INTRODUCTION TO

Strength Testing

A Foundational Guide for Coaches, Trainers, and Athletes of All Abilities

Written by Dr. Victor Katch

Dr. Victor Katch

- Best selling author of "Exercise Physiology"
- Helped develop the first NFL Combine
- Former University of Michigan woman's basketball coach
- U of Michigan Faculty and researcher for 43 years

FIT-C MEMBER
Fitness Industry Technology Council

UK active

ActiveLab
FINALIST

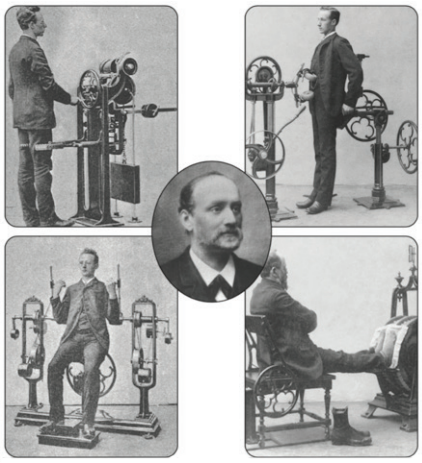
Introduction

Measuring strength seems so simple. For many, it's simply recording the amount of weight lifted for different types of movements, like a bench press, or bicep curl. But, as research shows, assessing amount of weight lifted presents many problems. For example, amount of weight lifted depends on factors like body position and muscle-bone joint angle during movement, speed of movement while lifting the weight, range-of-motion (ROM), type of weight lifted– free weights versus machines, and type of muscle action (eccentric or concentric or isometric)? Thus, in actuality, there are many different types of strength that depends on how you measure it. Also, there is great specificity of strength; meaning lifting a weight in one position does not necessarily mean you can lift the same amount of weight in a different position.

History of Measuring Strength

Weightlifting in America in the early 1840s became a spectator sport practiced by "strongmen" who showcased their prowess in traveling carnivals and sideshows. The military evaluated the strength of conscripts during the Civil War as a way to measure "fighting capabilities"; strength measurements also provided the basis for routine fitness assessments in the prototype college and university physical education programs.

An 1897 meeting of College Gymnasium Directors established strength contests for college undergraduates to determine overall body strength and the college's "strongest man." Measures included back, leg, arm, and chest strength evaluated with several of the devices depicted in the Figure on the right.



Examples of early 19th century "strength machines" popularized by Swedish physician Gustav Zander (insert; d. 1920), who produced 27 mechanical apparatus that became prototypes of common exercise/strength equipment now found in gyms everywhere.

By the mid-1900s, physical culture specialists, circus performers, bodybuilders, competitive weightlifters, field event athletes, and wrestlers trained predominantly using "weightlifting" exercises. Most other athletes refrained from lifting weights for fear such training would slow them and increase muscle size to the point where they would lose joint flexibility and become muscle-bound.

Eugen Sandow, born Frederick Mueller (d.1925) was one of the first successful muscular vaudeville strongman who was billed as "The Most Perfect Man". Sandow popularized strength training and bodybuilding and also designed strength equipment.

Subsequent research in the late 1950s and early 1960s dispelled this myth that muscle-strengthening exercises reduced speed or range of joint motion. Instead, the opposite usually occurred; elite weightlifters, bodybuilders, and "muscle men" had exceptional joint flexibility without limitations in general limb movement speed.

For untrained healthy individuals, resistance exercises increased speed and power of muscular effort without impairing subsequent sports performance.

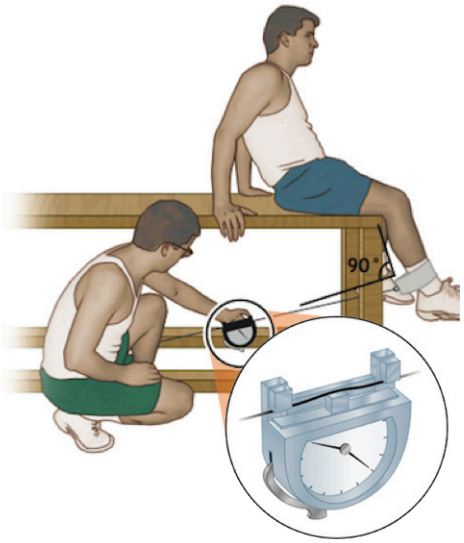
It is now known that resistance training is vital for optimum performance, maintaining strong and pliable bones during aging and to improve functional strength for people of all ages.

