Waist circumference: an update on the state of the art

In this document we aim at providing a global vision of one of the simplest clinical parameters to measure, which for that very reason, is many times underestimated. It provides a wealth of significant information to estimate risks associated with a series of cardiometabolic diseases, that is, diseases that imply cardiovascular, renal, metabolic, prothrombotic and inflammatory abnormalities. For this purpose we rely (mainly but not entirely) on the Declaration of Consensus of the Working Group formed by the International Atherosclerosis Society (IAS) and the International Chair on Cardiometabolic Risk (ICCR), agreed in 2017 in Prague, to discuss about the importance of abdominal obesity as a premature risk factor for atherosclerosis and cardiovascular disease in adults, and which seeks to synthesize the available evidence. This indicates that the Body Mass Index (BMI, calculated as the ratio between height and squared weight) is not by itself sufficient to assess cardiometabolic risk. The authors provide arguments for why it is essential to complement the measurement of BMI with the measurement of waist circumference, which would considerably improve the evaluation and treatment of overweight or obese patients (Ross 2020).

Risk and mortality marker

Waist circumference is highly correlated with both cardiovascular mortality (Zhang 2018, Song 2013) and general mortality (Pischon 2008, Cerhan 2014), without or with adjustment for BMI (Pischon 2008, Seidell 2010), becoming a better predictor of risk when used to stratify the different degrees of obesity, that is, it allows to discern obesity phenotypes of lower or higher risk. Likewise, both measures serve to evaluate the usefulness and effectiveness of the interventions designed by health professionals.

A relatively popular alternative to measuring waist circumference is the waist-to-hip ratio, but waist circumference has been shown to have a more robust association with the absolute amount of visceral fat, the fat deposits that carry the most risk (Snijder 2006, Neeland 2019). Other alternatives include the conicity index (Valdez 1993) and the abdominal obesity index (Amankwah 2018), but both measures are at best only slightly better predictors of risk than waist circumference alone.

The prevalence of obesity measured by BMI has reached an upper limit in several countries, while the prevalence of abdominal obesity measured by waist circumference in general continues to grow, waist circumference thus signaling an advance in the deterioration of the condition of the health of the population when high levels of obesity are reached. The recommendation is then to use waist circumference as a discriminant of a person's state of health, especially in cases of high BMI.

In the prospective cohort study (in which initially healthy individuals are studied), European Prospective Investigation into Cancer and Nutrition, the associations between BMI, waist circumference and risk of death were investigated among 359,387 adults. The authors confirmed that, for a given BMI value, the risk of death increases by 17% in men and by 13% in women for each 5 cm increase in waist circumference, further signaling the importance of considering the combination of BMI with waist circumference to improve risk prediction (Pischon 2008).

In several studies, including observations made in a cohort of 14,284 adults with cardiovascular disease and an average follow-up of 2.3 years, it was observed that when dividing the population into different

segments for both BMI and waist circumference, there is a significant association with an increased risk of death for the groups with greater waist circumference after adjusting the risks for age, sex, smoking, diabetes mellitus, hypertension and BMI. In contrast, when the risk is adjusted by the same parameters but replacing BMI by waist circumference (that is, adjusting for waist circumference), increasing levels of BMI have an inverse association with the risk of death. In other words, the risk of death is higher for a larger circumference considering the same BMI, and it is lower for a higher BMI considering the same waist circumference (Bigaard 2003, Coutinho 2011, Sluik 2011).

The reason for this phenomenon has not been established. A possible explanation may be the protective effect derived from the accumulation of subcutaneous adipose tissue in the lower part of the body, specifically in adipocytes located in the gluteal-femoral area that may protect against the appearance of excessive lipid deposits in visceral and ectopic adipose tissue (referred to fat storage in organs that do not normally contain fat stores such as liver, pancreas, heart and skeletal muscle) (Despres 2006, Eastwood 2014). It is precisely the accumulation of excess lipids in these tissues that has been associated with cardiometabolic risk (Snijder 2005, Eastwood 2014, Lewis 2002). On the other hand, visceral adipose tissue is a well-established marker of morbidity and mortality (Neeland 2019, Despres 1995).

