Handedness is usually defined as a preference to use one hand over the other, or that one hand performs more accurately or more skillfully than the other. For humans, there is a remarkable asymmetry in the distribution of handedness with no more than 2% of the population manifesting a left hand preference. The majority of infants develop a consistent hand preference during the 6 to 14 month period with most using their right hand (Michel et al., 2004). However, a good proportion of infants fail to exhibit a preference during this period. In the current study, we explore differences in group trajectories of handedness development between those infants with and without hand-use preference.

Some researchers have reported frequent fluctuations in infant handedness development (Corbetta & Thelen, 1999; Corbetta & Thelen, 2002; Fagard & Lockman, 2005; Pie, 2002). From one observation to another, infants appear to change their preferences in hand use for reaching and manipulation of objects as well as the choice of one-handed versus two-handed strategy for acquiring objects. Some researchers have explained the apparent fluctuations using a dynamic systems perspective (Thelen, 1986) in which the emergence of new motor skills such as sitting, crawling and walking can modify established patterns of infant handedness (Corbetta & Bojczyk, 2002; Corbetta & Thelen, 1996; Corbetta & Thelen, 2002).

For example, Rocchi (1992) and Goldfield (1993) note that both the mastery of sitting and the emergence of crawling are associated with an increased handedness and a decrease in the proportion of bilateral two-handed responses. In contrast, Corbetta and Bojczyk (2002) report that infants return to two-handed reaching pattern toward the end of their first year and this decrease in handedness coincides with the onset of walking. Corbetta and Bojczyk (2002) propose that upright locomotion imposes new constraints on balance control, bimanual coordination, and head and arm control that might disrupt the established reaching preferences.

Although handedness is an aspect of hemispheric specialization of function, its pattern of sex differences seems somewhat disparate. Annette (1985) reported that females seem to be more lateralized in handedness than males, whereas the majority of pioneer studies of hemispheric specialization using diversity of methodological like clinical studies, dichotic listening, tachistoscopic presentation, and electrophysiology frequently reported that females are less lateralized than males (Lake & Bryden, 1976; Lansdell, 1992; McCloine, 1978; Willston, 1976).

Thus, the goal of the current study was to examine the trajectory of handedness lateralization longitudinally using a multilevel model approach. Not only was the change in lateralization with age to be identified, but also the functional form of the trajectory was to be defined. Also, the trajectory of handedness lateralization was examined in relation to handedness status of the infant, sex, and the developmental onset of walking.

### Method

**Participants:**
- 290 infants (58 males, 50 females) from full-term pregnancies with uncomplicated births

**Apparatus:**
- 34 common infant toys were presented one at a time at midline in the air or on the table directly in front of the infant (double toys were presented in line with infant’s shoulders)

**Procedure:**
- A validated handedness assessment (Michel et al., 1988) was administered monthly from 6 to 14 months of age. During the assessment, infants were seated on their mothers’ laps at a novel level to a table.
- All of infants’ manual actions were recorded by two cameras located one overhead and one on the right-hand side of the infant.
- The software program Notus Observer was used to code observations. An acquisition was defined as the point at which infant’s fingers closed around an edge of a toy. 25% of videos were re-coded for inter-rater reliability which reached a minimum Cohen’s Kappa of 90%.
- The handedness status of a participant was determined as either right-hand preference, left-hand preference or no preference based on significant differences in the use of their hands during the nine monthly visits.
- The development of locomotor skills was assessed monthly with Touwen’s neuromotor development assessment scale that examines patterns of sitting, crawling and walking (Touwen, 1976).

**Analysis and Results**

**Development of Walking, Sex and Hand Preference Effects**

| Figures 1 and 2 illustrate the development of walking skills according to Touwen’s neuromotor development assessment scale. Males and females differ significantly in their acquisition of walking with females typically walking sooner than males (Figure 1). The development of walking is not significantly different between infants with right-hand versus left-hand preference. However, infants with a hand-use preference acquired walking skills significantly later than infants without a distinct hand preference (Figure 2). In exploring this previous research, the onset of walking results in decrease in lateralization (Corbetta & Bojczyk, 2002; Corbetta & Thelen, 2002). Our results are somewhat consistent with this argument in that having a hand-use preference may have delayed walking onset.

To investigate the relation of lateralization development to locomotion, we first analyzed the proportion of right-, left-, and both-hand acquisitions over the total number of acquisitions in the three handedness groups. Figure 3 shows the change in the proportion of right-hand, left-hand, and both-hand acquisitions over time for infants without a distinct hand preference (Figure 3). The figures reveal that right-hand and left-hand preference groups are very similar in their patterns of change in the proportion of bimanual acquisitions.

**Discussion**

The multilevel modeling with HLM showed that the development of lateralization changes significantly after the onset of walking, and this change is different for males and females, as well as for infants with right-hand preference and no preference status vs. those with a left-hand preference status. For infants with right-hand preference and no preference status, before the onset of walking males are more lateralized than females, but after the onset of walking males decrease and females increase in their lateralization so that males and females become very similar in their lateralization. The situation is reverse for infants with left-hand preference status; after the age of 7 months and before the onset of walking females are more lateralized than males, but after the onset of walking females decrease and males increase in their lateralization.

The multilevel analysis of longitudinal data showed that the onset of sitting and crawling did not significantly change lateralization development. The failure to find an effect on handedness lateralization for the onset of sitting and crawling suggests that other factors may be responsible for the increase in handedness at this period in development.

However, the exploratory analysis showed significant correlations between the onsets of sitting, crawling, and walking, and it may be that the most significant variable (probably the onset of walking) suppresses the influence of other variables which are collinear with the first one. In future analysis the onset of sitting, crawling, and walking will be included in a model at the same time.

The results also demonstrate that the large scale studies are needed to evaluate the developmental trajectories of handedness during infancy.