Family and infant characteristics in relation to age at walking in Turkey

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SUMMARY: Yalçın SS, Yurdakök K, Tezel B, Özbaş S. Family and infant characteristics in relation to age at walking in Turkey. Turk J Pediatr 2012; 54: 260-268.

The purpose of this study was to assess the onset of independent ambulation relative to possible relationships with maternal and infant characteristics. In a cross-sectional study, the health files of 1,553 Turkish children aged 12-23 months were selected by the multistage sampling method in the Nomenclature of Territorial Units for Statistics (NUTS) regions coded as low, medium and high malnutrition levels in Turkey. Children were selected from health centers by systematic sampling technique in each region. Kaplan-Meier analysis and estimated mean values were used for data description; log-rank test and the Cox multivariable regression analysis were applied for data analysis. Maternal education level, occupation, region of residence, gestational iron supplementation, child's gender, child's nutritional status, and presence of anemia in the infant during the survey period demonstrated significant relationships with walking unassisted in the univariate analysis. However, multivariable analysis showed that high maternal education, absence of parental consanguinity and appropriate weight-for-age Z score were positively associated with earlier age of walking. These findings showed the importance of improvement in girls' education, prevention of postnatal growth retardation and improvement in diet quality for children's gross motor development. In addition, counseling programs should be given to decrease the rate of parental consanguinity.

Key words: walking age, consanguinity, growth, girls' education.

Several studies have shown wide variations in the achievement of independent walking in healthy infants[1-3]. Walking attainment is a complex developmental process driven by a wide variety of genetic and environmental factors. Physical growth in length and weight, nutrient and micronutrient intake, muscle and bone tissue strength, maturation of the nervous system, cognitive development, quality of the home environment, stimulation and positive care-giving, and cultural and child-rearing practices play a role in the initiation of walking without support[1,4-7]. Healthy infants begin to walk around 12 months with some biological variability. By the age of 18 months, all healthy term infants attain walking ability. Later achievement of walking is an indicator of developmental disorders (cerebral palsy, psychomotor retardation)[8-10]. Therefore, the age of independent walking attainment may provide valuable clues about the overall health and development of infants. Studies are limited on the predictors for walking attainment.

The purpose of this study was to determine the effect of some demographic, social and infant characteristics (gender, birth order, maternal education, working status, family characteristics, infantile growth parameters, presence of anemia) on the age at walking without support among healthy children aged 12-23 months, already involved in a cross-sectional study to observe the effect of nationwide iron supplementation.

Material and Methods

The data were collected in the course of a cross-sectional study on the prevalence of anemia that was carried out in 2007 in three NUTS-1 (Nomenclature of Territorial Units for Statistics) regions of a total of 12 NUTS regions of Turkey[11]. The study population consisted of 12-23-month-old children, living in three different NUTS-1 regions of Turkey according to the prevalence of malnutrition (the percentages of height-for-age below -3SD; high, middle and low) in the Turkey Demographic and Health Survey (TDHS) 2003 and with "region with high malnutrition prevalence" defined as poor region, "region with middle malnutrition prevalence" as middle region and "region with low malnutrition prevalence" as good region. The detailed protocol was given before[11,12]. Any children who were extreme premature (<32 weeks), who had a condition preventing them from walking, birth weight less than 1500 g, an abnormal birth history, or a history of intensive care unit admissions, developmental problems, developmental hip dysplasia, or neuromuscular diseases were eliminated from the original data as were those who had a vague or unclear history. This study was reviewed and approved by the Ethical Committee of the Turkish Ministry of Health. Written informed consent was obtained from caretakers for each participant before enrollment.

Trained field workers made home visits and completed a questionnaire. The questionnaire provided information concerning the reason for the visit, gender, birth order, and child's health and age at independent ambulation. Anthropometric measurements of children were obtained by trained field workers. Standardization sessions were conducted during training and the course of data collection[11]. Z scores of weight-for-age, weight-for-height, height-for-age, and body mass index for age (WAZ, WHZ, HAZ, and BAZ, respectively) were calculated from the World Health Organization (WHO) Multicentre Growth Reference Study (MGRS)[13]. Due to the limited number of cases below -2 WAZ (n=15), WHZ (n=21) and BAZ (n=25), comparisons were done for cases below -1 and above 1 Z scores.

