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ORIGINAL ARTICLE

The association between weight perception and BMI: report and measurement data from the growing up in Ireland Cohort Study of 9-year olds

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BACKGROUND: The gold standard for categorisation of weight status is clinically measured body mass index (BMI), but this is often not practical in large epidemiological studies.
OBJECTIVES: To determine if a child's weight perception or a mother's perception of a child's weight status is a viable alternative to measured height and weight in determining BMI classification. Secondary outcomes are to determine the influence of a mother's BMI on her ability to categorise the child's BMI and a child's ability to recognise his/her own BMI.
METHODS: Cross-sectional analysis of the growing up in Ireland cohort study, a nationally representative cohort of 8568 9-year-old children. The variables considered for this analysis are the child's gender, BMI (International Obesity Taskforce grade derived from measured height and weight) and self-perceived weight status, and the mother's weight perception of the child, BMI (derived from measured height and weight) and self-perceived weight status. Cohen's weighted-kappa was used to evaluate the strength of the agreement between pairwise combinations of the BMI variables. Cumulative and adjacent categories logistic regression were used to predict how likely a person rates themselves as under, normal or overweight, based on explanatory variables.
RESULTS: Mothers are more accurate at correctly classifying their child's BMI ($\kappa = 0.5$; confidence intervals (CI) 0.38–0.51) than the children themselves ($\kappa = 0.25$; CI 0.23–0.26). Overweight mothers are better raters of their child's BMI ($\kappa = 0.51$; CI 0.49–0.54), compared with normal ($\kappa = 0.44$; CI 0.41–0.47) or underweight mothers ($\kappa = 0.4$; CI 0.22–0.58), regardless of whether the mother's BMI is derived from measured height and weight or self-perceived. The mother's perception of the child's weight status is not an influencing factor on the child's ability to correctly classify him/herself, but the child's self-perceived weight status influences the mother's ability to correctly classify the child.
CONCLUSIONS: A mother's BMI classification of her child is a viable alternative to BMI measurement in large epidemiological studies.

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INTRODUCTION

We have previously reported that body mass index (BMI) calculated from self-reported height and weight is not a reliable estimate of measured BMI.[1,2] We know that self-reported height is over reported[3–6] and self-reported weight is under reported,[3,5–8] irrespective of gender. Self-reported height bias is stable over time regardless of gender, age or clinical BMI category, and self-reported weight bias increases over time for both genders and in all age groups.[2]

Obtaining clinically measured BMI is often not practical in large epidemiological studies, due to the high costs involved. A practical and cost-effective method is to ask parents to report their children's weight and height, obtaining a BMI value. However, self-reported values of these variables, which although time and cost-efficient, are neither valid or reliable.[9-14] International literature evaluating the quality of parent-reported data has been inconsistent, as to the magnitude and direction of error in parent-reported weight and height, leading to significant BMI misclassification,[10,12,13,15–20] and this misclassification correlates with social circumstances, such as a lower socio-economic status, lower education level, parental obesity and child obesity.[9,11,12,16] The greatest problems seem to be with height underestimation, rather than weight overestimation, as parents are more likely to track their child's weight, than height.[12] In addition, parental underreporting of height tends to decrease with age and underreporting of weight tends to increase.[12,13,20] Further, both parental over reporting and underreporting of extreme values of height or weight have been observed, making it difficult to obtain accurate estimates of BMI, and track trends in BMI in large population surveys relying on parent-reported data.[12] A recent systematic review[21] indicated that 62% of parents with overweight children incorrectly perceived them as being normal weight, and that figure is inflated to 86% in children aged 2–6 years. It is also reported that children are just as inaccurate in predicting their own weight status.[22]

The importance of obesity as a public health issue, with well documented links between excess weight and disease in both children and adults, has been well cited.[4,6,7,23–26] Obtaining accurate estimates of BMI in a cost-effective manner has been shown to be unreliable. Exploration of new methods to obtain accurate measurements of BMI is necessary. The purpose of this study is to examine the possibility that weight perception, either a child's self-perception or a mother's perception of a child, is a

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viable alternative to measured height and weight in determining BMI classification in large epidemiological studies. Secondary outcomes are to determine the influence of a mother's BMI on her ability to categorise the child's BMI and a child's ability to recognise his/her own BMI.

