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Effect of acquisition ages of gross motor functions on functional motor impairment in children with cerebral palsy

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Summary

Aim: This study aimed to investigate effect of the age of acquisition of gross motor functions on functional motor impairment in children with cerebral palsy.

Material and Method: Six hundred seventy one children with cerebral palsy who were diagnosed by a pediatric neurologist and referred to Hacettepe University, Department of Physiotherapy and Rehabilitation, Cerebral Palsy Unit were included this study and acquisition ages of gross motor functions were asked to the parents. Functional motor impairment was determined with Gross Motor Function Classification System. Ethics committee approval was received by Hacettepe University Medical Faculty Ethics Committee, Faculty of Health Sciences (Number: HEK 06/60).

Results: Clinical types of the patients with cerebral palsy included 625 (93.1%) spastic, 32 (4.8%) dyskinetic, 10 (1.5%) ataxic and four (0.6%) mixed type. According to Gross Motor Function Classification System 152 (22.7%) of the children were in level I, 102 (15.2%) were in level II, 111 (16.5%) were in level III, 60 (8.9%) were in level IV and 246 (36.7%) were in level V. The median age of acquisition of sitting independently was nine months in level I, 12 months in level II and 24 months in level III. The median age of acquisition of crawling was 12 months in level I, 18 months in level II and 48 months in level III. The median age of acquisition of walking independently was 18 months in level I and 33 months in level II.

Conclusions: Age of acquisition of gross motor functions gradually increased as the severity of motor impairment increased, as we expected. We believe that the results of this study will provide information regarding prognosis of gross motor impairment in children with cerebral palsy. *(Turk Arch Ped 2012; 47: 191-196)*

Key words: Cerebral palsy, Gross Motor Function Classification System, motor skills disorders

Introduction

Cerebral palsy (CP) is a permanent disorder in movement and postural control which cause limitation in functions related to non-progressive problems in developing fetal or infant brain (1). Its incidence is 2-3/1000 in the general population (2). In Turkey, the incidence of CP which is 4.4/1000 is higher compared to most developed countries (3). The reason for this high incidence is thought to arise from consangineous marriages, inadequate prenatal and perinatal care and inadequate health conditions (4). Cerebral palsy is thought to be the most common cause of many physical handicaps in the childhood (5). Swedish classification system is used widely in classification of cerebral palsy and it is based on movement disorders (5). In all types of cerebral palsy, the main problem is motor deficit (7). Sensory, perception, communication, behavioral disorders, epilepsy and secondary muscle problems frequently accompany motor deficits (8). Motor deficits include delay in starting movement, weak streght, inadequate postural control and increased or decreased contraction (9).

Motor functional level of a child with cerebral palsy is delayed depending on the severity of the lesion in the central nervous system (10). Timely completion of motor development is needed for the child's functional independency and social and emotional development. Therefore, determination of delay in development of gross motor skills will provide starting of an early efficient rehabilitation program (11,12,13). Early diagnosis is difficult, since early neurologic signs can improve or change. In addition, most progressive diseases start at an early period and progress slowly. Observation of deviations from normal development by families and rehabilitation teams facilitates early diagnosis (14). Early diagnosis provides intervention at an early period and increases the success of rehabilitation. The importance of early physiotherapy and rehabilitation increases gradually, since the learning ability of the brain is higher during the first 18 months in the postnatal period (8). Therefore, normal

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motor development should be known very well to understand the development of gross motor skills. Thus, the rehabilitation team can decide for the appropriate physiotherapy and rehabilitation program.

In clinical practice, the stages of gross motor development are evaluated continuously and followed up. Evaluation of gross motor skills is an important method in the follow-up of development (15,16,17). In approximately 50% of children with cerebral palsy, delay has been found in acquisation of the stages of gross motor skills (18,19,20).

Gross Motor Function Classification System (GFCS) provides better understanding of gross motor development by classifying the child with CP in 5 stages. According to the movement of the child in the community the lowest level of defect is classified as stage I and movement with external support or fully dependent movement is classified as stage V (11). The majority of children with stage I and II can walk 10 steps without support, while the possibility of less than half of children with III, IV and V to walk 10 steps with or without support is lower. Conclusively, GFCS provides prediction of functional level and skills by the age of 12-18 years in the first year of life (21,22).

