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Predictors for changes in various developmental outcomes of children with cerebral palsy—A longitudinal study

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ABSTRACT

We aimed to identify predictors for the changes of various developmental outcomes in preschool children with cerebral palsy (CP). Participants were 78 children (49 boys, 29 girls) with CP (mean age: 3 years, 8 months; SD: 1 year, 7 months; range: 1 year to 5 years, 6 months). We examined eight potential predictors: age, sex, CP subtype, *Gross Motor Function Classification System (GMFCS) level*, *selective motor control*, *Modified Ashworth Scale*, and the spinal alignment (SA) and range of motion subscales of the *Spinal Alignment and Range of Motion Measure* (*SAROMM*). Developmental outcomes for cognition, language, self-help, and social and motor functions were measured at baseline and a 6-month follow-up with the *Comprehensive Developmental Inventory for Infants and Toddlers*. Regression model showed *GMFCS* level was a negative predictor for change of language (adjusted $r^2 = 0.30$, $p < .001$), motor function (adjusted $r^2 = 0.26$, $p < .001$), social function (adjusted $r^2 = 0.07$, $p = 0.014$), and self-help (adjusted $r^2 = 0.26$, $p < .001$). Age was a negative predictor for change of cognition (adjusted $r^2 = 0.21$, $p < .001$) and language functions (adjusted $r^2 = 0.26$, $p < .001$). *SAROMM*-SA was a negative predictor for cognitive change (adjusted $r^2 = 0.30$, $p < .001$). The *GMFCS* levels and age are robust negative predictors for change of most developmental domains in these children.

1. Introduction

Cerebral palsy (CP) is a non-progressive condition that results from injury to the fetal or infant brain. CP can cause developmental and movement disorders and severe disability. CP is often associated with perception, cognition, communication, and behavioral problems. Moreover, different CP subtypes present various developmental profiles (Chen, Chen et al., 2010). For example, compared to children with spastic diplegia, children with spastic quadriplegia show decreased developmental function in motor, speech, comprehension, self-care, personal, and social skills (Chen, Chen et al., 2010). Moreover, children with spastic quadriplegia demonstrated greater impairment in mobility, transfer (McCarthy et al., 2002), physical function and psychosocial function (Varni et al., 2005) than did children with spastic diplegia.

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Previous cross-sectional studies describe predictors for motor function and activity in children with CP. For examples, age has been correlated with gross motor functions (Hong et al., 2012; Ostensjo, Carlberg, & Vollestad, 2004) and mobility (Ostensjo et al., 2004), and sex has been correlated with walking ability (Maanum, Jahnsen, Froslie, Larsen, & Keller, 2010). CP subtypes are also associated with motor functions (Chen, Chen et al., 2010; Chen et al., 2011). The *Gross Motor Function Classification System* (*GMFCS*) predicted cognition (Kennes et al., 2002), self-care (Oeffinger et al., 2007; Ohrvall, Eliasson, Lowing, Odman, & Krumlinde-Sundholm, 2010), social skills (Chen et al., 2011), mobility (Ohrvall et al., 2010), and communication skills (Hidecker et al., 2012), whereas the *selective motor control* (*SMC*) (Boyd & Graham, 1999) correlated with gross motor function (Ostensjo et al., 2004), mobility (Ostensjo et al., 2004), and self-care (Ostensjo et al., 2004). Furthermore, spasticity in the lower limbs can affect gross motor functions (Damiano, Quinlivan, Owen, Shaffrey, & Abel, 2001). The distribution of contracture and spinal misalignment, measured by the *Spinal Alignment and Range of Motion Measure* (*SAROMM*), has correlated with performance of daily functions in children with CP (Wright & Bartlett, 2010).

