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Original Article

Normal motor milestone development for use to promote child care

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Abstract

Background Motor behavior is an essential aspect of child development, and usually assessed in terms of age of achievement of motor milestone. The early detection of infants experiencing subtle delays in motor maturation can allow early intervention in developmental problems. Intervention can be more effective if delays are identified early. In order to facilitate the identification of early delays, the Center of Nutrition and Foods Research and Development in Bogor has designed a simple tool to monitor the child (aged 3 to 18 months) motor development.

Objective To develop an observable of normal gross motor maturation for use to detect deviance or motor delay.

Methods A total of 2100 healthy children, aged 3 – 18 months, from high socio-economic group, in urban and suburban areas, were studied. Body length, weight and motor development were measured on all children. Gross motor development was measured 17 pre selected milestones: lie, sit, crawl, creep, stand with assistance, walk with assistance, stand alone, walk alone, and run.

Results and Conclusion There were no differences between males and females in the comparison of attainment motor maturation therefore a sex combined curve was developed. Conclusion The curve of normal motor milestone development can be used as a tool to evaluate motor development over time, and/or as a child development card for use in primary health care. **[Paediatr Indones. 2010;50:340-6]**.

Keywords: *motor milestone development, nutrition, child care*

It is generally believed that activity levels are reduced in poorly malnourished children, and this may have a detrimental effect on motor development.[1,2] The onset of developmentally significant action (e.g., creeping, sitting, standing), dependent on the reciprocal interactions of physical activity and motor maturation.[3] These authors suggested the motor test scores, but not mental test scores, predicted cognitive performance during the preschool years as well as in adolescent.

An association between poor nutrition and development has been shown in several studies of young children in the communities where under-nutrition is endemic (e.g., in Guatemala[4], Jamaica[5,6], Indonesia[7], and Costa Rica[8]). In those studies, the associations with poor development were more frequently found with stunting than wasting.[9] The results of meta analysis of six field studies in Colombia, Guatemala, Indonesia, Jamaica, Taiwan and United

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States[10] showed that early high energy and protein supplementary feeding has a beneficial effect on motor development in young infants (8-15 months old) and on both motor and mental development in older infant (18-24 months old) who are nutritionally at risk.

Although some variability of motor skills among infants is recognized, it is widely accepted that the sequence of motor skills is consistent. A child may miss a skill, such as crawling, while the other remaining skills emerge in predicted order. Because of this predictable, sequential pattern of motor development, assessment of milestones provides an observable tool to evaluate motor skills and to detect deviance or motor delay. In this article, current issue will be addressed on the development of a tool of gross motor maturation to identify at risk children with motor delay based on the study carried out in Indonesia.

Methods

This cross sectional study was conducted in four cities in Java: Surabaya, Malang, Bandung and Bogor. This study involved a total of 2100 healthy children, aged 3–18 months from high socio-economic families in urban and suburban areas who does not constrain growth, have access to healthy drinking waters and environment.

Body length and weight were measured on all children, with standard anthropometric procedures.11 Length was measured to the nearest 0.1 cm on a wooden length-board developed by the NFRDC in Bogor, Indonesia. Weight was measured to the nearest 0.1 kg on digital Secca (UNICEF), and all children were pondered without clothing. Length and weight measurements were converted to Z scores based on the means and standard deviations.[12] A cut-off point of zero and above standard deviation of all growth indexes: weight for age, length for age, and weight for length were used when identifying children to include in this study as adequate in their physical growth. Nutritional status is illustrated by anthropometric dimension converted to Z scores using the US National Center for Health Statistic Reference Standard.[18] If the resulting Z score was above minus 2 standard deviations, growth was considered normal.

Gross motor development was measured with 17 pre-selected milestones: lie, sit, crawl, creep, stand with assistance, walk with assistance, stand alone, walk alone, and run. Definition of these milestones and comparative definitions from the Denver Developmental Screening Test[13] and Bayley Scales of Infant Development Motor Scale[14] are provided in **Figure 1** and **Table 1**. The milestones were selected to represent major landmarks in self-produced bipedal minus one standard deviation from the mean for age. Based on our experience on the development pathways of the malnourished children[15], by using a time-sampling method and with aid of McGraw's[16] scheme, three Nutritionist spent over 100 hours observing children aged 9–24 months, to verify whether the nature and chronology of the motor skills observed agreed with description. Differences between our observation and McGraw's description led us to construct a new list of motor development skills and a new ordinal sequence. Finally we assembled in booklet form, drawings of children engaged in activities that required the motor skills chosen for study. The milestones were selected to represent the major recognized in the culture being tested (**Figure1** and **Table 1**).[7,17]