The aim of this study was to examine the effect of the age of acquisition of gross motor skills on functional motor impairment in children with cerebral palsy.

Material and Method

Participants

671 children who were diagnosed as CP by a pediatric neurologist and who presented to Hacettepe University, Faculty of Health Sciences, Division of Physiotherapy and Rehabilitation, Cerebral Palsy Unit for a physiotherapy and rehabilitation program were included in our study. Informed consent was obtained from the families. Approval was given by the ethics committee of Hacettepe University Medical Faculty (No: HEK 09/60).

Clinical types of the children with CP included in the study were determined by Sweden Classification System. According to this system patients with CP were classified as spastic, dyskinetic, ataxic and mixed type. Patients with spastic type are divided into subgroups by extremity distribution. These include quadriparatic, diparetic and hemiparetic. “Spastic quadriparetic” defines severe motor deficit including all four extremities (upper extremities should be affected at least as lower extremities). Patients whose lower extremities are affected with a higher degree compared to the upper extremities are defined as “diparetic” and patients whose arm and leg on one side of the body are affected are defined as “hemiparetic” (6).

Gross motor skills of the children were determined according to GFCS. Gross Motor Function Classification System is a valid and reliable classification system which defines motor deficit in 5 levels in children with CP. “Inter-rater” reliability was found to be 0.75. It was found to be 0.93 in the review. It was reported to be a good predictor (21,22). Gross Motor Function Classification System is based on 5 levels. The differentiation between the levels is defined according to functional limitations and need for assitive devices (21).

The ages of acquisition of gross motor skills were learned from the families and patient files with the help of a questionnaire including the seven motor development stages. This questionnaire is a short test adapted from the literature which evaluates the stages of motor development and which is regularly used in our unit to learn motor development stages (17). Gross motor skills include the stages of head control in the prone position, head control in the supine position, rotating from the prone position to the supine position, rotating from the supine position to the prone position, sitting independently, crawling and independent walking. Independent sitting is defined as unsupported sitting on the floor on a flat background. For the variable of crawling the quality of crawling has not been questioned. Independent walking was considered as walking 10 steps without the help of another person with or without an assistive device. The average of the ages at which head control in the supine position and in the prone position was acquired was taken and determined as the variable of “head control”, while the variable of “rotating” was determined by calculating the average of the ages at which the ability to rotate from the prone position to the supine position and vice versa was acquired.

The rates of deficits learned from the medical records of the patients included in the study are shown in Table 1.

Statistical Analysis

The ages at which gross motor skills were acquired were expressed as median, the minimum and the maximum values.

Results

The mean age of the participants was 51.92±41.9 months (the min:18; the max: 216). 275 of the patients were female (41%) and 396 (59%) were male. Clinical types of the patients with cerebral palsy were as follows: 625 (93.1%) spastic, 32 (4.8%) dyskinetic, 10 (1,5%) ataxic and 4 (0.6%) mixed type (Figure 1).

Table 1. Rates of accompanying deficits in children with cerebral palsy

	n	%
Hydrocephalus	28	4.1
Microcephaly	5	0.7
Epilepsy	214	31.8
Vision defect	133	19.8
Speech defect	196	29.5
Hearing defect	45	6.7
Learning disability	171	25.4

308 (45.9%) of the patients with spastic type CP were quadriparetic, 162 (24.2%) were diparetic and 155 (24.8%) were hemiparetic (Figure 2).

According to Gross Motor Function Classification System 152 patients (22.7%) had stage I CP, 102 (15.2%) had stage II CP, 11 (16.5%) had stage III CP, 60 (8.9%) had stage IV CP and 246 (36.7%) patients had stage V CP (Figure 3).

