New reference charts for weight-related body measurements in children

Body mass index (BMI) is used to diagnose overweight and obesity. Charts for sex- and age-adjusted body mass index, based on data from the Bergen Growth Study, have been published previously. We now present new charts for waist circumference, waist-height ratio, triceps skinfolds and subscapular skinfolds. These are measurements that provide a better description than BMI of fat mass and distribution in Norwegian children.

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Appendix at www.tidsskriftet.no/brannsetherfig1-6engappendiks

Overweight and obesity in children and adolescents represent a global health challenge (1). In the Bergen Growth Study, in which 8 299 children from Bergen, Norway, were measured in a cross-sectional survey in the period 2003–2006, the prevalence of overweight, including obesity, in the age group 2–19 years was found to be 13.2 % for boys and 14.5 % for girls (2). The highest prevalence for both sexes together was 17.0 % for the age group 7–10 years (2). Data from the Bergen Growth Study formed the basis for national growth references that are recommended by the Norwegian Directorate of Health (3). The Child Growth Study conducted by the Norwegian Institute of Public Health, which has monitored Norwegian third-graders since 2008, found in 2015 a similar prevalence of overweight, including obesity, of 13.3 % among the boys and 16.7 % among the girls (4).

Overweight and obesity cause considerable health problems for children (5, 6). The development towards overweight starts early in life (7), and overweight in childhood predicts overweight and hence also a health risk in adulthood (8, 9). Treating established obesity is demanding, and it is therefore important to take preventive steps from an early age. Parents often misjudge their children's weight (10). Prevention of overweight in children therefore depends on regular measurements, accurate diagnostics and good follow-up routines in the public health system.

The health risk associated with overweight is related to excess fat and the distribution of fat tissues (11, 12). Ideally, overweight diagnostics should therefore focus on body composition and fat distribution. Radiological methods describe body composition more accurately than anthropometric measures, but are not readily available except through research projects or in specialised obesity clinics (13). Anthropometric measurements therefore remain the standard in general clinical use.

Body mass index (BMI)

Body mass index with cut-off points adjusted for sex and age indicates weight status and is used to diagnose overweight and obesity in children (14, 15). The BMI is not a direct measure of fat mass or distribution, and body fat may vary considerably in children with the same BMI (16–18).

Ethnicity (19) and chronic diseases (20) may make it difficult to interpret BMI. When it comes to diagnosing high body fat content correctly, the sex- and age-adjusted cut-off points for overweight have a high specificity (few false positives), but lower sensitivity (more false negatives) (21).

Other weight-related body measurements

Waist circumference is a good measure of abdominal obesity, also in children (22). Studies have revealed a high correlation between waist circumference and risk factors such as fatty acid profile, insulin resistance and high blood pressure (23–25). A waist-height ratio of 0.5 has been proposed as a cut-off point for abdominal obesity and increased health risk (26, 27). However, some find that this limit is not very sensitive in young children, particularly those under the age of six (28).

Skinfold thickness is used as a measure of subcutaneous fat. The skinfolds most often used for children are triceps and subscapular skinfolds. Skinfolds correlate well with total body fat (29). The method requires the availability of skinfold callipers and a knowledge of how to use them.

New Norwegian reference curves and their use

We have previously published reference values for waist circumference, waist-height ratio, triceps skinfolds and subscapular skinfolds for Norwegian children (30, 31). The same papers presented the values for these variables that are most consistent with BMI-based diagnosis of overweight and obesity.

We now present new growth charts for these variables (see *www.tidsskriftet.no/brannsetherfig1-6engappendiks*) similar to the existing charts for weight, height and BMI (32). The curves pinpoint the position of the individual child in relation to other children from the same population, and are easier to interpret visually than tabular data. The technique for measuring each of the anthropometric parameters is described in Box 1, and is outlined in previous publications (32, 33).

Waist circumference is mentioned in the Directorate of Health's national guidelines of 2010, but in the absence of national references and cut-off points, it was proposed that waist circumference should be used primarily to monitor the effect of therapy (15). As well as enabling monitoring, the new charts provide further information about fat mass and distribution.

