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EDITORIAL

Absolute or relative measures of height and weight? An Editorial

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In this volume, Spiegler and coworkers present their work on very low-birth weight infants (VLBW), they analysed at what age parents start complementary food in these infants, they determined risk factors for early introduction of complementary food and they analysed whether the age at introduction of complementary food influences height or weight at two years of age. The study is an important contribution to infant nutrition. But there is more to the study: the study was performed at the crossroads between nutrition and auxology.

Studying nutrition and nutritional intervention on growth involves measuring length/height and weight. We measure height in centimetres and weight in g or kg, and quite intuitively consider these units appropriate for describing growth. Terms referring to absolute weight like low birth weight and VLBW infants are ubiquitously used in modern neonatology.

But absolute measures are not unambiguous. What does VLBW (< 1500 g) mean? In a group of infants born in the 34th week of gestation, < 3% weigh < 1500 g; when born in the 30th week of gestation, ~50% are below this weight; but ~97% when born in the 28th week of gestation.[1] A VLBW sample of infants born in the 34th week of gestation will consist of selection of hypotrophic infants, whereas a VLBW sample of infants born in the 28th week of gestation is just an appropriate for gestational age sample of prematurely born infants.

Height and weight measures become clinically relevant when compared with an appropriate reference. Growth references are statistical summaries of anthropometry, conditioned (usually) on age and sex. References describe how children do grow. They usually provide mean values and s.d. scores or *Z*-scores, that is, relative measures for an individual child's height, weight or body mass index. *Z*-scores refer to the difference between the individual measurement (X_i) and the age- and sex-specific mean values (X_{mean}) of the reference population, divided by the standard deviation.

$$Z\text{-score} = (X_i - X_{\text{mean}})/\text{SD}$$

Relative measures track growth within the reference group. Children tend to keep their *Z*-score throughout development, that is, those who start tall already early in life, tend to stay tall; those who start short, tend to stay short.

Complementary to growth references that describe actual growth, growth standards prescribe optimum growth. As groups of infants and young children from diverse ethnic groups whose nutrition, health and care needs are met were claimed to grow similarly,[2,3] a single set of so called growth standards has been developed to prescribe how children should grow. WHO growth standards are used across countries to assess the growth of children up to 5 years of age.[4]

The idea of growth standards is intriguing, not only biologically, but it pleases our modern belief that all humans be similar, and most differences in growth be due to differences in the environment and will disappear in a world where everybody is happy and healthy. But is this idea true? Is it possible to interpret all individual growth data in the light of one international growth standard?

Indian newborns are light and short[5] when compared with WHO standards. We are used to explain anthropometric birth data from India by unfavourable maternal conditions. But also Indian infants born to modern upper class women are shorter and lighter than WHO standards, and do not reflect maternal wealth and caste (Table 1).

Khadilkar and Khadilkar[6] state: 'The disadvantage of using charts such as these (WHO charts) is that they are likely to over diagnose underweight and stunting in a large number of apparently normal children in the developing countries such as India'. Not only wealthy Indian children are shorter and lighter than these standards. Figure 1 illustrates the Japanese situation. The average Japanese growth curve for height also falls below WHO standards. Not only historic Japanese cohorts are significantly shorter particularly early in life, but also modern Japanese children. Japanese growth patterns differ. The two Asian examples may underscore that the simple idea of one single set of globally applicable international growth standards needs to be questioned.[7]

Spiegler and coworkers[8] used German references. This is an important detail in their study, and we should be aware that Spiegler's approach is the exception. The majority of nutrition reports published world wide do not refer to national, but to the international WHO standards and references.

Meanwhile the discussion has become even more confusing: prominent research groups have started again questioning the use of *Z*-scores and published controversial opinions. Responding to a critical review by Prentice *et al.*[9] on the timing of growth faltering, Leroy *et al.*[10] suggested that rather than using relative measures to track growth faltering in groups of infants and young children, absolute 'height-for-age differences' should be used instead. Lundeen *et al.*[11] added that 'an important area for future

Table 1. Indian unisex birth weight[5]

	N	*Mean (g)*	*Z-score*	
			Males	*Females*
Wealth quintile				
First (highest)	1504	2933	−0.88	−0.67
Second	967	2831	−1.11	−0.91
Third	476	2758	−1.28	−1.09
Fourth	199	2738	−1.33	−1.13
Fifth	81	3001	−0.73	−0.52
Caste				
Scheduled caste	379	2814	−1.15	−0.95
Scheduled tribe	434	2879	−1.00	−0.80
Other backward class	1015	2883	−0.99	−0.79
General class	1244	2845	−1.08	−0.88
No caste	155	2879	−1.00	−0.80

As the Indian data are unisex, *Z*-scores are based both on male and on female WHO standards.[4]

