Upper Limbs Functional Problems in Different Forms of Cerebral Palsy

9

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9.1 The Child with Bilateral Spastic Cerebral Palsy

In bilateral spastic forms of cerebral palsy (BSCP), different levels of upper limb performances can be observed, as indicated in Table 8.3 of Chap. 8.

Children with moderate/mild impairment (functional levels 2–3, Table 8.3) can acquire basic reaching, prehension, and release patterns. However, it is possible to notice delays and difficulties in acquiring more advanced and mature prehension patterns (e.g., superior pincer grasp with extended wrist), release, in-hand manipulation movements, and bilateral hand use, which may be even more or less limited by the presence of unintended movements in the nonperforming hand (Kuhtz-Buschbeck et al. 2000; Kim et al. 2020).

Generally, these children can access the daily activities of childhood. However, it may be necessary to use the equipment and environmental adaptations, aids, and strategies allowing access to activities of daily life, handwriting, and other school tasks.

In these children with moderate/mild motor impairment, disorders in perceptual-cognitive development and educational achievements may also be present (Yin Foo et al. 2013). Perceptual, visual, and cognitive disorders can affect upper limb use and need to be properly assessed to carry out a realistic functional prognosis and to set up an appropriate rehabilitation project (Henderson and Pehoski 2005; Sigurdardottir et al. 2008; Case-Smith and O'Brien 2019).

On the other hand, in children with severe motor impairment (functional levels 0–1, Table 8.3), the upper limb use is extremely limited or completely impossible. They often tend to use primitive and synergistic patterns of flexion or extension, which can severely limit the functions of daily life.

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Even though access to the daily occupations of childhood will require ongoing support from caregivers, the therapist should highlight and value the child's available functional resources—accepting their deficits—by identifying one or more voluntarily controlled movements, which the child could use functionally. Consequently, it is possible to modify and/or adapt some of the child's daily life activities (ADL), which they can manage to carry out through bypass strategies. In some cases, the therapist can evaluate the use of other parts of the child's body (head, foot, etc.) or of their eye-gaze (Borgestig et al. 2015, 2016) to make them achieve some functional goals.

These children pose significant problems in daily care. They have difficulties in feeding (severe oral control dysfunction), in toileting, in performing their physiological functions (frequent constipation problems), in bathing, in dressing, etc. Therefore, through direct observation in natural contexts and interviews, it is necessary to evaluate the environmental factors (supports and barriers) that can affect daily care. Subsequently, the therapist can set up a rehabilitation project directed to ADL, aimed at supporting the caregivers, identifying and negotiating appropriate handling procedures, e.g., how to dress and undress the child. Often equipment adaptations, ADL aids, and environmental adaptations are needed, to lighten the burden of daily care (Fig. 9.1) (French et al. 1991; Korpela et al. 1992; Hammel 1996; Finnie 2009; Dormans and Pellegrino 1998; Østensjø et al. 2003, 2009; Henderson and Pehoski 2005; Pirila et al. 2018; Case-Smith and O'Brien 2019).

Very often children with severe motor impairment also have communication difficulties, and therefore, it is important to identify communication strategies and support that allow them to guide the adult's care, for example, by communicating their likings and choosing food preferences, clothes, or hairstyles (Fig. 9.2) (Morris and Klein 1987; Millar and Aitken 2003; Beukelman and Mirenda 2013).

"When I look up with my eyes, I am telling you to stop tipping the cup.
When I shake my head and say 'uh-uh', I don't want any more"
(Message added in the Personal Communication Passport, to guide care while drinking, Morris and Klein 1987)

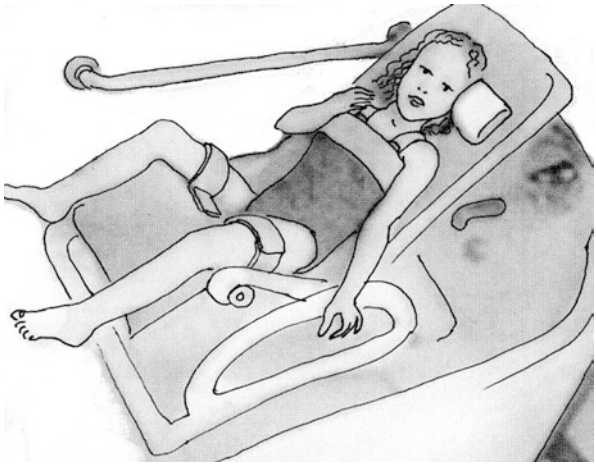

Fig. 9.1 Environmental adaptations and aids, facilitating daily care

Fig. 9.2 Exploiting a communication strategy based on iconic indication with finger or eye-gaze (redrawn from Morris and Klein 1987)

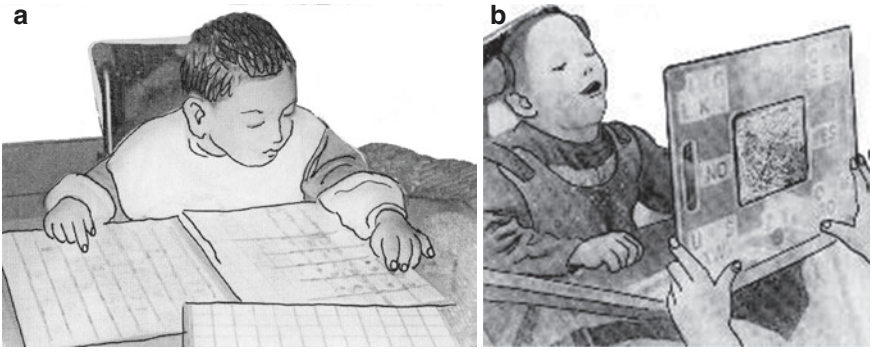

Fig. 9.3 Use of a communication board (**a**) and an Etran board (**b**)

They also have evident limitations in playing. Opportunities to enjoy and progress through the various stages of independent and cooperative play development depend greatly on the support of the caregiver as well as on the adaptation of toys (Pratt and Allen 1989; Case-Smith and O'Brien 2019).

Authors report that between 33 and 88% of children with severe CP impairment have speech and language disorders, such as decreased speech production, poor articulation, and reduced speech intelligibility (Yorkston et al. 2010; Beukelman and Mirenda 2013). These problems require a specific and earl intervention of augmentative and alternative communication (AAC) (see also Chap. 12) (Fig. 9.3a, b).

In severe bilateral spastic forms, there are often perceptual disorders, especially regarding stereognosis and two-point discrimination (Bolanos et al. 1989; Odding et al. 2006; Arnould et al. 2008, 2014; Auld et al. 2011; Ferrari et al. 2014).

Disorders in visual function, such as acuity deficit, oculomotor problems, etc., are common, and the literature shows that from 60 to 70% of children with severe BSCP manifest cerebral visual impairment (CVI), as also described in Chap. 11 (Fazzi et al. 2007, 2009, 2012; Dufresne et al. 2014).

Moreover, many children have an intellectual impairment (Bottcher 2010; Yin Foo et al. 2013; Stadskleiv et al. 2018; Batorowicz et al. 2018).

In children with BSCP, functional performance in the upper limbs is strongly determined by the combination of limitations in various factors, including postural control, reaching, and prehension/manipulation.

9.1.1 Postural Control

The child with BSCP will be more or less able to achieve and maintain independent sitting, the position they will use most frequently for play and during ADL.

The seated posture can be affected by synergistic flexion or extension patterns, by symmetrical tonic neck reflex (STNR), asymmetrical tonic neck reflex (ATNR), and startle reaction.

The child sits with a posterior tilt of the pelvis, with more or less relevant kyphosis, extended lower limbs, shoulder protraction, and internally rotated and flexed upper limbs (Fig. 9.4). In such an unstable position, the upper limbs are often used in support and balance function. When the upper extremities are fixed and used to

Fig. 9.4 Common sitting position of the child with BSCP

help stabilize and control the sitting posture, arms and hands are unavailable to be used for functional tasks.

Therefore, the choice of a personalized positioning system is essential to obtain better alignment and more stable shoulder girdle and to allow for better use of the upper limbs for the various ADLs.

The identification of a positioning system is essential in children with severe motor disabilities because it can improve interpersonal relationship and functional activities, prevent or delay deformities, increase comfort, and, if possible, permit powered mobility (Myhr et al. 1995; Furusamu 1997; Bottos et al. 2001; Stavness 2006; Ryan 2012; Case-Smith and O'Brien 2019) (Fig. 9.5).

Many of these children fail to adapt their body to the seat system because they cannot anchor the pelvis to the chair or cannot dissociate the trunk movements from those of the pelvis. Sometimes they do not even tolerate the sitting system itself for a long time. Therefore, it is important to evaluate the structural features of all components of the system (frame, texture, consistency, etc.) in case of possible perceptual interference.

Multidisciplinary teamwork, together with the caregivers, allows the identification of a positioning system that adapts to the needs of the child. Time is needed together with the caregivers to verify its effects on the child's posture and their functional abilities. In the case of severe impairment, custom-molded systems are often needed (Ward 1983; Noronha et al. 1989; Costigan and Light 2011; Ju et al. 2012; Sahinoğlu et al. 2017).

Fig. 9.5 Seating system

Trunk stability and performances in upper limbs and other parts of the body can also be enhanced through the use of a lap tray with recess, in particular when the lap tray cutout follows the contour of the child's thorax. The lap tray or school desk should be of the appropriate size for the child and adjustable in height and inclination (Fig. 9.6).

Sometimes, it is necessary to set up customized workstations, i.e., sitting posture aid and other positioning components, together with assistive technology (AT) devices. This requires the mounting of these alternative access systems also to allow access to AT systems for communication, playing, and writing to optimize the upper limbs or other body parts performances (Fig. 9.7) (see also Chap. 13).

Children with severe BSCP, especially those with speech impairments or a lack of speech, often tend to trigger total synergistic patterns to communicate, e.g., to express emotions and to declare YES/NO. The positioning system should be designed to minimize these effects, if the main goal is also to let the child acquire early or timely communication strategies through effective tools adapted to their needs (Fig. 9.8) (see Chap. 12).

In younger children, the performance of the upper limb can initially be enhanced also in the prone position or in side-lying (as described in Chap. 2), using various positioning aids, or even sitting the child on a parent's lap or playing in front of a table with a recess (Fig. 9.9).

Fig. 9.6 School desk with a recessed lap tray

Fig. 9.7 Customized workstation with switches activated by a movement of the thigh

Fig. 9.8 Extensor synergy used to communicate

To improve stability, trunk extension, and upper limb performance in children with mild/moderate motor impairment, less complex solutions can be adopted, such as standard wheelchairs and special chairs, sometimes by adapting existing equipment at home or in the classroom. Examples of these adaptions include anti-slip pads applied to the seat, special cushions that abduct the lower limbs, and a pelvic belt to improve the upright posture of the trunk. Even these children can benefit from the use of a desk with recess.

Fig. 9.9 Alternative positioning device to enhance upper limb functioning

In the mildest forms, the use of adapted equipment may be essential to enhance the child's participation in all ADLs. This equipment should also facilitate transfers and access to activities in all the environments of the child's life, e.g., accessible furniture for playing, bedroom adaptations, or choice of table/desk for accessing PC.

9.1.2 Reaching

Inability to maintain a stable sitting position, kyphotic posture, misalignment with shoulder protraction, and internally rotated upper limbs can all negatively affect reaching movements. In children with milder impairment, a predominantly parabolic approach to the target can be observed, and often there are difficulties in bilateral hand use (Koupernik and Dailly 1968; Erhardt 1995; Pratt and Allen 1989; Henderson and Pehoski 2005) (Fig. 9.10).

Reaching movements are possible mainly in front of the child, in a more or less limited area close to their body. They are generally slow and limited in amplitude and require a lot of effort. The child has difficulty crossing the midline, elevating the upper limbs, and accessing the lateral or rear spaces, e.g., to perform many ADLs, such as dressing and toilet hygiene.

In children who show greater impairment in one limb, reaching is carried out with the more efficient arm with different complementary use of the other. Some of them can only rest the less functional limb on the work surface; others can use it for locking an object on the table while others for grasping it with a massive grip.

Sometimes, stabilization and anchoring systems of the "secondary" upper limb can also be proposed to improve trunk and head postural control and promote a better use of the dominant working arm (Fig. 9.11).

In children with severe motor impairment, the persistence of primitive or atypical reactions, and disorders in muscle tone, all have a relevant negative impact on reaching. In these children, this movement is extremely laborious, reduced in

Fig. 9.10 Difficult bilateral hand use

Fig. 9.11 Anchoring system of the "secondary" arm

amplitude, and limited to certain areas of the work surface within a flexion or extension synergistic pattern (Fig. 9.12).

Often only imprecise, limited adduction/abduction horizontal movements and/or flexion/extension of the upper limbs is possible, which greatly restricts access to daily occupations of childhood.

Fig. 9.12 Difficult and limited reaching, with synergistic pattern

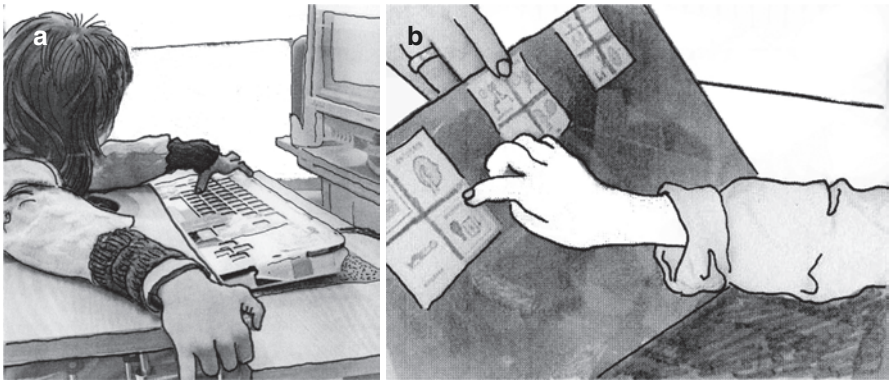

Fig. 9.13 Special work surface to enhance upper limb movements: (**a**) two-tiered desk and keyguard; (**b**) angled lap tray easel

Sometimes, besides special seated systems, a selection of a customed work surfaces is indicated to optimize the functional use of these limited abilities. These include an angled lap tray easel, forearm supports or keyguard, or a two-tiered desk, which allow the child to slide the upper limb on the work surface and play (e.g., move a car or activate a battery-operated toy) or access AT (e.g., computer writing) and AAC system (Fig. 9.13).

