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Behavioural and Cognitive Associations of Short Stature at 5 Years

SL STATHIS,[1] MJ O'CALLAGHAN,[2] GM WILLIAMS,[3] JM NAJMAN,[4] MJ ANDERSEN[5] and W BOR[6]

[1]Department of Developmental Paediatrics, [2]Child Developmental and Rehabilitation Services, Mater Children's Hospital, South Brisbane, [3]Tropical Health and Nutrition Program, University of Queensland, [4]Department of Anthropology and Sociology, University of Queensland, [5]Department of Obstetrics and Gynaecology, University of Queensland and [6]Child and Youth Mental Health, Royal Children's Hospital Health District, Brisbane, Australia

Abstract

Objectives: To determine the extent to which childhood short stature is associated with cognitive, behavioural and chronic health problems, and whether these problems could be attributed to recognized adverse biological, psychosocial or psychological factors.

Methodology: At their first antenatal session, 8556 women were enrolled in a prospective study of pregnancy. When their children were 4 and 6 years of age, mothers completed a detailed questionnaire concerning their child's health and behaviour. A Peabody Picture Vocabulary Test–Revised (PPVT-R) was completed by the child at 5 years of age. Z scores were used to categorize height measurements in 3986 children. The relationship of these height categories with the child's health, and behavioural and cognitive problems was then examined.

Results: No association was found between height and symptoms of chronic disease or behaviour problems in boys or girls. On the unadjusted analysis, mean PPVT-R scores were significantly lower in boys with heights < 3 percentile and 3–< 10 percentile compared with study children between 10 to 90 percentile ($P < 0.01$). Scores were similarly significantly lower in girls with heights < 3 percentile and 3–10 percentile ($P = 0.01$). Even after adjusting for psychosocial and biological confounders, short stature remained a significant predictor for lower PPVT-R scores in both boys and girls, although height only accounted for 1.1% of the variance in scores in boys and 0.5% of the variance in PPVT-R scores in girls. Psychosocial factors had a greater role than height in determining PPVT-R scores at 5 years of age.

Conclusions: These findings suggest a significant, though small, association between height and PPVT-R scores at 5 years of age, independent of psychosocial disadvantage and known biological risk factors.

Keywords: behavioural problems; cognition; height; Peabody Picture Vocabulary Test–Revised; short stature.

An increased prevalence of low self-esteem, social immaturity, behavioural problems, cognitive and academic difficulties have been reported in children with short stature.[1–3] The rationale for this association between short stature and increased behavioural and cognitive difficulties might include direct biological causes and indirect adverse environmental, psychological and social factors. The biological explanation suggests that intellectual, behavioural, and academic deficits result from adverse neurobiological events during pregnancy affecting physical growth and brain development, or chronic ill health during childhood affecting physical growth and opportunities for learning. Psychosocial explanations suggest an association between social disadvantage and family adversity, with later childhood growth, behaviour and learning difficulties.[4,5] Short stature, and the behaviour of peers, teachers and parents, may also affect the child's perception of his/her own social skills, resulting in low self-esteem and impaired behaviour and academic functioning.[6,7]

Short children are more likely to be seen as intellectual underachievers by both parents and teachers[8] with caregivers perceiving a discrepancy between a short child's ability to achieve and their actual academic records. A number of longitudinal population studies have reported children with short stature scoring lower than their normal sized peers on standardized intelligence testing, though still within the normal range.[9,10] While some attributed these findings to social class, biological factors and social disadvantage,[11,12] others found an independent effect of stature itself.[13–15]

Though an increased prevalence of behavioural and psychological problems, including poor self esteem and depression, have been reported in short children, many of the subjects were recruited from growth clinics and had endocrinopathies or other genetic disorders.[2,16–19] It has been suggested that such medical conditions may increase selection bias, with a higher prevalence of anxious parents and children in such cohorts.[8] Conversely, other clinic based studies suggest that the degree of height deficit is unrelated to psychological adjustment,[20–23] with short children in the general population functioning socially in ways that are indistinguishable from their normal sized peers.[24] Voss et al. in the community-based Wessex Growth Study, reported similar findings.[25]

There have been few recent, large scale, community-based research into this subject and limited data are available in an Australian context. The aims of this study were to establish the extent to which short stature was associated with cognitive, behavioural and chronic health problems in 5-year-old Australian children, and whether these problems could be attributed to recognized adverse biological, psychosocial or psychological factors.

