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Utility of the waist-to-height ratio as an instrument to measure parental perception of body weight in children and its use in a population-based survey of children

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Abstract

Objective: To investigate which anthropometric measure of overweight status, BMI or waist-to-height ratio (WHtR), is most closely associated with parents' perception of their child's overweight status.
Design: The sensitivity and specificity of parental perception against child-specific BMI and WHtR definitions of overweight were tested.
Setting: Primary schools in Queensland, Australia.
Subjects: Boys and girls aged 9·00–11·99 years (n 1431).
Results: Of the 138 boys and 202 girls who were classified as overweight according to BMI, only 27·5 % (boys) and 22·7 % (girls) were also perceived as overweight by their parents. Using WHtR, 206 boys and 333 girls were classified as overweight, of whom only 21·9 % and 13·8 %, respectively, were perceived as overweight. Perception of overweight was underestimated in approximately 15 % of boys and 21 % of girls when compared with BMI. Underestimation was higher when compared with WHtR: 25 % (boys) and 39 % (girls). Overweight prevalence was significantly lower according to perception than according to BMI or WHtR. Mother's education level was significantly associated with accurate perception of overweight status ($P < 0·001$).
Conclusions: The sensitivity of parental perception of child overweight was higher when BMI was used. However, emphasis needs to be placed on using WHtR as an actual measure of overweight because high central adiposity is associated with increased risk of CVD. The combined use of WHtR, body-shape images rather than word responses regarding perception and public health messages that educate parents and children about body shape and associated health risks may be the best combination in improving parents' perception of their child's overweight status.

Keywords
Perceived overweight
Children
Waist-to-height ratio
BMI

The prevalence of childhood overweight has risen over the last two decades in many developed countries[1]. The need for obesity prevention strategies has become paramount. However, active participation in these strategies depends partly on the ability of parents to recognize when their child is overweight. Several studies[2–10] have examined how parents perceive their child's weight status. Their perception of weight status is then usually compared with actual weight status categorized using BMI. These studies have reported that the prevalence of overweight, calculated from parental perception, is significantly lower than the prevalence of overweight categorized using BMI[2–10]. The reasons for underestimating weight status are varied and include: parents' belief that their child will 'grow into their weight' and is therefore not an immediate problem[4,9]; the belief that a bigger child may be healthier than one who is thin[4]; and the concern that highlighting overweight may encourage the development of eating disorders[3,4]. As overweight has become so much more prevalent, it is also possible that recognizing overweight is difficult because the perception of normal weight has shifted, so only the severely obese are being identified by visual inspection as having a weight problem.

The discrepancies between actual and perceived weight status may also be the result of using BMI to categorize actual weight. One of the disadvantages of BMI is that it is not a measure of body composition. For example, a muscular child may be erroneously classified as overweight using BMI. However, the parents may not perceive the child as such, and therefore a discrepancy would arise

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between actual overweight status and perceived overweight status. In 2011, Juliussen *et al.* compared parental perception of children's weight status with BMI, as well as measures such as triceps skinfold thickness (TSF) and waist circumference (WC). To the best of our knowledge, the cited study is the only one that has used measures other than BMI to predict parental perception of children's weight. It was found that 'parental perception of their children's weight status was similar if BMI, WC or TSF were used as predictors, although, it could not be confirmed if the added information of WC and TSF improved the ability of the parents to correctly classify their child's weight status'[11]. The issue with using measures such as WC and TSF is that there is no definitive cut-off for children that marks increased health risks associated with high adiposity. Therefore, unlike the use of BMI, there is no way of 'grouping' children according to weight status based on measures such as WC or TSF. If such cut-offs existed, then the agreement between the proportion classified as 'overweight' according to WC (or another measure of adiposity) could then be compared with the proportion classified as overweight according to parental perception.

Other measures, such as the recently described waist-to-height ratio (WHtR), have not been extensively tested as an alternative tool to categorize weight status in children. WHtR is a proxy measure of central fatness, which is an important risk factor linked to insulin resistance, type 2 diabetes and CVD. Obese children and adolescents are at greater risk of developing such conditions earlier in life[12–18]. WHtR may be superior to BMI and WC because it not only incorporates the waist circumference as a measure of abdominal adiposity, but also adjusts for the size of the individual by dividing by their height[19]. In adults, a WHtR of ≥0·5 is associated with high abdominal adiposity and increased risk of CVD[20]. In a recent Australian study, very high abdominal adiposity was defined as WHtR ≥0·48 in males and ≥0·47 in females aged 8–16 years[21]. The use of this index therefore comes with a simple public health message: 'keep your waist circumference to less than half your height'. Moreover, a centrally obese child may be visually easier for a parent to correctly classify as overweight or obese, potentially reducing the degree of discrepancy between parental perception of overweight status and actual overweight status categorized using WHtR.