MATERIALS AND METHODS

Study design and sample

Growing up in Ireland (GUI) is a major large-scale longitudinal study of children's health and well-being in Ireland, employing internationally recognised measurement protocols.[27–29] The data analysed here refers to a nationally representative cohort of 8568 9-year-old children residing in the Republic of Ireland, and were collected between September 2007 and June 2008.[28] The sample was collected using a two-stage sampling method within the national primary school system. Eligible children were those who were born between the 1st November 1997 and the 31st October 1998. In the first stage, 1105 primary schools from the national total of 3200 were randomly selected using a probability proportionate to size (PPS) sampling method. In the second stage, a random sample of eligible children was selected from within each school. An interviewer was assigned to each school to meet with the principal and explain the study objectives. In schools, which had 40 or fewer 9-year-old children, all children were included into the sample; in schools with more than 40 children, a random sample of 40 children was taken for inclusion in the sample. Information packs, including consent forms, were sent home with all selected children to give to their parent/guardian. These provided the children and their parents/guardians with information leaflets to allow them to make an informed decision on whether or not to participate in the study. Parents/guardians were asked to return completed consent forms (one each for a parent/guardian and child) to the school. The completed forms were then collected by the interviewer and returned to the study team. These forms contained the address and contact details of the family, which were then used to make direct contact with the family and arrange interviews. At the school level, a response rate of 82% was achieved, whereas at the household level (that is, eligible children selected from within the school) 57% of children and their parents participated in the study. This manuscript pertains to the household level of the study. The informants in the household-based component of the fieldwork were the 9-year-old child, their primary caregiver (defined as the person who provides most care to the child—in most cases, the child's mother) and, if resident in the household, the spouse/partner of the child's primary caregiver (usually, but not always, the child's father). The main interviews were completed in the child's home on a CAPI (computer-assisted personal interview) basis, and there was also a self-complete paper-based module for all respondents, which included some potentially sensitive questions. The completed sample was representative of the population at the level of school characteristics such as county, designated disadvantaged status, categorical size of the school (measured in terms of number of 9-year olds in the school) and gender mix of the school. The sample was slightly over-represented in terms of larger schools and also disadvantaged status. At the family level, the sample somewhat under-represents children from lower social class categories and those whose mothers had lower levels of educational attainment. These issues were addressed in a two-phased re-weighting of the data to reflect school characteristics as well as individual/family characteristics. The main external controls were extracted from administrative data provided by the Irish Department of Education and Skills in respect of the school-based characteristics, the Irish Census of Population 2006 and the European Union Survey of Income and Living Conditions (EU-SILC) in respect of individual/family-based characteristics. This ensures that the data are representative of the population of all 9-year olds resident in Ireland at the time of the survey.[29] The final sample was 8568 children. There were just over 56 400 9-year olds living in Ireland at this time.[27,29] Small incentives were offered for participation. School principals received €25 book tokens for their school and the 9-year-old children that participated received a pencil case set. Further details on the study and sampling methods have previously been documented.[27–29]

CAPI procedure

Interviewers administered the main questionnaires using a laptop (Model: IBM Thinkpad, Lenovo X60). Each question appeared on the computer screen for the interviewer to read out with space for an answer option to be recorded. Answers were recorded, in the main, by entering the number associated with the selected answer option using the keyboard. Answers were, however, also recorded using an integral mouse or by entering free text where appropriate. The questionnaire was programmed such that it facilitated the routing of questions (skipping non-applicable questions, for example), and the inclusion of hard and soft cross-variable and range checks to alert interviewers to improbable or impossible answers or conflicts between answers. Respondents were shown an extensive range of prompt cards with the available answer options. Completed interviews were outputted as ASCII files and were encrypted and uploaded to a dedicated server in the Economic and Social Research Institute by the interviewers, where the data was stored securely.

Questionnaires

There were seven questionnaires in total, which formed the GUI Study of 9-year olds. (1) Primary caregiver—core questionnaire, (2) Primary caregiver—sensitive self-completion module, (3) Spouse/partner of primary caregiver—core questionnaire, (4) Spouse/partner of primary caregiver—sensitive self-completion module, (5) Child core questionnaire, (6) Child sensitive modules, (7) A one-day time-use diary for the Study Child. These questionnaires are all available on the website www.growingup.ie.

Two questions relevant to this manuscript were taken from the primary caregiver's questionnaire which was completed on a CAPI basis. Question D9, 'Parent's perception of the study child's weight', and Question F7, 'Primary caregiver's perception of own weight'. These were both derived from growing up in Australia[30] and asked the respondent about his/her own weight or their perception of the study child's weight on a seven-point scale varying from very underweight to very overweight. Question D9 was as follows; looking at Card D9, do you think the study child is: Very underweight, moderately underweight, slightly underweight, about the right weight, slightly overweight, moderately overweight, very overweight, don't know. Participants selected one option. Question F7 was as follows; looking at Card F7, do you think you are: very underweight, moderately underweight, slightly underweight, about the right weight, slightly overweight, moderately overweight, very overweight, don't know. Participants selected one option.

