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Review

Systematic organization of skinfold calipers: an approach based on physical-mechanical properties and characteristics

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Abstract

Skinfold calipers are used internationally in research, clinical, and field settings to assess body composition and nutritional status. Notably, currently available instruments differ in important specificities that impact measurement. In this sense, this report proposes a methodological approach that organizes skinfold calipers into three categories (*Original*, *Generic*, and *Hybrid*) and three configurations (*Type A*, *Type B*, and *Type C*) based on physical-mechanical properties and characteristics. Therefore, this concept provides technical support for choosing the most appropriate skinfold caliper in different contexts.

Keywords: Anthropometry; Body composition; Nutritional Assessment; Skinfold thickness; Skinfold caliper

Abbreviations

ARG Argentina

BRA Brazil

ITA Italy

PRT Portugal

UK United Kingdom

USA United States

GHBCI Global Institute for Health and Body Composition

ISAK International Society for the Advancement of Kinanthropometry

NIST National Institute of Standards and Technology

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Introduction

Skinfolds represent an anthropometric-specific property used to describe body composition according to the 5th level of organization: the Whole-Body level[1]. They are derived from measurements taken on the individual's body surface, which determine the thickness of a double layer consisting of skin and subcutaneous adipose tissue at defined anatomical sites [2]. These measurements can then be used in a qualitative approach to assess body composition and monitored longitudinally as indicators of variations in body fat, as they are strongly associated with parameters related to health and athletic performance[3]. Alternatively, they can be used in mathematical models to quantify components belonging to other levels of organization of body composition, such as the molecular (2th) or tissue system (4th) level, thus estimating fat mass or adipose tissue mass, respectively[4,5].

Although alternative methods, such as ultrasound, have been explored to assess skinfold thickness, it remains a strictly anthropometric measure that can only be obtained with calipers. These instruments compress the skinfolds with a standardized mechanical pressure, equivalent to that applied when pinching with the thumb and index finger[6]. Calipers serve as a support for the operator's hand, since although they can form the skinfold, they cannot quantify it[7]. Over the years, numerous skinfold calipers have been developed and employed in the literature, yet no study has systematically organized them based on their defining features.

In contrast, other methods for assessing body composition classify their instruments into specific categories. For example, in bioelectrical impedance analysis, devices are grouped either by technology (hand-to-hand, leg-to-leg, foot-to-hand, and direct segmental) or by frequency (single-frequency and multifrequency)[8]. Establishing similar classifications for skinfold calipers is important, particularly in light of advances in both conventional and digital anthropometry, and the ongoing evolution of caliper designs. Identifying key physical and mechanical features enables the evaluation of potential similarities and differences among instruments. Therefore, this report aims to systematically organize skinfold calipers into categories and configurations based on their physical–mechanical properties and characteristics.

Development

The skinfold caliper is a specialized anthropometric instrument used to measure skinfold thickness. Notably, more than 20 calipers have been proposed over a 100-year journey of advancements in skinfold assessment and human body composition (Figure 1)[9-11]. These instruments were developed by manufacturers in Asia, Europe, Latin America, and North America. Early models were structurally rudimentary and were discontinued in the 1950s, after James Mourilyan Tanner (1920-2010) introduced a prototype caliper optimized with *helical extension spring* kinematics in 1953, which has since been considered the defining mechanical feature of a skinfold caliper[9]. Conversely, calipers that do not incorporate this principle are limited to a conventional precision instrument for measuring rigid, opposing surfaces. Therefore, the classic study by Edwards et al.[12], published in the *British Journal of Nutrition* in 1955, represents a milestone in the theoretical foundation of skinfold calipers.

Skinfold calipers: systematic organization by category and configuration

For decades, skinfold calipers have been classified according to their application settings: *clinical* or *scientific*. However, this approach, which originated in Brazil, is unfounded, influenced by commercial interests, and, most importantly, disregards critical physical-mechanical properties and characteristics[9]. In this report, we propose the first systematic organization of skinfold calipers based on these attributes. Thus, in our methodological framework, *properties* refer to the structural components present in all skinfold calipers, such as the jaws, springs, and dial, whereas *characteristics* describe measurable aspects associated with these properties, such as jaw surface area, spring force, and dial type and resolution. Consequently, skinfold calipers can now be organized into three categories: *Original*, *Generic*, and *Hybrid*. These categories will be detailed in the following sections.