It is also extremely important to pay attention to the adequate positioning of the caregiver with respect to the child (e.g., the adult's face at the child's eye level) and the position of all the objects and screens surrounding them (Goossens' and Crain 1992).

Furthermore, it is very important that the child achieves all possible elbow control for a more direct and accurate pointing, as well as the isolation of one finger for

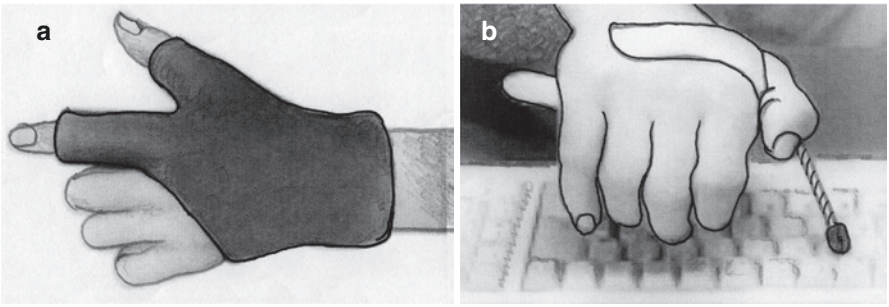

Fig. 9.14 Keyboard access tools: (**a**) special mitten and (**b**) typing aids

direct selection on a communication board, a speech-generating device (SGD) or for typing on the keyboard.

To isolate a finger and to allow typing, keyboard access tools can also be used (Fig. 9.14).

However, when reaching and pointing control are impossible or extremely tiring for the child, it is necessary to consider the use of other parts of the child's body and/or eye gaze (Borgestig et al. 2015, 2016), as alternative access to playing, writing, education, and AAC systems (Pratt and Allen 1989; Henderson et al. 2008; Sadao and Robinson 2010; Case-Smith and O'Brien 2019) (see also Chap. 11). For this, it is necessary to set up an adequate rehabilitation plan, selecting positioning and mounting systems.

9.1.3 Prehension and Manipulation

Prehension difficulties are linked to various factors, such as the child's postural control, reaching modalities, the persistence of primitive or atypical reactions, perceptual disorders, stiffness, contractures, and deformities (Twitchell 1965; Erhardt 1995; Mark Carter 1983; Henderson and Pehoski 2005; Eliasson et al. 2006).

In children with severe motor impairment, prehension is extremely difficult, limited to some objects and using only primitive grasp patterns. Sometimes, it is completely impossible. These youngsters can have considerable difficulty even in hand opening control, due to the grasping reflex, perceptual disorders and limited haptic experiences. Often the opening and closing of the hand are carried out using synergistic patterns.

The child could be able to only hold an object placed in their hand and for a limited time, also needing the objects to have particular features (in texture, weight, dimension, and ease to grip).

Manipulation is not present, and sometimes the child can only use a fisted hand, for example, to make contact with or move objects, press a large key, or a switch linked to a battery-operated toy or a large button in a music box (Fig. 9.15).

Fig. 9.15 Child operating a large key

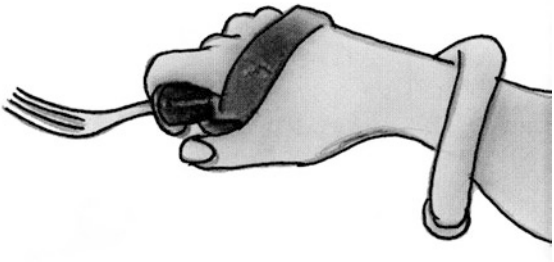

Fig. 9.16 Adapted equipment or orthoses to improve the functioning

Limited use of upper limbs can cause muscle contractures, increasing forearm pronation and wrist flexion, which may over time turn into deformities. It is therefore important to consider more global functional goals and other supporting solutions, such as adaptations of the workstation, adapted equipment, medical-pharmacological interventions, and orthoses, to improve function and limit deformity (Wilton 2003; Morris et al. 2011; Case-Smith and O'Brien 2019) (Fig. 9.16).

Children with moderate impairment can grasp and release objects with different modalities to control the pronation and supination of the forearm and wrist and fingers extension. They can usually grasp large objects using the surface of all finger pads and small objects with three-point or radial pinch, with little differentiation between radial and ulnar fingers (Fig. 9.17).

Manipulation is possible but there are difficulties in dissociating the two upper limb movements.

A milder impaired child can achieve more upper limb function: direct reaching with pre-shaping of the hand, adequate strength and precision of grip, in-hand

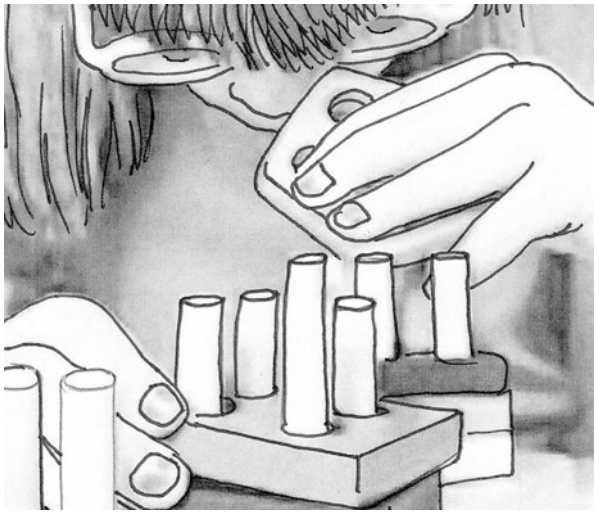

Fig. 9.17 Object prehension using a radial digital grasp

manipulation movements, and coordinated and more differentiated bilateral hand use (Koupernik and Dailly 1968). The therapist should work on the differentiation between radial and ulnar fingers and complex in-hand manipulation movements, e.g. combine translation with rotation and use tools and objects with varied shapes and sizes during ADL.

In the case of moderate/mild disabilities, the need for caregiver engagement is less, as the children can achieve greater autonomy in ADLs, although they often have limitations in more complex activities like fastening of smaller buttons, use of scissors, cutting, and lacing of shoes.

Mastery of the ADL tasks leads to increased self-esteem, self-confidence, and self-determination and gives the child a sense of autonomy. The acquisition of self-care skills in childhood is not only strictly involved in the development of motor skills but also conditioned by perceptual, cognitive, cultural, and environmental factors. Knowledge of the sequences in which typical children become self-reliant in ADLs is invaluable for the understanding of the possible milestones that the child with impairment can achieve (Henderson and Pehoski 2005; Case-Smith and O'Brien 2019).

To set up an appropriate ADL rehabilitation plan, a general and client-focused analysis is required, aimed at examining the essential components and physical requirements to carry out that specific activity and to identify possible intervention opportunities for the child with impairment (Coley and Procter 1989; Spitzer 2019). Based on this analysis, on the previous evaluation of the upper limbs and, if possible, on the observation of the child in their everyday environments, the therapist should use standardized assessment tools to define the goals of intervention for ADL, shared with the child and their family (Gordon 1992; Missiuna and Pollock 2000; Shepard 2019) (see Chap. 8).

In children with functional level 2–3 (see Table 8.3), it is sometimes necessary to propose alternative strategies that allow a more independent life, introducing

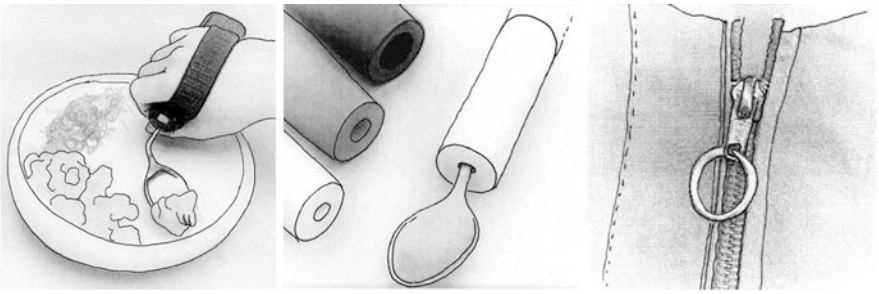

Fig. 9.18 Aids and adaptations to enhance independence in ADL

environmental changes and proposing alternative postures and aids that facilitate function: e.g., self-undressing in a sitting position instead of standing or using handles for toileting. To improve the child's self-feeding, the therapist can select more functional glasses, cutlery, and dishes, and, as support to dressing, they can suggest easy-to-tie shoes or modified clothes to overcome the difficulties in buttoning (Fig. 9.18).

It may also be necessary to identify the most suitable ADL teaching techniques for the child, such as gradually increasing the number of steps to complete an activity or using only verbal instructions, involving and educating their caregivers in these modalities (Klein 1983; Morris and Klein 1987; Shepard 2019).

In adolescents and adults, the aim is to support them to achieve everything essential for independent living and community participation, where necessary with the help of feasible instrumental ADLs (IADL) for the use of public transport, shopping, meal preparation, home management, and employment activities.

The child with mild bilateral spastic CP (level 3) can achieve handwriting. They can have handwriting movements that are slow, tiring, and of limited amplitude. They often hold the writing tools with unorthodox and contracted grips and put considerable pressure on the paper. The handwriting layout appears irregular, slanting, creased, and not fluid (Fig. 9.19).

Some children may need a specific intervention for handwriting, and/or the use of different bypass solutions (see Chap. 8, Sect. 8.3), such as a special pencil holder to enhance the tripod grasp, special notebooks with clearly marked margins, and colored guidelines to facilitate writing in rows, an anti-slip pad (Ajuriaguerra et al. 1964; Klein 1982; Edwards et al. 2002; Henderson and Pehoski 2005; Kim 2016; Case-Smith and O'Brien 2019) (Fig. 9.20).

To promote body stability and better upper limb use on the work surface, it may be advisable to extend the support of the forearms on the surface of the recessed desk.

In the presence of fatigue, excessive slowness, poor readability, and/or numerous written assignments, handwriting can be replaced or supplemented by computer writing or other advanced devices (see also Chap. 13).

In some milder children, the problem of unestablished handedness may emerge, which may affect the development of fine motor skills, particularly handwriting performances (Henderson and Pehoski 2005). Therefore, the therapist should carry out a prolonged evaluation with careful observation of the functional performance

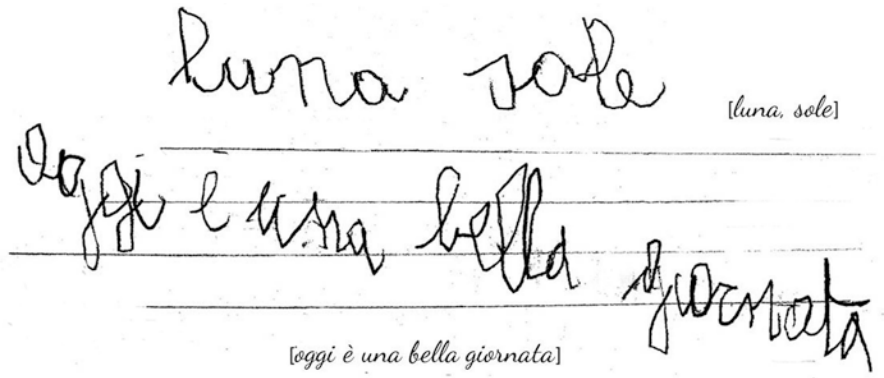

Fig. 9.19 Handwriting layout of two children with mild BSCP

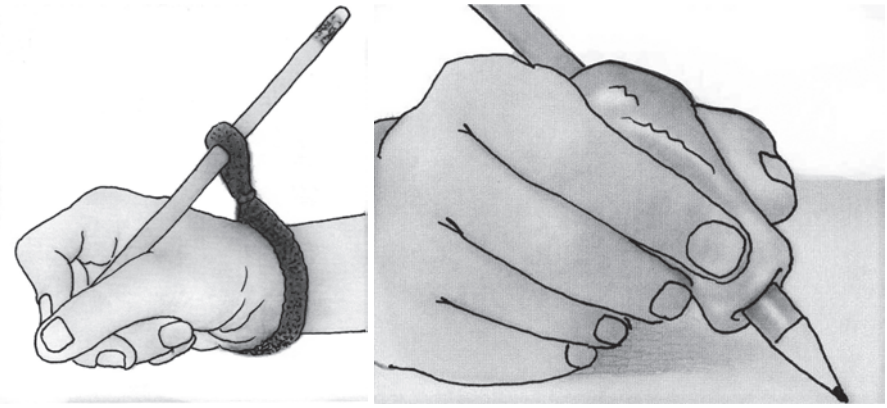

Fig. 9.20 Adaptive handwriting tools

of the two upper limbs and then propose the most efficient hand for writing (Auzias 1975) (see Chap. 8).

9.1.4 Aims of Functional Treatment of the Upper Limb in Children with BSCP

Based on the upper limb functional levels described in Table 8.3, the following aims and treatment modalities are proposed for children with severe (level 0–1) or moderate/mild (level 2–3) impairment. Aims for children with moderate/mild impairment can also be suitable in the rehabilitation plan for children with diplegia.