One question relevant to this manuscript was taken from the study child's questionnaire, Question C22 'Perception of weight', which was completed on a CAPI basis. The study child was asked how he or she would describe his/her physical appearance with regard to his/her weight. Response options were on a five-point scale and ranged from very skinny to very overweight. Question C22 was as follows; How would you describe yourself? Very skinny, a bit skinny, just the right size, a bit overweight, very overweight. The study child selected one option. The technical report (page 71)for the study states that 'Where no question sources are specified, these questions have been developed by Growing Up in Ireland, typically in conjunction with the expert panels'.[29] In this instance we can assume that the question was developed by the GUI expert panel. There is no evidence that any validity or reliability testing was conducted.

Objectively measured height and weight

Children and parents' heights and weights were measured at the time of the household interview. Height and weight were necessary to derive a BMI score and were recorded on the interviewer's Work Assignment Sheet for each household. Weight measurements of parents and children were recorded to the nearest 0.5 kg using a SECA 761 medically approved flat mechanical scales which graduated in one-kilogram increments and had an upper capacity of 150 kg. Parents and children were asked to wear light clothing for weight measurement. A Leicester portable height measure was used to record height. The Leicester measure gives height in imperial and metric units, but the interviewer recorded height to the nearest millimetre. It has a range of 0–2.07 m.

Calculation of the International Obesity Taskforce BMI for children

The relationship between BMI and body fatness in children is influenced by age, sex, pubertal status and ethnicity. Defining overweight and obesity in children requires the use of population reference data and established cut-off points to relate BMI in terms of age and sex. The most ubiquitous method for measuring childhood obesity is the International classification. This method links child and adult obesity by use of centiles which pass through adult BMI cut-offs allowing continuity from childhood. The International Obesity Taskforce (IOTF) developed this system based on data collected from six countries (Brazil, Hong Kong, the Netherlands, Singapore, Great Britain and the USA.[31] The resulting sample was comprised of 190 000 subjects in total aged 0–5. The BMI percentile

curves that pass through the values of 25 and 30 kg m^{-2} at age 18 were smoothed for each national dataset and then averaged. The averaged curves were then used to provide age and sex specific BMI cut-off points for children and adolescents aged 2–18. The benefit of this approach is that it allows international comparisons of levels of obesity in children to be made. The IOTF cut-off points for children of nine and a half years of age were applied in the present sample. They define healthy weight as a BMI of <19.46 for boys and 19.45 for girls (there is no underweight category). Overweight is defined as a BMI of 19.46 to less than 23.38 (for boys) or 19.45 to <23.46 (for girls) and obesity as a BMI of 23.38 or over (for boys) and 23.46 or over (for girls).

Treatment of the dataset

The variables considered for this analysis are the children's gender, their IOTF BMI[31] (derived from measured height and weight), the child's self-perceived weight status, the primary caregiver's weight perception of the child, and the primary caregiver's own self-perceived weight status. The height and weight of the primary caregiver was also measured and BMI was calculated as underweight (<18.5 kg m^{-2}), normal (18.5–<25 kg m^{-2}), overweight ($\geqslant$25–<30 kg m^{-2}) and obese ($\geqslant$30 kg m^{-2}).

Ninety-nine per cent ($n=8465$) of the primary caregivers in the study are female: biological mothers ($n=8357$), adoptive mothers ($n=54$), step-mothers ($n=29$), foster mothers ($n=20$), other relatives ($n=3$) and unrelated ($n=1$). The analysis reported here pertains to participants whose primary caregivers are female. Given the above numbers, for the purposes of this study, we will refer to the primary caregivers as mothers (Table 1). The mean age of the mothers was 39.9 years (s.d. 5.44). There were only 103 fathers in the study. The analysis was rerun with these included but there were negligible changes in the results.

As detailed in the questionnaire section, some of the weight status variables were not the same. In particular, they differed in the number of response levels, ranging from 5 to 7 and also in their nomenclature. For comparative purposes as can be seen in Table 1, the key variables were trichotomized into 'underweight', 'normal' and 'overweight'.

Ethical considerations

Ethical approval was granted by the Research Ethics Committee of the Health Research Board, Dublin, Ireland.