Age at walking was defined as the age at which the subject was able to arise from a sitting position on the floor and walk at least 6 feet without support. Birth order was classified into one of three groups as first-, second- or later born.

Capillary blood samples were obtained in two microtubes from the middle finger of the left hand of each subject using a microlance, and centrifuged to measure the hematocrit (Htc) levels. If the mean Htc value of a child was less than 33%, venous blood samples were taken for complete blood count [Hemoglobin (Hb), Htc and mean corpuscular volume (MCV) by STKS Coulter Machine]. Anemia was defined as Hb <11.0 g/dl, MCV <70 fL and red cell distribution width >14.5%[11,14].

Statistical Analysis

All analyses were performed with the Statistical Package for the Social Sciences (SPSS) for Windows (SPSS Inc., Chicago, IL, USA). The age at walking unassisted was calculated by the Kaplan–Meier method, and the differences were analyzed by a log-rank test. P values <0.05 were considered significant. Estimated means and standard errors were calculated. Cox regression models [Method = Backward Stepwise (Likelihood Ratio); probability for stepwise was 0.05 for entry and 0.10 for removal] were performed to assess the impact of factors including region of residence, maternal age (<25, 25-29, 30-34, ≥35), maternal education level (≥8 vs <8 years), maternal occupation (working vs housewife), parental occupation, family type (nuclear vs extended), parental consanguinity (absence vs presence), breastfeeding duration (≥6 vs <6 mo), infant gender, sibling under 5 years of age (presence vs absence), low birth weight or premature (absence or presence), birth order (first vs second and upper), iron supplementation of infant (present vs absent), vitamin supplementation of infant (multivitamin, vitamin D vs nothing), gestational iron supplementation (no, third, second trimester vs first trimester), infant anemia during the study period (present vs absence), WAZ (-1-0.99 Z score or ≥1 Z score vs <-1 Z score), HAZ (1-0.99 Z score or ≥1 Z score vs <-1 Z score). Hazard ratios with 95% confidence intervals (CI) were used to quantify the strength of these associations.

Results

The study sample consisted of 1553 children (816 males, 737 females). Overall, 26.1% of children were from a low malnutrition region, 34.3% from a moderate region and 39.6% from a high malnutrition region. Mean (±SD) maternal age was 28.1 (±5.6) years. Maternal educational status was low; only 33.6% had completed primary school (≥8 years). Only 7.4% of mothers were working. Approximately 23.1% were from an extended family.

The mean age (±SD) of infants was 18.0 (±3.6) months. The mean (±SD) birth weight of the enrolled children was 3.22 (±0.60) kg; about 8.8% of children were born premature and 7.4% had birth weight <2.5 kg. Overall, 14.5% of children in the study group were born premature or had low birth weight. 37.3% of children in the sample were the first-born. Breastfeeding was widespread; 98.6% of children were ever breastfed and 18.9% received breast-milk less than 6 months. Mean (95% CI; lower, upper bound) WAZ, HAZ, WHZ, and BAZ scores at birth were 0.51 (0.46, 0.56), -0.19 (-0.27, -0.11), 0.81 (0.75, 0.87), and 0.89 (0.82, 0.95), respectively. Overall, 7.9% of children had anemia. Mean (±SD) Htc level was 35.4 (±2.5)%. During study period, the estimated mean walking age of all study participants was 12.42 months, with a standard error of 0.06 month.