Measuring Muscle Strength

Measuring strength has evolved through the years and the latest research clearly demonstrates the need for clearer understanding of details of how to measure the different aspects of strength and why this is important for individuals engaging in resistance training.

One of the following four methods commonly assess different aspects of muscle strength but only the last method can successfully and precisely measure the different types of strength generated by a single muscle or related muscle groups:

1. Tensiometry
2. Dynamometry
3. One-repetition maximum
4. Microprocessor-assisted devices



1) Cable Tensiometry

The figure on the left shows a cable tensiometer for measuring knee extension muscle force. Increasing the force on the cable depresses the riser over which the cable passes. This deflects the pointer and indicates the subject's strength score.

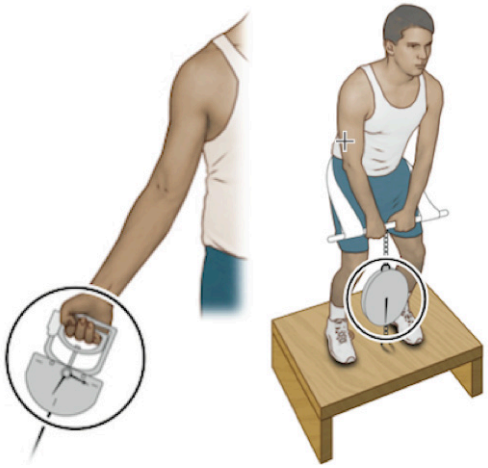
The instrument measures muscle force in a static (isometric) muscle action that elicits little or no change in the muscle's external length. The tensiometer (lightweight, portable, and easy to use) provides the advantage of versatility for recording force measurements at virtually all angles about a specific joint's range of motion (ROM).

Standardized cable-tension strength-test batteries can assess static force capacity of all major muscle groups.

2) Dynamometry

The two figures on the right illustrates a hand-grip and leg and back-lift dynamometer for static strength measurement based on the compression principle.

An external force applied to the dynamometer compresses a steel spring and moves a pointer. The force required to move the pointer a given distance supposedly determines the external force applied to the dynamometer.



METHODS OF MEASUREMENT

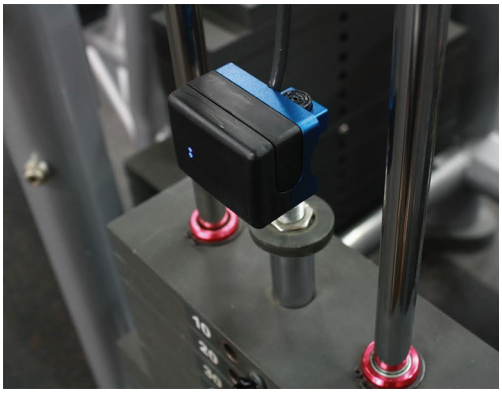
3) One-Repetition Maximum

A dynamic procedure for measuring muscular strength applies the one-repetition maximum (1-RM) method. 1-RM refers to the maximum amount of weight lifted one time using proper form during a standard weightlifting exercise.

To assess 1-RM for any muscle group, the tester makes a reasonable guess at an initial weight close to, but below, the person's maximum lifting capacity. Weight is progressively added to the exercise device on subsequent attempts until the person reaches maximum lift capacity. The weight increments usually range between 1 and 5 kg depending on the muscle group evaluated. Rest intervals of 1 to 5 minutes usually provide sufficient recuperation before attempting a lift at the next heavier weight.

4) Microprocessor Technology

Microprocessor technology has made it possible to rapidly and accurately quantify all aspects of strength including forces, torques, accelerations, and velocities of movement during all phases of a strength movement. The accuracy and flexibility of these devices are unprecedented and are ushering in a new era of understanding of human muscular strength heretofore unknown.