Therefore the aim of the present analysis was to investigate which anthropometric measure of actual overweight status – BMI or WHtR – is most closely associated with parental perception of overweight status in children aged between 9 and 11 years. The role of the mother's educational level as a factor in correct perception of overweight is also explored. The prevalence of overweight calculated from perception is also important to note, as the success of interventions will be based on the proportion of parents who can identify that their child's weight may be a health problem.

Experimental methods

Data from 686 males and 745 females aged 9·00–11·99 years, who could provide anthropometric data (height, weight, waist circumference) and whose parents could provide information regarding perception of body weight, were used in analyses. These children were participants of a larger, cross-sectional, population-based survey called the 'Healthy Kids Queensland: Physical Activity and Nutrition Survey' (*n* 3601). The survey used a randomized cluster design to select schools as the setting for data collection[22]. The school setting was chosen because children in the age groups of interest spent the majority of the week in school. A random sample of 112 schools, from all primary and secondary schools in the state of Queensland, Australia, were invited to take part. Of these schools, seventy-two (thirty-nine schools from urban areas and thirty-three schools from rural areas) agreed to take part (65% response rate). To maximize the statistical power of the survey, three key age groups were chosen: 5·00–7·99 years (*n* 1102), 9·00–11·99 years (*n* 1487) and 14·00–16·99 years (*n* 1012). Children in these age groups were typically in their first year, fifth year and last year of compulsory schooling, respectively. These years are also critical times in growth and development. The only children who were excluded from participation were those with conditions that affected normal growth and development. The children were predominantly Caucasian, with 19% identifying as either Aboriginal or Torres Strait Islander, born in a country other than Australia or spoke a language other than English at home.

The survey and the instruments used were approved by The University of Queensland and Education Queensland Ethics Committees.

The 9·00–11·99 years age group was chosen as the focus of the present analyses for two reasons. First, the WHtR cut-offs used in the analyses could not be applied to the youngest age group. Second, the children in the oldest age group answered the question on body size perception themselves (the question for the oldest children was worded: 'How would you describe your body weight?'). Therefore, it would not be appropriate to include them in the present analyses, where parental perception of body weight is of interest. Of the 1487 children in the group aged 9·00–11·99 years, fifty-six were excluded from analyses as they could not provide all the required information.

Anthropometric data including weight (in kilograms) in light clothing, height (in centimetres) without shoes and WC against the skin or very light clothing (at the level of the umbilicus, in centimetres) were collected, and are described in detail elsewhere[22].

The following question was asked to obtain information on parents' perception of their child's body weight: 'How would you describe your child's body weight?'. Parents could select from three responses: 'too thin',

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'about right' or 'too fat'. For these analyses, 'too thin' and 'about right' were collapsed to one category of 'not too fat'. These categories were collapsed because the focus of the analysis was between actual and perceived overweight status.

Information on who completed the questionnaire containing the above question was also sought. The following options could be selected from: 'mother', 'father', 'both parents', 'parent(s) and child' and 'other'.

Survey respondents were asked to indicate their highest level of education achieved. They could select from the following responses: 'compulsory education' (up to and including grade 10, ages 14·00–16·00 years); 'grade 11 and 12' (16·00–18·99 years); 'vocational training'; 'university degree'; and 'don't know'.

Statistical analysis

Weight and height data were used to calculate BMI. The International Obesity Taskforce definitions for overweight were applied (equivalent to ≥25·0 kg/m^2 at age 18 years).

WHtR was calculated and the cut-offs developed by Nambiar *et al.*[21] were used to categorize children with very high abdominal adiposity (overweight). These cut-offs were developed using analysis of receiver operating characteristic curves, where WHtR values associated with the highest sensitivity and specificity in identifying children with percentage body fat ≥95th percentile were chosen as cut-offs. These values corresponded to ≥0·47 in females and ≥0·48 in males[21].

Descriptive analyses were conducted to obtain summary statistics on the sample. Frequency analyses were performed to obtain proportions from perception and actual measured weight, who predominantly answered the question on perceived weight and mother's level of education. The *Z* test was used to compare proportions. The χ^2 test was used to study the association between mother's level of education and congruency between perceived weight and weight characterized with BMI and WHtR. The congruency variable was obtained by coding perceived weight responses as not too fat = 0 and too fat = 1. The same was done for the indices. Then for each child, matching code numbers 0–0 or 1–1 were coded 0 and non-matching code numbers (0–1 or 1–0) were coded 1. Sensitivity and specificity between perceived overweight status and actual overweight status were also calculated. The proportion of parents who underestimated overweight status was obtained using frequency analysis.