Univariate analyses showed that the mean age at walking without support was the youngest in the low malnutrition region and the oldest in high malnutrition region (Table I). Maternal age did not affect the walking age of children. Parental educational level (<5 years, 5-7 years, 8-10 years, 11-14 years and ≥15 years)

Table I. The Age of Walking without Support in Turkish Children 12-23 Months of Age According to Some Family Characteristics (Log Rank [Mantel-Cox])

		N	Estimated mean	Standard error	95% CI min	95% CI max	P
Overall		1553	12.42	0.06	12.30	12.54	
Region according to malnutrition	Low	406	12.17a	0.10	11.96	12.37	<0.001
	Moderate	532	12.43b	0.11	12.21	12.64	
	High	615	12.61c	0.10	12.41	12.80	
Maternal age, yrs	<25	439	12.48	0.12	12.25	12.72	0.917
	25-29	527	12.43	0.10	12.24	12.62	
	30-34	370	12.33	0.12	12.09	12.58	
	≥35	208	12.33	0.15	12.03	12.62	
Maternal education, yrs	<5	205	12.61a	0.17	12.28	12.94	0.002
	5-7	826	12.55a	0.09	12.38	12.71	
	8-10	175	11.91b	0.15	11.61	12.21	
	11-14	251	12.19b	0.12	11.95	12.43	
	≥15	96	12.26ab	0.21	11.85	12.67	
Maternal occupation	Working	112	12.03	0.13	11.79	12.28	0.042
	Housewife	1401	12.46	0.07	12.33	12.59	
Paternal education, yrs	<5	82	12.78a	0.31	12.16	13.39	0.004
	5-7	673	12.56a	0.10	12.38	12.75	
	8-10	212	12.57a	0.17	12.23	12.91	
	11-14	394	12.05b	0.09	11.87	12.23	
	≥15	182	12.32ab	0.14	12.04	12.59	
Paternal occupation	Yes	1329	12.38	0.06	12.26	12.50	0.085
	No	204	12.70	0.20	12.30	13.10	
Family type	Nuclear	1194	12.40	0.07	12.26	12.54	0.345
	Extended	359	12.52	0.12	12.28	12.75	
Parental consanguinity	Yes	339	12.73	0.12	12.48	12.97	0.002
	No	1206	12.33	0.07	12.20	12.47	
Social security	Present	1287	12.40	0.06	12.28	12.52	0.485
	Absent	259	12.59	0.19	12.23	12.96	
Number of household members	<5	846	12.40	0.08	12.24	12.56	0.396
	≥5	707	12.45	0.09	12.28	12.62	
Sibling aged 5 years of age	Absent	968	12.46	0.08	12.30	12.61	0.312
	Present	585	12.37	0.09	12.19	12.55	

showed a “U”-shaped interaction with the age of walking; maternal education level between 8-14 years and paternal education level between 11-14 years had the earliest age for walking unassisted. There were no significant differences according to paternal occupation, family type, presence of social security of the family, number of household members, or presence of any sibling under 5 years of age.

Table II lists the descriptive statistics for age at independent ambulation across gestational characteristics: presence of iron deficiency anemia (IDA), iron supplementation, birth type, birth interval and birth order, gestational age, and birth weight. Neither birth interval nor birth order was significantly associated with walking age in the univariate analyses. There were no differences according to maternal history of anemia. Interestingly, the mean age for walking without support was younger in children with mothers who received iron supplementation during the first trimester of gestation compared to the others.

The effect of some infant characteristics on age at walking unassisted is given in Table III. Among factors examined, females walked earlier than males. History of iron and vitamin supplementation during the first year of life was not associated with age of walking without support. However, children with anemia and palmar pallor had an older age of walking without support than non-anemic ones. In cases with infants whose breastfeeding duration was less than 6 months of age, the mean age at walking attainment was older than in the others. Birth weight was not significantly associated with walking attainment (Table II), but growth parameters during the study period were associated with attainment of walking; children with WAZ <-1 or HAZ <-1 had walked at a later age than the others.

Cox backward-stepwise regression analysis confirmed that the age at walking was younger in children with high maternal education level (≥8 years), longer breastfeeding duration (≥6 mo), absence of parental consanguinity, and appropriate WAZ (≥-1 Z score) compared to others (Table IV).

