ORIGINAL ARTICLE

Sensitivity and Specificity of Waist Circumference As A Single Screening Tool for Identification of Overweight and Obesity among Malaysian Adults

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SUMMARY

Generalised obesity and central obesity are risk factors for Type II diabetes mellitus and cardiovascular diseases. Waist circumference (WC) has been suggested as a single screening tool for identification of overweight or obese subjects in lieu of the body mass index (BMI) for weight management in public health program. Currently, the recommended waist circumference cut-off points of ≥ 94cm for men and ≥80cm for women (waist action level 1) and ≥ 102cm for men and ≥ 88cm for women (waist action level 2) used for identification of overweight and obesity are based on studies in Caucasian populations. The objective of this study was to assess the sensitivity and specificity of the recommended waist action levels, and to determine optimal WC cut-off points for identification of overweight or obesity with central fat distribution based on BMI for Malaysian adults. Data from 32,773 subjects (14,982 men and 17,791 women) aged 18 and above who participated in the Third National Health Morbidity Survey in 2006 were analysed. Sensitivity and specificity of WC at waist action level 1 were 48.3% and 97.5% for men; and 84.2% and 80.6% for women when compared to the cut-off points based on BMI ≥25kg/m^2. At waist action level 2, sensitivity and specificity were 52.4% and 98.0% for men, and 79.2% and 85.4% for women when compared with the cut-off points based on BMI (≥30 kg/m^2). Receiver operating characteristic analyses showed that the appropriate screening cut-off points for WC to identify subjects with overweight (≥25kg/m^2) was 86.0cm (sensitivity=83.6%, specificity=82.5%) for men, and 79.1cm (sensitivity=85.0%, specificity=79.5%) for women. Waist circumference cut-off points to identify obese subjects (BMI≥30 kg/m^2) was 93.2cm (sensitivity=86.5%, specificity=85.7%) for men and 85.2cm (sensitivity=77.9%, specificity=78.0%) for women. Our findings demonstrated that the current recommended waist circumference cut-off points have low sensitivity for identification of overweight and obesity in men. We suggest that these newly identified cut-off points be considered.

KEY WORDS:
Waist circumference, Obesity, Overweight, Sensitivity, Specificity

INTRODUCTION

Overweight and obesity are major public health problems, with a worldwide epidemic [1,2]. In Malaysia, the Second National Health and Morbidity Survey (NHMS II) conducted in 1996 reported the prevalence of overweight and obesity among Malaysian adults were 16.6% and 4.4% respectively[3]. However, in the Third National Health and Morbidity Survey (NHMS III) in 2006, the prevalence had risen to 29.1% and 14.2% [4], while, the overall national prevalence of abdominal obesity was 17.4% [5]. The health consequences of generalised obesity and abdominal obesity are increased risk of type 2 diabetes mellitus, cardiovascular diseases, cancer and all-cause of mortality [6-10]. Therefore, assessment of body adiposity is increasingly important in routine clinical practice. There are several ways to determine body adiposity. Measurements using magnetic resonance imaging and computed tomography generate highly reliable and valid results but are rather expensive, time consuming, requiring expertise and not feasible in large population based studies [11]. Hence, waist circumference (WC) measurement and body mass index (BMI) are being used as surrogate measures for assessment of body fat accumulation for those are overweight and obese with generalised obesity and abdominal obesity because they are simple, inexpensive, convenient and reliable [11, 12].

WC is closely correlated to BMI in measuring of excess body fat deposition [13]. Therefore, some researchers have suggested that WC measurements can be used as a single screening tool for identification of overweight or obese subjects in lieu of the body mass index (BMI) for weight management in primary health care for health promotion purposes [14, 15]. Besides, measuring WC takes no more time than measuring height and weight, easy to learn, and incurs minimal cost (compared to weighing scale and stadiometer required for BMI measurements) and is convenient for patients to self-monitor, unlike the BMI which requires some calculation [12, 16]. However, the sensitivity and specificity of the WC cut-off points to identify overweight and obesity as defined by World Health Organisation [17] have not been studied in the Malaysian population. Furthermore, recommended WC cut-off points for defining overweight and obesity were derived from studies predominantly in European or Caucasian populations [14, 18]. The proposed WC 'action levels' recommended that men