Original skinfold calipers: the reference instruments

The original skinfold calipers exhibit a specific physical-mechanical configuration based on a set of well-defined structural properties and functional characteristics, which constitute a reference standard. These key parameters include the lever class, jaw surface area, spring attachment point and angle, downscale force and pressure, and dial type and/or resolution, among others. In 2023, the *Harpenden*™ (Baty International, UK), *Lange*™ (Beta Technology, USA), and *Slim Guide*® (Creative Health Products, USA) skinfold calipers were designated as reference models, establishing the three configurations: *Type A*, *Type B*, and *Type C*, respectively[9]. These are presented below:

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Original *Type A* skinfold caliper (Figure 2): Designed with a third-class lever, the physical structure and mechanical components are metal. The jaws are rectangular with a surface area of 90 mm² (6 × 15 mm). Two extension springs are installed parallel and obliquely on the sides of the rods and in front of the pivot pin. The dial is an analog indicator with a resolution of 0.2 mm and a range of 0 to 80 mm. The mean static downscale force and pressure are 743 ± 12.9 g and 8.25 ± 0.3 g/mm², respectively, at 10 to 50 mm intervals[9,11].

Original *Type B* skinfold caliper (Figure 3): Designed with a first-class lever, the physical structure and mechanical components are metal. The jaws are rectangular with a surface area of 30 mm² (5 mm × 6 mm). A single extension spring is installed transversely to the handle and a rod that connects to the trigger-driven gears. The dial is a semicircular analog scale with 1.0 mm resolution and a range of 0 to 60 mm. The mean static downscale force and pressure are 250 ± 6.3 g and 8.37 ± 0.2 g/mm², respectively, at 10 to 50 mm intervals[9,11].

Original *Type C* skinfold caliper (Figure 4): Designed with a third-class lever, the physical structure is plastic and the mechanical components are metal. The jaws are rectangular with a surface area of 91 mm² (7 mm × 13 mm). Two extension springs are installed parallel and vertically on the sides of the rods and in front of the pivot pin. The dial is an analog linear scale with 1.0 mm resolution and a range of 0 to 80 mm. The mean static downscale force and pressure are 683 ± 23.7 g and 7.51 ± 0.3 g/mm², respectively, at 10 to 50 mm intervals[9,11]. Additional information about the original skinfold calipers is presented in Table 1.

Since the 1970s, the physical-mechanical configurations of the Harpenden® and Lange™ skinfold calipers, proposed by Edwards et al.[12] in 1955 and Lange & Brozek[13] in 1961, respectively, have been widely adopted internationally as the main reference standards for the development of new skinfold calipers[9]. Consequently, the generic and hybrid categories, corresponding to equivalent and combined variants of these instruments, constitute an expansion of the *original category*, as presented and described below:

Generic skinfold calipers: the equivalent instruments

The generic skinfold calipers have a typical physical-mechanical configuration based on an original skinfold caliper, such as Holway® (Holway Anthropometric Equipment, ARG), Lafayette® (01127A, Lafayette Instrument Company, USA) and Cescorf® (Innovare-4™, Cescorf Equipment, BRA), which can now be classified as *Type A*, *Type B*, and *Type C* generic skinfold calipers, respectively. The term *generic* does not imply inferior quality, but rather calipers that have properties and characteristics identical or equivalent to their original counterparts. However, potential differences in performance or compliance were not explored in this scientific report, as they are beyond its scope, which is limited to the organization of skinfold calipers. Furthermore, for commercial regulatory contexts, this analysis should be systematically evaluated by federal agencies specializing in metrology, such as the U.S. *National Institute of Standards and Technology (NIST)*, among others.

Some generic skinfold calipers within the same configuration, such as Holtain® (Holtain, UK), although mechanically similar, may present structural inconsistencies compared to the original skinfold calipers. Thus, researchers have suggested that these differences are primarily due to physical factors, such as the spring attachment point and angle and the jaw surface area, as well as aspects related to the quality, condition, and integrity of the pivot components (e.g., *screw*, *washer* or *gear*) and the calibration procedures employed by the manufacturers[9,11]. Comparative studies indicate that, in some generic calipers, such structural deviations do not appear to significantly compromise functional performance. Lohman et al.[14] demonstrated high inter-operator agreement using skinfold calipers with the same physical-mechanical configuration. Schmidt & Carter[11] and Esparza-Ros et al.[15] reported that some original and generic skinfold calipers provided statistically equivalent skinfold measurements. However, skinfold calipers cannot be used interchangeably to measure skinfold thickness and subsequently assess body adiposity[9,11,14,15].