- **The child with severe motor impairment**
  - *Reaching control: from adduction/abduction horizontal movement control to elbow control. Particularly, enhancing wide-ranging movements toward the*

preferred working area and proximal movements toward the most difficult area to reach
- *Hand use: from hand opening to maintaining/releasing contact with an object (*e.g.*, switch contact and releasing); from only moving objects on a surface to palmar grasp use and, if feasible, to three-point palmar or lateral pinch achievement*
- *Isolation of at least one finger for direct selection on AAC systems or for typing on the keyboard*
- *Bilateral hand use: from the simple maintenance of both upper limbs on the work surface to initial use of a more involved arm to stabilize objects, without grasping*
- *Eye/hand coordination*
- *Functional use of other parts of the body, particularly in severe upper limb impairment*
- *ADLs: caregiver training for positioning, handling strategies, and in the use of ADLs aids*
- *Writing: selection and training of alternative access to computer writing or advanced technology (AT) devices*
- *Play: positioning for play, adapted environment, alternative strategies, and adapted toy use; selecting AT for play*
- *Contractures and deformities prevention/containment, in association with general rehabilitation plan: positioning improvement, task modification, use of orthoses, eventual medical-pharmacological intervention*
- *Assessment and treatment of perceptual disorders*

- **The child with moderate/mild motor impairment**
  - *Reaching and pointing control: control of more precise trajectories, implemented in different postures and planes, with particular attention to midline crossing, to posterior reaching patterns (required for many ADLs, as in dressing and hygiene), prone/supination of the forearm, and the extension of the wrist*
  - *Prehension: from radial pinch to superior pinch with thumb opposition; gradual reduction of ulnar fingers use, in favor of the radial finger one; prehension of objects with various features (*e.g.*, flat, heavy); anticipatory control of the hand*
  - *Release: from control of hand opening with extended fingers to the precise and controlled release, with the increase of wrist extension—on a surface or in space or a small container—of objects of various sizes and features*
  - *In-hand manipulation: from isolated finger movements to the differentiation between radial and ulnar fingers; from finger to palm translation to complex intrinsic movements, combining,* e.g.*, translation with rotation; parallel intervention on tactile and proprioceptive awareness/discrimination*
  - *Bilateral hand use: from less proficient hand use in stabilizing (without or with grasp) function to bilateral simultaneous and differentiated hand use, even with smaller objects*

- *Handedness: investigate any problem of unestablished handedness, particularly in choosing hand for handwriting; related intervention, if necessary*
- *Handwriting: handwriting rehabilitation intervention, if necessary; training in computer writing*
- *ADLs: facilitation of functional strategies; environmental and equipment adaptations (*e.g.*, bathroom, classroom), ADL aids choice; caregiver training; IADL aids for adolescents/adults*
- *Assessment and intervention on perceptual disorders, if needed*

9.2 The Child with Unilateral Spastic Cerebral Palsy

In the hemiplegic child, the effective use of the arm and hand to reach, grasp, release, and manipulate objects is often compromised. The upper extremity is usually affected more than the lower extremity, in 40% of cases according to Uvebrant (1988) and in 30% of cases according to Beckung and Hagberg (2002).

Hand impairment depends on several factors, including the severity of paresis, the extent of sensory loss, the degree of stiffness or spasticity, and in some cases on cognitive disorders (Twitchell 1958; Uvebrant 1988; Cioni et al. 1999; Brown and Walsh 2001; Niemann 2001; Hoare et al. 2018). Different levels of hand impairment and different levels of bilateral hand use can be observed, which can differently affect functional independence and quality of life (Beckung and Hagberg 2002; Eliasson et al. 2006; Rosa-Rizzotto et al. 2014).

In children with unilateral spastic cerebral palsy (USCP), and particularly in severe cases, there are often upper limb perceptual disorders, especially concerning stereognosis and two-point discrimination (Bolanos et al. 1989; Yekutiel et al. 1994; Gordon and Duff 1999; Brown and Walsh 2001; Krumlinde-Sunddholm and Eliasson 2002; Fedrizzi et al. 2003; Odding et al. 2006; Kinnucan et al. 2010; Auld et al. 2011). Some authors also report sensory impairment in the unaffected hand (Lesny et al. 1993; Cooper et al. 1995).

Many studies report problems, such as hemianopia, visual hemiagnosia, hemiasomatognosia, and visual hemi-inattention, that need careful evaluation and sometimes a specific intervention (Fazzi et al. 2012; Dufresne et al. 2014; Philip et al. 2020).

The incidence of intellectual disability is lower than in BSCP and to a different extent (Cioni et al. 1999; Niemann 2001; Hoare et al. 2018). It is related to other features, such as epilepsy and language and visual problems (Cohen Levine et al. 1987; Vargha-Khadem et al. 1994; Bates et al. 1999; Salam et al. 2016; Stadskleiv et al. 2018; Blair et al. 2018).

Generally, these children can access the daily occupations of childhood, and, as adults, many are fully integrated into society after regular academic education and vocational training. Therefore, according to the suggestions of the International

Classification Functioning (ICF), the most general rehabilitation goal is promoting functional activity and the person's full participation in all aspects of life (Rosenbaum and Stewart 2004; WHO 2007).

9.2.1 Assessment of the Upper Limbs in USCP

To set up an adequate rehabilitation plan, it is necessary to assess both the prehension skills of the child and the spontaneous use of the affected limb in playing and in ADLs. Several standardized tools for functional assessment of prehension, manipulation, and daily life activities can be used (Gilmore et al. 2010; Klingels et al. 2010; Lemmens et al. 2012) (see Chap. 8) to assess the extent of spontaneous use of the affected hand and its involvement with the other hand.

Clinical experience suggests the use of the Besta scale (Rosa-Rizzotto et al. 2014), which was developed in 1985 to assess the quality of grasp (hand function on request) and spontaneous hand use (bilateral manipulation) in the child with USCP.

In the rehabilitation setting, this tool is a reliable method to follow-up and monitor the clinical evolution of unimanual and bimanual manipulation, to distinguish capacity from performance as suggested by ICF, and to identify the appropriate interventions in the short and long term (Fedrizzi et al. 1994, 2003; Rosa-Rizzotto et al. 2014).

The Besta scale considers three domains: (a) assessment of the grasp function of the impaired hand, (b) assessment of spontaneous use in bimanual manipulatory activities, and (c) assessment of spontaneous use of the impaired hand in ADL. A score from 0 to 3 is assigned for each domain, defined as follows:

(a) Grasp assessment:
  0: grasp absent
  1: palmar grasp
  2: whole-hand, radial, or three-finger grasp
  3: pincer grasp
(b) and (c) Spontaneous use in bimanual activities:
  0: no use of impaired limb
  1: use of an impaired limb (not hand) in a stereotyped pattern (wrist support) for holding
  2: cooperation of the impaired hand by holding with a restricted number of stereotyped patterns
  3: cooperation of the impaired hand by holding and manipulation, using a varied repertoire of patterns

Grasp function on request is assessed by using three cubes of different sizes (side measurements 4, 2.5, and 1 cm) and a marble. The unaffected hand is evaluated before the impaired one because it could often have subtle deficits as well (Gordon et al. 1999).

Spontaneous hand use in bimanual activities during playing and ADL is then assessed. The play and the ADL proposals have been standardized to age range (four tasks for each age group) and to play material that necessarily involves both hands use.

Based on the assessment of the grasp function on request, children with lower scores (score 0–1) show a severe upper limb motor deficit. Those with high scores can grasp objects with different grip patterns, from radial pinch to three-point pinch (score 2) and superior pinch (score 3).

Based on the assessment of the impaired hand spontaneous use, children with lower scores (score 0–1) have absent or severely limited impaired hand use in bilateral manipulatory activities. Those with high scores (score 2–3) spontaneously use the impaired hand in bilateral manipulatory activities with a more or less stereotyped pattern.

However, in younger children, more informal observation of possible perceptual disorders may be carried out, as suggested below.

Tips for an Informal Observation

- How does the child spontaneously use their affected hand? (Do they try to use it, to bring it to the mouth, suck finger, or leave it unused, against the body, or under the table?)
- Does the child look at their affected hand?
- Does the child turn their head and explore all the space around them or focus only on the unaffected side?
- Does the child accept that you put an object in their palm and that you touch their impaired hand?
- Does the child forget small objects inside the hand while playing, like bits of paper or crumbs, for example?
- How does the child react to caresses, tickles, or touches; to flowing water or to a blow on their hand; to a "sting" made for fun with the tip of a pencil; and to a toy car moved for fun on their affected side?
- Are there differences in the various parts of the arm and hand?
- Does the child use their affected hand in bimanual activities and in bimanual gestures (e.g., stretches their arms toward parent or claps their hands)?

9.2.2 Stereognosis

The evaluation of the upper limbs should therefore be completed by the evaluation of perceptual disorders, particularly stereognosis, as well as visual functions, muscle retractions, and RoM limitations.

Stereognosis is assessed first in the unaffected hand and then in the affected one and usually at the age of 5 because younger children often do not cooperate

or lack the necessary attention. The literature agrees on the characteristics of the objects, which should be familiar and of different shapes and materials, but the type of objects is not specified. Some studies use different objects, like a small ball, money, combs, toothbrushes, keys, etc. (Tyler 1972; Van Heest et al. 1993; Yekutiel et al. 1994), and other studies assess stereognosis by identifying shapes (Bolanos et al. 1989) or a combination of familiar objects and shapes (Cooper et al. 1995).

Examples of Different Sets of Objects Used to Assess Stereognosis

- Tyler (1972): two-inch diameter rubber ball, five-inch plastic spoon, two-inch metal car with movable wheels, three-inch plush stuffed dog, one-inch toy plastic chair, penny, one-inch plastic button with four holes, ticker than the penny
- Van Heest et al. (1993): block, pencil, little spoon, paper clip, safety pin, penny, button, pill, glove, string, marble, key
- Krumlinde-Sunddholm and Eliasson (2002): a LEGO[1] brick and an eraser, a wooden bead and a paper pellet, a coin and a shirt-button

The worsening of hand function in some children after the age of 11 years might be attributed to limb growth and to increased retraction of wrist tendons.

Further differences emerge between the methods used because, in some assessments, children are allowed to look at and touch objects before the test, and in others they are not. Other times, the task is to match the object with a corresponding visible object or with a photograph; others ask the child to verbally describe or name the object (Bolanos et al. 1989; Yekutiel et al. 1994; Fedrizzi et al. 2003).

For the assessment of stereognosis, each object is placed separately into the child's hand, shielded from vision behind a screen or a piece of cardboard, helping the child to manipulate and explore them if necessary. In Fig. 9.21, there is an example of a commercially available tool.[2]

Stereognosis was assessed in 25 of the 31 children at a mean age of 4 years 4 months. The other six children did not cooper ate sufficiently at this age to perform the test. All 25 children recognized the 5 objects with the unaffected hand: 13 were able to identify all the objects with the affected hand, and the other 12 children had astereognosis. Stereognosis in relation to the affected hand function is shown in Table I. Of the 13 children who identified all objects in the stereognosis test, none had a score of 0 or 1 on grip and use assessment; furthermore, all used the affected hand in bilateral manipulation activities: five used it to hold (score 2) and eight used the fingers to manipulate (score 3). By contrast, none of the 12 children with astereognosis scored 3 on either grip or spontaneous use.

[1] LEGO System A/S, Billund (DK), https://www.lego.com

[2] Officina Ortopedica Ferrero Srl, Venaria Reale (IT), http://ferreromed.it

Fig. 9.21 Device for the stereognosis assessment

9.2.3 Postural Control

Regardless of the level of impairment in the lower limbs, the child achieves autonomous independent walking, with a lot of variability in their motor behavior depending on the task to be achieved. The therapist should observe the child in their daily life environments and evaluate their behavior, as well as the characteristics of the equipment used (chairs, tables, etc.), suggesting to the family any changes, if necessary.

For infants, commercially available seats or postural systems can be suggested, to facilitate a better postural alignment and allow more involvement of the affected limb in the midline, within their visual field, for example placing a little cushion behind the child's scapula. The supported sitting position is useful to facilitate eye-hand-mouth coordination and the integration of the two sides of the body to favor the development of the interior mental body image.

The child with USCP can have the advantage of sitting in stable chairs of adequate height already in use in the home and school environments. Adaptations can be added, such as small anti-slip wedges applied to the seat to improve the distribution of weight-bearing. In preschool and school children, particularly those with severe upper limb deficits, a recessed table is very useful to favor forearm support on the work surface and allow better visual control and bimanual hand use (Kavak and Bumin 2009).

During the training to achieve some selective activities, such as self-feeding or writing, the therapist could also propose the use of anchoring systems of the affected arm, to promote a better postural alignment.

Moreover, to facilitate the affected arm function in playing and in ADLs, it may be necessary to reorganize the environments of child's daily life, for example, to

rearrange the child's room with shelves and desks of adequate height or selecting sinks in the bathroom, which allow better arm support, or utilizing adaptive equipment such as soap or toothpaste dispensers (Fig. 9.22).

9.2.4 Prehension

Many studies focus on the different levels of impairment regarding prehension ability in children with USCP (Uvebrant 1988; Eliasson et al. 1991; Sugden and Utley 1995; Kuhtz-Buschbeck et al. 2000; Fedrizzi et al. 2003; Holmefur et al. 2009; Pagliano et al. 2001).

Referring to the scoring system used by the previously cited Besta scale, in children with a score of 0 prehension is impossible. However, in some cases, the child will try on request to grasp the proposed items between the side surface of the thumb and index finger. Other children try to grasp with a half-opened hand and extended fingers. There is no thumb opposition, the forearm is generally semi-pronated, the elbow is flexed, the wrist is flexed in ulnar deviation, and the hand is closed.

During assessment of grasp on request, children with score 1 can use a digital palm grip, blocking the object with thumb adduction against the palm, or use a multi-digital grip with extended fingers, i.e., blocking a small object between the fingers. This object should be "easy to grip," be placed near the child's body, and has particular features, like be lightweighted, soft, and medium-sized. The prehension and release of the object is usually carried out using synergistic upper limb flexion and extension patterns. Furthermore, many authors report that children with scores 0–1 not only have hand impairments but also significant perceptual disorders (Van Heest et al. 1993; Cooper et al. 1995; Kinnucan et al. 2010).

