THE MOST COMMON DEVIATIONS IN THE DEVELOPMENT OF HAND MOTORICITY IN CHILDREN FROM BIRTH TO ONE YEAR OF AGE

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SUMMARY – The early child development, from birth until the age of one year is, amongst other changes, characterized by intense motor learning. During that period, the voluntary learning patterns evolve from reflexive patterns to coordinated voluntary patterns. All of the child's voluntary movements present active forms in which the child communicates with the environment. In this communication, the hand plays an important role. Its brain representation covers one-third of the entire motor region, situated in the close proximity to the speech region. For this reason, some authors refer to hand as a "speech organ". According to numerous studies, each separate finger also has a relatively large representation in the cerebral cortex, which points to the importance of the fine motor skills development, or precise, highly differentiated movements of hand muscles following the principles of differentiation and hierarchical integration. Development of the fine motor skills in the hand is important for the overall child development, and it also serves as a predictor pointing to immaturity of the central nervous system. The aim of this paper is to present the development of hand motoricity from birth until the age of one year, as well as the most frequent deviations observed in children hospitalized at Children's Department of Rehabilitation, Clinical Department of Rheumatology, Physical Medicine and Rehabilitation, Sestre milosrdnice University Hospital Center.

Key words: *Child; Developmental disabilities; Movement - physiology; Motor activity; Hand*

Introduction

All of the child's voluntary movements present active forms in which the child communicates with the environment. In this communication, hand plays an important role. Its brain representation covers one-third of the entire motor region[1]. According to numerous studies, each separate finger also has a relatively large representation in the cerebral cortex[2,3], which points to the importance of the fine motor skills development, or the importance of precise, highly differentiated movements of hand muscles governed by the principles of differentiation and hierarchical integration[4,5]. Development of the fine motor skills in the hand is important for the overall child development, but it also serves as a predictor, which points to immaturity of the central nervous system[6-9].

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Anatomically, the hand consists of three parts: the wrist (carpus), the palm (metacarpus) and the fingers (digiti mani). The wrist consists of 8 short bones grouped in two rows, the metacarpus of 5 long bones, while the fingers consist of 15 joints. In the hand area, there is a large number of connections, which not only strengthen the joint capsules**,** but also serve as a guide for executing the movements of the joints. Hand movements are the results of muscle activity[10,11].

The muscles which carry out hand movement are anatomically divided into those that originate in the forearm (15 of them) and those that originate in the anatomical structures of the hand (19 of them). According to their function, they are divided into palmar and dorsal flexors, radial and ulnar abduction muscles in the wrist joint and separate finger joints, as well as flexor and extensor muscles of the fingers. The muscles receive command for movement execution from three nerves: median, radial and ulnar**,** branches of the brachial plexus[10,11].

All hand bones develop by endochondral ossification. In the metacarpal bones of the core, ossification begins to appear only during the first year of life. Diaphyses of the metacarpal bones begin to ossify in the 9th week of intrauterine development, the earliest of which is diaphysis of the distal phalanx in the 8th week, followed by ossification of the diaphysis of the proximal phalanx in the 10th week and of the diaphysis of the middle phalanx in the 12th week. The difference between the metacarpal bones of the fingers and finger joints in relation to other long bones is that hand bones have only one epiphysis. In metacarpal bones, epiphysis appears at the distal end, while in phalanx bones it appears at the proximal end. Epiphyseal cores appear in the second year of life[10,11].

The central event during embryogenesis of the muscles takes place in the 11th week of intrauterine life. In this period, the muscle plates and muscle cylinder formation occurs. This constitutes the prerequisite for establishing the functioning of the muscle. After the 12th week, the muscle structures are completely developed and they contribute to the formation of strong reflex movements. Progress in the development of movements continues after birth as well[12]. The period up to the first year of the baby's life is characterized by intense motor learning, during which the voluntary motions develop from reflex patterns towards greater coordination and precision[13]. This is a result of the central nervous system maturation as well as the muscle and bone growth[12]. Two basic principles, the principle of differentiation and the principle of hierarchical integration, explain how the perfection of utilization of the body muscles occurs. In the differentiation phase from nonspecific, large motions in which many superfluous muscles take part, certain muscles gradually get specialized, and only the ones needed for specific motions remain active. Through repetition, the most useful muscular motions are being perfected as the child gains better control of them. Therefore, for example, when grasping with fingers, at first the entire body, the arm and the hand would participate in the motion, but gradually only hand muscles and fingers remain active. In the hierarchical integration phase, these differentiated motions are assembled into the more complex ones, so for instance, once the child has gained control of the head, torso and arm muscles, he/she would combine these simple motor activities into the more complex ones, such as supporting oneself, sitting, straightening up, etc.[4,5,14].