The generic skinfold calipers manufactured by Cescorf® have received international recognition[16]. Significant improvements in mechanical performance, especially in the *Type A* models, were groundbreaking. The pivot components are now made of polyacetal to reduce the coefficient of friction, thus allowing more elastic energy to be available in the two springs during the downscale actions[9]. In addition, because the two metal rods are connected in parallel by the pivot and are not convergent, the upper fixed rod now has a slight sinuosity that, according to the manufacturer, allows the jaws to align harmoniously. Another *Type A* model also feature movable jaws that better adapt to the skinfold, while some have been optimized with a linear scale, replacing the analog dial indicator. In this context, based on the 1979 study by Jones et al.[17], an improved generic *Type A* skinfold caliper with a digital dial indicator was introduced by Cescorf® in 1985, pioneering this development in Latin America. However, due to import restrictions on this component, production was later discontinued and only resumed in 2016. The ease of reading the measurement represents a notable strength of the device. Despite this, the reliability and cost-effectiveness of this caliper are questionable, given the dial indicator's susceptibility to impacts and the frequent need for calibration. Although this procedure can be performed by the operator using the *Gauge-Block* provided in the case, in most situations it still requires manufacturer intervention, resulting in additional shipping costs[9]. In 2025, an updated version of this skinfold caliper was introduced, incorporating an improved digital dial indicator, which, according to the manufacturer, offers greater metrological stability. Finally, the generic *Type C* skinfold caliper from the same manufacturer has been progressively optimized in four versions over the past 15 years. Notably, its structural dimensions have been ergonomically compacted, and the spring attachment angle and jaws area have been reduced. Therefore, static and dynamic calibration studies, predominantly based on load cells, among other reference metrological methods, should be conducted on all these generic skinfold calipers to assess the effectiveness and practical implications of the aforementioned improvements in skinfold thickness measurement.

Hybrid skinfold calipers: the combined instruments

The hybrid skinfold calipers have an atypical physical-mechanical configuration based on two original skinfold calipers. The Lipowise® (Wisify Tech, PRT) represents the first generation of skinfold calipers developed by integrating the key physical and mechanical characteristics of the *Type A* and *Type B* configurations, such as the jaws surface area and force transmission system, respectively[9]. Notably, the crucial difference lies in how the spring force is kinematically transmitted and applied: Lipowise® converts the spring force into torque through a lever shaft on the same rod, while Lange® applies the force directly and symmetrically through a 1:1 gear system that connects the rods. Therefore, given its hybrid nature, no typical configuration (Type A, Type B, or Type C) can be attributed to instruments in this category. Furthermore, Lipowise® caliper incorporates technological innovations, including digital measurement automation linked to a smartphone app via *Bluetooth*[9]. Finally, similar improvements are being introduced in other anthropometric instruments, such as ultrasonic stadiometers. Recently, Brazilian researchers validated a portable device developed in South Korea to measure standing stature in adults[18].

Absolute differences between the original and hybrid skinfold calipers have recently been documented[15,19]. Esparza-Ros et al.[15] demonstrated that the Lipowise® caliper provided skinfold measurements at eight sites that were statistically equivalent to those obtained with the Harpenden® caliper. Similarly, Leão et al.[19] reported no significant differences between these instruments. However, no studies have directly compared the Lipowise® and Lange™ calipers. Furthermore, although the Lipowise® incorporates features of both *Type A* and *Type B* configurations, the available evidence is limited to comparisons with the Harpenden®; so, it is not yet possible to precisely determine which configuration most closely matches its functional performance. Future studies should address this issue.

The organizational structure of skinfold calipers into categories and configurations provides a comprehensive approach that consolidates the instruments into a single, coherent classification. Figure 5 schematically illustrates this paradigm based on the critical physical-mechanical characteristics of the original models, including lever class, jaw surface area, spring force, and static downscale pressure. Notably, although the generic skinfold calipers presented in Figure 5 were selected by the author for convenience, their inclusion was determined by objective attributes rather than historical or commercial considerations.

Skinfold calipers: instrumental description and incremental evidence

The most commonly used skinfold calipers in research, clinical, and field settings were described and systematically organized into categories and configurations based on their physical and mechanical properties and characteristics (Table 1). Instruments recognized by international groups specializing in anthropometry and body composition, such as the *International Society for the Advancement of Kinanthropometry* (*ISAK*) and the *Global Institute for Health and Body Composition* (*GHBCI*), respectively, were included, as well as those used in studies that characterized population anthropometric profiles or proposed predictive regression equations based on skinfold thickness. Furthermore, criteria such as commercialization and adoption in various geographic and socioeconomic contexts were also considered, with priority given to skinfold calipers with the largest market share in developing and developed countries, such as Brazil and the United States, respectively. Finally, an observational and comparative analysis was also conducted using the original skinfold calipers as a reference to categorize the remaining calipers as generic or hybrid.