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with WC ≥94 cm and women with WC ≥80 cm (waist action level 1) should gain no further weight; men with WC ≥102 cm and women with WC ≥88 cm (waist action level 2) should reduce their weight. These WC action level 1 and 2 cut-off points are used for identification of subjects with overweight (BMI ≥ 25 kg/m^2) and obesity (BMI ≥ 30kg/m^2) respectively[14]. But, these cut-off points may be inappropriate for Asian people due to significant differences in physical build from Caucasian/Europeans [13, 19]. Some researchers have long suggested that the use of optimal WC cut-off points for screening should be population specific[20]. Therefore, the aims this study are to evaluate the sensitivity and specificity of recommended WC cut-off points for identification of overweight and obesity based on BMI as the reference standard and further determine the appropriate WC cut-off points for Malaysian adults using receiver operating characteristic curve analyses.

MATERIALS AND METHODS

Study design and sampling method

Data on WC was collected in the Third National Health and Morbidity Survey (NHMS III) conducted in 2006 based on a nationally-representative sample. The NHMS III is a population based cross-sectional study using two-stage stratified sampling proportionate to population size throughout all states in Malaysia. The NHMS III utilized the sampling frame of the Department of Statistics, Malaysia using Enumeration Blocks (EBs). A total of 2150 EBs consisting of 17200 living quarters (LQ) were selected using probability proportionate to size (PPS) linear systematic selection scheme based on the latest updated size measures. The study methods have been reported in detail elsewhere [4]. The Medical Research and Ethics Committee, Ministry of Health, Malaysia approved the study.

Out of 33,985 eligible adults aged 18 years and above, 33,465 were measured for weight, height or half arm span (for elderly subjects aged 60 years and above who cannot stand upright) and waist circumference. Respondents were excluded if they had increased abdominal girth not related to increased adiposity (e.g. pregnancy, abdominal ascites, hypothyroidism and other debilitating illness), physical disability or mental illness.

Data collection

The NHMS IIII household survey was conducted from April to August 2006, using 4 languages (i.e. Malay, English, Mandarin and Tamil) questionnaire and WC measurements were taken from adults aged 18 years old and above. Trained data collectors obtained written informed consent from the respondents prior to taking measurements and conduct of interview. The questionnaire included data on socio-demographic characteristics, gender, age, ethnicity, marital status, occupation, household monthly income, educational level and strata (urban or rural area). Waist circumference, body weight and height measurements were obtained by trained data collectors based on a standard procedure in the technical manual of NHMS III [21]. The measurement site selected for waist circumference was based on WHO recommendations [22], whereby WC was measured at the midpoint between the inferior margin of the last rib and the iliac crest, using SECA measuring tape ® (SECA, Germany) to the nearest 0.1 centimetre. Body weight and standing height measurements were carried out according to the protocol of the World Health Organization [23]. Body weight was measured in light indoor clothing without shoes to the nearest 0.1 kilogram using a Tanita digital lithium weighing scale (Tanita 318, Japan). Height was measured without shoes to the nearest 0.1 centimetre (cm) using a SECA portable body meter (SECA 206, Germany). For elderly subjects aged 60 years and above who cannot stand upright or had kyphosis, half arm span was measured to the nearest 0.1cm, using a SECA measuring tape (SECA, Germany). Standing height of these subjects was then estimated based on the arm span measurements using a predictive equation [24]. A total of 288 respondents' half arm span was converted to height. A study on the reliability and validity of all the anthropometric measurements was done prior to the survey in order to determine the precision of the instruments and measurements [25]. All measurements were taken and recorded twice and the averages were used in data analysis.

The respondent was classified as overweight or obese if BMI (computed as weight in kilograms divided by the square of the height in meters) was ≥ 25 or ≥ 30 kg/m^2 respectively, based on the classification recommended by the World Health Organization Expert Committee on Physical Status [23].

Data analysis

Analysis of the data was conducted using STATA version 10.0 and SPSS version 13.0. All analyses took into account the complex survey design of NHMS III. Findings are reported as the weighted estimates of the prevalence (mean value) and all analysis was performed at 95% confidence level. Sensitivity was calculated as true positive/(true positive + false negative) while specificity as true negative/ (true negative + false positive). The receiver operating characteristic (ROC) curve analysis was applied to determine the appropriate WC cut-point for identification of overweight and obesity.