Discussion

The mean age at walking attainment was 12.42 months (95% CI 12.30-12.54) in the present study. The ages at which children start to walk vary considerably. Based on data from five countries, the WHO MGRS Group developed normal age ranges for achievement of motor milestones among healthy children and reported that the mean age (SD) for walking alone was 12.1 (1.8) months (1st and 99th percentiles in months 8.2 and 17.6)[15]. Several factors, namely differences in the definition of motor milestones, the methods and frequency of data collection, child-rearing practices, and genetics could explain the variations around the world in the age of walking without support[16]. Differences in residence in the present study might be partly explained by differences in child-rearing practices and genetics. In addition, in the present study, walking attainment was inversely associated with HAZ and WAZ. Differences in nutritional status could have an additional role in development. The MGRS found that relationships among anthropometric indicators and accelerations in ages of milestone achievement or delays, even if small, appeared to vary qualitatively in healthy populations with respect to specific motor milestones[17]. The associations between motor development and states of undernutrition were reported previously[2,3,6,18]. Physical growth may constrain gross motor development. Children in some developing countries begin to walk 1.5–3 months later than their well-nourished American or European counterparts[5,18]. In a cross-sectional study of infants, stunting was associated with slower acquisition of locomotive milestones (i.e., crawling, walking) compared with developmental norms from a healthy United States (US) sample[19]. Similarly, length was positively related to motor development scores in 12- and 18-month–old Indonesian children, and stunting was associated with a delay in walking unassisted in Zanzibari and Nepali children[2,20,21]. In Guatemala, growth in length and weight during the first year of life predicted the age at walking unassisted[3]. Furthermore, in Pakistani infants, changes in LAZ from 0 to 6 months were inversely associated with age at commencement of independent walking[18]. In addition, supplementation was known to improve motor development in nutritionally at risk infants/toddlers[6,22]. A possible explanation is that growth retardation and poor diet may directly affect the developing central nervous system, resulting in disturbances

Table II. The Age of Walking without Support in Turkish Children 12-23 Months of Age According to Some Gestational Characteristics (Log Rank [Mantel-Cox])

		N	Estimated mean	Standard error	95% CI		
					min	max	P
History of IDA during gestation period	Present	756	12.40	0.09	12.22	12.57	0.274
	Absent	71	11.98	0.22	11.55	12.41	
	Unknown	726	12.50	0.09	12.33	12.66	
Iron supplementation during pregnancy	Present	1042	12.34	0.07	12.20	12.48	0.054
	Absent	511	12.57	0.10	12.36	12.77	
Starting time for iron supplementation	Trimester 1	382	12.19a	0.10	11.99	12.39	0.049
	Trimester 2	391	12.43ab	0.12	12.20	12.66	
	Trimester 3	177	12.61b	0.19	12.24	12.98	
	No iron usage	511	12.57b	0.10	12.36	12.77	
Delivery type	Vaginal	937	12.47	0.08	12.31	12.63	0.166
	Cesarean	599	12.32	0.09	12.15	12.50	
Pregnancy type	Single	1506	12.43	0.06	12.31	12.56	0.186
	Twin	45	11.97	0.15	11.67	12.26	
Low birth weight, g	<2500	115	12.68	0.25	12.20	13.16	0.221
	≥2500	1431	12.41	0.06	12.28	12.53	
Gestational age	≥37 wks	1399	12.40	0.06	12.28	12.53	0.330
	<37 wks	135	12.52	0.20	12.12	12.92	
Low birth weight or premature	No	1248	12.38	0.07	12.25	12.51	0.321
	Yes	211	12.49	0.16	12.16	12.81	
Birth order	1	579	12.51	0.10	12.31	12.70	0.396
	>1	965	12.38	0.08	12.23	12.52	
Birth interval†	<2 years	153	12.31	0.16	11.99	12.62	0.931
	≥ 2 years	847	12.37	0.08	12.21	12.53	

†for cases with birth order >1

in brain maturation, particularly affecting the division of cortical cells, coordinated development of the dendritic synaptic apparatus of neurons, myelinization, and the activity of neurotransmitter systems[7].