Sixteen skinfold calipers were described in Table 1: three original, twelve generic and one hybrid. Brazil and the United States lead industrial production. Some manufacturers have introduced multiple generic models within the same configuration. This variety is notable in Brazilian product lines such as Avanutri®, Cescorf®, Prime Med® and Sanny®. However, these additional instruments were not included in this report. Most skinfold calipers are metallic, relatively lightweight, and feature a semicircular or linear scale dial with a 1.0 mm

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resolution (Table 1). Furthermore, most commercially available generic skinfold calipers are predominantly based on the *Type A* configuration. Finally, driven primarily by international accreditation courses in anthropometry from ISAK, which currently have members in 85 countries, both original and generic *Type C* skinfold calipers are frequently used in clinical settings[9].

The jaw surface area and spring force were reported as the main physical and mechanical characteristics for selecting a skinfold caliper, since the upscale pressure of 10 g/mm^2 and the downscale pressure of 8 g/mm^2 may be confounding factors, as they are obtained with different combinations of *force* (g) and *area* (mm^2)[9]. However, no manufacturer publicly discloses these technical specifications. We contacted customer service for more details. Those who responded to our inquiries cited unavailability or confidentiality as reasons for not disclosing the information. Consequently, only 31% of the instruments were fully described (Table 1). Indeed, although these variables could have been determined through our own analyses, we emphasize that this gap highlights a substantial deficiency in the availability of technical information provided by manufacturers. Furthermore, calibration studies are scarce in the specialized literature and are limited to a few skinfold calipers[11].

Notably, over the last century, the skinfold measurement technique has been extensively explored and has well-defined standards[2,7]. Therefore, the construction, calibration, and maintenance of skinfold calipers must be standardized and regulated internationally based on the category and physical-mechanical configuration. To this end, the technical manual for commercially available calipers must also be updated. Manufacturers must determine and provide the following: category (Original, Generic or Hybrid); configuration (Type A, Type B or Type C); material (metal or plastic); lever class (first, second or third); jaw surface area (mm^2); static downscale force (g) and pressure (g/mm^2); dial type (scale or indicator); resolution and measurement range (mm); and weight without case (g). Some field calibration procedures have been proposed. The *Gauge-Block Test* and *Scale Test* are recommended to assess the accuracy (mm) and pressure (g/mm^2) of skinfold calipers, respectively[9]. Despite this, repairing or replacing critical components, such as the jaws, spring, pivot, and dial, remains challenging, particularly in clinical and field settings, as it requires technical expertise and specialized instruments. Consequently, manufacturers should be encouraged to provide ongoing, affordable maintenance services, preferably free of charge, to ensure the functionality, reliability, and longevity of skinfold calipers[9].

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Researchers have described important systemic differences among skinfold calipers[11,14,15,20,21]. Cintra, Ripka & Heymsfield[9] indicated in a scientific report that any original, generic or hybrid skinfold caliper, under favorable calibration conditions, can be used to assess body adiposity based on the comparison of skinfold thicknesses over time. However, based on mathematical prediction models and normative reference scales, the same skinfold caliper employed in the original studies should be used. Thus, the regression equations proposed by Durnin & Womersley[22] and Jackson & Pollock[23] to estimate body density and convert it into body fat percentage are important examples. They should be used based on skinfold thicknesses measured with original *Type A* and *Type B* skinfold calipers, respectively, or, when this is not possible, with their generic equivalents. A contrary approach results in significantly overestimated or underestimated relative and absolute values[20,21], since the Harpenden® caliper applies approximately three times more static downscale force than the Lange™ caliper (743 g vs. 250 g, respectively) to the subcutaneous tissue, while the Slim Guide® caliper applies 683g, comparable to the force exerted by the Harpenden® caliper[9,11]. This has a direct impact on skinfold thickness measurement[9,11,15]. Correction factors have been proposed as suitable alternatives to original and generic skinfold calipers[21,24]. When this is neglected by anthropometrists and researchers, the systematic bias produced by the *caliper-equation* conflict can affect resting energy expenditure estimated from fat-free mass derived from fat mass determined by skinfold thickness[25,26]. Indeed, this represents a relevant practical implication that future studies should directly address. Furthermore, inaccurate anthropometric measurements can also compromise the accuracy of body composition estimates. Machado et al.[27] observed significant variations between skinfold thicknesses at eight selected sites, obtained by anthropometrists with different levels of experience, resulting in substantial errors in the estimation and classification of total body adiposity. Therefore, standardized protocols, calibrated instruments, and continued specialization are critical factors in improving the skinfold technique and, consequently, data interpretation and health recommendations[2,7,27].

