutrition, motor skills, Senegal

INTRODUCTION

Protein-energy malnutrition (P.E.M.) results in smaller body dimensions. This relationship forms the basis for anthropometric malnutrition classifications (Keller *et al*, 1976). In 1972, Waterlow introduced a new parameter in P.E.M. evaluation: its duration, determined by growth retardation for a given age (Waterlow, 1972). Hence, at the present time, two different conditions are taken into account: on the one hand, current thinness or "wasting", which is a shortage of tissue and body fat; and, on the other hand, lack of height for age or "stunting", which represents an accumulation of lack of growth over a period of time. "Weight-for height" (W/H), or the difference between observed weight and weight of a reference group of the same height, and "height-for-age" (H/age), the difference between observed height and the norm for that age, respectively are anthropometric indicators of wasting and stunting (W.H.O., 1986).

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Observations show the existence of a strong connection between somatic deficiencies and mortality risk (Chen *et al*, 1980), or an increase in the likelihood of diarrhoea and infection among the undernourished (Black *et al.*, 1982; Zumrawi *et al.*, 1987), justifying the use of these indicators in clinical practice and epidemiology. However, little is known of the biological significance of these indicators for higher threshold of malnutrition, although the prevalence of children with only slight anthropometric deficiencies is very marked: in Senegal, where the present study was carried out, about 60% are underheight by 0 to −2 standard deviations (sd) (Garenne *et al.*, 1987). Papers on the effects of hidden malnutrition are rare and, apart from the one prepared by Ferro-Luzzi in Italy (Ferro-Luzzi *et al.*, 1979), none has covered functional capacity in the sense of ability to perform physical tasks in slightly undernourished preschool children. Notwithstanding, physical performance development and motor skills in children are essential to their learning and social integration.

The goal of this work, therefore, is to study the relationship between body dimensions, physical performances and motor skills in malnourished Senegalese children, and to show that, even for mild anthropometric deficiencies, their functional capacities may be reduced.

SUBJECTS AND METHODS

Site for the Study

The children came from two villages in West-Central Senegal (Diokhane and Ndondol in Bambey county) and from a small, coastal town, Mbour. The inhabitants of this region are muslims, ethnic Wolofs or — in the case of Mbour — Lébous fishermen, a related tribe. Their basic diet is the same: rice and fish at midday, millet or sorghum gruel in the evening. A study of food consumption showed more than half these families to be short of energy during the rainy season (Chevassus & Ndiaye, 1981). P.E.M. in this region ranks the highest in Senegal. When tabulating results, no account was taken of the children's geographical origin, since no differences in physical and functional characteristics were observed between the villages. Similarly, sex was disregarded as differences were statistically not significant, although ratings for girls were lower.

Sample

The sample was made up of 88 children (44 boys and 44 girls) divided into 3 cohorts according to their year of birth: 1983 (n = 36), 1984 (n = 34) and 1985 (n = 18) corresponding to mean ages 3.5, 4.5 and 5.5 years at the outset. These children were examined three times between October, 1988 and November, 1989. The average interval between the first and second examination (5 +/− 1.5 months) was shorter than between the second and third examination (6.4 +/− 0.5 months) because of delays in recruiting the children. Only children who appeared to be in good health were selected for the study, in particular those showing no signs of clinical denutrition, muscular collapse, pale conjunctiva, or orthopaedic or neurological disorders. The aim of the study was explained to the parents and the tribal leaders, and their consent was obtained. The children were examined with a relative present. Clear instructions about the tests they were to undergo were given in their vernacular language by a field assistant.

Measurements Taken

At each visit the children underwent a medical examination and undertook a variety of motor tests. They were weighed, clad in underclothes, on electronic scale accurate to within 100 g, and measured as they looked straight in front of them in the standing position, by means of an anthropometer accurate to within 1 mm.

Thereafter, the children undertook 4 physical tests: hand grip test to determine the maximal strength developed by the forearms; 20 meter race; long jump from a standing start with feet together; underarm throw with a baseball (softball). Except for the 20 m race, the best of three, consecutive attempts was retained.

Motor skills were evaluated using Hughes and Riley (1981) type tests for basic motor assessment, and Connolly's (1979) for fine coordination of upper members.-Table 1 summarizes the protocol for the various tests. Each type of skill test was graded separately, and the points were added together at the end to give a composite, global score. The highest possible score was 17, and the lowest 0.

Data Analysis

BMDP package (BMDP Statistical Software, Inc., Los Angeles, California, 1988) was used for the analysis. Two-way analysis of variance with age and chronology of visit as group factors, were undertaken to assess motor development evolution in the children. Analysis of covariance was then undertaken to study changes in motor variables for differing nutritional conditions, taking age and the chronology of the visit into account.

