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Non-contact assessment of waist circumference: will tape measurements become progressively obsolete?

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Waist circumference (WC) is a key variable to assess in health management as it is a proxy of abdominal fat mass and a surrogate marker of cardiometabolic disease risk, including the metabolic syndrome. Recently, a portable non-contact device calculating WC (ViScan) has been developed, which hence allows the tracking of WC independently of the inter-investigators error. We compared WC values obtained with this device with WC measured by simple non-stretchable tape in 74 adults of varying body mass indices (range 17–39 kg/m^2). The correlation between the two methods was very high ($r=0.97$, $P<0.0001$) and the reproducibility (precision) assessed with a rigid phantom was excellent (<1 cm, coefficient of variability<1%). The instrument constitutes a potentially valuable tool for longitudinal surveys and comparative international studies, which require simple but precise measurements of WC in order to track the effect of subtle changes on various health outcomes.

Keywords: body composition; viscan; abdominal fat; obesity

Introduction

Numerous methods that vary in technical difficulties, complications and costs have been developed and used during the last 20 years to assess abdominal and visceral fat, as centrally located adipose mass is the most strongly associated with metabolic disorders (World Health Organization, 2000). Waist circumference (WC) is generally used as proxy for abdominal fat, but this measurement is rather crude, depends upon abdominal morphology and is largely investigator dependent. WC measurement is widely advocated as a marker of cardiometabolic disease risk and constitutes a key diagnostic criterion for the metabolic syndrome (Mason and Katzmarzyk, 2010). Recently, a new objective method (ViScan, Tanita Corporation, Tokyo, Japan) has been proposed to assess WC, as well as visceral fat and trunk fat (the latter two variables will not be discussed here). This development is particularly interesting as, in epidemiological research, simple objective methods, with little dependence on the investigators' variability, remain to be developed.

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Subjects and methods

A total of 74 adult volunteers (41 females and 33 males) were studied with a range of age between 18 and 61, and a range of body mass index between 17 and 39 kg/m^2. WC was measured at the umbilicus in the standing position ($n=74$), and also in the supine position in a subgroup ($n=47$), by means of a non-stretchable tape at the end of expiration and according to the standardization reference manual described by Lohman *et al*. (1988). WC was also measured in all subjects ($n=74$), in random order to tape measures, using a new device (ViScan) whose principle of measurement has been detailed elsewhere (Browning *et al*., 2010; Thomas *et al*., 2010); the subjects were lying supine and relaxed while WC was measured at the umbilicus as identified by a red beam emitted from ViScan. Sagittal diameter was also assessed in 72 subjects with an anthropometric compass. The reproducibility of ViScan was measured with a rigid human phantom (waist 65 cm, hip 90 cm), as well as with human subjects.

Statistical analysis

Pearson's correlation coefficients were calculated to assess the association between WC measured by tape vs ViScan assessment. Systematic bias and differences among methods

Table 1 Comparison of WC measurements obtained from the non-contact device ViScan in supine position and from manual tape in conventional standing position

	ViScan	*Tape*
Human subjects WC (cm), n = 74		
Mean	86.4	85.2*
s.d.	12.8	13.1
Intra-individual variability; CV (%)		
Human subjects[a]		
Mean CV	0.61	0.67
Range	0–1.5	0.3–1.1
Human phantom[b]		
Mean CV	0.30	0.80
(range)	0–0.5	0–1.0

Abbreviations: CV, coefficient of variability; WC, waist circumference.
*$P<0.01$ (by paired *t*-test).
[a]CV assessed in eight subjects (3–4 replications per subject).
[b]CV assessed from 20 consecutive replications in four separate tests.

were assessed using Bland and Altman method. Level of significance was set at $P<0.05$.

Results

Table 1 shows the mean and s.d. values for WC measured by ViScan in supine position and by tape in standing position. The difference in mean WC obtained with the two techniques (86.4 vs 85.2 cm), although small (1.2 cm), is nonetheless about twice the difference between repeat WC measured by the tape or ViScan (about 0.5 cm); the intra-individual variability being low (coefficient of variability <1%) with both techniques applied to human subjects as well as to the rigid phantom. As shown in Figure 1a, there was an excellent relationship between WC assessed by ViScan in supine position vs by manual tape either in supine