According to Gross Motor Function Classification System 148 (23.7%) of the patients with spastic CP had stage I CP, 90 (14,4%) had stage II CP, 105 (16.8%) had stage III CP, 54 (8.6%) had stage IV CP and 228 (36.5%) had stage V CP. In the dyskinetic type group, 1 patient (3.1%) had stage I CP, 7 (21.9%) had stage II CP, 3 (9.4%) had stage III CP, 5 (15.6%) had stage IV CP and 16 (50%) had stage V CP. In the ataxic group, 3 patients (30%) had stage I CP, 5 (50%) had stage II CP and 2 (20) had stage III CP. In the mixed type group, one patient (25%) had stage III CP, one patient (25%) had stage IV CP and 2 (50%) had stage V CP (Figure 4).

The median age at which the patients acquired head control was three months in stage I (the min: 1, the max:9), five months in stage II (the min:1, the max:36), eight months in stage III (the min:2, the max:54) and 12 months in stage IV (the min:3, the max:108). The median age at which the patients acquired the ability to rotate was 7 months in stage I (the min:3, the max:24), 8 months in stage II (the min:4, the max:96), 15 months in stage III (the min: 4, the max: 120) and 24 months in stage IV (the min: 9, the max: 144). The median age at which the patients acquired the ability to sit independently was 9 months in stage I (the min:5, the max:30) and 12 months in stage II (the min:6, the max:120), 24 months in stage III (the min:7, the max:156). The median age at which the patients acquired the ability to crawl was 12 months in stage I (the min:7, the max:60), 18 months in stage II (the min:9, the max:132) and 48 months in stage III (the min:24, the max:144). The median age at which the patients acquired the ability to walk independently was 18 months in stage I (the min:11, the max:60) and 33 months in stage II (the min:24, the max:168). In patients with CP in stage V, gross motor development milestones had not been acquired (Figure 5).