Although the proposed organizational framework for skinfold calipers represents a significant conceptual advance, some limitations should be acknowledged. In particular, its practical application across different scenarios and contexts still depends on close cooperation between manufacturers, metrological institutions, and scientific societies to establish technical standards based on critical physical–mechanical specificities. This article therefore urges manufacturers to clearly report the discussed characteristics of calipers, ensuring their proper classification and enabling the evaluation of their validity in anthropometric measurement. Likewise, researchers are encouraged to provide and disclose this information whenever appropriate. Finally, comparative studies between different instruments, conducted under standardized calibration conditions and involving diverse population samples, are essential to support their integration into international guidelines.

CONCLUSION

This report proposed an innovative organization of skinfold calipers into three categories (*Original*, *Generic* and *Hybrid*) and three configurations (*Type A*, *Type B* and *Type C*), based on physical-mechanical properties and characteristics, thus providing a systematic approach to their use and technical support for choosing the most appropriate caliper in different contexts of body adiposity assessment. Given its structured, integrative nature, and its foundation in objective criteria, this proposal can therefore be referred to as *The Cintra Classification*. Finally, we also suggest that skinfold calipers be described in the literature based on their category, configuration, trade name and/or model, manufacturer and country, for example: *Original Type B skinfold caliper* (*Lange*™, *Beta Technology*®, *United States*).

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Authorship. J.C. conceived the idea and wrote the manuscript; F.C. wrote the manuscript; T.L. and S.H. critically reviewed and edited the manuscript. All authors approved the final version.

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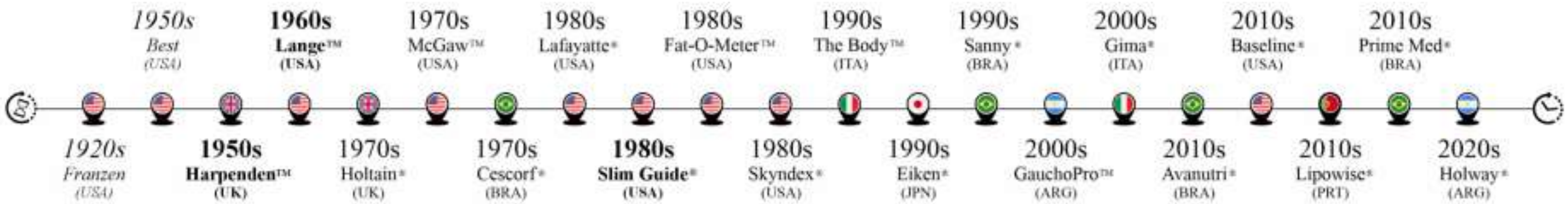

Figure 1. Calipers historically used to measure skinfold thickness (1920s–2020s).

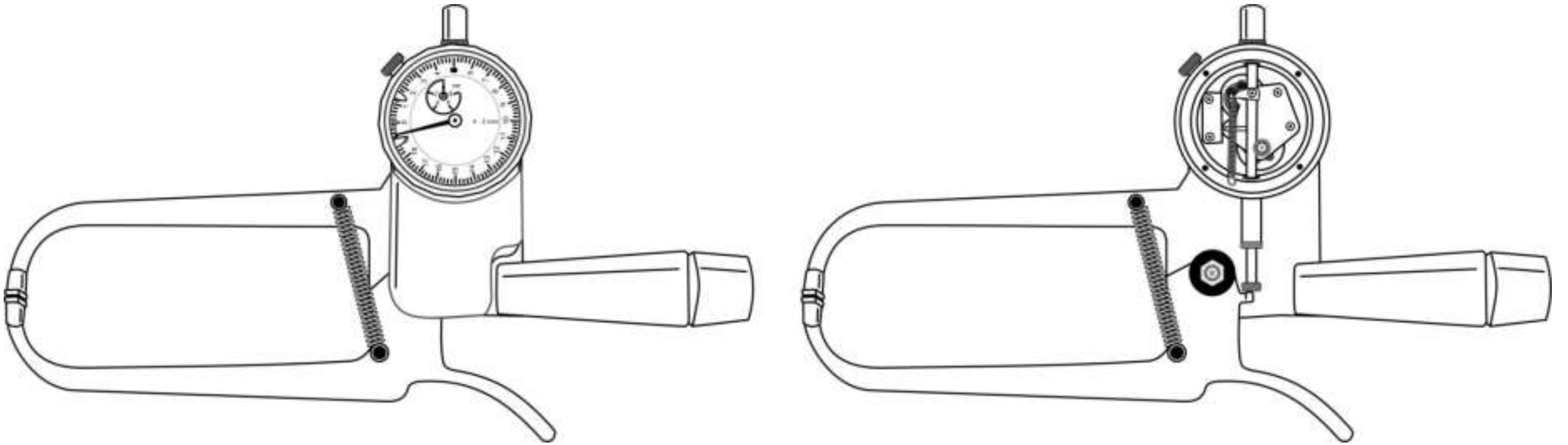

Figure 2. Original *Type A* skinfold caliper: *The Harpenden*™.

