Children Treated for Severe Acute Malnutrition Experience a Rapid Increase in Physical Activity a Few Days after Admission☆

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Objective To assess physical activity at admission and during recovery from severe acute malnutrition.

Study design Ethiopian children who were admitted with severe acute malnutrition received a clinical examination each week to monitor their recovery during rehabilitation. Using accelerometry (24 h/d for 5 consecutive days) at admission and again after 10 days of rehabilitation, we assessed the level and changes of physical activity.

Results Among 13 children included, the mean (SD) age was 31.1 months (15.5). At baseline, the day-night activity difference was relatively small, whereas the level of activity had substantially increased at follow-up. The diurnal mean acceleration level was significantly greater at follow-up for wrist (1158.8 vs 541.4 counts per minute, P = .003) but not hip movements (204.1 vs 141.5, P = .261). During daytime (6 a.m. to 10 p.m.), hip activity increased by 38% from baseline to follow-up (e^B 1.38, 95% CI 1.17-1.62), and wrist activity more than doubled (e^B 2.50, 95% CI 2.17-2.87).

Conclusion The level of physical activity among children with severe acute malnutrition is very low but increases rapidly during recovery. Accelerometry may be a useful approach in the recovery phase as an indicator of early improvement. *(J Pediatr 2014;164:1421-4)*.

Severe acute malnutrition in children causes considerable morbidity and mortality in low-income countries, with 19 million new cases of severe acute malnutrition documented each year.[1] The introduction of milk- and lipid-based therapeutic foods has revolutionized the treatment and prognosis of severe acute malnutrition, with a reduction in mortality in well-organized and -resourced facilities reported from 40% to 5%.[2] Previous studies have shown reduced subjectively assessed physical activity in children admitted with severe acute malnutrition,[3] and although children are screened routinely for regain of body weight during rehabilitation, quantitative and objective assessment of recovery of physical activity remains unexplored. Because physical activity correlates with lean body mass[4] and is associated with better immunity and survival,[5] recovery of physical activity may be a useful marker for evaluating/optimizing treatment and monitoring of patients with severe acute malnutrition.

Accelerometry is a commonly used objective method to assess physical activity in children[6-8] but has to our knowledge not yet been applied among malnourished children. The purpose of this study was to assess physical activity on the hip and wrist in Ethiopian children with severe acute malnutrition at admission as well as during recovery.

Methods

The study was part of Severe Acute Malnutrition Study in the Nutrition Rehabilitation Unit at Jimma University Specialized Hospital (JUSH) concerning recovery of body composition and linear growth during rehabilitation from severe acute malnutrition.[9] From March to June 2010, children (6 months to 14 years) admitted at JUSH and fulfilling the criteria for severe acute malnutrition (ie, weight for height <70%,[10] mid-upper arm circumference <11 cm [6- to 60-month-old children only], or bilateral pedal pitting edema[11]) were invited to take part. Children with impaired consciousness, shock, severe dehydration, or other severe conditions were excluded. The study protocol was approved by the Ethical Review Board of JUSH, and written informed consent was obtained from the caretaker of the child. Information about the use of the accelerometer was given to the caretaker by the study nurse.

All children received medical care according to the National Guideline for treatment of severe acute malnutrition in Ethiopia, which is based on recommendations from the World Health Organization.[11] For a limited time period, children from the larger study were invited to also participate in a study to objectively quantify their physical activity; this study forms the basis of the current

cpm	Counts per minute
JUSH	Jimma University Specialized Hospital

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investigation. Only children with complete activity data at both baseline and follow-up were included in the present analyses.

Physical activity was measured with a raw tri-axial accelerometer (ActiGraph GT3X+; ActiGraph, Pensacola, Florida) measuring accelerations in 3 orthogonal planes. Accelerometers were worn on the hip and wrist for 24 hours a day during a period of 5 days after admission ("baseline") and after approximately 10 days of rehabilitation ("follow-up"). Because newly admitted children are likely to lie in bed all day, we applied 2 accelerometers on each child (right hip and wrist); we hypothesized that hip measurements may not be of much discrimination but that wrist measurements may pick up lower levels of activity, including activity in children who were too young to walk. Monitors were programmed to sample data at 100 Hz and downloaded with ActiLife5 software (version 5.5.0; ActiGraph). To maximize compliance, posters with pictures and information on the use of the accelerometers were placed on the wall in every room in the nutritional rehabilitation unit.

A full clinical examination was performed each week, including weight measured to nearest 0.01 kg (Tanita BD-815MA; Tanita U.K. Ltd, West Drayton, United Kingdom) as well as length measured to nearest 0.1 cm, with the use of a free-standing stadiometer or a length board (seca, Birmingham, United Kingdom) for children unable to stand. Information about occupation and schooling of the children's caretakers was collected by use of a standardized questionnaire.

