

## Letters to the Editor

### RE: "COMPARISONS OF THE STRENGTH OF ASSOCIATIONS WITH FUTURE TYPE 2 DIABETES RISK AMONG ANTHROPOMETRIC OBESITY INDICATORS, INCLUDING WAIST-TO-HEIGHT RATIO: A META-ANALYSIS"

Kodama et al. (1) conducted a systematic review of prospective studies to compare the strength of associations of waist-to-height ratio, body mass index, waist circumference, and waist-to-hip ratio, respectively, with type 2 diabetes. For a 1-standard deviation increase in these indices, the relative risk of diabetes was 1.62 (95% confidence interval (CI): 1.48, 1.78) for waist-to-height ratio, 1.55 (95% CI: 1.43, 1.69) for body mass index, 1.63 (95% CI: 1.49, 1.79) for waist circumference, and 1.52 (95% CI: 1.40, 1.66) for waist-to-hip ratio, respectively. The authors concluded that the waist-to-height ratio (or waist circumference) is a better predictor of future diabetes than is body mass index or waist-to-hip ratio (1). To better evaluate the meaning of these observations, one must consider the reliability of the waist circumference measurement in comparison with the reliability of the other anthropometric indices.

It is well established that the reliability of weight and height measurements is higher than the reliability of waist circumference and hip circumference measurements (2). Intraobserver and interobserver technical error and reliability of these measurements were systematically reviewed by Ulijaszek and Kerr (2) and are reported in Table 1. The intraobserver reliability of all these metrics is high (reliability coefficients on average of 0.97 or above). However, while the interobserver reliability of weight or height is high, it is lower for waist circumference and hip circumference (reliability coefficient on average of 0.94 and 0.89, respectively). Similar observations were made in children (3).

A low reliability implies a relatively large random measurement error for waist or hip circumference measurement. Because of the regression dilution bias associated with the random measurement error in an exposure (4), estimates of the relative risk of the outcome diabetes are underestimated for the waist-to-height ratio, waist circumference, or waist-to-hip ratio. In theory, this would confer additional arguments for the use of waist circumference to assess the risk of diabetes if an

adjustment is made for the regression dilution bias (5). Nevertheless, in practice, the poor reliability of waist circumference, the difficulty to adjust for the regression dilution bias (4), and the availability and high reliability of weight and height measurements suggest that the waist-to-height ratio, waist circumference, or waist-to-hip ratio should not be preferred to body mass index to assess the risk of diabetes.

#### ACKNOWLEDGMENTS

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#### REFERENCES

1. Kodama S, Horikawa C, Fujihara K, et al. Comparisons of the strength of associations with future type 2 diabetes risk among anthropometric obesity indicators, including waist-to-height ratio: a meta-analysis. *Am J Epidemiol*. 2012;176(11):959–969.
2. Ulijaszek SJ, Kerr DA. Anthropometric measurement error and the assessment of nutritional status. *Br J Nutr*. 1999;82(3):165–177.
3. Stomfai S, Ahrens W, Bammann K, et al. Intra- and interobserver reliability in anthropometric measurements in children. *Int J Obes*. 2011;35(suppl 1):S45–S51.
4. Hutcheon JA, Chiolero A, Hanley JA. Random measurement error and regression dilution bias. *BMJ*. 2010;340:1402–1406.
5. Knuiman MW, Divitini ML, Buzas JS, et al. Adjustment for regression dilution in epidemiological regression analyses. *Ann Epidemiol*. 1998;8(1):56–63.

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**Table 1.** Intraobserver and Interobserver Technical Error of Measurement and Reliability for the Measurement of Weight, Height, Waist Circumference, and Hip Circumference<sup>a</sup>

	Intraobserver				Interobserver			
	Technical Error of Measurement		Coefficient of Reliability		Technical Error of Measurement		Coefficient of Reliability	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Weight, kg	0.2	0.1–0.3	0.98	0.95–1.00	1.3	0.1–4.1	0.98	0.94–1.00
Height, cm	0.4	0.1–1.3	0.98	0.93–0.99	0.4	0.2–0.8	0.99	0.95–1.00
Waist circumference, cm	1.3	1.0–1.6	0.97	0.97–0.98	2.3	0.6–4.2	0.94	0.86–0.99
Hip circumference, cm	1.3	1.2–1.4	0.97	0.96–0.99	2.8	0.7–6.1	0.89	0.68–0.99

<sup>a</sup> Mean values and range are reported from a systematic review by Ulijaszek and Kerr (2).