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Original article

Differences in body composition according to functional ability in preschool-aged children with cerebral palsy☆

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SUMMARY

Background & aims: Altered body composition is evident in school children with cerebral palsy (CP). Fat free mass and fat mass amounts differ according to functional ability and compared to typically developing children (TDC). The extent to which body composition is altered in preschool-aged children with CP is unknown. We aimed to determine the fat free mass index (FFMI) and body fat percentage (BF%) of preschool-aged children with CP and investigate differences according to functional ability and compared to TDC.

Methods: Eighty-five children with CP (68% male) of all functional abilities, motor types and distributions and 16 TDC (63% male) aged 1.4–5.1 years participated in this cross-sectional study. Body composition was determined via isotope dilution. Children with CP were classified into groups based on their Gross Motor Function Classification System (GMFCS) level. Statistical analyses were via ANOVA, ANCOVA, post-hoc Tukey HSD tests, independent *t*-tests and multiple regressions.

Results: There were no significant differences in FFMI or BF% when comparing all children with CP to TDC. Children classified as GMFCS levels III, IV and V had significantly lower FFMI levels compared to children classified as GMFCS I and II ($p < 0.05$). Children of GMFCS IV and V had the highest mean (±SD) BF% of all children (24.6% (±10.7%)), significantly higher than children of GMFCS I and II (18.6% (±6.8%), $p < 0.05$).

Conclusions: Altered body composition is evident in preschool-aged children with CP, with a trend towards lower FFMI levels and greater BF% across functional ability levels from GMFCS I to V. Further

Non-standard abbreviations: BF%, body fat percentage; BMI, body mass index; CP, cerebral palsy; DLW, doubly labelled water; DXA, dual energy X-ray absorptiometry; FFM, fat free mass; FFMI, fat free mass index; GMFCS, Gross Motor Function Classification System; TDC, typically developing children.

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research is required to determine optimal body composition parameters and investigate contributing factors.

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1. Introduction

An understanding of body composition is important in clinical practice, as a measure of body composition in addition to the usual measures of height and weight is essential for the assessment of nutritional status and adequacy.[1,2] This is particularly important in children with cerebral palsy (CP), where growth and nutritional status may be altered or compromised. For example, in a large study of 235 children with moderate to severe CP, aged between two and 18 years, malnutrition was characterised by low fat stores and decreased muscle mass combined with short stature. This malnutrition has then been linked with poorer health status and decreased societal participation.[2] Literature detailing nutritional concerns in children with CP indicate that all children are at risk of malnutrition, regardless of the level of motor impairment.[3–5] Nevertheless, the prevalence of overweight and obesity is also a concern, and is increasing in children with CP across the spectrum of functional abilities, particularly over the last decade.[6,7]

Current literature details differences in body composition that are evident in school aged and adolescent children with moderate to severe CP.[4,8–10] Lower amounts of fat free mass (FFM),[4,8] and either lower[4,8] or similar[9] amounts of body fat were apparent when compared to typically developing children (TDC). Results can be partly explained by the fact that children with CP were shorter and lighter than the TDC.[4,8] When considering functional ability, a high body fat percent (BF%) was found in school aged children with severe CP classified as Gross Motor Function Classification System (GMFCS) V compared to those who were GMFCS IV.[10] Studies of body composition in ambulant children with mild CP detail similar[11,12] amounts of FFM combined with similar[11] or greater[12] amounts of body fat when compared to TDC. In comparison to children with severe CP, children with mild CP have similar amounts of body fat,[13] but greater levels of FFM.[14] Feeding method also affects body composition, with orally-fed children with severe CP displaying greater amounts of FFM and lower BF% when compared to those who are tube- fed.[10,15]

The extent to which body composition is altered in preschool-aged children with CP across the spectrum of functional abilities has not been comprehensively reported. The provision of early nutritional management strategies to a group of young children with CP has the potential to impact favourably on body composition and growth.[8,16] The aim of this study, therefore, was to investigate and evaluate the differences in body composition (namely fat free mass index (FFMI) and BF%) according to functional ability (GMFCS) in preschool-aged children with CP and compare to TDC.

2. Materials and methods

2.1. Participants

Children living in the community in the state of Queensland, Australia, diagnosed with CP were invited to participate. To be eligible for inclusion, children were required to have a confirmed diagnosis of CP by a physician, be aged between 1.4 and 5.1 years at the time of assessment (April 2009–March 2012), and reside in Queensland, Australia. We defined CP as “a group of permanent disorders of movement and posture that are attributed to non-progressive disturbances that occurred in the developing foetal or infant brain”.[17] The characteristic signs are spasticity, movement disorders, muscle weakness, ataxia and rigidity.[18] Children with a progressive or neurodegenerative lesion, or a genetic abnormality were excluded. Typically developing children were included if they were living in Queensland, Australia at the time of the study, were in the same age range, and had no condition or were taking no medications that altered body composition. Written, informed consent was obtained from parents or legal guardians of the participants. Appointments were conducted at the closest tertiary clinical centre or at one of nine outreach locations for all children. Data were collected by the same study team at all locations throughout Queensland. Corrected age was calculated for those children under two years of age who were born at less than 37 weeks gestation to account for the influence of prematurity on growth and body composition. Chronological age was used for all other children. Data regarding birth weight and gestational age were collected via physician interview, parent report or retrospective chart review.

2.2. Body composition

Body composition was measured non-invasively using one of two stable isotope dilution procedures: deuterium[19] for the majority of children ($n = 72$ children with CP) or oxygen-18 ($n = 13$ children with CP and all 16 TDC).[20] This was due to a small subset of the children with CP and all TDC being involved in a concurrent study investigating total energy expenditure. Children were given a dose of deuterium or oxygen-18 in the form of water, either orally or via a feeding tube. Caution was taken to ensure that any spillage was collected in a cloth which was weighed before and after dosing to determine how much fluid was lost. Prior to consumption of the dose, a single urine sample was collected to determine natural baseline enrichments of the isotopes in the body. For the deuterium-dilution technique, a second urine sample was collected at approximately five hours after dosing.[19] When using oxygen-18, daily samples were collected for the 10 days following the appointment.[20] Parents of children with poor or no bladder control were instructed to collect samples using either urine bags or absorbent cotton wool balls placed in the nappy, from which urine was extracted. All urine samples were analysed using a Dual Inlet Isoprime isotope ratio mass spectrometer (Isoprime Dual Inlet IMRS – IonVantage Software, Isoprime, Manchester, UK) to determine isotopic enrichments. Dilution spaces for both deuterium and oxygen-18 were calculated according to standard equations,[19] and adjusted by 4% and 1% respectively to correct for overestimation when compared to the body water pool and give consistent total body water measures.[19,20] The subsequent total body water values were divided by age and gender specific hydration factors to give a result for FFM.[21] To account for the influence of height, FFM was adjusted to give an FFMI (FFM/height^2).[22] Body fat was determined by the difference in FFM and total body weight. Body fat percent was calculated to account for weight differences between children.