RESULTS

A total of 32773 adults aged 18 years and above (14,982 men and 17,791 women) were included in the analyses after a series of data cleaning. The response rate of the study was 98.5% (33,465/33,985). The ethnic composition of the respondents was 54.4% Malay, 21.7% Chinese, 8.8% Indian, 10.3% other indigenous and 4.8% other ethnicities. It was observed that 86.0% of the respondents were between 18 and 60 years old (Table I). In men, the mean body weight, height and WC was 66.7kg (95% CI: 66.5 – 67.0), 165.7cm (95% CI: 165.5 – 165.8) and 84.0cm (95% CI: 83.8 – 84.3), respectively. In women, the corresponding values were 59.3kg (95% CI: 59.1 – 59.6), 153.6cm (95% CI: 153.5 – 153.7), 80.2cm (95% CI: 80.0 – 80.5), respectively. The prevalence of overweight and obesity among men was 29.7% (CI: 28.9 - 30.5) and 10.0% (CI: 9.5 - 10.5) respectively while 28.6% (CI: 27.9 - 29.3) and 17.4% (CI: 16.7 - 18.0) among women. There was a significant high correlation between BMI and waist circumference (r= 0.756, p = 0.001).

The sensitivity and specificity of waist action level 1for men were 48.3% and 97.5%; and for women 84.2% and 80.6%.

Table I: Selected socio-demographic characteristics of study subjects

	Men n (%)	Women n (%)	Total n (%)
Strata			
Urban	8607 (63.0)	10823 (60.8)	19,430 (64.8)
Rural	6,375 (37.0)	6,968 (39.2)	13,343 (35.2)
Ethnicity			
Malay	8,269 (54.6)	9,744 (54.2)	18,013 (54.4)
Chinese	3,093 (22.1)	3,549 (21.4)	6,642 (21.7)
Indian	1,154 (8.2)	1,557 (9.3)	2,711 (8.8)
Indigenous	1,706 (10.2)	2,066(10.4)	3,772 (10.3)
Others	760 (4.9)	875 (4.8)	1,635 (4.8)
Age group (years)			
18-19	817 (5.4)	842 (4.7)	1,659 (5.0)
20-29	3,282 (22.0)	3,800 (21.5)	7,082 (21.7)
30-39	3,049 (20.3)	3,749 (21.1)	6,798 (20.7)
40-49	3,178 (21.3)	4,053 (22.9)	7,231 (22.1)
50-59	2531 (17.0)	2933 (16.6)	5,464 (16.8)
60-69	1409 (9.3)	1,551 (8.6)	2,960 (9.0)
≥70	716 (4.8)	863 (4.8)	1579 (4.8)
Marital status*			
Not married	3,725 (25.0)	3348 (19.1)	7,073 (21.8)
Married	10,810 (72.6)	12,289 (69.2)	23,099 (70.7)
Divorcee	188 (1.2)	523 (3.0)	711 (2.2)
Widow/widower	179 (1.2)	1570 (8.7)	1749 (5.3)
Level of education*			
None	913 (5.8)	2,517 (13.5)	3,430 (10.0)
Primary	4,430 (29.2)	5,017 (28.1)	9,447 (28.6)
Secondary	7,894 (53.7)	8,519 (48.9)	16,413 (51.1)
Tertiary	1,595 (11.4)	1,586 (9.5)	3181 (10.3)

* Sample sizes may differ due to missing values

Table II: Number and proportion of men and women in different categories of body mass index by varying waist circumference, NHMS III

Waist action level		BMI classification#	
		BMI ≥ 25.0 kg/m² n (%)	**BMI ≤ 25.0 kg/m²** n (%)
Waist action 1			
Men	≥ 94cm	2842 (48.3)*	223 (2.5)
	≤ 94cm	3039 (51.7)	8878 (97.5)†
Total		5881 (100)	9101 (100)
women	≥ 80cm	6936 (84.2)*	1849 (19.4)
	≤ 80cm	1304 (15.8)	7702 (80.6)†
Total		8240 (100)	9551 (100)
		BMI ≥ 30.0 kg/m² n (%)	**BMI ≤ 30.0 kg/m²** n (%)
Waist action 2			
Men	≥ 108cm	775 (52.4)*	264 (2.0)
	≤ 108cm	703 (47.6)	13,240 (98.0)†
Total		1478 (100)	13,504
women	≥ 88cm	2461 (79.2)*	2134 (14.5)
	≤ 88cm	648 (20.8)	12,548 (85.5)†
Total		3109 (100)	14682 (100)