Longitudinal studies of children with CP indicate that potential predictors, such as age, *GMFCS* level, limb distribution, *SMC*, muscle strength, range of motion (ROM), and spasticity, are associated with developmental outcomes. In a 2-year study, the *Gross Motor Function Measure (GMFM)* was associated with different levels of limb distribution, *SMC*, muscle strength, hip and knee ROM, and hamstring spasticity (Voorman, Dallmeijer, Knol, Lankhorst, & Becher, 2007). A slight decrease in social functioning was found in children of all *GMFCS* levels in a 3-year study, but no difference was found among the different *GMFCS* levels (Voorman, Dallmeijer, Van Eck, Schuengel, & Becher, 2010). In addition, a poor *GMFCS* level was associated with increased communication impairments (Voorman et al., 2010). The *GMFCS* curves in children with CP from birth to 12 years were similar in shape. The curves were characterized by an increased rate in gross motor function at younger ages that plateaued at each predicted maximum score (Palisano et al., 2000). Analysis of age-related trends in 184 children with CP indicated that GMFM scores continued to improve until age 13 (Kerr, McDowell, Parkes, Stevenson, & Cosgrove, 2011), but deteriorated thereafter. A similar trend was observed in mobility and social function, which continued to improve until age 14 and then deteriorated (Kerr et al., 2011). A 4-year study including 657 children showed no evidence of gross motor function decline in children with *GMFCS* levels I and II, but gross motor function was estimated to peak and then decline in *GMFCS* levels III, IV, and V (Hanna et al., 2009).

Most follow-up studies have focused mainly on the predictors of gross motor functions in children and teenagers with CP. Few studies have examined predictors for functional changes in various developmental domains in preschool children with CP. Here, we attempted to identify these predictors for the developmental changes in preschool children with CP. We examined eight potential predictors: age, sex, CP subtype, *GMFCS* level, *SMC*, *Modified Ashworth Scale* (*MAS*), and the spinal alignment (SA) and ROM subscales of the *SAROMM*. Developmental outcomes for cognition, language, self-help, and social and motor functions were measured with the *Comprehensive Developmental Inventory for Infants and Toddlers* (*CDIIT*) (Liao, Wang, Yao, & Lee, 2005). We hypothesized that different predictors are associated with functional changes in various developmental domains. Identifying predictors for developmental changes in children with CP can help clinicians anticipate such changes at appropriate time periods, and better target their therapeutic strategies.

2. Methods

2.1. Participants

Young children with CP from the rehabilitation clinics of three tertiary hospitals (Taipei, Linkou, and Kaohsiung branches of Chang Gung Memorial Hospital) and one regional hospital (Chiayi branch) were consecutively recruited to this longitudinal follow-up study. A physiatrist and a physical therapist determined a patient's eligibility for the study. The inclusion criteria were: (1) diagnosis of CP, and (2) age between 1 year and 5 years, 6 months. The exclusion criteria were: (1) genetic or metabolic disorders, (2) progressive neurological disorders, and (3) severe concurrent illness or medical condition unassociated with CP (e.g., traumatic brain injury or active pneumonia). The physiatrist confirmed the CP diagnosis with a physical, clinical examination, and chart review (medical charts, brain imaging, and laboratory tests). The study protocol was approved by the Institutional Review Board for Human Studies at Chang Gung Memorial Hospital. Caregivers for each participant gave their written informed consent for study participation and publication.

2.2. Assessment procedures

Test measures were administered at the beginning of the study (baseline developmental outcome measure and potential predictors) and at a 6-month follow-up (follow-up developmental outcome measure). Two trained raters (physical therapists) administered all measures. Raters were trained by reviewing the written instructions and through repeated practice; a senior certified physical therapist assessed rater competence.

2.3. Developmental outcome measure

The *CDIIT* (Liao et al., 2005) diagnostic test, which is widely used in Taiwan, contains five developmental subtests that examine cognition (81 items), language (62 items), motor function (97 items, including 56 items for gross motor and 41 items for fine motor), social skills (56 items), and self-help (47 items). The rater administered all cognition items, motor