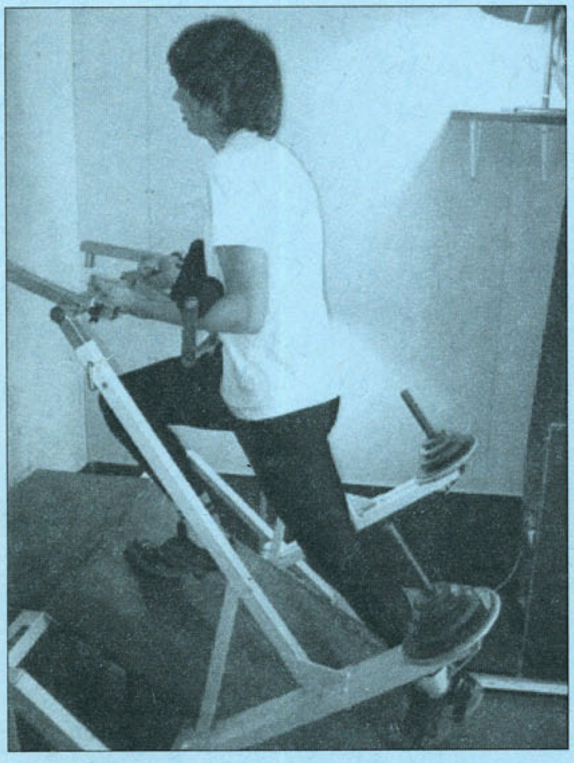
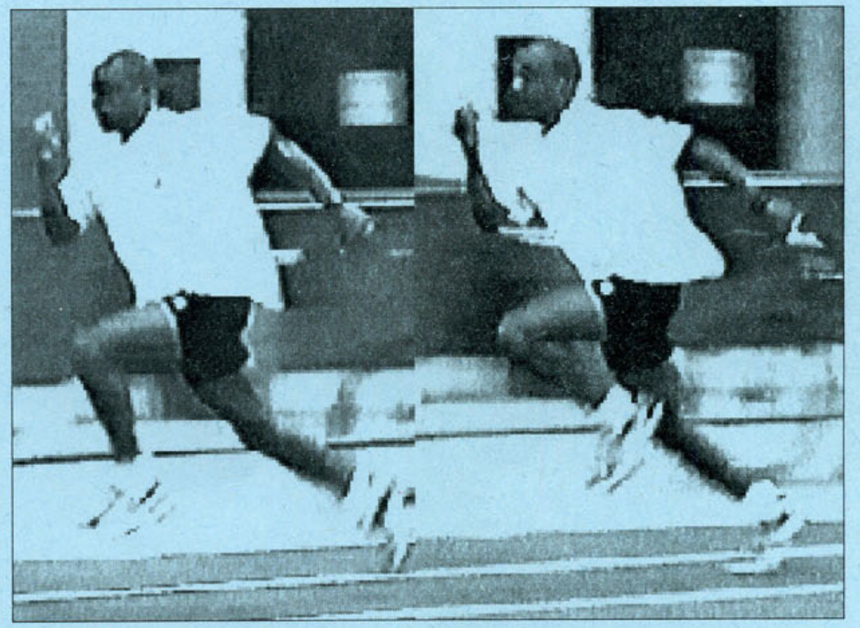
Strength Speed





Technology and training for sprinter speed and long jump. A new type of specific strength training for speed called Powersprint is presented. Muscle strength - Scientific basic.

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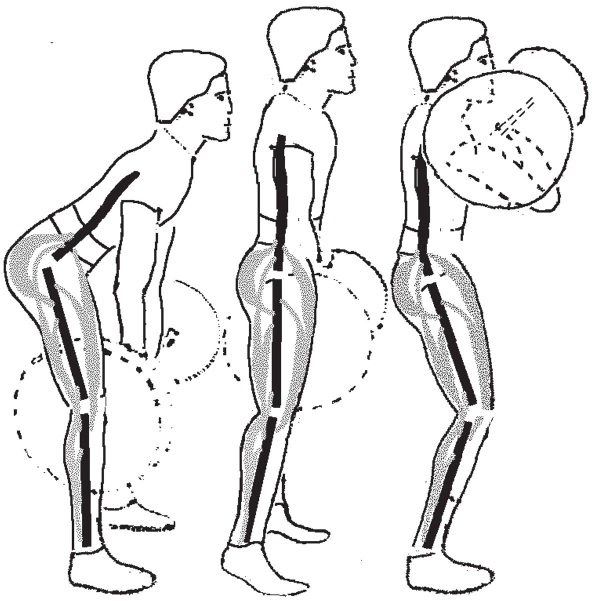

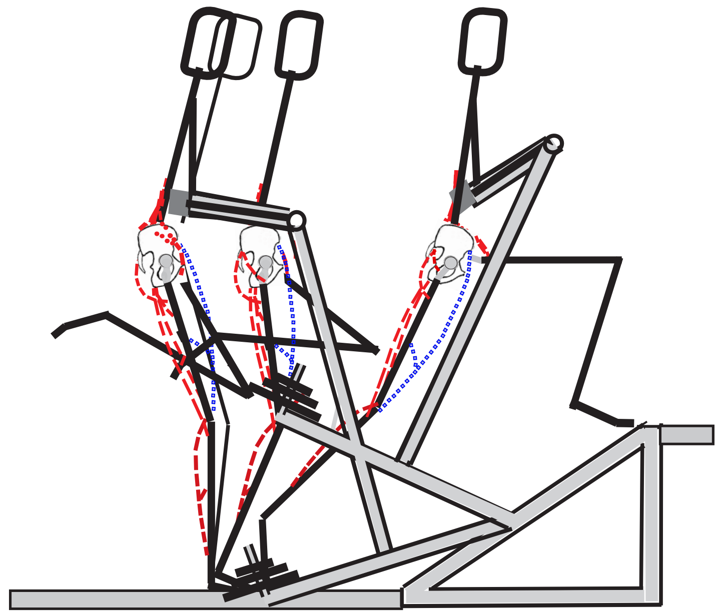

Drawings and photos
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CONTANT

Foreword

Over the years, many articles have been written about new research findings about strength and speed. Among the coaches, it has existed great frustration to study all this scattered knowledge. In order to support their training. "Track and field general training learn" by Rosenberg have gratefully been received by a broad readership, which also is represented by other sports. 1985 was "Strength of the sport" published with very illustrative example by Alf Thorstensson and Bengt Saltin. In recent years, the dossier produced in book form by writers like Jonny Nilsson / Jan Seger, Janne Carlstedt, Per Tesch, Hatfield United States, Germany Grosse and others. Articles in Leichtathletik, 90-99 years, then was valuable sources. During the 2000s, then, in addition to the internets amount of information, writers like Frank Bosch, Tudor Bompa and Nick Newmann added essential "pieces". In addition, all the advices I have been privileged to receive by both Swedish and international coaches, got me to finally complete this work.

Year 2010 the book has been complemented with a chapter about longjump technique and with a special trainingprogram for powersprint. The periodizing in this program has been updated in 2012 with great inspiration from Nick Newman's book *"The Horizontal jumps"*.

This and later provided Tudor Bompas new edition of *Periodization Training for sports* **and mainly Håkan Andersson uniquely well-planned workout template as valuable data for now new training plans for Sprint and Long Jump. It is with gratitude I think back of the support and help with the theoretical by Hakan over the years. I am also very grateful for interesting dialogue with Magnus Warfvinge, Varberg GIF from 2013, which has contributed to my ideas to document the modern Sprint training and technology and how to use Power Sprint, as technology developing strength training.**

Jan Melén - January 2019

Introduction

This compilation of facts in the book's introductory section is intended as a contribution to knowledge of the concept of strength and speed. Chapter 1-3 (page 8-43) then deals with speed from a general perspective-tive, with different strengths concepts, training principles, planning and exercise storage, which can also be read separately. Then the book covers mainly the technology of sprint and training (Chapter 4, pages 44-67) but also the long jump (Chapter 5, 68-78), as examples of an athletics branch with large elements of both strength and speed.

Henrik Olausson has with great interest and perhaps not so little patience, helped me to describe Tom Tellez technique model (page 44-48) and training program (page 61-64). At a visit in Houston -99 talks offered with Tom Tellez, and the opportunity to film a world elite sprinter, Mike Marsh. This resulted in significant contributions to the essence of how the sprinter speed can be developed.

Following summary of sprint technique (pages 49-59) with the help of several biomechanical studies is an attempt to document the ideal technology model, which eventually leads to the recommendation of a new development of strength training for speed using a so-called Power Sprint® Machine. The machine as a first simpel prototype has been tested by Hakan Andersson on 1990 - century Swedish best sprinters Peter Karlsson and Torbjorn Eriksson before, they at Indoor European Championship 1996, both won a bronze medal each on 60m resp. 200m. Hakan still use this machine, mainly for the development of the basic muscle strength of the gluteus and hamstrings, hip-extending function in the sprinter step. In recent years, Hakan has coached Stefan Tärnhuvud, best Swedish 100m sprinter from 2008 to 2012, and together with him, 100m champion in 2013-15, Tom Kling-Baptiste. The year 2017 a new star shot came, the young Austin Hamilton with a surprising 60m bronze at the Indoor European Championship plus100m gold at the Swedish Championship with the great time 10.18. So far this year SM gold at 60m - exciting continuation follows. Austin's basic year at the Malmö Friidrottsgymnaset included "Powersprint training" in combination with Olympic Lift. The coaches, including Morgan Rosberg, Alexander Lyshag and Jörgen Becke believed in the idea of Powersprint. Austin Hamilton has continued to use this strength training's form under Jörgen Becke's leadership.

3. SPEED - MUSCLE STRENGTH

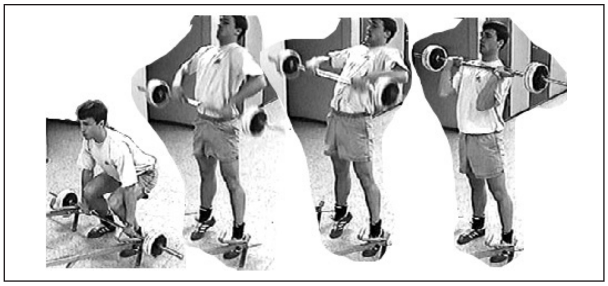


Fig. 12 *Strength training for speed.*

Speed is largely dependent on muscle strength. For example 1980-1990s Track and field's Olympic gold medalists Carl Lewis, Mike Marsh and nowadays superstars från Jamaica, Bolt, Asafa Powel, Shelly-Ann Phraser-Pryce and Alaine Thomson have all devoted much of their training in the strength room to build, besides a general basic strength mainly a specific muscle strength especially developed for speed. To explain how and why it is so important issue, will bothering biological and mechanical general grounds for the strength to be treated. This and the various concepts of strength, training principles, planning, exercise stores and strength programes can be read as a separate part (Chapter 3).

3.1 Muscle strength, biological bases

We begin by describing biological muscle strength, the complex nervous and muscular system's build-up and function.

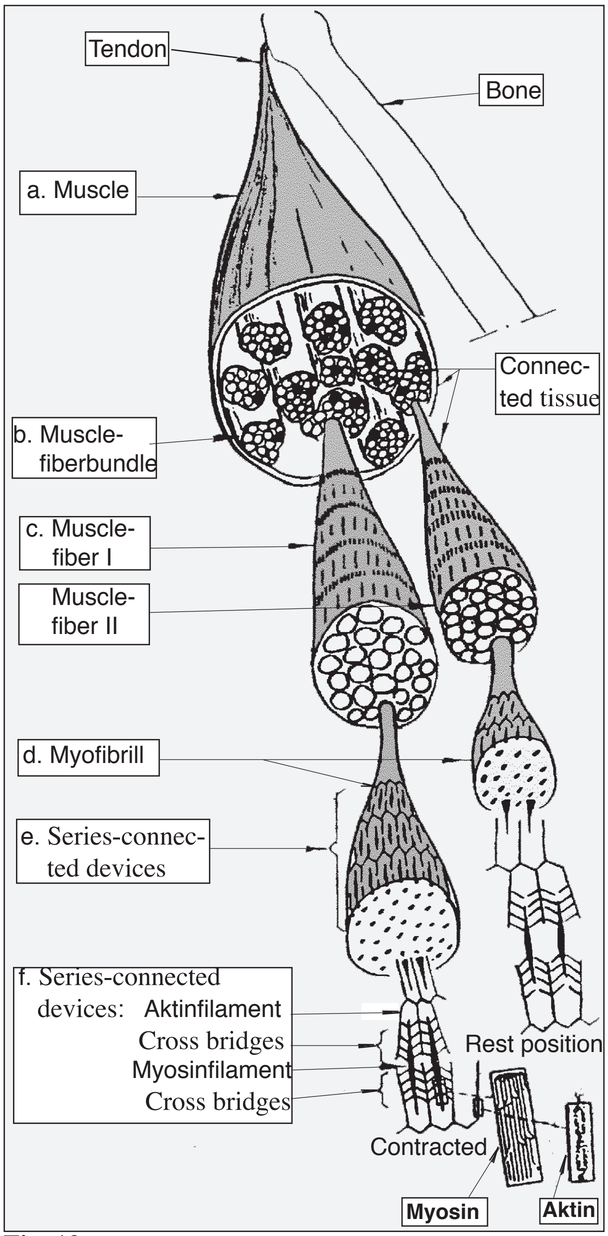


Fig. 13 *Schematic picture of the muscle's build-up och function*
c- f *: Muscle fiber (I) contracted*
Muscle fiber (II) in rest position

The muscle's build-up

With the help of fig.13 we shall study the muscle build-up in detail. Muscle (a) consists of bundles of elongated cells (fibers), muscle fiber bundles (b). Muscle fiber (c) are in turn composed of so-called myofibriller (d).

Connective tissue surrounds both fiber bundles and individual fiber as the entire muscle. The muscle's ends is collected the connective tissue and turns into a strong tendon, which attaches to the bone.

In a microscope you can see myofibrill' s characteristically cross-striped, consisting of series-connected devices (e) * whose ingenious design can create a muscle contraction. The units consist of two different proteins (f) with astringent properties:

Aktin- and Myosinfilament

In a muscle-contraction the myosin- and aktinfilaments are sliding into one another, with each unit and thus the entire musclefiber shortened. The mechanism behind this is the formation of so-called cross bridges (f) between the filaments. When cross-bridged, filaments "drawn" into one another. This will create a muscle contraction and power.

Figure 13c-f shows, first one muscle fiber' s (I) in contraction and a fiber (II) in rest position

*) Sarkomerer

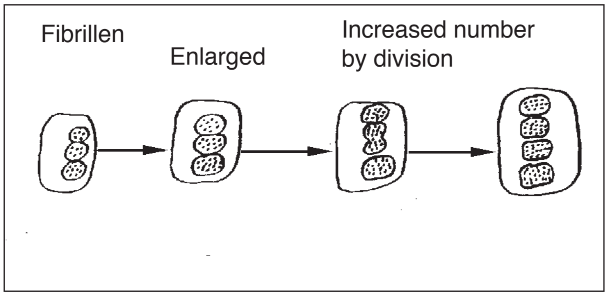


Fig. 14 *Muskelfibrill's growth (schematic sketch). When the fibrill is growing after training the muscle is increasing in volume and strength.*

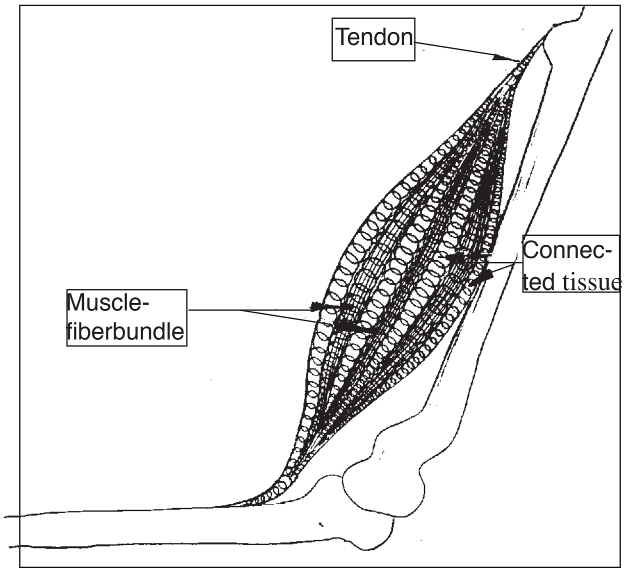


Fig. 15 *Elastic muscles (schematic sketch)*

Strength training is stimulating the increased formation of contractile proteins. The muscle is then growing in volume and can therefore develop greater force. The volume increase (increased cross-sectional area),scientifically known as muscle hypertrophy (Mh), is done by fibril becomes enlarged, possibly extended and increased in number (by division). See Figure 14.

Muscle elastic quality

Earlier, we talked about the growth of muscle in volume (cross section) by training increased the strength. Strength depends however on many important factors. Such is the muscle elastic quality.

Tendons and connective tissue, and possibly the filament of the muscle thread, acts as a "rubber band". This provides an additional force such as in fast movements, sprint and jump, but also in easier muscle activities such as walking (especially in downhill) or jogging. Actually, in almost all of our daily movements the muscles works with a certain elasticity.

Figure 15 shows a schematic sketch of muscle function as **elastic** "springy". In fast moments, such as the ground contact ("ground phase") in the sprint stride, the muscle's elastic quality   also together with the so-called stretch reflex (described in detail on page 15) is contributed with considerable force.

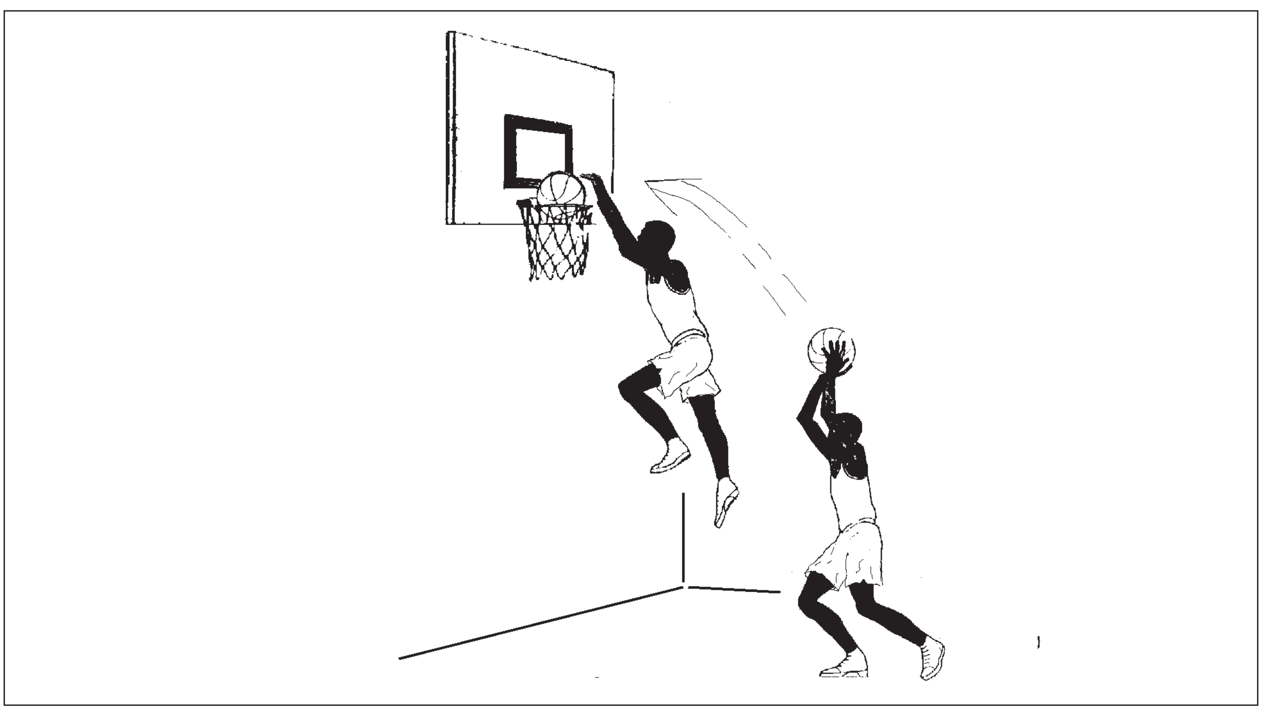


Fig. 16 *(Processed from IPC Big Sport-lexicon 1975,126)*

Muscle fiber types

The muscle have two different types of fiber:

Slow twitch	Fast twitch
ST-fiber	**FTa- alt. FTx-fiber** [1]

The following table summarizes the type of fiber characteristics

The table shows characteristics of the fiber types . Every human being has inherited a certain distribution of these. Maybe one of 20 000 individuals have muscle required to become a world-class sprinter, marathon runner and so on. Or play heritage smaller role than we think (-85 M. Sjostrom, M. Esbjörnsson -93, see ref.litt.)?

Fi-ber-type	Endu-rance	Contrac-tion velocity	Ablity to quickly reach max force	Mean cross-cut surface (Volume)	oxidation capacity			Anerobic enzyme activity [3) 4)]
					Mito-chon-drie-number	Capilla-ry den-sity	Mitochon-drial [3)] enzyme activity [2)]	
ST	***	*	*	*	***	***	***	*
FTa	**	***	**	**	*	*	**	***
FTx	*	***	***	***	*	*	*	***

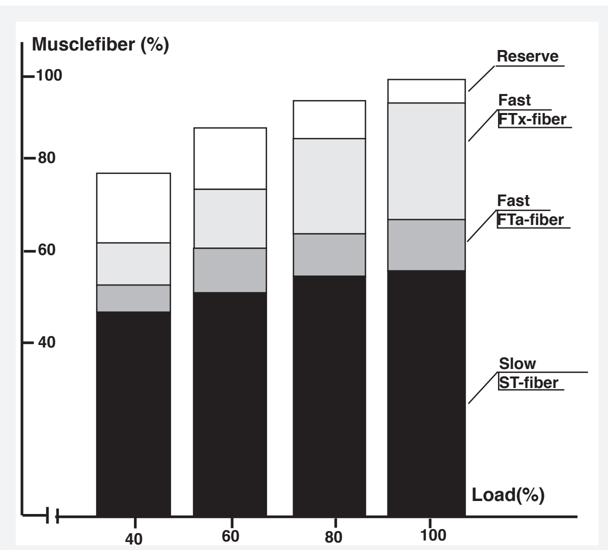


Fig. 17
(Modif. Grosser/Ehlenz/Zimmermann-91, 39)

Fig. 18
(Modif. Grosser/Ehlenz/Zimmermann-91, 39)

The distribution of these fibers differs between:

* Groups of muscles (e.g. gastrocnemius have usually more rapid than slow fibers, whereas the reverse is the case for Soleus).
* Individuals (marathon runner might have 80% long-the ST fiber, sprinters instead of 80% FT fibers)

With the help of diagrams, we now describe how the different fiber types are engaged at various loads and movement velocity (see also page 14 and 17). Fig.17 shows how at rising load the fast FTA and mainly FTX fibers progressively are engaged in larger scale. We also see that to a large extent also the slow-ST fibers must assist.

If you increase the movement velocity more and more of the fast muscle fibers must be activated (Fig. 18 and 19). We realize that if you need speed in your sports, strength training should normally be done with "explosive" force of effort and sometimes the high operating speed.

1) Previously known as: Slow Type I and Type IIa fast alt IIb
2) With the enzymatic activity is meaning biologically particulary proteins, which accelerates cell metabolism.
"Without enzymes - no life"
3) See muscle energy metabolism (page 18)
4) Among others ATPase

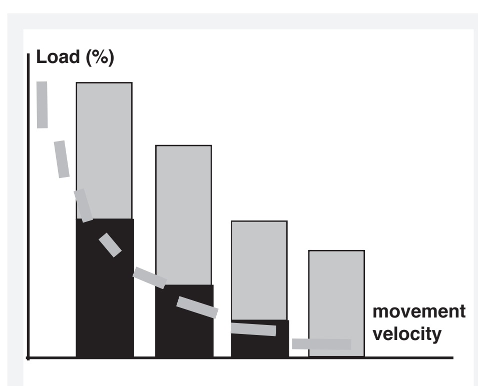


Fig. 19
(Modif. Grosser/Ehlenz/Zimmermann-91, 39)

Nerve - muscular systems

Muscle strength and speed are highly depending on the properly functioning nerve - musculary system *), in the following lists some important components and functions

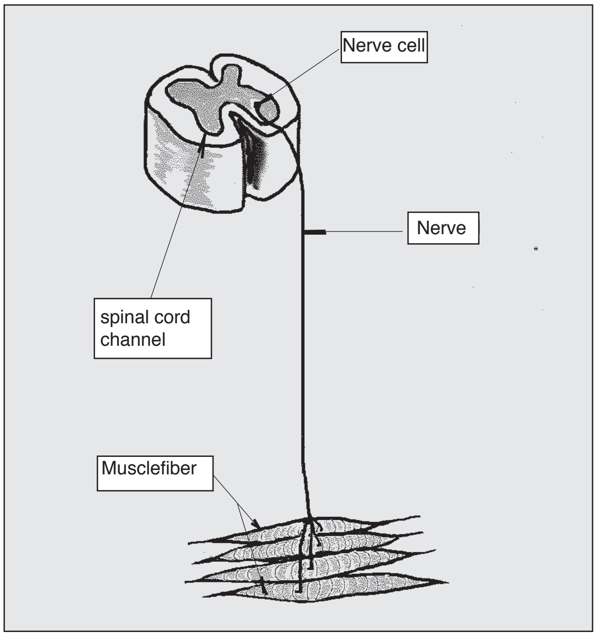


Fig. 20 *Motor unit* (Modif. Grosser/Ehlenz/Zimmermann -91, 24)

Motor unit

Figure 20 is showing an example of a so-called motor unit. A nerve cell **) in the spinal cord channel is interconnected through its nerve ***) and branched, with a few muscle fibers. It is here question about a small engine unit with few fibers, for controling of fine muscle movements, as finger or facial muscles.)

Larger motor units with many fibers (up to about 1000 per neuron) are intended for the muscles, which can develop more power (such as location muscles, m. gluteus). The largest motor unit has except for biggest nerve cell also coarser muscle fibers of the fast type IIb. They are used in sporting moments that require high power and speed.
Exampel: Different kind of accelerations and jumping eg in basketball, soccer, athletics, "explosive" sports.

Neurons in the motor unit is similar to a battery that is recharged and "discharging" of electrical impulses ****) (Fig. 21). These impulses or nerve signals are transmitted with a certain frequency (pulse / sec) to activate the muscle fibers.

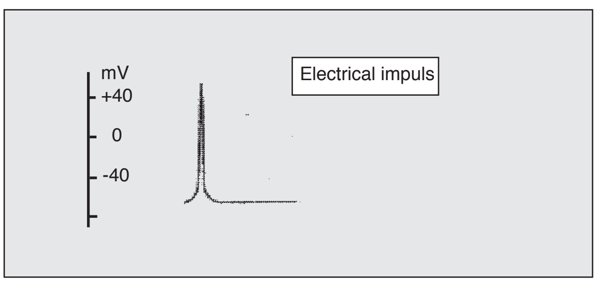


Fig. 21 *Electrical nerve impuls ****)*
(Modif. Grosser/Ehlenz/Zimmermann -91, 19)

Muscle sensory organ

In order to control muscle activity, nervous system needs information about muscle length and tension, etc.

As an information source special sense organs (receptors) works and partly so-called muscle spindle (Fig. 22) in the muscle and partly "Golgi tendon organ" (See fig. 23, page 15) at the transition between tendon and muscle.

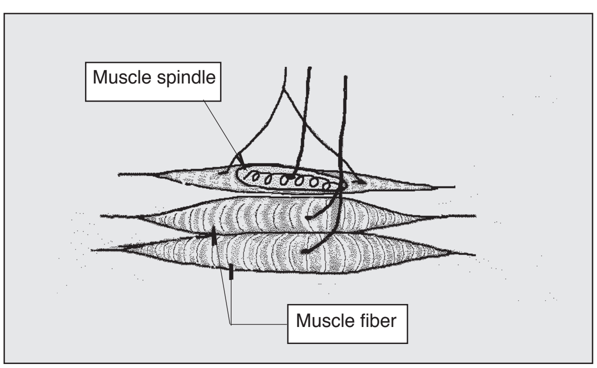


Fig. 22
(Modif. Grosser/Ehlenz/Zimmermann -91, 43)

*) Neuromuscular system **) Motorneuron ***) Axon (Alt. Neurit)
****) Action-potential

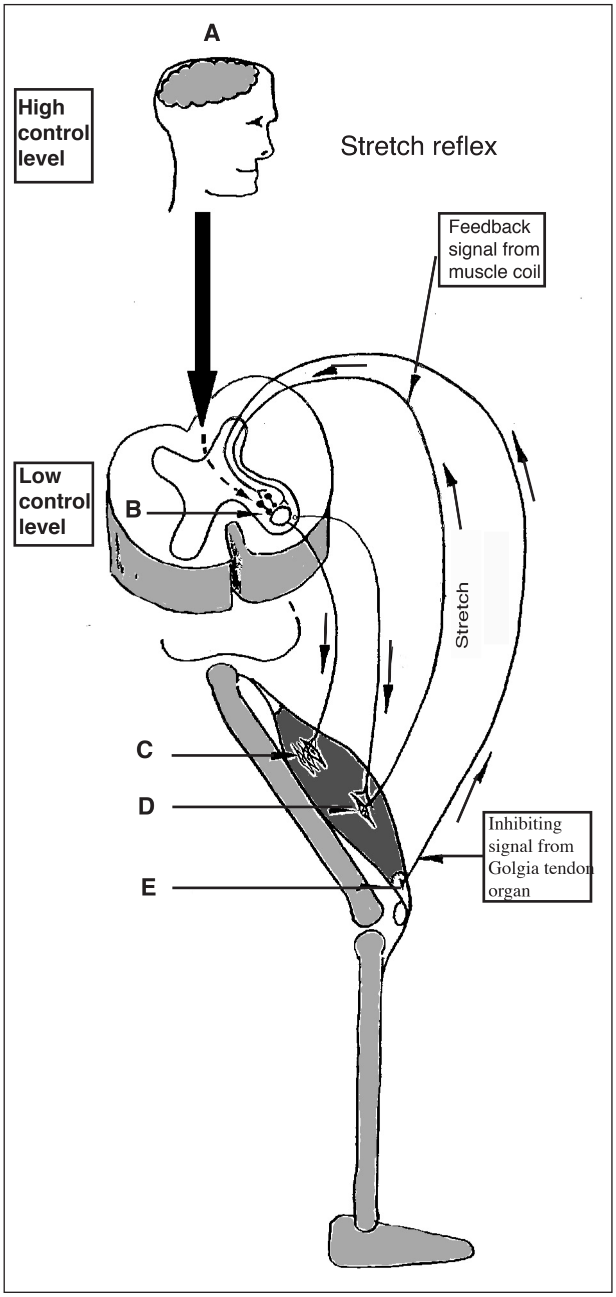


Fig. 23 *Control of muscle, Strength model* (Modif. J. Nilsson/Seger.-92, 10)

Control of muscle, strength model. Stretch Reflex.

We shall now show a model of how the control of a muscle can be done. See Figure 23 and consider the brain and spinal cord as a "human computer '

From the "highest level of control" in the brain (A) nerve signals goes to a lower level of control in the spinal cord, nerve cell (B). The signals moving on to the muscle fibers (C), which be contracted. Muscle spindle (D) registers the muscle length changes and provides a feedback signal if for example, the muscle suddenly will be stretched. From the nerve cell (B) a new signal comes to the muscle fibers for more muscle-power development. 1)

The latter process is called **stretch reflex**, which together with the **elastic properties** in the muscle are involved in the so-called **stretch-shortening cykle (SSC)**. In fast moments, such as ground contact ("ground phase") in a sprinter stride, SSC along with the muscle's elastic properties is contributing with force, called reactive force. To achieve this effect, we are talking generally about this concept as plyometric strength, but we use here simply **Reactive strength (Rs).** Rs is an important factor to train for (see page 33) for speed.