The newest of these devices, introduced by ShapeLog, promises to revolutionize strength assessment and training for all individuals.

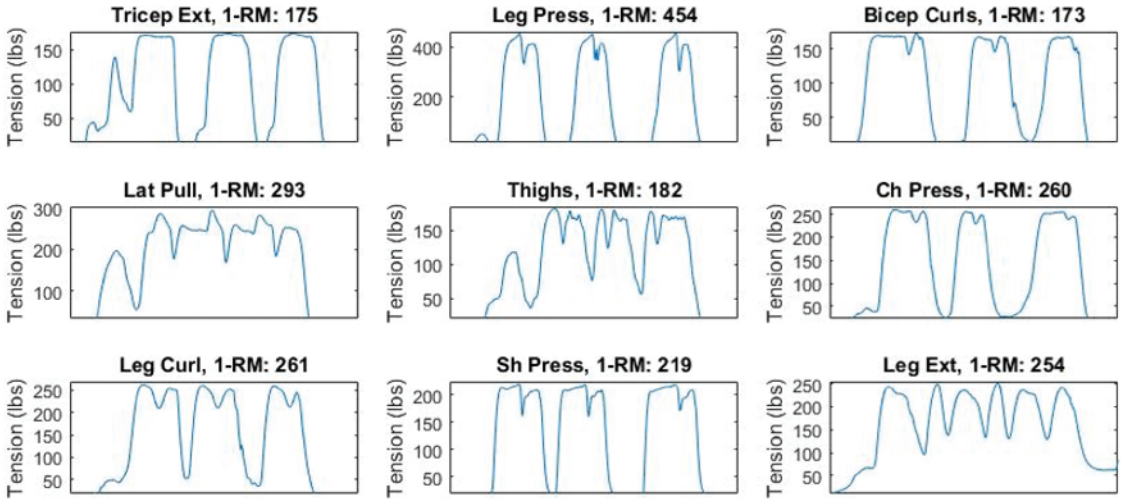
ShapeLog is able to record all different aspects of strength and use this information to create real-life training programs to maximize functional strength for all people, from elite athletes to everyone else.

ShapeLog permits training (and measurement) under a continuum from high-velocity (low-force) to low-velocity (high-force) conditions. A microprocessor within ShapeLog continuously monitors applied force at 180 data points per second. An integrator within ShapeLog monitors and displays the most important aspects of strength assessment.

METHODS OF MEASUREMENT

For example it is possible to measure and display average or peak force generated during any time interval for almost instantaneous feedback about performance (e.g., force, power, work, velocity, number of repetition). The ability to measure tension in the cable regardless of whether or not the weights are moving also enables the sensor to use isometric cable tensiometry as a form of strength assessment. This means an individual's 1-RM could be easily estimated without requiring the person to experiment with a variety of weights setting.

The example below shows results from a ShapeLog isometric strength assessment, illustrating how a quick evaluation can provide insight into recommended weight settings for different training goals. It also enables more accurate tracking of long term strength development.



	ENDURANCE	*POWER*	*STRENGTH*	*1-RM*
REPS:	**15-20**	**8-12**	**3-6**	**1**
Tricep Extension	110	130	160	170
Leg Press	270	340	410	450
Bicep Curls	100	130	160	170
Lat Pull	180	220	260	290
Thighs	110	140	160	180
Chest Press	160	200	230	260
Leg Curl	160	200	230	260
Shoulder Press	130	160	200	210
Leg Extension	150	190	230	250

*Weight setting recommendations are in pounds (lbs)

Clearly, ShapeLog's technology can provide the individual and sport and exercise scientist with valuable data to evaluate, test, train, and rehabilitate individuals– the applications are endless. The advantage of microprocessor technology compared to other techniques, especially the 1-RM technique is clear.

In subsequent posts we will present specifics of how ShapeLog works and how you can use it for documenting your strength performance and for personal coaching. Stay tuned.

