

Muscle toning term used in fitness and sports: a critical confusion

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Abstract:

The concept of 'tension in the relaxed muscle' or 'the resistance felt by the examiner during passive stretch of a joint when the muscles are at rest' (Campbell, WW; Barohn, 2019) is known as "muscle tone". In addition, this concept about tonic muscle tone in antigravity leg muscles, is responsible for the maintenance of posture and is fully determined by the monosynaptic stretch reflex. On the contrary, in the field of physical exercise and fitness, the term "muscle toning" is usually expressed referring to the obtaining of "stiffness in muscle fibers" resulting from strength training in various methodologies be misused by some coaches and health professionals in sport and exercise science. **Objective:** The purpose of this article is to redefine from the neurophysiological bases, the term 'muscle toning' in the field of fitness and physical exercise, explaining and proposing a theoretical contextualization towards health professionals. **Methods:** We conducted a systematic search of PubMed, Medline, Google Scholar, and EBSCO-host, (2000–2023) looking for muscle toning in science of exercise and sport. The selected publications included 44 articles. **Results:** No scientific studies were found in the consulted databases that define the term "muscle toning". Within the selection process, the neuromuscular and physiological adaptations are reaffirmed by the strength training program, but they differ from the term used in mention. **Conclusions:** Neuromuscular adaptations of skeletal fibers don't define "muscle toning". Finally, instead of calling the inflammatory and vasodilator effect after a strength-resistance exercise "toning", it is suggested that the term "neurostimulated muscle" be used in the contextualization and scientific evidence by sports and health professionals.

Keywords: Tension, stiffness, motor control system, skeletal fibers, strengthening.

Introduction:

Within the various physical conditioning processes there are healthy objectives which promote the improvement of strength, the cardiovascular component and quality of life (Pedersen & Saltin, 2015). Furthermore, there are ideal goals on the aesthetic aspect, making the practice of exercise in fitness centers and gyms have popularized supposed concepts by various professionals (trainers, doctors, athletes) about obtaining "greater rigidity or muscle firmness", as in the case of the muscular condition where the term "toning" is specified, which tries to refer to various responses after strength exercise, establishing a sense of "hardness" that is supposedly achieved from training with low load percentages (intensity) and a high number of repetitions.

On the other hand, when referring to neural type adaptations different from the "toning" concept, it is very important to highlight that, to a large extent, there are corticospinal factors that improve the skeletal muscle contraction process (Tøien et al., 2018) where the efferent neural impulse does achieve an increase in its level, but it does not reflect the effects on the myofibrils in a superficial way, which generates an uncertainty in the "determination of the increase in muscle tone".

Additionally, rigidity describes an increase in muscle tone leading to a resistance to passive movement throughout the range of motion. Parkinson's disease, is a typical example of muscle rigidity resulting from central nervous system (CNS) disorders leading to co-contraction of antagonist muscles (Ferreira-Sánchez et al., 2020), different to increase to nervous impulse like a strength adaptations factor since the process by which different motor units are activated to produce a given level and type of muscle contraction is by changes in firing rate (rate coding) of individual motoneurons (MNs).

Consequently, muscle inflammation post exercise is the result of eccentric contractions, generating high tensions in compressed, micro injured type II fiber nerve endings and the myofibrils "microtears" with sensations of ache or stiffen for a few days after exercise (Laaksonen et al., 2006; Sonkodi et al., 2020a) and is known as "delayed onset muscle soreness" (DOMS) (Hilbert, 2003; Zeng et al., 2022). Similarly, this would give rise to misinterpretations that the muscle would be in "toning" although in reality, would be a damage secondary

inflammatory effect, that is characterized by being a process of acute and diffuse, causing hyperexcitability during the first 24 hours reaching its peak of pain between 24 and 48 hours.