If the stretching would be too strong, Golgi tendon organ (E) registers this and sends an inhibitory impulse to the nerve cell (B). This "throttles the impulse flow to the muscle, thereby the force is diminishing rapidly. The Golgia tendon organ thus protects muscle and the tendon for congestion.

In all sports training and competition you must do some "Stretching" to avoid short, "tight" muscles. In addition, you have to put careful attention of the training to strengthen muscles and tendons. Otherwise the Golgia tendon organ is sending inhibitory impulses and throttling the flow to the muscle impulse in an early stage. Of that reason the muscle cannot develop the force, which it normally should do. 2)

Via specific neural pathways (F) muscle spindles can sensitivity be controlled by the brain. Stretch reflex may then, with just the right mental stress level during the contest, be triggered more quickly and so on.

1) Processed from J. Nilsson/Seger -92, 10

2) Facts from Grosser, -94, Hatfield -89

The regulation of muscle force (Nerve - muscle coordination)

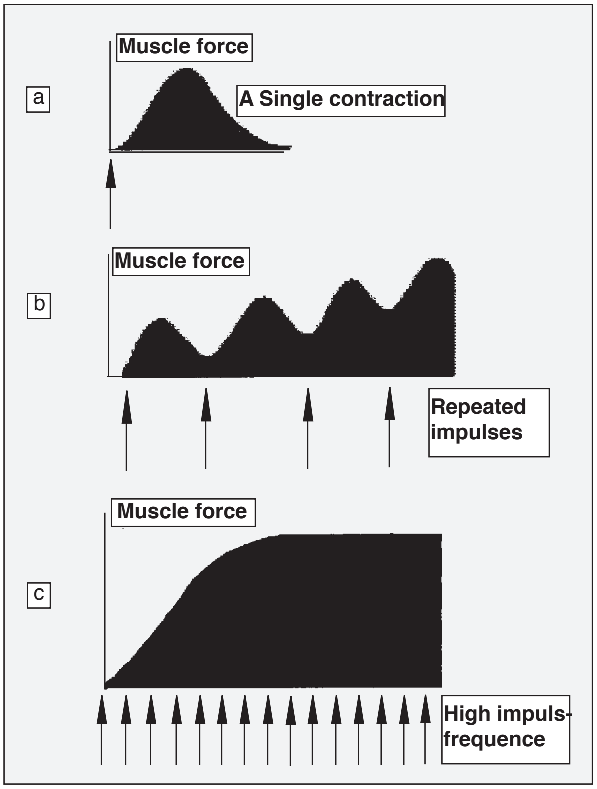


Fig 24 *Variation of impulsfrequence*
Modif. Saltin/Sjöström-85, 22

The regulation of muscle force, called the **nerve muscle coordination**. (**NmC)** We shall later in the training section (page 28, 31) specifically describe how to improve that capacity. Full understanding of the training process requires that we also know anything about the principles that apply to the regulation of muscle power. NmC is also divided:

Intra- and Inter musculary coordination

Intra musculary coordination:

1. Variation of impulse frequency

"If a muscle fiber is activated with a pulse a single contraction (contraction)* is obtained". See Figure 24a.

"If contractions is repeated sufficiently dense, the contractions is summed to each other, ie. a greater force will be developed than in a single contraction (Fig. 24b).

If contractions comes even more frequent it will be a stable high power development "(Fig. 24c). If the force does not increase more at even higher pulse frequency**, the motor unit's maximum peak force has reached. 1)

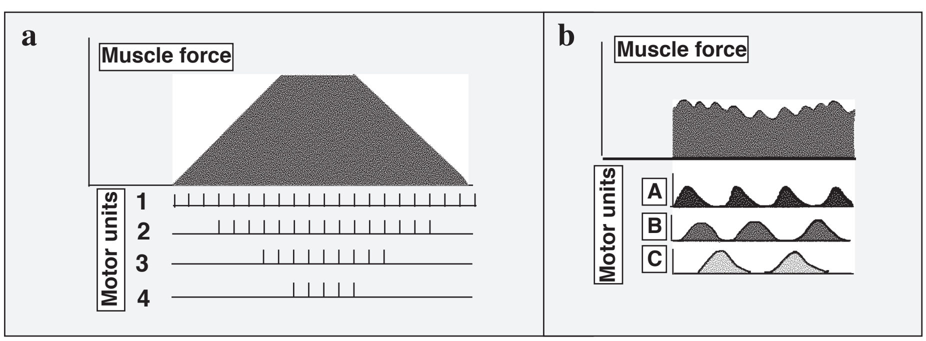
2. Variation of the number of motor units

The force can be increased when more motor units are engaged (recruited)*** See Figure 25a and b

"Fig.25a shows schematically how the motor units are engaged when the muscle strength gradually is in creased. Unit (1), a slow (ST fiber) is first connected and is active throughout the muscle work. Unit (4), a fast (FTX-fiber), is engaged last but will be discon nected first. "2)

Fig.25b shows an example where the "motor unit (A)" load out "four, (B) three and (C) twice in a given time. Together, the motor units gives a relatively smooth force curve. "" 3)

Fig 25a och b
Variation of number of motor units
Modif. P.Tesch-86, 6

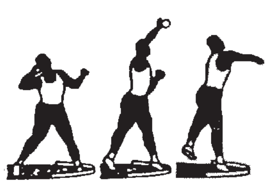


Inter musculary coordination:

Coordination of motor units

By the motor units are coordinated (Synchronized)****, great force can be produced simultaneously, as required in many sports such as for exemple shot put.

Fig 26
Coordination of motor units
(Modif. IPC Stora Sportlexikon 1975, 19



*) Twitch **) Frequency modulating
) Recruitings princip *) Synchronizings princip

1) Saltin/Sjöström -85, 22
2) Processed from J. Nilsson/Seger-92, 12
3) P. Tesch -86, 6

Other properties depending of muscle structure

The complex design of the muscle involving additional factors, which affect muscle strength (see also previous section, page. 11 and 12).

Relation between muscle force - velocity.
A muscle contraction in which muscle is developing force (tension) during shortening, is called **concentric** contraction. The muscle can also develop tension when the muscle is extended - a so-called **eccentric** contraction.

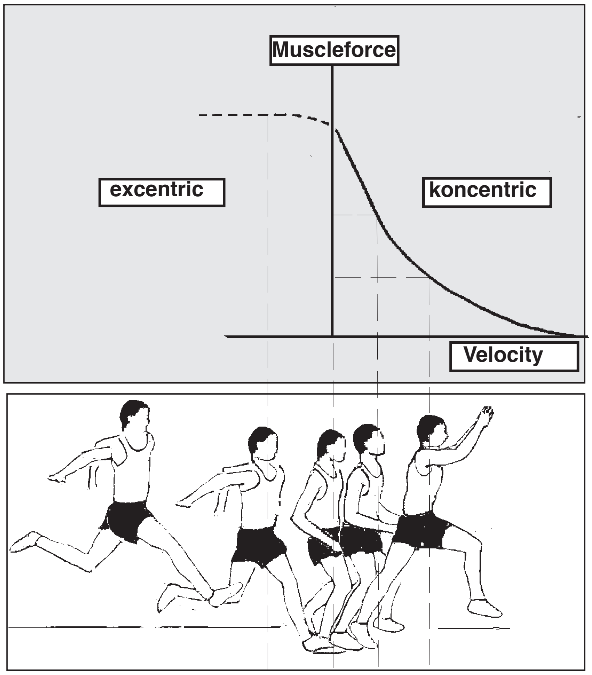


Fig. 27 *Triple jumpers is devloping high eccentric force*

For sport, it is interesting to study the relationship between muscle force and kontraktionshastighet (see diagram, Figure 27). In concentric contraction the muscle force is reducing when increasing speed. In concentric muscle contraction force decreases with increasing speed. This is because there is not enough time to form cross bridges between myosin and aktin filament (See page 11.) in the same quantity, as at lower speeds.

Many sportsmoment, such as in the take-off in the long jump, begins with an eccentric contraction (see also page. 24, Figure 44). According to the relationchip between the force - velocity can the biggest muscle power be developed during the eccentric kontraktionsfasen and even at high speed. This explains that the triple jumpers can create big jumping force (Fig. 27, 32 and 44). See also page 66-73 about longjump.

One explanation for the increase of force during eccentric work could be the theory about the stretch reflex (see page. 15), with the "throttle" from the muscle spindle . A more important reason is that muscle takes up much of the load thanks to its elastic properties.

Relation between muscleforce - muscle length
Figure 28 shows that muscle strength also varies depending on the muscle length. Ultimately, muscle strength, depends on how many cross-bridges that can be created. This depends among others on the impulse frequency to the muscle fiber. The number of possible cross-bridges and thereby force development, however differ considerably at different lengths on as well the muscle, as the smallest units in myofibrillen (see page 4). In normal length (B in Figure 28) the greatest number of cross-bridges can be connected.

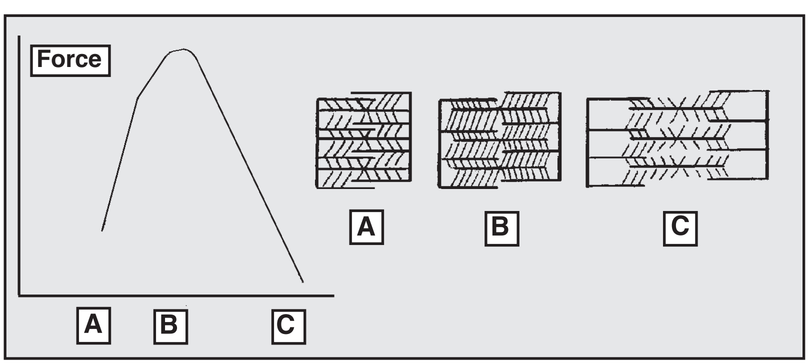


Fig. 28 *Muscular force at different length of the muscle and fibrillens smallest units*

Muscle energy metabolism [2)]

A muscular work requires that energy is available. The muscle produces energy according to three systems (Fig. 29, three-step model):

A. Anaerob process without lactic acid *)
B. Anaerob process with lactic acid **)
C. Aerob process with oxygen

Energy is stored in muscle (Fig. 30) in the form of fat and carbohydrate (glycogen). However this energy must first be transformed into so-called **ATP** in order to the muscle will be able to develop force. ATP must always be present in the muscle as small "energy package".

At a maximum force input, as for example a sprintstart, it is first **energy system (A)**: ATP which is used and lasting about 2 seconds or 3-4 maximum muscle contractions. Order to after this quickly get ATP so-called CP (**Creatine phosphate**) can be broken down. This is enough for about 6-8 seconds (In special cases up to 20 sec), or about 20 muscle contractions (at 40-60% of RM).

At slightly longer muscular work with still high intensity, **energy system (B)** is used: Now the glycogen is broken down with producing of lactic acid . This also provides new ATP as energy. This energy process has twice the capacity, but 50% less power compared to the energy (A).

At prolonged work ATP is produced in muscle fiber's **Mitochondria**, the cell's "power center" (Fig. 30), by the burning of glycogen, glucose and fat. This is **energy system (C)**, which has low power but much larger capacity. Ever occurs this burning process. At harder work, where the pulse is over 115, glycogen storage is used in muscles. For brain functions constant glucose, is needed partly from storages in the liver, partly from the diet we eat after processing in the gastro-sac and small intestine. At rest and light work it is primarily fat burning.

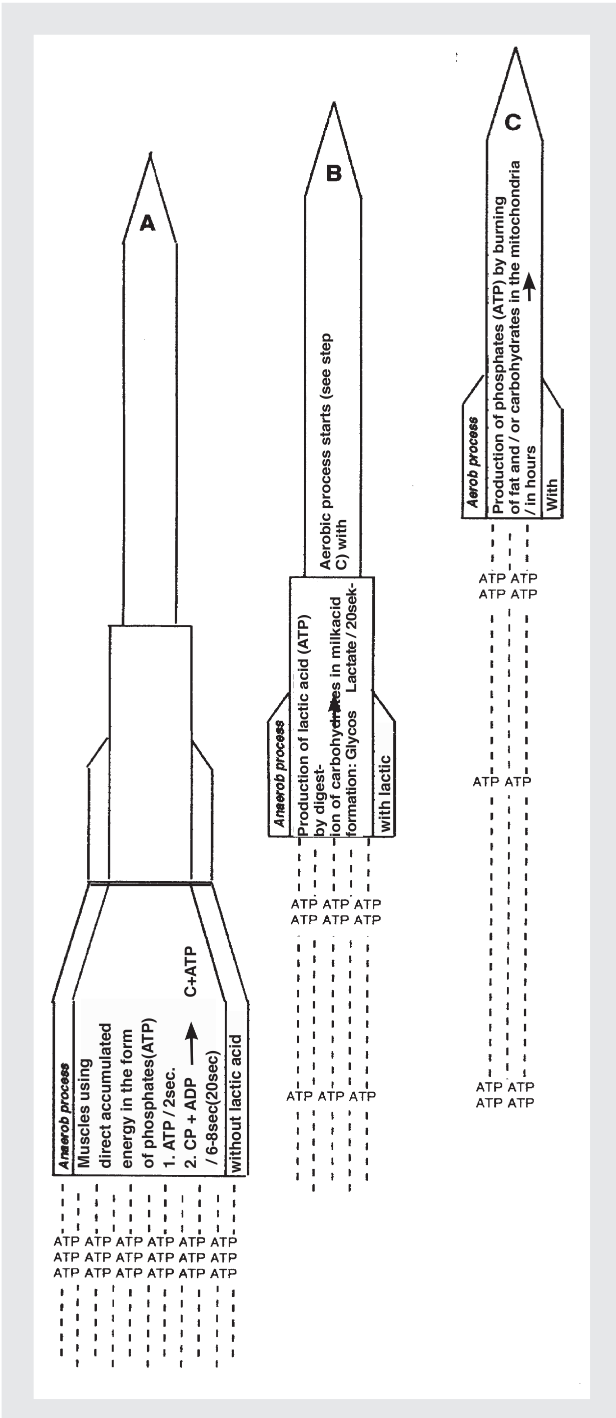


Fig. 29 *Three energy systems, symbolized as a 3-stage rocket 1)*

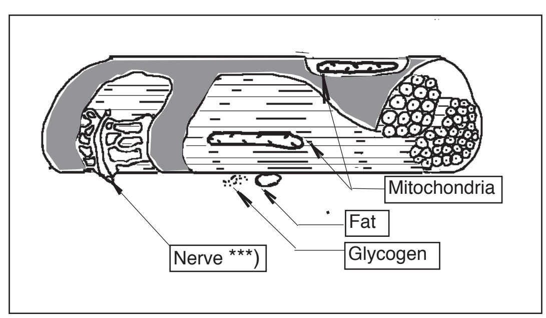


Fig. 30 *Model over muscle fiber* [3)] *with among others mitochondria*

*) Anaerob alactacid
**) Anaerob lactacid
***) Sarcoplasmatic reticulum

1) Author's idea. Table data from Grosser/Zimmermann/Ehlenz -91, 48 and Grosser/ Starischka /Zimmerman -93, 107.
2) Processed from P. Tesch -86. 3
3) Modif. Grosser/ Ehlenz/Zimmermann -91, 22 and P. Tesch-86.

3.2 Muscle strength, mechanical bases

What is muscular strength? Definition

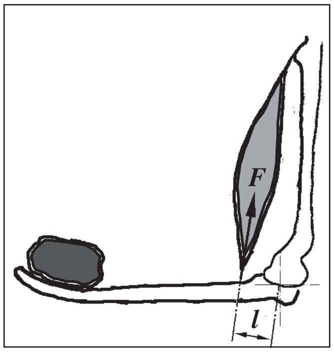
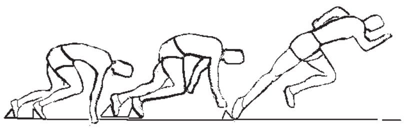
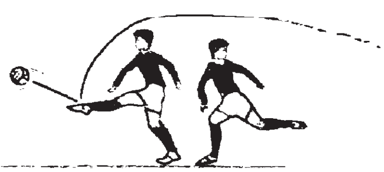


Fig. 31 *The biceps muscle's force and lever arm of the elbow joint*

Muscle Force / Capacity





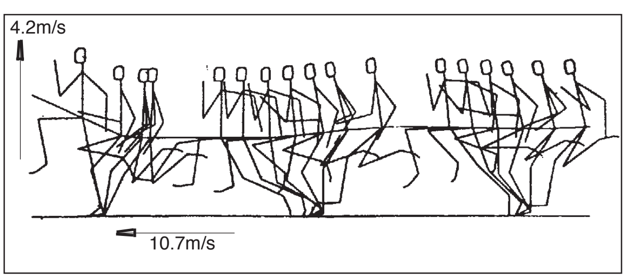


Fig. 32 *Motion analysis using the stick figure, from the film recording (OS-68) shows the last two steps in the approach and the take-off of Bob Beamon's legendary long jump record at 8.90. With such a high speed in the approach as 10.7 m / s and a vertical jump speed 4.2 m / s. Beamon performed an incredibly jump. From these data it is estimated the pressure on his jump leg was nearly a ton.*

With simple mechanical bases, we can better understand the importance of the muscle strength at a sporting performance.

With maximum strength is normally understood as the maximum strength that can be produced in a single muscle movement so-called RM 1 = 1 Repetition Maximum. Different conditions then affect the strength development, such as movement speed and angles of joints.

Muscle strength is also described as the torque of force the muscle can produce around a point with the help of his lever.*) Such a force torque exists in interaction between bicepsmuskelns force and lever arm, which makes it possible to lift and hold a weight in the hand. See schematic illustration, Fig 31st [1)]

Moments of forces = Muscle force x Lever arm

$$(M = F \times l)$$

One purpose of the muscular power in sport is usually to achieve accelerating movements, such as sprint, jump, maybe with gears or ball. From a mechanical point of view, we can see that **force = mass** **) **x acceleration**

$$acceleration = \frac{Force}{mass}$$

The above so-called force equation tells us that the greater the force, the greater the acceleration. If we continue with some mechanics performance in many sporting moments simply could be described as:

Power development ***)

power development = force x speed

---

*) Lever arm = The perpendicular distance from muscle force's direction to the joint's rotation point

**) The mass of the sport can involve such as the body weight

***) $\text{power development} = \frac{work}{time} \qquad (P = \frac{W}{t})$

When work (W) = Force (F) x distance (s) we get

$$P = \frac{W}{t} = \frac{F \times s}{t} \quad \text{och då} \quad \frac{s}{t} = v \text{ (hastighet)}$$

We obtain: P = F x v

"Sport performance = Force x Speed" 2)

1) Processed from J. Nilsson/Seger -92, 3
2) Processed from Grosser/Ehlenz/Zimmermann -91, 12

The link between body weight and relative strength

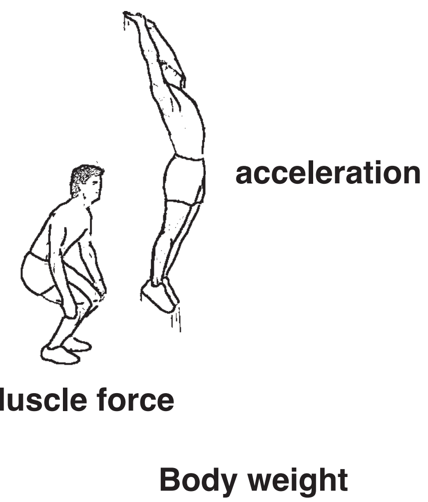


Fig. 33 *The acceleration is equal to the muscle force divided by body weight. The picture shows a ver tical jämfota upphopp, a typical acceleration in a number of sports that require jumping strength.*

	Force *(F)* Spec.strength Exercise:	Mass *(m)* Body weight	Relative strength
Test I	Powerclean: 100kg	70kg	100 *(F)* / 70 *(m)* = 1.43
Test II	Powerclean: 110kg	70kg	110 / 70 = 1.57
Ana-lysis	*10% Improvement Rel. strength increased from 1.43 to 1.57)*		
Test III	Powerclean: 120kg	76kg	120 / 76 = 1.57
Ana-lysis	*0 % Improvement (Rel. strength still 1.57, As a result of in-creased body weight*		

If we study force equation again

$$Acceleration = \frac{Force\ (muscle\ force)}{Mass\ (body\ weight)}$$

and instead of force and mass, in sport, type muscle force respectively. body weight, we realize that in addition to the acceleration depends directly on muscle force, it is inversely dependent on body weight. If this increase muscle force instead must increase percentage more e.g. for better jumping strength (Figure 2).(33).

In a 100m race sprinter accelerates over approximately 60-70m at a maximum speed. Long jumpers must, in near top speed, accelerate the body vertically, soccer player would win the nod duels and so on.

If you train strength e.g. only with slow movements and heavy weights, you will increase relatively quickly in muscle mass and body weight. But then you perhaps are training up a lot of slow fiber type, which are very little involved in muscular power output at a jump or sprint.

If we also plan the nutrition*) for our sportsmen bad (we should have great insight in the importance of nutrition for sport and health), we can easily obtain a "ballast". Too often "sweets", as for example ice-cream, with content of rapid "sugar' carbohydrate and much fat may be the cause.

Ballast, ie. increased body weight does not contribute to power generation, thus implies that the mass in the force equation is increasing. If not muscle strength, and then so-called the Rapid strength is increased by the more efficient strength-training is a great risk to our jumps or sprints deteriorate. The table shows examples of how you, through tests, could calculate the relative strength = muscle force divided by body weight. An Increase in the relative strength factor is a good basic signs of improvement of the speed and jumping ability

*)

To keep down body weight, may not go to exaggeration, particularly girls must be carefully to eat properly. It is a sad fact that there is a anorectic behaviour of many young people in sport. This particularly applies to girls but perhaps also boys today.

Internal and external moments of forces

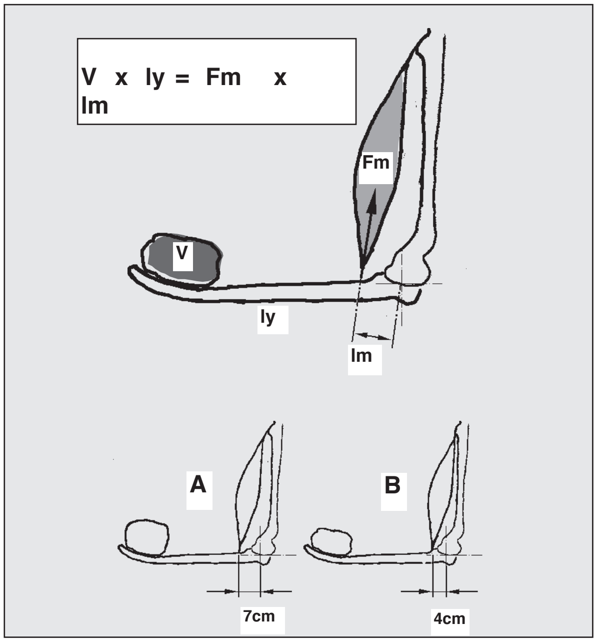


Fig. 34 *At the Top shown internal moment (Fm x lm) and external moment (W x ly) at a weight lifting. Bottom two people with different internal lever lengths*

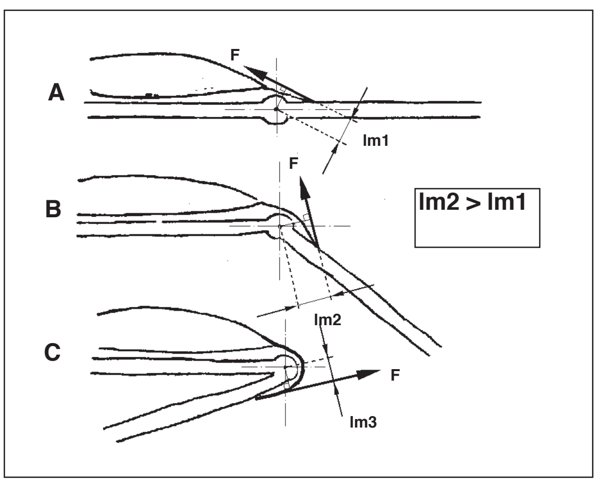


Fig. 35 *(Schematic layout)*

In the opening section (1.1) we defined inter alia muscle strength as a moments of forces:

Muscleforce x Lever arm

Now we shall analyze a simple weight lifting (Fig. 34) with a biceps muscle. Then we need to distinguish between an internal and external moment.

If the biceps develops the Power ***Fm*** and has lever arm ***lm***, constitute ***Fm x Lm*** the internal moment. The external moment is formed of lever arm ***ly*** (= forearm length) x weight ***V.*** In order to keep the weight lifted in position as shown, there must be a balance between external and internal moment i.e.

V x ly = Fm x lm

The importance of the internal moment.

Example: Two people (A and B) may have different attached points for his biceps muscle in the forearm (Fig.34 A and B). For the biceps tendon attaches A 7cm on forearm. B has an attachment point 4 cm from the joint center. If both then develop the same muscle power, A will achieve much greater moment of force and therefore be able to lift more weight. 1)

The moment of force also varies according to different angles of joints. Figure 35 shows the schematic for a knee extension.The internal lever arm is greatest in position B. Fig .36 shows the measured moments at different knee angles and speeds. Here the current muscle length, has although (Cf. previous page.17) great importance.

The importance of the external moment.

Example: A person A with long arms have a greater external moment in such as bench press than person B with shorter arms. B therefore need not perform equal muscle force as A at the same weights

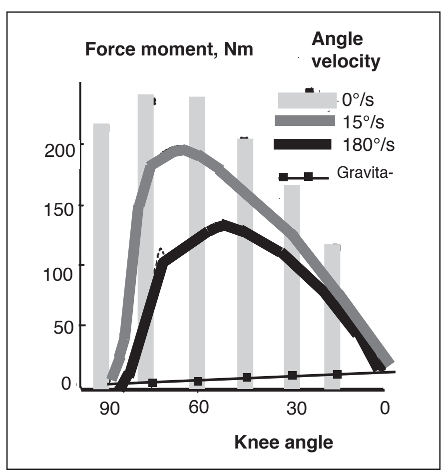


Fig. 36 *Strength variations at different knee angles and constant movement velocities (0 ° / s (= Isometric) 15 °/s and 180 ° / s) measured at a spec. dynamometer testing.* 2) 1)

Modif. from A. Thorstensson-85, 59

1) Bearb. ur P. Tesch-86, 9

Different types of level arms. **People use three types of lever arms:**

I. The most common lever arm with the base (pivot axis) is located at one end, resistance in the second and muscle force between (Fig. 37). The figure shows as example an armcurl with weight.

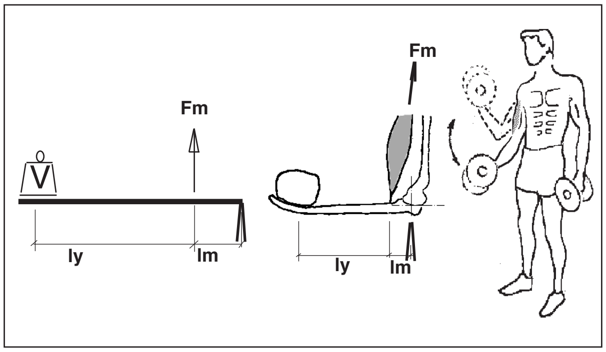


Fig. 37 *Leverage example I: Weight lifting with the biceps*

II. Where the base of lever arm is located between muscle force, in our example (Fig. 38) tricepsmuscle, and the external resistance. The figure illustrates this with tricepspress with barbell and throw with the arm or similar motion.

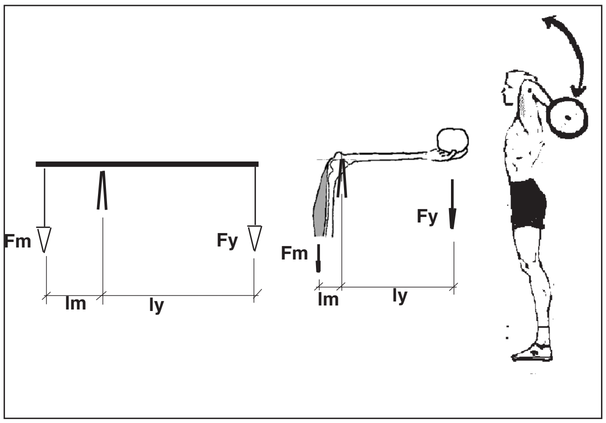


Fig. 38 *Lever example II: Is used for example when throwing with the arm alt. tricepspress*

III. Both the external resistance and muscle force are on the same side as the base but directed in different directions. In our example (Fig. 39) the muscle force **Fm** of the calf muscle is pointing up while the body's gravitational force **Fy** is directed downward through the lower leg. Here we use a toe raise as appropriate motion to show this kind of lever.

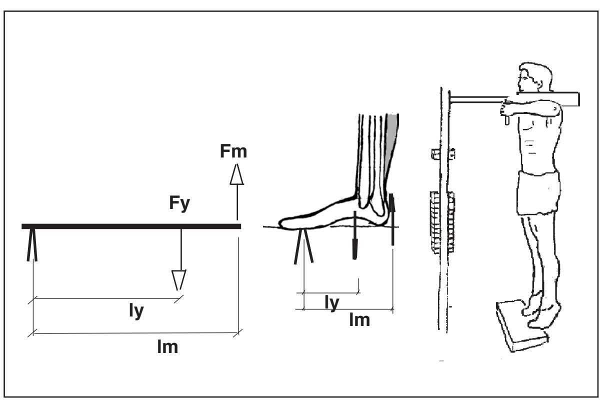


Fig. 39 *Lever example III: Toe raise*

It is not difficult to imagine the how great impact hereditary differences in leverage ratio may have to develop force and speed.