In addition to correlating well with abdominal fat, waist circumference has been found to correlate better than the BMI with percentage body fat, also in physically active subjects (34). It may therefore be useful to measure the waists of children suspected of having aberrant weight development. The World Health Organisation (WHO) has proposed a graded action plan for the follow up of overweight adults, in which waist circumference is a key factor (35). The action level is stepped up if the waste circumference exceeds certain cut-off points for adults, specifically ≥ 80 cm for women of Caucasian origin, and ≥ 94 cm for men.

A graded action plan of this kind may also be useful with children, but at present

BOX 1

Technique for measuring waist circumference and skinfolds in children

Waist circumference is measured at the minimal waist level between the lowermost rib (costa 10) and the top of the iliac crest after normal expiration. If there is no minimal level, the measurement should be taken midway between these landmarks. A non-elastic measuring tape should be used.

Subscapular skinfold: Find the lowermost corner of the shoulder blade (inferior angle of the scapula). Mark a point 2 cm below this, at a 45 degree angle towards the middle of the back. Pull out a skinfold between finger and thumb at this point. The skinfold calliper must be held at 90 degrees to the body surface, and a measurement taken 1 cm below the marked point.

Triceps skinfold: Find the lowermost edge of the radial head (caput radii) and the outward end of the shoulder blade (acromion) and mark these points. Measure the distance between them and mark the midpoint on the back of the upper arm. Pull out a skinfold between finger and thumb at this point. The skinfold calliper must be held at 90 degrees to the skinfolds, in the direction of the arm's length, and placed 1 cm below the marked point.

Skinfolds should be measured with a skinfold calliper (e.g. Holtain skinfold calliper) which must be calibrated before use. Inaccuracy increases with the size of the skinfolds, and it may therefore be difficult to measure skinfolds in the most overweight subjects. It is important not to pull out the muscle – only the double skinfold with underlying fatty tissue must be measured.

there is no consensus as to which cut-offs should be used. The international diabetes federation (IDF) has recommended a waist cut-off value in its consensual statement on the diagnosis of metabolic syndrome in children (36). It recommends a waist circumference cut-off value equivalent to ≥ the 90th percentile for children aged 10–16, or the adult cut-off values if they are below the 90th percentile for sex and age. For young people aged over 16, the same cut-offs are recommended as for adults. It is not recommended that the diagnosis metabolic syndrome be made for children aged 6–10 years, but if the child has a waist ≥ 90th percentile, weight reduction should be strongly recommended. The recommendations are based on several studies that have shown that children with a waist ≥ 90th percentile are more susceptible to multiple risk factors associated with cardiovascular disease.

It has been pointed out that the BMI cut-offs have a low sensitivity, i.e. that many children (close to 25 % according to a meta-analysis (21)) with a high fat percentage are not identified by these cut-off points. We are not aware of any studies that have considered whether it is possible to identify more children through routine measurement of waist circumferences. This would be an interesting topic to study, particularly as adults with a large waist circumference are found to have an increased health risk, even if their BMI is normal (12). Such routine measurement would be resource-intensive, however, and prior to implementation, cut-off values would have to be decided on and a plan of action established for following up the measurements.

Measuring skinfold thickness may potentially be useful for assessing fat mass in children with clinical conditions that make BMI and waist circumference difficult to assess, for example children with cerebral palsy or skeletal dysplasia (20). These measurements should be carried out by a few persons who do it frequently, since studies have shown that the degree of inaccurate measurement is related to experience. Skinfolds may be difficult to measure in individuals with severe obesity because of the high accumulation of subcutaneous fat, but such measurement may supplement follow-up of overweight persons undergoing treatment.

Weight aberrations, and in particular overweight in children, have major consequences – not just for the individual child, but for society. In our encounter with the overweight epidemic, we believe that there is much to be gained from early diagnosis and more differentiated risk analyses. The charts for waist circumference, waist-height ratio and skinfold thickness that are presented here allow us to consider other weight-related anthropometric variables for children, also in Norway.

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