Statistical Analyses

The raw data were reduced to 2-second epoch data with the use of ActiLife5 software (version 5.5.0; ActiGraph), with all further analyses performed in Stata (StataCorp LP, College Station, Texas). Monitor nonwear time was determined as 90-minute or longer strings of zero activity. We calculated the vector magnitude of the 3 axes and summarized average intensity (mean counts per minute [cpm]) by hour and further collapsed it by day and overall while minimizing diurnal bias caused by any imbalance in availability of valid wear data for both baseline and follow-up. Days with less than 22 hours of wear time as well as recordings with an average intensity of more than 10 000 cpm were excluded from all analyses.

A paired *t* test was used to test for differences in physical activity from baseline to follow-up, and a linear mixed-effects model[12] was used to assess the daily changes in physical activity for each location (ie, hip, wrist) and time-point (ie, baseline, follow-up). Log-transformation (natural logarithm) of activity was used to assess the ratio (e^B) between baseline and follow-up.

Results

A total of 53 children participated in the physical activity study. Forty (75.5%) were excluded because of daily wear time less than 22 hours at either baseline or follow-up. A total of 13 (24.5%) children were included in the present analyses with complete physical activity measurements (hip and wrist) at both baseline and follow-up. Mean (SD) age was 31.1 (15.5) months, and 10 (76.9%) were boys. The majority of the children's caretakers had no formal schooling (61.5%) and received their primary income from farming (61.5%). Baseline anthropometrical status is available in Table I. There was no significant change in weight between baseline and follow-up (8742 vs 8675 g, $P = .94$). Upon admission, 11 (84.6%) had some degree of edema (4 on feet, 3 on legs, 4 generalized), and at discharge 1 (9.1%) remained edematous.

Overall, average wrist movement was greater at follow-up (1158.8 vs 541.4 cpm, $P = .003$), and there was no significant difference in hip movement (204.1 vs 141.5 cpm, $P = .261$) (Table II). Expressed in relative differences, the wrist activity was 2.5 times greater at follow-up (e^B 2.45; 95% CI 1.43-4.19), and the hip activity increased by 46% but did not reach statistical significance (e^B 1.46, 95% CI 0.79-2.72).

During both baseline and follow-up assessments, average daily wrist movement measured on the wrist increased from day to day (P for trend <.001 and .043, respectively; Table II), but the hip activity did not.

When analyzing the diurnal patterns of activity (Figure), we found that children were most active from 6 a.m. to 10 p.m. At baseline, the day-night activity difference was relatively small, whereas the amplitude at follow-up for wrist measurements was substantially increased, showing more activity particularly during the day. With absolute night activity being similar across time points, relative differences in activity were reassessed during daytime (6 a.m. to 10 p.m.). Using this approach on hour-by-hour data, we identified a significant 38% increase in hip activity from baseline to follow-up (e^B 1.38, 1.17-1.62), and changes in wrist activity remained significant (e^B 2.50, 2.17-2.87).

Discussion

This study of 13 Ethiopian children admitted with severe acute malnutrition shows a fast daily recovery of wrist activity during the first 2 weeks of rehabilitation. Wrist activity increased markedly within the first days after admission

Table I. Background data from 13 children admitted with severe acute malnutrition

Background data	
Male sex, n (%)	10 (76.9)
Age, months	31.1 (15.5)
Caretakers occupation (primary source of income), n (%)	
Farmer	8 (61.5)
Employed	3 (23.1)
Other	2 (15.4)
Caretakers education	
Some level of schooling	5 (38.5)
No schooling	8 (61.5)
Anthropometry	
Weight, g	8741.5 (3291.8)
Height/length, cm	78.3 (22.2)
Mid-upper arm circumference, cm	11.8 (3.5)

Data are mean (SD) or n (%).

Table II. Physical activity data from admission (baseline) and recovery (follow-up; 10 days postadmission) among 13 children admitted with severe acute malnutrition

	Baseline	Follow-up
Overall average movement, cpm		
Wrist	541.4 (300.4-782.4)	1158.8 (828.7-1489.0)
Hip	141.5 (71.7-211.4)	204.1 (105.9-302.3)
Day-to-day average movement, cpm		
Wrist		
Day 1 (of baseline and follow-up, respectively)	457.5 (254.7-660.3)	1186.2 (982.8-1389.5)
Day 2	509.9 (304.4-715.4)	1120.9 (917.6-1324.3)
Day 3	597.3 (393.9-800.6)	1216.3 (1010.1-1422.5)
Day 4	658.3 (446.8-869.8)	1405.2 (1166.4-1644.0)
Day 5	813.1 (532.2-1094.1)	N/A
P for trend	<.001	.043
Hip		
Day 1 (of baseline and follow-up, respectively)	117.3 (0.0-326.6)	189.4 (0.0-386.7)
Day 2	111.7 (0.0; 321.0)	174.8 (0.0; 375.6)
Day 3	142.7 (0.0; 343.5)	180.1 (0.0; 380.9)
Day 4	221.9 (5.2; 438.6)	210.1 (0.0; 436.6)
Day 5	308.9 (0.0; 662.6)	N/A
P for trend	.176	.902

N/A, not available.
Data are mean (95% CI) or n (%).