In all of the above examples the case is a short internal lever and long external so-called resistance arm. This is favorable for the development of higher speed, eg movement of an object (in the sport: Throwing tools, body weight, etc.). Short stature weightlifters, who inherited the long internal lever, has good conditions to develop great power in its lifting. A long throwers instead has special leverage ratio in order to give the throwing equipment high-speed. 1)

1) Processed from G. Dyson -72, 69

Specific strength (movement angles, -velocity, -technique). Powersprint®

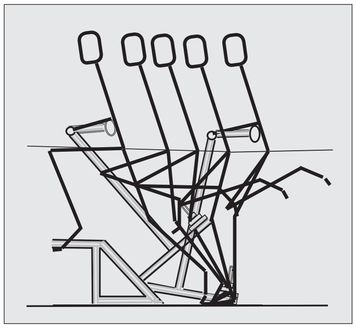


Fig. 40a *Special strength machine* ***Powersprint®*** *for sprint and jumping* 1)

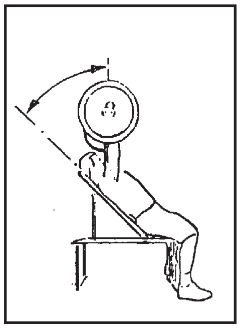


Fig. 40b *Discipline-specific training for shot putter*

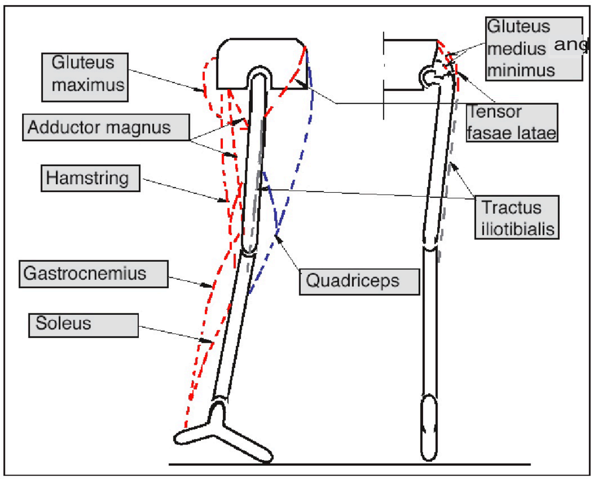


Fig. 41 *Schematic layout for understanding the muscular function of the hip, knee, and ankle.*

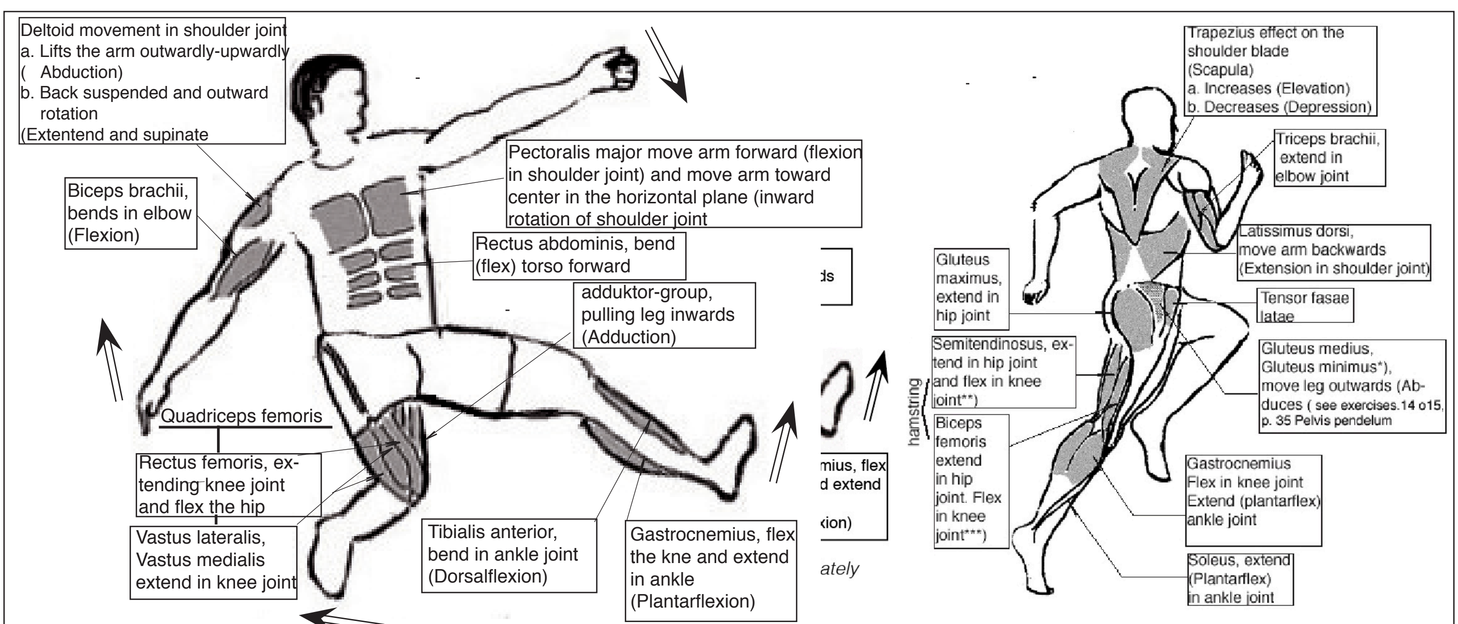
In the case of the specific strength training (more about this in chapter 3.4) the operating angles of the strength exercises should be in close conformity with technique in the sport's discipline (Fig. 40). This is due to that improvements in muscle strength is so "specific" related to how and what you practice. For this the have developed a Special strength machine for sprint and jumping called **Powersprint®** 1)

Since muscle strength or force moment varies strongly depending on angles of the joints, we understand that shot putter is training specific strength with for exemple oblique bench press (Fig. 40b).

When you train more special strength training for competition you should, except angles of the joints, also be thinking of form of contraction and movement speed. See pages 24 and 32

You must have knowledge of muscles and movement techniques in your sport. In Figure 42 (football and fast running) we can study the most important muscles seen from the front and rear.

A schematic layout (Fig. 41) can help us better understand muscular function of the hip, knee and ankle.



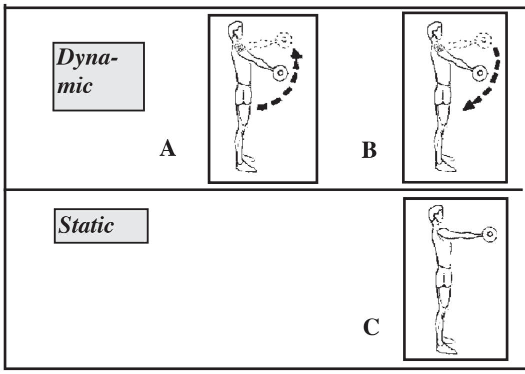
The drawing shows a long jumper with hitch-kick technology immediately before landing.

Fig. 42 *The most important muscles*

1) **www.powersprint.space2u.com**
*) m. gluteus minimus is completely covered by the m. gluteus medius
**) These muscles covering almost a third: m. semimembranosus

3.3 Strength, different concepts, muscle working methods and type of contraction

The table below together with Figure. 43 A-C sums up different muscle work and type of contractions. [1)]



MUSCLE WORK	TYPE OF CONTRACTIONS
"Keeping against" in-motion and "overcoming" (A)	**Koncentric** [2)] **(A)** Contraction with shortening
Keeping against in-motion and "give after"(**B**)	**Excentric** [2)] **(B)** Contraction during lengthening
Keeping against without motion (**C**)	**Isometric** [3)] **(C)** Contraction without length change

Fig. 43 *Ex. Dumbbell Lift for the shoulder muscles*

1) Processed from Grosser/Ehlenz/Zimmermann 1991, 59

2) **Isotonisk =** Unifying concept for the contraction of length change of muscle. Som pure form rare. Instead there are mostly together with Isometric contraction as above.

3) The type of contraction is rare in pure form but instead as: Isometric-Concentric alt. Isometric, Eccentric

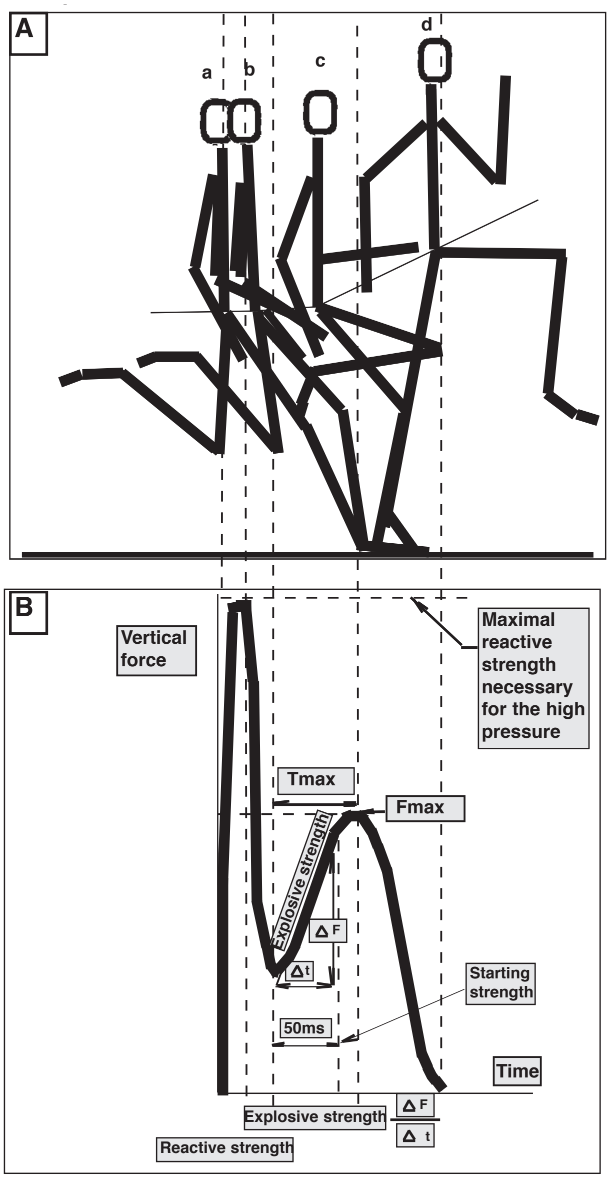


Fig. 44 *Biomechanical analysis of a longjump.*

As examples of the different muscle work and type of muscle contractions muscle is showing shown in Figure 44A and B, a biomechanical analysis of a longjump .[4)] With the help of motion description with line figures and a so-called pressure diagram can the take-off be analyzed as follows:

Muscle work and type of contraction, fig. 44A

a - c : Elastically give after
(**Excentric** type of contraction)
c : Keeping against
(**Isometric** type of contraction)
c - d : Keeping against and "overcoming
(**Koncentric** type of contraction) at last counterforce from the track with an "ex plosive drive".from the board.

Strength forms - different definitions, fig44B

With help of the pressure diagram and strength tests different kind of strength forms can also be analyzed (se äv. sid 25):**Maximal reactive strength**
Explosive strength
Speed strength
Start force

Linguistic meant by the Speed strength usually same as explosive strength. The measurement technology (according Byhle 1985) the following definition:

Start force: Reached force after 50ms

Explosive strength: $\frac{\Delta F}{\Delta t}$ (the slope of the curve)

Speed strength: $\frac{Fmax}{Tmax}$

4) Processed from Grosser/Ehlenz/Zimmermann 1991, 61, 65
- " - Hatfield 1989, 11

3.4 Strength training for speed

General. What happens to the body in the training of strength

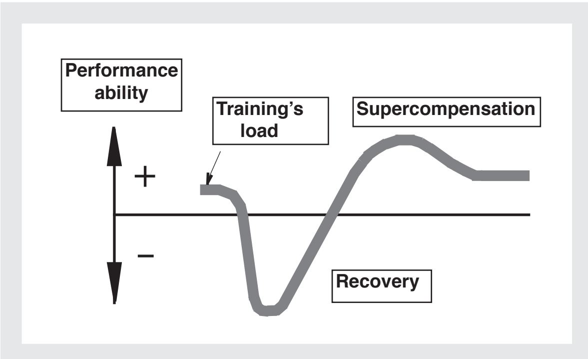


Fig. 45 *Schematic picture of performance ability at training's load and recovery.*

See Figure 45. When the body is exposed to training load "body tissue is broken down and the performance ability deteriorate. Eventually it happens a recovery and tissue's adapting (so-called super-compensation) to the new requirements. All-round strength training improves the following: [1)]

- Muscle strength increases due to that the muscle volume increases
- Nerve-muscle coordination.
- Reactive strength
- muscle contraction speed
- Muscle's ability to produce energy.

General principles of training planning

The following general principles should be considered when planning training. [1)]

- Just enough rise of load *)
- The balance between training load and recovery should be balanced.
- varying training load, so-called pulsation.
- Planning of training's periods.

Load and recovery. Pulsation.

The following table summarizes the most important factors, which constitute training's load.

The table lists the main load factors for strength training. These vary with the individual "feeling", and after a carefully prepared training's planning.

Frequency	Training's load	Intensity		
		Weight Load	Pause	Pace
Number of workouts per week and days	Set. Reps Tons.	% Of 1 RM = 1 repetition maximum	Min	Kontraction speed

Different training's loads means different great tissue degradation. The time required for recovery is individual and depends, inter alia, the type of workout, intensity, quantity, etc.

The following table[2)] indicate examples of 90-95% (almost complete) and 100% (full) recovery during training for muscle hypertrofy training respectively speed strength alt. reactive strength.

Examples of the recovery times, which may be required in ¨ "Muscle hypertrofy-" respectively. speed strength- alt. reactive Strength training. [2)]

	Muscle hypertrofy training	Speed strength alt. Reactive strength
Almost complete recovery (90-95%)	3/4 - 1 Day and night	3/4 - 1 Day and night
Complete recovery (100%)	2-3 day	3-4 day

*) s.k.Progressivity

1) Processed from Grosser/Ehlenz/Griebl/Zimmermann-94, 26-28

2) - " - " Grosser/Starischka/Zimmermann/Zintl -93, 77

At almost full recovery good training's results can be achieved in direct subsequent day of training. However, days of rest and easier training days should be added in the week so that next week begins full recovered

Fig. 46 *Example of weekly pulsation with rest days*

Fig 46 and 47 show example of a week's training (So called microcycle, see page 29). To vary the training load with lighter and heavier training days, weeks and alternating periods called training pulsation. For example, a long jumpers weeks may consist of the following training:

Måndag	Tisdag	Onsdag	Torsdag	Fredag	Lördag	Söndag
Strength	Jumps Tech-nique Speed	Plyomet-ric trai-ning	Rest	Strength	Speed	Rest

Fig. 47 *Examples of the weekly ("Microcycle") training*

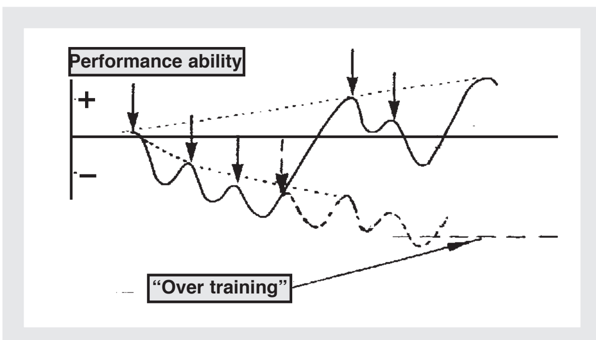


Fig. 48 *Performance ability with days of rest (seamless drawn in fig.) Performance ability without days of rest (dashed in Fig.)*

Seamless drawn in Figure 48 shows schematically how the performance ability may vary during the week. Important to both coach and the active are aware of what's happening. A degree of "finger sensitivity" may be needed.

After 2-3 weeks of training you need an easier week to avoid "overtraining" (dashed i Figure 48) and get a good balance between training load and recovery. Different variants of the weekly pulsations shown in Fig 49.

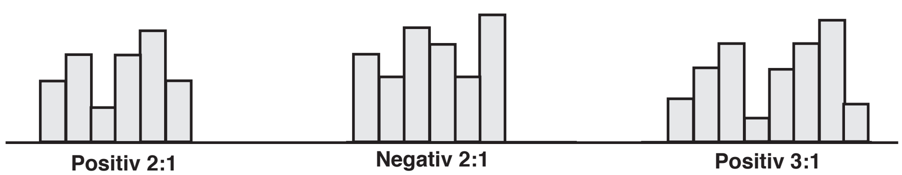


Fig. 49 *Weekly pulsations*

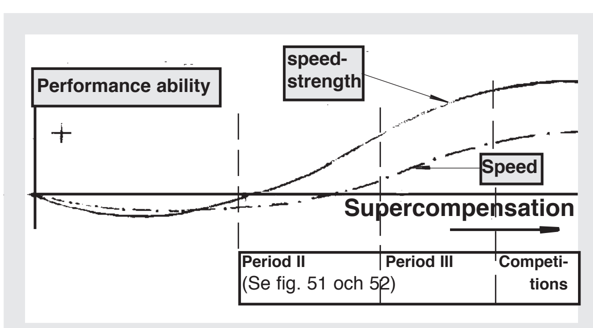


Fig. 50 *Performance will fall slightly, to gradually increase by superkompensation, first speed strength and a little later speed.*

After several weeks of high training's load, the performance nevertheless reduces slightly (Fig. 50). Then you lower the total training's load during a few weeks . The intensity continues to increase, but by the significantly decreased the amount of training a major super-compensation can be obtained by ascending form. The Figure 50 shows this schematic with speed strength and speed as an example.

In the next section, we continue the planning of strength training for speed. We then give examples of specific training in different sub-periods. Examples of more complete training's planning, which also includes speed and technique training will be dealt with later in Chapter 4.

Planning of training periods

Reactive strength (RS)*)			
MAXIMAL STRENGTH (MS)		SPEED STRENGTH (SS) alt.	
Anatomic adaption (Aa)) (Hypertrophy) 3 (Mh) + (SS)	Nerve-muscle (“Intra/Inter-muscle”) Coordination (NmC)	SS + NMC + RS	
40-60(60-80)%	75-85%	55-60 / 80-90	
4-8veeks	3-5v.	3v.	5-12v.
General preparation Period I	Specific preparation Period II	Competition-preparation Period III	Performance peak Period IV

Fig. 51 [1] *Period schema, half-year period*

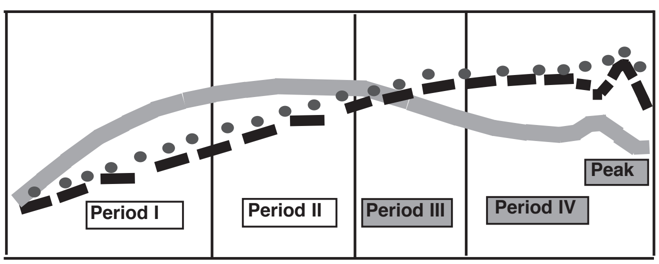


Fig. 52 [2] *Training volume*:
Intensity:
Shape (performance):

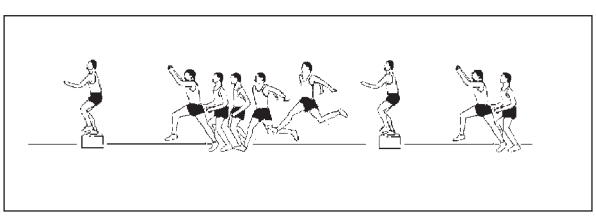


Fig. 53 *Box-jumps with high intensity*

It is not possible to maintain high performance in the sport longer than about two months. We must also build up our “shape curve” with a phased plan of development , spanning several years. This is among others the reason for the scheduling of training in sub-periods, with the general and specific requirements for the sport in correct balance relation.

You can choose to plan for a full-year but usually the most popular is planning in half-year periods, because of the advantage with two contest periods per year. It can facilitate the motivation and high-quality training in a shorter period. Examples of such are we now describe, with the help of Figure 51 and 52.

Examples, period planning, the main content [1]

Figure 51 shows an overview diagram of the fitness goals of different sub-periods . Figure 52 illustrates how the training volume, intensity and shape curve are planned schematically.

General preparation, period I (4-8veckor):

- Slowly increasing training volume (size) and intensity (Fig. 52). More focus to train the entire body.
- Anatomic adaptation **(Aa)** to heavier loads. Certain slight
- hypertrophy[3]: 15-25rep, 40-60% alto. 10-6, 60-80%. (Sid.27-28)
- Reactive Strength (**Rs**) is trained to begin with plyo metric so-called long multi-step (12 alt. 15 jumps /series, see sid33).

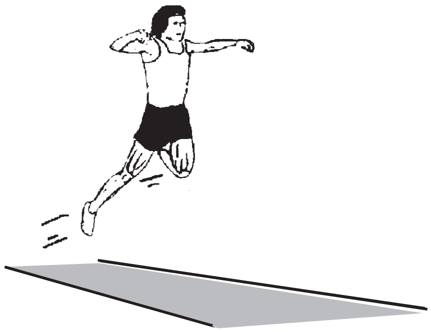
Specific preparation, period II (3-5veckor):

- The training volume “levels off” and remains on the highest level from the period, while the intensity increases (Fig. 52).
- Specific training for speed.
- The training is now aiming to improve the nerve-muscle coordination (**NmC**) (Intra/Inter-musculary coordination (Se page 16)) : 1-5 rep, 75-85%.
- In the training of reactive strength now also plyometric so-called short multi-steps (3, 5, 10 jumps / series, see p. 33) are included.

Competitions, period III (3v):

- During the weeks you prepares for competition, the training volume is reduced and the intensity increases.
- For sprint and longjump which requires “explosive” speed, reactive ability, etc. the training now is aimed to even better neuro-muscle coordination (5-1rep, 80-90/100-150%). At the same time the specific speed strength training (Ss) is starting: 6-8rep/55-60%. The intensity of the reactive training is increased further with higher volume of “short-short” high-intensive multi-steps (3 o 5 steps / series) and so-called depth jumps (“Box-jumps”, see page 33).

1) Processed from Grosser/Ehlenz/Zimmermann 1991, 131-134
2) Processed from Bill Freeman 1989, 39-46
3) Muscle-cross section increase. For speed and jumping ability applies primarily to increase the relative strength. Therefore, the general training, which of course usually consists of more reps and sets, is made with good judgment by the coaches and the active for only moderate or slight hypertrophy. Maximum- and speed strength are improved mainly by improved NmC.



Performance peak, period IV (6-12 veckor):

- During this period, the aim is only to maintain muscle strength, why the volume of weight training is reduced to low levels. At "performance peaking" the volume is usually increased two weeks before important competition, while during the last week the intensity increases and the volume is reduced.
- The intensity is high throughout the period.

Transitional period (see fig. 54 och 55)
The purpose of this period, is mental and physical recov ery, which is achieved through:

- "Active rest" with easier general development activities, like jogging, swimming, other sports
- Eventual medical therapy
- Very small volume of training. Performance should not fall too much. As basic of later training, you can even increase general fitness something.

Examples of full-year (single) periodization.
Other terminology: Macro- Meso- Micro Cycles.
Figures 54 and 55 shows an example of a full year schedule, a "Macrocycle" for a whole year where the focus is primarily on outdoor season. In a "mesocycle" of eg three weeks could one or two competitions be put in . Example: The programs on pages 66, 76. consisting of "Microcycles" (usually weeks) with training days with varied training volume (See (page 27 about pulsation).

GENERAL STRENGTH		REACTIVE STRENGTH (HS)			
		MAXIMAL STRENGTH (MS)		SPEED STRENGTH (SS) alt.	
General fitness	Circuit-training	Anatomic adaptation (Aa)	Nerve-muscle Coordination (NmC)	SS + NMC + RS	
		40-60(60-80)%	75-85%	55-60 / 80-90 / 100-150%	
4v	6v	11v	15v	5v	11veeks
Transi-tional period		General preparation Period I	Specific preparation Period II	Spec. prep. P III	Performance peak Period IV

Fig. 54 *Period Schedule, full-year*
1)Processed fr. Grosser/Ehlenz/Zimmerman 1991, 131-134

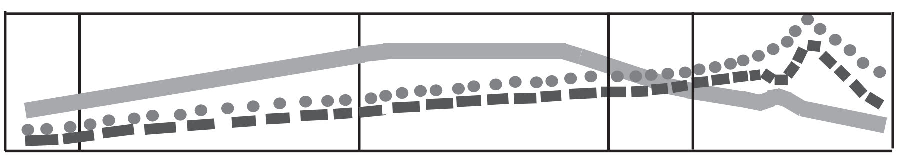


Fig. 55 (Processed fr. B. Freeman 1989, 48)
Training volume:
Intensity:
Shape (performance):

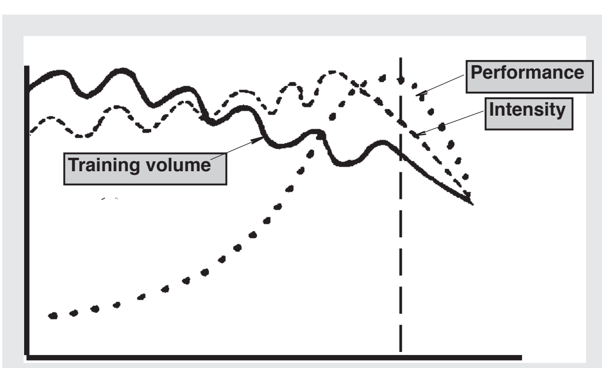


Fig. 56 (Processed fr. B. Freeman 1989, 48)

Period planning for elite.
For elite athletes, that can handle larger volumes of training applies all the planning principles we talked about earlier but with one significant change (see Figure 56). Instead of a slow increase in the volumes of training, the training start with a large volume, which then gradually is reduced while the intensity increases up to performance peaking.

Maximum strength

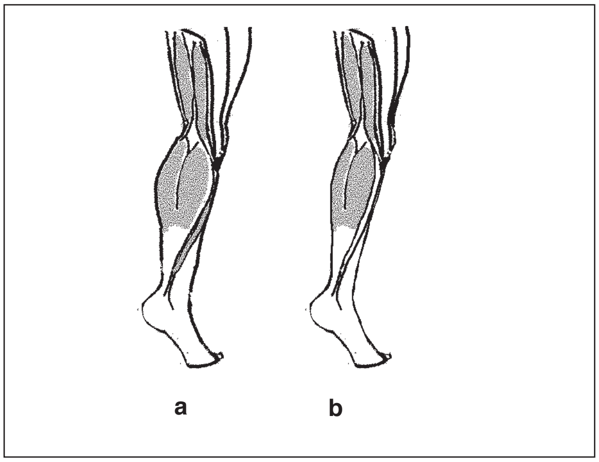


Fig. 57 *How comprehensive should a sprinter train muscles?*

Method 1				
Performance: Rapid movement gearchanges ("Pump" Eccentric-concentric continuous work until easy fatigue ("ATP-discharge")				
Load	**Rep.**	**Pause**	**Set**	**Tempo**
40-60% of RM	**15-25**	**3-5min Gladly longer**	**2-3 /exercise (1-2 övn. / muscle group)**	**Fastest possible**

In the latest section, we planned strength training into periods, among other things, with an overview plan. If the ambition is improved speed and reactive strength and finally speed the basic concept is usually to improve maximum strength. Each year should then be started with a few weeks of "anatomical adaptation" with some limited hypertrophy for later heavier loads during specific preparing periods. Its volume and choice of training method should be carefully considered individually (fig.57) and for sprint / jumps in particular is minimized to promote the relative strength (see page 20).

Here we shall now describe three methods, of which the first (method 1) is particularly useful during the initiation phase of adolescence. Then the method is used whith the body, as the only load or with light weights (40-60% of RM) and are known as the gymnastic for strength or circuit training. It is used often by the elite sprinters, with both general and specific exercises.

Anatomic adaptation (Aa),[1] period I

In period 1 (see Figure 51 and 52) you can train with lighter loads (40-60% / 15-25rep/set) by **method 1** (see table). It is important to use a long rest between each set (3-5min) so that the exercises can be carried out with high intensity and work for developing speed. This can be achieved if the training is carried out with so-called circuit training. Then one goes from exercise to exercise until 2-3 laps are completed.

Efficiency of the training:[2]

- Some limited muscle hypertrophy with improved maximum strength, but also improved speed strength endurance.
- By relatively fast performance and large number of reps. primarily fast FTA fibers with endurance should be trained
- The method provides a good basis for improved force development in stretch-shortening phase with the stretch reflex and the elastic properties. Tendons and attachments of the muscle becomes stronger, which means that inhibitory impulses of Golgi tendon organ are delayed (page 15) which means even more opportunity to develop force.
- Improves the so-called start force (explosive start of muscle contraction).
- Improves the speed of contraction .

*) The anaerobic alaktacida phase

1) Tudor Bompa
2) Processed from Grosser/Starischka/Zimmermann/Zintl. 1993, 62, 64.

Method II				
Performance “Controlled” performance, during the eccentric phase followed by an acceleration during concentric phase.				
Belastning %	**Rep.**	**Pause**	**Set**	**Tempo**
60 - 80	10 -6	2 - 4	2-3 /exercise (1-2 övn/ mucle group)	Slowly to fast

NmC-Metod				
Performance: 80-90% ”Accelerating” with explosive maximal force effort. Concentric muscular work** . Variant: Maximum “Explosive” kraftinsats. Lower weights, 70-80% allowing higher moving speed and 2-3 extra reps. Concentrically - Eccentric.				
Belastning	**Rep.**	**Pause**	**Set**	**Tempo**
80-90 (-100%) alt. 70-85%	3-2 ** alt. 6-4)***	3-5min Gladly longer	2-6 One exercise / muscle group	Accelera-ting with explosive force

An alternative is to train with concentration on a perfect (“controlled”) performance with full range of motion according to **method II** (The bodybuildings method). Normally this method is used by bodybuilders with a slow moving speed. At training for speed the method is used with concentration on acceleration during the concentric phase. [1)]

Efficiency of the training:

- Since the development of power is lower (see speed strength, page 32) with a slower motion performance and increase of muscle volume become too large (possibly worse relative strength, see page 20), one can be critical to the method. Individually, the method may yet function perfectly well *). A key advantage is that it also allows training of the fastest FTX fibers. A condition for this is heavier weights and fewer repetitions. (8-6 rep/set).
- With slow performance at heavy weight loads fast FT-fibers are trained , but also slow ST fibers .*

Nerve - muscle coordination, period II.

Maximum strength is also largely dependent on the nerve-muscle coordination **NmC**(see page 16).This strength factor is trained with fewer reps and heavier weights. In the planning period II, we write **NmC method**** to create maximum strength. NmC is also required for “explosive” force (see page 24). In a variant of the exercise includes 2-3 extra reps*** with somewhat higher moving speed (see Table). No use of a slow eccentric phase, but rather focus on a rapid shift between the eccentric and the explosive concentric phase. We can call the method **NmC-”Explosive”** (auther). [2)]

Efficiency of the training:

- Insignificant increase in muscle volume due to the explosive performance = short tension time. For increased muscle growth, prolonged tension with such as increased number of reps., heavier weights, which leads indirectly to slower movements, eccentric periods etc.
- Improves nerve-muscle coordination and thus maximum force. This coupled with the moderate increase in muscle volume means improved relative strength = better acceleration capability (page 20). The Strength training method is popular with sprinters and jumpers.
- Improves the start strength why indirect the speed strength is improved. (se sid 24 och 32)

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*) For sprinters, equipped with - say 40-45% slow-ST fibers, the volume growth of these (training effect of method II) ought to be a clear disadvantage. ST fibers may then give too much body mass, which adversely affects acceleration capability (page 20). Equipped with very few (perhaps 20%) ST fibers, common among elite sprinters, this perhaps has less useful because of the fast FT-fiber predominance.

**) Another name: Intramuscular coordination (Ik method)

***) Training Examples.: 4 x 5reps /80-85% (See page 43, Fig. 93 Carl Lewis)

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1) Processed from Grosser/ Starischka/Zimmermann/Zintl. 1993, 61-62
2) - ” - - ” - - ” - - ” - - ” - „1993, 64-65

Speed strength

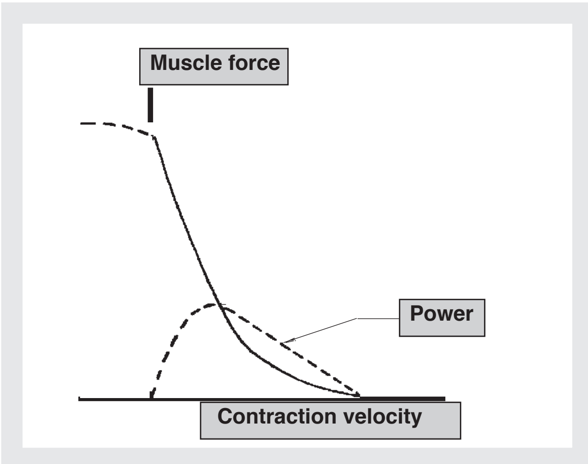


Fig. 58 *Force-velocity diagram with development of the muscle power*

Muscle Power method Train the ability to develop power (see page 16)				
Performance: Explosive acceleration by 55-60% **) load.				
Load	Rep.	Pause	Set	Tempo
55-60%	6-8	3-7min	2-4 / exercise	Fastest possible with 55-60%**) load

Speed strength method Train the explosive ballistic ("bouncing") speed strength.				
Performance: Explosive, fast and ballistic ie. "bouncing" up the load. Concentric muscular work.				
Load	Rep.	Pause	Set	Tempo
30-40%	6-8	3-7min	1-4 / exercise	Explosive fast

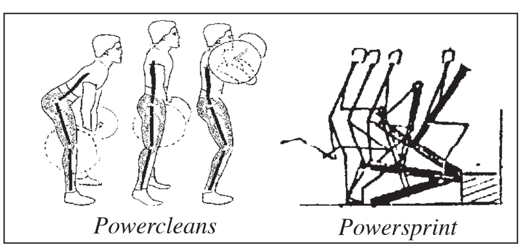


Fig. 59 *Specific exercises for speed running*

We are now studying force-velocity diagram (Fig. 58), which also contains muscle power development. We were agreed that this was what ultimately decided speed performance in a speed demanding sport (page 19).The diagram shows that the power is greatest at about 30-35% of maximum load. However, this is in a single muscle. In practice, it is about muscle groups in action and the best kind of "power training", it is calculated to 55-60% of maximum load.

Competition preperation, period III

After training maximum strength Nk method of 3-5 weeks we will start competition preperation in period III with speed strength training. Then we usually use the so-called **Muscle Power method** [1].
Training efficiency:

- Improves, If the exercises are done branch-specific, the coordination of the current sport.
- Improves maximal power.
- Improves the activation (page 16) of FT fibers.
- Improves nerve-muscle coordination by increasing the frequency of nerve impulses to muscles, which means more "explosive" strength.
- Improves the speed of contraction for both the slow ST-, as fast FT-fibers.