All analyses were performed using the SPSS statistical software package version 18·0 (2010; SPSS Inc.).

Results

Summary statistics for selected variables by sex are presented in Table 1. Boys were significantly older than girls ($P < 0·01$).

In the current survey of young children, mothers predominantly answered the question on perception of their child's weight. The question was answered by 72·8 % of mothers about their sons and 65·8 % of mothers about their daughters. This difference between the sexes was statistically significant ($P < 0·05$). The proportion of fathers or both parents who answered the question on perception was less than 4 % each. A further 15·6 % of parents answered this question with their son and 24·7 % answered the question with their daughter. This difference in proportions was not significant. The question was answered by someone other than the parent(s) in less than 5 % of the sample.

Tables 2 and 3 illustrate 2 × 2 tables for perception of overweight against actual overweight defined using the different anthropometric indices. Of the 138 boys and 202 girls who were categorized as overweight by BMI, only thirty-eight boys and forty-six girls were also perceived as overweight by their parents, resulting in sensitivities of 27·5 and 22·7 %, respectively (Table 2). The sensitivities were lower, especially among girls, using WHtR (Table 3),

Table 1 Summary statistics for selected variables by sex: boys and girls aged 9·00–11·99 years (*n* 1431), Queensland, Australia

Sex	Variable	Mean	SD	Min	Max
Male (*n* 686)	Age (years)	10·20*	0·41	9·07	11·53
	Height (cm)	140·8	6·5	113·9	160·4
	Weight (kg)	36·3	8·2	19·9	69·9
	Weight *Z*-score	0·318	1·003	−3·362	2·863
	WC (cm)	65·6	9·0	43·7	102·5
	WHtR	0·47	0·06	0·31	0·86
	BMI (kg/m^2)	18·2	3·2	12·2	44·2
Female (*n* 745)	Age (years)	10·12*	0·38	9·39	11·90
	Height (cm)	141·5	6·8	121·1	167·9
	Weight (kg)	37·2	8·9	21·9	79·1
	Weight *Z*-score	0·312	1·000	−2·603	3·210
	WC (cm)	66·4	9·5	47·0	103·2
	WHtR	0·47	0·06	0·34	0·69
	BMI (kg/m^2)	18·4	3·3	12·7	34·7

*Denotes statistically significant difference in means between males and females ($P < 0·01$).

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Table 2 The sensitivity and specificity of parental perception of overweight against actual overweight measured using BMI: boys and girls aged 9·00–11·99 years (*n* 1431), Queensland, Australia

		Perceived			
Sex	Index	'Too fat'	'Not too fat'	Total	Sensitivity/specificity
Male	BMI				
	Overweight	38	100	138	27·5*
	Not overweight	2	546	548	99·6
	Total	40	646	686	
Female	BMI				
	Overweight	46	156	202	22·7†
	Not overweight	1	542	543	99·8
	Total	47	698	745	

*Denotes statistically significant difference in sensitivities between BMI and WHtR for males ($P<0·01$).
†Denotes statistically significant difference in sensitivities between BMI and WHtR for females ($P<0·01$).

Table 3 The sensitivity and specificity of parental perception of overweight against actual overweight measured using WHtR: boys and girls aged 9·00–11·99 years (*n* 1431), Queensland, Australia

		Perceived			
Sex	Index	'Too fat'	'Not too fat'	Total	Sensitivity/Specificity
Male	WHtR				
	Overweight	37	169	206	21·9*
	Not overweight	3	477	480	99·3
	Total	40	646	686	
Female	WHtR				
	Overweight	46	287	333	13·8†
	Not overweight	1	411	412	99·8
	Total	47	698	745	

WHtR, waist-to-height ratio.
*Denotes statistically significant difference in sensitivities between BMI and WHtR for males ($P<0·01$).
†Denotes statistically significant difference in sensitivities between BMI and WHtR for females ($P<0·01$).

where of the 333 girls classified as overweight, only 13·8% were perceived as such. The differences in proportions between the two indices were statistically significant ($P<0·01$).

Table 4 illustrates the proportions of parents who underestimated, overestimated or were in agreement about weight status according to BMI and WHtR. Only 5% of boys and 6% of girls were classified as overweight according to BMI and WHtR and their parents also perceived them as overweight. Parents also underestimated the fact that the child was overweight: among boys and girls who were classified as overweight according to BMI, 14·6% and 20·9%, respectively, were not perceived as overweight by their parents. When WHtR was used to classify children as overweight, 24·6% of boys and 38·5% of girls were not classified as overweight according to their parents.