Children with moderate motor impairment, i.e., with a score of 2, can grasp objects with radial (Fig. 9.23) or three-point grip. The thumb is usually adducted or in some cases in opposition with the middle finger; the wrist may have different

Fig. 9.22 Sink with large forearm support

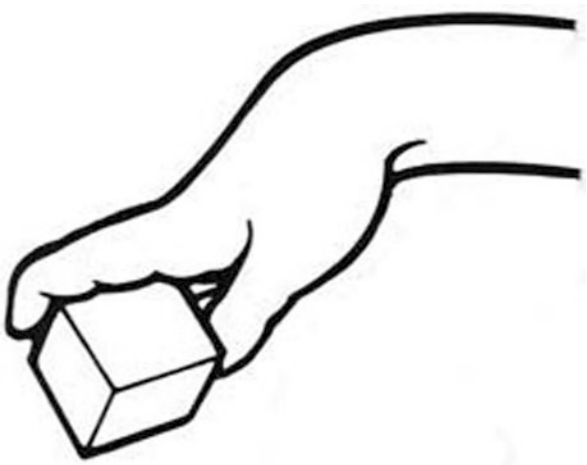

Fig. 9.23 Radial grip with wrist flexion (redrawn from Erhardt 1995)

RoM of flexion and ulnar deviation, with some simpler in-hand manipulation movements, e.g., simple rotations. The resulting lack of experience can possibly lead to stereognosis disorders.

Children with mild impairment, i.e., with a score of 3, can use various power and precision grips, such as lateral and superior pinch, and their thumb can be opposed. The child can pre-shape the hand in relation to the features of the objects and accurately release them on both on a surface and into a small container (Eliasson and Gordon 2000; Gordon et al. 2003). Pronation-supination of the forearm is possible, and the wrist can be in a neutral position or extended. More complex in-hand manipulation movements are possible, and therefore these children do not have major stereognosis disorders (Fedrizzi et al. 2003; Kinnucan et al. 2010.)

9.2.5 Bilateral Hand Use

Already in the first months of life of a child with USCP, it is possible to observe asymmetry in postural organization and active movements of the upper limbs (see also Chap. 3). Difficulties are noted when the child brings both hands to the mouth to explore them when fingering or reaching for objects on the midline (Fig. 9.24). Very often, parents or grandparents are the first to notice these postural and functional asymmetries.

In children with moderate/mild impairment, symmetric reaching can be observed early on, but as soon as the unaffected hand reaches the object faster and more effectively, there is a progressive reduction in the use of the affected hand.

Over time there is a continuous maturation in the functional use of the unaffected hand to the detriment of the impaired one, and a reduced spontaneous use of the affected arm and hand can be observed during bimanual activities (Kuhtz-Buschbeck

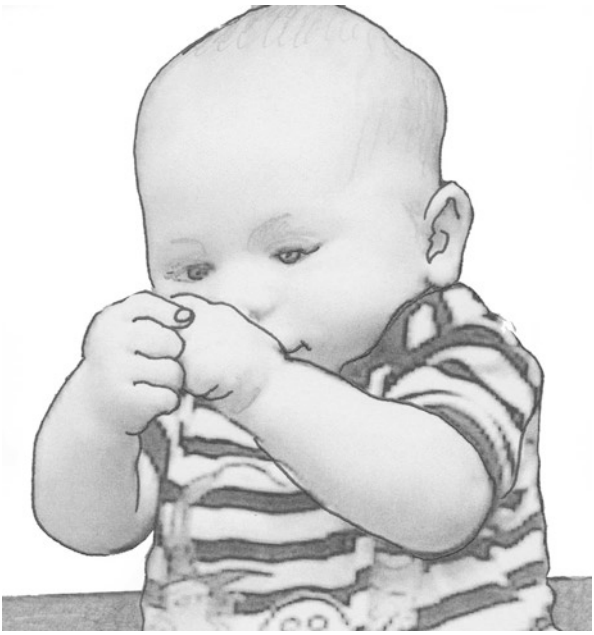

Fig. 9.24 Bilateral hand use in a child with mild USCP impairment

et al. 2000; Beckung and Hagberg 2002; Eliasson et al. 2006; Rosa-Rizzotto et al. 2014).

Children with severe unilateral impairment have extremely limited or no use of the affected arm and become increasingly skilled at performing bimanual tasks, such as drinking, using a fork, combing, etc., by using more and more the most efficient hand. This is the beginning of neglect of the affected arm (Taub et al. 2004, 2006; Aarts et al. 2010; Fedrizzi et al. 2013).

Seated in front of a table, the child with 0 score often leaves the affected arm under the table and does not use it for simple tasks, like blocking/holding objects, even when the limb is in their visual field.

In other cases, i.e., in children with a score of 1, the affected upper limb is used in a synergistic pattern with the aim of carrying out simple tasks, like moving a toy car on the table or blocking an object by bringing the upper limb to the chest or mouth.

The child with moderate impairment and a score of 2, even only with a limited number of stereotyped patterns, can spontaneously use their upper limb particularly in bimanual tasks, such as blocking an object on the work surface or holding medium-sized objects (Fig. 9.25). The bimanual activity can also be affected by the presence of involuntary movements in the unaffected hand (Kim et al. 2020; Kuhtz-Buschbeck et al. 2000). Difficulties in stereognosis recognition tasks can be observed also if with a limited number of stereotyped patterns.

The child with mild impairment and score 3 spontaneously involves the affected hand in bimanual activities using a varied repertoire of patterns, and in-hand manipulation movements of medium complexity are possible. The child can manipulate

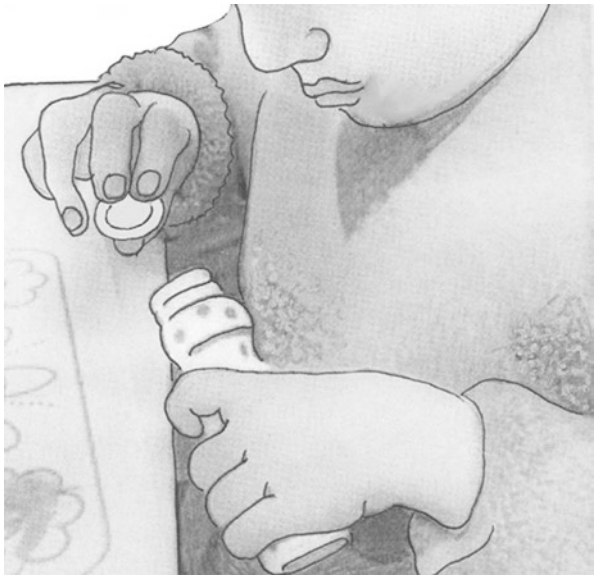

Fig. 9.25 Spontaneous use of the affected hand to hold an "easy to grip" object

small objects, such as medium-sized and small beads, with both hands and can switch them from one hand to the other even without visual control. Generally bimanual activity is not disturbed by involuntary movements of the unaffected hand, and no stereognosis disturbances have been reported (Fedrizzi et al. 2003; Kinnucan et al. 2010).

The main goal of upper extremity rehabilitation in the child with USCP is to reach functional independence in ADLs by improving bimanual skills.

Intervention should start early from the first months of life and be implemented continuously and intensively until school age, because the greatest improvements are obtained during this period, and they generally last over time. Several studies have reported that the intensity of treatment and coaching to parents are the most important factors to facilitate the learning of new strategies and to improve the quality of the hand use (Hanna et al. 2003; Charles and Gordon 2006; Holmefur et al. 2009; Gordon 2011; Akhbari Ziegler et al. 2019).

During daily handling, the caregiver can promote early sensory experiences for both "hemi-sides" of the child's body, to improve the reception of visual, tactile, and proprioceptive inputs of the affected limb and to seek its integration into the body schema (Nuara et al. 2019).

To encourage the child's visual contact toward space on their impaired side, therapists and caregivers should pay attention to where toys and other interesting objects are positioned with respect to the child. For the same reason, adults should also remember to enter the child's visual field from their most problematic side. Another possible suggestion to the family is to rearrange the child's bedroom, for example, orienting the cot/bed in such a way the child is attracted to look at interesting toys or light from windows (Finnie 2009) (Fig. 9.26).

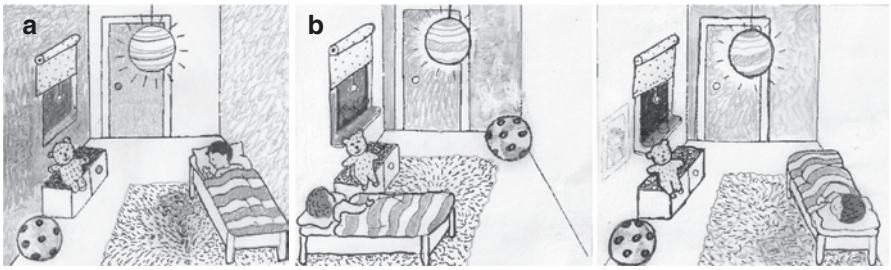

Fig. 9.26 (**a**) Inadequate sleeping position for a child with right hemiplegia; (**b**) Adequate sleeping position (redrawn from Finnie 2009)

Fig. 9.27 Handwrist baby rattle

To promote the child's interest in the affected arm, as well as eye-hand-mouth coordination, it is useful to offer toys with different properties (tactile, visual, auditory) or use a handwrist baby rattle, equipped with bells, pets, and even lights (Fig. 9.27). It is also important to encourage exploration of the face, facilitating the child's hand to reach and touch their mouth, nose, and head. With a toddler, caregivers can propose play with the finger colors, water, sand, and beans.

Involvement of the affected arm/hand in their daily routine activities is also important, for example, during feeding, toileting, and hygiene, even using commercially available adapted equipment (Finnie 2009; Case-Smith and O'Brien 2019). During bathing, the toddler can be washed with different kinds of sponges and can play with water or with floating objects to stimulate them to use both hands (Fig. 9.28).

Fig. 9.28 Floating toys in the tub, during bathing

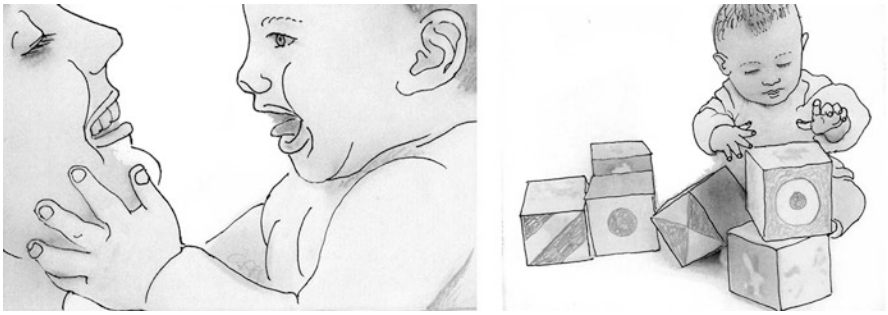

Fig. 9.29 Baby games and toys that promote bilateral hand use

It should be remembered that, during un/dressing of the child with USCP, there is a specific procedure to follow where the impaired arm (or leg) is always the first to be involved in the functional sequence: during dressing, the first arm to be brought forward is the impaired one, and vice-versa during undressing.

Parents offer to the infant baby games and toys of different sizes and tactile properties, proposing play activities to promote bilateral hand use (Fig. 9.29).

These games and toys have to gradually adapt to changes in the child's interests, to play development, and to their acquisition of functional abilities, e.g., by selecting toys suitable for the size and other features that enhance bimanual use (Fig. 9.30).

Already from the first year of the child's life, the presence of parents and caregivers at the rehabilitation treatment is important because they need to be able to understand the child's difficulties and therefore pay attention to their postural orientation, the criteria for choosing toys, and the modalities to propose them.

In preschoolers with moderate/mild impairment, two of the main goals are fine motor skills development and the use of the affected hand in more complex and differentiated bimanual activities. Through play activities, related to the child's mental development, the therapist can promote, where possible, the pre-shaping of the hand, according to the object's features, the differentiated power and precision

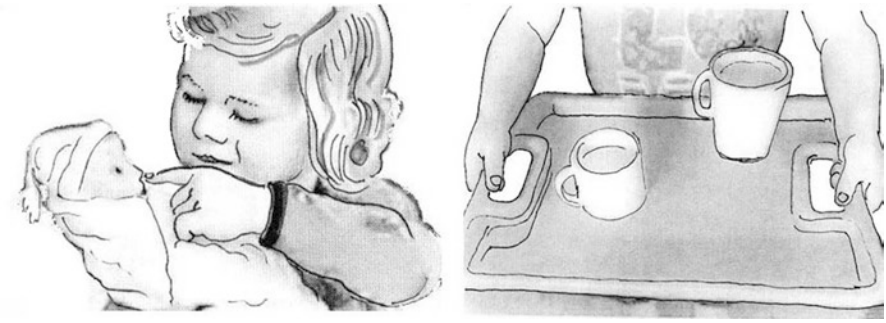

Fig. 9.30 Toys and games that promote bilateral hand use

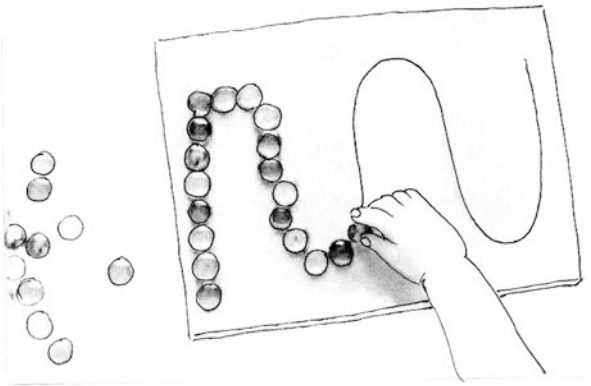

Fig. 9.31 Play activity for fine motor skill development

grips, the release, the finger singularization, the distinction of use of the radial and ulnar fingers, and the in-hand manipulation movements, while simultaneously refining various tactile discriminatory skill.