TERMS TO KNOW

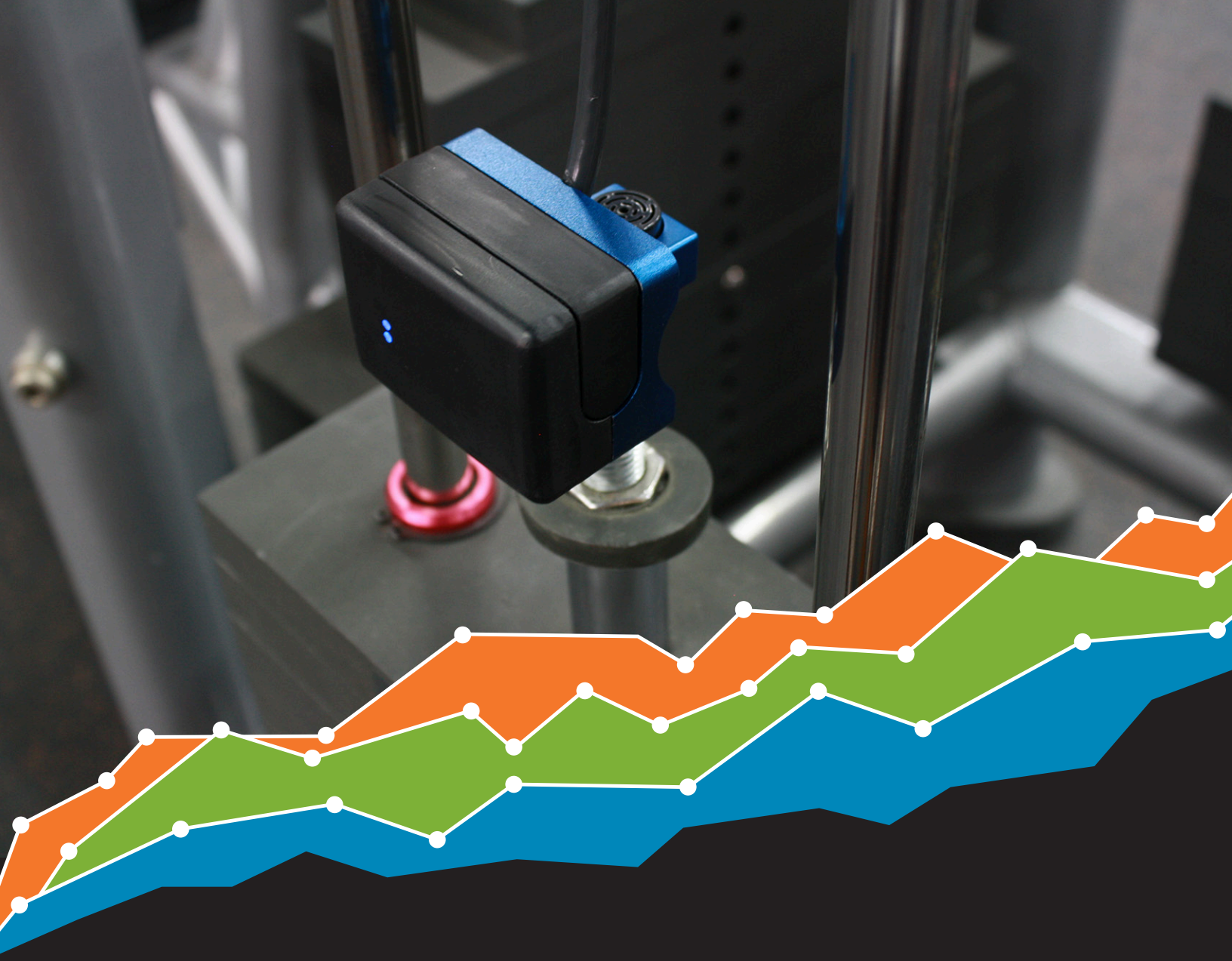
Term	Definition
Circuit resistance training (CRT)	Series of resistance exercises performed in sequence from one exercise "station" to the next with minimal rest, usually 20 to 30 seconds, between exercises.
Concentric action	Muscle shortening occurs during force application.
Dynamic constant external resistance (DCER)	Resistance training in which external resistance or weight does not change, yet joint flexion and extension occurs with each repetition.
Dynamometer	Force measuring instrument to assess a mechanically-derived output such as force, power, torque, speed, and velocity during diverse muscle actions.
Eccentric action	Muscle lengthening that occurs during force application.
Exercise intensity	Muscle force expressed as a percentage of a muscle's maximum force-generating capacity or some level of maximum.
Fiber hyperplasia	Increase in muscle fiber number.
Force–velocity relationship	An intrinsic relationship when a muscle shortens against a constant load, with velocity assessed during shortening and plotted against the resistive force.
Functional strength training	Type of training that requires neuromuscular adaptations in the important movements that necessitate improved strength.
Hypertrophic development	Increase in muscle fiber size from strength development techniques.
Isokinetic action	Muscle action performed at constant angular limb velocity where constant torque or tension is maintained as muscle shortens or lengthens.
Isometric action	Muscle action performed at constant limb position where no noticeable movement occurs.
Maximal voluntary muscle action (MVMA)	Maximal force generated in one repetition (1-RM), or performing a series of submaximal actions to momentary failure.
Muscle endurance development	Developing sustained maximum or submaximum force, often determined by assessing maximum number of exercise repetitions, at a percentage of maximum strength.
Muscle fiber hypertrophy	Increased size of individual muscle fibers.