RESULTS

At the outset, the children were suffering from no serious sickness and showed no sign of undernutrition. By anthropometrics standards, none was underheight for his age (H/age) or underweight for his weight (W/H) by more than 2 sd on the National Center for Health Statistics (N.C.H.S.) scale (W.H.O., 1983). Seventeen children however showed a H/age deficiency ranging from −2 and −1 sd, and 37, a W/H deficiency of between −1 and −2 sd. It should be stressed that only 19 children had H/age, and 10 W/H, above the median of the N.C.H.S. reference.

Figure 1 shows the children's somatic growth during the course of the study: although regular, it is deficient by N.C.H.S. standards. On average the children are 1.5 years behind in weight development,and 3 to 6 months behind in height.

Table 1 Description of tests for motor performances and abilities in preschool Senegalese children.

Item	*Description of the test*	*measurement*
	Motor performances	
20 m race	20 m barefoot race	time (1/10 th sec)
Throwing	upper arch throw with a 184 g softball.	distance (m)
Jumping	long jump from a standing start	distance from toes to heels (cm)
Grip strength	squeezing a rubber bulb connected to a manometer (Martin, Tuttlingen)	pressure (kpa)
	Motor abilities	
Standing balance	standing balance on one leg eyes open during 10 sec	quotation (1)
Tandem walking	2 forms: (a) walk forward and (b) backward the length of a 3 m line.	quotation (2)
Hopping	2 forms: (a) hopping on the left leg (b) on the right leg, the length of a 3 m line	quotation (2)
Heel and toe	2 forms: (a) walk on heels, (b) on toes, along a 3 m line.	quotation (2)
Stride Jump	the child jump forward and then jump again backward returning to the starting position. These two movements constitute one stride jump. 5 stride jumps may be observed.	quotation (1)
Catching a tennis ball	3 forms: (a) with rebound two-steps in front of the child, (b) the child throws ball on ground and catches it (c) ball is thrown above the child	quotation (1)
Bimanual accuracy	thread 10 coloured glass beads	time (1/10th sec)
Unimanual accuracy	Screw nuts on 8 mm diameter bolts mounted on a square plate, 2 cm apart.	Number of nuts. screwed in 2 min.

Quotation: (1) 0 = failure; 1 = good.
(2) 0 = failure; 1 = medium; 2 = good

Motor skill output measurements vary with the age of the child and the order of the visit, due to growth and increasing maturity. The oldest children performed the best and there was an improvement also from visit to visit (Table 2).