METHODS

Between 1981 and 1984, 8556 women attending their first antenatal session at the Mater Mothers' Hospital, Brisbane, were enrolled in the Mater–University Study of Pregnancy. Of the subsequent 7785 singleton deliveries, 7357 children remained for consideration. Reasons for the exclusion of the other 428 infants have been described elsewhere.[26]

The children's age at follow up varied from 4 to 6 years with a mean age of 67 months for boys and 66 months for girls. A completed detailed questionnaire concerning the child's health, development and behaviour was obtained from 5627 mothers. Unfortunately, mainly due to insufficient funds during the latter part of the study, only 4019 children underwent individual clinical assessment including measurements of height and administration of the Peabody Picture Vocabulary Test (PPVT-R). Overall, children not seen at 5 years were more likely to be preterm or of lower birthweight, while their mothers were likely to be younger and less well educated.[27] Fourteen children with a PPVT-R score of less than 50, or with cerebral palsy or other serious neurological disorders, were excluded from the study. Due to incomplete data, the association between child behaviour and height was examined in 3968 children (2072 boys and 1884 girls). In addition, the association between PPVT-R scores and height was examined in 3956 children (2088 boys and 1880 girls).

Data concerning the child's current physical health were taken from a mother reported questionnaire concerning general and specific health issues of their child at the 5-year visit (Table 1). Standard questions taken from the Rand survey[28] were used. Emphasis was placed on whether these health problems limited the activities that the child could perform, and if so whether the limitations affected them 'a little' or 'a lot'.

Both acute and chronic medical issues were explored. Mothers were asked a series of questions aimed at assessing acute (less than a month's duration), subacute (1–3 months duration) and chronic (greater than 3 months duration) medical conditions. They were then asked to rate their child's general health as being 'excellent, good, fair, or poor'. The number of times the child had been sick or visited a doctor in the previous 6 months, and how many times the child had been hospitalized since birth was also reported.

Table 1 Symptoms included in health questionnaire

Past month:	Head cold, sore throat, runny nose
	Bronchitis
	Asthma
	Ear Infections
	Vomiting and/or diarrhoea
	Skin rashes
	Home accidents needing a doctor's help
	Accidents outside the home requiring a doctor's help
Less than 3 months:	Head cold, sore throat, runny nose
	Bronchitis
	Asthma
	Ear infections
	Vomiting and/or diarrhoea
	Skin rashes
More than 3 months:	Asthma
	Bronchitis
	Epileptic fits
	Anaemia or 'low blood' counts
	Mental retardation
	Birth defects of the heart
	Cancer or leukaemia
	Malabsorption
	Cystic fibrosis or chronic respiratory disease

Height was measured using a portable stadiometer (KaWe Personen – Messgerat 4440). Standardized Z scores for height were then calculated according to age and sex using Epi Info 6, Epinut Software.[29] Children were categorized as having a height ² 3 (very short), 3–< 10 (short), 10–90, 91–97, > 97 percentile within the study population.

Children seen for clinical assessments were also administered the PPVT-R, a well-established standardized test of receptive vocabulary. Although not a specific measure of intellectual ability, it correlates closely with intellectual ability.30 The test also correlates well with other measures of vocabulary and general ability tests for young children, including the Stanford–Binet Fourth Edition31 and the Kaufman Brief Intelligence Test.[32] Adjusted PPVT-R scores were calculated separately for boys and girls from the regression analysis.