These goals can also be achieved by using commercially available toys that require fine motor skills but also crafted toys, created with everyday objects that can be easily found in the family environment (Fig. 9.31).

In children with severe motor difficulties, the main goal is to involve the impaired hand as an auxiliary to the unaffected one during ADLs: for example, involving the affected hand in blocking a sheet or in a holding function, such as to unscrew the lid of a jar or holding the play dough to break into small pieces with the unaffected hand.

To promote a more functional bimanual activity, adults can suggest to the child alternative ways of fixing objects, e.g., locking objects against the trunk or inserting them between the fingers. If possible, they can also try to improve the involvement of the affected limb, promoting horizontal adduction/abduction movements in some play activities, such as coloring with finger colors, or the palmar/interdigital grip use, identifying, also together with the child, feasible ways to open their hand.

In some cases, it could be necessary to consider, the prescription of orthoses and/or medical-pharmacological interventions within the rehabilitation plan in order to

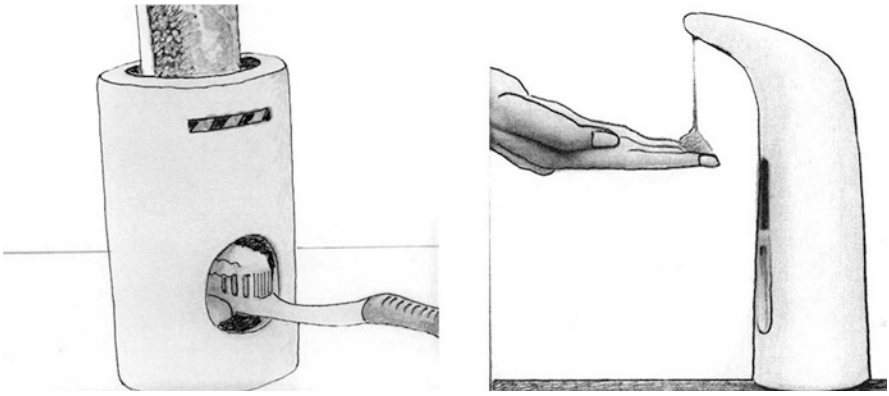

Fig. 9.32 Adapted equipment for one-hand use

improve function and prevent or reduce deformities (Wilton 2003; Burtner et al. 2008; Morris et al. 2011; Case-Smith and O'Brien 2019).

9.2.5.1 ADLs

Based on the functional ability level of the child, the therapist should carry out a further evaluation regarding the ADLs, focusing on goals shared with the child and/or their family, and feasible both in the short and long term (Shepard 2019; Spitzer 2019). Depending on the age and level of impairment, they can also identify and agree on possible compensations, using bypass strategies or modifying equipment to allow one-hand use, e.g., folded toilet paper, toothpaste, and soap dispenser (Fig. 9.32) (Klein 1983; Morris and Klein 1987; Pratt and Allen 1989; Finnie 2009; Missiuna and Pollock 2000; Spitzer 2019; Case-Smith and O'Brien 2019).

As in the BSCP form, the therapist should suggest step-by-step facilitation techniques for ADL not only to the child but also techniques which involve parents and caregivers (Klein 1983; Morris and Klein 1987; Shepard 2019).

Adolescents and adults may need periodic reassessment to evaluate not only ADLs but also IADLs, because sometimes previous functional strategies need to be updated, such as, for example, to address the needs of a new job.

Adolescents with USCP can often be stressed out by attending rehabilitation services for a long time, especially if the rehabilitation goals are not constantly verified and updated. Because of this, they *be quite upset,* and so, for this reason, many authors underline the importance of adapting therapy to life rather than having the young person's life adapt to therapy (Scrutton 2001; Goodman and Yude 2001; Fedrizzi et al. 2003; Skold et al. 2004; Blank et al. 2012).

From the early years of life, these youngsters can be encouraged to engage in sports and play activities, such as swimming, volleyball, horseback riding, canoeing, or skiing, to promote not only motor skills but also social interaction.

9.2.5.2 Handwriting

The child with USCP acquires handwriting because they spontaneously use the unaffected hand.

However, sometimes, due to arm dominance or to sensory-perceptual-motor and cognitive problems, there may be writing that need to be carefully evaluated early on and sometimes require a specific intervention. In these cases, it is possible to observe tactile-sensory impairment, bilateral incoordination, visual and spatial perception, as well as lack of speed and dexterity (Kavak and Bumin 2009; Bumin and Kavak 2010). Occasionally "assisting hand" anchoring systems or stabilizing solutions for books and notebooks can be used, for example, anti-slip materials or magnets.

Moreover, due to the child's fatigue, excessive slowness, or any associated reactions in the affected limb, handwriting can be combined with computer writing to overcome these difficulties.

9.2.6 Aims of Functional Treatment of the Upper Limb in Children with USCP

- *Intervention for perceptual aspects: early sensory experiences during play and daily handling, to integrate visual, tactile, and proprioceptive inputs between all parts of the body and improve the body schema and later on, if possible, enhance the tactile discrimination in the impaired limb*
- *Prehension: from hand opening/closing control to three-point pinch and, if possible, to superior pinch use; hand pre-shaping depending on the object features; improving wrist control and thumb opposition; differentiation between radial and ulnar fingers*
- *Release: from whole hand opening to precise release control, with previous wrist extension, of objects of various sizes and features on a surface or in space or small containers*
- *In-hand manipulation: from the differentiation between radial and ulnar fingers to more complex intrinsic movements; parallel intervention on tactile and proprioceptive awareness/discrimination*
- *Bilateral hand use: early experiences of bilateral hand use, stimulating the spontaneous use of the affected hand in more complex bimanual play activities; parent and caregiver training, sharing postural care, toy choice criteria and modalities to propose games and toys*
- *ADLs: selecting compensatory strategies; teaching standard and adapted techniques; environmental and equipment adaptations; use of ADL aids; caregiver training; IADL intervention in adolescents*
- *Orthoses: possible use to improve function and/or to prevent or reduce deformities, in association with eventual medical-pharmacological intervention, if needed*

9.3 The Child with Dyskinesia

The child with dyskinesia shows more difficulties in the upper limb use compared to the child with spastic CP, related to several factors such as postural control disorders, primitive reflexes persistence, tone fluctuations, involuntary movements, and perceptual disorders. These difficulties also greatly affect participation in daily occupations of childhood.

In children with moderate/mild impairment (functional levels 2 and 3 of the Table 8.3), there is a significant delay and sometimes limitations in some strength and precision grip achievements (e.g., superior pinch), in more complex in-hand manipulation movements and bilateral, coordinated, and differentiated hand use. Generally, these children can access the daily activities, but it will often be necessary to adapt or modify the task features.

Children with severe motor impairment (functional levels 0 and 1) have a significant limitation in the most basic hand functions, such as reaching, grasping, and releasing. The use of the upper limbs for even simple tasks can be extremely difficult and sometimes completely impossible (Kyllerman et al. 1982; Monbaliu et al. 2016, 2017b).

Access to ADLs is greatly limited and requires continuous support from caregivers. Therefore, for the child with dyskinesia, it is important to rely on all the functional resources available, identifying one or more voluntarily controlled movements, which can be used functionally, and modifying and/or adapting the daily activities through bypass strategies (see Chap. 8, Sect. 8.3). For some functional goals in more complex cases, other parts of the body, such as head, foot, or eye-gaze use can be evaluated (Borgestig et al. 2015, 2016).

These children have significant limitations in achieving autonomy in many ADLs, as in toileting, bathing, dressing, and feeding, the latter due to dysfunction in oral control and upper limb use (Monbaliu et al. 2017a). It is also necessary to evaluate environmental factors, such as types of assistance and barriers, that may affect day-to-day care, as well as interviewing and supporting the caregivers regarding the handling procedures for the child. Equipment adaptations, ADL aids and environmental adjustments are often needed to lighten the burden of care (Finnie 2009; French et al. 1991; Korpela et al. 1992; Dormans and Pellegrino 1998; Østensjø et al. 2003, 2009; Henderson and Pehoski 2005; Pirila et al. 2018; Case-Smith and O'Brien 2019).

It is also important to identify communication strategies and supports (Millar and Aitken 2003; Beukelman and Mirenda 2013) that allow the child to guide their caregivers in taking care of them.

Limitations in play are considerable, especially in children with severe impairment. For most of them, the opportunity to enjoy and progress through the various stages of play development, independent or cooperative, depends greatly on caregiver support and play adaptations. The therapist can suggest some simple play aids: if the child does not have a functional grip, a Velcro[3] glove can lock a small toy, or

[3] Velcro Ltd., Knutsford (UK), www.velcro.uk

Fig. 9.33 Play adaptation: battery-operated toy with a customed switch

the child can activate a battery-operated toy with a customed switch (Fig. 9.33) (Pratt and Allen 2009; Case-Smith and O'Brien 2019).

The child with communication difficulties can also use AAC boards to guide a partner, for example, to play with them (see also Chap. 12).

If manipulation of play materials is impossible, other parts of the body could become involved for play, for example, for using a head pointer with a brush to paint, a head switch as an alternative access to special computer games, or eye pointing to play a memory game (Fig. 9.34).

Bypass strategies are also needed for children with moderate/mild dyskinesia to access many ADLS, enhance autonomy, and guarantee safety. For example, in washing, toileting, and grooming, they can use compensatory strategies, environmental adaptations, and/or simpler aids, sometimes also adopting bathing and commercially available toileting equipment for kids (Fig. 9.35).

Regarding self-feeding, there may be difficulties related to oral control, perceptual disorders, and upper limbs use, especially in more complex tasks, like cutting with a knife, eating with a fork, using a spoon, and pouring water.

Disorders in fine motor skills often limit physical access to more complex toys and games, and it is necessary to select among commercially available products toys that are easy to handle and appropriate to the interests and performance capacities of the child, with characteristics like easy-to-grip, of medium size, magnetic, or Velcro-fitted objects (Fig. 9.36).

Another problem for the child is that, due to their involuntary movements, their toys tend to move when they attempt to manipulate them. Therefore, it is advisable to adopt a wide table or lap-tray with edges or to propose toys to put into socket

Fig. 9.34 Play with other parts of the body: head pointer with a paintbrush

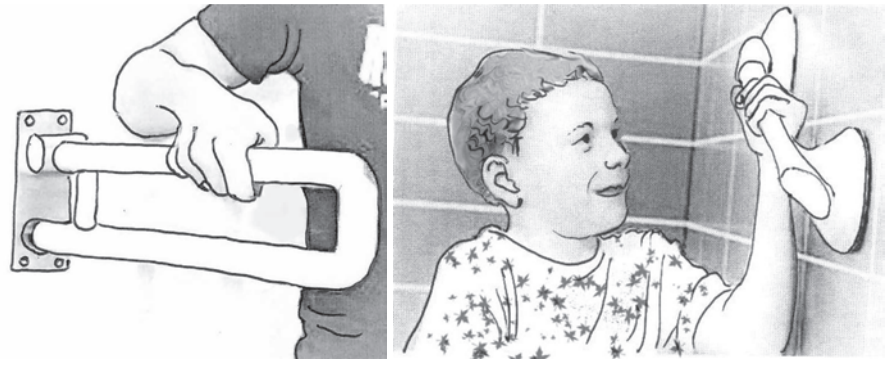

Fig. 9.35 Equipment commercially available for toileting and bathing

frames or that are stabilized on the work surface with a non-slip mat, suction cups, or c-clamps or strapped to the child hand (Fig. 9.37).

The child usually has dysphonia and dysarthria. These problems make it difficult to understand their speech, more than in the child with BSCP, and they often require a specific and early intervention of AAC (Yorkston et al. 1998; Himmelmann et al. 2013; Beukelman and Mirenda 2013) (see further details in Chap. 12).

Perceptual disorders are very frequent mainly related to the selection, suppression, and calibration of the various sensory inputs (Odding et al. 2006; Sanger and Kukke 2007; Himmelmann et al. 2009; Monbaliu et al. 2017b).

Especially in the most severe children, there are often auditory impairment (Shevell et al. 2009) and visual disorders (Jan et al. 2001; Fazzi et al. 2007; Ghasia et al. 2008; Dufresne et al. 2014; Ego et al. 2015).

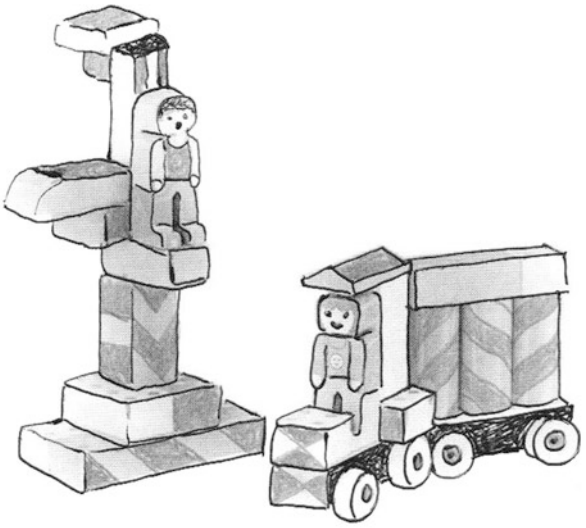

Fig. 9.36 Easy-to-handle and magnetic toys

Fig. 9.37 Toy socket set placed on a non-slip mat

Also, again mainly in the severe motor challenged children, there may be relevant cognitive impairment (Kyllerman et al. 1982; Sigurdardottir et al. 2008; Himmelmann et al. 2009; Yin Foo et al. 2013; Stadskleiv et al. 2018; Batorowicz et al. 2018; Ballester-Plané et al. 2018; Laporta-Hoyos et al. 2019).

Perceptual, visual, and cognitive disorders, which are significantly interrelated, can affect the use of the upper limbs and need to be properly assessed to define a realistic functional prognosis and to set up an appropriate rehabilitation project (Beckung and Hagberg 2002; Henderson and Pehoski 2005; Case-Smith and O'Brien 2019).