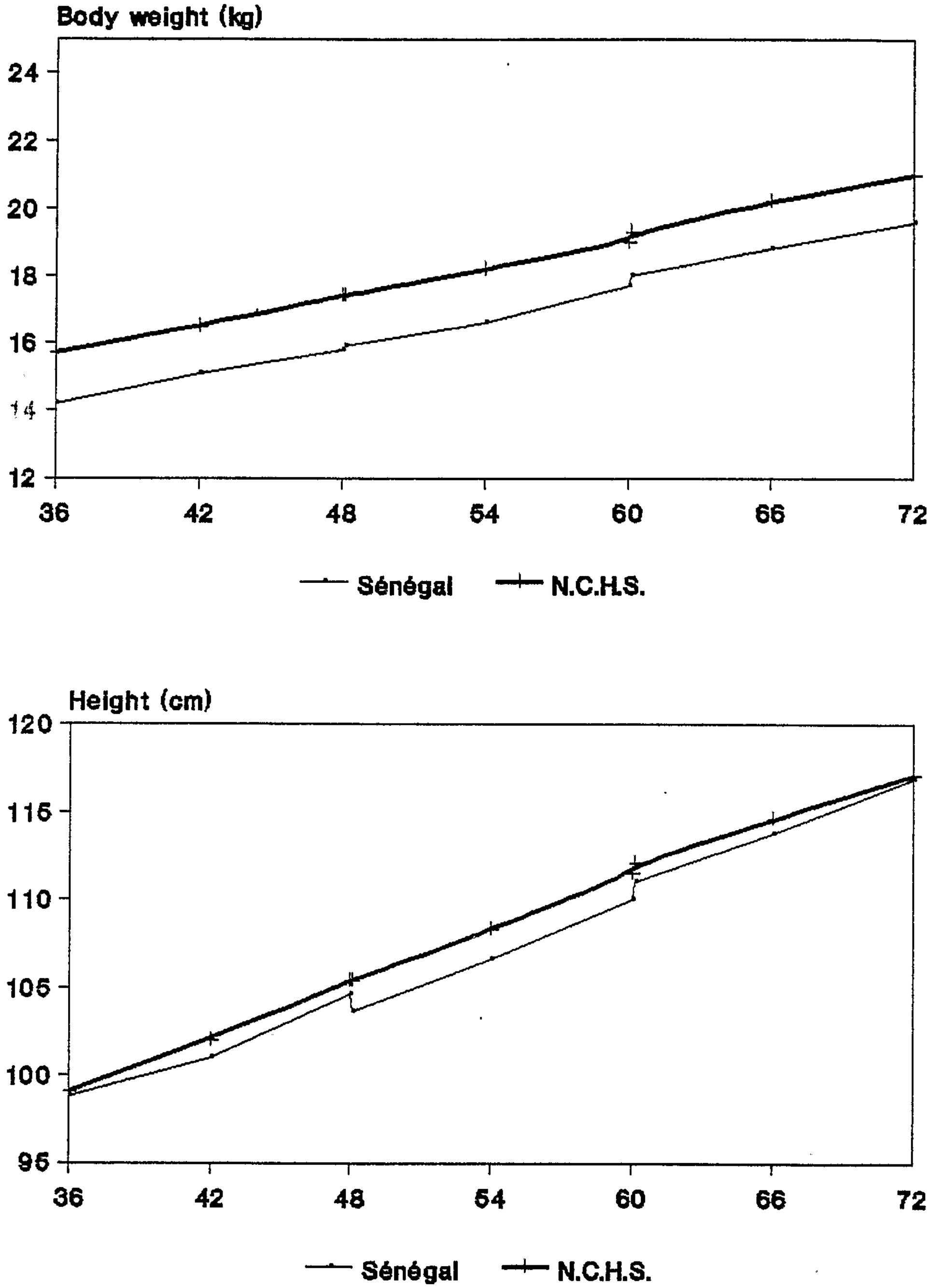

Figure 1. Weight and Height by age of preschool Senegalese children.

Table 2 Mean values of motor performances and abilities according to age group and visit number in preschool Senegalese children.

Age group	5–6 years (n=36)	4–5 years (n=34)	3–4 years (n=18)	Two-way analysis of variance: Between age group F(2,261)	Between passage F2,261)
20 m run (sec)					
1st (1)	6.27 (2)	7.05	8.01	62.0	50.6
	0.95 (3)	0.83	1.33	*** (4)	***
2nd	5.80	6.47	7.10		
	0.59	0.69	0.75		
3rd	5.24	5.76	6.55		
	0.61	0.52	0.90		
Standing broad jump (cm)					
1st	78.5	56.3	42.5	60.1	33.1
	10.8	16.5	16.3	***	***
2nd	89.4	62.4	59.9		
	19.9	24.3	19.0		
3rd	103.5	85.7	66.4		
	18.1	19.2	21.6		
Throwing soft ball (m)					
1st	5.9	3.9	2.6	118.2	19.2
	1.4	1.2	0.7	**	***
2nd	6.9	4.5	3.0		
	1.8	1.6	1.2		
3rd	7.8	5.7	3.6		
	1.8	2.0	0.9		
Hand grip strength (kpa)					
1st	32.0	26.0	21.0	64.3	5.2
	8.0	7.0	7.0	***	***
2nd	39.0	30.0	22.0		
	9.0	7.0	7.0		
3rd	39.0	27.0	23.0		
	10.0	7.0	5.0		
Composite motor abilities score					
1st	12.5	10.3	5.8	90.7	23.4
	4.3	4.0	3.4	***	***
2nd	14.8	11.4	7.1		
	2.7	2.3	2.3		
3rd	15.8	12.9	9.9		
	1.7	2.7	2.4		

(1) visit number; (2) mean; (3) 1 standard deviation (4) *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$.

The children were classified according to their H/age or W/H deficiency, with −0.5 sd of N.C.H.S. median as cut-off point. On the first visit, the sample was divided up as follows:

— Group a: small for age children, H/age <-0.5 sd and W/H >-0.5 sd (n = 20).
— Group b: small for age and wasted children, H/age <-0.5 sd and W/H <-0.5 sd (n = 14).
— Group c: wasted children, H/age >-0.5 sd and W/H <-0.5 sd (n = 33).
— Group d: normal children, H/age >-0.5 sd and W/H >-0.5 sd (n = 21).

This breakdown by nutritional status remained constant throughout the visits (Chi2 = 0.7 for 6 df).