Parents completed a modified Child Behaviour Checklist with three scales based on the second order groupings of syndromes identified by Achenbach.[33] The externalizing scale consisted of 11 items (Cronbach Alpha 0.84), the internalizing scale had 10 items (Cronbach Alpha 0.77), while the third scale of 10 items comprised social, attention and thought (SAT) behavioural problems (Cronbach Alpha 0.75).[34] A 10 percentile cut-off, as suggested by Achenbach, was used to identify behavioural problems.

Separate analyses were performed for boys and girls. Using the Chi-squared test for statistical significance, frequency counts in height categories were compared with the presence of medical problems and externalizing, internalizing and SAT behavioural problems. Strength of association was measured by Relative Risk (RR). Analysis of variance (ANOVA) and 2-Sample t-tests were used to examine height categories differences in mean PPVT-R scores. Difference between the means and 95% confidence intervals using boys and girls with heights between 10 and 90 percentile as reference were calculated. To adjust for possible confounders, separate multiple linear regression models for boys and girls were used with PPVT-R scores as the dependent variable. As the method of adjustment was internal to each separate analysis, adjusted mean scores for boys are not directly comparable to those of girls. Biological factors included in the model were birthweight, gestational age, small for gestational age (< 10 centile for gestation and gender within the cohort), maternal age, maternal height and maternal estimates of paternal height, head circumference of the child at birth, length of the child at birth, a history of chronic otitis media at 5 years, in addition to height percentile categories. Psychosocial factors included in the same model were maternal and paternal level of education, measures of low family income and chronic poverty,[35] a maternal history of smoking during early and late pregnancy and at 5 years, marital status of the mother during pregnancy and at 5 years, a maternal history of anxiety and depression at birth and 5 years, ethnicity of the mother and father, time spent in Australia, and whether the child was born in an English speaking country.

RESULTS

For all aspects of health described in Table 1, mothers with children ² 3% in height failed to report any significantly increased prevalence in acute, subacute, or chronic health problems when compared with parents of normal controls (10–90th percentile). There was also no increase in the limitation in the kind or amount of vigorous activities that these short children could perform. Children with a height < 3 percentile on average suffered just as many illnesses, and visited the doctor the same number of times, as their normal sized controls. No increased prevalence of hospitalizations or accident rates was reported in these children.

No association was found between the prevalence of externalizing, internalizing, or SAT behaviour problems and height categories (Table 2). There was an apparent increase in internalizing behaviour problems in girls with heights 3–< 10 percentile (18.0%: RR 1.7; 95% CI 1.2–2.6) compared with normal controls (10.4%). However, this finding was inconsistent, as girls with heights < 3% did not have an increased rate of internalizing problems (9.3%: RR 0.9; 95% CI 0.4–2.0). The higher prevalence in girls with heights 3–< 10 percentile may therefore be a statistical reflection of the multiple correlations being made.

Mean PPVT-R scores were then compared for each height percentile groups in boys and girls separately (Table 3). Analysis of variance showed significant differences between PPVT-R scores across height categories both in males ($F_{(4, 2067}$ = 6.89: $P < 0.01$) and females ($F_{(4, 1879)}$ = 6.95: $P = 0.01$). Boys with heights $\leq$3 percentile (PPVT-R 93.3: difference in means (Diff.) – 6.3; 95% CI – 9.8, – 2.8) and between the 3–< 10 percentile (PPVT-R 94.8: Diff. – 4.8; 95% CI – 7.1, – 2.5) had significantly lower PPVT-R scores than study children with heights between 10 and 90 percentile (PPVT-R 99.6). Similar though less marked differences were found for girls. Those with heights $\leq$3 percentile (PPVT-R 96.2: Diff. – 3.8; 95% CI – 7.4, –

0.2) and between the 3– < 10 percentile (PPVT-R 95.9: Diff. – 4.1; 95% CI – 6.4, – 1.8) had lower PPVT-R scores than girls with heights between the 10–90 percentile (PPVT-R 100.0). No significant increase in PPVT-R was found in taller boys. However, increasing height was associated with significantly higher PPVT-R scores in girls. Girls with a height > 97 percentile had an average PPVT-R 4.7 points higher than normal sized girls on the adjusted analysis.

