Prevalence of under and over weight in children with neurodisability, using body composition measures

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Abbreviations:
BMI body mass index
CP cerebral palsy
DS Down Syndrome
NDD Neurodevelopmental Disorders
SF Skinfolds

ABSTRACT
We aimed to compare rates of under and over weight in children with different neurodevelopmental disorders (NDD) by measuring weight, height/length, arm-to-leg bioelectrical impedance (BIA), subscapular and triceps skinfolds in 146 children aged 4-16 years attending special schools. Z scores were calculated and skinfolds and lean mass Z scores were further adjusted for height. Underweight was found in 9% (14) children with body mass index (BMI) <2nd, but only 3% (4) had skinfolds <5th centile. Overweight was much commoner, with 41% (58) children having BMI >95th and 20% (14) had skinfolds >95th centile. Children with cerebral palsy were very short with low BMI and lean mass, but only 8% (3) had skinfolds <5th centile. The children with Down syndrome were also very short and once adjusted for height, half had skinfolds >95th centile. We conclude that over weight and raised body fat is now common in children with NDD, even when the BMI is low.

BACKGROUND

Children with neurodevelopmental disorders (NDD) may have oromotor dysfunction and poor growth[1] but they are also at risk of becoming overweight because of their low activity and psychosocial constraints[2]. Children with NDD tend to grow slowly for non-nutritional reasons[3] and have altered body composition due to underdeveloped skeletal muscle[4]. It has thus been suggested that assessment methods that can measure body composition should be used in this group [5]. We conducted a cross-sectional observational study in all the complex needs special schools in the NHS Greater Glasgow & Clyde board area, in order to establish the prevalence of over and underweight in children with neurodevelopmental problems.

METHODS

Ethical approval was obtained from the West of Scotland Local Research Ethics Committee (REC number 10/S0703/77). Parents completed questionnaires and, once consent was obtained, children's were measured in school between February and May 2011. Weight was measured using *SECA 834* electronic scales or the school's wheelchair scales. A *Leicester Height Measure* was used for Height and a *Dunmow* rollameter for length. Triceps and subscapular skinfolds was measured using *Holtain Skinfold Calipers*. Lean mass was measured using arm-to-leg Bio electrical impedance (*BodyStat® 1500MDD). LMSgrowth* software was used to convert height, weight, and BMI to standard deviation scores (SDS) compared to the UK 1990 reference and skinfolds compared to the Tanner and Whitehouse reference. For children with Down Syndrome (DS) height was also compared to the UK Down Syndrome growth reference. The impedance reading was converted into Lean SD scores adjusted for gender and height[6].

As skinfolds vary substantially with height, skinfold SDS adjusted for height (HSF) were also calculated, using data from healthy children aged 7 years enrolled in the Gateshead Millennium study (GMS)[6]. Regression of the GMS cohort Height SDS on the mean skinfold SDS revealed that for every 1 SD rise in height, mean skinfold SDS rose by 0.348 SDS. This constant was thus used to derive residual SD score skinfold SDS adjusted for height in the special school data set:

*Adjusted skinfold SDS = mean skinfold SDS – (Height SDS * 0.348)*

RESULTS

There were 396 children in 10 special schools, but only 151 could be studied (43% females) mainly due to lack of parental consent. The commonest diagnosis was cerebral palsy (CP) followed by autism, Down syndrome (DS) and spina bifida (Table 1); the remainder had other learning difficulty/global developmental delay, or other problems such as chromosomal abnormalities, syndromes and epilepsy. Only 9% (13) children had BMI <2nd centile and 3% (4) children had low skinfolds (<-2SD), decreasing to 1.4% (2) after adjustment for height, but 29% (41) were obese (>95th) and 13% (18) severely obese (>99.6th). Three % (20) had unadjusted skinfolds above 95th centile, rising to 25% (34) after adjustment for height.

Of the 13 children with BMI <2nd only two had unadjusted skinfolds <5th centile and after adjustment for height this dropped to one (table 2). Only half the 39 children with BMI >95th also had unadjusted skinfolds >95th centile, but after

adjustment for height this rose to 74%. Even after adjustment for height only 20% of those with BMI 85-95 had skinfolds >95th.
Children with CP were extremely short, had low lean mass and were the only group with mean BMI and skinfolds below the 50th centile (table 1). However, once adjusted for height, their skinfolds were also above the 50th centile. Children with DS were also very short, but had high lean mass and once adjusted for height nearly half had skinfolds >95th centile (Table 2).
There were 31 children where length or height measurement was hard to measure; and three of these measurements had to be excluded as implausible. For the remainder their mean [SD] height (1.8 [2.0]) was not significantly different from those measured without difficulty (1.2 (2.2 P=0.17).

DISCUSSION

This study builds on the very few previous studies that have examined the body composition of children with NDD[7-10], by comparing different conditions using the same methodology. We were able to recruit sufficient numbers within four reasonably distinct conditions to make interesting comparisons. It has recently been suggested that there are still high rates of unrecognised undernutrition in children with CP[1] but in this study as in an earlier study in one special school[2] it seems likely that over nutrition is the greater problem. High levels of overweight in children with NDD are a concern, because obesity can worsen existing mobility impairments in children with physical disability, while children with LD tend to be excluded from community and school based programmes.
Many of these children had low BMI because of low lean mass, so the simple body composition (BC) measures used proved informative. Skinfolds are now recommended for the assessment of children with neurological impairment[5]. Traditionally these measures are entered into a prediction formula and then expressed as percentage fat, but there are no valid prediction formulae for most patient groups, with the exception of CP[9] , and percentage fat will always tend to overestimate fat mass in NND children because of their low lean mass[11]. Conversely we have shown that simple measures of subcutaneous fat levels do vary in proportion to height in children without neurodisability, so it seems possible that in conditions with intrinsically short stature, such as Down syndrome and CP, fat stores will still be underestimated.
BIA is a valid field measure of lean mass which has already been tested in cerebral palsy[7, 10]. The lean mass readings were compared to standards for a large UK cohort aged 8-12 years[6] so estimates may be less robust below and above those ages, or for the exceptionally short. Our finding of raised lean mass in children with DS is interesting but not consistent with an earlier study in DS, using DXA[8].