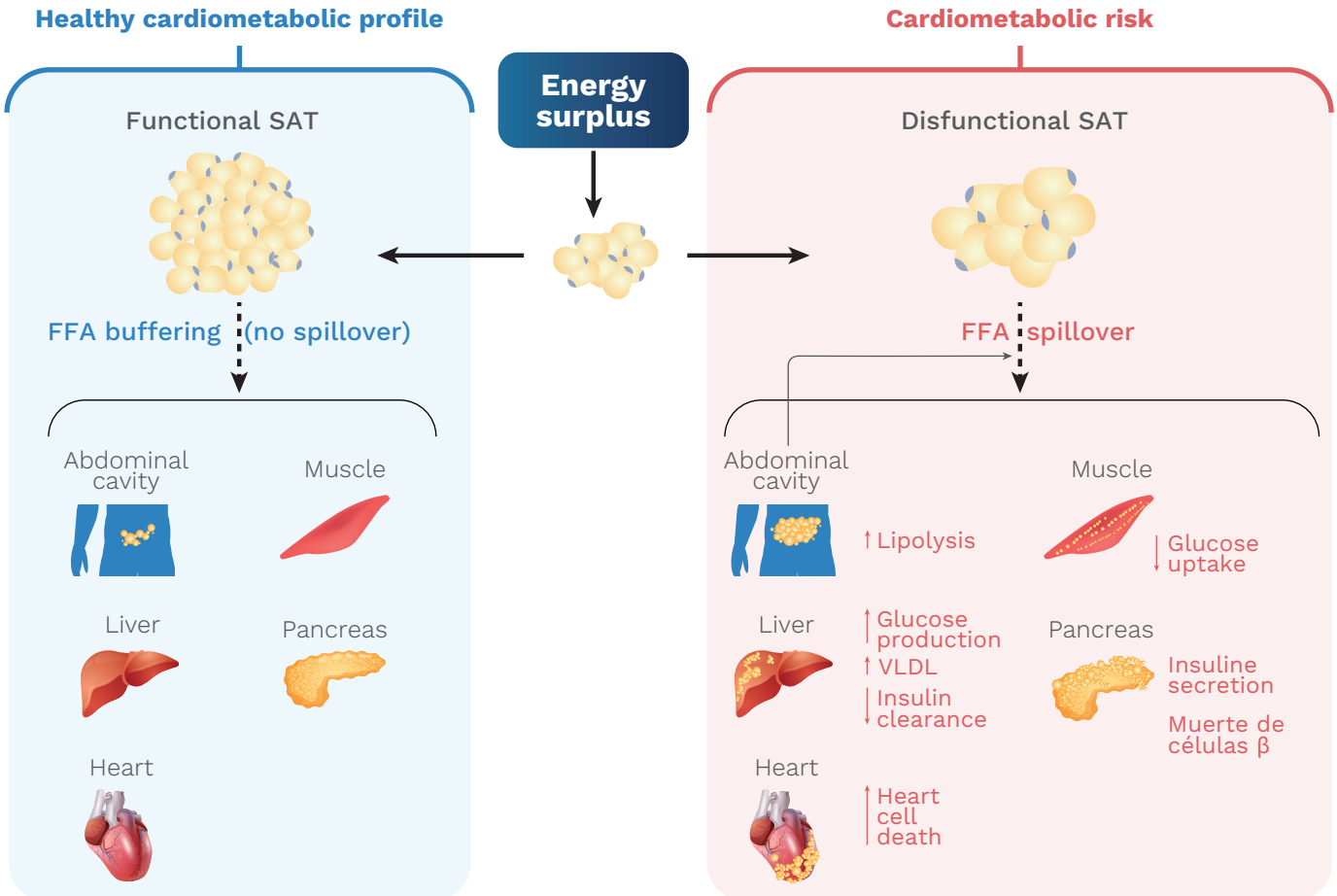

Illustration 1. Increased cardiometabolic risk derived from adipose tissue: Healthy adipose tissue expands allowing the correct storage of excess energy, but under limiting conditions there is a spillage of excess fatty acids and ectopic fat deposition. Modified from Ross, 2020.

Association with cardiometabolic diseases

Waist circumference is one of the main drivers of alterations in cardiometabolic risk factors, and its use in risk predictor algorithms is an area of interest, but it is even more clinically relevant to highlight that this marker operates as a modulator of risk on morbidity and mortality, considering that there are several examples in which a risk marker improves risk prediction, but its clinical modification does not impact on a risk reduction (for example, HDL cholesterol).