Separate Multiple Linear Regression Analysis was performed for male and female children with PPVT-R scores as the dependant variable. Biological and psychosocial factors included in the model are described in 'Methods'. For male children, the relationship between height < 10% and lower PPVT-R scores remained statistically significant despite all factors being added to the model (unadjusted $F_{(4, 2078)} = 6.9$; postadjustment $F_{(4, 1641)} = 5.4$: $P < 0.001$). In this adjusted model, maternal age ($F_{(4, 1641)} = 7.2$; $P < 0.001$), maternal education ($F_{(5, 1641)} = 9.8$; $P < 0.001$), a non-English speaking background ($F_{(4, 1641)} = 5.3$; $P < 0.001$), age at evaluation ($F_{(2, 1641)} = 6.4$; $P < 0.01$), maternal depression at birth ($F_{(1, 1641)} = 5.0$; $P = 0.03$) and maternal height ($F_{(1, 1641)} = 4.1$; $P = 0.04$) were all strong independent predictors of lower PPVT-R scores. Maternal ethnic background ($F_{(4, 1641)} = 2.1$; $P = 0.08$) and paternal ethnic background ($F_{(4, 1641)} = 2.1$; $P = 0.08$) were not statistically significant independent predictors for lower PPVT-R scores. In girls, the relationship between PPVT-R scores and height diminished, though continued to remain significant, when all factors were added to the model (unadjusted $F_{(4, 1890)} = 6.95$; postadjustment $F_{(4, 1445)} = 2.4$; $P = 0.05$). Maternal education ($F_{(4, 1445)} = 12.3$; $P < 0.001$), poverty ($F_{(4, 1445)} = 10.5$; $P < 0.001$), a non-English speaking background ($F_{(4, 1445)} = 5.0$; $P < 0.001$), maternal height ($F_{(1, 1445)} = 5.0$; $P = 0.003$), maternal ethnicity ($F_{(4, 1445)} = 3.7$; $P = 0.005$), paternal ethnicity ($F_{(4, 1445)} = 3.5$; $P = 0.007$), and maternal age ($F_{(4, 1445)} = 3.0$; $P = 0.02$) were strong independent predictors for PPVT-R scores, and confounded the association between short stature and PPVT-R score.

Table 2 Prevalence of externalizing, internalizing, and SAT behaviour problems according to height categories in boys and girls

Height category	*n*	Externalizing (%)	RR (95% CI)*	Internalizing (%)	RR (95% CI)*	SAT (%)	RR (95% CI)*
				Male			
< 3%	61	14.8	1.3 (0.7-2.3)	13.1	1.2 (0.6-2.3)	21.7	1.6 (0.9-2.6)
3-<10%	147	8.8	0.8 (0.4-1.3)	14.2	1.3 (0.8-1.9)	15.8	1.1 (0.8-1.7)
10-90%	1671	11.7	1.0	11.1	1.0	13.8	1.0
>90-97%	147	10.2	0.9 (0.5-1.4)	11.6	1.0 (0.7-1.7)	14.3	1.0 (0.7-1.6)
>97%	62	9.7	0.8 (0.4-1.8)	12.9	1.2 (0.6-2.2)	12.9	0.9 (0.5-1.8)
P Value		0.7		0.8		0.5	
				Female			
< 3%	54	13.0	1.6 (0.8-3.3)	9.3	0.9 (0.4-2.0)	7.4	0.8 (0.3-2.1)
3-<10%	130	10.0	1.3 (0.7-2.1)	18.0	1.7 (1.2-2.6)	12.3	1.4 (0.8-2.2)
10-90%	1507	8.0	1.0	10.4	1.0	9.0	1.0
>90-97%	134	9.7	1.1 (0.6-2.0)	14.2	1.4 (0.8-2.1)	13.3	1.5 (0.9-2.3)
>97%	55	10.9	1.4 (0.6-3.0)	14.5	1.4 (0.7-2.7)	16.4	1.8 (1.0-3.4)
P Value		0.6		0.06		0.1	

*Relative Risk (RR) and 95% confidence interval (CI). Normal height (10-90%) as references. SAT, social, attention and thought behavioural problems.