The results of motor tests were then compared for the 4 nutritional groups after adjustments for age and visit chronology by means of covariance analysis. Equality of slopes of regression lines was tested and no difference was found, authorizing comparison of adjusted means, except for throwing (Snedecor and Cochran, 1967). In the case of throwing, there was a significant interaction with age for this variable ($F(3,261) = 3.6$, $p < 0.01$). This interaction disappeared when 2 groups — aged over 60 months and under 60 months — were formed, and only the older group showed a significant connection between nutritional condition and the ability to jump.

Tables 3 and 4 summarize the results of adjusted means comparisons: normal and wasted children have better physical performances output than small for age and small and wasted children. Similarly, they have a better score for basic motor skills; the small for age and wasted children have less unimanual skill than the others, but no difference emerges between the groups for bimanual accuracy.

DISCUSSION

The results of this study on a group of healthy Senegalese children experiencing regular growth show that those who were underheight or both underheight and underweight, had lower output on physical performances and motor skills than normal sized or simply underweight children. As far as is known, these results are the first to specifically cover the effects of hidden malnutrition in African preschool children.

The tests employed are simple to operate, can be reproduced, and furnished unambiguous responses. For all that, all measurements were made by the author, and the longitudinal character of the observations allowed close control over the quality of the results. However, these precautions do not justify the conclusion that a relationship of cause and effect exists between the somatic measurements and the motor ones: individual factors of variation exist such as behaviour, education and family micro-environment; more, it was difficult to piece together the children's nutritional history. Nevertheless, it can be assumed that the great cultural and ecological hegemony in the area limited any variations; as for the type of malnutrition, it is reasonable to assume that chronically low food intake in the area has resulted in moderate but permanent undernourishment (Chevassus-Agnès & Ndiaye, 1981). This leads to the acceptable supposition that a close connection exists between the results of the tests and the nutritional status of the children. Whatever the case, in view of the number of children involved, the attention of the health and education authorities should be drawn to this worrying phenomenon.

Table 3 Motor performances for preschool Senegalese children with different nutritional status, compared by analysis of covariance, controlling for age and visit number.

Dependent variable	groups (1)	Adjusted mean	Standard error	*T-test matrix* *a (1)* *n=60*	*b* *n=46*	*c* *n=99*	*d* *n=59*
20 m race	a	6.42	0.10	0			
(sec)	b	6.58	0.11	1.0	0		
	c	6.25	0.07	1.3	2.4 **	0	
	d	6.12	0.10	2.1 *	3.0 ***	0.9	0
Comment				d < a, b	c < b		
Jump	a	73.4	2.6	0			
(cm)	b	69.9	3.0	0.8	0		
	c	75.0	2.0	0.5	1.4	0	
	d	79.8	2.6	1.7	2.5 **	1.4	0
Comment				b < d			
Throw (m)	a	6.2	0.27	0			
Children	b	5.2	0.36	2.2 **	0		
>60 months	c	6.6	0.21	1.1	3.3 ***	0	
(2)	d	7.1	0.28	2.3 **	4.1 ***	1.4	0
Comment				a < d	b < a, c, d		
Hand grip	a	0.28	0.01	0			
strength	b	0.27	0.01	0.7	0		
(kpa)	c	0.32	0.01	2.8 **	3.3 ***	0	
	d	0.33	0.01	3.6 ***	4.1 ***	1.3	0
Comment				a < c, d	b < c, d		

(1) Nutritional groups: a = T/age < -0.5 sd and P/T > -0.5 sd
b = T/age < -o.5 sd and P/T < -0.5 sd
c = T/age > -0.5 sd and P/T < -0.5 sd
d = T/age > -0.5 sd and P/T > -0.5 sd

(2) Significant interaction with age: $F_{(3,261)} = 3.6$, $p < 0.01$. a: n = 39; b: n = 21; c: n = 60; d: n = 34.

Studies undertaken on this subject have produced contradictory conclusions. Thus, Ferro-Luzzi's study undertaken in Italy (1979), in contrast to this present one, tended to attribute greater physical aptitude to below school age children in the south of Italy than to their better fed counterparts in the north. Similarly in Tunisia, small, underprivileged children performed better than bigger, affluent ones (Parizkova, 1974). On the other hand, in Mexico, Malina showed motor skills for tiny Mexicans to be inferior to those of North American children, bigger for their age (Malina & Bushang, 1985). In Zaire, children from poor areas had lower functional capacities than those from well to do areas, but this difference disappears when account is taken of their height (Ghesquière & Eeckels, 1984). These last mentioned studies, nevertheless, concerned school age children, and divergences as to the conlusion can be explained by the degree of growth retardation and the form it took (Parizkova, 1987). Thus the Senegalese children in this present study were smaller and about 10% lighter than the southern Italians.