This study indicated that there was no significant association between some birth characteristics (birth weight, gestational age, interval, twin pregnancies) and walking age. Firstborns did not reach independent walking any earlier than their subsequent siblings. However, the ability of this study to prove this with certainty is somewhat limited by the design of the sampling method. Mostly, low birth weight and premature infants might have postpartum problems; however, children with disabilities, mechanical ventilation and sepsis were not included into the study. In addition, the present study did not include very low birth weight and premature infants. Similar to the present study, Kuklina et al.[3] found that growth in length and weight during the first year of life, rather than size at birth, had predicted age of walking.

Several micronutrients such as iron, zinc and essential fatty acids have been proposed to play a role in child development[2,3,6,22,23]. As seen in the present study, iron deficiency (ID) and IDA have been associated with lower scores on global tests of motor development[24]. Zanzibari children who were neither anemic nor ID were 66% more likely to be walking unassisted than those who were anemic with or without ID[10]. In addition, Nepali children

Table III. The Age of Walking without Support in Turkish Children 12-23 Months of Age According to Some Infant Characteristics (Log Rank [Mantel-Cox])

		N	Estimated mean	Standard error	95% CI min	95% CI max	P
Infantile age, mos.	12.0-14.9	392	12.46	0.14	12.19	12.74	0.354
	15.0-17.9	386	12.40	0.10	12.21	12.59	
	18.0-20.9	378	12.36	0.11	12.14	12.57	
	21.0-24.0	397	12.29	0.11	12.07	12.52	
Gender	Male	816	12.57	0.09	12.40	12.74	0.005
	Female	737	12.24	0.08	12.09	12.40	
Ever breastfed	Yes	1528	12.41	0.06	12.29	12.52	0.026
	No	22	13.36	0.71	11.97	14.75	
Duration of breastfeeding, mos.	<6	292	12.68	0.15	12.38	12.97	0.036
	≥6	1252	12.37	0.07	12.24	12.50	
Vitamin supplementation	Absent	421	12.54	0.12	12.31	12.78	0.373
	Vitamin D	811	12.34	0.08	12.19	12.50	
	Multivitamin	291	12.44	0.14	12.16	12.72	
Infant iron supplementation	No	460	12.41	0.11	12.19	12.63	0.836
	Yes	1093	12.43	0.07	12.29	12.57	
Presence of anemia	Yes	123	12.88	0.26	12.37	13.40	0.039
	No	1430	12.38	0.06	12.26	12.50	
Weight for age, z score	<-1	102	14.14a	0.43	13.29	14.99	<0.001
	<1 - -1	955	12.39b	0.07	12.24	12.53	
	≥1	463	12.17c	0.09	12.00	12.35	
Height for age, z score	<-1	427	12.79a	0.13	12.53	13.05	0.001
	<1 - -1	776	12.29b	0.08	12.14	12.44	
	≥1	302	12.17c	0.11	11.95	12.39	
Weight for height, z score	<-1	97	13.12a	0.34	12.46	13.79	0.012
	<1 - -1	780	12.45b	0.09	12.27	12.62	
	≥1	619	12.28b	0.08	12.12	12.43	
Body mass index for age, z score	<-1	112	12.58	0.22	12.14	13.02	0.433
	<1 - -1	701	12.43	0.09	12.26	12.60	
	≥1	683	12.38	0.09	12.21	12.56	

who were anemic were less likely to be walking than those who were not anemic[20]. Olney et al.[22] reported that children who received any iron walked unassisted sooner than those who received no iron, and this effect was stronger in those who had IDA at baseline. On the other hand, Perez et al.[25] focused on the effects of ID in mothers with regard to the potential negative effect of poor maternal functioning on infant development and mother-infant interactions. Indeed, the present study showed that maternal iron supplementation during the early gestational period was associated with earlier walking unassisted.