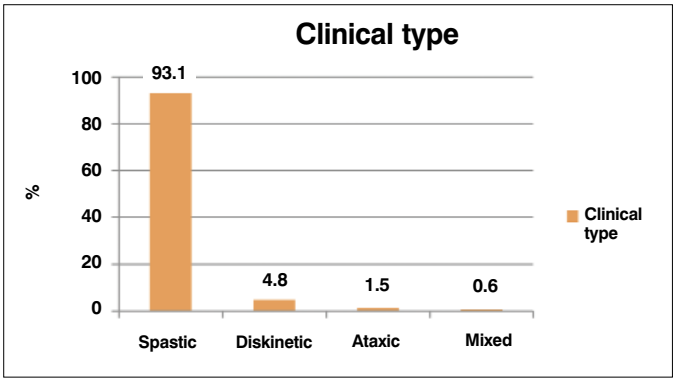

Figure 1. Distribution of clinical types in children with CP

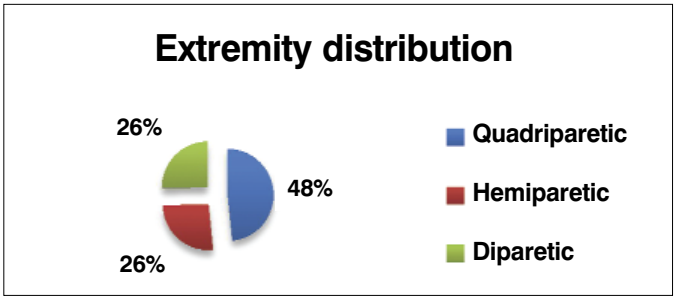

Figure 2. Extremity distribution in children with spastic CP

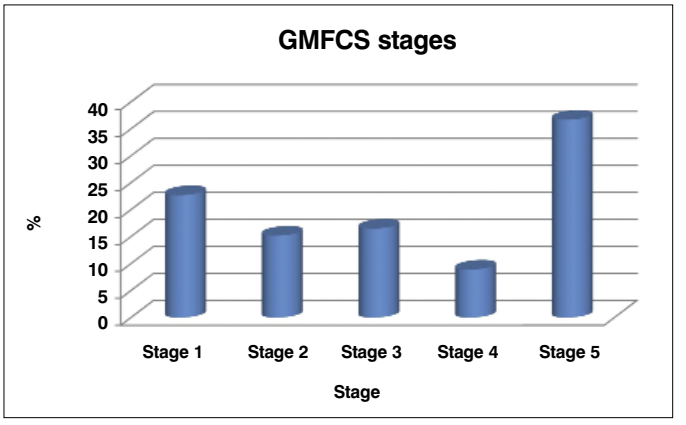

Figure 3. Distribution of the patients by GMFCS

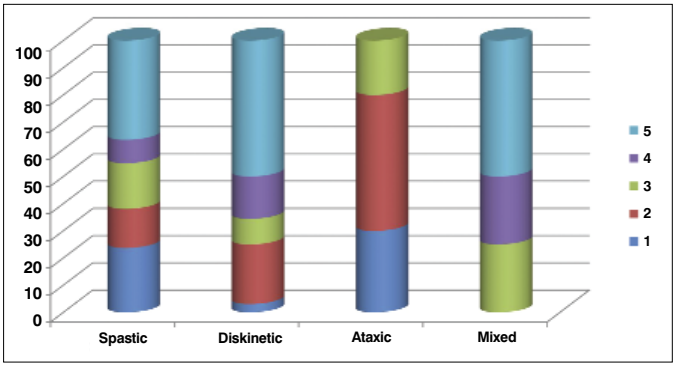

Figure 4. GMFCS distribution by clinical types

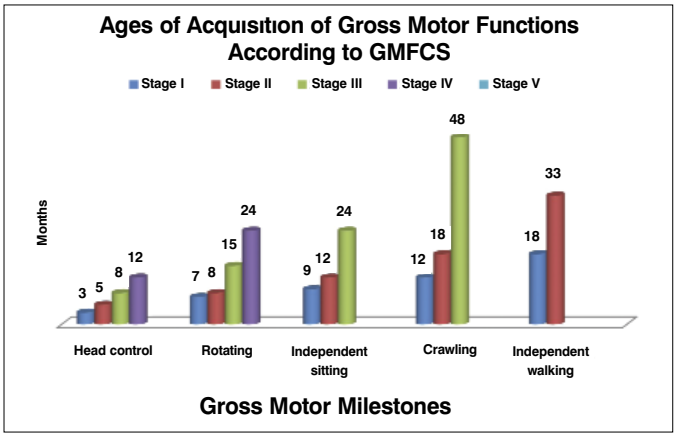

Figure 5. Ages of acquisition of gross motor functions according to GMFCS

Discussion

Timely acquisition of developmental stages is one of the important indicators of neurologic integrity. In addition, diagnosis of developmental delay has an important role in the follow-up of sequential problems. Therefore, evaluation of developmental stages has an important role in evaluation of development. In addition, it provides comprehensible results for families and experts. One of the most important problems in children with cerebral palsy is delay in motor development. The delay can be predicted by evaluation of the age of acquisition of gross motor skills. The aim of this study was to investigate the effect of the age of acquisition of gross motor skills on functional motor deficit in children with CP.

In the literature, there are limited number of studies investigating the ages of acquisition of motor development stages in children with CP. The first publication on this subject we could reach belong to Allen and Alexander (17). In this study, the investigators investigated if the follow-up of the stages of gross motor skills was an efficient method to determine the risk of CP in high-risk premature infants. Conclusively, they found that this method was efficient and practical. When we approach to the present time, we can find studies investigating the ages of acquisition of gross motor skills in different deficit groups. Ireland et al. (23) examined the developmental milestones in children with achondroplasia and found a delay in the ages of acquisition of gross motor skills. Ohmann et al. (24) compared the ages of acquisition of gross motor skills of infants with congenital muscular torticollis with the ages of an healthy group in 2009. They found a significant retardation in the ages of acquisition of motor function in the early period in the infants with muscular torticollis compared to the healthy group. In this regard, we believe our study is one of the first studies demonstrating the importance of follow-up of the ages of acquisition of gross motor milestones in children with CP using objective data and a large sample group in the present time.

The importance of classification of CP which is a heterogeneous group has gradually increased in recent years. Another system which classifies children with CP in 5 stages is GMFCS developed by Palisano and is a practical system. Since motor function of children changes by age, functions were defined for each stage for below 2 years of age, 2-4 years of age, 4-6 years of age and 6-12 years of age. While stage I reflects deficit of the lowest degree, stage V reflects deficit of the highest degree (21,22). In the study performed by Mutlu et al. (26), 26.5% of the patients had stage I CP, 16.8% had stage II CP, 22.8% had stage III CP, 15,6% had stage IV CP and 18% had stage V CP according to GMFCS. In a study performed in Canada in 586 children with CP, 28% of the children had stage I CP, 13% had stage II CP, 19% had stage III CP, 21% had stage IV CP and 19% had stage V CP (21). In our study, more patients had stage V CP in contrast to these studies.