Therefore, it is suggested that the previously mentioned concept "toning" could lead to errors about the respective muscle adaptations and strength training methods (Evans, 2019; Gentil et al., 2021; Grgic et al., 2022; Grgic & Mikulic, 2022; Howe et al., 2017; Kazior et al., 2016; Kushner et al., 2015; Lasevicius et al., 2018; Maffiuletti et al., 2016; Rodriguez-Lopez et al., 2021; Romero-Arenas et al., 2013; B. Schoenfeld et al., 2021; B. Schoenfeld & Grgic, 2018; B. J. Schoenfeld et al., 2019, 2019; Seaborne et al., 2018).

However, scientific research has evolved during the last decade, allowing studies in exercise and sport to clarify physiological events, highlighting the justification of the neuromuscular process in relation to the stated term.

Finally, there is still much indecision about the definition of the concept in question and therefore the present study is proposed in order to redefine from the neurophysiological bases, the term 'muscle toning' in the field of fitness and physical exercise, explaining and proposing a theoretical contextualization towards health professionals, sports coaches, athletes and sports researchers based on scientific evidence.

Background

Despite the high quality of most of the research, the notion of "muscle toning (TM)" continues to be enunciated without having a biological or physiological foundation, by some sports trainers, personalized trainers and in general in the population of physical conditioning and fitness centers. For this reason, the conceptualization and scientific foundation are decisive to clarify the term in question, recognizing the effects that are generated from resistance training.

The term TM has been used with the aim of disseminating certain clinical and physiological properties that cause confusion and controversy, even more so when talking about "muscle tone" at rest, which refers to the minimum vital passive tension and resistance to stretching to maintain the postural stability in balanced balance positions.

In particular, when talking about muscle co-contraction, active neuromotor control is exercised that increases TM and therefore stabilization (Masi & Hannon, 2008), which can be confused with greater muscle shaping and definition. This should help standardize terminologies published by scientists from around the world. In this sense, the concept "toning" raises various concerns for the following reasons. Throughout time, in the jargon of sports trainers and among those who exercise, it is common to hear the term toning up, but when conducting a literature review, no specific articles that specify the concept can be found. Likewise, there is no programming that generates an acute or chronic response to said event on the increase in tone.

Likewise, over time there are multiple definitions about "muscle toning" from the physiological field, which support the actions in the planning and execution of the prescription of bodily exercise, which are developed in weight rooms and gyms. For this reason, neurological principles describe the concept as "a slight tension that can be detected in a resting muscle" (Shortland, 2018).

In the same way, said muscle resistance to passive distension; It is not executed voluntarily or consciously, which determines the control of an individual's posture. Otherwise, the stimulus that is generated to the passive mobilization or a change of position of a specific part of the body, is the foundation of the prevention of excessive mobility of the joints. Otherwise, muscle tone traditionally referred to as "the tension in the relaxed muscle" (Gurfinkel et al., 2006) or "the resistance generated by passive stretching (Foster M., 1892) of a joint when the muscles are in at rest (Campbell, W.W.; Barohn, 2019; Gurfinkel et al., 2006) define the fundamental part of the body axis that joins the four extremities and the head in a single functioning unit during complex motor tasks, as well as in static postures. and it is responsible for keeping the skeletal muscles firm, but it does not generate a force of sufficient magnitude to produce movement (Campbell, W.W.; Barohn, 2019; Takakusaki, 2017).

In the same way, the hierarchical model (Cano-de-la-Cuerda et al., 2015) of movement postulated that muscle tone is "an adaptive function of the neuromotor apparatus that responds appropriately to commands coming from higher levels of construction of the movement by adjusting the excitability of sensory and motor cells for tasks of postural activity or movement control. This definition makes the tone actively contribute to movement and postural tasks. Similarly, (Greene & Carpenter, 1985) have given a clinical definition of tone as "the constant muscular activity that is necessary as a background for movement and to maintain the basic attitude of the body, particularly against the force of gravity" (Profeta & Turvey, 2018).