Subjects and Methods

A total of 111 children diagnosed with dystonia syndrome undergoing diagnostic procedure at the Rehabilitation Department of the Clinical Department of Rheumatology, Physical Medicine and Rehabilitation, Sestre milosrdnice University Hospital between 2009 and 2012 were analyzed in this study. The results were divided into four sets of data: first set on the children aged 3 to 4 months (n=46), second set on the children aged 5 to 6 months (n=22), third set on the children aged 7 to 8 months (n=19), and fourth set on the children aged 9 to 10 months (n=24). Data were obtained from patient history taken by physicians, physiatrist and educator-rehabilitator (former

Table 1. Distribution of study participants according to sex and age (N=111)

	Sex		Age (months)			
	M	F	3-4	5-6	7-8	9-10
Children with dystonia syndrome	58%	53%	46%	22%	19%	24%

special educator), collected during the child's first stay at the Department. Some basic data on the sample are shown in Table 1.

Data analysis

The following variables were created from history data: age, sex, palm supination and palm pronation. Data were analyzed using the SPSS (version 19) software, and the percentage of the results on the palm supination and palm pronation variables was calculated from their frequencies.

Results

Figures 1-4 show the frequencies of the result(s) for the palm supination and palm pronation variables according to age groups.

Discussion

This study showed that in all age groups, a relatively high percentage of children had closed hands, although, in line with regular development for the respective age, the hands should have been open. According to the normative tables of motor development, as observed by a number of authors[15-18], in the 3rd and 4th months the hand is predominantly half-open, and in the 5th month, palmar grasp with extended thumb is already present. In a very large number of children aged 7 to 8 months (73.68% in supination and 57.89% in pronation), the fists were clenched.

Deviation in the phases of development can be considered as a predictor of immaturity of the central nervous system. Continuous clenching of the fist prevents the child from spontaneously participating in manipulative activities making it impossible for

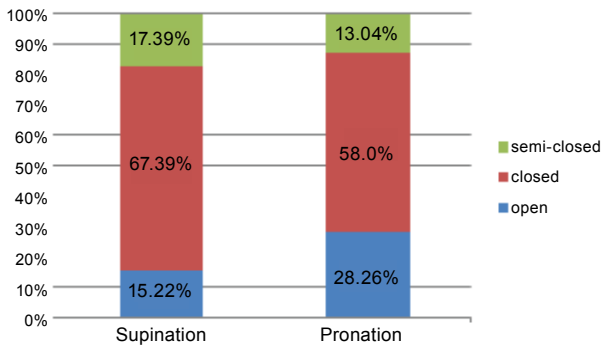

Fig. 1. Results of the palm supination and palm pronation variables from 3 to 4 months of age (n=46).

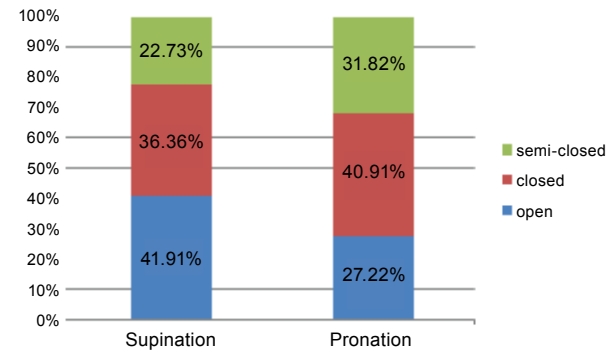

Fig. 2. Results of the palm supination and palm pronation variables from 5 to 6 months of age (n=22).

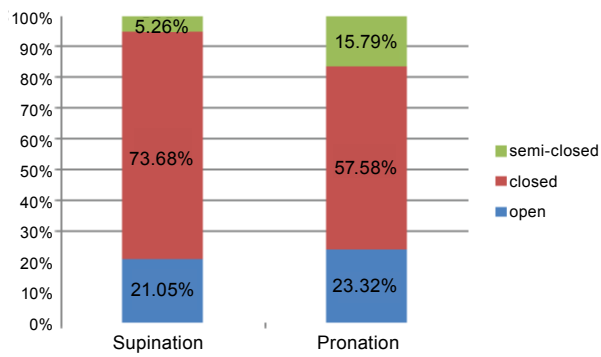

Fig. 3. Results of the palm supination and palm pronation variables from 7 to 8 months of age (n=19).

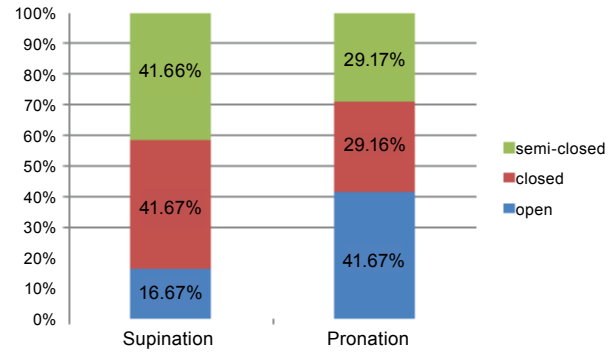

Fig. 4. Results of the palm supination and palm pronation variables from 9 to 10 months of age (n=24).