In a normal child, motor, sensory and cognitive integrity are the most important variables of development (26). Damage in the central nervous system is rarely focal. Therefore, delay in motor development may indicate retardation in other areas. Because of "plasticity" in the central nervous system the infant with CP has the potential to improve his/her function (27). Plasticity is the ability of the brain to learn, remember and forget and correct and heal damage. Synaptic connections are increased with activity (28). This configuration is very important in the nervous system which is developing. Special motor learning can be provided by practical and task-oriented education (29). Physiotherapy is effective on motor outcome of the child with CP. Therefore, physiotherapy should be started in the early period in children of 4-24 months of age with a high risk of CP (30). Observation of delay in motor milestones is an efficient and cheap method especially in infants with a high risk of CP (20). Thus, problems which would arise due to delay in motor function can be prevented by early intervention, normal movement and reactions can be facilitated, functional movement ability can be developed, sensory and motor experience can be normalized and education can be given to families (31,32,33).

Allen and Alexander (17) reported that observation of delay in acquisition of motor milestones was effective in demostrating the risk of CP at an early time in high-risk infants. They found that delay with a rate of 35.3-50% was observed depending on the degree of premature birth. They also reported that independent sitting, walking, rotating and crawling were important determinant variables in prediction of CP. However, it was emphasized that clinicians should be careful while evaluating the ability to rotate, since children with CP can rotate at an early time because of abnormal movement patterns (extansor tonus, shoulder rotation) (17). Therefore, use of motor milestones in combination provides superiority, because children with CP have a delay in acquisition of independent sitting, walking and crawling or they can never achieve these abilities, even if they start to rotate at an early time (20). In this study, patients with stage I and II CP acquired the ability of independent walking, whereas patients with stage II and IV could not acquire independent walking, even if they acquired the ability to rotate. This shows the importance of follow-up of the basic gross motor milestones respectively instead of only one motor function during evaluation of gross motor milestones.

Ywonne et al. (34) reported that motor milestones at the age of two (the ability to rotate, sit or stand) were very helpful in predicting the type of CP and future ambulation of blindness. It was proved that basic motor function at the age of two reflected future ambulation prognosis in 3152 children who were observed until the age of 6 among 5366 children with CP. In the study performed by Ywonne et al. (34) , it was confirmed that presence of the ability to sit independently at the age of two was a good indicator of good prognosis of future ambulation. Again, the chance of walking with or without support at the age of 6 was reported to be 50%, if the child could stand at the age of two. It was shown that 76% of children who could both sit and stand at the age of two could walk with and without support at the age of 6. In accordance with the literature, the variables of

rotating, independent sitting, crawling and independent walking (10 steps) were used while interrogating gross motor milestones in 671 patients with CP in this study. Head control was added to these variables. Patients with stage II CP according to Gross Motor Function Classification System acquired the ability to sit independently at the age of approximately 12 months and had the ability to walk 10 steps independently. This showed once again that the ability to sit independently among gross motor milestones was an important determinant in predicting the prognosis of CP. Patients with stage III CP according to Gross Motor Function Classification System can use wheelchair and sit without support. In our study, patients with stage III CP acquired this ability averagely at the age of 24 months. Patients with stage IV and V could not acquire the ability to sit independently and independent walking was not observed in these patient. We believe these data will provide realistic objectives related to the potential of the child for families and rehabilitation teams.

In a comprehensive retrospective study including 657 children with CP, classification between stage 1 and 5 according to GMFCS was reported to be a beneficial method in predicting the ability to walk 10 steps without support. While children with stage I and II have a perfect chance for achieving this milestone, less than half of the children with stage III CP can achive this (11).