Similarly, it is important to take into account that the basic unit of integrated nervous activity is known as the reflex arc and is made up of an afferent and an efferent pathway; where the afferent pathway has a stimulus receptor, which transfers the information to the central nervous system (CNS) through the interneurons and once the CNS produces the response, the information travels through the interneurons of the afferent pathway to the motor neurons that activate the receptor tissue. This defines a constant communication between

the central and peripheral nervous systems where a myofibrillar tension is established within a state of pre-contraction to execute voluntary and involuntary actions of the effector type. (Field-Fote et al., 2017)

Methodology

This review was completed using a non-systematic narrative approach. A variety of databases, including PubMed, Medline, Google Scholar, and EBSCO-host, were searched for this review article. A representative but not exclusive list of keywords for these searches included: tone, toning, muscle toning, muscle firm. Articles were chosen for inclusion on: based on the information they described and with a specific focus on toning, resistance strength training, and neuromuscular adaptations.

Further citations were found, evaluated, and incorporated from the bibliographies of the selected literature. Articles focused on thematic reviews and clinical applications or study protocols conducted among health, fitness, and sport populations. Likewise, published studies that were not in Spanish or English were excluded.

Search Strategy:

A document search was carried out using the MeSH comprehensive controlled vocabulary tool, with keywords such as: tone, toning, muscle stiffness, muscular endurance, fitness. of the same way, it was done a new search wearing operators Booleans (logical) like: “tone” OR “muscle toning” OR “toning endurance” AND “muscle toning”, “stiffness toning” OR “elite athletes” AND “strength training”, “muscle” AND “neuromuscular toning”, “tone skeletal muscle” AND “fitness athletes” OR “resistance endurance training”, “muscular endurance” AND “athletes” OR “fitness athletes”.

Selection process:

A total of 6835 articles were found, from which duplicate studies and those that did not correspond to the study objectives (exclusion criteria) were eliminated, with a final result of 70 publications.

Of the remaining articles that included neurophysiological foundations of tone, those (n = 16) that referred to pathological situations and did not include resistance muscle stimulation were eliminated. Finally, of 54 articles that met the inclusion criteria proposed by the researchers, 44 were used for the present review. (As shown in Figure 1)

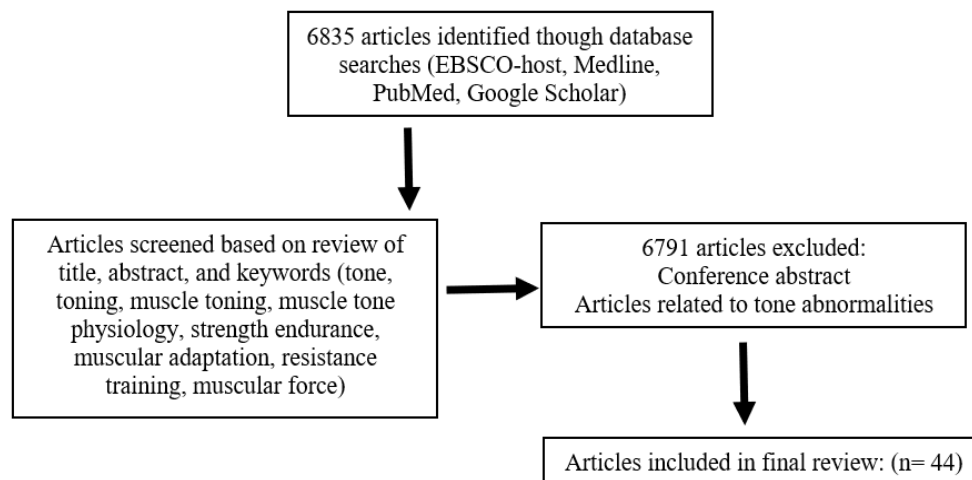


Figure 1. A general flow diagram highlighting the selection process for included articles.

Results:

Articles on literature reviews, systematic reviews, meta-analyses, and clinical trials regarding the neurophysiology of muscle tone, as well as muscle resistance training, were found, highlighting pertinent physiological characteristics on supraspinal and neuromuscular control.

Likewise, the usefulness of the documents related to muscular resistance strength training that could be useful is highlighted (As described in Table 1).

Table 1. Summary of selected studies that define the clinical concept of muscle tone.