Evidence obtained from various randomized controlled clinical trials has consistently revealed that, regardless of sex and age, a reduction in waist circumference induced by lifestyle changes is associated with an improvement in cardiometabolic risk factors with or without correspondence to weight loss (Church 2007, O'Donovan 2005, Ross 2000, Ross 2015, Ross 2004, Short 2003). These observations remain constant regardless of whether the reduction is induced by caloric restriction or by an increase in energy expenditure through exercise, highlighting the critical role of waist circumference measurement in reducing morbidity and mortality.

Thus, it has also been observed that waist circumference is a better predictor of diabetes than BMI, but not a better predictor of hypertension (both waist circumference and BMI being good predictors). This may be explained by the fact that certain visceral adipose tissue deposits directly induce hepatic insulin resistance via lipolysis (Zhao 2020).

Through these observations, the recommendation of using the combination of BMI and waist circumference to identify high-risk phenotypes is highlighted once again, considering that waist circumference is a risk factor highly correlated with cardiovascular risk.

Table 1: Waist circumference thresholds stratified by BMI. (110)

BMI Category(kg/m2)	*Waist circumference (cm)*	
	Women	**Men**
Normal weight (18.5 – 24.9)	**≥80**	**≥90**
Overweight (25-29.9)	**≥90**	**≥100**
Obese I (30-24.9)	**≥105**	**≥110**
Obese II (≥35)	**≥115**	**≥125**

Waist circumference in practice

Currently there are two main protocols used to measure waist circumference, the one recommended by the NIH (National Institute of Health of the United States), in which the measurement is taken at the height of the iliac crest (hip bone), and the one by the WHO, in which the measurement is taken at the height of the midpoint between the last rib and the iliac crest.

Both measurements yield very similar results among men, but there are greater differences among women. Both forms of measurement are considered valid as they adequately correlate with all-cause mortality, mortality from cardiovascular disease, incidence of cardiovascular disease, and diabetes mellitus. The main recommendation is that, regardless of the protocol used, the same protocol should be utilized consistently to keep patient records (Ross 2008, Wang 2003). A final point to consider is that measurements made by the patients themselves can be obtained relatively easily and can generally be as accurate as measurements made by a trained technician (Wolf 2008).

Table 1: Waist circumference thresholds stratified by IMC. (Ardern 2004)

Considerations for measuring waist circumference

- Measure at a level parallel to the floor
- Midpoint between the top of the iliac crest ans the lower margin of the palpable rib in the axillary line.

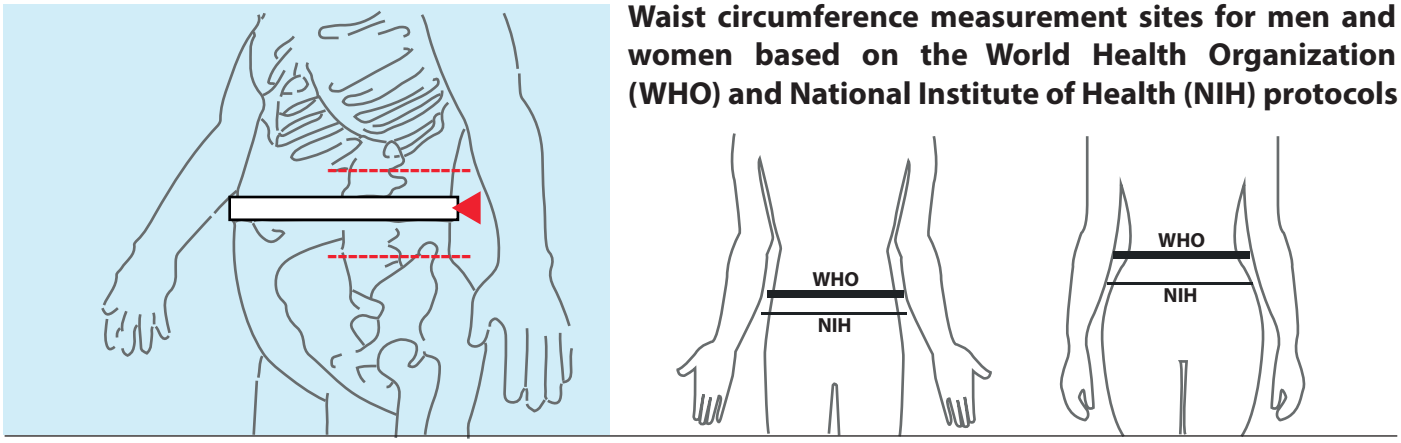

Illustration 2: How to measure waist circumference by the WHO method (Ardern 2004).

