Postural adjustments during reaching

Fits, Ingrid Barbara Maria van der

SUMMARY

The aim of the present study is to investigate the neurophysiological mechanisms underlying normal and abnormal development of postural adjustments during reaching movements in infancy. Adequate postural control is essential for our daily functioning. The normal development of postural adjustments facilitates the development of fluent motor performance, of a successful social interaction and communication, and of cognitive abilities. Abnormalities in the development of postural control are frequently reported in preterm children and children with cerebral palsy, but knowledge on the pathophysiological development of postural control is only limited. Still, such knowledge is a prerequisite for the understanding of the effects of current therapeutical interventions and for the development of proper methods to treat postural dysfunctions.

Chapter 2 describes the neural structures which are involved in postural control, and briefly reviews their development. Chapter 3 summarizes the structural development of the central nervous system (CNS), and the motor development in healthy full-term infants, preterm infants and infants with cerebral palsy.

The chapters 4-8 present results of our studies on the organization of postural adjustments accompanying reaching movements. After the study on postural adjustments in adult subjects, we longitudinally studied the development of postural adjustments between the ages of 3 and 18 months in three groups of infants: healthy full-term infants, relatively healthy preterms, and infants with cerebral palsy. During each session we recorded surface EMGs of arm, neck, trunk, and leg muscles while the subjects were placed in various sitting and lying positions. Only in the adult subjects EMG activity was also recorded during stance. Simultaneously, we recorded the whole session on video. In addition, simultaneous kinematic recordings were made in the adult subjects and in an extra sample of healthy full-terms, who were only studied once, between the ages of 9 and 15 months.

The results of the adult study are reported in chapter 4. A remarkable finding was that the adults consistently used a specific movement strategy to perform the arm movement (*i.e.* pointing towards a visible target). Despite identical instructions, half of the subjects started the pointing movement with a flexion of the shoulder while keeping the arm extended throughout the movement. These subjects activated the deltoid (DE) as the first arm muscle. The other subjects initiated the movement with a slight flexion of the elbow after which an elevation and extension of the arm

followed. These subjects used the biceps brachii (BB) as the prime mover. The postural data clearly demonstrated that the organization of the postural adjustments during the unilateral pointing movements depended on the movement strategy. Another important finding concerned the position dependency of the postural adjustments. During stance the dorsal postural muscles (which were consistently activated before their ventral antagonists; direction specificity) were recruited in a caudal-to-cranial order. This means that the leg muscles were activated before the trunk and the neck muscles. But in the various sitting and lying positions this order was reversed. Furthermore, we demonstrated that the postural adjustments depended on a variety of task-specific constraints, such as the arm movement velocity, the position of the pelvis and the trunk at movement onset, and the load of the task. The task-load effects were studied by the performance of two additional series of pointing movements, one consisting of bilateral movements and the other of unilateral movements with an additional weight (500 gr or ± 0.7% of body weight).

Chapter 5 deals with the organization of postural adjustments during the period in which successful reaching emerges in healthy infants. The onset of successful reaching - around 4-5 months - and the development of the accompanying postural adjustments were related more closely to the postmenstrual age of the infants (which is denoted by the number of weeks after the first day of the last menstruatial period of the mother) than to their postnatal calendar age. This suggests that endogenous maturational mechanisms are particularly involved in the development of successful reaching and the accompanying postural activity. Already before reaching resulted in successful grasping, the goal-directed arm movements were accompanied by a high, but variable amount of postural activity. The postural activity already showed the adult characteristics of direction specificity and, in a crude way, the position dependency (lying versus sitting). With increasing age, the amount of postural activity decreased significantly, but the temporal organization of the activity which remained, was more consistently organized in the top-down order than that at earlier ages.

In chapter 6 the normal development of postural adjustments during reaching in infants between 6 and 18 months is described. After the period of low postural activity at 6 months, ample postural activity reappeared at 8 months. From that age onwards the amount of postural activity continuously increased till 18 months. The period of little postural activity around 6 months probably served as a transition phase, as after this transition the ability emerged to adapt the postural adjustments to task-specific constraints, such as the arm movement velocity and the position of the pelvis at movement onset. Between 12 and 15 months a second transition occurred. From 15 months onwards infants developed anticipatory postural control, which was reflected by the consistent activation of one of the neck muscles before the activation of the first arm muscle. Moreover, from this age onwards the infants were able to adjust postural activity to an increased task-load, *i.e.* a small weighty bracelet (56 gr or ± 0.7% of body weight, comparable to the additional weight used in the adult study).

Chapter 7 concerns the development of postural adjustments in preterm infants. At the age of 18 months five infants showed minor neurological dysfunctions, the other seven were neurologically normal. The preterm infants showed a remarkable high amount of postural activity during reaching movements at all ages studied. Furthermore, the postural adjustments were temporally disorganized and could not be adapted to the task-specific conditions. We proposed that the preterms' disability to modulate the postural responses might be related to a reduced capacity to learn from prior experience.

In chapter 8 the results of the study on the postural development in infants with cerebral palsy are presented. Five of the infants developed a spastic hemiplegia, one a spastic tetraplegia and one a spastic tetraplegia with athetosis. In the infants with the 'pure' spastic forms of cerebral palsy the basic organization of the postural responses was apparently intact. The main problem of these infants - like that of the preterm infants - consisted in a deficient capacity to modulate the postural adjustments. This deficit was attributed to a combination of an impaired motor performance and sensory integration. The child with the mixed (spastic-dyskinetic) form of CP showed distinct abnormalities in the basic organization of the postural adjustments. It was suggested that such a fundamental deficit in postural control precluded the development of independent sitting.

In the final chapter (Chapter 9) we reflect on the results our studies. In general, a large variation was present within the postural response patterns accompanying the reaching movements. This large variability can be regarded as a sign of primary variability. The finding that a multitude of postural response patterns is present in all the infants studied, suggests that the primary variability is retained in infants at risk for the development of postural dysfunctions. A common finding in the preterm infants and the infants with cerebral palsy was their disability to adapt the postural adjustments to task-specific constraints, *i.e.* to develop appropriate adaptive

variability. Likely, deficits in the processing of sensory information are involved in the abnormal development of postural adjustments in both groups. We argued that the underlying mechanisms of this deficit differed. This has consequences for treatment of the postural abnormalities in these groups of infants. The postural development in preterm infants might be enhanced by a combination of relaxation and balance exercises. The postural development of children with cerebral palsy might be improved when the infants are placed in sitting devices with a backward tilted seat-surface - providing a biomechanical compensation for the forward directed body sway induced by the reaching movement. Furthermore, explicit afferent cues should be provided in order to facilitate the processing of sensory information in this particular group of children.