The proportion of the variance in PPVT-R scores explained by height and the other independent biological and psychosocial predictors in this model was examined.

In boys, height contributed 1.1% to the overall variance in PPVT-R scores. Maternal education (2.5%), maternal age (1.5%), a non-English speaking background (1.0%), age at evaluation (0.7%), maternal depression at birth (0.3%) and maternal height (0.2%) all made a contribution to the variance in PPVT-R scores. Similarly in girls, height (0.5%) contributed little to the variance in PPVT-R scores, with maternal education (3.5%), poverty (1.2%), a non- English speaking background (1.1%), maternal (0.8%) and paternal (0.8%) ethnicity, and maternal height (0.5%) all having a greater contribution.

Table 3 Height categories and Peabody Picture Vocabulary Test-Revised (PPVT-R) Score in boys and girls

	n	Unadjusted mean†	SD	Diff mean (95% CI) ‡	Adjusted mean	Diff§ adjusted mean
				Male		
< 3%	60	93.3	13.8	-6.3 (-9.8, -2.8)	92.1	-6.2
3-<10%	145	94.8	12.9	-4.8 (-7.1, -2.5)	94.0	-4.3
10-90%	1660	99.6	13.7	0	98.3	0
>90-97%	145	99.8	14.0	0.2 (-2.1, 2.5)	96.7	-1.6
>97%	62	99.3	12.1	-0.3 (-3.8, 3.2)	97.1	-1.2
				Female		
< 3%	53	96.2	15.6	-3.8 (-7.4, -0.2)	92.3	-2.4
3-<10%	132	95.9	14.8	-4.1 (-6.4, -1.8)	92.5	-2.2
10-90%	1508	100.0	13.1	0	94.7	0
>90-97%	135	102.6	12.7	2.6 (0.3, 4.9)	95.1	0.4
>97%	56	104.6	16.2	4.6 (1.1, 8.1)	99.4	4.7

Analysis of variance: Males ($F(4, 2067) = 6.89$: $P < 0.01$); females ($F(4, 1879) = 6.95$; $P = 0.01$).

†Unadjusted means: 2 Sample *t*-test with equal variance and $P < 0.05$ indicating significance:
Males < 3% *vs* males 3–10%. $P = 0.5$ Females < 3% *vs* females 3–10% $P = 0.9$
Males < 3% *vs* males 10–90% $P = 0.0005$ Females < 3% *vs* females 10–90% $P = 0.04$
Males 3–< 10% *vs* males 10–90% $P = 0.0001$ Females 3–< 10% *vs* females 10–90% $P = 0.007$
‡Difference in means and 95% confidence interval. Normal height (10–90%) as reference.
§Difference in adjusted means.

DISCUSSION

Short stature has been the subject of a number of studies over the last few decades, with conflicting data related to academic performance and psychological characteristics of these children. We found no association between short stature and maternal reports of symptoms of acute and chronic disease. Mothers of short children were as likely to report their child as enjoying good to excellent health as were the mothers of normal sized children (10–90 percentile). Short stature was not associated with an increased prevalence of behavioural problems in boys or girls aged 5 years. In the unadjusted analysis, there was a significant association between height and PPVT-R scores for both boys and girls. Those boys !9 3 percentile, and between the 3–< 10 percentile in height scored over 5 points below their normal size controls (height 10–90 percentile) despite adjust-ment for a wide variety of psychosocial and biological factors. In girls, the association between height and lower PPVT-R scores was independent of psychosocial adversity though the magnitude of the association diminished when independent predictors were added to the model.

Chronic disease is well known to be associated with short stature. The lack of an association between maternal reports of chronic disease and short stature was

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therefore unexpected but may be due to the low prevalence of chronic disease reported in the cohort. Subjects were not assessed medically to determine the true prevalence of chronic disease.