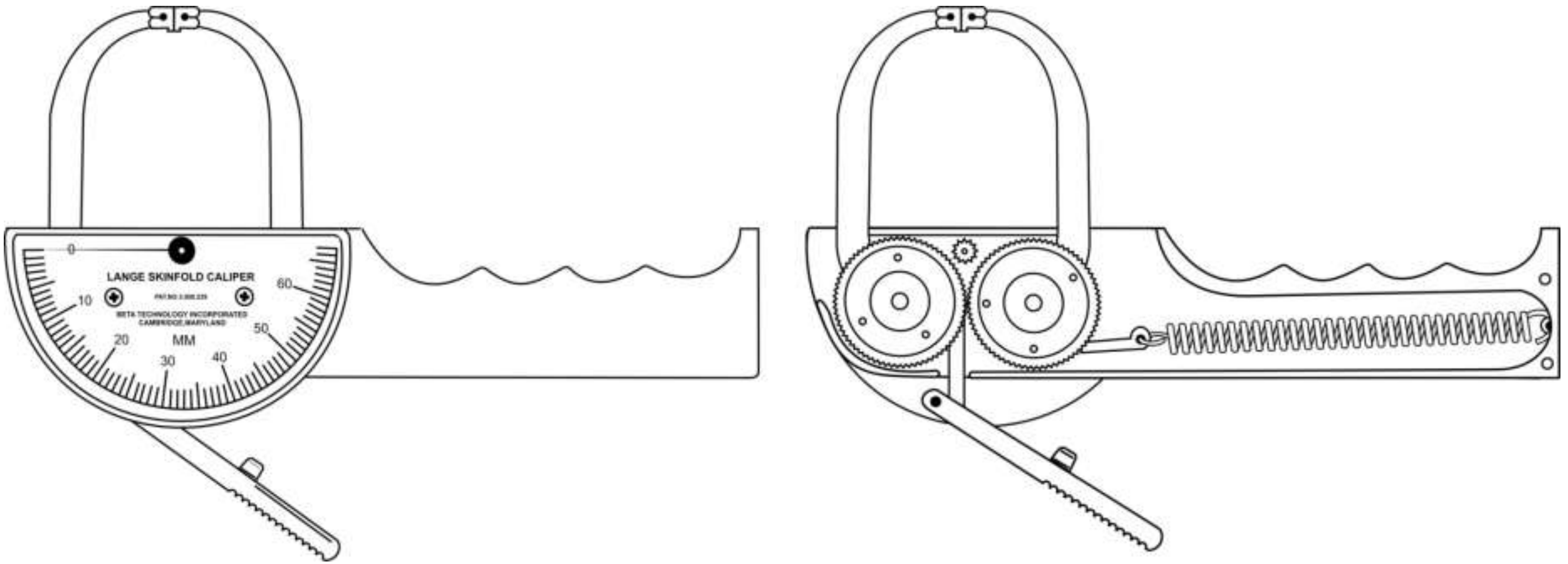

Figure 3. Original *Type B* skinfold caliper: *The Lange*™.