Statistical methods

Cohen's weighted-kappa[32–34] (reported with accompanying 95% confidence intervals (CI)) was used to evaluate the strength of the agreement between pairwise combinations of the key variables. The weighted-kappa statistic was used in preference to the unweighted version due to the ordinal nature of the variables studied. Kappa compares the observed agreement to what would be expected if the ratings are independent and is used to evaluate the ability of children and primary caregivers to classify themselves at a particular level of obesity. The value of κ can be interpreted as follows;[35] $\kappa<0.20$, poor agreement; $\kappa=0.21$–0.40, fair agreement; $\kappa=0.41$–0.60, moderate agreement; $\kappa=0.61$–0.80, good agreement; $\kappa=0.81$–1, very good agreement.

In addition to the Kappa statistic, cumulative logistic regression is also used to predict how likely a person rates themselves as under, normal or overweight, based on certain explanatory variables. The structure of cumulative logistic regression is that there are various outcome categories for the response variable and the model is built on the observed values for the explanatory variables. Adjacent categories logistic regression, which takes account of the ordinal nature of the variables, was also conducted.

RESULTS

Child's measured BMI

In this cohort 6% measured as underweight, 63% as normal, 26% as overweight or obese and 5% were uncategorised because the data were missing. Table 2 measures the kappa (κ) index of inter-rater agreement between the child's measured BMI and their self-perceived weight status, and the child's measured BMI and the mother's weight perception of the child. The first reported squared Kappa value is 0.25, indicating fair agreement between children's measured BMI and their self-perceived weight status. The reason for this low level of agreement is seen in the table. Overall, 76% ($n=1665$) of children who measure as overweight, see themselves as normal. In addition, 22% of normal weight children ($n=1150$) see themselves as underweight. When analysed separately by gender, the kappa values remain the same. When considering the agreement between the child's measured BMI and the mother's weight perception of her child, the kappa value is 0.5, indicating moderate agreement between the two measures. The mothers are better raters of their children's weight status than the children are, indicating that they can identify with moderate accuracy their child's BMI status. Overall, 86% ($n=4586$) of normal weight children are correctly identified as being normal. Just 47% ($n=1050$) of overweight children are correctly classified as being overweight, whereas 51% ($n=1133$) of those overweight are misclassified as normal by the mother.

When examining both subjective measurements (data not shown), there is fair agreement between the mother's perception of her child's weight status and the child's self-perceived weight status, with a kappa value of 0.32 for all children, $\kappa=0.34$ for male children and $\kappa=0.3$ for female children ($n=8381$). Of those considered normal by the mother, 78% of children agreed with this, whereas 17% felt they were underweight. Of those that were considered overweight by the mother, just 26% of children agreed, whereas 68% felt they were just normal. Of those considered underweight by the mother, 51% were in agreement, whereas 47% felt they were normal. Two per cent ($n=19$) felt they were overweight.

Table 1. Definition of weight status variables

Variable	*Underweight*	*Normal*	*Overweight*
Measured BMI of child (IOTF grade)	Thinness grade 1 Thinness grade 2 Thinness grade 3	Normal weight	Overweight Obesity
Child's self-perceived weight status	Very skinny A bit skinny	Just the right size	A bit overweight Very overweight
Mother's weight perception of child	Very underweight Moderately underweight Slightly underweight	About the right weight	Slightly overweight Moderately overweight Very overweight
Mother's self-perceived weight status	Very underweight Moderately underweight Slightly underweight	About the right weight	Slightly overweight Moderately overweight Very overweight
BMI of mother (measured)	BMI <18.5 kg m^{-2}	BMI 18.5–<25 kg m^{-2}	BMI $\geqslant 25$ kg m^{-2}

Abbreviations: BMI, body mass index; IOTF, International Obesity Taskforce.

Table 2. Measured BMI (IOTF) versus child's self-perceived weight status and mother's weight perception of their child (all children)

N = *7986*		*Child's self-perceived weight status*			*Squared Kappa*	*CI Lower*	*CI Upper*
		Underweight n(%)	*Normal n(%)*	*Overweight n(%)*			
Children's Measured BMI	Underweight	228 (45.5)	261 (52.1)	12 (2.5)	0.25	0.23	0.26
	Normal	1150 (21.7)	3923 (74.2)	218 (4.1)			
	Overweight	149 (6.8)	1665 (75.9)	380 (17.3)			
N = 8039		*Mother's weight perception of child*					
		Underweight n(%)	*Normal n(%)*	*Overweight n(%)*			
Children's Measured BMI	Underweight	204 (40.6)	294 (58.4)	5 (1.0)	0.5	0.48	0.51
	Normal	620 (11.7)	4586 (86.3)	110 (2.0)			
	Overweight	37 (1.7)	1133 (51.0)	1050 (47.3)			

Abbreviations: BMI, body mass index; CI, confidence intervals; IOTF, international obesity task force.