TERMS TO KNOW

Term	Definition
Muscular endurance	Sustaining maximum or submaximum force, often determined by assessing the maximum number of exercise repetitions at a percentage of maximum strength.
Muscular strength	Maximum force, tension, or torque generated by a muscle or muscle groups.
One-repetition maximum (1-RM)	Maximum force generated for one repetition of a movement or predetermined number of repetitions (e.g., 5- or 10-RM).
Overload	A muscle acting against a resistance greater than normally encountered.
Overload principle	Basic tenant of training strategy whereby a muscle makes physiological adaptations to the progressive level of tension placed on it.
Plyometrics	Special form of training to develop powerful, propulsive movements—requiring jumping in place or rebound jumping, drop jumping from a preset height—to mobilize the inherent stretch–recoil characteristics of skeletal muscle and its modulation via the stretch or myotatic reflex.
Power	Rate of performing work (Force × Distance ÷ Time, or Force × Velocity).
Progressive overload	Incrementally increasing the stress placed on a muscle to produce greater force or greater endurance in subsequent workouts.
Progressive resistance exercise (PRE)	Practical application of the overload principle, which forms the basis for most resistance training programs influenced by number of sets, repetitions, frequency, and relative intensity of training to improve strength.
Range of motion (ROM)	Maximum range through a joint's arc.
Relative strength	Computed relative to either body mass, segmental or total FFM, and MCSA to help introduce "fairness" when comparing individuals of widely different strength profiles including gender.
Repetition	One complete exercise movement, usually consisting of concentric and eccentric muscle action or one complete isometric muscle action.
Repetition maximum (RM)	Maximum force generated for one repetition of a movement (1-RM) or predetermined number of repetitions (e.g., 5- or 10-RM).
Set	Preset number of repetitions performed in resistance training.
Strength	Maximum force-generating capacity of a muscle or group of muscles.

TERMS TO KNOW

Term	Definition
Strength development	Using a variety of methods to enhance maximum force-generating capacity of a muscle or group of muscles.
Strength training zone	Intensity of effort from 60% to 100% of 1-RM during resistance training to increase muscular strength.
Torque	Force that produces a turning, twisting, or rotary movement in any plane about an axis; commonly expressed in newton-meters (Nm).
Training volume	Total work performed in a single training session.
Variable resistance training	Training with equipment that either uses a lever arm, cam, hydraulic system, or pulley to alter the resistance to match the increases and decreases in a muscle's capacity throughout a joint's ROM.
Voluntary maximal muscle action	Highest force a muscle produces under voluntary control.



Patented Fitness Technology

ShapeLog Powers Next Generation Fitness Experiences

ShapeLog

We are a fitness technology startup in Ann Arbor, MI with backgrounds in software, hardware, machine learning, events, and exercise science.

We partner with fitness equipment manufacturers to identify, learn about, and delight users at the gym or at home. By collecting high-resolution workout data, we learn about you, and offer evidence-based programming that has the potential to change your life forever.