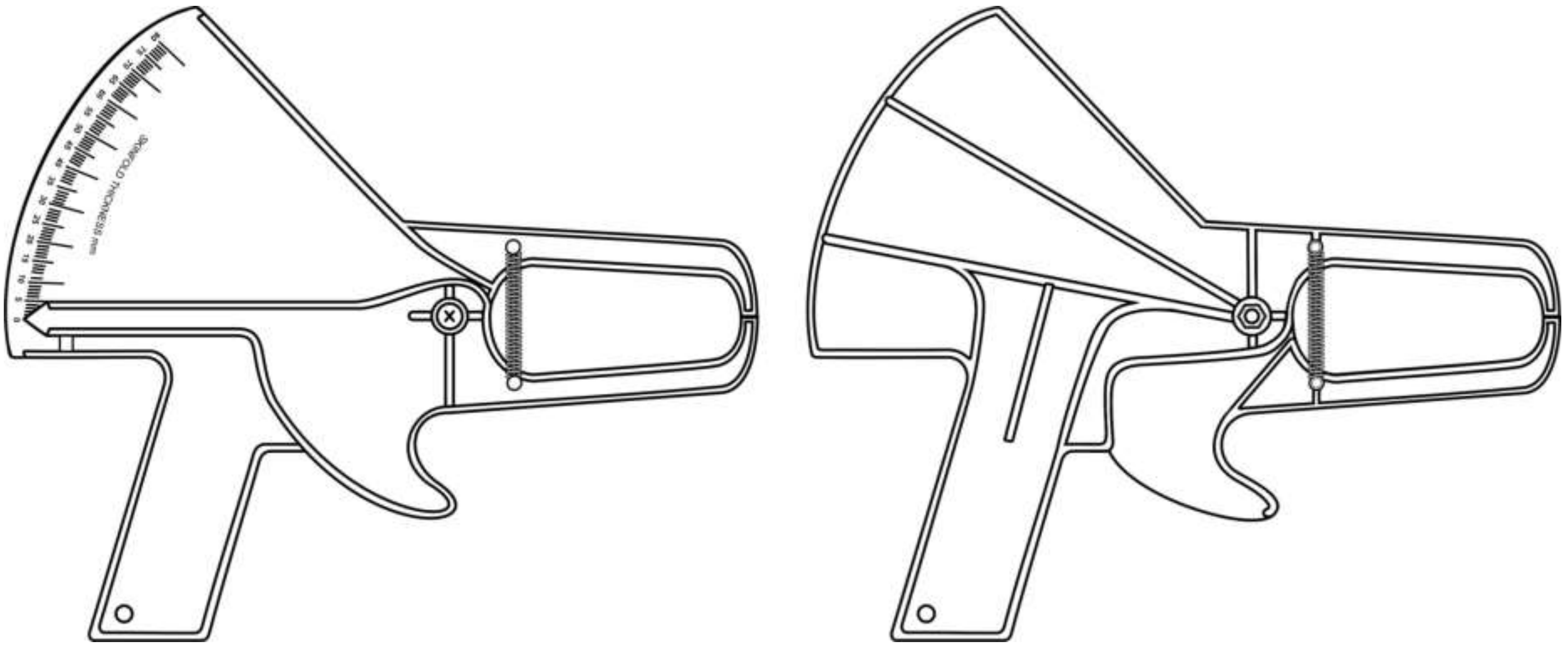

Figure 4. Original *Type C* skinfold caliper: *The Slim Guide*®.