Another training method, ideal for branch-specific training because of the light load, is called simply **speed strength method .** Training efficiency: [1]

- Same training efficiency as above. The speed strength method is especially suited for branch-specific exercises and therefore it has directly impact on the sport.
- The method, which is performed "bouncing" with light weight loads, corresponds to plyometric training The principle of that method is described in next chapter.

Examples of specific training:
The olympics - **powercleans** have shown to be an effective specific training for sprint speed. To get even closer to a real sprint stride and also use the pelvic side's musclegroup (see page 38, exercise 15) a special machine*) so called **Powersprint®**(fig. 59) has been constructed by the author. See also p. 23, 57-60, 66 and 76

*) In the 1990s sprinter coach Håkan Andersson in Sundsvall, tried a prototype of the machine primarily intended to develop the hamstrings and gluteus explosive force in hip extension, but with less focus on specific sprint technique. The result of this exercise was positive for Sweden's then best sprinters Peter Karlsson and Torbjörn Eriksson. Maybe marginally so yet certain contributory factor to an indoor European Championship bronze in 60m or 200m. In the 2000s the swedish soccer player Christian Hemberg built up his speed with the machine. Several coaches have responded very positive to this equipment idea. For example Tom Tellez (the author got a talk with him in Houston 1999) and Leif Dahlberg, coach for the swedish 8m longjumper Mattias Sunneborn,

1)Processed from Grosser/Starischka/Zimmermann/Zint 1993, 68

Reactive strength

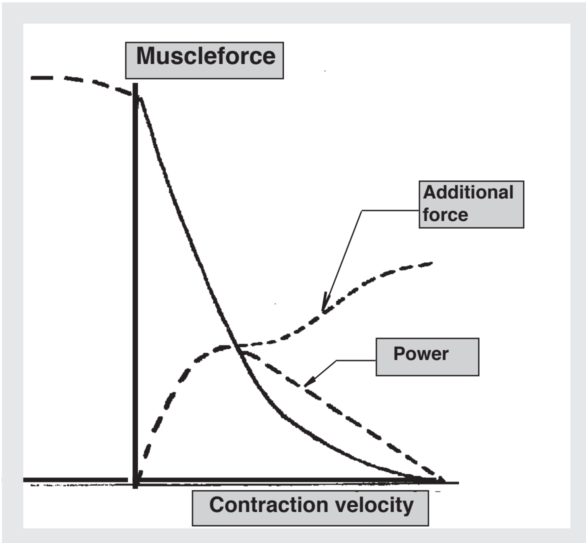


Fig. 60 *Force-velocity diagram with muscle power development och elastic additional force*

Multi-step jumps for reactive strength training

Performance:

Maximum or near maximum. force action on preferably as so short time as the 200ms. Example: 5-step jump with six strides in the approach, see Fig 61

Eccentric-concentric muscle work.

Load	Rep.	Pause	Set	Tempo
Body-weight or 3-5% weightload	"Short": 3,5,10 "Long": 12, 15	2-7min	2- 4 / exercise**)	Maximal velocity

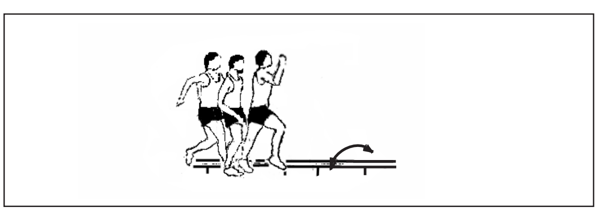


Fig 62b *"Ankle jumps", low quick jumping in zigzag over a line or a low bench.*

*) We usually separates on short- and long multi-jumps

See pages 12 and 15. Here was treated on the one hand muscle's elastic characteristic, on the other hand the so-called stretch reflex. These can in conjunction contribute with a hefty additional force (fig.58), which for speed demanding sports can be of crucial importance for the performance. It's about force development, such as in a jump, during very short time (<250ms).

The ability to develop this force, which we called **reactive** or **plyometric** ability, can be significantly improved with methodical **reactive strength training**. Figure 61, 62a and 62b gives examples of some of the usual forms of so-called mul-ti-step jumps. The corresponding reactiv ability in the upper part of the body can be trained, such as with medicine ball.

Training efficiency:**:**[1)]

- Provides specific strength for jumping ability and löpsnabbhet.
- Fast FT-fibers are engaged
- Strengthens tendons and muscle attachments (pages 15 and 30)
- Jump training in uphills with many repetitions and short breaks are an excellent specific training for many sports. It improves among other things, speed endurance.

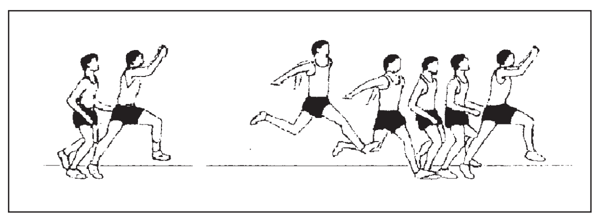


Fig 61 *The figure shows the so-called "One leg jump". One can jump eg solely on left leg i one serie, next on right leg and so on. Other usual ways to jump:*
- *left-right-left-right*
- *left-left-right-left-left-right .*
- *right-right-left-left-right-right*

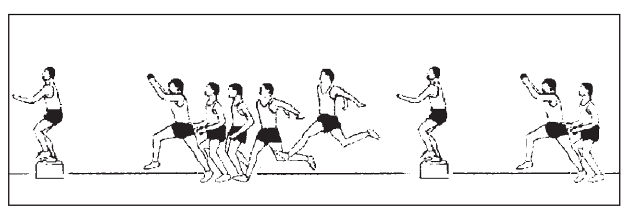


Fig 62a *"Box-jumps', favorite exercise for Carl Lewis and others U.S. sprinters.*

1) Modif Grosser/Starischka/Zimmermann/Zintl 1993, 70

Strength exercise storage

Here is now a storage with examples of strength exercises to be used with different focus - general preparing, “regenerating”, injury preventive, strength endurance or speed and so on. Two first simple example of the strength training program for speed on pages. 43-44 have been created with the help of our exercise store. You can be yourself using this to compose a personalized program. Muscle or muscle group is marked in Fig. An overview table of figures (page 42) and appendices with software giving us, finally, an overall picture of the material. See also fig 41 and 42, sid.23

Exercise, muscles and performance:

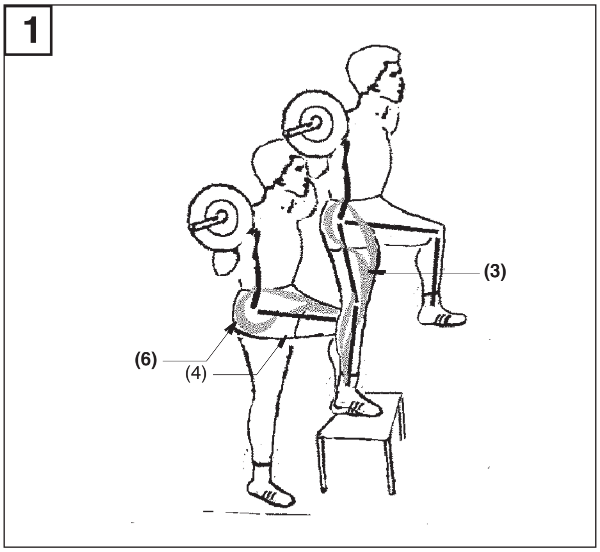


Fig. 63 *Step-up*

1. **Step-up**. Speed Strength (SS)- exercise.
   General or possibly with some specific result

Gluteus maximus (6)
Quadriceps femoris (3)
Hamstring (4)

Step-up onto a stable bench with barbell on the upper back and shoulders (knee angle approximately 90 °). Concentrating on a perfect hip extension. See Technology section, p. 46.

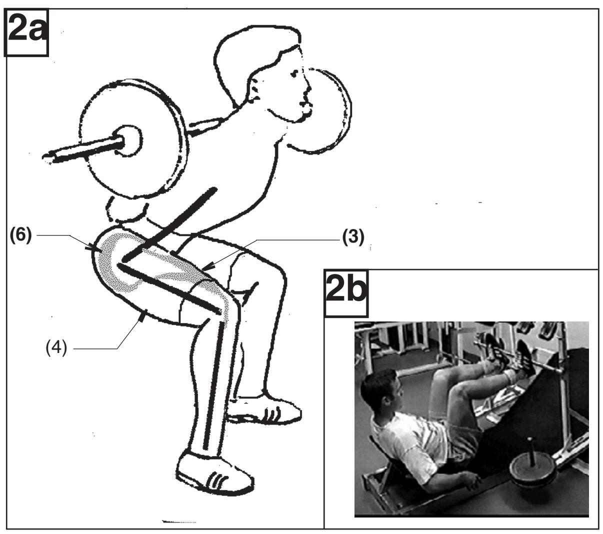


Fig. 64 *2a Squat, 2b Legpress, lying.*

2a **Squat.** General (Aa)-, (SS)- and Nerve-muscle coordination (NmC)- exercise.

Gluteus maximus (6)
Quadriceps femoris (3)
Hamstring (4)

Stand with approximately shoulder width between your feet. Hold the babell as exercise 1. Look straight-ahead. Lowering down until the thighs are almost parallel to the ground, rise up with full control, with your back straight. The knees and thighs should always be targeted in line with their feet ie. easy parallel or slightly outwards.

2b **Legpress**. Lying in legpress mashine. It’s an effective but mainly “safe” exercise, for seat- and the anterior thigh muscles. See also page 77.

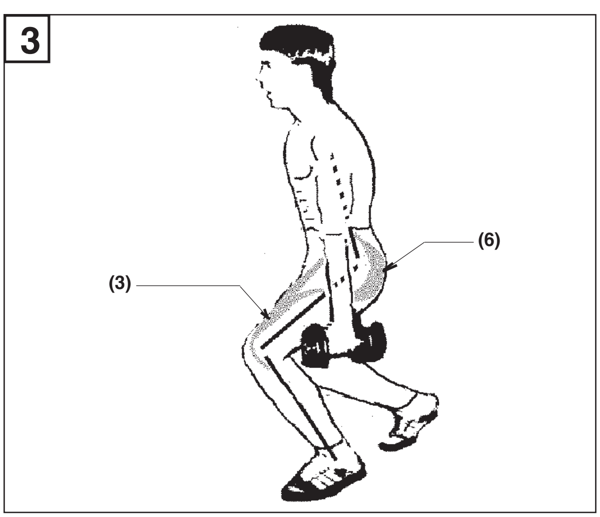


Fig. 65 *One leg squat*

3. **One leg squat**.
   General or possibly with some specific result

Gluteus maximus (6)
Quadriceps femoris (3)
Hamstring (4)

Stand with one foot most a pair foot lengths in front of theother. Lower your body vertically and up-rise like regular squats (Exercise 2), but emphasize especially the hip extension, as the pushing action in jumping and running. Use dumbbells or barbell. .

4. **”Power clean” (a-c)**. Power clean from knee*).
(NmC)- or SS-exercise. General or possibly with some specific effect for running speed.**)

Gluteus maximus (6)
Quadriceps femoris (3)
Hamstring (4)
Gastrocnemius(1a)
Soleus (1b)
Trapezius (17)
Latissimus dorsi(18)
Deltoideus (16)

Stand with hip distance between feet and with the toes pointing straight ahead. Gaze directed straight ahead. Straight back. Keep the barbell hanging with straight arms and back conducted shoulders. Bend your upper body forward until the bar is almost just above the knee (a). From this position raise the upper body and “jump” ie. extend the hip and ankle joint “explosive” (b). Only when the upper body is raised begins the “arm pull”, which concludes with that the barbell is caught up on the shoulders with a light knee bending (c). In a completed lift the elbows will be pointing forward.

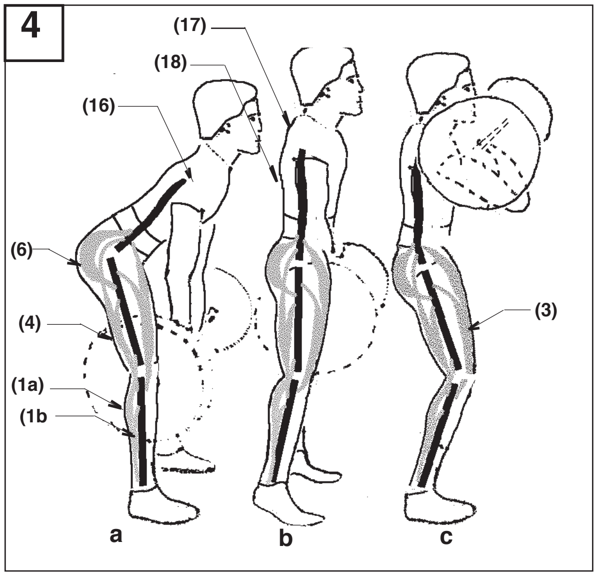


Fig. 66*”Power clean”*

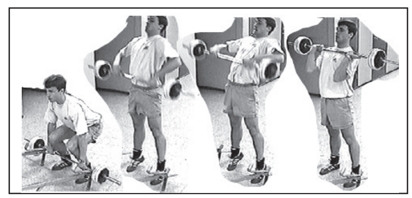


Fig. 66b *Power clean from floor*

5. **”Legextension”.** Sitting knee extension. The exercise “Isolates” and efficient builds the muscles on front thigh. General exercise

Quadriceps femoris (3)
Sit so that the edge of the bench is in the knee fold. The pad should be pressed against the lower leg near the ankle. Kick forward so that the knee joint is extended.

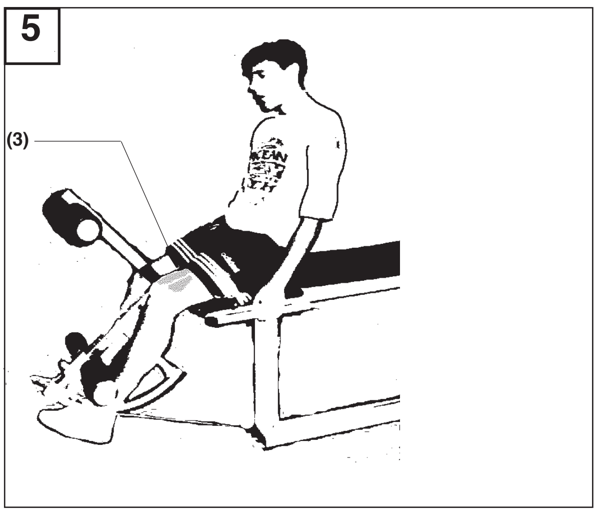


Fig. 67 *”Legextension”(5)*

6. **One leg squats “Hack Lift”with Powersprint machine**
Squats straight upright torso. May complement exercise 5. Corresponds exercise called. “Front squats” with barbell. General exercise.

Quadriceps femoris (3)
Here a proposal (Author.) To perform the exercise using a power sprint machine. Press gluteus against “back plate”och extend knee joint from start with 90°knee angel while the upper body is raised backwards upwards to perfectly straight posture.

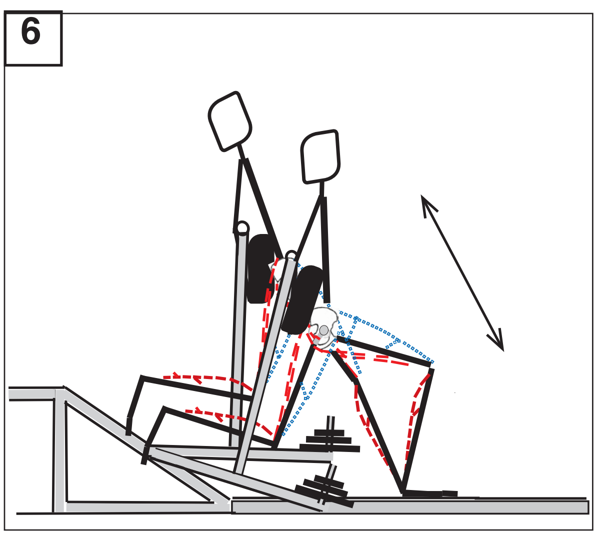


Fig. 68 *One leg quats(“Hacklift”) with a powermachine.*

*) Usually we practice clean (with barbell) from the floor. You then get a “total exercise”, which includes the start moment of the squat (see exercise 2, p. 34).

**) A variation of the power clean can be training “Powersprint” (see p. 23, 58-59 och 74-77).You could perform the same extension of foot, knee and hip joint, but also with an additional force in the form of extension of the hip side. You can then also perform the “smooth” pendulum swings in the hip side (the hip, see also page 38 övn14 and 15). You can create a feeling of a perfekt sprint stride, a start-up acceleration or a jump.

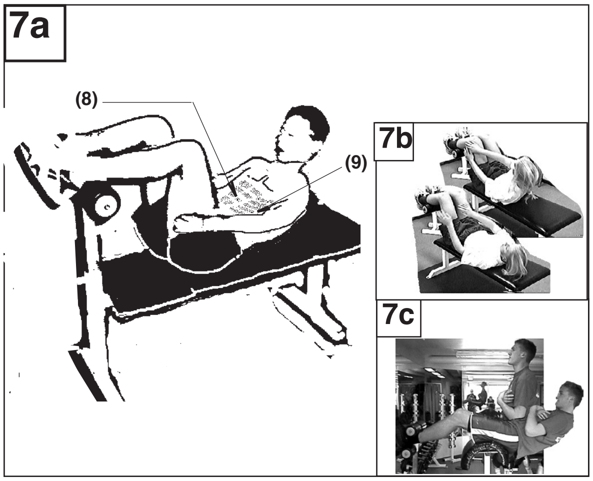


Fig. 69 *7a Sit-ups, 7b Sit-ups (twisting), 7c Sit-ups (coupled)*

7a. **”Sit-ups”**. General exercise which must never be neglected. Well-developed abdominal muscles in cooperation with strong back muscles is the precondition for stable posture of the trunk. In all possible sporting moments these muscles are performing a powerful elastist supportive work, protecting his back to overload and contributes to better techniques. Variations:

7b. **Twisting sit-ups**

Rectus abdominis (8)
Obliquus externus abdominis (9)
Obliquus internus abdominis

Lie on the bench or floor with hip flexors unloaded by highly placed legs with knees bent. Attempts press the lower ribs of the chest against the hip. Let the whole time the lower lumbar rest against the surface.

7c. **Sit-ups, “coupled”.** Abdominal muscle exercises, which also effectively train the hip flexor, m.iliopsoas (see also exercise 15)

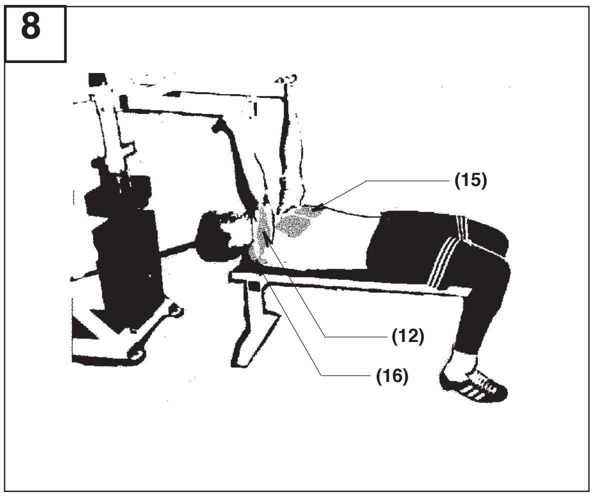


Fig. 70 *Bench press*

8. **Bench press.** Perhaps the most important general exercise for the upper body. Suitable for all the type of strength trainings that we use (Mh, NMC, SS), *)

Pectoralis major (15)
Triceps brachii (12)
Deltoideus (16)

Lie down with the seat and the whole back in contact with the bench. The feet are placed flat on the floor behind the knees. Grasp the bar with a grip slightly wider than shoulder-width. Note: Here is room for variety. The bar is lowered after a deep breath to the chest to a position just below the pectoralis. After a second’s pause the bar is pushed up on straight arms.
Training with skivstång should always be carried out with assistant at very heavy lift. Then It’s also possible to train with “overload” (100-150%, see maximal strength page 31) on the eccentric phase.

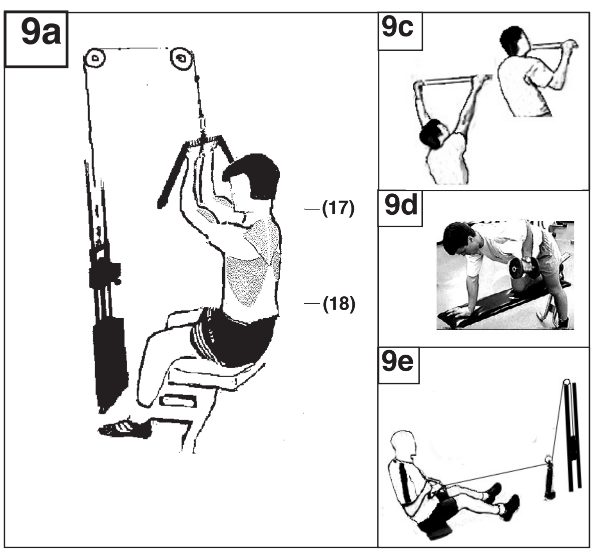


Fig. 71 *9a Lats, narrowly grip. 9c Chins-up, 9d Dumbell rowing, 9e Dumbbell rowing in a haul machine.*

9a. **Lats, narrowly grip** specific to armpendling backward in running / sprint.

Trapezius (17)
Latissimus dorsi (18)
Biceps brachii (11)

Grasp the bar in a tensile machine with upwards stretched arms and the hands with your palm facing backward. Pull vertically downward with your elbows tight in to the side of the body. Concentrating on the back muscles. These muscles can also be trained with nedanst. exercise options.

9b. **Lats, wide grip** with your palms facing forwards
9c. “**Chins-up”** (See fig.71 9c)
9d. **Dumbbell rowing**
9e. **Dumbbell rowing** in a haul machine.

Perform the rowing as shown seated, with a straight back and bent knees

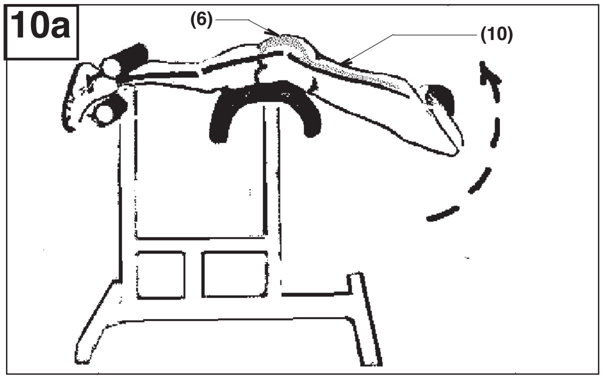


Fig. 72 *Back raise*

10a.**Back raise.** General exercise for back muscles. Should always be included in the training. It's also important to prevent injuries .

Gluteus maximus (6)
Erector spinae (10)
Anchor your feet well and lie on the special support pad so that the trunk can move freely in the hip. Keep your back straight and lower the torso just right, just prior to the vertical position. Raise back to the horizontal, not higher. Increase the load with dumbbell or barbell, which can be placed on the shoulders and upper back (trapezius). One can work quickly, but should then carry out "soft" and controlled movements of constant speed for a better training effect and to avoid injury. Variation: Roll up your back slowly vertebra to vertebra.

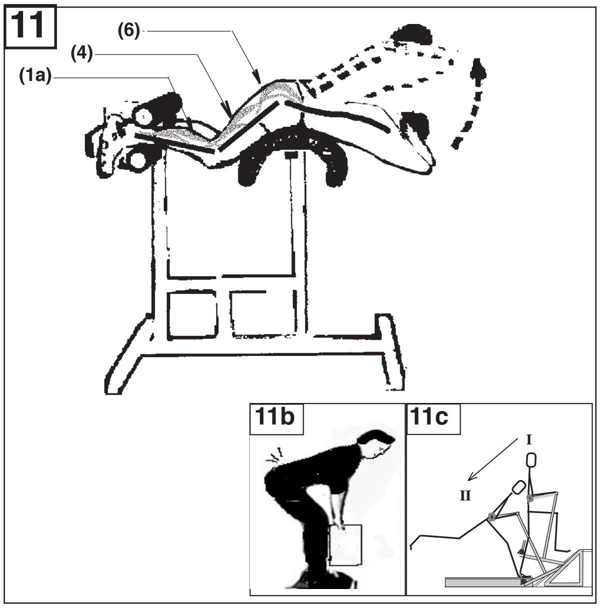


Fig. 73 *Hamstring raise. 11b. Stiff legged deadlifts.*
11c One-leg Romain Deadlift (RDL) med Powersprint

11. **Hamstring raise.** Lying trunk raise where also posterior thigh and calf muscles are performing a static and / or dynamic work. When also gluteus (6) is activated, the exercise often is called the GHG (Gluteus / Hamstring / Gactrocnemius). As Muscle hypertrofy training of fast muscle fibers according to method 1 (see page 30), this is an excellent choice as weight training exercise for speed. Exercise with some specific effect.

Gluteus maximus (6)
Hamstring (4)
Gastrocnemius (1a)
Place the body so that the front thigh muscles may rest against the curved support pad. Anchor the feet so that the feet pressed against a support (base plate). Knees must be located just above the lower padded edge of the support pad. With bent knee pendulate torso up and down. Concentration on the gluteus, but also hamstring and calf muscle.

Hamstring can better be trained with the exercise:
11b **Stiff legged deadlifts** (small picture)
11c **One-leg Romain Deadlift (RDL) with Powersprint**
(See more page 60 and fig 136b)

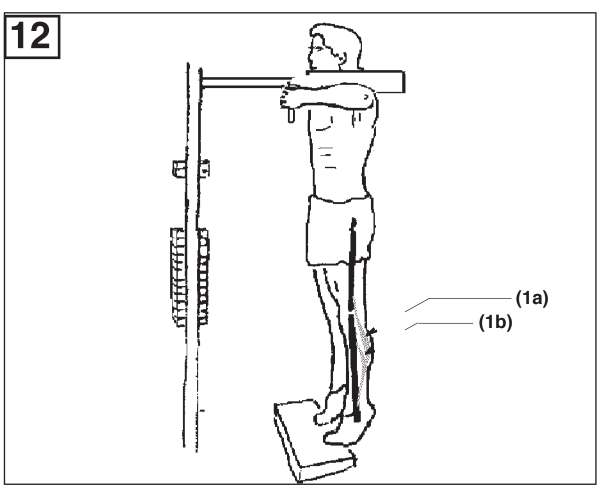


Fig. 74 *Calf raises. (Plantar flexion)*

12. **Calf raises**. General exercise for calf muscles. Should not be trained too much, then the risk of a sort of periostitis could occur if the calf muscle increases in volume too soon. Calf muscles can also be trained in more specific exercises (power cleans, GHG, etc.).

Gastrocnemius (1a)
Soleus (1b)
Stand with only the front ball of the foot on the base plate and find a balance with a straight body. Immerse deeply enough so that the strength in the calf can be fully exploited (see page 17). Raise up high on the toe. If we choose to work quickly under method I (p. 30), this works excellent. Quick short movements in even pace.

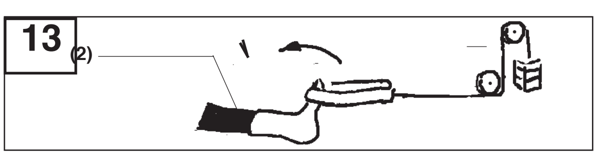


Fig. 80 *Dorsal flexion*

13.**Dorsalflexion***. The exercise is general and protects against certain forms of inflammation of the perios-

Tibialis anterior (2)

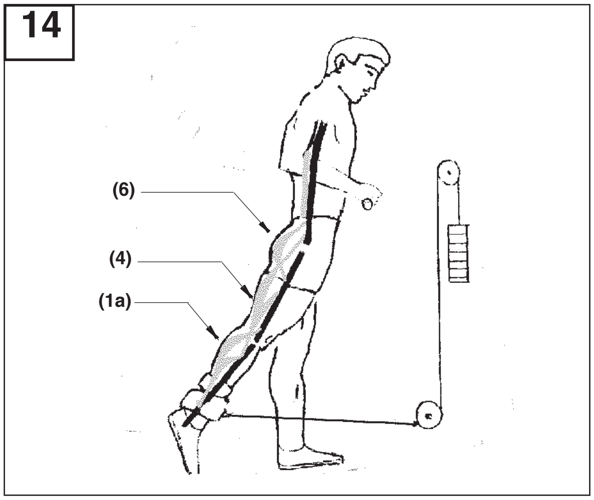


Fig. 75 *Cable kicks backwards*

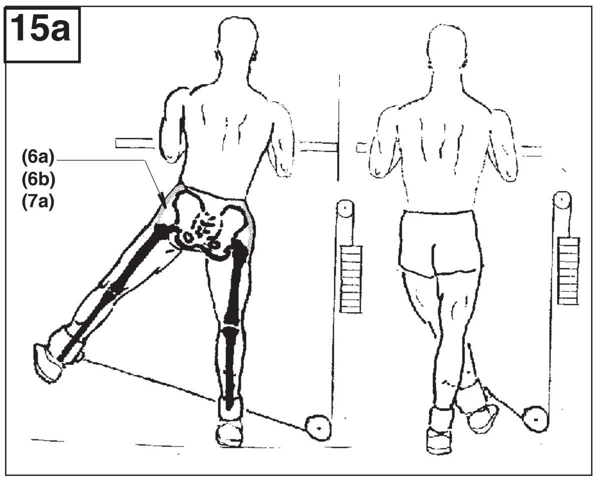


Fig. 76 *Cable kicks outward*

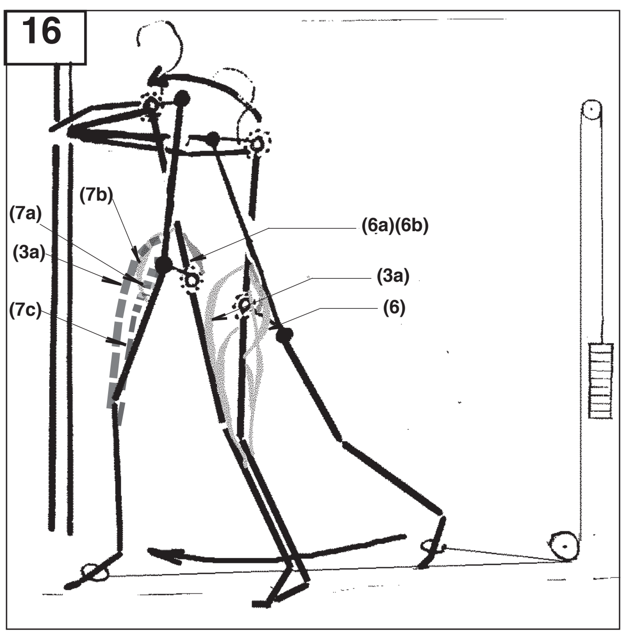


Fig. 77*) *Forward kick with straigth leg.*

13. **Cable kicks backwards.** Could be a good alternative instead of hamstring raise (see exercise 11).

Gluteus maximus (6)
Hamstring (4)
Gastrocnemius (1a)
In a cable machine, "kick" the foot backward with a "locked slightly bent knee. Important to stand with support for good balance. The upper body should be kept fixed and the concentration focused on the gluteus and hamstring. At fast work (method 1, page 30), hold steady pace and avoid jerky movements

14a.**Cable kicks outward.** General exercise for the muscles, which pull the leg outward. These muscles make the important pendulum movement in the pelvis at walking and running possible.[2)3)]

Gluteus medius (6a)
Gluteus minimus (6b)
Tensor fasciae latae (7a)

The same instruction as in above exercise 13, but now the leg is pulled outwards to the side.