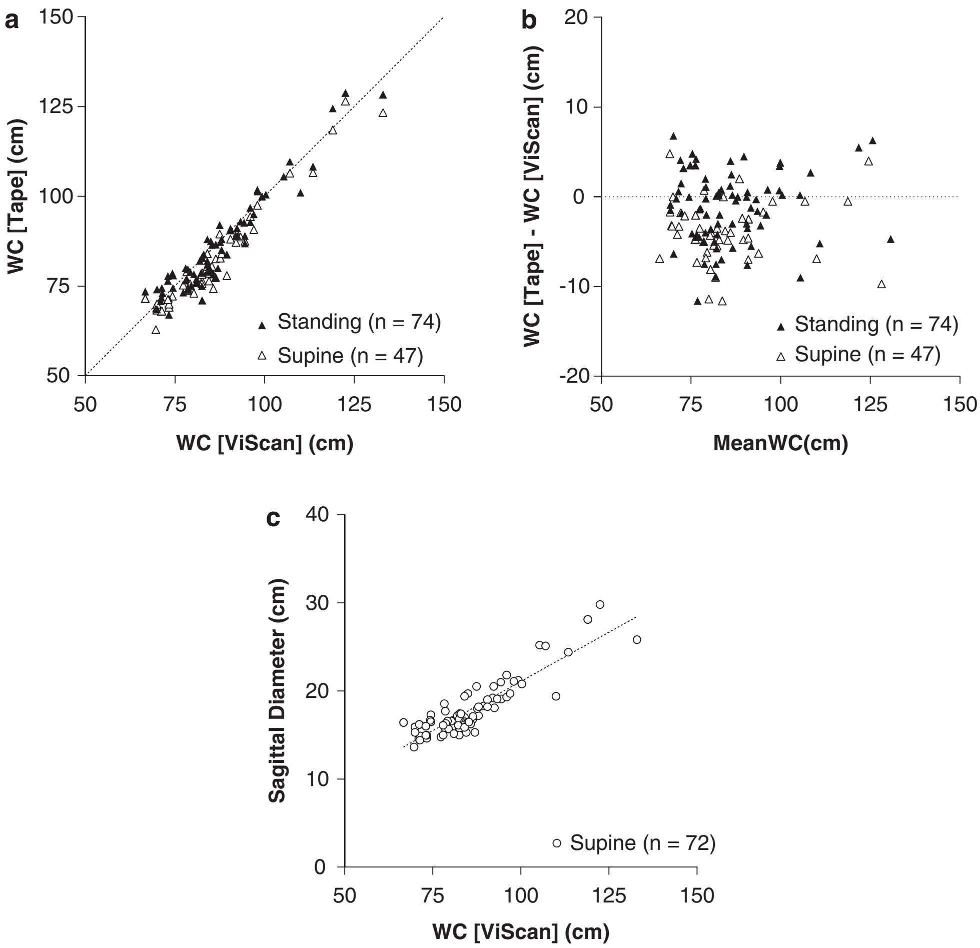

Figure 1 (**a**) Relationship between WC assessed by non-contact measurement (ViScan) vs by manual tape either in supine position ($r=0.97$, $n=47$, $P<0.0001$; $y=-2.27+0.98x$) or standing position ($r=0.95$, $n=74$, $P<0.0001$; $y=0.69+0.98x$). The dotted line represents the line of identity. (**b**) Bland–Altman plot of agreement between WC measured by non-contact measurement (ViScan) vs by manual tape either in supine position ($r=0.05$, $n=47$, $P=0.75$) or standing position ($r=0.08$, $n=74$, $P=0.49$). (**c**) Relationship between WC assessed by non-contact measurement (ViScan) vs sagittal abdominal diameter ($r=0.89$, $n=72$, $P<0.0001$; $y=-1.23+0.22x$).

($r = 0.97$, $P < 0.0001$) or standing positions ($r = 0.95$, $P < 0.0001$). The regression line had a slope close to identity line (0.98), with zero intercept of −2.27 cm in supine and 0.69 cm in standing position, reflecting a lower mean value for WC measured by tape in supine than in standing position in 47 subjects (82.6 vs 85.2 cm, $P < 0.001$). The magnitude of difference between the two techniques (ViScan vs tape) and the bias are visualized in Figure 1b. The residuals showed very little bias with 95% of the points within +4 and −4 cm. WC measured by ViScan also correlated well with sagittal diameter ($r = 0.89$, $P < 0.0001$) (Figure 1c).