WHO (1995) classification
* Sensitivity
†Specificity

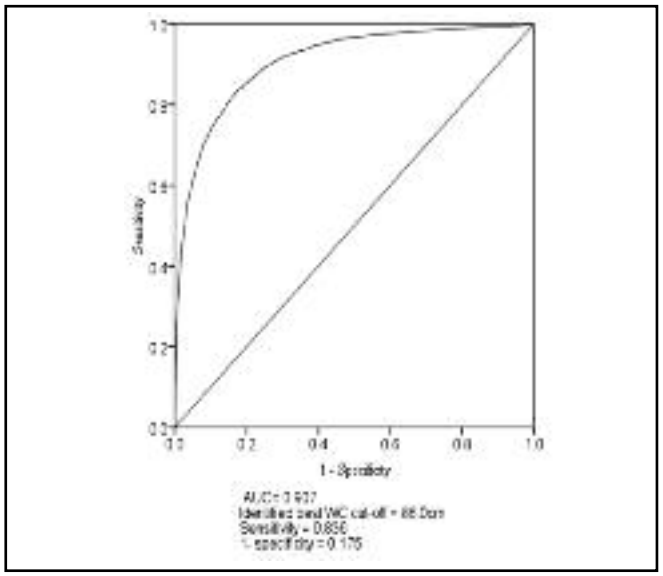

Fig. 1: ROC curve demonstrating the sensitivity and 1 - specificity for identification of overweight at various WC cut-off points for men.

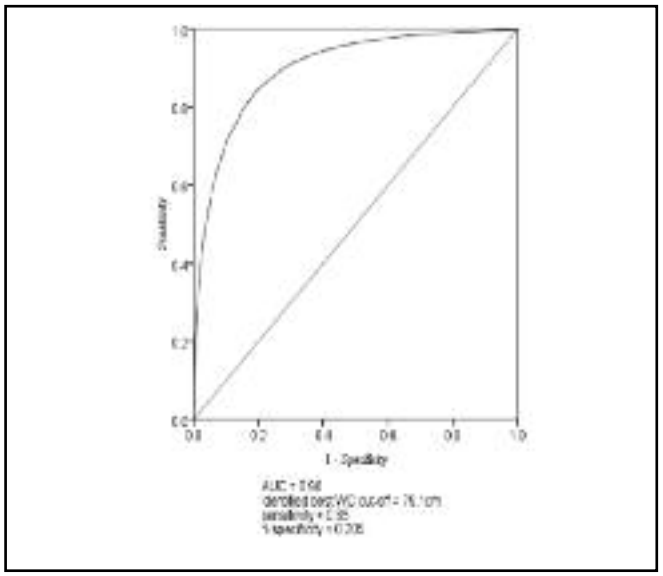

Fig. 2: ROC curve demonstrating the sensitivity and 1 - specificity for identification of overweight at various WC cut-off points for women.

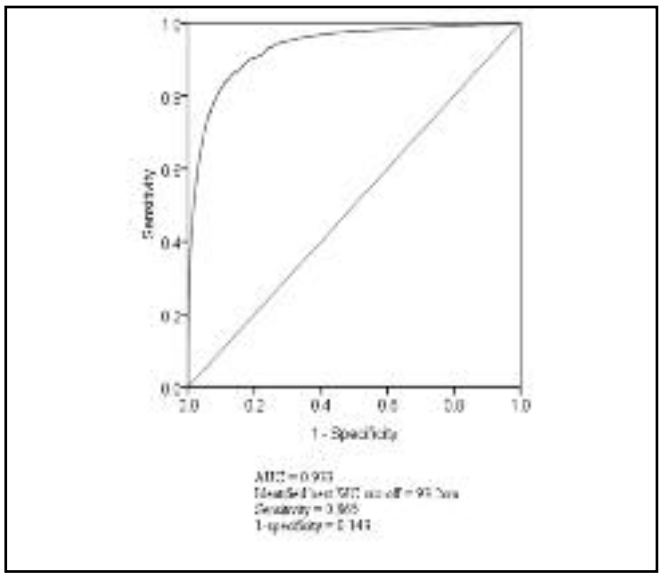

Fig. 3: ROC curve demonstrating the sensitivity and 1 - specificity for identification of obesity at various WC cut-off points for men.