In dyskinetic forms of CP, the use of the upper limbs is influenced by a combination of several different factors. It can even be impossible in cases of severe motor impairment.

9.3.1 Postural Control

The child with dyskinesia has considerable difficulties in maintaining the sitting posture, which is the most used during play and ADLs. Sitting can be affected by various factors, such as synergistic flexion or extension patterns, involuntary movements, atypical or abnormal primitive reflex persistence (e.g., ATNR, Galant. etc.), tone fluctuations, and perceptual disorders (see also Chap. 4).

Seated on a chair, this child tends to be dominated by synergistic patterns, which force their lower limbs to extend or to go into flexion under the seat, making it difficult to keep their feet on the ground (Fig. 9.38).

The problems above make it difficult to use the upper limbs for support. If the child manages to stabilize their posture with their arms, then they cannot use their hands for other functional tasks.

To improve the use of the upper limbs and visual control and to provide greater stability and alignment, the therapist should choose positioning aids that can contain the child without preventing them from moving. Different aids may be needed for the various ADLs, when the child needs different positioning for self-feeding, un/dressing, playing, or writing.

Sometimes, in moderate/mild forms, commercially available stable chairs can be adopted, using soft or anti-slip pads, modifying existing equipment, or adding the simplest sitting aids, such as foot support with a back edge to promote better control of the lower limbs.

Children with severe motor impairment greatly benefit from a seating system, often customized, which will allow them - as seated - to enhance their relationships with people, feasible functional activities and facilitate caregiving (Costigan and Light 2011; Ryan 2012; Sahinoğlu et al. 2017). Here, teamwork between different

Fig. 9.38 Inappropriate posture with synergistic pattern in extension

rehabilitation professionals is highly recommended because together they need to evaluate and verify the effects of the proposed system on the child's posture and functional abilities.

For a long time, many of these children cannot even tolerate the separation from caregivers and the seating system itself, and they only accept to sit on their parents' and other known adults' lap.

Due to the child's perceptual disorders, it is important to consider the features (texture, consistency, measures) of all components of the positioning system and identify the most suitable strategies to help the child gradually accept the posture system.

Depending on the extent of the motor impairment, additional components for hips, lower limbs, and the head as well as any anchoring system can be considered.

To improve stability in sitting, this child benefit from a recessed table that facilitates arm support and functional activities. It is typical for them to organize compensatory strategies when seated, such as anchoring one foot to the chair's leg. These strategies should be carefully evaluated because sometimes they are functional, but in other cases, they could cause future contractures and deformities.

Sometimes, it is necessary to set up customized workstations, including some alternative access to AT on the seating system to facilitate communication, play, writing, etc. The same problem can arise about mobility with a wheelchair when the arms are dysfunctional. In these cases, the therapist evaluates and proposes the use of control interfaces managed by other parts of the body (e.g., head or foot) or scanning methods (Furusamu 1997; Bottos et al. 2001; Case-Smith and O'Brien 2019). For further information on AT for mobility aids, read Chap. 13, Sect. 13.1.5.

Children with dyskinesia, especially those with impaired or absent speech, tend to trigger total synergistic patterns and unintentional movements, to communicate (Fig. 9.39). The postural system can be designed to minimize these effects and should also be linked to timely communication intervention that provides the child with strategies and tools suitable to their communication needs (see Chap. 12 and Chap. 13, Sect. 13.1.3).

Fig. 9.39 A total synergistic pattern for function

9.3.2 Reaching in the Child with Dyskinesia

Here reaching is greatly affected by various factors, which include postural control problems, persistence of abnormal primitive reflex (mostly by ATNR and avoiding reactions) involuntary movements, tone fluctuations, and perceptual disorders.

Children with severe disabilities have considerable difficulties in maintaining postural alignment and the upper limbs on the work surface, under visual control. They can therefore functionally engage only one upper limb, often exploiting the extension of the facial arm of the ATNR, which allows the use of the hand to perform sweeping movements. Despite this, intervention might be aimed at optimizing the use of these even limited movements for some functional activities, for example, to operate a toy with a switch (Fig. 9.40).

To enhance participation in ADLs using AT, it is important to identify a functional work area for the child, within which to place objects, toys, or switches. However, when reaching and other upper limb use is impossible or extremely tiring, it is necessary to evaluate the use of other parts of child's body, eye gaze, or voice, as alternative accesses to play, writing, and education. The therapist can propose the use of AT or AAC systems, planning adequate rehabilitation training for a better positioning and functional use of the alternative parts of the body and/or eye gaze (Henderson et al. 2008; Pratt and Allen 2009; Sadao and Robinson 2010; Borgestig et al. 2015, 2016; Case-Smith and O'Brien 2019) (Fig. 9.41).

Children who are moderately impaired show better postural alignment and visual control over their actions than those with severe impairment, even if using various compensatory strategies. They often alternate the use of the two upper limbs, depending on the task and the localization of the target, even when the more functional arm is in extension when ATNR is present. For tasks which require more precision, such as for pointing to symbols on a communication board or typing on a computer keyboard, they usually isolate one finger exploiting the wrist flexion

Fig. 9.40 Operating a toy with a switch, despite the influence of ATNR

Fig. 9.41 Using eye-tracking to access computer game

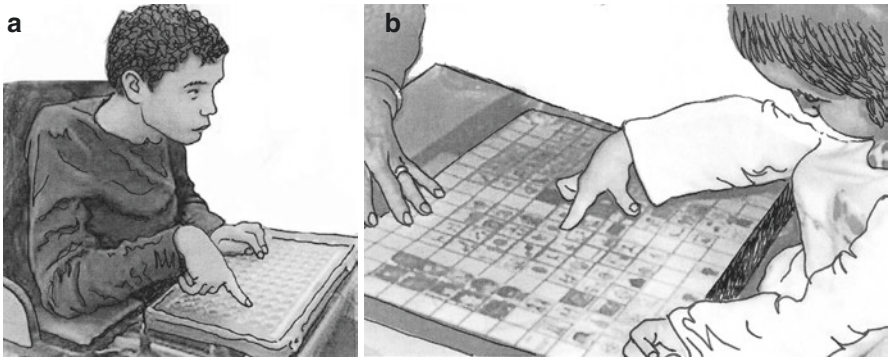

Fig. 9.42 Isolation of index finger exploiting the wrist flexion

(Fig. 9.42). In other tasks requiring wide movements in a large working area (e.g., painting), they carry out the task moving the extended arm in adduction/abduction.

Sometimes, to promote better postural alignment and improve functional use of the more competent arm, the therapist may introduce "no-accessing" arm anchoring systems or apply boundary bumpers to improve the postural stability of the child (Fig. 9.43). It is also important to pay attention to the position of people in relation to the child and where objects and all other types of inputs are placed (Goossens' and Crain 1992).

The child with mild dyskinesia has better reaching control; more coordinated, differentiated bilateral hand use; and better eye-hand coordination. They also have more postural and forearms alignment, allowing them to move both upper limbs closer to the midline, sometimes even crossing it, and have better control of elbow flexion/extension movements. They may also have a supination range between full pronation and neutral position, which allows for more direct reaching and functional hand orientation toward objects.

As previously stated, it is fundamental to the use of a desk or lap-tray with recess, which allows the child to firmly rest their forearms on a surface and has supination and wrist extension for an easier use of the hand.

Fig. 9.43 Boundary bumpers for promoting a functional use of arms in midline

9.3.3 Prehension and Manipulation

In the child with dyskinesia, the prehension and manipulation difficulties are considerable, even in the mildest form and are related to several factors, such as those described regarding reaching problems (Sanger et al. 2010; Monbaliu et al. 2016).

In the case of severe impairment, the child is unable to handle objects and is greatly limited in performing even simple actions. Hand use is possible only with an extended arm. The hand is brought to the object in various ways, for example, with flexion of the wrist and extended fingers or with pronation of the forearm and ulnar deviation of the fisted hand. At the first contact with an object, the hand often closes or moves away from the object due to the avoiding reaction, together with the associated gaze avoiding. Bimanual manipulative activity is not possible.

Hand use can also be disturbed by hand-eye coordination disorders. To have visual control over their actions, this child sometimes uses peripheral vision or dissociates gaze and action (first looks and then touches).

The main goal of intervention for these children is to let help them achieve some voluntary hand opening (Fig. 9.44) and, if feasible, to facilitate a palmar grasp pattern when a change in arm position is required, for example, to manipulate a joystick and drive a power chair (Fig. 9.45).

In the case of moderate impairment, the child handles a limited selection of easily manageable objects in an adapted situation. If well seated, the child with dyskinesia can have better reaching and a better range of supination control, which allows them to grasp with palmar or three-point grip objects with particular features, such as a drinking cup with wide handles or "easy-to-grip" pencil, brushes, etc. (Figs. 9.20 and 9.49).

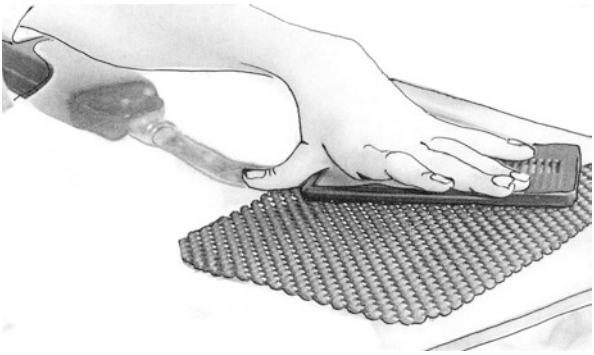

Fig. 9.44 Pressing a device with open hand

Fig. 9.45 Operating a power chair with a joystick

Prehension and release of objects can also be facilitated by the use of anchoring systems on the not-accessing arm and by stabilization of these objects on non-slippering surfaces, as in Fig. 9.44.

These children can usually achieve one finger isolation, often by flexing the wrist, for typing on the keyboard or for direct selection on a communication board or speech-generating device (SGD).

A child with a moderate motor disability can achieve manipulation and the more basic skills for bilateral use of the hand, even if influenced by the ATNR. They usually hold objects still with one hand, for example, to hold a piece of paper on the desk, while the other hand has manipulative tasks, such as coloring.

To manipulate easy objects and enhance visual control over their actions, the child with dyskinesia often uses compensatory strategies, e.g., leaning forward on the table or even using shoulder protraction to block the upper limbs against their body.

These children can access some ADLs, even if it is often necessary to modify or adapt to the characteristics of the environment.

Children with mild impairment can achieve some power and precision grip, more complex in-hand manipulation movements, and coordinated and differentiated bilateral hand use, even when arms are in an open kinetic chain. The acquisition of better fine motor skills depends on reaching control, on the influence of the unintentional movements (which often become more evident over time), and on the child's ability to adopt compensatory strategies. It is important to evaluate the functionality of such compensatory strategies, sometimes helping the child to organize those that are easier to use, less strenuous, and more effective for performing various tasks, e.g., holding a pencil with a "cross-thumb" grip, to control unintentional distal movements when writing (Fig. 9.46).

9.3.3.1 ADLs

Usually, children with moderate/mild impairment can achieve greater autonomy, but with some limitations in more complex ADLs (e.g., buttoning, scissors using, lacing shoes, hair combing). Adolescents and adults may also have difficulties in achieving some IADLs, for example, public transportation use, home management, jobs, and leisure time.

To set up a good functional rehabilitation project, it is always necessary to periodically evaluate the child's potential and difficulties, first making an assessment of the upper limbs and then observing them in their everyday environments (Law et al. 1999). The use of standardized assessment tools allows the therapist to define more precisely the short/-medium-/long-term aims of the project, sharing them with the youngster (child and adolescent) and the family (Gordon 1992; Missiuna and Pollock 2000; Shepard 2019; Spitzer 2019).

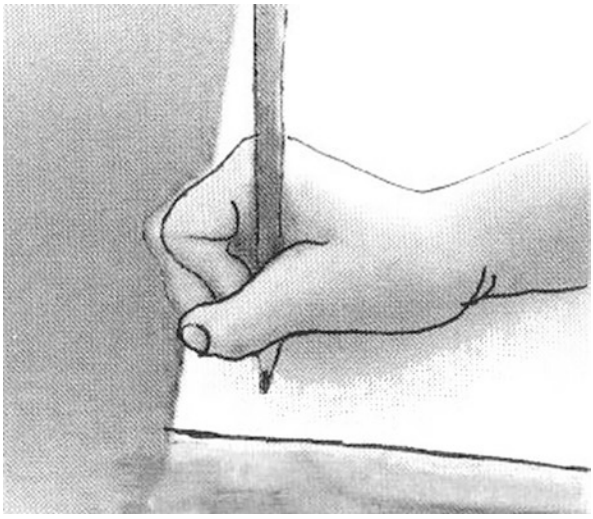

Fig. 9.46 Cross-thumb pencil grip

Fig. 9.47 Self-feeding: strategy to bring food to the mouth

In the case of dyskinesia, it is often necessary to modify the environment or/and adapt tasks (with bypass strategies) to allow them to achieve more autonomy in ADL. For example, in self-feeding, professionals can reduce sensory inputs from the environment, facilitate better positioning with suitable chair and table, and/or select ADL aids, such as easy-to-hold cutlery or drinking devices with big handles (Morris and Klein 1987). The therapist could also accept compensatory strategies, if necessary, for function.

The child with dyskinesia can have many difficulties with self-feeding, for example, in bringing a bowl or food in the mouth using cutlery (Fig. 9.47).

Positioning also requires attention: the therapist may have to adapt the chair with a recessed tray or table, to provide greater stability to the trunk and shoulders or propose adaptive equipment, such as rubber strips to secure the cutlery to the hand or suction cup with a raised edge to facilitate the scooping of food (Fig. 9.48).

To facilitate self-drinking, it is possible to select a suitable device according to the child's prehension patterns, such as a mug with a wide handle (Fig. 9.49). Some children with good oral control prefer cups with flexible straws, but in severe cases, special drinking aids, which do not require upper limb use, can be proposed.