Clinical muscle tone definition	Population	References
“Function of the nervous system controlling muscle, but also it is a function of the natural elasticity of the muscular and fibrous tissue”	Men and women	(Campbell WW; Barohn R.J. <i>Muscle Tone. In DeJong's The Neurologic Examination, 7th Ed.; Lippincott Williams & Wilkins: Philadelphia, PA, USA, 2019; Pp. 467 – 474, 2019</i>), (Basmajian, 1957; Poppele, 1985; Takakusaki, 2017; Takakusaki et al., 2016)
“Resistance to passive stretch is physiologically a complex interlaced network encompassing neural circuits in the brain, spinal cord, and muscle spindle”	Men and women	(Ganguly et al., 2021; Howell et al., 1993; Profeta & Turvey, 2018; Walker et al., 2017)
Contribution of the muscle spindle to both the phasic and tonic stretch reflexes.	menu	(Cameron Tucker, 1983; Um et al., 2015)
Human resting muscle (myofascial) tone (HRMT) is the passive tone or tension of skeletal muscle that derives from its intrinsic (EMG-silent) molecular viscoelastic properties.	Humans	(Clemmesen, 1951; Grgic & Mikulic, 2022; Masi & Hannon, 2008)
The sensory innervation of the muscle spindle arises from both group Ia and group II afferent fibers (also sometimes called type Ia or type II fibers, respectively), which differ in their axonal conduction velocity	Humans	(Bewick & Banks, 2015; Kröger & Watkins, 2021)
Contraction of a muscle in response to its passive stretching by increasing its contractility as long as the stretch is within physiological limits.	Humans	(Bhattacharyya, 2017; Blum et al., 2020)
Residual tension in a muscle at rest. Resistance to passive movement. Two kinds of stiffness. Can be measured, elastic and viscoelastic	Humans	(Madhok SS, 2022; Simons & Mense, 1998)
Muscle tone is resistance to passive movement	Humans	(Swaiman & Finkel, 2018)
'The tension in the relaxed muscle' or 'the resistance, felt by the examiner during passive stretching of a joint when the muscles are at rest'	menu	(Campbell WW, Barohn RJ2019)
Resistance to passive stretch. “The constant muscular activity that is necessary as a background to actual movement in order to maintain the basic attitude of the body, particularly against the force of gravity”	Humans	(Carpenter R., Reddi B. <i>Neurophysiology: A Conceptual Approach. CRC Press; Boca Raton, FL, USA: 2012., 2012</i> ; Shortland, 2018)

Discussion

Supraspinal central control and descending tract of muscle tone

Muscle tone is used by the central nervous system to complete the information about joint movement, it excites the neuromuscular spindles, making them fire proportionally to the displacement and thereby contributing to the complex sensory information that the central nervous system processes to obtain a precise image of the spatial situation of the joint. The myofibrillar sensory receptors consist of a sensitive part that is made up of gamma motor neurons that innervate the intrafusal fibers, control tension, relaxation and speed of elongation (Cao et al., 2023). Similarly, the contractile part is formed by the intrafusal muscle fibers contained within a connective tissue capsule that are parallel to the extrafusal fibers of skeletal muscle.

To maintain muscle tension, small groups of motor units are used that alternately activate and inactivate, avoiding fatigue. The motor unit is the functional unit of movement and is composed of the somatic motor neuron and the muscle fibers it innervates. Usually, the muscle fiber receives signals from a single neuron, however, one motor neuron may contact an average of 150 muscle fibers all contracting at the same time (Cameron Tucker, 1983). In addition to this, TM results entirely from a low rate of nerve impulses coming from the spinal cord and these, in turn, are controlled partly by signals transmitted from the brain to the anterior motor neurons of the spinal cord and partly by signals that they originate from muscle spindles located in the muscle itself, and even when the muscles are at rest there is usually a certain amount of tension.

Since normal skeletal muscle fibers do not contract without any action potential stimulating the fibers, skeletal muscle tone is due entirely to low-frequency nerve impulses from the spinal cord. These, in turn, are controlled partly by signals from the brain to motor neurons in the anterior horn of the spinal cord and partly by signals originating in muscle spindles located in the brain itself. muscle. Both stimuli are analyzed in relation to the function of the muscle spindles and the spinal cord (Clemmesen, 1951; Gurfinkel et al., 2006a, 2006b; Masi & Hannon, 2008; Simons & Mense, 1998; Takakusaki, 2017).