Table 5 illustrates the prevalences of overweight based on perception and according to BMI and WHtR. As expected, the prevalence was lowest according to perception.

There was a higher proportion of mothers who received compulsory education (boys: 37·3%; girls: 35·0%) compared with mothers with a tertiary degree (boys: 16·8%; girls: 15·1%). This was a statistically significant difference for boys and girls ($P<0·05$). Mother's education level was significantly associated with correct perception of overweight status ($P<0·001$).

Discussion

The prevalence of childhood overweight has risen dramatically in many developed countries since the 1980s. As a result, the need for obesity prevention strategies has become increasingly important. Active participation in such strategies, however, depends partly on the ability of parents to recognize when their child is overweight. Several studies have explored parents' perception of their child's weight status[5,23–25]. Questionnaires are often used to record their responses by means of selecting a word response to a question or by providing images of different body shapes as a comparator[2,3,5,26]. The parents' responses are then compared with their child's actual weight status which is categorized as thin, normal, overweight or obese, usually by BMI. In the past, large discrepancies have been noted between perception and measured overweight status, with far fewer parents classifying their child as overweight or obese compared with what was actually measured[23,25,27,28]. The aim of the present analysis was to investigate which anthropometric

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Table 4 Proportion (%) of parents who underestimated, overestimated or were in agreement about weight status according to BMI and WHtR: boys and girls aged 9·00–11·99 years (*n* 1431), Queensland, Australia

Sex	Perceived *v.* actual weight status	BMI	WHtR
Male (*n* 686)	Parents' perception and index both agree child is not overweight	79·6	69·5
	Parents underestimate overweight	14·6	24·6
	Parents overestimate overweight	0·3	0·4
	Parents' perception and index both agree child is overweight	5·5	5·4
Female (*n* 745)	Parents' perception and index both agree child is not overweight	72·8	55·2
	Parents underestimate overweight	20·9	38·5
	Parents overestimate overweight	0·1	0·1
	Parents' perception and index both agree child is overweight	6·2	6·2

WHtR, waist-to-height ratio.

Table 5 Prevalences (%) of overweight based on parental perception, overweight categorized by BMI (International Obesity Taskforce cut-off) and high abdominal adiposity categorized by WHtR

Sex	Perception	BMI	WHtR
Males (*n* 686)	5·8	20·1	30·0
Females (*n* 745)	6·3	27·1	44·7

WHtR, waist-to-height ratio.
Prevalence of overweight by perception is significantly different from prevalence by BMI or WHtR; prevalence of overweight by BMI is significantly different from prevalence by WHtR ($P < 0·05$).

measure of actual overweight status – BMI or WHtR – was most closely associated with parental perception of overweight status in children.

In our study, parents (predominantly mothers) were accurate in perceiving their child as 'not too fat'. This is evident from the high specificities between perception and BMI or WHtR (Tables 2 and 3). Up to 70 % of the time, parents' perception of their child not being overweight was in agreement with WHtR. The agreement was higher (up to 80 %) when BMI was used (Table 4). This is comparable to the findings of Abbott *et al.* who performed a similar analysis on the same data using BMI as the comparator[2].

The parents in our study were extremely poor at correctly perceiving their child as overweight. The sensitivities between perception and both BMI and WHtR were very low (Tables 2 and 3), with BMI performing significantly better ($P < 0·01$). It was unexpected to find that parental perception of overweight and BMI was more sensitive than overweight perception and WHtR. It was hypothesized that a centrally obese child may have been visually easier for a parent to classify correctly as overweight or obese. As a result, perception of overweight status and actual overweight status measured using an index of central adiposity (WHtR) would be more closely associated. One explanation for these results might be that previous research has shown measures of central obesity such as the WHtR to be more sensitive than BMI in identifying children with the highest percentage of body fat[21,29,30]. Therefore, if WHtR identifies more children as overweight than BMI, then this, coupled with parents being poor assessors of overweight, has resulted in lower sensitivities for WHtR than for BMI.

There was agreement between perception of overweight and overweight according to BMI or WHtR in only 5–6 % of the sample (Table 4). In this instance, the agreement between perception and BMI was not significantly different from the agreement between perception and WHtR.

For both BMI and WHtR, the prevalence of underestimation (i.e. overweight children were perceived as normal weight) was higher in girls than boys. This is in contrast with previous literature where maternal misclassification of weight status was significantly associated with the gender of the child; that is, mothers tended to underestimate their son's weight status and overestimate their daughter's weight status[26,31].