Table 3. Agreement (kappa scores) between child's BMI and mother's weight perception of the child, for mothers measured as underweight, normal and overweight

N = *93*		*Mother's weight perception of child (Underweight mother)*			*Squared Kappa*	*CI Lower*	*CI Upper*
		Underweight n(%)	*Normal n(%)*	*Overweight n(%)*			
Child's Measured BMI	Underweight	5 (41.7)	7 (58.3)	0 (0)	0.4	0.22	0.58
	Normal	9 (13.2)	57 (83.8)	2 (2.9)			
	Overweight	0 (0)	9 (69.2)	4 (30.8)			
N = 3725		*Mother's weight perception of child (Normal weight mother)*					
		Underweight n(%)	*Normal n(%)*	*Overweight n(%)*			
Child's Measured BMI	Underweight	112 (37.1)	186 (61.6)	4 (1.3)	0.44	0.41	0.47
	Normal	303 (11.2)	2347 (86.7)	58 (2.1)			
	Overweight	12 (1.7)	404 (56.5)	299 (41.8)			
N = 3811		*Mother's weight perception of child (Overweight mother)*					
		Underweight n(%)	*Normal n(%)*	*Overweight n(%)*			
Child's Measured BMI	Underweight	74 (45.1)	89 (54.2)	1 (0.6)	0.51	0.49	0.54
	Normal	283 (12.3)	1971 (85.7)	45 (2.0)			
	Overweight	24 (1.8)	649 (48.1)	675 (50.1)			

Table 4. Cumulative logistic regressions determining the probability of correct classification

		Child's self-perceived weight status		
		Underweight (probability)	*Normal (probability)*	*Overweight (probability)*
Child's Measured BMI	Underweight	0.50	0.48	0.01
	Normal	0.21	0.74	0.05
	Overweight	0.07	0.77	0.16
Mother's Weight Perception of Child	Underweight	0.52	0.47	0.01
	Normal	0.17	0.77	0.06
	Overweight	0.04	0.73	0.23
		Mother's weight perception of child		
		Underweight (probability)	*Normal (probability)*	*Overweight (probability)*
Child's Measured BMI	Underweight	0.62	0.38	0
	Normal	0.1	0.86	0.05
	Overweight	0.01	0.57	0.42

Table 5. Adjacent categories logistic regression showing the probability of the child correctly self-classifying given their gender, measured BMI and their mother's perception of their weight status

Sex of child	*BMI (IOTF grade)*	*Mother's weight perception of child*	*Child's self-perceived weight status*		
			Underweight (probability)	*Normal (probability)*	*Overweight (probability)*
Boy	Underweight	Underweight	0.63	0.37	0
		Normal	0.35	0.64	0.02
		Overweight	0.14	0.79	0.07
	Normal	Underweight	0.45	0.54	0.01
		Normal	0.2	0.76	0.04
		Overweight	0.07	0.8	0.14
	Overweight	Underweight	0.28	0.69	0.02
		Normal	0.11	0.8	0.09
		Overweight	0.03	0.72	0.25
Girl	Underweight	Underweight	0.6	0.4	0
		Normal	0.32	0.66	0.02
		Overweight	0.12	0.8	0.07
	Normal	Underweight	0.42	0.57	0.01
		Normal	0.18	0.77	0.05
		Overweight	0.06	0.79	0.15
	Overweight	Underweight	0.26	0.71	0.03
		Normal	0.09	0.8	0.1
		Overweight	0.03	0.7	0.27

Abbreviations: BMI, body mass index; IOTF, International Obesity Taskforce.

Table 6. Adjacent categories logistic regression showing the probability of the mother correctly classifying the child given the child's gender, measured BMI classification and their self-perceived weight status

Sex of child	*BMI (IOTF grade)*	*Child's self-perceived weight status*	*Mother's weight perception of child*		
			Underweight (probability)	*Normal (probability)*	*Overweight (probability)*
Boy	Underweight	Underweight	0.77	0.23	0
		Normal	0.52	0.48	0
		Overweight	0.26	0.73	0.01
	Normal	Underweight	0.23	0.76	0.01
		Normal	0.09	0.87	0.04
		Overweight	0.03	0.85	0.13
	Overweight	Underweight	0.02	0.83	0.14
		Normal	0.01	0.65	0.35
		Overweight	0	0.37	0.62
Girl	Underweight	Underweight	0.72	0.28	0
		Normal	0.46	0.54	0
		Overweight	0.21	0.78	0
	Normal	Underweight	0.19	0.8	0.02
		Normal	0.07	0.88	0.05
		Overweight	0.02	0.82	0.16
	Overweight	Underweight	0.02	0.80	0.18
		Normal	0	0.59	0.41
		Overweight	0	0.32	0.68

Abbreviation: IOTF, International Obesity Taskforce.