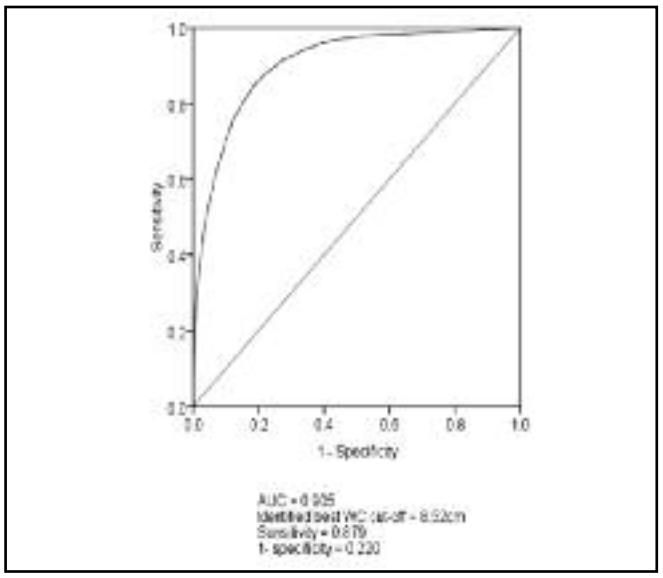

Fig. 4: ROC curve demonstrating the sensitivity and 1 - specificity for identification of obesity at various WC cut-off points for women.

Sensitivity and specificity of waist action level 2 (WC ≥102cm in men and ≥88cm in women) were 52.4% and 98.0% for men, and 79.2% and 85.4% for women (Table II).

Receiver operating characteristic curve analyses showed that the appropriate screening cut-off points for WC to identify subjects with overweight (≥25kg/m^2) was 86.0cm (sensitivity=83.6%, specificity=82.5%) for men (Figure 1), and 79.1cm (sensitivity=85.0%, specificity=79.5%) for women (figure 2). While appropriate WC cut-off points to identify obese subjects (BMI≥30 kg/m^2) was 93.2cm (sensitivity=86.5%, specificity=85.7%) for men (Figure 3) and 85.2cm (sensitivity=77.9%, specificity=78.0%) for women (Figure 4).

DISCUSSION

This is the first nationally representative population-based study in Malaysia showing sensitivity and specificity of waist action level cut-off points using BMI as reference criteria of overweight and obesity. The results of our study demonstrated that recommended WC action levels have low sensitivity for identification of overweight (48.3%) and obesity (52.4%) among Malaysian men. But, these WC cut-off

points had acceptable sensitivity in women for identification of overweight (84.2%) and obesity (79.2%). However, our study demonstrated high specificity of both waist action levels in men (> 95%) and women (>80%). Similar findings were reported by the WHO MONICA survey which examined the sensitivity and specificity of different WC cut-off points (waist action levels) in identification of overweight (BMI ≥ 25kg/m^2 or BMI ≤ 25kg/m^2 BMI with high waist-to-hip ratio) and obesity (BMI ≥ 30kg/m^2 or BMI ≤ 30 kg/m^2 with high waist-to-hip ratio) in 19 studied populations [20]. The WHO MONICA survey found that at waist action level 1, sensitivity ranged from as low as 40% to 80% in men and 51% to 86% in women for identification of overweight in all populations.

At waist action level 2, sensitivity was further reduced in identification of obese men (22-64%) and women (26-67%) in all populations. In another study conducted by Misra *et al.* [26] also found that the recommended WC cut-off points (102cm in men and 88cm in women) were less sensitive (47.8% in men and 69.7% in women) to identify overweight (BMI ≥ 25.0 25kg/m^2) among Asian Indians. In contrast, Carroll *et al.* [27] and Tanyolac *et al.* [28] found high sensitivity and specificity values of both waist action levels in identifying overweight and obese adults (BMI ≥ 25 kg/m^2 and ≥ 30kg/m^2, respectively) and those with lower BMI but high WHR. The differences in findings between the present study and the studies cited above is probably due to differences in WC measurement sites (mid-way between the iliac crest and the lower rib margin in the present study or measured WC at the umbilical level); the inclusion of WHR in defining overweight and obesity in cited studies; and differences in respondent characteristics.