As in BSCP, the child with dyskinesia also needs to learn step-by-step strategies to best perform ADLs, and the family and caregivers need to be involved and trained to help the child achieve these goals. In adolescents and young adults, intervention should be aimed not only at independence but also at positive participation in the community.

9.3.3.2 Writing

Children with moderate/mild impairment may be able to draw and paint, usually using easy-to-hold tools such as large markers and brushes, faceting pencils, or a

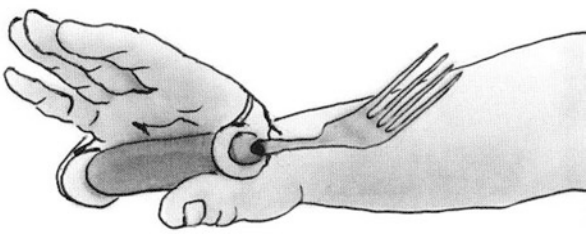

Fig. 9.48 Adaptive equipment: rubber strip fixing the fork

Fig. 9.49 Adaptations for self-drinking

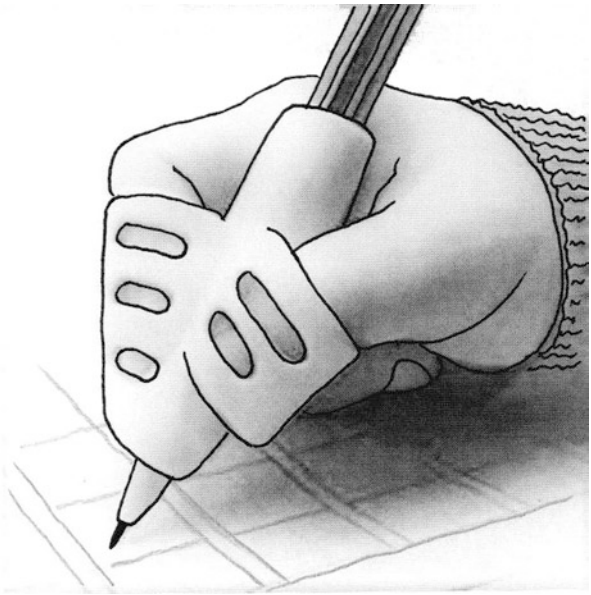

Fig. 9.50 Adaptive tools for writing

special pencil/brush holder (Klein 1982). It may also be necessary to facilitate such activities by using anti-slip materials on which to place the paper or notebooks (Fig. 9.50).

Children with moderate dyskinesia can only do—and with great effort—a limited amount of handwritten work. Generally, they write a few single words to take

Fig. 9.51 Handwriting layout of two children with dyskinesia

notes or to make a simplified signature and prefer to write in capital letters that require only short, quick strokes (Fig. 9.51).

The recessed table, which is usually recommended for all children with CP and severe/moderate impairment to favor the support of the forearms and therefore better functional use of the upper limbs, is also recommended for children with mild dyskinesia (Kavak and Bumin 2009).

Sometimes, in this mild form, it is necessary a prolonged and careful observation and assessment of the functional performance of upper limbs, because the unestablished handedness problem may emerge and could affect the child's handwriting performances (Auzias 1975; Henderson and Pehoski 2005).

Equally, a careful evaluation should be carried out with the moderate/mild child, if they access computer writing to meet educational needs, identifying also the most functional positioning and/or adaptive equipment for the computer access, e.g., type of keyboard, keyguard, and/or alternatives mouse use (Fig. 9.52).

9.3.4 Aims for the Functional Treatment of the Upper Limb in Children with Dyskinesia

According to the child's upper limb functional level, as indicated in Table 8.3, suggestions for the upper limb treatment plan are presented below.

For Children with Severe Motor Impairment

- *Reaching control: from adduction/abduction horizontal movement control to elbow control. Particularly: improve movement's range of at least one arm, moving closer to the midline, more visual control on the action*
- *Hand use: from voluntary hand opening to maintaining/releasing contact with an object (*e.g.*, switch) and, if feasible, initiating and sustaining a palmar grasp pattern with changes in the arm positions (*e.g.*, to operate a joystick to drive a power chair)*
- *Isolation of at least one finger for direct selection on AAC systems or for typing on a keyboard*
- *Bilateral hand use: from the simple maintenance of both upper limbs on the work surface to initial use of a more involved arm to stabilize object, without grasp*
- *Assessment and intervention on perceptual disorders*
- *Eye/hand coordination*
- *Rehabilitation intervention for the functional use of other parts of the body (if upper limbs are severely impaired)*

Fig. 9.52 Alternative keyboard with keyguard, for computer writing

- *ADLs: caregiver training for positioning, handling strategies and ADLs aids use,* etc.
- *Writing: selection of alternative access to computer writing (hardware and software selection and training)*
- *Play: positioning for play, adapted environment, alternative strategies and adapted toys use; selecting AT for play*

For Children with Moderate/Mild Motor Impairment

- *Reaching and pointing control: control of more precise trajectories, implemented in different postures and planes, with particular attention to midline crossing and posterior reaching patterns required for many ADLs (*e.g.*, in dressing, hygiene,* etc.*), pronation/supination of the forearm, extension of the wrist,* etc.
- *Prehension: from three-point pinch to superior pinch with thumb opposition; gradual inhibition of ulnar fingers, using only the radial fingers; prehension of objects with various features (*e.g.*, flat, heavy,* etc.*)*
- *Release: from the control of hand opening with extended fingers and neutral wrist to the precise and controlled release—on a surface or in space or a small container—of objects of various sizes and features*
- *Isolation of at least one finger for direct selection on AAC systems or for typing on a keyboard*

- *In-hand manipulation: from isolated finger movements to the differentiation between radial and ulnar fingers; from finger to palm translation to complex intrinsic movements,* e.g.*, combining translation with rotation; parallel intervention on tactile and proprioceptive awareness/discrimination*
- *Bilateral hand use: from less proficient hand use for stabilizing (without or with grasp) function to bilateral simultaneous and differentiated hand use; evaluation of compensatory strategies functionality, helping the child to organize those easier to use, less strenuous, and more effective for performing various tasks*
- *Handedness: detailed analysis of any problem of unestablished handedness, particularly to choose the hand for handwriting*
- *Handwriting: handwriting training, when functionally possible; training of computer writing (hardware and software selection)*
- *Assessment and intervention on perceptual disorders, if needed*
- *ADLs: teaching standard and adapted techniques; environmental and equipment adaptations (*e.g.*, bathroom), ADL aids selection; caregiver training; IADLs rehabilitation intervention in adolescents*

9.4 The Child with Ataxia

Children with nonprogressive congenital ataxia (NPCA) may have varying degrees of difficulty in functional upper limb use, depending on whether antigravity postural control or fine limb movements and associated disorders are more involved. Their performance is characterized by a lack of muscle coordination, and therefore movements are performed with abnormal strength, rhythm, and precision. Also, slow tremor and low pitch are observed. However, albeit with very long learning times, these children can reach good levels of autonomy in playing and in the ADLs, with difficulties in some more complex and coordinated activities, such as self-feeding, writing, buttoning, and other fine motor skills.

Many authors report a high incidence of associated problems in NPCA (Hagberg et al. 1993; Esscher et al. 1996; Steinlin et al. 1998). They are related to (a) cognitive function (2/3 of children have learning problems, half of which are quite severe); (b) visual problems, detected in more than 50% of children (Black 1982; Dufresne et al. 2014; Kozeis and Jain 2018); (c) perception and language disorders; and (d) epilepsy (Bertini et al. 2018).

It is essential to evaluate all these aspects in order to plan an adequate upper limb rehabilitation project, following the guidelines suggested in Chap. 8.

9.4.1 Postural Control

Postural instability is the main problem that conditions the maintenance of the sitting posture, the position most frequently used by the child while playing and performing ADLs.

The use of the upper limbs together with the visual control of the environment is essential to provide greater stability to the child, choosing suitable positioning

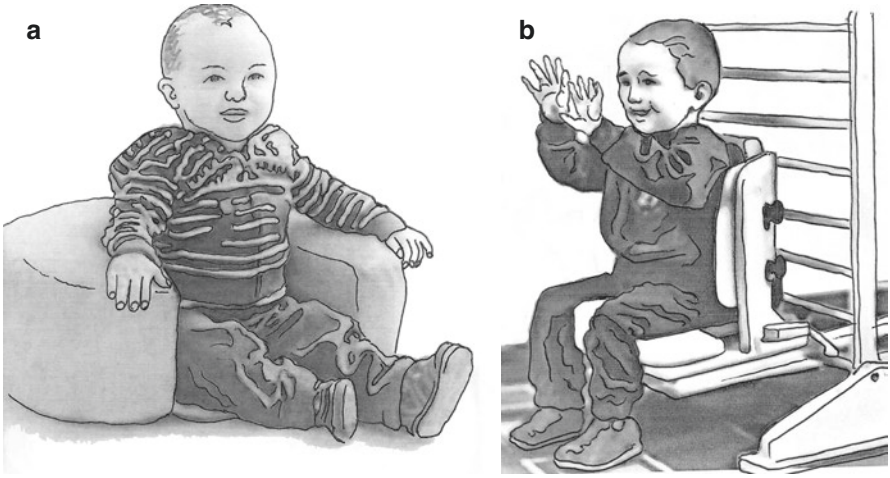

Fig. 9.53 Positioning for children with ataxia

sitting systems to improve writing, self-feeding, and more complex and coordinated play activities.

For this purpose, it is also possible to use commercially available, very stable chairs or other equipment already existing at home or in the classroom. In some cases, it is necessary to use non-slip mats applied to the seat surface or special cushions that improve stability.

To facilitate and enhance the functions of the upper limbs, the child with ataxia also needs to be seated with a recess in front, to facilitate the support of the forearms, and, in some cases, with a non-slip pad under their buttocks or feet, to increase stability. The same measures are also proposed in the infant/toddler to facilitate play, even while sitting on the ground (Fig. 9.53).

As in all other forms of CP, here again it is necessary to evaluate the characteristics of the environment in which the child lives and consequently adapt it to their needs. To improve the child's transfers and their participation in all ADLs, it may be useful to reorganize the bathroom, bedroom, etc. and allow furniture to be accessible for feeding, play, or pc use, sometimes applying adaptive equipment, e.g., grab bars in the bathroom (Fig. 9.35).

9.4.2 Upper Limb Use

Children with ataxia usually have a normal repertoire of the basic patterns of the upper limbs, but their functional acquisitions can be delayed in time and their use is affected by dysmetria (hyper/hypometria). Poor temporal coordination of the motor sequences causes acceleration, braking, and sudden adjustments of the gesture (asynergy). Another typical feature is past-pointing, i.e., the over-/undershooting of goal-directed movement. This means that children with ataxia may have a "plan" for how to achieve a goal but fail to execute it with accuracy. Further details about these features can be found in Chap. 5, Sect. 5.1.2.

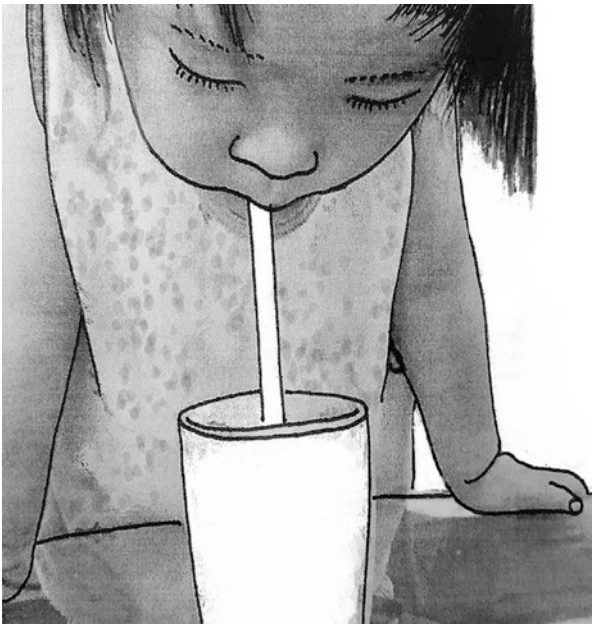

Fig. 9.54 Using the trunk to transfer weight to arms

Typical "ataxic" behaviors can be observed frequently in these children. For example, during self-feeding, they bring the spoon to their mouth and the movement is adequate but starts with a rapid, uncontrolled movement, and they risk hurting themselves. Particularly when the infant is not too stiff, they could begin to feed by themselves without apparent problems, but as feeding progresses, their posture becomes more unstable and movements less controlled. In this case, the therapist should facilitate the task by providing more support to arms and trunk, with specific equipment to reduce fatigue and effort.

Concerning visual-motor behavior, it is frequently observed that, during tasks that require to coordinate the movements of the eyes with arm-hand, these children exhibit peculiar patterns. For example, in order to fixate a target, they break down the task in two phases: first they rotate the head to an extreme opposite position and thereafter they turn the eyes to the target.

In the case of mild/moderate ataxia, the child can generally improve over time their strength, precision grip, simple in-hand manipulation movements (e.g., rotation, translational movement), and coordinated or differentiated bilateral use of the hand. The acquisition of these fine motor skills depends on postural and manual control, on the incidence of movement incoordination and on the child's ability to adopt compensatory strategies.

Indeed, this child may be very able and imaginative in discovering compensatory patterns to succeed in the task. Examples of the most common compensatory strategies include keeping the arms close to the body, fixing the elbows on a surface, and using the trunk to support weight on the arms (Fig. 9.54).

These compensatory strategies reduce the task of managing multiple joints, thus facilitating the functional performance of only a few joints, with the benefit of controlling dysmetria and allowing for more efficient manipulation.

However, families and therapists should pay attention to avoid the use of too many abnormal compensatory patterns in the infant/toddler while encouraging the habitual use of normal functional patterns. Nonetheless, when the child begins to be more independent, it is equally important to evaluate the functionality of such compensatory strategies, sometimes helping the child to organize those that are easier to use, less tiring, and more effective for performing various tasks.