14B.A variant, as a general exercise, is kick inward.

adductors

16. **Forward kick with straight leg.** Exercises for jump and sprint. Note in Figure 77 how the pelvic side (Hip) is lifted up in an "oval"-shaped motion. It is the same "lifting" movement, which in.övning14 but with a simultaneous movement framåt.[1)]

Rectus femoris (3a)
Gluteus maximus (6)
Gluteus medius (6a)
Gluteus minimus (6b)
Iliopsoas (7b)
Tensor fasciae latae (7a)

The same instructions apply as to above exercise 13 and 14 but now the leg kick forward during simultaneous stretching of the pelvic side. One must from a sleep mode with hip immersed, extend the pelvis side so that the hips (a point on the front of hip) reaches far forward.[1)] ***)**

1) This pendulum motion of the hip is of central importance to sprint and jump. An exercise for this is forward kick with straight legs (exercise 16). The author got this exercise described by John Smith (the coach of many of the U.S.`s Olympic stars) during the visit of California at Los Angelos in the U.S. 1989th. The exercise was of significant importance for UCLA sprinter's strength training according to John Smith.

*) Exactly the movement that fig.77 is showing is the secret to modern hop-step-and-jump technology (also in the long jump take-off). This was the opinion of Valeri Bunin, a Russian-trained "guru". The man behind four 8m long jumpers and fourteen triple jumpers, which all reached a jumps longer than 17:40m. Valeri Bunin has told this to the author.

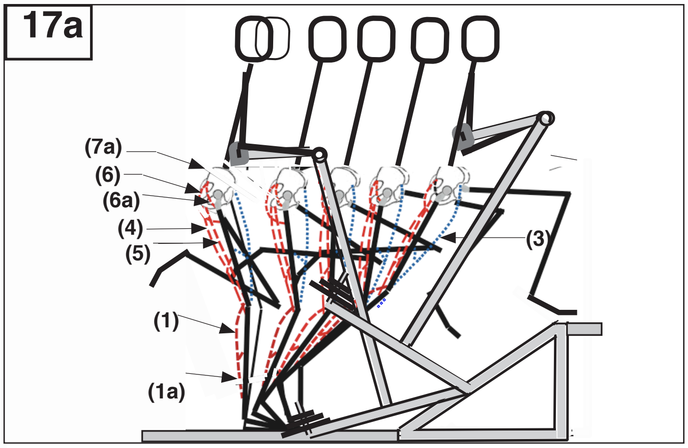


Fig. 78a *Powersprint. Specific training for max phase sprint model: APT-mode, "Long rotation in the hip joint"*

17a. **Powersprint** (Author). Exercise for sprint model ATP mode, "Long rotation in the hip joint", (See p. 50, 58-59) You train horizontally force development using hip extensors, but also the elastic leg "stiffness" .

Gluteus maximus (6)
Gluteus medius (6a)
Hamstring (4)
Adduktor magnus (5)
Quadriceps (3)
Tensor fasciae latae (7a) (fig 77)3)4)
Gastrocnemius (1a)
Soleus (1b)

The leg seems, mainly with help of hamstring, as a driving elastic ("rigid") rod where the quadriceps, gluteus and calf muscles in the front support phase has a dampening effekt on the high vertical reactive force at touchdown. More detailed description see pages 45, 47 50, 54, 58-59.

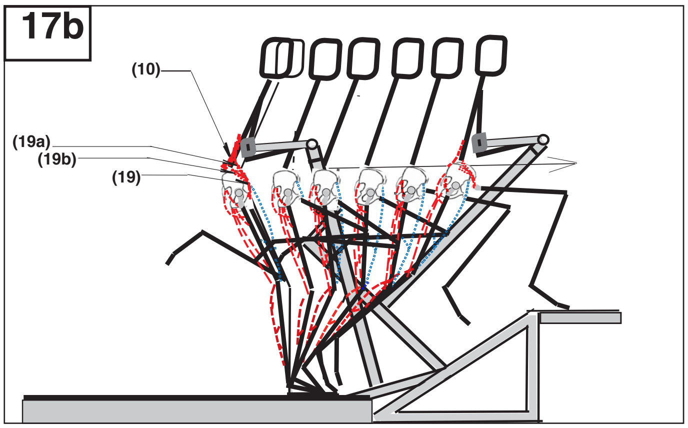


Fig. 78b *Powersprint. Specific training for the sprint model: PPT-APT mode. The picture here shows "unique long rotation in the hip joint,"*

17b. **Powersprint** (Author). Exercise for Maxfas sprinter model PPT-APT mode "Short alt. long rotation in the hip." Also particularly suitable exercise for quadriceps dominant sprint model with very isometric muscle work performed by hamstring. (See also the technology description on page 45, 47, 50, 54, 58 and 59)

Erector spinae (10)
Psoas major (19a)
Iliacus (19b)
Iliopsoas (19))

Erector spinae and the strong iliopsoas of the free swing leg with their branches (19a, b) in front of the hip joint is tilting Pelvis, as an additional lever forward toward ATP-mode (page 50), in interaction with that the femur is rotated backwards.

17c. **Powersprint** Specific exercise for the second step after starting. Malmö sprinters often use it as "trigger" first in training.

From straight body, knee lift (**I**) and fast foot insert (**II**). Note This should be done under the already started movement ahead, followed by a perfect extension (**III**).

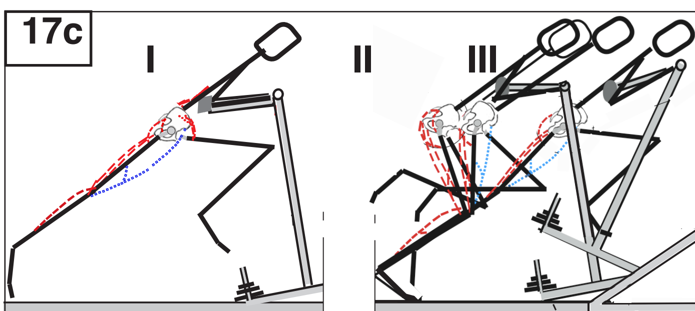
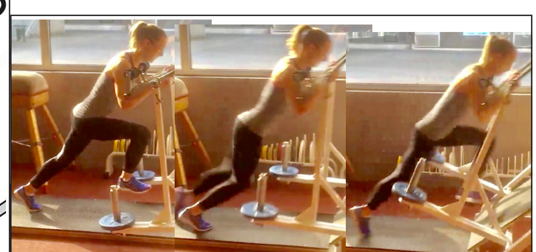


Fig. 78c *Powersprint®. Specific exercise for Acceleration I (See page 58), second step from the block start. This exercise have been used by sprinters in Malmö many years.(See also Fig. 33, pag56.*



Josefin Magnusson Powersprint training acceleration. For many years belonging to the highest Swedish elite at 400m

18a. **Powersprint, total basic and "start" specifik execise**
Basic total exercise for mostly gluteus and quadriceps and also muscle specifik for the advanced deep sprint start. Hamstring work here according to Wiemann "isometric".

Gluteus maximus (6)
Gluteus medius (6a)
Adduktor magnus (5)
Hamstring (4)
Gastrocnemius (1a)
Soleus (1b)

Important to keep your back straight (easy ATP position) in the entire movement. Note the extremely long support phase, which give strengthtraining for versatile strength with large motion amplitude. Important also for the pendulum phase. Note also that you need to build a rather high platform.

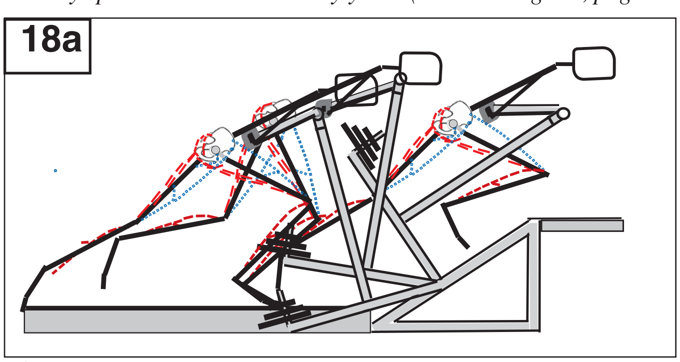


Fig. 79 *Powersprint. Deep advanced "total" start exercise. Consiously extremly long support phase*

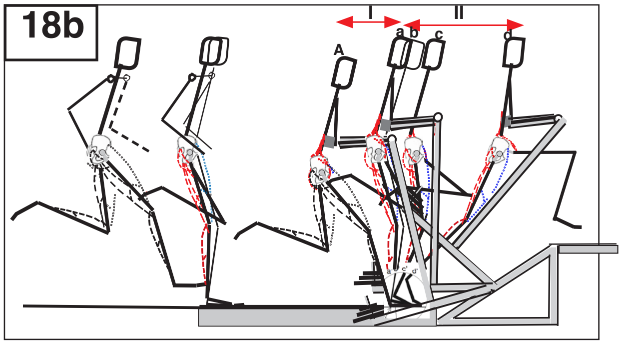


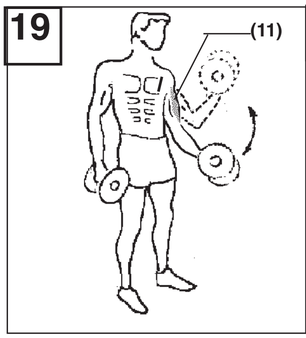
Fig. 80 *Powersprint®. "the total ways" to muscle specific strength training for the maximum phase (Se more details at page 76*

18b. **Total basic /specific exercises for maximum phase**

Fig. 80 shows "The total ways" to use Powersprint.

Alt. A: Use combination of acceleration I from deeper positions with the maximum phase, where this is starting with the powersprint machine in an uplifted position (**II**).

Alt. B: Exercise the leg's movement as an elastic rod striking the ground (**I**). This in combination with maximum support phase (**II**). **I** and **II** could be done as one movement with a small focus before the explosive support phase **II.**



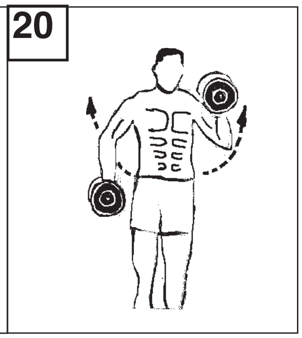


Fig. 81 *Alternate dumbell curls*

Fig. 82 *Arm swing*

19.**Alternate dumbell curls.** General exercise. Although if trunk and leg strength is critical för speed, strength is required in the upper body among other things for arm pendulum in sprint.(see page 50)

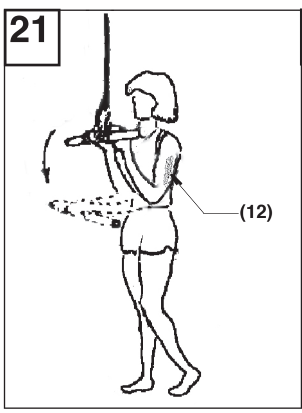
Biceps brachii (11)

Stand with arms hanging along the sides and the dumbells parallel to each other. Alternating bicepscurl means that right dumbell is lifted to shoulder height and then is lowered down at the same time as the left is lifted and so on. The dumbell is lifted with an arm flexing and hand wringing so that the palm are upward.
A variation is bicepscurl without hand wringing with the palm constantly upward ev. without alternating lifting.

20 **Arm swing with dumbell.** The exercise mimics the arm swing in fast running. Weights then must be small, so that the right movement technology and fast paced can be implemented. This is a good example of specifik sprint exercise.

Biceps brachii (11)

Stand with arms hanging along the sides and the dumbells parallel to each other. Swing the arms with dumbells as in sprint running. This also requires some technical training



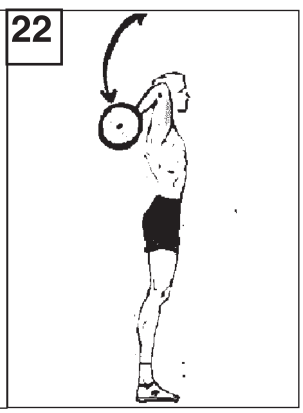


Fig. 83 *Triceps push down*

Fig. 84 *Triceps press*

21.**"Triceps push down".** Downward push in cable machine. General exercise for arm extensors.

Triceps brachii (12)

Stand with one foot over the other for good balance. Take in a high position with bent arms and push down. Keep your elbows all the time still low into the side even during the return to starting position.

22."**Triceps press".** Arm extension with barbell or dumbells. The exercise isolate triceps. is performed as one arm- or two arm press.

Triceps brachii (12)

Dumbell or barbell is lowered behind the neck with the elbow in a high position. Then press up the load while maintaining a high elbow,.

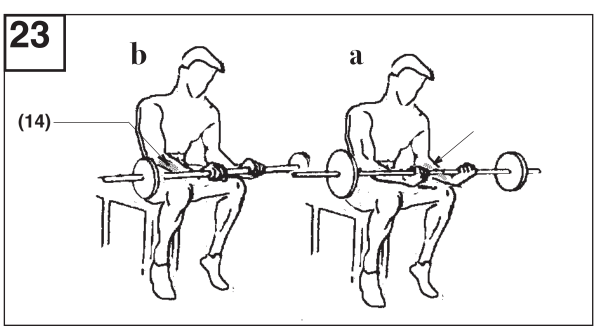


Fig. 85 *Wrist curl (23a)*
Reverse wrist curl (23b)

23a.**Wrist curl.** General exercise to strengthen the the forearm's wrist flexor. For all-round physical development. Improves grip strength for example barbell training, etc.

23b.**Reverse wrist curl.** General practice for strength of the forearm wrist extensors

Forearm flexor (13) Forearm extensors (14)

These exercises are performed seated as shown in the figure, appropriate with a barbell. The forearm is resting on thigh muscles, while the wrists are swinging freely.

4. SPEED, SPRINT RUNNING

4.1 Technology Model, sprint 100m.

Acceleration.

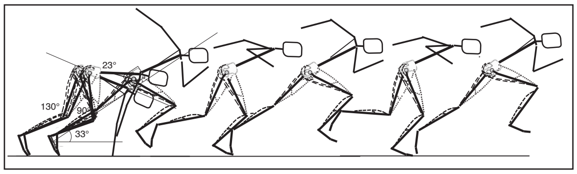


Fig. 96a *Schematic diagram showing an example of a modern start of the "super elite": "Ready" and the first two steps.*

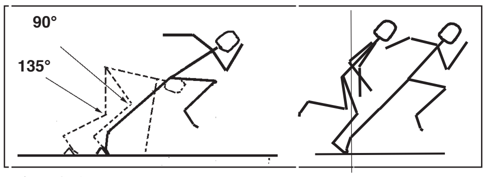


Fig. 96b *Chematic diagram showing an example of start technology for youth and moderate elite*

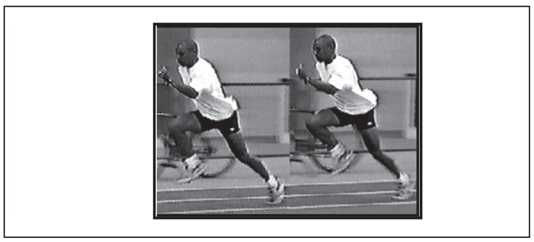


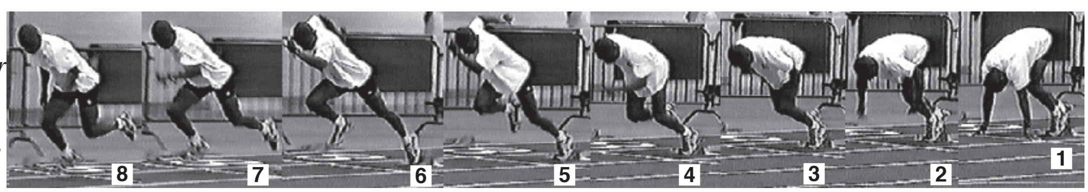
Fig. 97 *Mike Marsh.*[4] *Note the incomplete knee extension during the ground phase (ground contact).*

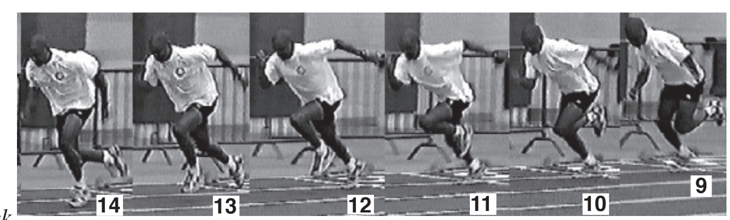
As an example of maximum speed performance in sport, we will now process sprinter running. We begin by highlighting sprint technique, with a technique model[1] for the track and field's classic 100m sprint.

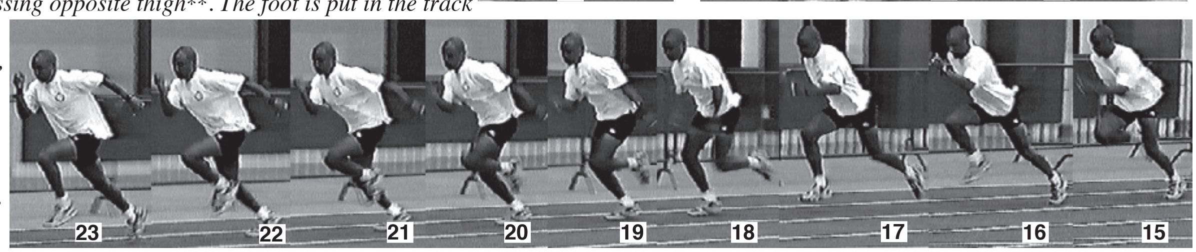
Today's top sprinter, among others characterized by a long acceleration distance of the 100m race, the whole 60m before the maximum speed is reached.

The start and Acceleration I

From the start block the pushing force is directed from the foot through leg, hip and the body's center of gravity in a straight line with slope of about 35-45° inclination against the track. Start angle must individually be selected depending on the sprinter stage of development. (Fig. 96a, b). Sprinter puts in the foot with "stiff", usually about 90 ° angled ankle-joint,* behind the center of gravity. The push off from the starting block and in the first two steps is usually done with full stretching of the knee joint. The stretching of the ankle, knee and hip, then takes place in the beginning of the race, which we here call **Acceleration I**, with a gradual steepening inclination of lower leg until the angle to the track is 90 °.
During acceleration I the running occurs, with concentration of both the large range of motion in the hip joint ((See also pages 46-49 and 58)) as high step frequence.[2] This seems to characterize today's elite sprinters at the expense of push offs knee extension, usually over the course becomes something incomplete (Fig 97-100).[3] The running becomes more "fluid", which also characterizes good technique. The work is done with higher power output, ie large force during the short contact time. It utilizes a better SSC (stretch shortenings cykle) (stretch reflex, elastic energy, see page 15) from the hip extensors - mainly hamstring for the production of larger horizontal force. Favorable may also was an earlier forward swing of free leg.[5]







*Pictures of Mike Marsh shows his starting technique during the first four steps. At the push from start block right arm swings back up relatively extended in the elbow (120 °) (5). Left arm however swings more flexed up to head height. The power from the arm swing is in harmony wit the pushing action from the start block, in an ideal direction through trunk (cf. Fig 99a). When the right knee moves forwards, the foot is describing a motion (3-6) forwards upwards to knee height. The angle of the knee becomes first quite small when the knee swings up to a relatively high position (5) and the foot is crossing opposite thigh**. The foot is put in the track on the ball of the foot (8, 14, 18) **) and with the first running steps without heel-contact. At the "touchdown" the knee of pendulum leg is hanging in a low position*

Fig.98 *Mike Marsh*[4] *USA Houston Feb.-99 at start training. Figure text describing some important technical details.*

**) Today's elite sprinter instead bring forward the foot lower and quicker

*) Ankle angle? Perhaps individual variation, but the "stiffness" applies to everyone.
1) Many details of this technology model is according to Tom Tellez (coach of C. Lewis, L. Burell,
2) Acc. John Smith, UCLA, Los Angelos-89 (a talk with the author)
3) Ralph Mann -85. (See page47)
4) Mike Marsh, the Olympic gold medalist in the 200m -92 (only one hundredth of the world record in the semifinals).
5) EMG values have also shown very low - perhaps negligible - from the push off force just before the foot leaves the track.

Acceleration II to maximum speed

After acceleration I, the distance of 15-25m, depending on the speed level, posture become more up-right[1]. (See fig.99 and page 58). From this position, we talk about **acceleration II**. The touch-down now usually occurs slightly in front of the body's center of gravity (fig.99a). The heel is then pressed downwards and for a "milli-second" it's easy touching the track 1 (fig.99b). In fig100. Mike Marsh is analyzed with so-called stick figures. Among others here is a enlarged detail of the ankle at touchdown (a) and at the heel contact (b) [4]

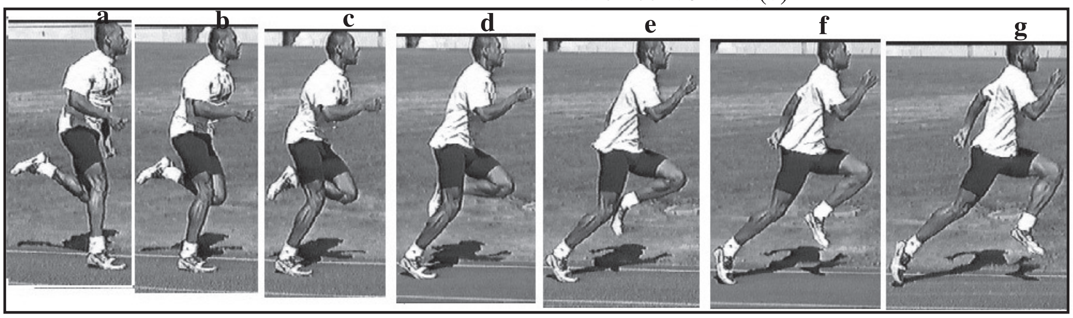
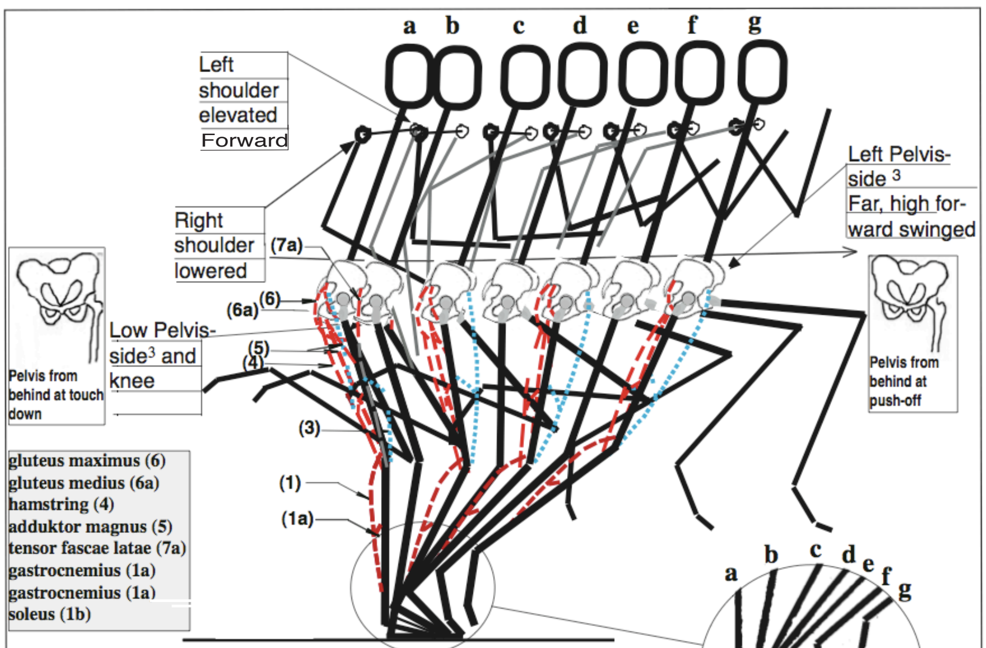
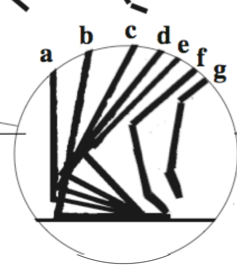


Fig. 99 *Mike M., is accelerating, at training in Houston in February -99*





IMPORTANT TECHNOLOGY DETAILS

The figure shows schematically the important pendulum movement of the hip (See also page 38 övn. 14 and 15 and p. 60). At right touchdown left hip and knee are in a low position. From here, the left hip swings (Pelvis side) forward in an oval-shaped moving . It is important to reach far forward with the hip at the knee lift.[3]

Note that at the touchdown of the right foot, left shoulder is forward elevated in the high position while the right shoulder instead is clearly lowered. Important that the shoulders are lifted and lowered to create balance and long external levers (see also page 22 and 50). This is a technique detail that you now clearly can see in particular characterizes the Jamaicans Bolt and Powel, but also for former U.S. Green and Others (author)

The arms will also provide a significant force additions to the push off the ground by pendulum force[2] *See in particular the left arm (position a and b, dashed) relative outstretched position, with your hand low along the side. Sprinter drops down the arm relaxed and then "swings" arm high up near the face (see p.48) Even backwards swing contributes with force.*

a - b: The leg naturally strike the ground from low altitude, as an elastic rod with slightly flexed knee. The touchdown occurs optimally in front of the body (see page 51). The heel meet the ground a very short moment

b - c: Reflexively knee is flexed further under uplifting of the heel.[4] *Here possibly hamstrings, biceps femoris "actively" can contribute with force. Gluteus take part in hipextension powerful but seems at the front phase together with the quadriceps mainly elastically damping of the high vertical reactive force.*

c - f: Extension of the hip and usually incompletely even in the knee joint can be made individually with either hamstring (Tidoff, Wiemann) or quadriceps, which get the help of the hamstrings isometric antagonistic function (see Sprint models p. 58-59). Adductor magnus (outer, lower part) is helping in the push off with an inward rotation of the leg in the hip. (See more detailed on page 54, 55, 58-59).

Note: The last ground contact in the position (f) with clearly uncomplete extension of the knee and hip (see also biomechanical analysis of the sprinters, p. 51-56. All sprintmodels can be excellent trained specifically with Powersprint

Important! Movement = The rotation in the hip joint must be clearly accelererad.

Fig. 100 *Analysis by Mike Marsh with the help of stick figure*

1) Tom Tellez model (Houston -99). It should, however, be the personal feeling and experience which is crucial (Author)
2) (Tom Tellez -99)
3) This is a very important technology details."The pelvic side is moving in an oval -shaped moving, and the hip is pressed far forward". (John Smith told the author at visit, UCLA-89. Medical parlance: = Pelvis Pelvis, will continue to be used.
4) Note! The circled. The short ground contact and subsequent uplift of the foot (b - c) takes place so fast that a normal video recording rarely can show this. The common perception is that the foot contact is always on toe without the heel contact.

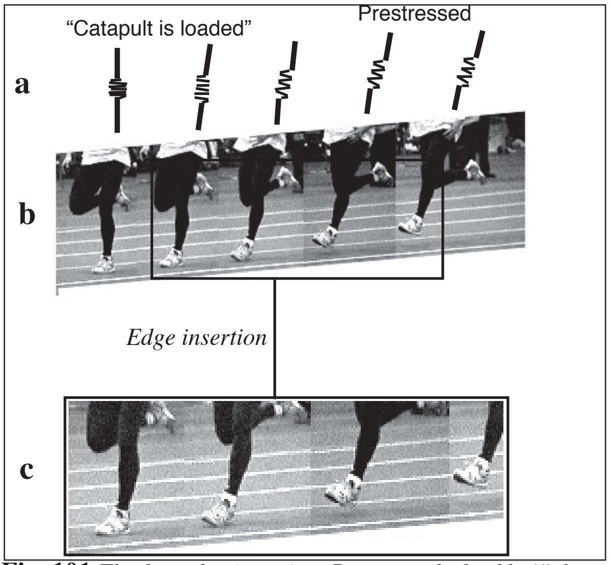


Fig. 101 *The feet edge insertion. Prestressed of ankle ("elastic steel shank"). Extension with "catapult effect"*

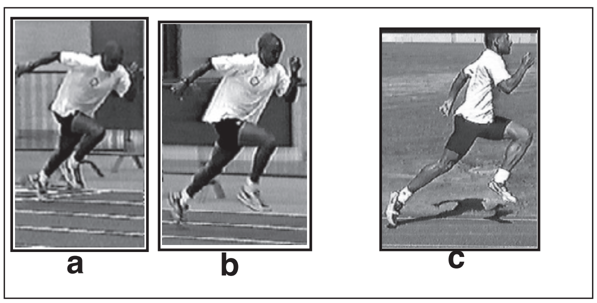


Fig.102 *The direction of the take off's force*

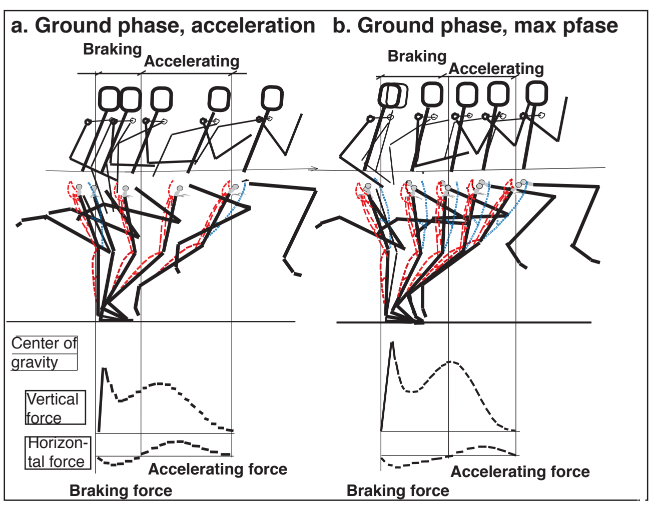


Fig.103 *Biomechanical analysis*[1)2)] *of the ground phase in the sprint stride (also page 51) shows motion technique, and vertical and horizontal "reaction force" from the track during ground contact, the so-called ground phase.During the front of ground phase , before the vertical line of center of gravity is crossed, there is a braking. Therefore, we are talking about a braking phase during which, among other things, the elastic energy is loaded ("steel stick - bent and stretched" when the muscle is stretched (stretched). The latter results in the stretch reflex, which together with the elastic energy is starting the push off action. During the rear ground phase the take off is accelera-ting and as long as the horizontal acceleration energy is greater than the braking force the acceleration takes place.*

1) Stick figure (author)
2) Processed from Ralph Mann Leichtathletic train. 12/99, 24 and Schöllhorn -95, 45.

The initial contact with the runway makes the the edge of the ball of the foot (Fig. 101C), then during "a micro second" the heel (Fig.99-101). Elastic energy, stretch reflex and muscle power then extends the ankle, which helps boost the power. This power is also affected by will*), with the exception of the ankle's extension. Foot arch - lower leg (Fig.101, a-c) can be likened to a biased elastic steel strip, which at the touch-down is bent and clamped together followed of a "catapult" effect.

The right feeling in sprinting

- The take off from starting block occurs with perfect extensions directed through the trunk (Fig. 102 a and b)*). Already in the early stages of the race most of the sprinters characterized with a more imperfect extension in the knee joint, providing a more propulsive force. The inclination of trunk becomes progressively more upright (Fig. 102c). The final push off occurs with an inward rotation of the leg in the hip. After the foot's edge-insertion and heel contact, the leg is pushed backwards and inward rotated over the big toe.

- The touchdown is done with a feeling of "wait for" the ground pliable as frequency and speed increas. Important the sprinter does not force a stamping action from a high position into the ground. At low altitude (Fig. 101C) the explosive take off process is starting with muscle prestressed to add the elastic energy ("steel shank catapult" is loaded). The foot then is rotated" downward-outward which creates edge insertion. The challenge is to find the right location at touchdown ie. just right high center of gravity in which the foot hits the track gradually longer in front of CG. During the continued acceleration of the race (**Acceleration II**) and at maximum speed, front foot optimal landing whereby the highest power could be developed during the SSC (stretch shortenings cykle) (p. 15)

- Quadriceps is absorbing the shock at touch-down and possibly extends the knee and hip with help of the hamstrings antagonistic function. Individually, the rotation of the hip joint of the leg during the stance phase also take place with muscle force from hamstring. This will be described more in detail later for example (p. 54, 58-59).The whole pendulum phase, also called recovery phase, with heel kick, knee lift and forward swing occurs, however unconsciously, as a result of total relaxation in the knee, largely with help of mechanical elastic energy.