In our study, the ages of acquisition of motor milestones of the patients with stage I CP were more close to normal limits, whereas patients with stage V CP could not even acquire the ability of head control fully in the prone and supine position. While children with stage I and II CP acquired all gross motor functions, children with stage III CP could not acquire the ability to walk 10 steps independently. Children with stage IV and V CP were in the CP group with severe involvement, since they had delay in acquisition of gross motor functions or never achieved these milestones. Therefore, the pediatric physiotherapist aims to develop the function of walking with assistive device for a child with stage III CP, whereas he/she would aim to increase the present function to the highest level with use of wheelchair for a child with stage IV and V CP. Conclusively, the age of acquisition of motor milestones delays as the stage of GMFCS increases. This once again showed the importance of evaluation of gross motor milestones in classification of gross motor function and differentiation of the stages more clearly.

In our study, learning the ages of acquisition of gross motor functions from the families made the collection of the data difficult. Another limitation of our study was the fact that the quality of achievement of movements was not considered.

Conclusively, this study proved that the ages of acquisition of gross motor function are important indicators for the prognosis of the child with CP and can help to determine realistic objectives for families in treatment of the child with CP. Studies examining the ages of acquisition of fine motor skills and communication skills should be performed in the future.

Conflict of interest: None declared.

References

1 Bax M, Goldstein M, Rosenbaum P, Leviton A, Paneth N, Dan B, Jacobsson B, Damiano D; Executive Committee for the Definition of Cerebral Palsy. Proposed definition and classification of cerebral palsy. Dev Med Child Neurol 2005; 47(8): 571-576.
2. Mayston MJ. Physiotherapy management in cerebral palsy: an update on treatment approaches. In: Scrutton D, Damiano DL, Mayston M, (eds). Management of the motor disorders of children with cerebral palsy. 2nd ed. Cambridge: Cambridge University Press, 2004: 147-160.
3. Serdaroğlu A, Cansu A, Ozkan S, Tezcan S. Prevalence of cerebral palsy in Turkish children between the ages of 2 and 16 years. Dev Med Child Neurol 2006; 48(6): 413-416.
4. Tuncbilek E. Clinical outcomes of consanguineous marriages in Turkey. Turk J Pediatr 2001; 43(4): 277-279.
5. Surveillance of cerebral palsy in Europe. Surveillance of cerebral palsy in Europe (SCPE): a collaboration of cerebral palsy surveys and registers. Dev Med Child Neurol 2000; 42(12): 816-824.
6. Hagberg B, Hagberg G, Olow I. The changing panorama of cerebral palsy in Sweden 1954-1970. I. Analysis of the general changes. Acta Paediatr Scand 1975; 64(2): 187-192.
7. Odding E, Roebroeck ME, Stam HJ. The epidemiology of cerebral palsy: incidence, impairments and risk factors. Disabil Rehabil 2006; 28(4): 183-191.
8. Rosenbaum P, Paneth N, Leviton A, Goldstein M, Bax M, Damiano D, Dan B, Jacobsson B. A report: the definition and classification of cerebral palsy April 2006. Dev Med Child Neurol Suppl 2007; 109: 8-14.
9. Bartlett DJ, Palisano RJ. A multivariate model of determinants of motor change for children with cerebral palsy. Phys Ther 2000; 80(6): 598-614.
10. Kerem Gunel M. Rehabilitation of children with cerebral palsy from a physiotherapist's perspective Acta Orthop Traumatol Turc 2009; 43(2): 173-180.
11. Rosenbaum PL, Walter SD, Hanna SE, Palisano RJ, Russell DJ, Raina P, Wood E, Bartlett DJ, Galuppi BE. Prognosis for gross motor function in cerebral palsy: creation of motor development curves. JAMA 2002; 288(11): 1357-1363.
12. Hanna SE, Bartlett DJ, Rivard LM, Russell DJ. Reference curves for the Gross Motor Function Measure: percentiles for clinical description and tracking over time among children with cerebral palsy. Phys Ther 2008; 88(5): 596-607.
13. Hanna SE, Bartlett DJ, Rivard LM, Russell DJ. The natural history of gross motor development in children with cerebral palsy aged 1 to 15 years. Dev Med Child Neurol 2007; 49(10): 751-756.
14. Krageloh-Mann I, Bax M. Cerebral palsy. In: Aicardi J, (ed). Diseases of the nervous system in childhood. London: Mac Keith Press, 2009: 210-242.
15. Alexander GR. Gross motor milestones in preterm infants: correction for degree of prematurity. J Pediatr 1990; 116(6): 955-959.
16. Allen MC, Alexander GR. Using gross motor milestones to identify very preterm infants at risk for cerebral palsy. Dev Med and Child Neurol 1992; 34 (3): 226-232.
17. Allen MC, Alexander GR. Using motor milestones as a multistep process to screen preterm infants for cerebral pasly. Dev Med Child Neurol 1997; 39(1): 12-16.
18. Da Paz AC Jr, Burnett SM, Braga LW. Walking prognosis in cerebral palsy: a 22-year retrospective analysis. Dev Med Child Neurol 1994; 36(2): 130-134.
19. Molnar GE, Gordon SU. Cerebral palsy: predictive value of selected clinical signs for early prognostication of motor function. Arch Phys Med Rehabil 1976; 57(4): 153-158.
20. Watt JM, Robertson CM, Grace MG. Early prognosis for ambulation of neonatal intensive care survivors with cerebral palsy. Dev Med Child Neurol 1989; 31(6): 766-773.
21. Palisano R, Rosenbaum P, Walter S, Russell D, Wood E, Galuppi B. Development and reliability of a system to classify gross motor function in children with cerebral palsy. Dev Med Child Neurol 1997; 39(4): 214-223.