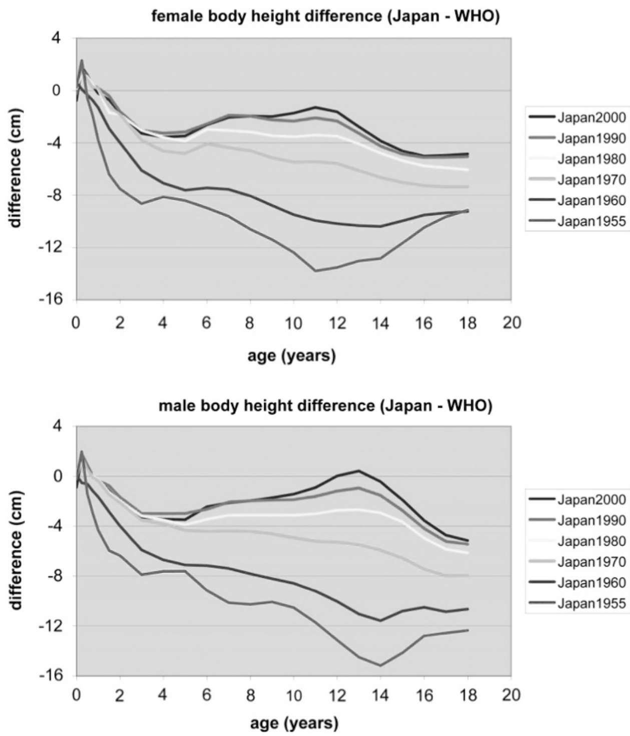

Figure 1. Height difference between modern and historic Japanese children[14,15] and WHO standards/references.[4]

research is determining which metric, changes in height-for-age *Z*-scores or changes in height deficit over time, is better at predicting different outcomes'.

It is misleading to assume that good reasons to quit the concept of analysing relative growth are in sight. Instead, it is 'obvious that there are many instances in biology and in public health in which absolute and relative scales provide apparently contradictory results',[12] and no evidence has been provided so far that such contradictory results are clinically relevant. Children tend to track along their *Z*-scores—first drawings showing this characteristic human growth pattern were published by Bowditch in 1872 (cited after 13, p 475), long before the term centiles and *Z*-scores were inaugurated.[13] Thus, transforming length/height and weight into *Z*-scores, describing growth in relative, rather than in absolute terms, and analysing patterns of growth on the basis of a valid local reference, must still be considered appropriate. And this is what Spiegler and coworkers did.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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REFERENCES

1 Voigt M, Friese K, Schneider KTM, Jorch G, Hesse V. Kurzmitteilung zu den Perzentilwerten für die Körpermaße Neugeborener. *Geburtsh Frauenheilk* 2002; **62**: 274–276.
2 Habicht JP, Martorell R, Yarbrough C, Malina RM, Klein RE. Height and weight standards for preschool children. How relevant are ethnic differences in growth potential? *Lancet* 1974; **1**: 611–614.
3 WHO Multicentre Growth Reference Study Group. Assessment of differences in linear growth among populations in the WHO Multicentre Growth Reference Study. *Acta Paediatr Suppl* 2006; **450**: 56–65.
4 WHO multicentre growth reference study group. WHO child growth standards. *Acta Paediatr Suppl* 2006; **95** (Suppl 450): 1–104.
5 Subramanyam MA, Ackerson LK, Subramanian SV. Patterning in birthweight in India: analysis of maternal recall and health card data. *PLoS One* 2010; **5**: e11424.
6 Khadilkar V, Khadilkar A. Growth charts: a diagnostic tool. *Indian J Endocrinol Metab* 2011; **15** (Suppl 3): S166–S171.
7 Hermanussen M. *Auxology—Studying Human Growth and Development*. Schweizerbart: Stuttgart, Germany, 2013.
8 Spiegler J, Eisemann N, Ehlers S, Orlikowsky T, Kannt O, Herting E *et al.* Length and weight of very low birth weight infants in Germany at 2 years of age: does it matter at what age they start complementary food? *Eur J Clin Nutr* 2015; **69**: 662–667.
9 Prentice AM, Ward KA, Goldberg GR, Jarjou LM, Moore SE, Fulford AJ *et al.* Critical windows for nutritional interventions against stunting. *Am J Clin Nutr* 2013; **97**: 911–918.
10 Leroy JL, Ruel M, Habicht JP, Frongillo EA. Linear growth deficit continues to accumulate beyond the first 1000 days in low- and middle-income countries: global evidence from 51 national surveys. *J Nutr* 2014; **144**: 1460–1466.
11 Lundeen EA, Stein AD, Adair LS, Behrman JR, Bhargava SK, Dearden KA *et al.* Height-for-age z scores increase despite increasing height deficits among children in 5 developing countries. *Am J Clin Nutr* 2014; **100**: 821–825.
12 Victora CG, de Onis M, Shrimpton R. Linear growth faltering should be assessed in absolute and relative terms. *J Nutr* 2014; **144**: 2092–2093.
13 Boyd E. *Origin of the Study of Human Growth*. University of Oregon Health Science Center Foundation, 1980, p 475.
14 Technology. Report on school health survey 2003 National printing bureau, Tokyo, 2004, pp 130-133, and Satake T personal communication 2012.
15 Takahashi E, Atsumi H. Age differences in thoracic form as indicated by thoracic index. *Hum Biol* 1955; **27**: 65–74.