Acceleration I, II and Maxfas.

- Technology and muscular demands. See Figure 103. During acceleration the run takes place "driving" in a slightly deeper center of gravity with the torso leaning forward and with the knee joint in the front support phase naturally more flexed. At this stage during the initial stages it is great demands on muscle power from the quadriceps and gluteus. (See also page 54). Gradually, the angle of the knee joint will be greater concurrent with the stature of the torso.

- In the acceleration II and maxfas force from Quadriceps must provide enough elastic "stiffness" in the knee joint, and to withstand the increased vertical reaction force * (see Figure 103 and the data on page 51), and also to use the leg, as a long stable torque arm, rotating in the hip joint with power from hip extensors - mainly hamstring. the "Catapult" of the Ankle must be ended with Pelvis in the forward tilted position (ATP) ** - individually short or far behind the hip. (Pelvis function. See pages 50, 58-59).

*) From Fig. 103b shows that maxfasens vertical force has increased while the horizontal reaction force is reduced. The former is always more than fifth times greater. Most of the buses has perceived the vertical force as the most crucial for a sprint performance, which greatly influenced the educational method. 2015 JB Morin showed when comparing 4 Elite (9.95 to 10.29), and 5 under the elite (10.4-10.6) as follows: 40m during acceleration load carried a higher (10%) more crucial horizontal force and the vertical force lower (2%) compared with these both. This better acceleration sannorligt expensive leads to better top speed.
**) At the back tilted Pelvis (PPT) any backward movement of the femur isrestricted..

Maximum speed

Figure 104 and 105 shows a sprint stride in maximum speed. Already after acceleraton 1 (“Drive Phase”, international designation) is the posture usually in the nearest or close fully upright. During acceleration II until the maximum speed is reached at 50-70m (elite) can still too many sprinters in the world elite of the videos see the hint of a slight, but still somewhat further upraised posture. The picture shows Henrik Olausson (pers.rec. 10.43) such a typical posture. A top sprinter can today with relaxed coordination and an extreme endurance implement the entire 100m race with minimal speed reduction. See more details at page 58.

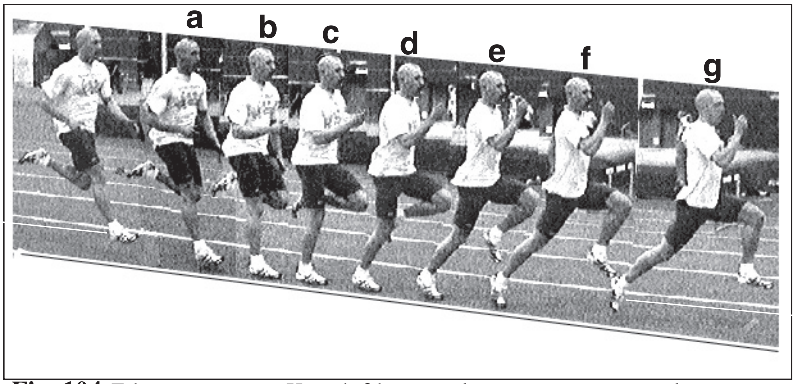


Fig. 104 *Film sequence on Henrik Olausson during maximum speed sprint Note: Location (a) is just before touchdown (Fig. 105(a) below)*

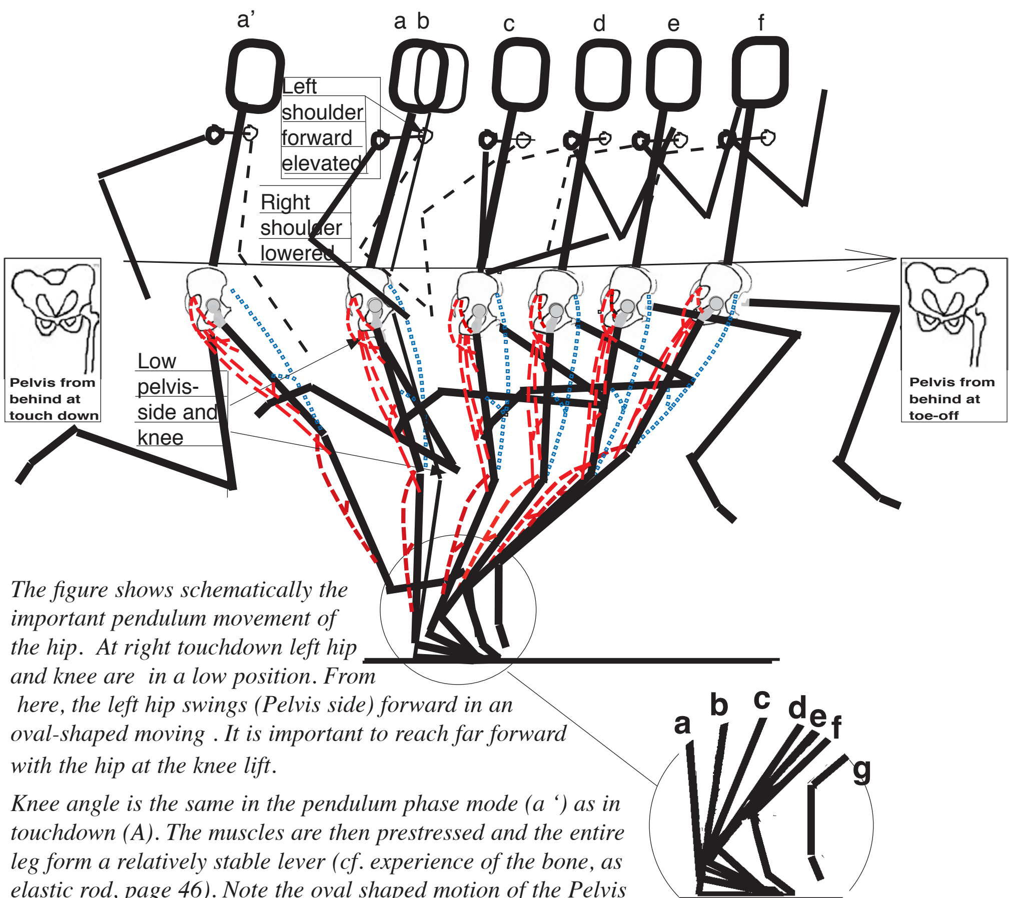
The challenge is to complete the 100m race at top speed with the concentration of detente. The muscle energy is discharged (page 18) but good speed endurance coupled with mental concentration makes it possible to maintain the speed. The sprinter must concentrate on a long acceleration distance. Often starting speed over-emphasized at the expense of the very long acceleration.

That during the first third part of the 100m race achieve high step frequency, the second third part obtain maximum speed and during the last third maintain momentum with speed endurance might be a good tactic. [1]

Focus 1: High step frequency and “float” with the help of large horizontal “driving force” from the beginning.

Focus 2: Accelerate to maximum speed, while maintaining high frequency, but with a powerful shoulder and hip work[2] (See Figure 105 with text.) producea drive force in harmony with a “big wheel “- that is, long levers - Pelvis + the whole the rotating leg in the hip joint (More about this on page 59)

Focus 3: When the maximum speed is reached, try to maintain it, without too large speed reduction, with fast endurance ability. During this final phase of the race, may relaxation also be extremely crucial. Among other things, to exploit the elastic energy and the stretch reflex (SSC, see page 15)



The figure shows schematically the important pendulum movement of the hip. At right touchdown left hip and knee are in a low position. From here, the left hip swings (Pelvis side) forward in an oval-shaped moving . It is important to reach far forward with the hip at the knee lift.

Knee angle is the same in the pendulum phase mode (a ‘) as in touchdown (A). The muscles are then prestressed and the entire leg form a relatively stable lever (cf. experience of the bone, as elastic rod, page 46). Note the oval shaped motion of the Pelvis sides[2] *and large elevating foreward and lowering of the shoulders, the latter typically specifically for Bolt. An important finding of the technique of Bolt and Asafa Powell is a tangible forward inclination of the trunkat foot touch down (15 °) followed by an elevating to about 5°. This short “rocking” motion*[3] *occurs rhythmically, so that both the trunk’s center of gravity comes closer to touch down reducing the braking. The raising of the trunk also compensates forward rotation . The movement is accomplished primarily by a strong back muscle work, which also affects the Pelvis tilting against the ATP mode. The latter is described in more detail on page 59.*

Fig. 105 *Analysis of maximum speed*

1) John Smith, interview (Author-89)). Without losing focus on a job well done hip work with the large range of motion ((“Ovals”,(Author))
2) According to John Smith. important technique detail (Author-89)
3) Magnus Warfvinge 151212 (Described for the author, which enthusiastically confirmed iaktagelsen. Common conclusion: “A neglected technical detail.”)

Note again! The circled. The short ground contact and subsequent uplift of the foot (b - c) takes place so fast that a normal video recording rarely can show this. The common perception is that the foot

The start.

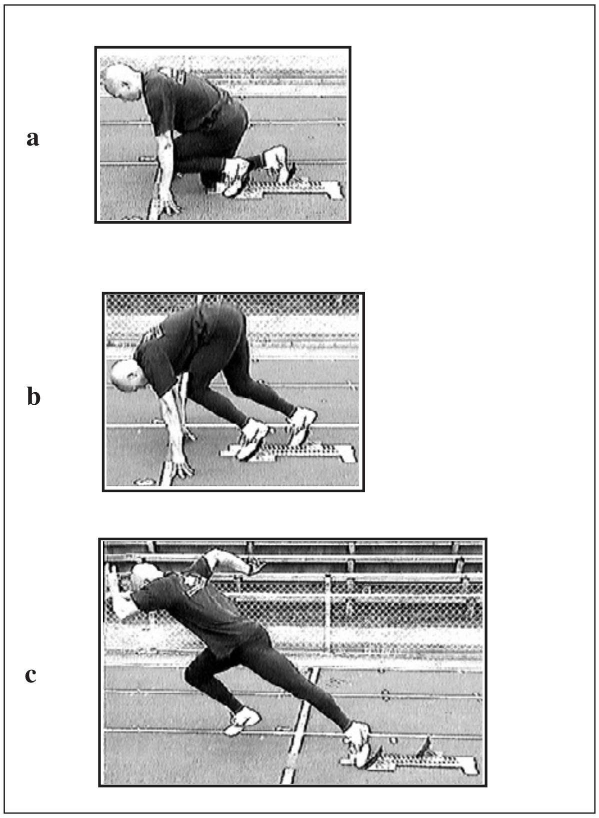


Fig. 106 *The start*

The requirements for a good sprinter start is requiring some perfectly executed technologies details.

"On your marks"

At "on your marks" (Fig. 106a), a few seconds for a final total concentration. Important details, such as: Vertical arms with shoulder width distance, fingers spread out, appropriate distance between the blocks and the starting line, the head possibly bowed.

"Finished"

Evenly distributed weight of the support points. The "finished" foot blades are pressed against the front and rear boot block so that a muscle preload is created. Important that both leg's muscles get the preload.

"The starting gun"

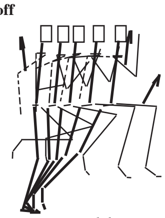
At the starting gun the sprinter push-off from the front block while at the same time a backlash is created through the body against the rear block. *) Henry: "a bang on the block" (Occurs few hundredths of seconds before the pressure on the front block).

The starting method lead to that the sprinter natural is running out from the block and quickly achieve high cadence. At the push off, Henrik Olausson is showing (see picture), a perfectly executed extension in a straight line through the torso and head.

The importance of arm / leg pendulum. Impulse concept.

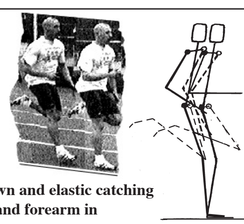
a

Rapid deceleration of arm and leg pendulum at the take off



When the arm and benpendlingens upward motion slowed, an impulse is transmitted through the body and an additional force is obtained. The faster the deceleration, the greater the impulse.

b



Drop down and elastic catching of hand and forearm in touchdown

Left hand and forearm (dashed in fig) is dropped down and "is catched" by an elastic biceps muscle witht an "open angle" in the elbow joint (in a phase of more realigned left arm when the hand passes the thigh in low position). The arm "bounce" up to a slightly smaller elbow angle. Right arm swings forwards upwards with a smaller angle (about 90 °) to coordinate with the left knee lift.

This rapid motion switching, the transition from extending to flexing of the arm, (Biceps muscle works eccentrically here and elastic) give a significant impulse and force.

Fig. 107 *Analysis of the importance of arm / leg pendulum, cont. (See fine text style) **)*

Below and in fig.107 the arm / leg pendulum are analyzed. See also fig.100.

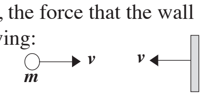
---

*) The mechanics explains this with the concept of impulse. The backlash through the body is an impulse **I** where **I = mv = Ft** force) (**t =** time) (**m** = mass, body weight) which can be written $F = \frac{I}{t}$
We see here that if the time may can be reduced at the creation of an impulse the force increases and $a = \frac{F}{m}$ then also the acceleration is increasing. Examples of rapid movement whose impulse is transmitted through the body are arm and leg pendulum in jump and sprint.
Study Figure 110a, b, and then do the following experiments:

a. Double arm swings sitting on the floor. The arms swings up and is braked.
b. Simple arm swings as in running. The arms upward movement slowed in the backward and forward swing. You "lift" from the floor. In the attempts feels increased pressure in contact with floor
c. The same experiments as a. and b. but standing on a wave.
d. Try standing on the wave arm technique described in Figure 110b. The wave makes a strong response.

) This movement can mechanically be compared to when a ball bouncing against a wall. Suppose that a ball with mass ***m* and velocity ***v*** is on the way against a wall (picture below). If the ball after impact is going back with the same speed ***v***, the force that the wall appeared against the ball becomes as following:

$$F = (p2 - p1) / t = (mv - (-mv)) / t = I / t$$



Where ***p*** is momentum, defined as mass times the speed ***v***. The ***P1*** and ***P2*** is the momentum before respectively. after the impact. t is the period of contact with the wall. The impulse is then ***I*** = ***2mv*** ie. doubled! This also applies force ***F*** if the time ***t*** is constant. The force always is increasing if time can be reduced (compare with a Karate strike - the same principle).

Which muscles are involved and how they work in the 100m-race.

The following description of the 100m race's muscle work is a brief summary of what we will later show by biomechanical studies.

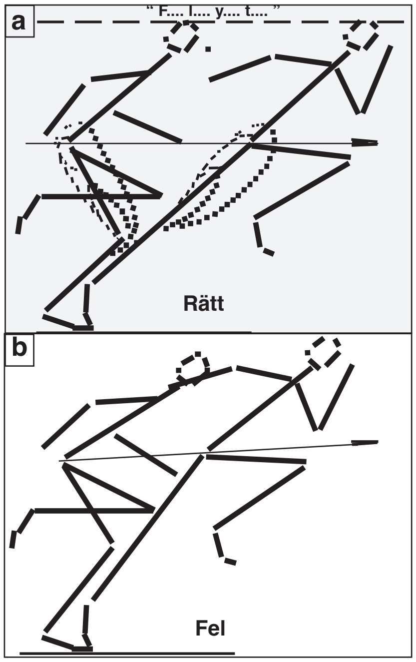


Fig 108
100m race's first strides. Figure a) shows a perfect extension that drive the body floating forward. In Figure b), the knee extension occurred too early.

I. The start phase and Acceleration I.

As previously told, this process applies to sprinter in race first two accelerating strides to extend the ankle, knee and hip so that the pushing force is directed straight line through the legs, hips and the body's center of gravity (Fig. 108a). The condition of the front thigh muscle (m.quadriceps) to be able push the body flat forward (“liquid”) is that the knee joint are not extended too early (fig.108b). Therefore the rear leg muscle (hamstring) performs a powerful isometric work (Wiemann, fig 109). The muscle brakes the extension of the knee joint *) so that instead the hip joint have time to stretch (see Fig.109). Also the gluteal muscle (gluteus) has here a significant role in the pushing action.

Acceleration II and Maximum Phase.

During the remainder of the race as a whole and during the long acceleration, with gradual upright posture to the maximum speed **) at about 60m, the legs are working as elastic rods. Front leg muscle, but also the ankle, “the elastic steel rail / catapult” gives a bounce effect.

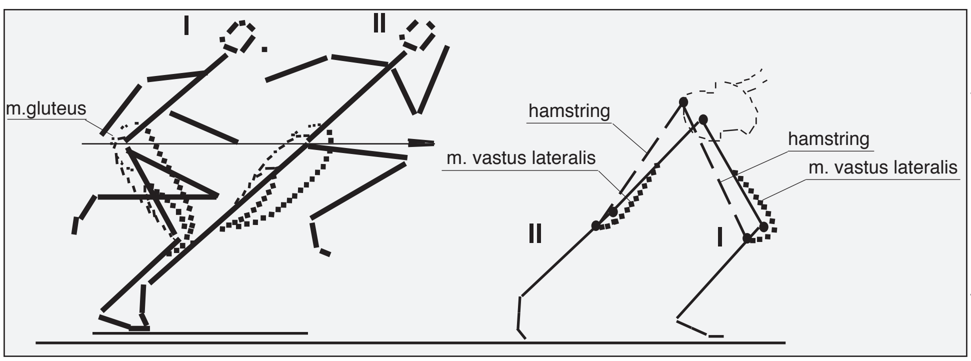


Fig.109 *(According to Wiemann)1) From position I to position II (in the first accelerating strides from the start) rear leg muscle (hamstring) is working isometric (static) ie. is keeping against without being extended or shortened. The front thigh muscle (mainly m.vastus lateralis) is working concentrically and is involved forcefully to a knee extension, which also with help of the gluteus pushes the body flat forward.*

As a whole, is created a “bounce step” or flat jump ahead, the flatter the better “flow”. Just “fluency” is perhaps the most important feature of a well-developed technology sprinter. (Fig.110a)2). Here, both the anterior thigh and calf muscles have great role in preventing an excessive big sinkage in the ground phase (fig.110b), by among other things taking up the impact against the ground with elastic energy and stretch reflex. The whole leg forming a solid elastic lever from the hip joint, which both seem to ballistic (“bouncing”) for stride length, and rotating with a speed crucial for the short contact time in the ground phase and thus stride frequence. Dominant muscle groups in the leg's rotation is the hip extensors gluteus and posterior thigh muscles during down pendulating of the foot towards the path and the latter muscles for the rest of the pushing action. This will be illustrated with summary of biomechanical analysis of sprint running (p. 51-56).

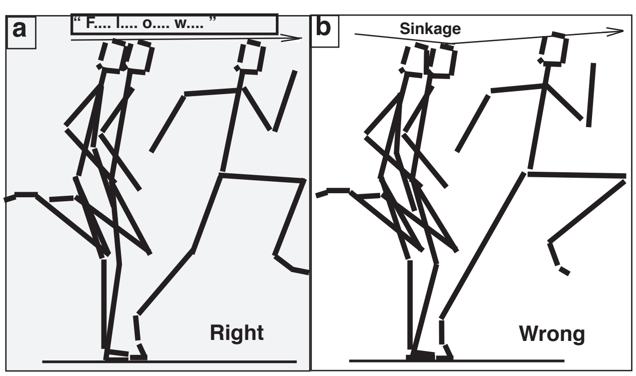


Fig.110
“Bouncy step”, a flat jump ahead. The flatter the better “flow” in the run. The sprinter's up and down movement is hardly visible in top speed but is there biomechanically considered . Note the incomplete extension of the knee joint at the push action. Figure b shows an big sinkage at full and steep extension, which gives a bad flow (= too long strides and low frequence).

*) Hamstring works here as a so-called antagonist muscle to the anterior thigh muscle.
**) The most important part of the race. Here the greatest difference between the intermediate and the elite.

1) Processed from Wiemann, Leichtatletic nr.27-89
2) The 's talk with Joe Douglas in Stockholm -83

The rod as a lever and technology model in jumping and running

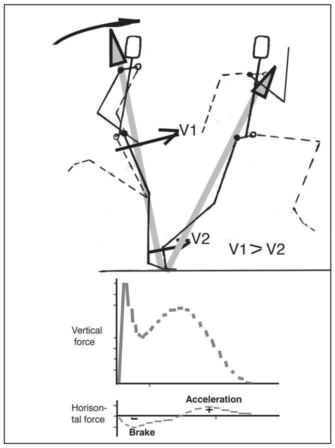


Fig 111 *At the touchdown in fast running and jumping, leg and torso together can be like a springy rod*

Body posture of the maximum speed. The Pelvis, different sprinter models

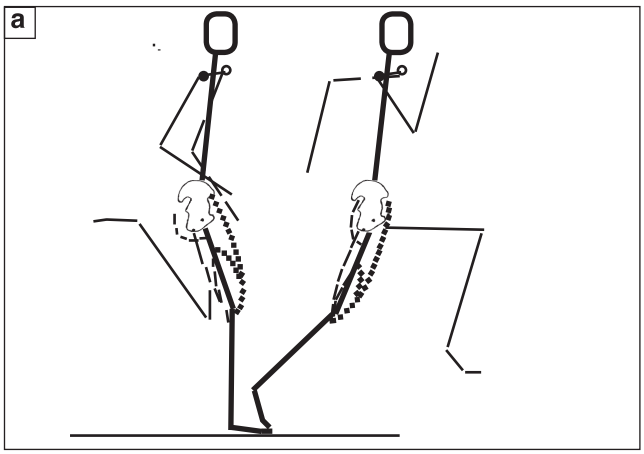


Fig 112a *Previously, the advise mostly has been an attitude for a neutral stance with slightly forward tilted pelvis.*

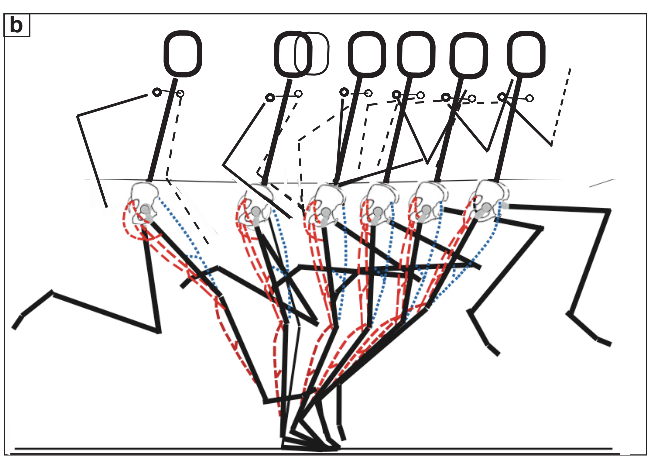


Fig 112b *Sprint Model: APT mode, "long rotation in the hip joint"*

In some positions in ground phase of the sprinter's stride and the take off in longjump the legs and the body together is like a springy rod (fig. 114). The rod is a lever with its support point of the ankle. The force from the ground throug the rod during the rotation forward-upwards, gives both a braking and by means of elastic energy, an accelerating force.
Upper parts of the rod have higher operating speed (V1) than the lower (V2) at the same rotational speed (so called angle speed). This would mean benefits with a high center of gravity position to make better use of the pole of rotation. The figure also shows the vertical and horizontal reaction force from the ground. The sprinter / Jumper creates among other things, increase in the external lever (see page 22) and higher CG position by that left shoulder is lifted higher when the right foot is landing in the ground and the opposite relationship right shoulder and left foot (see also fig.100, p. 45). Furthermore the pelvic posture is important for the same reason. This especially true for sprinter model B (see below) with typically tall posture which creates long levers.

Previously, the view was that it should creates a body posture in neutral position (Figure 112a). Only with slightly forward tilted Pelvis ("APT" (Anterior Pelvic Tilt)). This couldn't be the whole truth given the presence of world elite sprinters with significantly APT mode. With respect to Pelvis stance and the push-off leg motion during we can distinguish these two sprint models:*:

A. APT mode. "Long rotation in the hip joint", [1](mostly incomplete knee extension).(fig 112b, detailed description p 58)

Advantages:
1. Long distance between muscle attachments of the hamstring gives the possibility to high horizontal force in the ground phase.
2. Contributes to a more "floating" running - an important basic principle for all sprinting.
3. Ability to extreme improvement of hamstrings horizontally force production.

Disadvantage: Requires, which many lack, extra specifik strength in the hip extensors, with a very well developed posterior chain
May be possible by training specific technically with Powersprint®

B. PPT-APT-mode. "Short-long rotation in the hipjoint," Hamstring (Tidoff, Wiemann) **alt. Quadriceps- dominance. Hamstring, isometric antagonistic.**

Pelvis first backward-tilted, PPT-mode (Posterior Pelvic Tilt (Fig.112c) Then individually to APT mode. Description p. 59).

Advantage:
1. Tall posture with long levers is created (see above)
2. Energy saving way to develop great horizontal force, both during acceleration and maximum speed, as in final phase of the race.

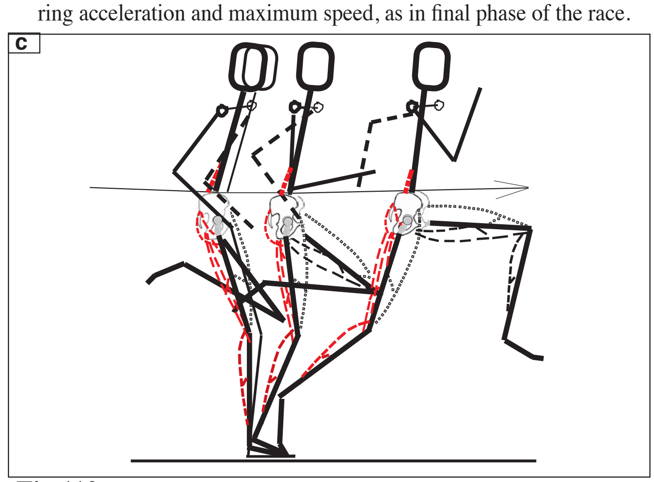


Fig 112c *Sprint Model: PPT-APT mode. Here "short rotation in the hip joint"(Long rotation, see p. 47 and 59)*

Biomechanical studies of sprinter technology

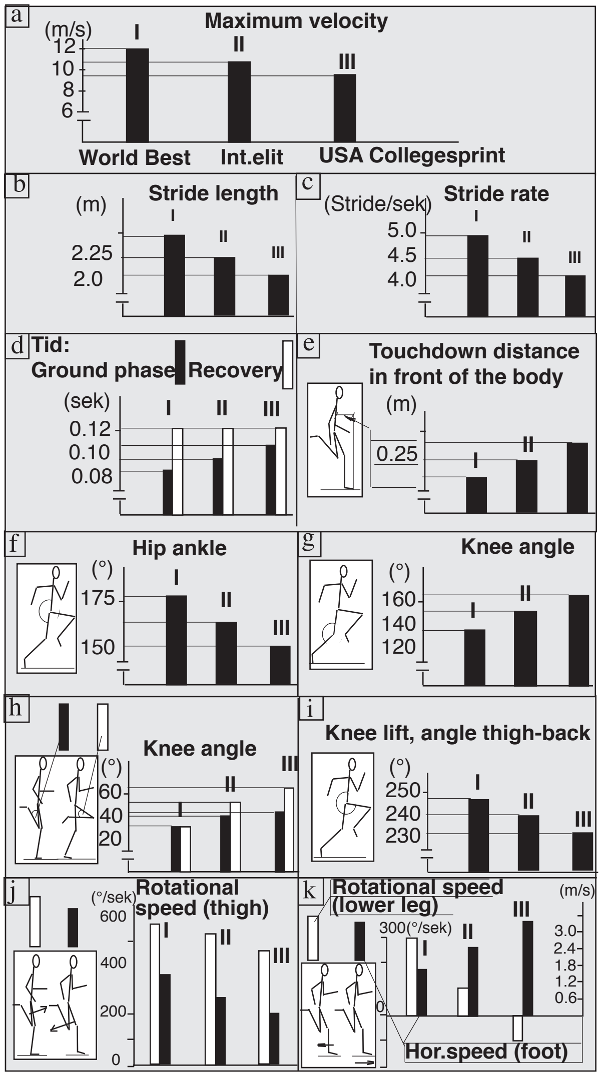


Fig. 113 *Biomechanical comparison:* I. *World Best (9.8)* II. *Average (10.3),* III. *College Sprint*

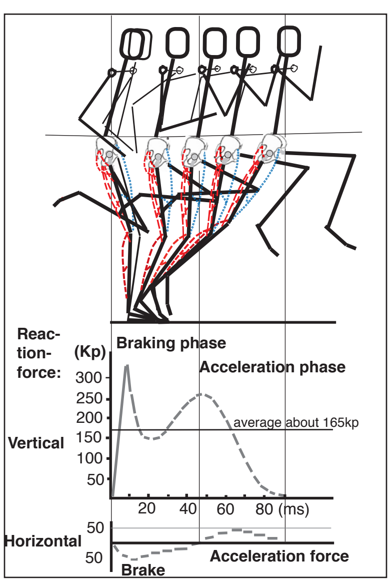


Fig. 114 2)
Max speed, vertical and horizontal reaction force from the runway.

The forces are measured with the pressure plate and This applies the world class sprinters with a contact time of only ca.87ms

Maximum velocity, comparative biomechanical analysis of world-record holder, international average level and U.S. College Sprinter

Extensive research has been conducted in the United States to determine biomechanical differences between performance level equivalent: [1)]

a. World record sprinters (Green, Lewis, Burrell and others (9.8s / 100m),

b. Average international elite (10.3)

c. American College printers

We shall now briefly summarize what is characteristic for max speed running of these groups.

In Figure 113a-k, we can study:

Velocity (fig. a) **Stride length** (fig. b)

Stride rate (fig. c). World record sprinters achieves both higher benfrekvens as stride length (at body length 180cm, close to 5 steps per second respectively. 2.50m in stride length.

Ground contact and recovery phase time (fig. d). Better sprinters have less contact time, while the time of the recovery phase, interestingly, is equal for all levels.

Distance at touchdown between toe and body (fig. e). Better sprinters makes the touchdown closer to the body. Note: But not too close, you have to find an optimal position for the stretch shortening cykle (see page 15).

The angle between the trunk and upper leg on the takeoff (fig. f). Better sprinters quit the takeoff with upper leg nearly in line with the torso.

Knee angle at takeoff (fig. g). Better sprinters have a partial knee extension, thus with a small knee angle.

Angle, thigh and lower leg at the knee lift (fig. h) are for better sprinters less. Through a shorter lever, these will have a faster knee lift during ground phase.

Knee lift at takeoff (fig. i). The angle between the torso (back) and the thigh at knee lift is greater for the better sprinters.

Rotational speed (thigh) (fig. j). **and lower leg** (fig. k) Higher rotational speed of the better sprinters. **Foot horizontal velocity** (fig.k). Foot speed close to zero at touchdown of better sprinters.

Max speed, biomechanical force for a world class sprinter

Fig 114 shows the vertical and horizontal so-called reaction force from the track for a world class sprinter. The contact time in the ground phase is only approx. 83ms and the vertical force as high as 450kp (= 4500N) in the tought down . There is a brief "power spike", which shortly subside followed by an increasing force to approx. 350kp. The forces are measured with the pressure plate.

1)Processed from Leichtathletic training 12/99-24. Fig 120j och k (Exercise and Sport,-84)
2) Drawings (.). Diagrammet processed from Ralph Mann, -Leichtathl. train. 12/99, 24

Film Analysis of 100m races at the Tokyo World Championships -91

A film analysis 1) of 100m races at the Tokyo World Championships -91 showed:

1. Changes in stride length and step frequency followed a patterns, which allowed to keep the speed to the finish.
2. In the final, Lewis had a shorter stride length and higher cadence than Burrell.
3. In order to achieve high speed sprint requires high speed in the leg backward movement before the touchdown.4.

High hip extension speed is more crucial than the knee or ankle extension shows a comparison between elite and university-level sprinter.