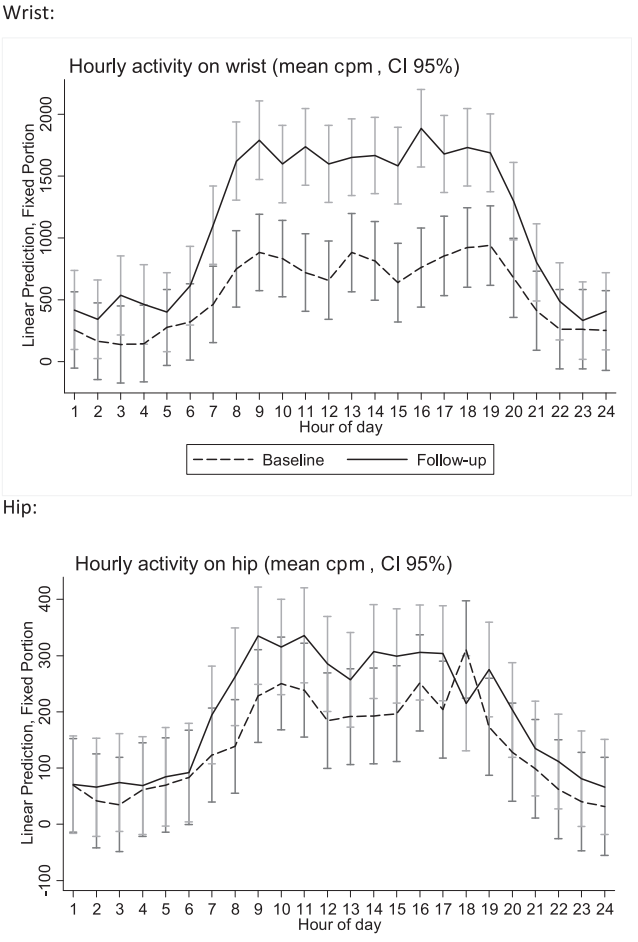

Figure. Diurnal activity (mean cpm) for the wrist and hip at baseline and follow-up among 13 children admitted with severe acute malnutrition.

and between admission and recovery, and hip activity increased slower and primarily during the daytime. In general, the first few days after admission consisted of low activity without much difference in activity between night and day, thus resembling a typical day for a severely sick person lying in bed, but indication of recovery was apparent on wrist movement at day 3. The constant low hip movement indicated bed rest all through admission, and because this activity did not increase significantly over time, we do not believe that carrying the child by caretakers or staff would have influenced results. However, we do not know whether hip activity at baseline reflected activity from being carried (passive movement) and whether hip activity at follow-up was generated by child activity (active movement) and thus potentially concealing a real effect of hip activity. In absolute numbers, hip movement almost doubled between admission and recovery, and although this number did not reach statistical significance, probably because of our low sample size, this size of the estimate suggests clinical significance.

There was no change in weight between the 2 periods, which also was expected. In the initial phase of nutritional rehabilitation, the energy intake is restricted to avoid refeeding syndrome.[13] In this phase, children are not expected to gain weight, and those with edema are expected to lose the edema. Then the energy intake is increased, and the children will start gaining weight, which explains why we did not see weight gain. Hence, physical activity seems to be an earlier marker of rehabilitation than weight gain.

At follow-up, the circadian rhythm seen from wrist movement was definite, a shift clearly indicating physical improvement during rehabilitation. This most likely reflects recovery from infections and normalization of metabolic functions, which precedes weight gain. Because no comparable studies exist, it is difficult to tell what absolute levels to expect during the acute phase of severe acute malnutrition recovery, let alone what reference values would be for healthy Ethiopian children.

The use of accelerometers in the critical phase of rehabilitation from severe acute malnutrition facilitates monitoring the association between nutritional status and physical movement capabilities. The obvious shift in physical activity levels within just a few days of rehabilitation shows that the method used here has potential in acute rehabilitation research, for example, when testing new nutritional and medical treatments. Also, there is substantial lack of evidence concerning the treatment of infants and children with severe acute malnutrition,[14] and the role of physical activity on long term recovery needs to be explored.

In conclusion, physical activity among children admitted with severe acute malnutrition is very low but increases rapidly during recovery, showing additional benefits on health of the World Health Organization nutritional recommendations. The use of accelerometers to monitor changes in

physical activity may be helpful for future research of the recovery phase during rehabilitation and may be a rapid and solid indicator of early improvement. However, population studies are needed to determine normal activity levels of Ethiopian children to ascertain whether the treatment for severe acute malnutrition evaluated here managed to completely restore normal behavior, and larger trials are needed to explore the association between activity levels and various prognostic factors. ■

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