Few studies have examined the association between short stature and behaviour in young children. Stabler *et al.* found a high frequency of problems with academic achievement, poor behaviour and social competency in children referred for growth hormone treatment.[1] A number of studies of children referred to paediatric endocrinology clinics with concerns about short stature reported no increased risk for behavioural and psycho-logical problems in males or females.[20,21,24] Voss *et al.*, in the community-based Wessex Growth Study, reported no difference in self esteem or behaviour between a non-referred sample of 140 short children aged 7–9 years and 140 children of the same age but of average height.[25] Parents however, tended to under-estimate the well-being of the child.[36] Short preadolescents seem as happy with their appearance as their normal sized peers,[8] though they tend to be less assertive.[5] These findings suggest that prior to adolescence short children do not see themselves as different from their taller peers, and support our findings of no association between short stature and behavioural problems.

A number of other longitudinal population studies have reported lower standardized intelligence test scores in children with short stature when compared with their normal sized peers.[9,10,14] Lacey and Parkin, in a community-based study, reported that short children obtained lower scores on tests of verbal and nonverbal performance. However, they concluded that lower intelligence test scores in short children were related to social disadvantage.[11] However, Douglas *et al.* in a longitudinal study of over 5000 British children, found a significant relationship between height and intelligence scores, even after controlling for age, social class and family size.[13] Wilson *et al.* reinforced Douglas *et al.*'s findings after analysing data from the US National Health Examination Study. The authors reported a highly significant correlation between height and intelligence ($P < 0.001$), despite adjusting for socioeconomic status and race.[15] In a recent paper reporting a follow up of the Wessex growth study, Downey *et al.* reported that short children at 11–13 years had significantly lower IQ scores than normal sized controls,[12] though such differences had not been reported at 7–9 years.[25] Social class was found to be a better predictor for lower intelligence scores than height, with social class explaining 14% of the variance in IQ scores and height only explaining a further 2%. It was concluded that social class has more influence than height on a child's psychosocial development.[12] Using the same cohort as our study, O'Callaghan *et al.* demonstrated strong associations between social and environ-mental disadvantage and development.[37] We found maternal education, maternal age and poverty in girls to be more powerful predictors of PPVT-R scores than height. After adjusting for social disadvantage, height explained only 0.5% of the variance in PPVT-R scores in girls and 1.1% of the variance in boys, and is of uncertain clinical significance. Psychosocial factors therefore appear to have more influence on PPVT-R scores than height in both girls and boys at 5 years; this may be secondary to environmental and psychological factors contributing to bias and poor performance on testing.[5,8] Performance scores are known to be associated with a number of independent factors including maternal age, low self esteem, behavioural problems, family attitudes and support networks, ethnic background and a lower socioeconomic status.[1,3,24,25] Furthermore, short children from socioeconomically disadvantaged backgrounds remain at high risk of later educational failure.[38]

The explanation for the independent association between height and PPVT-R score is uncertain. Children in this study were not examined medically. It is possible that a number of medical and genetic disorders were not recognized, though the low prevalence of these is such that it is unlikely to explain differences in the PPVT-R scores. The distribution of PPVT-R scores among children < 3 percentile was also approximately normal, so that the association was not due to a small number of children with more severe impairment of PPVT-R scores. Not all possible measures of psychosocial disadvantage were examined, though given the range of factors included in the model and the absence of association with behavioural problems, this is unlikely to be the explanation. A number of tests of statistical significance involving clinically plausible hypotheses were performed in this study. Although this raises the possibility of Type I error, each was associated with a credible biological hypothesis. Finally, it should be emphasized that the PPVT-R is primarily a measure of receptive vocabulary, and only an indirect measure of intellectual ability.

Our findings suggest a significant though small association between height and PPVT-R scores, independent of psycho-social disadvantage and known biological risk factors. The absence of behavioural concerns reported in this study should not imply that short stature is not a problem, but rather it may not be so before puberty. These children require further follow up during the teen age years, when long-term adjustment issues become increasingly important and the findings related to lower PPVT-R scores may be further clarified.

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