E.D. Lemain & D.G.E. Robertsson

High-speed filming (100bilder/sek) and computer processing 2) (speed, acceleration, momentum, energy and power) of the top-ranked elite printers from Canada and the U.S. showed (see Figure 119), among others:

a. Hip flexor worked concentrically during forward swing and then developed 4100w.
b. The power output was 3200w for hip extensors (concentric work), when the foot pendulate's downwards against ground.
c. Knee absorbs (eccentric) when the foot lands (the so-called. foot-strike) with effect 2500W followed by only 200w at beginning of the knee extension .*)
d. Knee flexors (hamstrings): 4800w in the takeoff! This muscle activity is needed, explains these researchers, in order to prevent knee hyperextension. **)

The researchers concluded of the the survey:

It should be higher priority than in the past for training of hip muscularity before training of the knee and ankle-joint muscles.

A.O.Korneljuk, National Coach U.S.S.R -81

113 sprinters incl. national elite participated in the survey which extensive 600 different biomechanical factors. It was found among others that at the foot-strike, and the first part of the ground phase (fig.119c), developed maximum force torque in the ankle and hip. Ankle will then take up the eccentric force***) with the 8400w. The researchers concluded that the ankle had a crucial role.

Main technical requirements to achieve high top speed, according to researchers:

1. Reduction of the brake in the first part of ground phase
2. **Emphasize the role of hip extensor to reduce the speed loss in the ground phase.**
3. High acceleration of the thighs so that they cross each other with the highest possible speed ****)

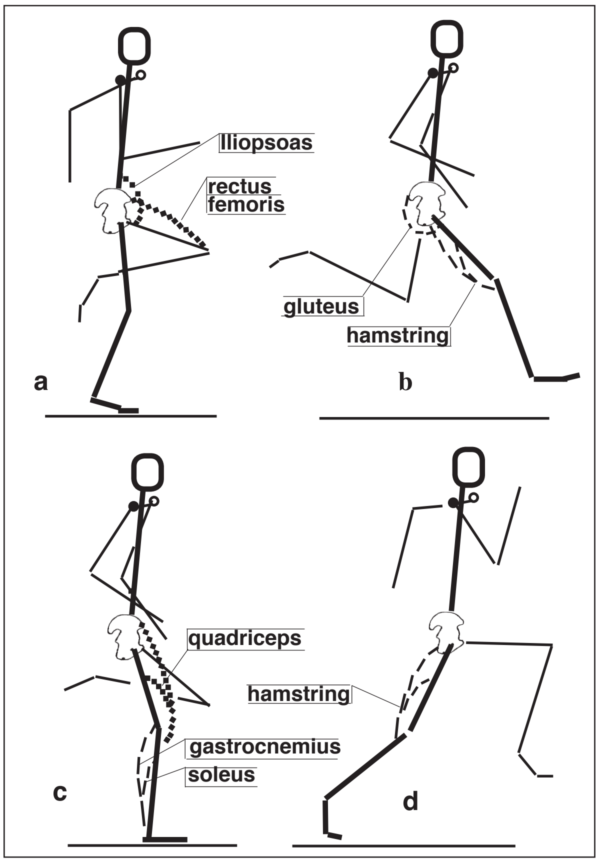


Fig 119 *Dominant muscle groups during the phases of sprinter stride*

*) The last low value indicates that the quadriceps mainly have a dampening function ie. helps to prevent a large sinkage during braking phase

**) Wieman and Tidof have another more compelling explanation (p. 53).

***) Is also called amortisation. The ankle suppresses elastic and prevents excessive sinkage (p. 49).

****) Heel kick close to the seat, among other things, contributes to this. see also p. 51;

1) Processed from a new stud. in Athletics, london 7(-92, 1, s. 47-52

2) Canadian study. Processed from Track and Field Journal, 13-17,-89

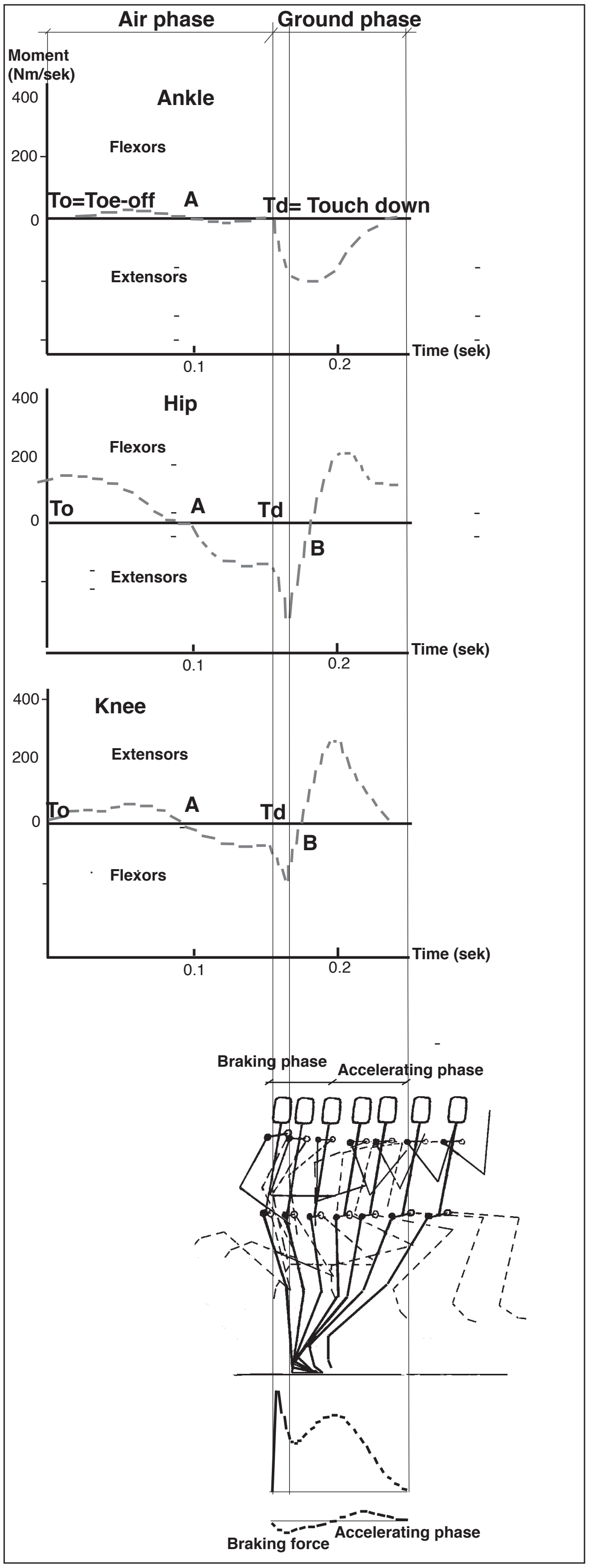


Fig 116 *15 top-ranked U.S. sprinters were investigated in max speed 2). Upper graphs show power moment and the lower reaction force from ground as measured by pressure plate.*

Ralph Mann and Paul Sprague [1)]

15 U.S. sprinters of high class was filmed at top speed after 40m acceleration distance. Filming with 150bilder/sek and computer analysis revealed the following facts about the muscles that dominate the different phases in a sprinter's stride.

1. Hip extensors (gluteus, hamstring) and knee flexors (hamstring) dominated when the leg pendulate's downwards (Fig. 116, A - Td) against the ground and during the ground phase's first part, Td - B. This suggests sprinter attempt to reduce the brake at the foot-strike by these muscles pull the body over the touchdown point
(better: With these muscles rotate the legs so that the body is driven over the touchdown point *)
To achieve this requires considerable muscular effort from the hamstring. Here is also the greatest risk of injury. Statistically has an elite sprinter greater risk of injury than a less good sprinter according to the researchers.
2. The ground phase's center (B) the hip extensors (gluteus) is changed to the hip flexors to rotate the torso forward, **)
Hamstring dominate the end of take-off' to according to scientists prevent knee hyperextension .***)

3. It was found that the contribution from the ankle extensors (the gastrocnemius and soleus) to the take-off power, is slightly less than previously thought. Ankle strength was namely also important for to suppress the foot-strike to prevent excessive great sinkage. Similarly seems knee (quadriceps) absorbing .****).

The researchers argued in summary that:

Hip extensors and flexors provides the greatest contribution to high running speed.
Important is also the body's location at fotisättningen, with an optimal distance, foot - center of gravity (see p. 51, figs 113E). For just the right step length, the foot is placed in front of the body, giving rise to an inevitable brake. This can be reduced by the foot's horizontal speed in the running direction is reduced to

---

*) Tom Tellez denies strongly the expression "pull", in his description of sprint technique occurs simple terms: "Naturally strike the ground and push," make cycling movements ", etc. In Houston they talked about Quadriceps as most important musclegroup - hamstring antagonist.

**) Iliopsoas is braking the rotation of the leg (femur), which lead to the trunk is rotated forward. (See also p. 50). Iliopsoas will also be stretch here reactive which speed up the swingleg after toe-off.

***) Wiemann and Tidoff explains instead hamstring muscle group with adduktor magnus starring role in the take-off. Hamstring works as knee and hip extensors. see page 54).

****) Ankle- and knee- extensors as such contributes to a floating run ning, see p. 49, fig 110. In order to have time to develop sufficient power during the short time touchdown occurs, contributing stored elastic energy and stretch reflex to this.

1)2) Processed from Exercise and Sport 2, -83 Drawings ()

G. Tidow and K. Wiemann[1)]

Sprinter technique is explained in a simple way of German bio-mechanics, mainly thanks to a new anatomical approach. It has been demonstrated that the posterior thigh muscles **hamstring (ha) and adduktor magnus (am)**, in a natural motion works as hip extensors and that these muscles in the take-off at the upright running position also could extend the knee joint. A comparative study (see page 55) between sports students without specific training and elite sprinters showed that, among other things.

Fig 117 shows a model2)of **gluteus maximus (gm)** and the posterior leg muscles hip extension function[1)]. You can metaphorically think of muscles as “reins”. If these be abbreviated, the leg is brought backwards and its rotational speed at touchdown increases (see page 53). This reduces the horizontal deceleration at the front ground phase (see detailed analysis, sid.57). The movement is accelerating during the trailing phase and hamstrings is continuing its work with the help of stored elastic energy all the way up to ‘heel kick “after the take-off. When the foot lands in path **am** is disconnected while **gm** together with the front thigh muscles and ankle extensors are cushioning the impact and prevents excessive sinkage (ie. maintains “fluency”, author.).

Recessed figure (Author.[2)]): What an amazing design. Small leverage l_h gives with short muscle contraction l_m a relative large movement l_r when the leg is rotated backwards. Large force F is possibly produced because hamstrings also pennate design (biceps femoris and semimembranosis, unipennated [3)]

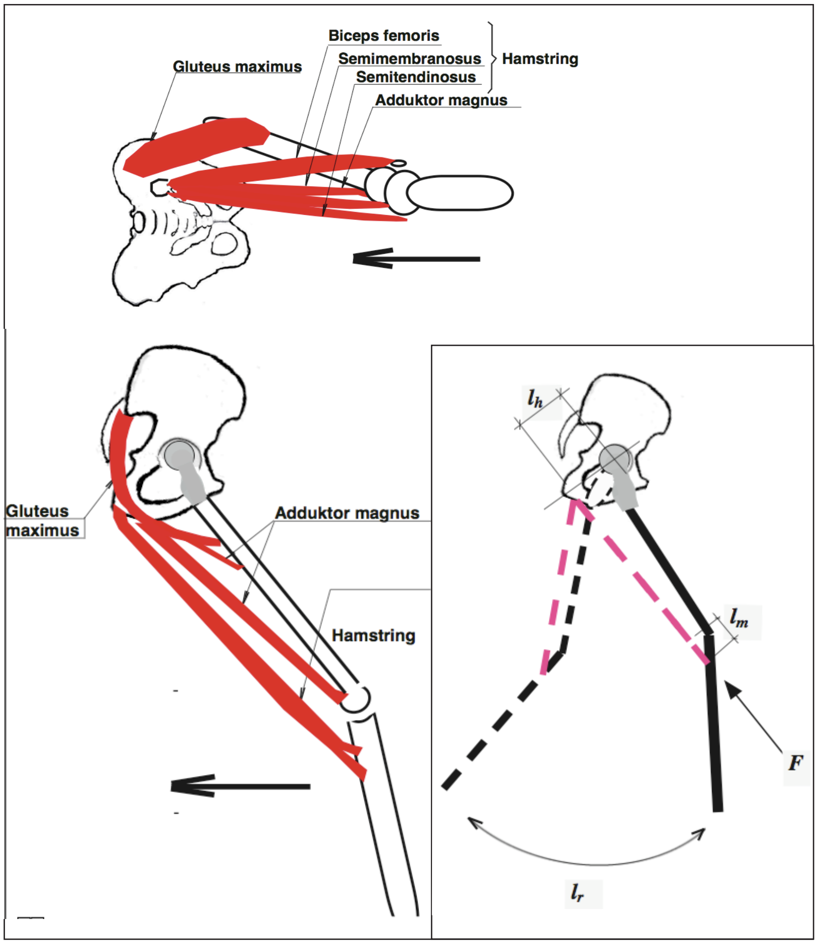


Fig 117 *Schematic model [2)] of m.gluteus maximus, hamstring and m.adduktor magnus hip extending function.*

Figure 118 provides a further description of muscle function. Here you can clearly see how **ha** and **am** are shortening (please measure by yourself with a ruler, author.) While the model shows the muscles that dominate the work. (Darker = more toned dominance). At the end of the stance phase (see also page 57) **am** is connected and help **ha** to extend in both hip- and knee joint. The front thigh muscles (**rf** and **vm**) take part only slightly, which overturns all previous ideas of an accentuated role of these muscles, as extensors in the upright sprint position (except first accelerating section of the 100m race (see page 51).

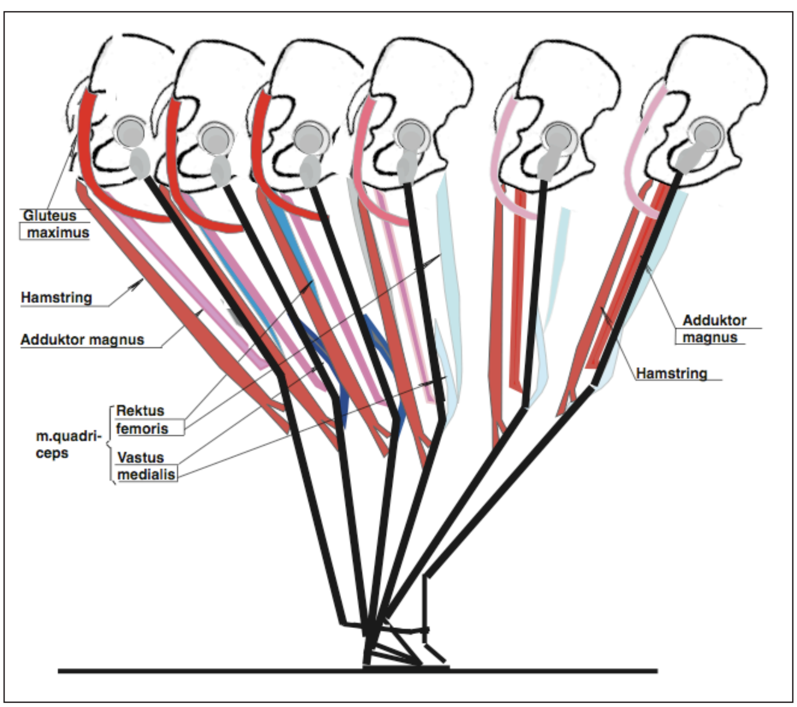


Fig 118 *The figure schematically show the stance phase at maximum speed sprinter model Long “rotation in the hip joint” + “Push”. Pelvis tilted forward, the APT position (see page 50). The principle of the hamstrings and adductor magnus.[2)]The more gray muscles, the more it is activated. For example:*

1. *Hamstring with darker tone is active during touch down and the whole stance phase. Its muscular attachments approaching each other ie. muskeln shortened throughout stance phase. If you look at it as a simple mechanical machine it will feature:*
   The whole leg, which forms a lever with hip as rotation axis, is and rotated (screwed) backwards by the muscle power.
2. *Gluteus and quadriceps is active in beginning and adduktor magnus in the late stance phase.*

1) Processed from Die Lehre der Leichtathletic, -94, 8
2) modif. Wieman. Die Lehre der Leichtathletic, -89, 27
3) Unipennated: Biceps femoris long head och semimembranosis. Parallel-fiberd: Semitendinosus and Biceps femoris short head, (Kubota, Jun 2008: Architectural and functional properties of the semitendinosus muscle.) (Woodley, Mercer. Hamstring muscles: Architecture and Innervation.) 54

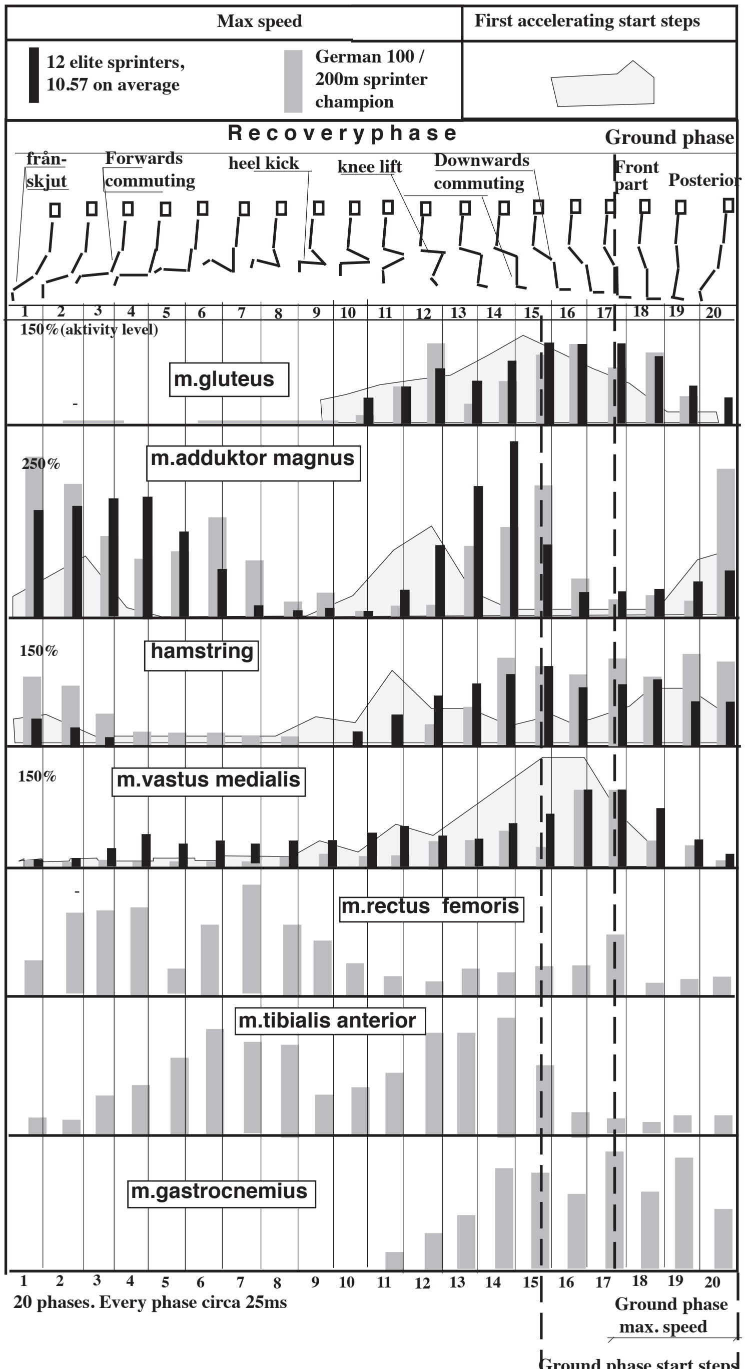
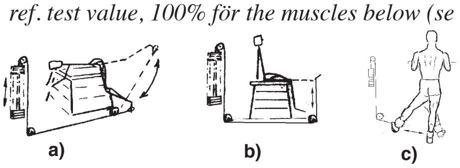


Fig 120 *EMG test 2) of 12 German elite sprinters (p.rec.10:57 on average), black bars. German champion (p.rec. 10:40), gray bars. The first sprint steps from the start, light gray fields. Activity Level (= effort) was measured as % of isometric ref. test value, 100% för the muscles below (se below fig)*



a) m.gluteus maximus och hamstring. b) m.vastus medialis c) m. adduktor magnus

All these four muscle groups were activated more than 100%. (M.adduktor magnus 250%!)

Interesting older German EMG analysis of sprinting (Wiemann and Tidow) 1)2)

EMG test *) to indicate "muscular effort" was performed on 12 sprinters of the German elite class incl. German champions The compilation
(Fig. 120) in graph form, we will now analyze. 1)

Phase 1-8: Large activity remaining in the adducts magnus (**am**) and hamstring (**ha**). This and mechanical energy leads to an automatic hälkick .**)

Phase 4-12: Front thigh muscle, m.rektus femoris (**rf**) and **am** giving force to the knee lift

Phase 5-9: Ankle flexor m.tibialis anterior (**ta**) is activated to bend the ankle at heel kick. The foot's center of gravity will then more close to the axis of rotation of the hip joint which lead to higher rotational speed at the forwards commuting of the knee

Phase 9-16: The knee joint is "opened" with a "relaxed" help of m.vastus medialis (**vm**)

Phase 12: Gluteus (**gl**), **am** and **ha** brakes the knee lift and start the downwards commuting.

Phase 12-16: Knee joint is opened by the lower leg's inertness ie. the movement of the thigh leg is transfered to lower leg***)

Fhase 16: Stabilized (fixed) of the knee joint explosive by **vm** assisted by **am** and **ha**. An important technique detail means that just before touchdown **ta** bends the ankle and the gastrocnemius (**ga**) becomes tense.

Phase 17: **ta** relaxes and **ga** extends ankle so outer edge of the footplate is dipped in the track.****)

Phase 18: At ground phase front part **gl, vm, rm** and **ga** is dampening and avoid excessive sinkage.

Phase 14-20: **ha** rotates the leg back down and gives the foot a speed close to zero prior to landing. **ha** is continuing work throughout the ground phase. (see fig.118, p. 53)

Phase 19-20: Ground phase's posterior with the take-off. **ha** get help of **am** and these muscles also extends in the knee joint.

Phase 13-17: During the start steps before the upright posture the quadriceps dominates as the knee and hip extensors (Wieman, p. 49) with **vm** as representative from the vastus muscle group in this EMG study.

*) Interesting of the reason that even adductor magnus is EMG tested and that hamstrings are active during the entire ground phase. Would love to see the corresponding EMG test of Jamaica's elite today.

**) Thus you should not deliberately emphasize this. This would only imply a tight race. The diagramme indicates a relaxed running by the German champion. Muscle effort is sparingly optimized and occures in the right contraction's succession ie. with better coordination than other sprinters.

***) Here it is important with relaxed knee joint (according to Tom Tellez). Commuting out of the bone is then faster, which when it will be braked since just before landing creates an intense "stretch shortening" (p. 15) for force to backward speed increase of the foot.

****)Down commuting of the leg occurs with an accelerated motion, but with the "feel of waiting on the runway" before the explosive action just above the runway and "Naturally strike the ground" according Tom Tellez is excellent education to learn the correct rhythm in the recovery phase. The commuting must be very relaxed but with a clear accelerated movement at end. This seems the German champion succeeds excellent in contrast to the other, which seems force violently with, among others. overactivity by am. which is whipping in his leg from an elevated position (the risk of injury increases then too dramatically).

1) Processed from Leichtathlethic -94, 7 och -94, 8 samt Schöllhorn, 95, 41-42

2) The four upper diagrams modif. Leichtathlethic -94, 7 och -94, 8
The tree lower modif, Schöllhorn -95, 43.These lacks measure values and levels may therefore not be compared with upper values

Wheel model for sprinter running

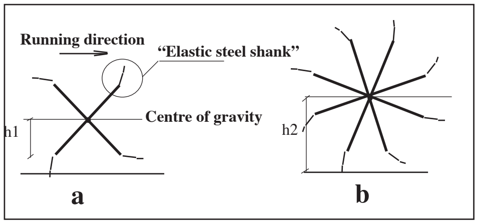


Fig 121 *Wheelmodel for sprinter running*

Vector Force Analysis

The wheel can be used as a model for the sprint race. With our previous sense of elastic rods that rotates in the hip and ankle made of elastically "feather steel" should we construct our model as Figure 121 shows.Higher situated wheel axle (h2) is equivalent to a higher center of gravity mode and multi-spokes higher step frequency (Fig121b). The pendulum rhythm in sprinter running, with a rapid and accelerating touch down and ground phase followed by a calmly gathering pendulum phase *) (see p. 51, fig 113D) correspond to a gear wheel, som step by step cogs around.**) The figure 123a below shows occurrence of the brake force and fig 123b the importance of the pendulum leg impulse (Fp) and foot's force (Ft) in the "touch down". In fig.123c the braking force have been created by the weight resistance at specific training of strength for sprinter running. Figure 122a-d shows examples of such a strength training.

Important conclusions by biomechanical research of sprinter running. Trainings forms

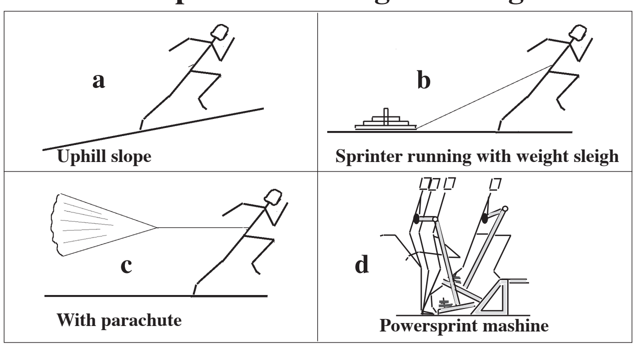
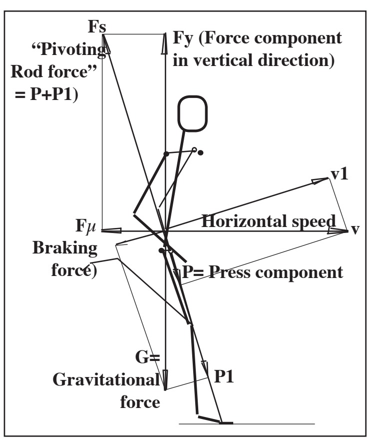


Fig 122 *Some specific strengthening exercises for the sprinter speed*

The biomechanical researches about sprinter running from different countries like USA, UK, Russia, Canada and Germany, which we have treated here, have been consistent conclusions that:

- **Hip extensors and flexors are most important for the development of high speed running.**
- You should find specific training techniques to train the strength particularly in the posterior thigh muscle group (see example fig.122a-d and p.57-60)

*) Called. "Recovery phase" **) "bicycling movements", "Naturally strike the ground", "Wait for the ground", "relax your shoulders and kneejoints" excellent teaching tips by Tom Tellez about the perfect pendulum rhythm acc. our wheel model.



When the foot is landing in the track ("touch down") we have the following components to study:

Fμ = Braking horizontal friction force
Fs = Force (from "pivoting rod"), reaction force from the track
Ft = Reactions force at touch down
Fp = Reaction force from pendulum leg
Fy = Force component in vertical direction
G = Gravitational force P = Press komponent
v = Horizontal speed
v1 = Rörelsekomposant

Fig 123a *shows emergence of the brake power (Fμ) .*

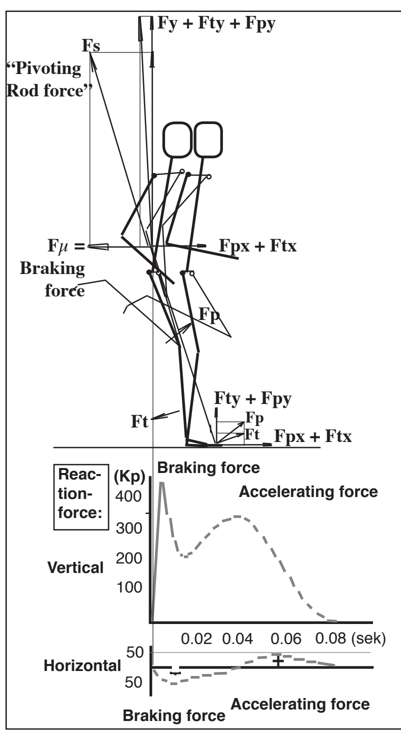
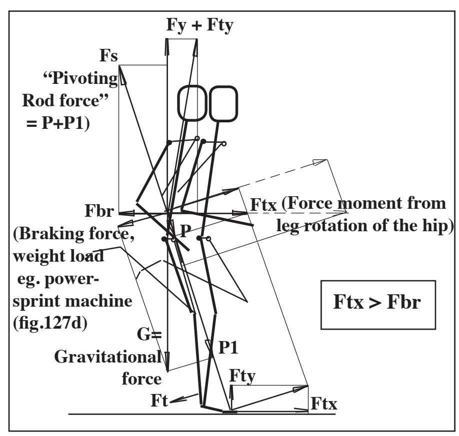


Fig 123b *shows the importance of pendulum leg impulse (Fp) and the foot force against the track (Ft), at touch down. Below we can as comparison also study a presure-graph of maximum speed sprint.*

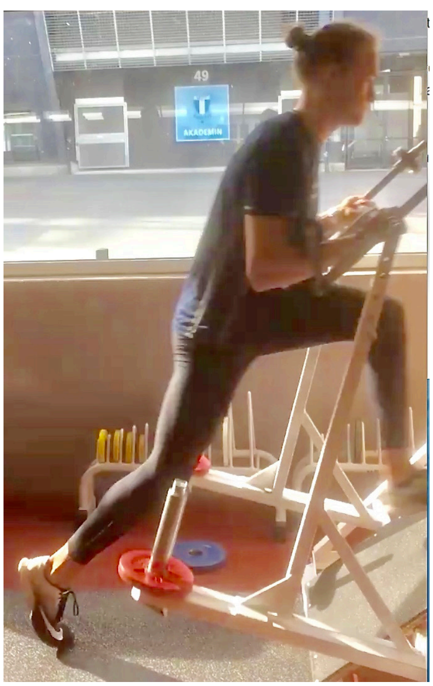


The horizontal braking force (Fμ) has been replaced by a weight resistance (Fbr) eg barbell weight in powersprint mashine. Now the force torque from the leg's rotation in the hip must be greater than the weight's braking torque to create a running movement. With optimal load (maximum and rapid weight training, see page. 30-32, and 57) in a power sprint machine (Fig. 126-128) can mimic a sprint stride and effectively train the hip extensors specifically.

Fig 123c *shows analysis of the forces in branch specific weight training. Example: Resistance running, sprinter running in a power sprint machine.*

Fig 125a *Here the international elite sprint at high level. "Wind Sprint" in Sundsvall in 2009. Note how the heel is pressed down and a short moment, here captured by the high-speed camera, is touched the ground.*

Powersprint

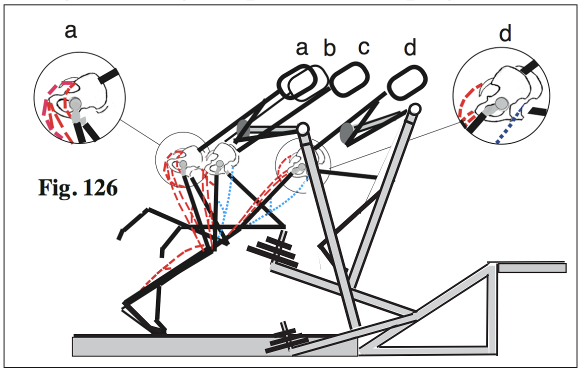


In 2008 Kenneth Riggberger decided that for Malmö's Indoor hall for track and field to purchase two powersprint machines. Since then Malmö's track and field high school as a complement has used Powersprint in addition to other strength training as Olympic lifting. Even seniors sprinters have used the machine and here on the picture, the 400m elite sprinter Anton Sigurdsson is training accelerations that correspond to sprint technology during the 100m race first 15-25m.