Influence of mother's BMI on her ability to rate her child

Table 3 displays the agreement between the child's measured BMI and the mother's weight perception of the child for an underweight, normal weight and overweight mother, calculated from measured height and weight. The kappa values for each of the mother's weight categories are 0.4, 0.44 and 0.51, respectively. Caution should be applied in the interpretation of the underweight analysis, as the numbers are small ($n = 93$). Repeating the analysis, but replacing the mother's measured BMI with their self-perceived weight status, does not alter the kappa statistics. The Table 3 findings also show that mothers with a measured BMI in the overweight category are better judges of their child's weight status than either underweight or normal weight mothers, that is, mothers who consider themselves as overweight, will be better raters of their child's BMI. For example, the underweight mother will correctly classify the overweight child 31% of the time, whereas the normal weight mother will correctly classify the overweight child 42% of the time. However, the overweight mother will be correct 50% of the time.

Logistic regression models

We used cumulative logistic regression models to determine, given their measured weight category, the probability that children would rate themselves in the same category (Table 4). Children with a measured BMI classified as normal, will consider themselves to be normal weight with a 0.74 probability, overweight with a probability of 0.05 and underweight with a 0.21 probability. Children with a measured BMI of overweight will correctly classify themselves as a bit/very overweight with a probability of 0.16, or 16% of the time and normal 77% of the time. If underweight, children will correctly classify themselves as underweight with a probability of 0.5 (50% of the time) and overestimate their weight status and consider themselves normal, 48% of the time. We also used cumulative logistic regression models to determine, given their measured weight category, the probability that the mother would rate the child correctly. If the child measured as normal, the mother's perception of the child as normal was correct with a probability of 0.86. If the child was measured as overweight, then the probability of the mother seeing the child as overweight was 0.42, but 57% of the time, the mother saw the child as normal. If the child measured as underweight, the probability of the mother rating the child as underweight was 0.62, and normal was 0.38. Table 4 also shows the probability of children rating themselves as underweight, normal or a bit/very overweight, given their mother's perception of their weight status. The results remain largely unchanged.

Finally, we conducted adjacent categories logistic regression, allowing the relationship between multiple raters to be examined, expressed as probabilities in Table 5. Boys, whose measured BMIs are normal, and are seen by their mother as normal, will rate themselves as normal 76% of the time. If the same boys are seen by their mothers as overweight, they will still correctly classify themselves 80% of the time. Boys, who measure as overweight and are seen by their mother as overweight, will rate themselves as overweight only 25% of the time. Seventy-two per cent will feel they are normal. However, if these overweight boys are viewed by their mother as normal, they will correctly self-report as overweight only 9% of the time and report they are normal 80% of the time. The same trends appear in the data collected on girls, for example, in Table 5, we can see that girls, who measure as overweight and are seen by their mother as overweight, will rate themselves as overweight 27% of the time. Seventy per cent will feel they are normal. However, if these overweight girls are viewed by their mother as normal, they will correctly self-report as overweight only 10% of the time and report they are normal 80% of the time, just like their male counterparts.

Table 6 focuses on the child's self-perceived weight status and the mother's perception of the child's weight status, given the child's gender and measured BMI. If a boy, is measured as overweight, and sees himself as overweight, he will be rated as overweight by the mother 62% of the time and misperceived as normal 37% of the time. This is slightly better for girls whereby in the same circumstance, the mother will rate her as overweight 68% of the time and normal 32% of the time. For boys and girls, if they measure as normal, and see themselves as normal, then the mother will rate them as normal 87% and 88% of the time, respectively.