Additional considerations

Different subgroup analyses have shown that a high waist circumference is a better predictor for the development of diabetes in women than in men, and for people over 60 years of age than for other age groups. This difference between genders and ages can be explained by the changes induced by menopause in older women, who are more likely to gain weight during the transition to menopause, showing a special tendency towards abdominal weight gain independent of body weight gain. (Lovejoy 2003, Van Pelt 2001, Ho 2010). Peri- and post-menopausal women may also experience unfavorable metabolic changes, including increased abdominal visceral adipose tissue, which is a better predictor of cardiometabolic risk compared to superficial adipose tissue (Liu 2010, van der Leeuw 2013).

Other observations have shown that both BMI and waist circumference can predict the development of hypertension, but in the Hispanic/Latino race only the waist circumference (> 102/88 cm) correctly predicts the development of hypertension, and not so the BMI (Rahman 2009). This may be explained by the fact that Hispanics/Latinos have a relatively shorter height for the same weight, making it difficult to differentiate individuals at risk using only BMI (National Center for Health Statistics 2012, Lara-Esqueda 2004) . Finally, it is important to note that age is the factor that correlates the most with the development of hypertension, so the predictive power of BMI or waist circumference should not be emphasized over the effect of age (Seo 2017).

Interventions and supplements

Evidence derived from randomized controlled studies indicates that a substantial reduction in waist circumference is possible through physical exercise or caloric restriction, and that this effect is independent of age, gender, or race. Interestingly, the notion that higher energy expenditure correlates with greater waist circumference reductions is not supported by current evidence (Church 2007, Ross 2015, Keating 2015, Slentz 2004, Slentz 2005), although anaerobic training has been reported to have greater effect than medium-to-high intensity aerobic exercise (Mekary, 2015).

The magnitude of the effect will depend on the type of intervention, the most beneficial effect achieved when diet and exercise are combined. Results of the meta-analysis of 15 randomized studies with 556 participants show a reduction in BMI of 2 kg / m2 and 3 cm of waist circumference for the joint intervention, which is considered a clinically significant reduction. This study yielded inconclusive effects in relation to dyslipidemia markers (Stoner 2016).

Several dietary supplements have shown significant effects in reducing waist circumference, among which the following stand out:

- Alpha-lipoic acid: the effect of ALA supplementation did not mean translate to a significant difference in the reduction of waist circumference in a meta-analysis of 12 clinical studies, although a reduction in BMI was observed (-0.38 kg / m2). The authors point out that its supplementation appears not to be cost-efficient (Namazi 2017).

- Beta-glucan: beta-glucan is a soluble fiber that has been evaluated in numerous randomized studies for its effect on anthropometric measurements. In a meta-analysis of 20 studies, a reduction of 0.6 kg / m2 was observed but there was no significant effect on waist circumference (Rahmani 2019).

- Chlorogenic acid: also known as green coffee extract. Its effect as a facilitator of weight loss has been considered for more than a decade. A meta-analysis of 16 randomized studies revealed that its supplementation reduces BMI by 0.4 kg / m2 without significant changes in body weight or waist circumference (average reduction of 0.8 cm), although greater reductions were observed in the BMI group greater than 25 kg / m2 (Gorji 2019).

- Cinnamon: From a total of twelve studies supplementing an average of 2 g of cinnamon for more than 12 weeks, a reduction in BMI of 0.51 kg / m2 and a waist circumference reduction of 2.4 cm was obtained (Mousavi 2019).

- Conjugated linoleic acid: also known as CLA, it is a mixture of fatty acids (c9, t11 and t11, c12). The authors of a systematic review that considered a universe of 3,095 clinical studies in reference, to then consider only 32 eligible randomized studies, point out that no differences are observed in waist circumference from CLA supplementation (Rahbar 2017).

- Curcumin: The results of curcumin supplementation in patients with metabolic syndrome have not been without exempt of debate. A meta-analysis considered seven randomized studies to conclude that curcumin is not associated with a significant change in waist circumference, but does show improvements in triglycerides and HDL cholesterol, although some studies report gastrointestinal upset (Azhadari 2019).