Another important component is the myotatic reflex, which is the functional basis of tone, which contributes to maintaining a muscle's resistance to stretching. The TM depends directly on the myotatic reflex

circuit, which is contrary to stretching and causes the reflex contraction of the muscle (Masi & Hannon, 2008). Moreover, the brainstem through the nuclei of the ventromedial system and these patterns can be modified by the action of the dorsolateral system.

Neurophysiology has paid particular attention to TM as a manifestation of the neuromotor control of the stretch reflex (Denny Brown, 1929; Simons & Mense, 1998). In order for the muscle to remain at a constant length, the stretch reflex is automatically regulated by increasing its contractility and relaxing the antagonistic muscles. When a muscle lengthens, the muscle spindle located within it stretches and the rate of neural firing of its afferents increases, this in turn increases the activity of alpha motor neurons, producing contraction of the fibers and generating resistance to said muscle stretching (As shown in Figure 2). Subsequently, a different group of neurons through the mechanism of reciprocal inhibition relaxes the antagonist fibers. The sensitivity of this reflex is regulated by gamma motor neurons (Bhattacharyya, 2017)

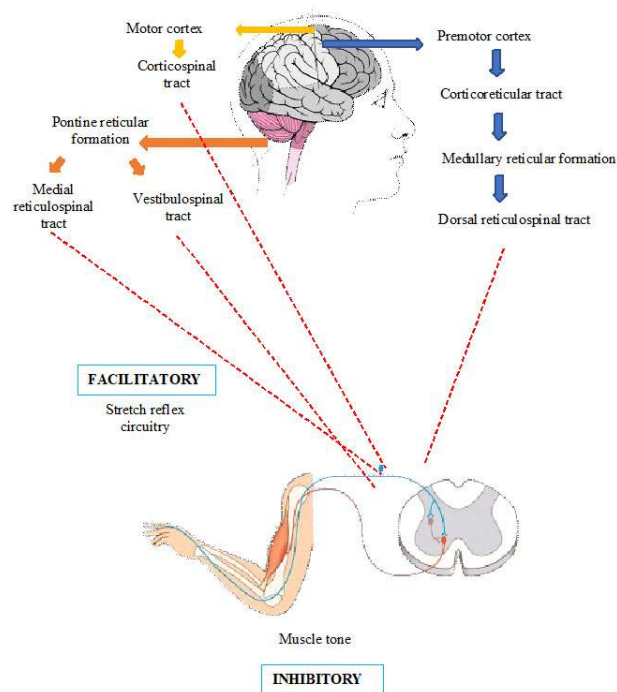


Figure 2. Own elaboration, adapted from (Ganguly et al., 2021)

Classification of muscle tone:

According to the hierarchical control of the central nervous system, under a vertical distribution which generates descending stimuli from the neck, trunk to the lower limbs (Gurfinkel et al., 2006b; Takakusaki, 2017), muscle tone can be classified into two types "tonic" and "phasic" postural movements. Tonic muscles are those that tend to shorten and for this reason, their muscle activity is modulated by lengthening and shortening reactions, that is, decreased lengthening activity and increased contraction activity in shortened muscles, which have an essential function in maintaining posture. On the contrary, phasic tone is what is commonly evaluated in the extremities having a rapid response and short duration. That is, they have a low stage of muscle tension as a result of rapid tendon stretching and the elongatively predominant muscle spindle, both of which tend to lengthen rather than shorten through voluntary contraction (Ganguly et al., 2021; Simons & Mense, 1998; Takakusaki, 2017).

However, when relating said classification to the definition of the term "toning up", said denomination that supports the firmness, rigidity and increase in the apparent fibrillar tension due to strength training and the increase in the contractile component of the muscle fibers is imprecise. Therefore, said process of fibrillar stimulation through resistance to force, would give a proposal for the definition of "*neurostimulated muscle*" modifying the term "tone" since the muscle is determined both by the passive elasticity or turgor of tissues muscular (and fibrous) as by elastic active (although not continuous) muscle contraction, in response to the nervous system's reaction to stimuli. Thus, at complete rest, a muscle doesn't lose its "tone" even though there is no force-resistance neuromuscular activity in it, either, no describes an increase in muscle tone leading to a "rigidity" like a pathology.