Table 1. Motor milestone development by definition

No.	Label	Motor Development Description
1.	Sit 1	Sit with support
2.	Crawl 1	Lying on abdomen; can raise himself up with his hands
3.	Sit 2	Sit without support; the body is not upright
4.	Sit 3	Sit without support; the body is upright
5.	Crawl 2	Lying flat on his abdomen; can raise the body bearing his weight on his hands and the tips of his toes alone
6.	Creep 1	Crawl and starting by going backwards
7.	Creep 2	Creep on all fours (on his hands and knees)
8.	Stand 0	Learning to stand
9.	Walk 0	Walk with assistance of other; his feet flat on the floor
10.	Walk 1	Walk with assistance of other; his feet are not steady yet
11.	Stand 1	Stand with support
12.	Walk 2	Walk by himself with support
13.	Stand 2	Stand without support
14.	Walk 3	Walk a few steps without support
15.	Walk 4	Walk alone with small steps
16.	Walk 5	Walk with large steps
17.	Run	Run

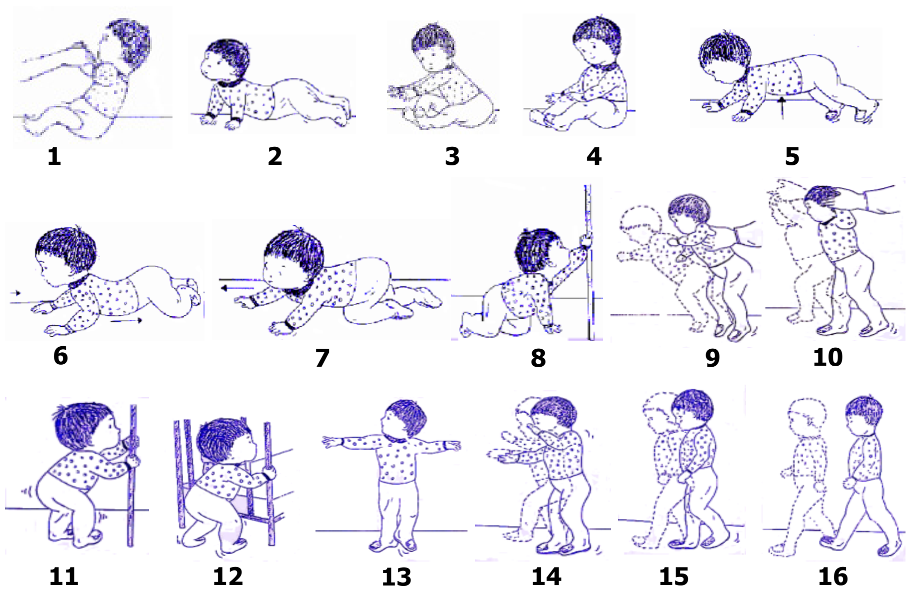

Figure 1. Motor milestone development

The data collection on socio-economic status, anthropometric measurements, and motor milestones observation were carried out by trained nutritionists. They were recruited from local Academy of Nutrition, and most of them were lecturers. They were assigned into groups consisted of two persons in each group, therefore 3 to 4 groups of field workers in each study areas (cities). In particular on motor milestones, the observation was carried out by the two testers who had been trained intensively by the authors. The training consisted of observation of more than 50 children ranging in age from 3 to 18 months. Interpreter reliability ($r > 0.80$) was established between pairs of testers for 15 children and between all two testers on an additional 3 children.

Motor status was assessed during 5-10 min testing session. During a testing session, each child was challenged to achieve the highest milestone possible. Instruction was given to the child and/or the caretaker encouraging these desired behaviors. The observation took place at the subject's home. During the collection of data in the field, researchers from Bogor visited the area and supervised the activities such as accuracy of the measurement, interpretation of the findings, coverage and others. Rough tabulation of data was done on site, so the local staff could know the temporary results. In order to ascertain that recorded data were properly reported, the data were reviewed by senior researchers. Then we calculated summary statistics which include mean, standard deviation, percentiles for continuous variables, frequencies and proportion for each level of variables.

Results

The characteristics of participating parents are shown in **Table 2**. Most of age ranges for mothers was 20 – 29 years and fathers was 30 – 39 years, graduated from university was 27.6% for mothers and 42.5% for fathers, and birth weight was between 3,100 to 3,400 g. The highest proportion of father's job was private company staff and entrepreneurs (79.2%). Almost all birth assistance in this population was health personnel either doctors (48.3%) or midwives (50.1%).

Figure 2 shows the trend of nutritional status of the children studied. On average the weight for age, length for age, and weight for weight in each age group was above minus one Z score. It is apparent that nutritional status was better in younger children either by the index of weight for age, length for age or weight for length.