DISCUSSION

To our knowledge, this is the first time we have a conclusive finding that a mother's assessment of her child's BMI is more accurate than the child's. Previously published studies have reported either the parent's assessment or the child's own assessment, but have not considered these together. This is an important step forward in obtaining accurate clinically measured BMI data in large epidemiological studies. Our primary outcome was to determine if a child's self-perceived weight status or a mother's weight perception of a child is a viable alternative to measured height and weight in determining BMI classification. The findings are quite complex. We can conclude that a child's self-perception is not particularly suitable, but a mother's perception of a child is. However, we have also shown that in this cohort of 9-year olds, the child's self-perception influences the mother's ability to correctly classify the child. This is an important finding, as improving the child's self-perceived weight status, will improve the mother's ability to correctly recognise her child as 'underweight, normal, or overweight'. In addition, we have found that a mother's own BMI status influences this assessment, and overweight mothers are better raters of their child's BMI, compared with normal or underweight mothers. This can be concluded regardless of whether the mother's BMI category is derived from measured height and weight, or their self-perception. This finding is at variance with a recent meta-synthesis of studies conducted between 1998 and 2006 on parental disconnect between perceived and actual weight status of children, where it was concluded that parents were more likely to misperceive their child's weight and this was especially true for parents who were themselves overweight.[17] This apparent contradiction may be due to demographic differences. The meta-synthesis includes studies from a range of countries including the UK, the US, Australia and Italy with a wide age range of children, and different methods for classifying weight status. Our study is from one population, and the children were all born within one calendar year and 9 years old at the time of data collection. Also, the meta-synthesis was published in 2009, with included studies from between 1998 and 2006. In that time, there has been a shift in the awareness of obesity in the population and the findings in our study may be a reflection of this awareness. In Ireland, healthy eating policies are in place in the majority of primary schools and the 'Food Dudes' programme, run by Bord Bia, the Irish Food Board, introducing fruit and vegetables to children between 4 and 12 years of age is run yearly. Documentation on the 'Food Dudes' programme is provided to the parents of these young children. There are numerous television programmes focused on healthy eating and on weight loss. Ireland has also signed up to the million pound challenge, that is, to lose a million pounds in weight nationwide. The Irish Pharmacy Union supports this and the public can have their weight monitored at their local pharmacy. All of these initiatives have increased awareness of being healthy and maintaining a healthy body weight.

We know from a prior study on the same dataset that children of obese parents have greater than 15 times the odds of being obese than children of normal weight families,[36] but we have just shown that the mothers of these children can recognise the overweight/obesity. Young *et al.*[37] cite the importance of being able to recognise obesity, to be able to prevent it. Therefore, there is significant potential to intervene in this overweight/obese group, but it is challenging as evidence shows that even health professionals have difficulty in accurately classifying obesity.[38]

As we have previously found in adults,[1,2] and as reported in the international literature on children,[3,7,39] children in our study underestimate their obesity levels, particularly overweight children. More than three-quarters of measured overweight children see themselves as normal, although almost half of these will be correctly classified by their mother, a further indication that mothers are better raters of their children's overweight than the children themselves. This finding is new, and not consistent with the current literature. Numerous studies have investigated parents' views on their children's weight[12,13,17,18,20] and most have involved mothers,[40] and the majority have reported mothers cannot recognise when their child is overweight.[17,41] However, these studies have some notable methodological issues and sample size differences. The meta-synthesis by Doolen *et al.*[17]

included studies with a very large age range, and many of the studies had children aged 3–5 years and reported overweight accuracies of between 1.9 and 5% in this age range, whereas our study was exclusively focused on 9-year olds. The study by Carnell *et al.*[41] also focused on 3–5 year olds. Small sample size was also an issue in Doolen's meta-synthesis. The included studies citing lower parental accuracy had sample sizes ranging from 83 to 1082. The largest sample size and the study closest in age to our study had a sample size of 5000 children, with a 29% overweight diagnostic accuracy. There were no clear factors listed that influenced the biases in these studies. Our study however is nationally representative, in a homogenous population, with a large sample size and good response rate.

Our study shows that just over half of overweight children are perceived by their mother as having normal weight, a somewhat lower figure than that reported in a 2013 systematic review,[15] which reported that 62% of parents with overweight children perceive them as having normal weight. This may reflect some self-selection bias amongst respondents, in that responders may have been more aware of the issues around overweight and obesity, but is arguably a positive finding in the context of this population and is suggestive of the fact that there is an improvement in such awareness of overweight and obesity among the population and possibly a stabilising of the increasing weight misclassification bias identified, in our recent study over time.[2] We have previously reported that the widening gap between self-reported BMI and measured BMI is attributable to an increased weight bias, rather than height bias which has remained stable over time. It also suggests that public health measures being implemented, may be taking effect. There have been concerted attempts at National and community level to raise awareness about obesity and healthy eating and a recent systematic review of studies in Ireland shows at least a plateauing effect of measured overweight and obesity.[42] Other International studies show the same.[7,13,43,44]