Post-exercise muscle microlesion vs "toning"

The inflammatory response that occurs after exercise is associated with muscle, nerve and/or connective tissue damage, sometimes causing loss of function and pain. This process, known as DOMS (Delayed Onset

Muscle Soreness) (Andersen et al., 2013; Herbert et al., 2011; Sethi, 2012; Sonkodi et al., 2020b) a sensation of pain Throbbing combined with tenderness and stiffness, usually peaking around the 24–72-hour range after exercise and can last up to 5 days depending on the complexity and intensity of the exercises (Heiss et al., 2019)(Heiss et al., 2019). This process could confuse or misinterpret the terminology of "toning", since what is evident is a proinflammatory state, product of a compression of the nerve receptors that occurs due to the inflammation present in the fibrillar tissue due to an excessive stretching and that acts by stimulating the nerve endings of pain or nociceptors (Domínguez-gavia et al., 2022), after a muscular resistance exercise (strength resistance) which is based on "performing repeated contractions against a load during a prolonged period" (Grgic & Mikulic, 2022; Kell et al., 2001).

For this reason, excessive stretching that causes rupture of the sarcomeres, the fiber membrane, the T tubules, the sarcoplasmic reticulum, the increase in inflammatory markers, (Clarkson & Hubal, 2002; Hody et al., 2019; Owens et al., 2019; Peake, 2019; Schoenfeld, 2010; Sonkodi et al., 2020b; Souza-Teixeira, 2012; Van Hooren & Peake, 2018) would generate the sensation of sarcoplasmic and capillary hypervascularity, interpreting said increase in the fibrillar sectional area as "toned muscle".

Compression micro injury of nerve endings

Within the practice of exercise, especially strength, various scientific studies have determined that the stretching of the neuromuscular spindles comes along with the extension of the sensory region and the annulospiral space of the free endings (Poppele, 1985)(Poppele, 1985). In this way, and especially eccentric exercise, produces an excessive elongation of the aforementioned spindle, causing a harmful increase in interstitial volume due to osmotic changes (extracellular matrix) to the integrity of the cellular structure, resulting in compression that could trap nerve microfibers. within the myofibrillar component as the decelerating repetitions of contractions lead to further micro-injury to neuronal filaments (Bewick & Banks, 2015; Sonkodi et al., 2020b).

Finally, the muscular microinflammation that occurs due to alteration of the intracellular and extracellular water balance induced by increased vascular permeability, averaged by osmolytes (Lambert et al., 2008; Snijders et al., 2017) related to interstitial compression, the alteration of the free endings and the excessive elongation of the neuromuscular spindle would have the unintelligible interpretation of a "toning" due to effects proinflammatory (Cameron Tucker, 1983; Campbell, W.W.; Barohn, 2019; Masi & Hannon, 2008), which do not represent an increase in "tone" as would be described in the pathological aspect of "hypertonia" where the spinal circuit excitatory and inhibitory is altered generated by the deficit of the regulation of the myotatic reflex or alteration in the process of reciprocal inhibition (Ganguly et al., 2021).

Conclusions

Although there are significant evidences already studied in the neurophysiology muscle tone of individuals, there is evidence of the improper excessive use of "muscle toning term". In this review, we explain through the studies that there is a misconception of strength training and increasing toning from people, letting sports coach, physicians, professional of sports science to use the term confused and indiscriminately.

Thus, it is clear that, based on these results, instead of calling "muscle toning" it is suggested that use the phrase "neurostimulated muscle" based on the contextualization and the scientific foundation, due to sensations of muscle stiffness, established in an inflammation post exercise like a result of eccentric contractions, that generate high compression, tensions and micro injured in type II fiber nerve endings and the myofibrils", different to "increase tone like a rigidity pathological".

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Conflict of interest

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