Table 2. Characteristics of sample's parents

Characteristics	Values (N=2100)
Average mother's age (years)	20-29
Average father's age (years)	30-39
University graduate:	
a. Mothers (%)	27.6
b. Fathers (%)	42.5
Father's occupation	
a. Private company staff (%)	79.2
b. Government officials (%)	14.4
c. Others (%)	6.4
Place of birth:	
a. Hospital (%)	52.2
b. Birth clinics (%)	45.6
c. Missing (%)	2.2
Birth assistant:	
a. Doctors (%)	48.3
b. Midwives (%)	50.1
c. Missing (%)	1.6
Average birth weight (g)	3100-3400

Motor development by age for sex combined is illustrated in **Figure 3**. The figure depicts the age at which 5, 50, and 95% (i.e., the 95th, 50th, 5th percentiles) of the children reached a particular milestones. For example, at 10 months, 95% of children are able to crawl, 50% are able to walk with assistance, and only 5% could walk alone several steps. **Table 3** presents the Mann-Whitney different test of motor achievement scales between males and females. The difference is not significant at any points of observation at each of age groups from 3 to 18 months.

Based on these findings the sex combined motor milestone development as shown in **Figure 4** represents for both females and males can be used either for females or for males. This curve is presented in the motor milestone development tool for use in identifying children at risk and for monitoring.

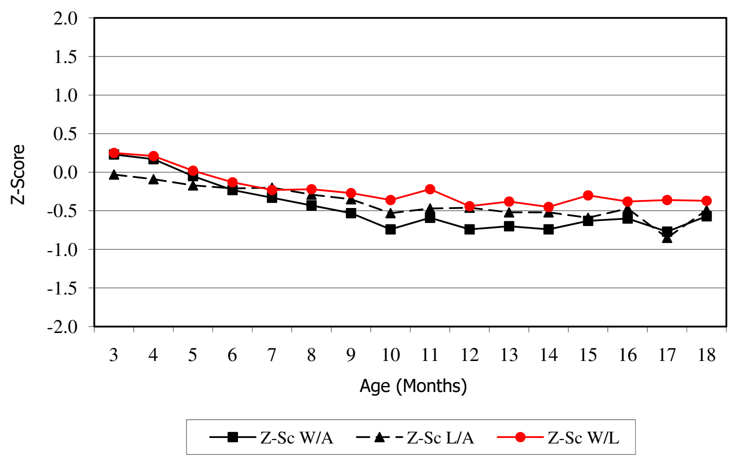

Figure 2. Means of Z-score weight-for-age, length-for-age, and weight-for-length, sex combined aged 3-18 months

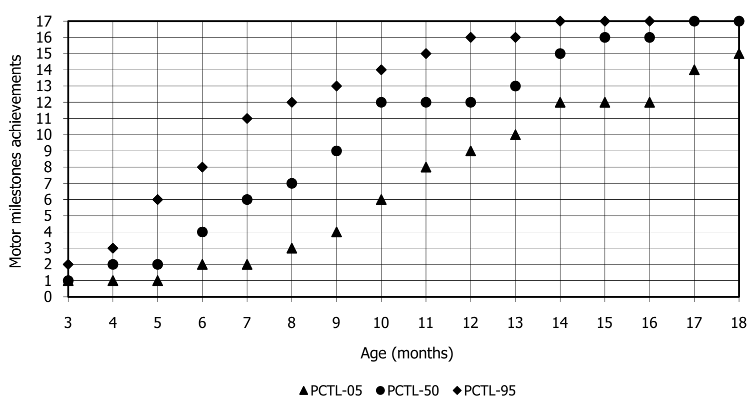

Figure 3. Scattered of motor milestone percentiles, sex combined aged 3-18 months

Table 3. Statistical different test of motor milestone achievements between boys and girls – Mann-Whitney

Age (months)	Mann-Whitney		Age (months)	Mann-Whitney	
	Z-value	P (2-tail)		Z-value	P (2-tail)
3	- 1.298	0.194	11	- 2.332	0.020
4	- 0.318	0.750	12	- 1.591	0.112
5	- 1.493	0.135	13	- 0.057	0.954
6	0.000	1.000	14	- 1.151	0.250
7	- 1.286	0.198	15	- 0.121	0.904
8	- 0.018	0.985	16	- 0.497	0.632
9	- 0.112	0.911	17	- 1.956	0.050
10	- 1.090	0.276	18	- 0.100	0.920
3-18	- 0.930	0.352		Not significant	