If WC measurements are to be used as a single anthropometric tool for identification of overweight and obesity in Malaysian adults; an insufficiently sensitive WC will result in the under classification of a large proportion of overweight and obese subjects. Our results showed that for men, waist action level 1(≥ 94cm) missed approximately 52% (false negative) of the overweight subjects. While with waist action level 2 (≥108 cm), almost half of the obese men failed to be identified. Therefore, the use of the recommended WC cut-off point instead of BMI in identification of overweight and obesity should be exercised with caution [20]. However, WC cut-off values of 80 cm and 88 cm would be able to detect approximately 84% and 79% of overweight and obese women, respectively.

Early weight management is crucial since overweight and obesity are closely related to cardiovascular risk, diabetes, cancer and mortality. In addition, weight management costs are much less compared to costs of treatment for obesity related diseases [29]. Therefore, some researchers have suggested a higher sensitivity (which also means higher false positive rate), while minimizing the false negative rate as much as possible in determining the appropriate WC cut-off point because there is relatively less harm in recommending the false positive group for weight management. Furthermore, it will create awareness among the false positive group about the risks of further weight gain in health promotion program [15]. But, the downside is, it may incur unnecessary costs (purchase of exercise equipment, special diet, pharmaceutical products and surgical expenses) [30], time commitment and adverse psychological effects resulting from progressive weight loss program [31]. Therefore, an optimal cut-off value of WC to detect those requiring weight management, with high sensitivity and specificity is needed.

From the current study results, we propose that WC cut-offs of 86cm for men and 79cm for women to be classified as overweight and 93cm for men and 85cm for women for obese. Our proposed WC cut-off points are lower than the internationally accepted WC cut-off points [14]. Similar findings were found by Moy & Atiya [15] in their study on a group of Malay adults from Kuala Lumpur. They suggested WC cut-off points of 90 and 80cm for men and women respectively as appropriate for identification of overweight subjects. Similarly, Moy & Atiya [15] also found that WC measurement identified overweight better for women than men as indicated by the larger area under the ROC curve (AUC). Another study conducted on adult patients attending primary health care clinics in Malaysia suggested that the WC cut-off point of 83cm in both men and women [32], which was slightly lower for men and higher for women compared to our study. But, this WC cut-off point was determined in relation to cardiovascular risk factors, and from a small sample compared to the present study which was a large, population-based study.

In the present study, we determined the sensitivity of WC with BMI-based classification as the gold standard. Hence, the sensitivity of waist action levels are highly dependent on the validity of the BMI cut-off points. However, currently used BMI cut-off points may be inappropriate because literature reviews have shown that the Asian population should have lower BMI cut-off points compared to their European counterparts [33, 34]. Furthermore, Asians also have higher risks of cardiovascular disease, diabetes or other adverse health outcomes at lower BMI [34,35]. But, WHO experts opined that the current international classification of overweight (BMI ≥ 25 kg/m^2) and obese (BMI ≥ 30kg/m^2) should be retained since available data have not indicated clear BMI cut-off points for Asians for overweight or obesity [36] . The sensitivity of WC may also be influenced by the prevalence of overweight in the studied population. The WHO MONICA survey reported that sensitivity was generally lower in populations in which prevalence of overweight was relatively low, whereas it was higher in populations with relatively high prevalence of obesity [20]. The sensitivity and specificity of waist action levels should also be determined in relation to health risk factors Therefore, we suggest future studies should ascertain the association between WC and health related risk factors (diabetes, hypertension, cardiovascular risk) in order to determine the appropriate waist action level (public health action level) for early weight management and chronic diseases prevention programmes.

CONCLUSION

Our study aimed to identify appropriate waist action levels for the Malaysian population and also to increase awareness among the public and health personnel involved in weight control programmes and health promotion activities regarding lower WC cut-off values compared to currently

recommended cut-off points. We conclude that current waist action levels have low sensitivity for identification of overweight and obesity in men. We suggest that these WC cut-offs be considered for identification of those with increased risk of overweight and obesity related diseases, so weight management can be instituted earlier.

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