Journal of Hand Therapy 28 (2015) 106–113

Contents lists available at ScienceDirect

Journal of Hand Therapy

journal homepage: www.jhandtherapy.org

JHT Read for Credit Article #347.
Special Issue

Upper extremity function: What's posture got to do with it?

Regina Harbourne PhD, PT, PCS [a,*], Kathi Kamm PhD, OTR [b]

[a] Department of Physical Therapy, John G. Rangos School of Health Sciences, Duquesne University, Pittsburgh, PA, USA
[b] Infant and Early Childhood Development, Fielding University, Skokie, IL, USA

ARTICLE INFO

Article history:
Received 20 December 2014
Received in revised form
16 January 2015
Accepted 17 January 2015
Available online 28 January 2015

Keywords:
Postural control
Reaching
Developmental
Systems approach
Therapeutic intervention

ABSTRACT

This perspective paper reviews the linkage between developing postural control and upper extremity function. We suggest updated principles for guiding clinical practice, based on current views from motor learning, motor development, and motor control research. Using three clinical examples, we illustrate principles focusing on the use of variability, the importance of errors in learning movement, task specific exploration and practice, and the critical timing necessary to build skill of the upper extremity in a variety of postures. These principles differ from historic approaches in therapeutic exercise, which treated posture as a separate system and a precursor for extremity skill building. We maintain that current movement science supports the tight interaction of posture and upper extremity function through developmental time and in real time, such that one system cannot be considered separate from the other. Specific suggestions for clinical practice flow from the guiding principles outlined in this paper.

> "Concepts that have proven useful in ordering things easily achieve such authority over us that we forget their earthly origins and accept them as unalterable givens… everything should be made as simple as possible, but no simpler."
>
> -Albert Einstein

In this paper, we explore the relationship of posture and reaching and assumptions from our historic neuromaturational therapeutic approaches. We illustrate several new concepts supported by developmental research, opening up a wide range of therapeutic reasoning to benefit our patients. When viewed as two systems, the relationship between postural control and upper extremity function appears deceptively simple. The proximal postural system orients and reacts to external forces in the service of distal mobility for the reaching system. It is a maxim that guides treatment in everything from working proximally before distal skills are addressed, to providing seating and stabilizing systems to "free up" the reach.[1,2] Current evidence for both the developmental process and clinical applications, however, supports principles that are neither that simple nor clear cut. Surprisingly, the developmental evidence supporting the idea of postural control preceding distal function is minimal, and the evidence for alternative views suggests a change in perspective for effective therapeutic intervention.[3–6]

Although some researchers found a primacy of postural control in early development, and postulated that reaching skill advances due to greater postural stability,[7,8] an alternative view can also be supported. We found that postural control in sitting and ongoing reaching skill in infancy both appeared to be "under construction" concurrently.[9] Other research also supported the relationship of the two systems as intertwined, but not simple.[10–12] Infants appear to gradually learn to manage their body within each specific task, through exploration, in order to build complex problem-solving skills for successful interactions with people and objects. These problem-solving skills allow new strategy formation as novel situations arise through the developmental process.

Movement of any of the extremities alters the body's center of mass, requiring a postural response. However, if walking is a series of falls, then reaching is a dance of adjustments.[13] These more subtle adjustments may go unnoticed but they are no less important to skilled action. When a new skill like reaching is developing, these postural adjustments may be reactive or coincident with limb movements. Varied experience and "play" with the actions provides the raw data and impetus for the postural adjustments to occur in *preparation* for limb movement. We suggest that the two systems are interrelated (Fig. 1), but not in a hierarchic manner as suggested in historic therapeutic approaches.[1,14] Thus, the maxim that proximal stability precedes distal mobility has minimal

Conflict of interest statement: The authors declare no conflict of interest.

* Corresponding author. 104 John G. Rangos School of Health Sciences, Duquesne University, 600 Forbes Avenue, Pittsburgh, PA 15282, USA.
E-mail address: harbourner@duq.edu (R. Harbourne).

0894-1130/$ – see front matter © 2015 Hanley & Belfus, an imprint of Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.jht.2015.01.008