Table 4 Motor abilities for preschool Senegalese children with different nutritional status, compared by analysis of covariance, controlling for age and visit number.

Dependent variable	*groups (1)*	*Adjusted mean*	*Standard error*	*T-test matrix* a (1) $n=60$	*b* $n=46$	*c* $n=99$	*d* $n=59$
Composite	a	11.7	0.37	0			
motor	b	10.4	0.42	2.2 *	0		
abilities	c	12.2	0.29	1.0	3.3 ***	0	
score	d	12.7	0.37	1.9 *	3.9 ***	1.0	0
Comment				d>a, b	c>b a>b		
unimanual	a	4.49	0.21	0			
accuracy	b	4.20	0.25	0.8	0		
(number)	c	4.86	0.17	1.3	2.1 *	0	
	d	4.83	0.22	1.1	1.9 *	1.5	0
Comment				b<c, d			
Bimanual	a	1.57	0.11	0			
accuracy	b	1.63	0.13	0.3	0		
(time)	c	1.82	0.09	1.7	1.2	0	
	d	1.68	0.11	0.6	0.3	0.9	0
Comment				equality of adjusted means			

(1) Nutritional groups: a = T/age <-0.5 sd and P/T ≥ -0.5 sd
b = T/age <-0.5 sd and P/T <-0.5 sd
c = T/age >-0.5 sd and P/T <-0.5 sd
d = T/age >-0.5 sd and P/T >-0.5 sd

A number of hypotheses can be advanced to explain the lower scores obtained by slightly undernourished children. Active muscular mass deficiency constitutes a direct cause of inaptitude, easily noticeable in tests requiring strength. With the threshold set at –0.5 sd, the deficiency is insufficient to provoke a significant loss of performance in children who are simply thin, but it does show for small for age and small-and-thin children. In such children, lack of height not only implies a supplementary muscular deficiency in absolute terms, but also, from a biomechanical viewpoint, constitutes a disadvantage in tests such as running or jumping. In an earlier study it was effectively discovered that a significant proportion of physical performance variance could be explained by differences in height and lean body mass (Bénéfice, in preparation). These observations justify the need to take stature into consideration when evaluating a child's nutritional condition.

An indirect mechanism frequently referred to is below normal habitual physical activity, which would result from low energy intake and restrains the child's explorations and experiences, thus delaying motor development (Ferro-Luzzi, 1985). This low physical activity could be the "first line of defence" for undernourished children (Spurr & Reina, 1987), but, at the same time, it implies less training at motor activities and retarded development. Thus, Solomons (1978) has shown that great flexibility exists in motor development in accordance with the measure of exercise which stimulate it? In this connection, it is interesting to note that, in the present study, the only test unaffected by nutritional condition, the pearl test, concerned a very traditional occupation in this milieu: every child has seen his mother or sisters thread necklaces and has probably helped them to do so. In the same way, Malina showed that the only task Mexican children could do better than American ones, throwing, corresponded to a daily action employed in hunting or herding animals (Malina, 1985).

These explanations suggest that correcting somatic deficiencies through an improved diet would increase these children's functional abilities. It must be ruled out, however, that more sensitive mechanisms controlling the acquiring of motor skills could also be affected. This is shown by certain studies on the long term effects of serious malnutrition on mental behaviour and fine motor skills (Galler *et al*, 1987 a; Galler *et al*, 1987 b; Stoch & Smythe, 1976) and of chronic malnutrition on intersensorial integration (Cravioto, 1979). In these cases, the degree and duration of malnutrition must be taken into account, and it must be clear that, as far as the reactions of our children are concerned, they are outside the pathological realm. Apparently, these small for age and thin children are simply retarded in comparison to the others, as is shown by the good progress in results from one visit to the next (Table 2). It is also possible that the traditional way of life is sufficiently flexible and stimulating to allow these children to catch up (Super, 1976), but this might not be so in the rapidly changing situation (urbanization, migration, agricultural development) and consequent upheaval prevailing in rural Africa. The drop in motor performance resulting from minimal nutritional deficiency should induce prudence over highly debatable theories about the advantages which stunted growth might confer. Waterlow (1990) and Martorell (1985; 1989) among over authors, recently criticized the "small but healthy" hypothesis.

W.H.O. selected thresholds of malnutrition are low; they correspond to a deficit of 2 sd (W.H.O., 1983) and are justified by the need to make a proper selection of children requiring nutritional aid when resources are limited.That does not signify that the others are out of danger: the differences concern the kind of risk which no longer concerns life and death, but the cost for these children of a reduction in functional ability could be very heavy in terms of development and learning.

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