Breastfeeding could affect infant development. Certain constituents of breast-milk (e.g., docosahexaenoic acid) are known to be associated with infant mental development[26], but there is little evidence that they affect motor development. On the other hand, Vestergaard et al.[27] reported that achievement of two motor

Table IV. The Factors That Affect the Age of Walking Unassisted in Turkish Children 12-23 Months of Age, Multivariate Analysis Cox Regression (Backward Stepwise)

		95.0% CI for Exp(B)		
Parameters	Exp(B)	min	max	P
Breastfeeding duration (<6 months vs ≥6)	1.16	0.99	1.35	0.061
Maternal education (<8 years vs ≥8)	1.14	1.01	1.28	0.041
Parental consanguinity (present vs absent)	1.16	1.00	1.34	0.045
Weight for age Z score				0.008
"<-1 Z score" vs "≥-1 - <1 Z score"	1.40	1.09	1.81	0.008
"<-1 Z score" vs. "≥ 1 Z score"	1.52	1.17	1.98	0.002

skills (crawling and pincer grip) was linked to the duration of breastfeeding in a large sample of Danish infants, even after adjustment for potentially confounding variables. The present study showed that ever breastfed infants and infants breastfed more than 6 months walked earlier. However, no significant change was detected in cases breastfed more than 11 months (the estimated mean months for walking attainment were 12.39 for children breastfed more than 11 months and 12.28 for children with breastfeeding duration between 6-11 months). Some possible mechanisms include differences in maternal caregiving or infant motivation to explore the environment or be upright[4,26,28], all of which could be altered by the amount of time spent nursing. In the present study, unassisted walking also depended on maternal education and occupation. It is known that maternal education improved infant development[28]. Lung et al.[29] showed that the maternal education directly affected gross motor development at 18 months and all four dimensions of gross motor, fine motor, language, and social development at 36 months by a further analysis of structural equation modeling. Forns et al.[30] reported that maternal educational attainment was strongly related to child mental test scores at 14 months using Bayley Scales of Infant Development. In turn, Barros et al.[31] reported that low maternal education was found to be an important predictor of neuropsychological developmental problems in different contexts[31]. Education can serve as the factor required to help the mother obtain the resources she needs to improve her child-rearing behavior [29]. Educated women might offer better parenting, involving factors such as lifestyle, healthcare, housing, and the provision of a cognitively stimulating environment.

Delays in motor milestone acquisition were found in the presence of parental consanguinity in the present study. This might be explained by the poor quality of child-rearing environmental factors including low maternal education. Also, it is known that high consanguinity can be a contributing factor to the high incidence of some rare autosomal recessive neurometabolic diseases. However, the rate of consanguinity has been approximately 20-25% in Turkey[32].

Girls in the MGRS tended to achieve milestones at earlier ages than did boys. However, the magnitude of the observed differences is too small to justify sex-specific norms[33]. In the present study, univariate analysis showed that unassisted walking also depended on gender; girls walked sooner than boys. However, there were no differences in gender in the multivariate analysis.

The strengths of this multicenter study include its design as a large cross-sectional study, use of standardized protocols and analysis at the same time of several factors that might influence walking. There are some limitations of the study. First, no data were collected to validate the mothers' reports of their infants' motor skills. Additional data on measures such as social support and directly measured parent-child interaction (including abuse, neglect) and child-rearing practices should be included in future investigations. For example, children who are carried a lot or not encouraged to move around may start to walk later. Although we analyzed maternal factors such as age, education, occupation, and family size, as well as infant birth order, these variables may not serve as adequate proxies of factors such as socioeconomic status, parent-child interaction and quality of the home environment.

Our results indicate the importance of: prevention of postnatal growth retardation, improvement in diet quality for the child and iron supplementation during the gestational period, maternal education (girls' education), and prevention of parental consanguinity with pre-marriage counselling programs.

Acknowledgements

We are grateful to the infants and their mothers for their willingness to participate in the study. We are indebted to the health workers and doctors of the primary health care center whose dedication and effort made this project possible and to the Advisory Board of the "Iron like Turkey" program of the Turkish Ministry of Health, without whose encouragement and support this project could never have been undertaken.

Sources of Funding

The cost of the participant health workers in the fieldwork, laboratory work and data entry was supported by the ADEKA, Abdi İbrahim, Santa Farma.

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