22. Wood E, Rosenbaum P. The gross motor function classification system for cerebral palsy: a study of reliability and stability over time. Dev Med Child Neurol 2000; 42(5): 292-296.
23. Ireland PJ, Johnson S, Donaghey S, Johnston L, McGill J, Zankl A, Ware RS, Pacey V, Ault J, Savarirayan R, Sillence D, Thompson E, Townshend S. Developmental milestones in infants and young Australasian children with achondroplasia. J Dev Behav Pediatr 2010; 31(1): 41-47.
24. Ohman A, Nilsson S, Lagerkvist AL, Beckung E. Are infants with torticollis at risk of a delay in early motor milestones compared with a control group of healthy infants? Dev Med Child Neurol 2009; 51(7): 545-550.
25. Mutlu A, Akmese PP, Gunel MK, Karahan S, Livanelioglu A. The importance of motor functional levels from the activity limitation perspective of ICF in children with cerebral palsy. Int J Rehabil Res 2010; 33(4): 319-324.
26. Livanelioglu A, Kerem Günel M. Normal motor development in children. In: Livanelioglu A, Kerem Günel M, (eds). Physiotherapy in cerebral palsy. 1st ed. Ankara: Yeni Ozbek, 2009: 6.
27. Mayston M. People with cerebral palsy: effects and perspectives for therapy. Neural Plast 2001; 8(1-2): 51-69.
28. Johnston MV. Clinical disorders of brain plasticity. Brain Dev 2004; 26(2):73-80.
29. Eyre JA. Development and plasticity of the corticospinal system in man. Neural Plast 2003; 10(1-2): 93-106.
30. Hadders-Algra M. General movements: a window for early identification of children at high risk for developmental disorders. J Pediatr 2004; 145(2 suppl): 12-18.
31. Kerem M, Livanelioglu A, Aysun S. The importance of the early diagnosis and rehabilitation of cerebral palsy. Turkiye Klinikleri J Pediatr 2000; 9(1): 23-27.
32. Gunel MK. Neurodevelopmental therapy approach on pediatric physiotherapy and rehabilitation applying. Turkiye Klinikleri J PM & R-Special Topics 2010; 3(3): 1-7.
33. Kerem M, Livanelioğlu A, Meriç A, Ataş A. Comparison of the effects of rehabilitation based on physiotherapist and home exercise program on motor developmental level in children with cerebral palsy. Turkiye Klinikleri J PM & R 2001; 1(3):167-172.
34. Wu YW, Day SM, Strauss DJ, Shavelle RM. Prognosis for ambulation in cerebral palsy: a population-based study. Pediatrics 2004; 114(5): 1264-1271.