To allow this child to achieve the greatest autonomy in ADL, it is often necessary to adapt tasks introducing bypass strategies. For example, with regard to self-feeding, professionals can implement positioning adaptations, e.g., suitable chair and table, also commercially available, and/or use ADL aids, e.g., easy-to-hold cutlery (Morris and Klein 1987; Case-Smith and O'Brien 2019).

Bimanuality can also be facilitated by proposing objects of adequate weight, size, texture, and friction and stable, robust, and easy-to-handle magnetized toys. Sometimes, it is enough to make some simple adaptations, like stiffen the end of the thread used to make a necklace with wooden beads.

Manipulation can also be facilitated by encouraging greater use of visual control to verify, guide, and adapt the gesture to the task. It is also important to propose more complex and fine activities to induce an accurate perception of auditory, visual, and tactile inputs regarding the task, supporting their intermodal integration.

In infants and toddlers, rehabilitation intervention to improve fine motor skills should start early and be integrated into all daily activities. As with other age groups, careful evaluation by the rehabilitation team is needed as well as precise indications for home activities and, in particular, for kindergarten time, where many creative manipulation experiences can be proposed to promote hand and arm development (Novak et al. 2009).

9.4.2.1 ADLs

Impairments of gestures and postures greatly influence the acquisition of some ADLs and subsequently of IADLs. The ADL assessment generally highlights clumsiness and major difficulties evident in some finer and more coordinated activities, such as picking up small items, dressing up, and self-feeding. Also, handwriting problems are often encountered, as described below.

9.4.2.2 Self-Feeding

In self-feeding, the child may have difficulty performing all or most of the necessary bowl-to-mouth tasks, for example, managing cutlery and coordinating simultaneously the movements necessary to bring the food to the mouth. To partially overcome these problems, it could be wise to fix the cutlery with rubber strips to the child's hand or to use a plate with borders to facilitate food collection (Fig. 9.55).

With regard to positioning during self-feeding, a regular chair with a recessed tray or table can provide greater trunk and shoulder stability and reduce the tendency of the trunk to slump forward.

Together with an oral control intervention, it may be necessary to identify first of all useful bypass strategies for the simplification of the task and to promote the gradual acquisition of self-feeding.

Fig. 9.55 Plate with borders and sucker

Particular care should be taken to facilitate the independent drinking, evaluating the most suitable drinking device for the child's current abilities, proposing, for example, a stable plastic cup with or without handle/s. For some children with significant motor function disorders, the therapist can suggest the strategy of "mouth to drinking device" by using, for example, a tilting cup fixed to a stable support, or a stable tumbler with a straw, with or without a straw holder (Fig. 9.49).

As in all other forms of CP, the rehab team should propose a gradual increase in the number of steps to complete every functional task, involving and training family and caregivers at home and school. In young adults, the aims are focused mainly on the most realistic IADLs, for work and leisure activities and community participation.

Practical Suggestions

- It is always useful to suggest a few simple basic tips to caregivers to improve self-feeding in the child with ataxia:
- *Ask the child to place their elbow firmly on the table to stabilize the upper limb and to steady their hand*
- *Choose finger foods and textures such as mashed potatoes and so on which make self-feeding easier*
- *Use a non-slip placemat, to stabilize bowls and plates, or a bowl with a suction cup to stop them moving around*

9.4.2.3 Bathing and Toileting

Placing bars and rails near the tub and/or toilet (Fig. 9.35) can increase safety and independence in the bathroom. It is important to foresee the problems that will arise when the child grows up and therefore to also plan the use of a bath chair or a shower to decrease the effort involved and increase independence. A further useful tip is the use of a washcloth with soap or "soap on a string" to avoid the soap slipping around and being dropped (Fig. 9.56).

Fig. 9.56 Washcloth with soap and "soaps on a string"

9.4.2.4 Handwriting

Generally, children with ataxia can achieve the task of handwriting, first in capital letters, which requires only single-stroke movements, and then in cursive letters, with significant interpersonal differences in acquisition time and regarding speed, fatigue, and legibility. The child may have difficulty in adjusting and coordinating the upper hand/arm movements of progression and inscription, especially when prolonged for a long time (Ajuriaguerra et al. 1964). Especially in the dynamic phase of handwriting, they can maintain childlike and sometimes bizarre grips of the writing tool.

To facilitate handwriting, the child can adopt compensatory strategies such as leaning the trunk and upper limbs heavily on the work surface to give stability to the forearm and wrist. Particularly, they can press the ulnar side heavily on the table to allow the radial side to move more freely, but this behavior, together with the need to control involuntary movements, causes the child to put excessive hand pressure on the graphic instrument and indirectly also on the sheet of paper.

The handwriting trace appears broken, trembling, imprecise, and sometimes too light but other times too heavy, with variations in the size and orientation of signs and letters that will make the handwriting often unreadable (Fig. 9.57).

The therapist needs first to evaluate the child's drawing ability when they are at the prewriting stage between 2 and 3 years old. Later, between 5 and 5 years, handwriting can be assessed, if the development of handwriting looks promising and special handwriting tools and other adaptive equipment may be indicated.

The therapist can also propose easy-to-hold tools, such as large markers and brushes, faceting pencils for drawing and painting activities, suggesting the use of anti-slip pads on which the child can place paper or notebooks (Klein 1982). Furthermore, a writing board inclined at 45° may provide more stability for the forearm and make it easier for the child to look at the task (Fig. 9.58).

Commercially available writing tools are often suitable for the handwriting of the child with ataxia. Of course, it is necessary to evaluate the different characteristics of the tools regarding their smoothness, size, and shape, e.g., hexagonal pens can be more functional than cylindrical ones. In some cases, the child can take advantage of adaptive handwriting tools such as a weighted pen or a magnetic cuff that facilitates the maintenance of their forearm and wrist on the work surface or special notebooks with clearly marked margin lines and colored guidelines as a reference for writing in rows (Fig. 9.59).

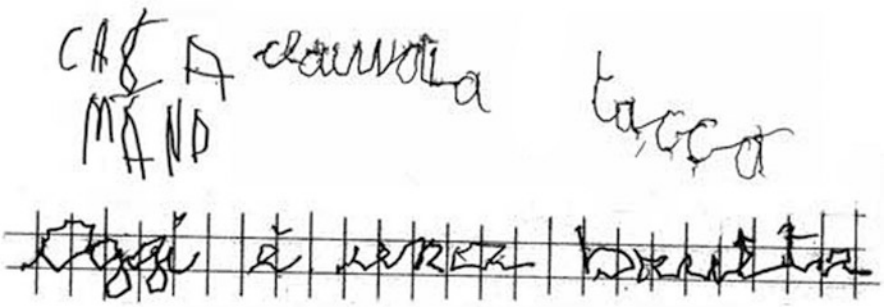

Fig. 9.57 Handwriting layout of two children with ataxia

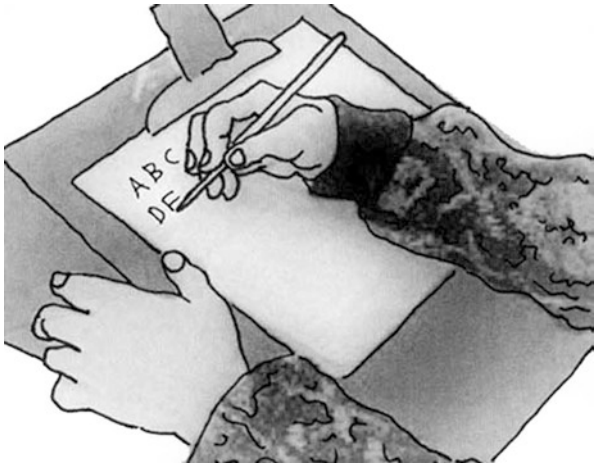

Fig. 9.58 Adapted equipment for handwriting

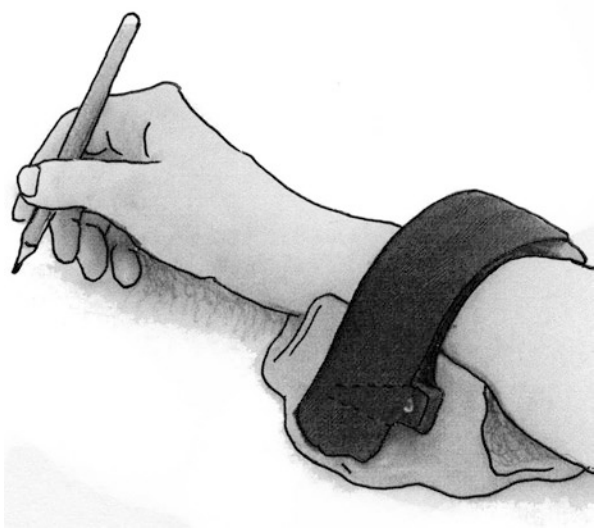

Fig. 9.59 A magnetic cuff to facilitate handwriting

As well as during feeding time, the child can sit with a recessed table in front for handwriting, drawing, or activities using different writing devices (Kavak and Bumin 2009).

Often due to fatigue, excessive slowness, poor readability, and/or the great amount of written work requirements, handwriting can be replaced or complemented by computer writing ("mixed writing") and other educational devices.

However, computer writing may pose other access difficulties for the child, e.g., a finger singularization, and accurate typing may be problematic like activating a selected key or two keys at the same time.

Once more, careful assessment of the functional resources of the upper limbs is necessary, to identify the most functional positioning and/or adaptive equipment for computer access and the type of keyboard, keyguard, touchscreen, and/or alternative mouse use followed by an appropriate rehabilitation intervention.

In the child with ataxia, it can also be necessary to define which is the dominant hand for fine skill development and handwriting. This requires an accurate observation and specific assessment of the functional performance of both upper limbs and, if indicated, specific training (Auzias 1975).

9.4.3 Aims for the Functional Treatment of the Upper Limb in Children with Ataxia

- *Support for perceptual development (active tactile, visual,* etc.*) and intermodal integration*
- *Support for the acquisition of more advanced prehension and manipulation patterns (with a particular focus on bimanual hand use and in-hand manipulation) through the proposal of gradually more complex play and everyday activities, carried out first with the child seated "at the table" and then in different positions*
- *Continuous monitoring of compensatory strategies, spontaneously adopted by the child and, if necessary, proposals of more functional solutions (with a focus on positioning equipment selection in some activities such as writing and feeding)*
- *Play: toys selection, fixation systems use*
- *ADLs: teaching standard and adapted techniques; environmental and equipment adaptations, if needed (*e.g.*, bathroom), ADL aids choice; caregiver training; IADL intervention in adolescents*
- *Handedness: study in detail of unestablished handedness problems, particularly for choosing hand for handwriting; related intervention, if necessary*
- *Handwriting: handwriting rehabilitation intervention, if needed and if it is predicted that the child should be able to develop a usable handwriting; training to computer writing*

9.5 Play Activities for Children with Cerebral Palsy: Some Suggestions

The games and toy proposals suggested here need to be selected and adapted to the child's interests, functional abilities, level of development, as well as the rehabilitation goals.

- **Reaching**
- Activities to improve adduction/abduction horizontal movements, elbow flexion/extension, and progressive hand opening control:
  - *Touch and hold, if possible, objects, toys, and materials to explore/activate them (*e.g.*, put a hand in a water bowl and play with water, activate a battery-operated toy with one large switch and then with two switches)*
  - *Push objects (in relation to play developmental level) from one side of the work surface to the other and closer and further (*e.g.*, push a toy dog near peers, push toy cars into the parking lot, or slide objects, classifying them by color or shape)*
  - *As above, but requiring the object to be introduced into a toy house (*e.g.*, put a toy dog into a large and then smaller kennel)*
  - *As above, but requiring the child to do "multiple stops" with toys (*e.g.*, the toy car runs on petrol and then goes to the car wash and then to the garage)*
  - *Paint with finger colors and then with sponges or easy-to-hold brushes, within larger (or smaller) spaces, gradually reaching areas where the use of the upper limbs becomes more difficult*
  - *Wash a doll, iron, brush, or dust (fixing/stabilizing objects on the table, if needed)*
  - *Play musical instruments with large buttons*
  - ….
- **Prehension/Release**
  - *Grasp easy-to-hold items in two or more containers (*e.g.*, arrange the goods in various baskets to prepare the shop game,* etc.*)*
  - *Build large ring towers; play with large and magnetic constructions with easy-grip items: animals, car, brand puzzles with large knobs,* etc. *(elements arranged on stable planks, if needed)*
  - *Play with a* LEGO DUPLO[4] *construction games, pegboards,* etc.
  - ….
- **In-hand manipulation**
- Looking for translation, shift, and rotation patterns:
  - *Getting a coin out of a purse (*e.g.*, in a shop pretending to pay)*
  - *Getting a coin in a box with holes in different positions*
  - *Crumpling paper*

[4] LEGO System A/S, Billund (DK), https://www.lego.com

  - *Moving a magnetic piece—from palm to finger—to put it on a magnetic panel* (e.g.*, two-dimensional magnetic game)*
  - *Separating playing cards*
  - *Putting on/removing or rotating little characters in/out a toy car*
  - *Turning pages in a book*
  - *Buttoning* (e.g.*, playing with doll)*
  - *Playing with the stickers*
  - *Holding pen and pushing its top off with the same hand*
  - ….
- **Bilateral Hand Use**
- Aim: from less efficient hand use (in stabilizing function, with/without grasp) to bilateral simultaneous and differentiated hand use, even with smaller objects:
  - *Hold a paper with one hand while coloring/drawing on the paper with the other hand*
  - *Blocking a puzzle base*
  - *Uncap and cap markers for coloring; disassemble necklaces with large plastic pieces*
  - *Pouring water or sand in a large container, using two hands*
  - *Use play dough, squeeze, roll, and squish it with two hands*
  - *Play musical instruments that require two hands: cymbals, drums, xylophone*
  - *Pulling interlocking blocks apart or putting interlocking blocks together*
  - *Make necklaces with medium-sized pearls*
  - *Scissoring*
  - *Make origami*
  - ….

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