A normal weight child's self-perception is not important to the mothers rating of the child's weight status, as determined by adjacent categories logistic regression. If a girl is measured as normal, regardless of whether she perceives herself to be underweight, normal or overweight, the mother will rate the girl as normal over 80% of the time. This is also true for boys, though the mother's accuracy drops slightly to 76% for boys measured as normal but who see themselves as underweight. This is different for the overweight child whose self-perceived weight status is very influential on how the mother will rate the child. For example, boys who are measured as overweight and see themselves as overweight, will be perceived as overweight by the mother with a 0.62 probability. The same overweight boys, who see themselves as normal weight, will only be viewed as overweight by the mother with a probability of 0.35, and if these boys see themselves as underweight, the probability the mother will rate them correctly drops to 0.14. This finding is also true for objectively measured overweight girls, though the probability of the mother correctly classifying the girls as overweight is slightly higher for all three categories; underweight (0.18), normal weight (0.41) and overweight (0.68). What appears to be happening is the mother is concurring with the overweight child, but is more objective when it comes to the normal weight child. This suggests there is an emotional component involved and that an overweight child's self-perception influences maternal accuracy. This theory is supported in the literature. Warschburger *et al.*[45] compared maternal perception of weight status between related and unrelated children and found that related children were much more incorrectly/inaccurately perceived by their mothers. They speculated an emotional component was at have but had insufficient data to delve into the factors that influence this. This could have potential knock on effects for tackling overweight in this group. It will almost certainly have potential implications for obesity in later life as we know that an overweight child is more likely to be an obese adult.[46] Educational programmes in primary school could perhaps tackle this issue of self-perception by delivering programmes to develop children's understanding of personal health and weight status, which would educate them on ideal body weight and perhaps improve their ability to rate their own body size. In addition, existing programmes targeted at adults, such as the motivational interviewing technique to prevent childhood obesity,[47] should potentially also consider targeting the children, given that the child's self-perceived weight status has substantial influence over the mother's ability to recognise his/her obesity classification, especially in overweight children.

From cumulative logistic regression, the probability that an overweight child will incorrectly self-categorise as normal is higher than the mother's error when categorising the child. Also, regardless of whether the child's BMI is measured, or is categorised by the mother (mother's weight perception of child), the probability of the child correctly classifying him/herself remains the same. Therefore, once again the mother's perception of the child's weight status is a superior alternative than the child's self-perceived weight status for BMI classification. We have also shown that the mother's perception of a child is not an influencing factor in the child's ability to correctly classify him/herself, but the child's self-perceived weight status influences the mother's ability to correctly classify the child. This is a new finding, and provides scope for future interventions. If we can improve a child's self-perception, it is likely we will improve the mother's ability to correctly classify the child, and hence improve the accuracy of BMI measurement in large-scale epidemiological studies.

A mother's perception of the child's weight status is a reasonable substitute for BMI measurement, but whether or not it is superior to parent's reported height and weight for the child is not tested in this study. However, given the current findings, and the fact the literature tells us that parental reported height and weight for the child is inferior to the child's measured BMI,[10,13,15–20] it is reasonable to infer that the mother's weight perception of the child is a viable alternative for BMI classification but further studies are needed to confirm this.

Strengths and limitations

The dataset for this analysis, GUI, is a nationally representative sample. In fact, the sample employed represents one in seven of all births in Ireland in 1997. Sample weighting was used and thus the results are applicable at a population level. Missing data was not an issue in this study as the percentage of missing values in the variables of interest were extremely small, as evidenced by the large numbers in each table, therefore imputation was not necessary. Measurement bias is a consideration in this study but weight and height data in GUI were measured by trained personnel using standardised equipment following a standard protocol thereby minimising any potential measurement biases. There was a low response rate at the household level (57%) but the data has been weighted to adjust for the response rate so we do not anticipate this as having an effect on our findings. This is a cross-sectional study therefore it is not possible to establish causal inference in this study. The study sample consisted of 9-year olds only and extrapolating the findings to children of other ages should be done with caution.

CONCLUSIONS

Our study shows that a mother's perception of a child's weight status is a viable alternative to BMI measurement, when this is not measureable due to the high costs involved, and it further shows that it is superior to the child's self-perceived weight status. In addition, the child's self-perception is influential in the mother's ability to correctly classify the child. We have also shown that overweight mothers are better raters of their child's BMI than normal weight or underweight mothers. This is an important

finding from a public health perspective and is at variance with the trend reported in the current literature. Given the familial associations of overweight and obesity,[36] and the high prevalence of overweight and obesity worldwide, including in the Irish population,[1] this group of mothers represents an appropriate target for public health interventions. If parents recognise their child as at risk for overweight or obesity, they can intervene to diminish the risk factors for childhood obesity and its related complications. Verification of these findings is necessary in other international cohort studies.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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