the child to enjoy and have fun with the movements. If the child's motor skills are well developed, he/she will be more successful in taking part in playing with various toys, as well as later with his/her peers. Poorly developed motor skills bring slowness, clumsiness and insecurity, which can ultimately block out the natural curiosity and slow down the intellectual development[17]. The scientists claim that hand motions are the result of associative connections, which develop during the activity of the visual, audio and verbal-motor system. It has been proven that games and exercises for developing motor skills stimulate the development of speech[19]. Researches of the Russian Academy of Sciences proved the level of speech in children to be directly dependent on the level of the ability to execute the fine motor skills of the fingers. Having conducted a research on a large sample of children, they conclude that speech development is normal if the finger motions match the child's respective age. If the fine motor skills are falling behind, even if the general motor skills develop normally, the speech would fall behind. Formation of the speech centers in the brain is being attained under the impact of nerve impulses in the hands[20]. In compliance with the abovementioned, it is important to prompt the opening of the hand from the early age on, through sensory motor stimulation. In this process, together with the experts, parents have a very important role. They should be advised and educated to practice with the child to open the hand by, for example, stimulating the fingers and the hand *via* gentle massage, by prompting the baby to play with his/her hands, to lead his/her hands to touch his/her own body with full palm, and others. Researches have shown that providing support, education and counseling to the parents and entire family results in better child developmental outcomes[21]. Each child has a maximal capacity for development; therefore, his/her ultimate level of development depends upon the stimuli of the environment. If we have access to a higher number of stimulation ways, the development would reach higher levels[22].

A relatively large number of children (n=46) were admitted to clinical department at 3 to 4 months of age, which reveals an early detection of deviation by the pediatrician-neonatologist. This fact is relevant in the context of the opportune detection of the deficit in order to start the process of early rehabilitation, as well as the most efficient use of the phenomenon of the brain plasticity (the phenomenon of reorganization of neuronal networks in response to environmental stimulation) while avoiding or mitigate the more serious damage to motor skills, to which many authors draw attention[23-28].

Among the data collected, there was no registered admission of children younger than 3 months, which can be explained by the experts' tolerance towards certain deviation during the first two months of the child's life. As cited by Ljubešić, the authors Brazelton and Greenspan indicate that almost 99% of the doctors who notice an early deviation consider that "...it's best to wait and see whether it would normalize on its own"[29]. Researches show that parents themselves are not sufficiently informed about the importance of the early period of the child's life and child's deviations[30]. Education will impact parental competence[31]. On the other hand, the fact that there was no first admission of children aged 11 to 12 months speaks in favor of the practice of early referral of children for detailed diagnostic work-up, that is, in the period between the 3rd and 10th month of age, which is a period when the highest number of children are being diagnosed.

Conclusion

The results of this research contribute to the subject of early detection of deviations in the psychomotor development of children. A relatively large number of deviations in motor development of the hand indicate the necessity of further research into early diagnosis and treatment, within the multidisciplinary team approach and with active participation and education of parents. Moreover, further research is needed to investigate the connection between hand motoricity and development of other areas of development (speech, motor skills, etc.).

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Sažetak

NAJČEŠĆA ODSTUPANJA U RAZVOJU MOTORIKE ŠAKE OD ROĐENJA DO PRVE GODINE ŽIVOTA

V. Matijević, A. Šečić, T. Kauzlarić Živković, Z. Dimić i *J. Borošak*

Rani razvoj djeteta, od rođenja do prve godine života, obilježen je između ostalog i intenzivnim motoričkim učenjem kojim se obrasci voljnih pokreta od refleksnih obrazaca razvijaju u koordinirane voljne pokrete. Svi voljni pokreti djeteta njegovi su aktivni oblici komunikacije s okolinom. U toj komunikaciji veliku važnost ima ruka. Njezina reprezentacija u mozgu zauzima trećinu cjelokupnog prostora motorne regije koja se nalazi u neposrednoj blizini regije za govor. Stoga neki autori ruku nazivaju "organom govora". Kako su pokazale različite studije, svaki prst zasebno također ima relativno veliku zastupljenost u moždanoj kori, što upućuje na važnost razvoja fine motorike, odnosno preciznih visokodiferenciranih pokreta muskulature šake po načelima diferencijacije i hijerarhijske integracije. Razvoj fine motrike šake važan je za cjelokupni razvoj djeteta, a također je i prediktor koji ukazuje na nezrelost središnjega živčanog sustava. Cilj ovoga rada je prikazati razvoj motorike šake od rođenja do prve godine života, kao i najčešća odstupanja koja su zapažena kod djece koja su boravila na Odsjeku za rehabilitaciju djece Klinike za reumatologiju, fizikalnu medicinu i rehabilitaciju Kliničkog bolničkog centra „Sestre milosrdnice".

Ključne riječi: *Dijete; Razvojni poremećaji; Pokretljivost – fiziologija; Motorička aktivnost; Šaka*