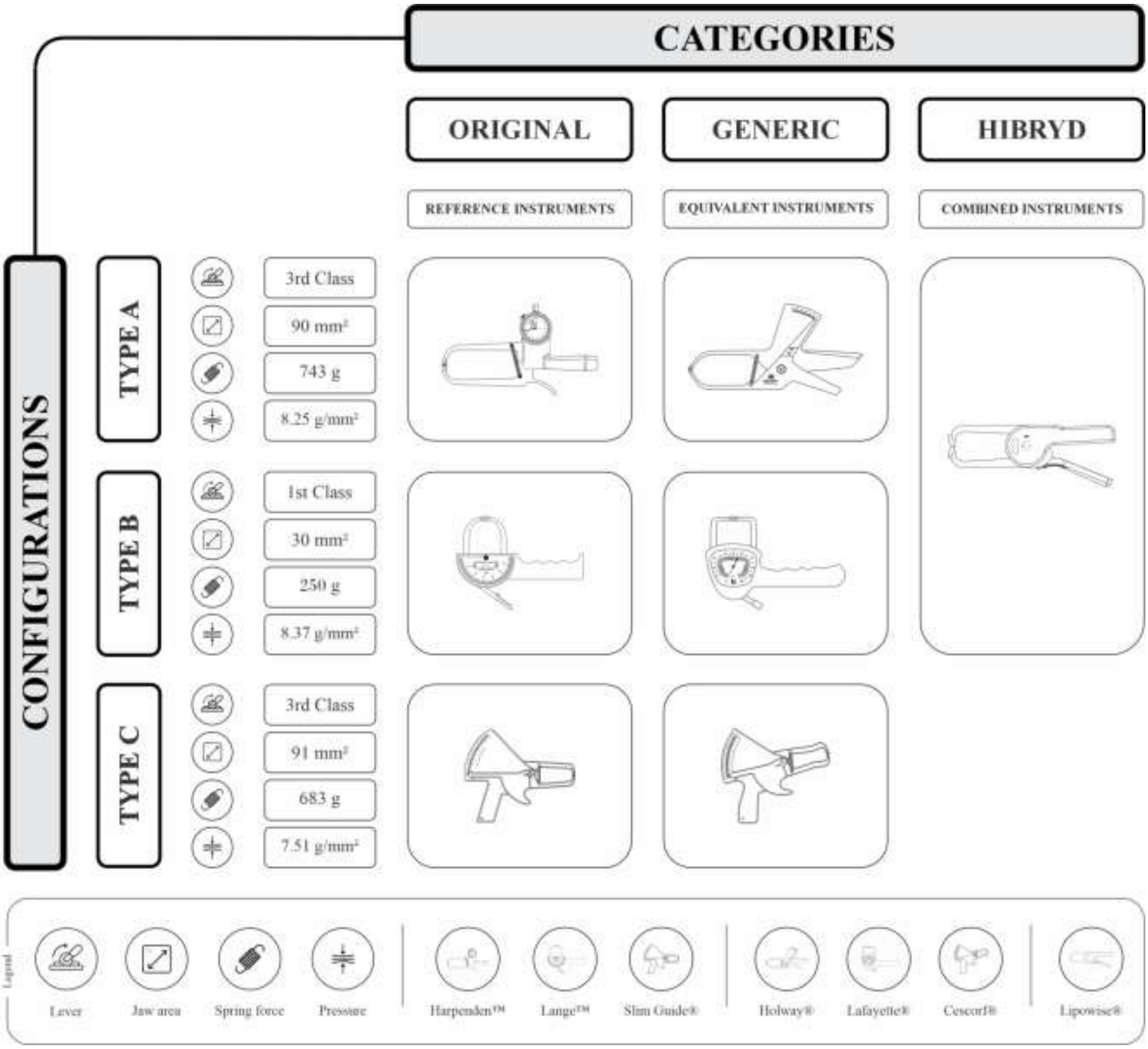

Figure 5. Organization of skinfold calipers by category and configuration.

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Table 1. Original, generic and hybrid skinfold calipers described according to the new systematic organization.

	Country	Name	Model	Material	Type	Lever	Jaws (mm²)	Pressure (g/mm²)	Force (g)	Dial	Resolution (mm)	Range (mm)	Weight (g)
Original	UK	Harpenden™	N/A	Metal	A	3rd Class	90	8.2	742	Indicator	0.2	0-80	498
	USA	Lange™	N/A	Metal	B	1st Class	30	8.4	251	Scale	1.0	0-60	200
	USA	Slim Guide®	N/A	Plastic	C	3rd Class	91	7.5	683	Scale	1.0	0-80	122
Generic	UK	Holtain®	N/A	Metal	A	N/R	N/R	10.0*	N/R	Indicator	0.2	0-46	400
	USA	Skyndex®	N/A	Plastic	A	3rd Class	102	7.3	744	Electronic	0.1	0-60	398
	BRA	Cescorf®	Clinical	Metal	A	N/R	N/R	10.0*	N/R	Scale	1.0	0-75	190
	BRA	Sanny®	AD1007	Metal	A	N/R	N/R	9.8*	N/R	Indicator	0.1	0-70	N/R
	BRA	Avanutri®	Scientific	Metal	A	N/R	N/R	10.0*	N/R	Indicator	0.1	0-83	388
	BRA	Prime Med®	A30	Metal	A	N/R	N/R	9.8*	N/R	Indicator	0.1	0-92	N/R
	ITA	Gima®	27320	Metal	A	N/R	N/R	10.0*	N/R	Indicator	0.1	0-40	N/R
	ARG	Holway®	N/A	Metal	A	N/R	N/R	10.0*	N/R	Scale	1.0	0-60	168
	USA	Lafayette®	01127A	Metal	B	1st Class	30	7.5	225	Scale	1.0	0-100	317
	USA	Baseline®	12-1110	Metal	B	N/R	N/R	N/R	N/R	Scale	1.0	0-70	N/R
	BRA	Cescorf®	Innovare	Plastic	C	N/R	N/R	10.0*	N/R	Scale	1.0	0-80	95
	BRA	Avanutri®	Clinical	Plastic	C	N/R	N/R	10.0*	N/R	Scale	1.0	0-80	80
Hybrid	PRT	Lipowise®	Pro	Metal	N/A	N/R	N/R	10.0*	N/R	Electronic	0.1	0-100	260

Note: Pressure and force: static downscale. *Static upscale pressure. N/A: not attributed. N/R: Not reported by the manufacturer or in the literature. The Lafayette® caliper was discontinued in 2004.

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