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A comparison of ultrasonic and mechanical stadiometry

V Watt, M Pickering, J K H Wales

Abstract

Aim—To compare an ultrasonic height measuring device (Gulliver) with mechanical stadiometry and the classical “book and tape measure” method.

Methods—Blinded duplicate measurements of height were made on each of 14 children by a pair of observers using a stadiometer (H) and Gulliver (G). Height was measured on a further 18 children by parents and an auxologist using Gulliver and the book and tape method (TM), and the results were compared with those obtained with a single stadiometry measurement. Finally, measurement of a rigid metal box was made on 10 occasions by the three methods.

Results—In the group of 14 children, the mean difference (range) in height (H minus G) was +2.8 cm (+0.5 to +4.55 cm), with H giving a systematically higher value in 276 of 280 individual measurements. In the group of 18 children, height by H was greater than by G or TM in 47 of 52 individual measurements. The mean (SD) height of the box by H (61.60 (0.07) cm) was greater than by G (60.96 (0.15) cm; $p < 0.001$) but not TM (61.4 (0.16) cm; $p > 0.05$). G and TM produced three times less reliable estimations of height than H, but with a large difference in cost, and there was evidence of systematic underrecording of height by 0.5 cm with G.

Conclusions—Stadiometry is precise and reproducible, and can detect true changes in height over one month periods in mid-childhood, and should remain the standard way of observing growth. The book and tape method can produce clinically acceptable quarterly estimations of height that can be performed in the home.

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Keywords: stadiometry; height measurement; ultrasonic height measurement; Gulliver

An ultrasonic device for the measurement of standing height (Gulliver, Syrx-Diagnostika GmbH, Frankfurt, Germany) has been described and proposed as a means of home measurement of daily changes in height by parents to rapidly assess response to growth hormone treatment.¹

Gain in height is an irregular process at all time scales, and frequent measurements using compliant subjects and trained auxologists using a standard mechanical stadiometer or knemometer may allow observations on the biology of growth.² Previous attempts to detect

clinically significant acceleration of height or leg length velocity in response to growth hormone have only been partly successful³ because of this inherent irregularity of height velocity, and have been largely limited to hospital based studies (although portable knemometry has been described⁴). The ultrasonic stadiometer is portable and if accurate might allow frequent measurement of subjects in their own home. However, it has not previously been formally evaluated.

Methods

Fourteen unselected children attending a hospital outpatient clinic were each measured 10 times on a single occasion by a pair of observers (MP, an auxologist; VW, a medical student), using both a wall mounted Harpenden stadiometer (H) (Holtain, Crymch, Wales) and Gulliver (G). The observers were blinded to both their current measurement and their own previous measurements on each individual to reduce measurement bias (by placing an opaque card over the readout with the value being transcribed by the other measurer).

Eighteen further unselected outpatient attendees were measured on a single occasion by a parent using Gulliver after instruction. Each child was also measured once using a simple builder's metal tape measure (TM) to measure the distance from the floor to the base of a book placed horizontally on the head against a wall. The results were compared with the same single G and TM measurements as performed by the auxologist (MP) and with a single standard measurement of height using the wall mounted Harpenden stadiometer.

A rigid metal box was measured on 10 occasions using G, H, and TM.

The measurements were analysed for within subject standard deviation (*sw*), the coefficient of variation, the difference between the methods and the range of that difference, as described by Bland and Altman.⁵

Results

The results of the 10 duplicate measurements on 14 children are given in table 1. The mean difference between measurements (H minus G) was +2.8 cm and the range of these mean differences was +0.5 to +4.55 cm. Harpenden stadiometry gave a systematically higher value in 276 of 280 individual measurements. Differences between two measurements for the same subject using a single device greater than 2×1.96 *sw* may be regarded as real with 95% confidence. This index of repeatability was H = 0.46 cm; G = 1.79 cm, equivalent to the ability

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Table 1 Within subject standard deviation *sw* (cm) and coefficient of variation (CV %) of measurements with Harpenden caliper and ultrasonic Gulliver

	<i>sw</i> (cm)	CV (%)	Mean range (cm)	Minimum and maximum difference (cm)
H (MP)	0.12	0.08	0.38	0.2, 0.5
H (VW)	0.19	0.14	0.61	0.3, 1.0
Combined	0.15	0.11	0.50	0.2, 1.0
G (MP)	0.52	0.38	1.96	0.7, 3.8
G (VW)	0.68	0.50	2.00	1.0, 3.4
Combined	0.60	0.44	1.98	0.7, 3.8

Mean range of 10 measurements and the minimum and maximum extent of this mean range performed on 14 individuals for both observers (MP and VW). The values are given for each observer and also combined and compare the mechanical Harpenden stadiometer (H) and ultrasonic Gulliver (G).

Table 2 Mean difference (cm) and standard deviation (SD) of difference for height estimated on single occasion by Harpenden stadiometer (H) minus tape measure (TM) and Harpenden stadiometer minus ultrasonic Gulliver (G) for both parent and auxologist (MP) in 18 individuals

	Difference (cm (SD))		
	H-TM	H-G	
Parent	0.75 (0.49)	0.88 (0.70)	NS
Auxologist (MP)	0.76 (0.38)	0.74 (0.47)	NS

to detect true changes in height with 95% confidence over 28 and 109 days respectively at 6 years of age (or alternatively the ability to estimate a height velocity in mid-childhood to within 0.45 and 1.81 cm/year, respectively). For the professional auxologist (MP) these values were 19 days and ± 0.33 cm/year.

In the 18 children measured by G and TM, the results comparing the values obtained by parent and auxologist (MP) with H are given in table 2. Again in 47 of 52 individual measurements the height obtained by H was greater than that obtained by G or TM. There was no statistical difference between the height estimated ultrasonically or by book and tape and the "true" H measurement.

The mean (SD) height of the metal box estimated by H was 61.60 (0.07) cm; by G, 60.96 (0.15) cm; and by TM, 61.4 (0.16) cm. The difference between H and TM was not statistically significant; the difference H and G was significant ($p < 0.001$).

Discussion

This study is one of the few published reports showing that highly accurate measurements of height can be obtained by conventional stadi-

ometry in unselected children, even by a relatively inexperienced observer (VW). The ultrasonic method and the tape measure and book method are both "free standing," whereas the Harpenden stadiometer is used with a gentle stretch, and this is likely to account for most of the systematic under-recording seen using these methods, although a difference of around 0.5 cm was also observed between Harpenden and Gulliver measurements when used with the rigid metal object. So long as a single method is used the accurate estimation of *changes* in height does not depend on the *absolute* height measured, so this systematic difference in itself is not a major problem for the ultrasonic technique used as originally described,¹ unless comparison is being made with population standards. However, the ultrasonic method was significantly less repeatable than conventional stadiometry (but probably no worse than some of the less accurate results of stadiometry that have been reported⁶). It should not be relied upon to produce meaningful results over a time scale less of than three months in a child growing at a normal rate, although during a rapid phase of catch up growth this period will be reduced. The ultrasonic device was novel, portable, and relatively simple to use; however, it performed no better than the much simpler means of standing a child against a wall and measuring to the base of a book placed on the head—a traditional home method with which most parents are familiar. At a current cost of £550, Gulliver is unlikely to replace standard or simple mechanical stadiometry (Harpenden stadiometer £710; tape measure and book around £9) on grounds of accuracy and cost, respectively.

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