- Linseed: the effect of linseed supplementation on anthropometric parameters was studied in a meta-analysis that considered 450 randomized studies, finding a reduction in BMI of 0.3 kg / m2 and are found in interventions with doses greater than 30 g per day, interventions of more than 12 weeks, and in patients with BMI greater than 27 kg / m2 (Mohammadi-Sartang 2017).

- Omega 3: in a meta-analysis of seven randomized studies, a reduction in waist circumference of 0.5% was observed, and a slight reduction in BMI of 0.19 kg / m2, there were no significant changes

observed in plasma cholesterol levels (Zhang 2917).

- Phytosterols - Nano-dispersed: specially formulated phytosterols in the form of nano-dispersed phytosterols (CARDIOSMILE) have shown additional beneficial effects compared to traditional phytosterols, for which it is necessary to separate both formulations, as has been demonstrated in their ability to reduce triglycerides. In a clinical study carried out on 200 patients with metabolic syndrome (average waist circumference of 100 cm), a reduction in waist circumference of 4% (4 cm in general, 5 cm in women) was obtained during the intervention period. The trend for BMI reduction in this study was -0.6 kg / m2 (p = 0.15), with an average BMI at baseline of 30.9 kg / m2 (Palmeiro 2020).

  Phytosterols - Traditional: in a meta-analysis where five studies were considered, no reduction in waist circumference was observed, although a slight reduction in BMI (-0.063 kg / m2) was observed (in 39 studies); the effect being greater in patients with a BMI greater than 25 and hyperlipidemic patients (Ghaedi).

- Resveratrol: A meta-analysis of 28 clinical studies found that dietary supplementation with resveratrol reduced MC BMI by 0.17 kg / m2 and waist circumference by 0.8 cm on average. Subgroup analysis showed significant reductions in BMI and body weight in studies using less than 500 mg resveratrol per day, in interventions lasting longer than 3 months on obese people (Mousavi 2018).

- Soluble fiber: the protective effects of soluble fiber in controlled studies on obesity have been mixed. A meta-analysis showed a reduction of 0.84 kg / m2 in BMI and a reduction of 2 cm in waist circumference, whereas previous meta-analyses had not found significant differences in anthropometric measures (Thompson 2017).

- Spirulina: A meta-analysis considered 5 studies showing that Spirulina supplementation reduced waist circumference by 1.4% but did not change the BMI (Moradi 2019).

- Synbiotics (probiotics and prebiotics): the results with the use of synbiotics have been inconsistent. In a meta-analysis in which 23 randomized studies were analyzed, it was concluded that supplementation with synbiotics reduced the waist circumference by 2 cm, without affecting the BMI (-0.12 kg / m2) (Hadi 2020).

Below there's a summary of the results mentioned above:

Table 2: Main lifestyle interventions for the modification of BMI and waist circumference

Intervention	*BMI (kg/m2)*	*Waist circumference**
Exercise and diet	**-2**	**-3 cm**
Alpha-lipoic acid	**-0,38**	**NS**
Chlorogenic acid	**-0,4**	**-0,8 cm**
Conjugated linoleic acid (CLA)	**ND**	**NDif**
Beta-glucan	**-0,6**	**NS**
Cinnamon	**-0,51**	**-2,4 cm**
Curcumin	**-0,48**	**NDif**
Linseed	**-0,84**	**-2 cm**
Omega 3	**-0.19**	**-0.5 %**
Phytosterols - Nano-dispersed	**-0.6**	**-4 cm**
Phytosterols - Traditional	**-0.06**	**NDif**
Resveratrol	**-0,17**	**-0,8 %**
Soluble fiber	**-0.84**	**-2 cm**
Spirulina	**NDif**	**-1,4 %**
Synbiotics	**-0.12**	**-2 cm**

* The baseline of intervened patients fluctuates around 100 cm, for which different authors indicate results in cm and %.
NS: not significant
ND: not determined
NDif: no differences observed

Conclusion

Waist circumference, when complementing the measurement of BMI, is an excellent tool for both risk prediction and management of clinical interventions; notably, when reductions close to 5 cm are obtained there is a significant reduction indeath and morbidity risks. Among the interventions mentioned, the joint intervention of exercise and diet and supplementation with nano-dispersed phytosterols (CARDIOSMILE) stand out.

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