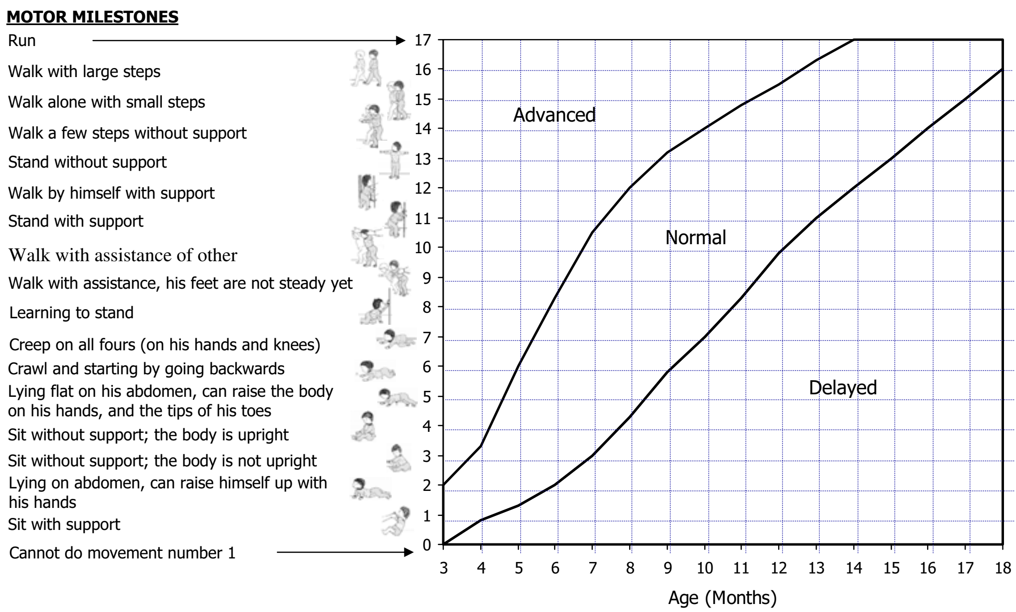

Figure 4. The motor development curve, sex combined, aged 3-18 months.

Discussion

The characteristics of education of parents as shown in **Table 2** were relatively high; 27.6% of mothers and 42.5% of fathers graduated from university. When this condition is compared to the national wide where women and men (sex combined) with university graduate is 3.7%19, therefore the population studied is belonged to the high socio-economic class.

This study revealed that there were no differences in the comparison of the achievement of motor milestones between females and males at any age groups. This finding is consistent with the evidence from our previous study in Pengalengan – Indonesia.[7] In these communities, we found no ethnographic or statistical evidence of a bias against females children. These current findings are in part similar to the study in US carried by Capute et al[19], WHO Multicentre Growth Reference Study Group[20], and in Japan[21]. They reported that comparison of males and females in the attainment of milestones scales revealed inconsistency within the race groups. Among whites, males tended to be advanced relative to females, but females were advance relative to males among black.

In this study, 13.4 months, in contrary with our previous study in malnourished children[7] the mean age of walking was 14.2 months. Those study[7] concluded that among population at risk for malnutrition, motor development is more likely to correlate with length-for-age than weight-for-length. When these findings comparing the mean age of walking for American and European population, there was a delay in the achievement of motor milestones. Malina[22] reported that the median age at walking is 11.4–12.4 months for American samples, and 12.4–13.6 months for European samples. In addition, a WHO longitudinal multi-centre growth reference study showing that the role of nutrition in motor development of infants provides an important addition to the literature and should serve as a baseline for more focused studies of both motor and cognitive development.[23,24]

In contrast to early theories of motor development[16,25] the onset changes among individuals does not follow a fixed chronology as suggested by the curves generated in this cross-sectional study (**Figure 4**). However, these data, based on estimates of the ages at which individual children acquire particular motor milestone, provide a reference for comparative purposes among individuals.

Since the majority of studies of infant motor development have collected cross-sectional rather than longitudinal data, variation among individuals (inter individual variability) are discussed more often in developmental literature than is variation within the same infants (intra individual variability). Although some variability of motor skills among infants is recognized, it is widely accepted that sequence of motor skills is consistent. A child may miss a skill entirely, such as crawling, while the other remaining skills emerge in a predicted order. Because of this predictable, sequential pattern of motor development, assessment of milestones provides an observable way to evaluate motor skills and to detect deviance or motor delay. The pattern of skills may vary across individuals, but the order remains constant for the majority of normally developing infants.[26]

The curve of motor milestones for normal children in Indonesia has been constructed to measure the motor development of children age 3 to 18 months. The purpose of this particular assessment is to identify children who are delayed or deviant in their motor development and evaluate motor development or maturation over times. Infants are considered to be at risk because of adverse genetic, prenatal, neonatal, postnatal, environment or nutrition influences that may lead to subsequent problems in development.[26] In the areas where malnutrition is endemic, it is likely that the influence of nutrition is becoming more significant. The motor development tool is useful in evaluating and monitoring the motor development of malnourished children and/or at risk children over time. It will be also expected to promote better child care by increasing the level of awareness of the women, village cadres and health personnel.

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