Discussion

WC is a 'simple, inexpensive and reliable tool that should be included as part of physical examinations in the doctor's office' as pointed out by Wang (2003). The issue is whether or not in clinical and epidemiological studies in the twenty-first century, we should continue to use a device classically used by dressmakers to track WC? What then are the arguments? First, innovation is the motor of research; second, improvement in accuracy and precision of WC is important in order to detect the effect of subtle changes on various health outcomes; third, in daily practice, standardization of WC measurement among multiple field workers in different parts of the world is difficult when a tape is used, as the inter-operator accuracy and intra-individual reproducibility varies substantially (Nádas *et al.*, 2008; Panoulas *et al.*, 2008; Mason and Katzmarzyk, 2009) and this may jeopardize the diagnosis of metabolic syndrome. Potential errors using the manual tape may arise from poor training harmonization of investigators and poor motivation of some operators. By contrast, the use of a portable non-contact device for measuring WC, such as ViScan, allows the tracking of WC independently of investigators errors. Furthermore, the utilization of a fixed and highly reproducible reference point (umbilicus) as well as measurements made in supine position are clearly advantages in WC assessment. The potential advantages and shortcomings of the ViScan are indicated in Table 2. If one exempts the cost of the device, the advantages outweigh the disadvantages.

There are two issues regarding variability of measurements that need emphasis. First, the ViScan has a reading resolution of 1 cm only (i.e. zero decimals) compared with 0.1 cm for the tape that hence has a resolution which is 10 times greater—a difference that could introduce a bias in calculating the precision of the ViScan device, that is, inflating its value. However, we found similarly low values of repeatability (mean coefficient of variability < 1%) for both the techniques (Table 1), and our tape data are in line with the commonly reported within-investigator variability of WC measured by the tape that is generally low (coefficient of variability < 1%) and often below 1 cm (Nádas *et al.*, 2008; Panoulas *et al.*, 2008; Geeta *et al.* 2009) and hence not necessarily worse than with the ViScan. Nonetheless, the primary advantage of the ViScan device is that, in contrast to the tape method, it is operator-independent, and hence the inter-investigator variability in WC for a given subject is not expected to be larger than the intra-investigator one. Second, using the tape as gold standard, systematic differences (overestimations of several cm) have previously been reported between the measurements of WC by the ViScan and the tape at umbilical level (Browning *et al.*, 2010; Thomas *et al.*, 2010), and in our study WC obtained by Viscan was about 1 cm less than by tape. These differences may not only be explained by the above-mentioned potential errors when using the tape, but could also be attributed to the fact that the ViScan device uses a very simple algorithm to assess WC: this is based on the relationship demonstrated, in one specific Asian population group, between width diameter and WC.

Further development of the device could be well envisaged for field and epidemiological studies: for example, combination of abdominal width diameter with sagittal diameter (height) measurements (using an additional beamer) may improve the accuracy of the model used to calculate WC, as for a given width there are large individual differences in WC (Figure 1c). Finally, we believe that in order to objectively compare WC values among different nations and ethnic groups, a low cost, simple and reliable device (even excluding trunk and visceral fat measurements but having the improvement mentioned above) could be developed in

Table 2 Potential advantages and limitations of the non-contact method (ViScan) for assessing WC obtained from abdomen width

Advantages	*Shortcomings*
Concomitant estimation of trunk fat and visceral fat	High cost (if limited budget)
Supine measurement (reproducibility)	Invalid for pregnant women
Simple reference anatomical site (ombilic)	Error due to differences in sagittal diameter for a given width diameter
No contact on the skin	Uncertainty about effect of ethnicity
Ethnic friendly for 'sensitive' people	Tunnel too narrow for morbid obese (need XXL version)
Portable (light)	
Quick measurements (20 s maximum)	
Very reproducible (< 1 cm)	
Pulmonary ventilation has less influence on WC	
Large series assessed quickly, also in the field (autonomous battery)	

Abbreviation: WC, waist circumference.

order to be independent of operator bias and to fully harmonize the measurement of WC in field and epidemiological studies.

In conclusion, the ViScan has the potential to provide a precise and objective measurement of WC but its cost may preclude a wide utilization of the device due to limited budget. It could permit a sound comparison of WC at the international level, provided the device is further validated in different ethnic groups and at different body mass indices and in different gender.

Conflict of interest

The authors declare no conflict of interest

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