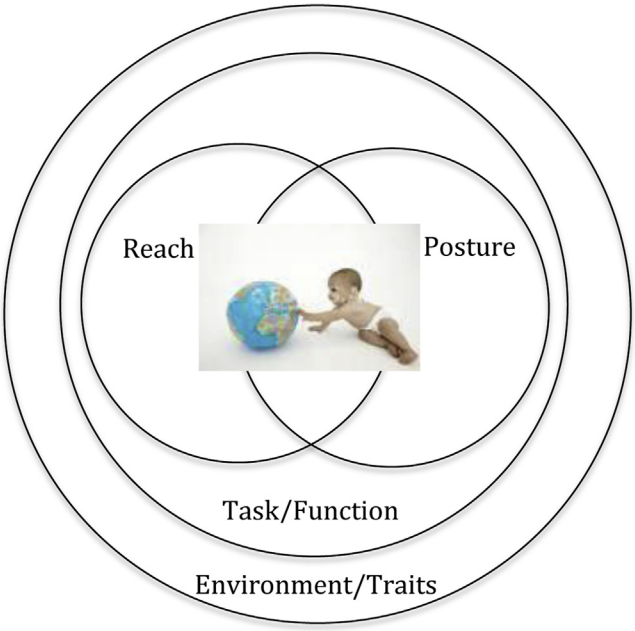

Fig. 1. Posture and reach interaction is defined by the functional task and shaped by the environment around the individual and the traits of the individual. Environment/traits includes age, physiology (fatigue, health), reward, supports, distractions, position of person to object, socialization, cognition, and perception.

supporting evidence. The relative importance and coordination of posture and upper extremity skill is more dependent on task, traits, environment, and experience than due to a hypothesized neuromaturational order.

Our purpose in this paper is three-fold: 1) to suggest an ecological approach in which posture and reach interact with environmental constraints to create one functional and adaptive system; 2) to examine the relationship of posture and reach in the service of functional goals within intervention; and 3) using hypothetical case examples, illustrate a set of principles, which are based on current developmental and motor control evidence, that may be useful in guiding intervention for the improvement of upper extremity function.

Examining our assumptions

The first correction to earlier assumptions is that posture and reaching are not separate systems. Rather, the two terms describe one unified perceptual-motor system, nested within contextual, social, and environmental constraints or supports (see Fig. 1). The unity of the motor system derives from the degrees of freedom problem proposed by Nikolai Bernstein[15]: given that the human body has countless ways to perform a task due to multiple joints, forces, and external factors, how does one reduce these degrees of freedom to perform a given task consistently, efficiently, and functionally? The movements we recognize as typical reflect many possible solutions that are assembled in real time to optimize energy and flexibility to meet variable demands. This solution, even if it is a simple reach forward involves the entire body. Thus, the movement of one body segment requires prospective control of other body segments, as well as requiring controlled actions of other segments throughout the kinetic chain to control reactive forces. This process of ongoing assembly and adjustment is in the service of, and therefore must be tuned to, the goal.[16] Reaching, by definition is "to" something, so misjudging the trajectory of the reach or the weight of the object will fail to meet the goal. Therefore, reaching and posture form a prospective action system, that unite adaptively depending on the environment and task.[17,18]

In addition to mechanical factors, the desire and drive to engage physically, socially, cognitively and emotionally with our world fundamentally drives human experience. During the developmental process, infants garner the resources at their disposal and assemble actions to the best of their abilities to *attempt* reaching actions even before the first reaches can be clearly identified. In service of this engagement, infants use "foot reaching" developmentally before reaching with the arms.[19] Infants also reach with the mouth very early to grasp a nipple or explore objects.[8] Infants socially "reach" with a smile and glance to a caregiver when they know an object is beyond their reach.[20] The developmental process of achieving an accurate reach involves assembling and reassembling actions as strength, body proportions, perceptual acuity, social skills, and cognitive awareness change. We focus in this paper on reaching with the arms to explore and manipulate objects with the hands. To support the purposes stated above, we use a developmental perspective to illustrate how reaching and postural skill first emerge, and hypothetical clinical examples to illustrate select principles of intervention that are supported by evidence. The principles we support are:

1. Variability matters in building new skill.
2. Posture-reach linkages matter.
3. Timing matters in motor learning and motor control, and within developmental time.
4. Specificity of the task matters during motor learning and development.
5. Hand and arm skills do not necessarily transfer from one posture to another.
6. Errors can be good to build parameters of what constitutes a successful strategy.

Clinical lessons and supporting evidence

To exemplify the principles we introduce three case examples: 1) an infant with cerebral palsy learning to sit and reach; 2) a school-aged child with developmental coordination problems; and 3) an adolescent with congenitally acquired hemiplegia. These cases illustrate the principles listed in Table 1.

Case 1: infant with cerebral palsy learning to sit and reach

Our first example of the unity of posture and upper extremity function during skill emergence is an infant with cerebral palsy (CP) learning to sit and reach; this child may elect to reach for and explore toys with his mouth because his arms need to assist and stabilize posture. However, the child may also use the hand to reach if the trunk, head and pelvis are stabilized by external forces, such as a seat. Typically, clinical reasoning has been dichotomous. Should the therapist help the child progress in reaching by providing an adaptive seat that stabilizes the proximal body segments, or should postural control be addressed first as a precursor for reaching skills? Both strategies have trade-offs, and trade-offs matter when using the developmental time of the child! Providing a postural seat insert reduces postural play and opportunities for learning these skills, but may allow the child to engage in the developmentally important goals of object exploration. Waiting for posture to develop before working on reaching delays developmental experience of object exploration and the cognitive understanding gleaned from this activity.