CONCLUSIONS

Children with neurodevelopmental problems are now more likely to be over weight than underweight and tend to have very low lean mass, so a low BMI in this group does not usually imply low fat stores. Efforts are needed to protect severely disabled children from overfeeding and to help families of children with LD to manage their overweight.

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CONFLICT OF INTEREST

None of the authors have any conflicts of interest to disclose

ETHICAL APPROVAL

Ethical approval was obtained from Glasgow City Council Educational Services, NHS Greater Glasgow and Clyde Research Ethics Service and the West of Scotland Regional Ethics Service *(REC:10/S0703/77).* Consent was requested from head teachers of special schools before commencing data collection

STATEMENT OF AUTHORSHIP

CW organized the design and supervised the study. AC and SL wrote the ethics application and prepared the relevant documentation. SL carried out the field work, data entry and initial data analysis and wrote the first draft of the manuscript. CW undertook further analyses and wrote the final draft, which was reviewed by all authors before submission.

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Table 1: Body composition characteristics broken down by diagnostic group, mobility and feeding.

Values are mean (SD) z scores

Diagnostic group	Number (%) in each category	Height N=146	BMI N=146	Skinfolds N=140	Skinfolds Adjusted for Height N=136	Lean adjusted for height (BIA) N=139
Cerebral Palsy	38 (25.0)	-2.38 (1.8)	-0.65 (2.4)	-0.34 (1.1)	0.49 (1.2)*	-1.65 (1.6)*
Down Syndrome	18 (12.0)	-2.72 (1.0) -0.78 (1.0)[$]	0.99 (1.9)	0.70 (0.95)	1.59 (0.93)*	2.29 (1.1)*
Spina Bifida	13 (8.6)	-0.95 (1.9)	0.58 (1.3)	0.27 (1.1)	0.60 (0.28)	-0.16 (1.6)
Autism	30 (19.9)	-0.18 (1.6)	1.29 (1.5)	1.00 (0.98)	1.13 (0.99)	0.39 (1.5)*
Other Learning difficulty	15 (9.9)	-1.11 (1.8)	0.49 (1.9)	0.36 (1.2)	0.80 (1.4)	-0.90 (2.1)
Other diagnoses	37 (24.5)	-1.65 (2.0)	0.41 (2.1)	0.64 (1.1)	1.32 (1.1)	-1.30 (2.7)
Mobility						
Fully ambulant	75 (49.7)	-1.09 (1.7)	0.78 (1.8)	0.59 (1.1)	1.01 (1.2)	0.45 (1.8)
Partially	35 (23.2)	-1.53 (2.2)	0.36 (2.2)	0.54 (1.1)	1.11 (1.1)	-0.41 (2.2)
Non-ambulant	41 (27.2)	-2.42 (1.8)	-0.26 (2.4)	-0.037 (1.2)	0.83 (1.2)	-2.17 (2.0)
P (Anova)		0.002	0.039	0.016	0.57	<0.001
Feeding						
Not Artificially Fed	133 (89.3)	-1.42 (2.0)	0.46 (2.0)	0.40 (1.2)	0.94 (1.2)	-0.34 (2.2)
Artificially Fed	16 (10.7)	-2.66 (1.5)	-0.24 (2.8)	0.24 (1.2)	1.23 (1.2)	-2.24 (1.7)
P t-test		0.017	0.21	0.62	0.36	0.002

[$] using Down syndrome standard * t-test P <0.05 for that diagnostic group compared to all other groups

Table 2: Proportion with low or high skinfolds fat before and after adjustment for height

Value are % (N)

	Raw skinfolds results		Adjusted for height	
	<5thcentile	>95thcentile	<5thcentile	>95th centile
All children	2.9 (4)	14.3 (20)	1.4 (2)	24.5 (34)
BMI >95th centile	0	46.2 (18)	0	74.4 (29)
BMI 85-95th centile	0	0	0	20.0 (3)
BMI <2nd centile	15.4 (2)	0	7.7 (1)	0
Diagnostic group				
Cerebral Palsy	8.3 (3)	2.8 (1)**	2.8 (1)	16.7 (6)
Down Syndrome	0	16.7 (3)	0	47.1 (8)*
Spina Bifida	0	7.7 (1)	0	7.7 (1)
Autism	0	25.0 (6)	0	25.0 (6)
Other Learning difficulty	0	21.4 (3)	0	21.4 (3)
Other diagnoses	2.9 (1)	20.6 (7)	0	31.3 (10)
Mobility				
Non-ambulatory	4.9 (2)	4.9 (2)	0	22.0 (9)
Partially	3.1 (1)	15.6 (5)	3.2 (1)	26.7 (8)
Fully ambulant	1.5 (1)	19.4 (13)*	1.5 (1)	26.2 (17)
Feeding				
Not Artificially Fed	3.3 (4)	15.4 (19)	1.6 (2)	23.5 (28)
Artificially Fed	0	6.7 (1)	0	33.3 (5)

* P <0.05 **P<0.01for that diagnostic group compared to all other groups