Results in our analyses indicated that the prevalences of overweight by each index were significantly different. This is expected because of the many definitions of overweight that currently exist[32–35]. The prevalence of overweight as measured by parental perception was significantly lower than that by either BMI or WHtR definitions. In fact, the prevalence of 'overweight' according to perception was similar to the prevalence of 'obesity' determined using BMI. According to Abbott *et al.*[22] the prevalence of obesity in this same sample of children was 6·2 % in boys and 6·5 % in girls. Therefore, by visual inspection, parents are only identifying the severely obese as having a weight problem. Children who are overweight but not obese have been missed by parents, while the BMI and WHtR cut-offs applied in these analyses have identified these children, thus resulting in large discrepancies between perceived and actual overweight status. While these indices may capture the true prevalence of overweight, it is the prevalence calculated from perception that is important. Only these parents have identified their child as being overweight, and therefore only these children may benefit from weight-loss interventions.

In our study, the overweight status of the children may have been underestimated for several reasons. One possible reason may be that because overweight has become so much more prevalent, recognizing overweight has become more difficult. The high prevalence of overweight has shifted the perception of 'normal weight'

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in the community, with only the severely obese being identified by visual inspection as having a weight problem. The peers of an overweight child may be of similar weight also, and parents may then start to see this as being normal. This may be compounded by the familial nature of childhood obesity so that if the overweight child has overweight parents, it is more likely that parents may underestimate their own and their child's overweight status[9,36].

This then raises the question as to whether or not the indices themselves are reliable indicators of the true prevalence of overweight, particularly BMI. It is possible that there could be a proportion of children identified as overweight by the index whose excess weight may not be related to body fat, but rather muscle. This is because BMI cannot explain body composition, one of the main reasons why its use has been criticized[37,38]. Therefore, comparing parents' perception of their child's overweight status against a flawed index is a major issue in itself. The WHtR cut-offs, on the other hand, identify children with a higher percentage of body fat accumulated centrally. In addition, these cut-offs have been shown to be more sensitive than BMI in identifying children with the highest percentage of body fat[21].

Similar to the findings of Baughcum *et al.*[3], in our study the level of education attained by the mother was significantly associated with whether she correctly identified her child as overweight, with reference to the indices used.

A clear limitation of our study is that only one question was asked in regard to body weight status with only three options to select from: 'too thin', 'about right' or 'too fat'. These choices are broad and are bound to be interpreted differently. For example, a parent who has a slightly overweight child may be more likely to say the child is about right rather than selecting too fat. The addition of 'slightly thin' or 'slightly overweight' may result in parents perceiving their child's weight status correctly. The use of images of different body shapes may also result in more parents correctly matching their child's body shape to the images. In a study conducted by Eckstein *et al.*[5], one of the tools used to obtain data was a set of seven images of body shape, ranging from heaviest to lightest, that were gender- and age-specific. The responses to this selection were compared with worded responses (i.e. 'my child is.. slightly normal; overweight; very overweight') and measured weight categorized by the Centers for Disease Control and Prevention BMI cut-offs. The authors found that the child sketches more sensitively assessed the child's BMI than parental report by words[5]. This was similar to results obtained using the Children's Body Image Scale[26,31].

An improvement to the study design would be to also collect data on maternal BMI and WC. Studies have demonstrated that overweight mothers are likely to underestimate their child's weight[7,9,10,36]. These data were collected as part of a large population-based survey targeting children, so no attempt was made to measure parents.

The results of the present study indicate that parents' perception of their child's overweight status did not match well with actual overweight status, regardless of the index used. Parents and children would both benefit from public health messages that emphasize the relationship between body shape and its association with health risks. This may then result in more parents correctly identifying their child as overweight. In terms of selecting an index to measure actual weight status, it is proposed that WHtR be used, despite the current analyses indicating that BMI was associated more closely with parental perception of overweight. BMI has been criticized because it does not explain body composition, or the distribution of body fat. Moreover, BMI was never intended to be used as an index for overweight and obesity, although its use over time as resulted in it being interpreted as such. WHtR, on the other hand, explains how body fat is distributed, is highly sensitive in identifying abdominally obese individuals and is strongly correlated with cardiovascular health risks in both adults and children[15,39–43]. The cut-offs to define overweight and associated health risks in children are close to 0·5[21] and therefore 'keep your waist circumference to less than half your height' is a simple health message to convey[20].

The present study is unique in that another measure apart from BMI was used to compare perceived overweight with actual overweight. The use of the WHtR in future analyses should be used with body-shape images instead of worded responses. This, together with public health messages that emphasize body shape and associated health risks, may be the best combination in improving parental perception of overweight.

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