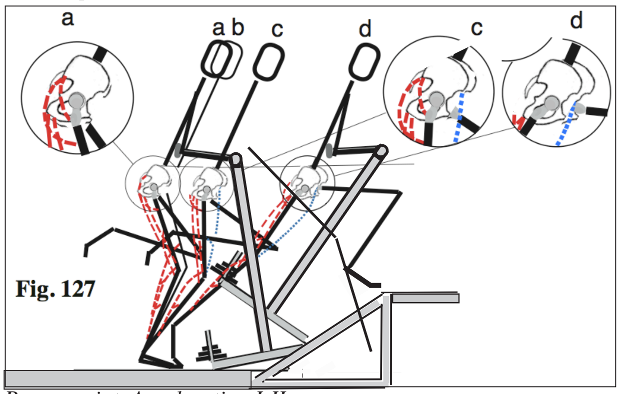
Stefan Tärnhuvud, multiple Swedish champion, here is training with Håkan Andersson's Powersprint Machine, a"hybrid"of the Powersprint machine for general strength training of gluteus and hamstring with great motion width. This can also effectively be chieved with exercise (17), described in page 39.

Fig 125b *In order for Sweden to ever get a world-class sprinter, it is probably need for a more effective way to train specific strengths for sprint srunning. (Author.) Such a "driving" sprint step as shown above requires a unique horizontal power production of hip stretchers, especially hamstring. For this purpose, the author since the 70's has experimentally developed the Powersprint machine. Page 39 as well as the following pages (58-60) describes powerprint exercises for the 100m race's various phases and also a couple of general exercises.*

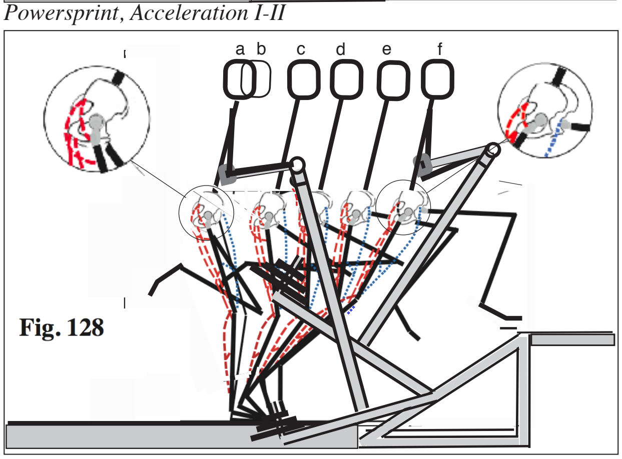
4.2Tactics example för100m. Sprint models. Pelvis posture. Powersprint®, specific strengthtraining for sprint and jumping.



Powersprint, Acceleration I



Powersprint, Acceleration I-II



Powersprint. Acceleration II and max phase, sprint-model: APT-mode. "Long rotation in the hip joint".

Acceleration I

Fig.126 shows training of the acceleration phase in the deep position du-ring the first two strides. The foot is inserted just behind the center of gravity with trunk in 35-45 ° inclination. Typically the foot hits the track easily turned outwards , with so-called. "Skating" (see color image), the foot sole first meet the track with the inner edge (Note the gradual foot insertion to the outer edge toward the midline). The push-off occurs first with the leg, after the foot edge insertion and heel contact, is inward rotated over big toe possibly help of the adductor magnus. Pelvis tilts back-wards explosively to PPT position (see page 50). Muscle work is switched to the quadriceps, which ending the push off with hamstring as antagonist (acc. Wiemann works hamstring here isometrically. (Page 49).In this very short and rapid steps (a-b) stretch-shortening phase function works (see page function 15) in which the elastic energy together with stretch reflex and muscle-specific force brings about the "start force" in the push off. During acceleration I (15-25m), the following running strides occurs with the foot insertions gradually closer to the lower body center of gravity (Fig. 127). The following occurs from the second step gradually:

1. Opening the angles in the knee, hip and ankle joints.
2. Lower leg angles to the track are moving towards 90 °, ie, vertical position.
3. The upper body is lifted to a raised position.
4. Pelvis tilted more towards the APT mode in the push off, which already from step two is done with relatively incomplete knee extension, (page 44, 50)
5. The hip extensors, primarily hamstring gets progressively more dominant function

Acceleration II and Maximum speed.
Sprint model: APT-mode. "Long rotation in hip joint".

Figure 128, 129a and b shows the technique in "Acceleration II" and Maximum speed with upright posture and lower leg in the vertical position at touchdown. Maximum speed is built up by that touch down is done with a sense of "waiting for" the ground smoothly while step frequency and speed increases. The foot should not be flogged from an elevated position in the ground[1]. At low altitude starts the "natural strike" against the ground with muscle preload for imparting elastic energy ("elastic catapult" charging). At relaxed sprint the foot naturally is turned angled down and out and the edge of the foot meets the track first. It applies to during the Acc.I will find a position at touchdown ie with optimal Tpkt position where the foot successively meet under and finally in front of CG[2]. During acceleration II to maximum speed (Elite: At 50-70m) and the rest of the race, foot optimally is landing in front CG. Muscle Work can now also occur as technology model: **APT-mode. Long rotation in hip"**(fig 129a
a-d : The whole leg is Rotated backward by the force of mainly gluteus,
(a-f) hamstring and the adductor magnus. Hamstring extend hip in such a rapidly rotating and accelerated motion as possible. Then Pelvis all the time are forward-tilted (APT mode, page 50), the leg, using the posterior muscular chain force, is rotated long behind the hip even with a certain - albeit incomplete final knee extension. This applies particular in max pfase (Figure 129). Some sprinters also in the world elite level, is using this technology throughout the race. This and following technique model use relatively high knee lifts with early knee forward swing (early heel passage of the support leg knee).

1) Tom Tellez recommendatio. Individual deviation can probably also be useful
2) Individual touchdown may be slightly longer in the front CG. Applies Primarily to extreme hamstring strong sprinters (Please see the youtube movie with Christophe Lemaitre's 9.92s race, (author))

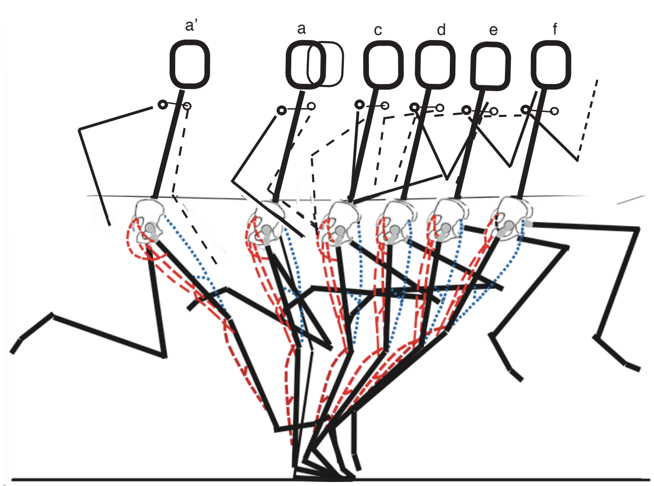
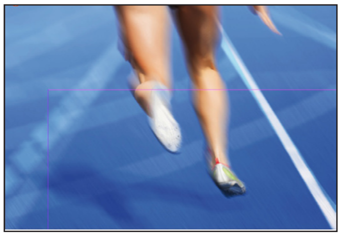


Fig. 129a *Sprint-model: APT-mode. "Long rotation in the hip joint".*

Fig. 129b *Sprint-modell: PPT-APT-mode. "Long rotation in the hip joint" (see also p. 47).*



Sprint model: PPT-ATP mode. “Short or long rotation in the hip”.

This technology model (Figure 129b, 130, 131) can be described as follows:

f-h: In the swingphase Pelvis is backward tilted from APT to PPT mode in the touchdown (a-b). The movement provides a “Stretch Shortening Cykle (SSC)” in the hamstring for increased rotational (angular) speed.

a-c: In the touchdown (a-b) is also a SSC in hamstring which first is working isometrically with stabilization of the knee joint and the femur in conection to the pelvis. With a focus on PPT location it now will be a short slower rotation of the leg with Pelvis as an “extra extended” lever. The back (erector spinae) and gluteus driving the leg backwards, together with the pelvis forward tilt, as a high lever (With a high positioned axis of rotation above the pelvis).

c-e: The back and iliopsoas muscle work also causes that Pelvis is tilted even more towards the ATP position, the hamstring then will be stretched some (“as tightening a bow”) which again provides an SSC with a finishing accelerated rotation in the hip joint.

However, this backward rotation of the leg can also as an alternative be performed in a longer distance to produce large horizontal force.

a-b: Because of the the high pressure (see diagram fig. 130) that occurs when the machine is attacked the fixed ankle joint (should be seen as a “stiff” elastic steel shank) will be slightly compressed. The heel is (see the picture below) pressed against the track an touch it.

b-e: Pelvic that extra leverage, starts tipping forward toward the APT mode. The final push-off is done as previously during the drive phase, with that the leg, after the foot edge insertion and heel contact, is inward rotated over the big toe - this possible with help of the adductor magnus. A slightly more forward tilting of the pelvis now allows place in the hip joint for a longer accelerated rotation, where great power can be developed mainly by hamstring and adductor magnus. Important is a certain “locked knee-joint”, so that leg forms an elastic lever before final push-off. See Fig. 129 b and also page 47, fig.105, Note the “rocking” motion of the trunk as previously described on page 47.

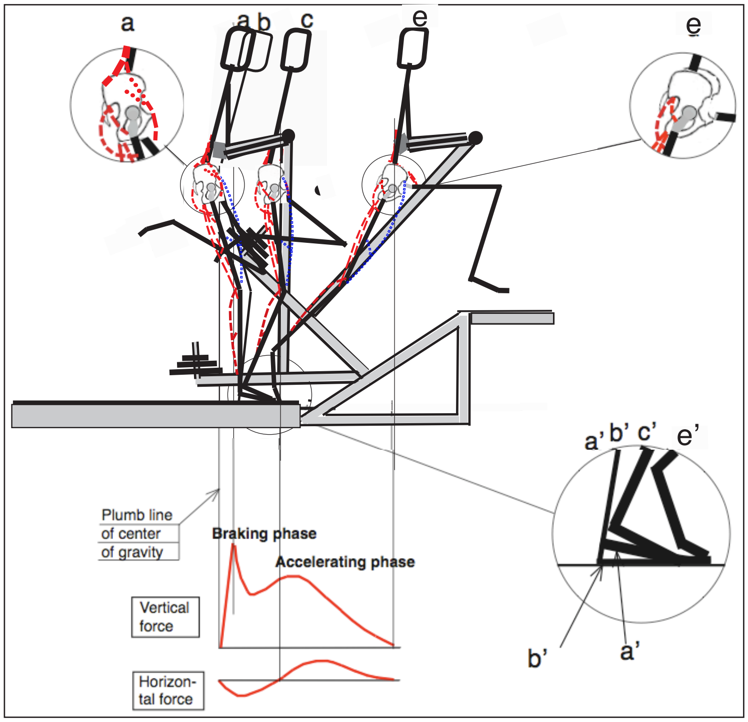
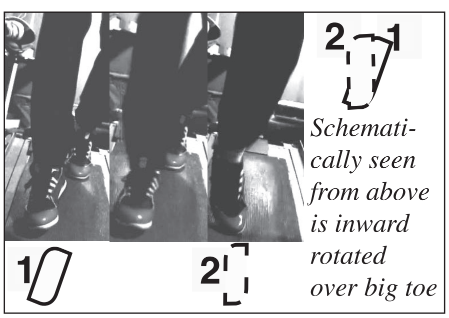


Fig. 130 *Analysis of the maximumspeed. Here Powersprint. Sprint model:PPT-ATP mode.*
At touch down the heel is pressed quickly down by the high pressure (a’-b‘) and touches the track. See also page 39, Fig. 78b. Exercise 17b in the exercise storage, which shows unique touch-down further in front of the hip.

Sprint model: PPT-APT-mode short*) alt. long rotation in hip, Quadriceps dominance. Hamstring, isometric antagonistic function.

The vertical pressure in touchdown and front support phase may also require a certain eccentric muscle work of the quadriceps. Fig. 131 shows PPT-APT mode with short rotation in power sprint training, but also that hamstring works isometrically, as an antagonist during the entire ground phase. s in the drive phase then muscle work can be done by the quadriceps dominance in the extension of knee and hip in the push off. This technique has been most common in the US and is probably also the traditional, which most coaches still is teaching. It also corresponds well with the activation of the quadriceps in clean alt. snatch hanging. As Figure 130 shows, it also can be applying with Power Sprint excellent with the advantage that even coordination in the hip side can be trained specifically. Focus on the horizontal force also applies here with powerful isometric hamstring work.**



*) Note! See pages also p. 50 and 53, which describes iliopsoas braking effect on the rotation of the femur in last part of stance (d-e). This results in the upper torso part is rotated forward with increased velocity (see page 50). Iliopsoas stretch even reactive which favors a quick knee lift after the toe-off. This technique should be particularly suitable for this sprintmodel.

**) Instead, it primarily is hamstring which extending the hip for today’s top sprinters, completely according Wiemanns theory (page 54) (which the author with this book attempted to describe)

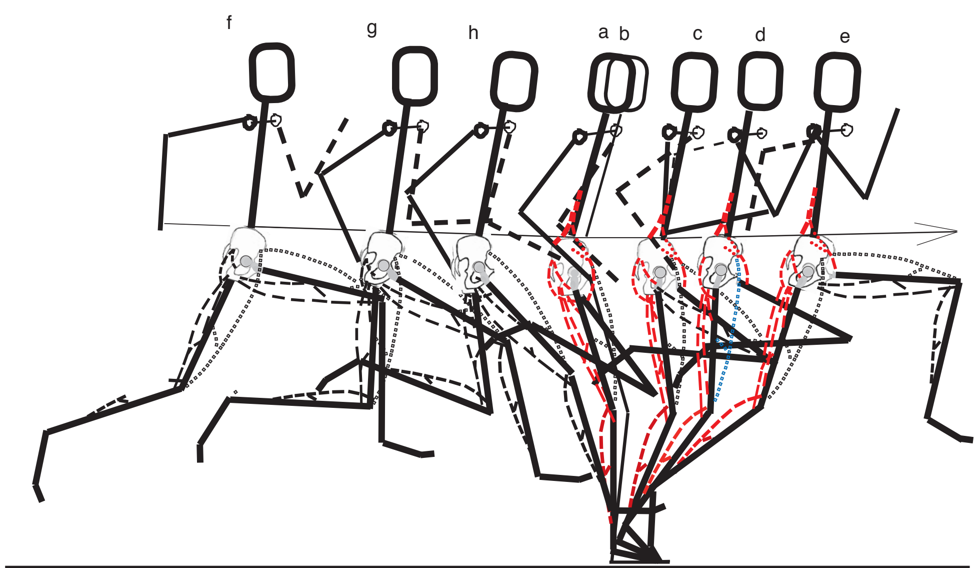


Fig. 131 *Sprint-model: PPT-APT-mode. “Short rotation in the hip joint”.*

Powersprint exercises.

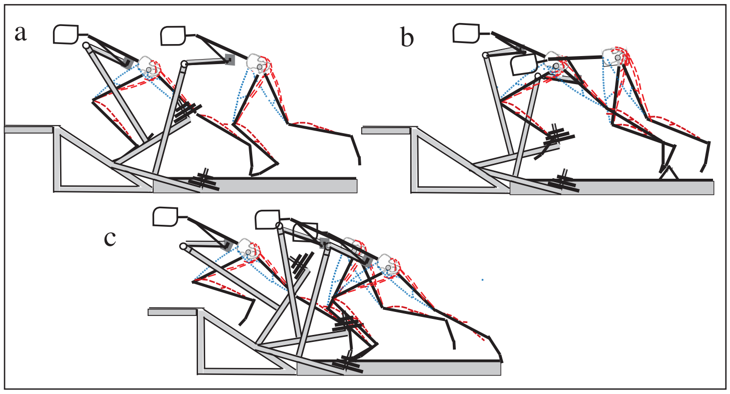
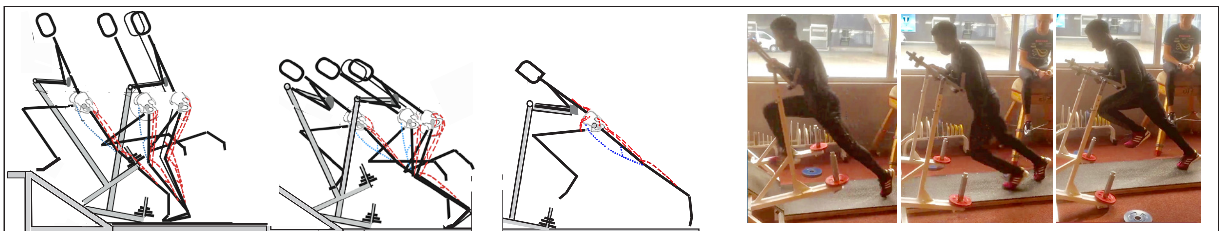


Fig. 132 *Powersprint:* a. *Accelerationphase I. First two steps* **(2a)**
b. *Blockstart* **(1)** *(Start block or similar)*
c. *Consiously extremly long support phase (Basic strength)*

1. Powersprint, Block start och Acceleration pfase I
Fig 132a, b shows strength training for block start **(1)** and first steps of the acceleration: Acceleraton I ((**2a**) in the trainings program). This exercise gives mainly a basic specific strength for quadriceps, gluteus and hamstring, but also for plantar flexors soleus and gastrocnemius. In addition, hip side and adductors will be trained if the typical "Skating"is used (See again page 58-59.

Figure 132 also shows how to use a startblock on a rather high platform for block start. This could easily be built as a construction by wood material.

Fig. 132c. shows basic total strength exercise for mostly gluteus and quadriceps but also muscle specifik for the advanced deep sprint start. You work consiously extremly long distance in the support phase for the total basic strength development



Acceleration I, second step after start. young sprinter, promise Raymond Mpanga (19 year) *100m pers.rec. 11.03) here training sprint specifik explosive powersprint in Malmö's indoor hall Athleticum.*

Fig. 133 *Powersprint®: Acceleration I, From second step to Acceleration I in higher positions* **(2b)**

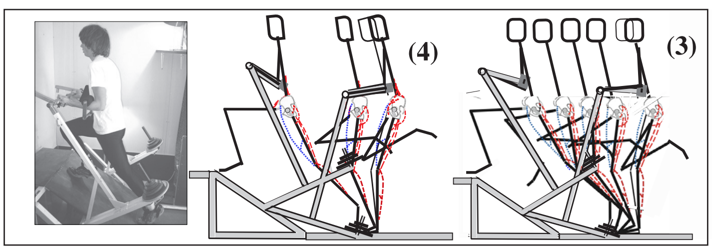


Fig. 134 *Powersprint®: Acceleration II* **(3)** *and Maximum pfase* **(4)**

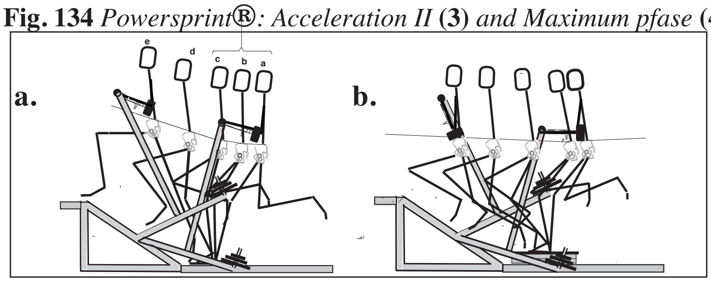


Fig. 135 *Powersprint®: Exercise for long jump* **(4b)**
a. *Take off* **b.** *Penultimate step approach*

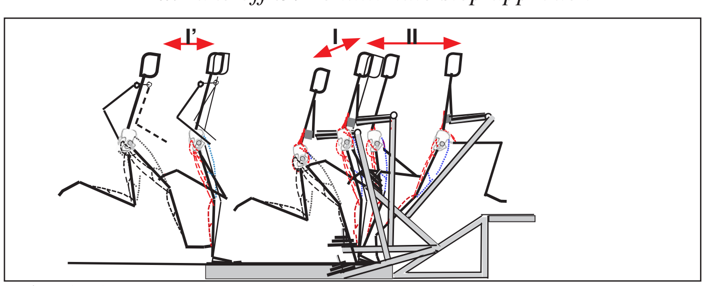


Fig. 136 *Powersprint. "the total ways" to muscle specific strength training for the maximum phase (Se more details at page 79*

2. Powersprint, Acceleration pfase I at higher position
Fig. 133 shows Powersprint®, for sprint Acceleration I, From deep position in second step to Acc.I in a higher position **2b**). Raymond Mpanga shows here perfectly sprint specific explosive performance.

3. Powersprint , Acceleration II and Maximum pfase.
Fig 134. shows Powersprint® with a specific exersice for Acceleration II, (**3**) and Maximum pfase, (**4**) .

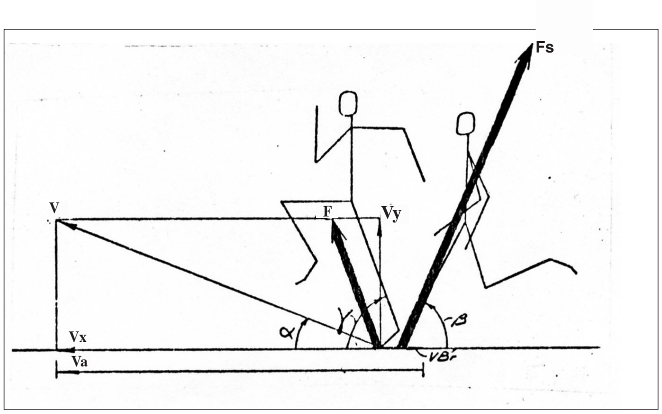
4. Powersprint for training of long jump's penultimate step and the take off in long- (or triple jump) from the board
Fig 135 shows PowerSprint ® with specific exercise for take off in the long jump and the final approach phase with the important penultimate step. Long jumpers! Please read chapter 5. There you could perhaps find your technique. See especially page 72, fig 153.

5. Powersprint, total muscle specific exercises for maximum phase (In the strength exercise storage, we might have shown the best exercise. Therefor we here repeat it and so also at page 79 in more detail). Fig. 136 shows:

Alt. A: Use combination of acceleration I from deeper positions with the maximum phase, where this is starting with the powersprint machine in an uplifted position (**II**).

Alt. B: Exercise the leg's movement as an elastic rod striking the ground (**I**). This in combination with maximum support phase (**II**). **I** and **II** could be done as one movement with a small focus before the explosive support phase **II.**

5. SPEED, LONG JUMP



Va = Run-up velocity
V = Take-off velocity
Vy(Vx) = Vertical (Horisontal) komponent of take-off velocity
Fs = Force throug the "rod" at touch down (se p.52)
F = Take off force
VBr = Braking
α = Take off angle
γ = Jump leg's angle against the ground in take off
β = Jump leg's angle against the ground at touchd.

L1 = Last stride of approach
L2 = Second last stride of approach
L3 = Third last stride of approach

Fig 140 *Vector parallelogram with the mechanical magnitudes, which are used to analyze a long jump.*

Another typical exemple where speed is of most importance for performance is long jump. We shall now first analyse different variants of jump techniques. Usually longjump has been considered easy with only two requirements:
- Fastest possible approach speed
- Strong take-off with concentration on height of the jump.

Instead, it is faced with a complex technique with several variants. Of this, the following sections dealt specifically two types of jumpers, who after their characteristic style we call:

- High Long Jumper
- Sprinter Long Jumper

High Long Jumper seek primarily large vertical force, with a prominently marked "take- off." Sprinter Long Jumper, however trying more to maintain speed through a flatter "uthopp". This, done right, experienced by the jumper, as running out from the board.

We shall try to describe various ways to perform a long jump with optimal technology. This is possible using stick figures made from movies and data from various studies 1) of jumps which have been performed with lengths from 6.50m to 8.90m.

Long jump Mechanics

A common way to explain längdhoppets mechanics is that use a so-called. vector parallelogram Fig. 140), which shows the size and direction of take-off velocity, V, and its horizontal (Vx) respectively. vertical (Vy) component. The diagram is an interesting beginning to an analysis of the long jump technique. Take-off velocity V and its direction (Take-off angle) is what primarily determines the long jump. The most important quantities, which are used in a long jump analysis is also shown by the table in Fig 151 page 73.

Jesse Owen, 1935 8.13m

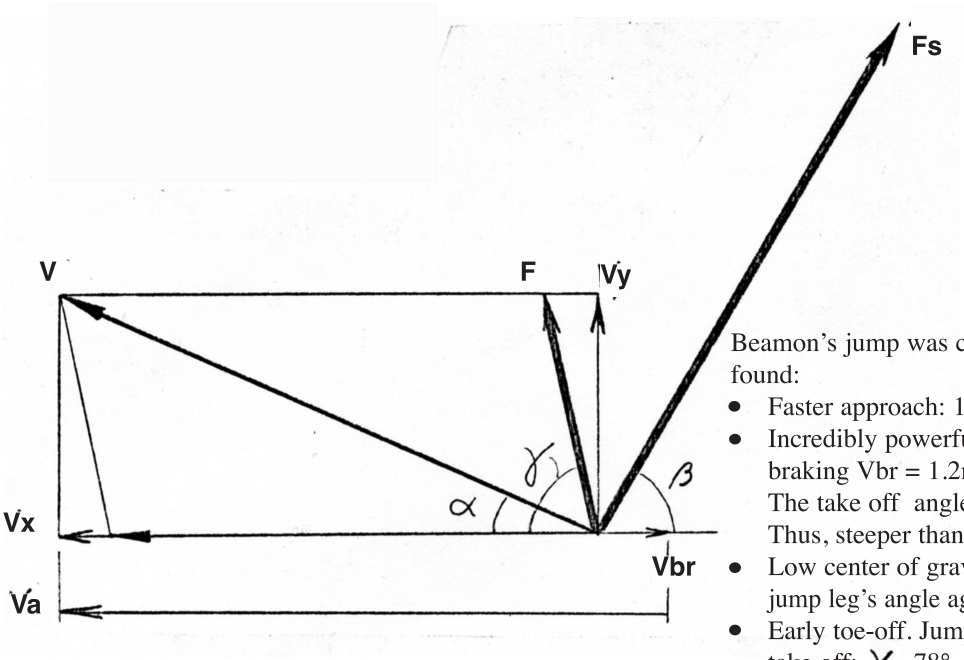
Jesse Owen, the owner of the world record 8.13m between 1935 and 1960 was, judging by the pictures and videos, a typical sprinter long jumper (Author). He succeeded extremely well make use of a high approach speed.

Legendary Jesse Owen, holder of world record 8.13m 1935 to 1960.

5.1 “High Long jump”

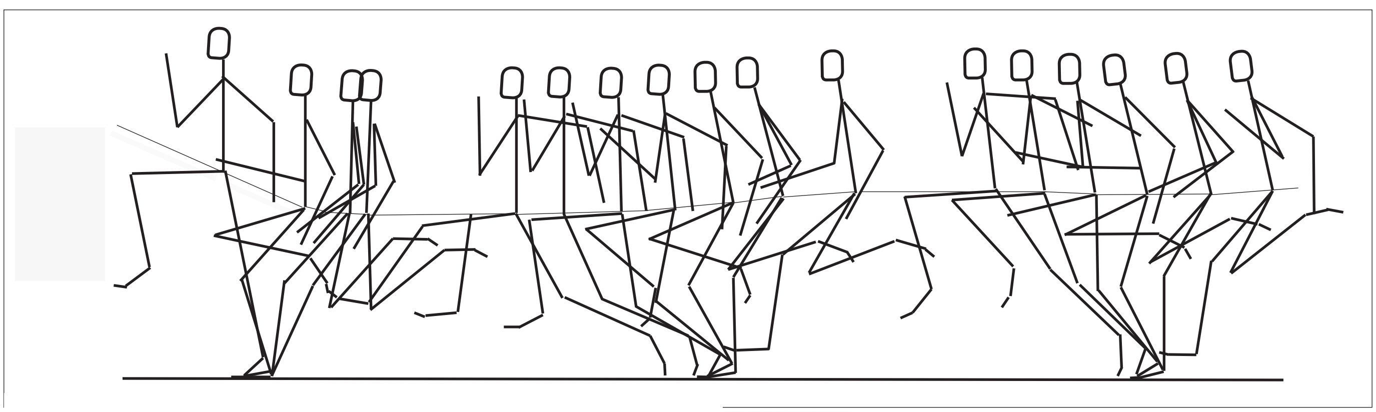
Bob Beamon 1968 8.90m

At the Mexico Olympics in 1968 Bob Beamon USA, took the world with amazement at his amazing world record jump 8.90m. Here we present data from this jump.
For several decades into the modern time, many have been inspired by Beamon’s powerful jumping technique.



Beamon’s jump was compared with the elite and it was found:

- Faster approach: 10.7m / s
- Incredibly powerful take off: Vy = 4.2m / s). With braking Vbr = 1.2m/s were obtained: Vx = 9.5m / s. The take off angle became α=24 ° (Tg = 4.2 / 9.5) Thus, steeper than normal for elite jumpers.
- Low center of gravity in touchdown on board, with jump leg’s angle against the ground at touchdown: β = 60°
- Early toe-off. Jump leg’s angle against the ground in take off: γ_2 =78°.



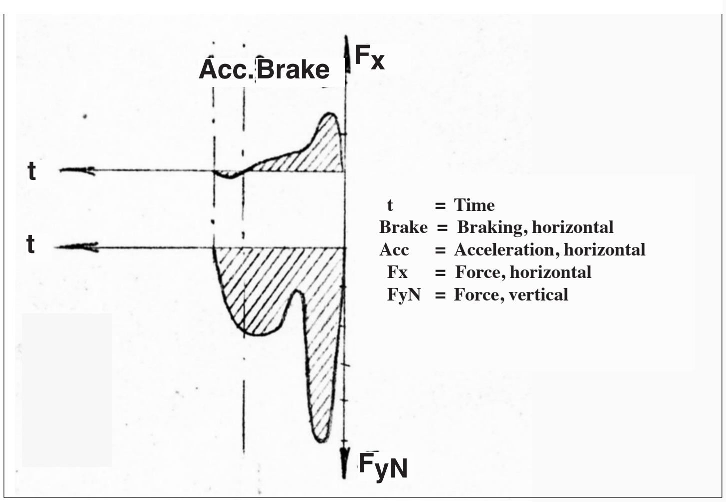


Fig 141 *Bob Beomon’s 8.90m jump, as the pressure diagrams probably looks like (The author)*

- Beomons penultimate step measured 2.40m and the last step all over 2.57m. The explanation for this is Beomons technology with a relatively high knee lift in the last step’s push off, followed by a marked out oscillation of the lower leg. Hereby the jump foot had a very long acceleration when it was whipped in the board. The pressure against it must have been very high, but when the jumping leg’s motion direction was backwards compared the jump’s forward move ment the braking was reduced significantly. Elite
- jumpers otherwise normal have a shorter last step. Beomons pendulum work with the free leg supports the jumping leg’s work with a peculiar rhythm and swing.

High long jump, approach.

The approach can be likened to a “loose” sprint start, with an slightly slower acceleration than in a 100m race. A good planning of the approach described Mike Powel -08 [1]. See Figure 144. For example, at 16 or 20-step approach you count every two step (eg only the jumping leg as in Fig 144). The approach then consists of 8 respectively. 10 “cycles”. Then you divide the approach in four parts: “The drive phase”, “transitional phase”, “attack phase” and “take off phase. “

Drive phase. You push off relatively powerful and about 45 ° trunk inclination in the starting step with head bowed. Now it’s full extensions particularly in the jumping leg with strong supportive arm- and leg-swings.

Transition phase’s tactic is to slowly rise head and trunk during relaxed sprinter running. This is the long jumper’s characteristic easy “sitting” with high knee lift.

During the **Attack phase** the velocity is driven up to near max usually by increasing leg frequency. Hereby focus on pretension (“elastic steel rail”, “stiffness”).[2]

Take off phase implies a special approach to rhythm and technique (see fig.147) where the first step is a normal sprinter step with concentration on the following important third step ahead of the board. The push off is done with incomplete knee extension, which is making that the jumper “float” forward more horizontally. The second step and last steps before the board is also done with incomplete extensions. The later is pulled out something. It is like waiting for the landing on the runway (Tom Tellez, “Just wait a little:). The last step is usually more shortened.

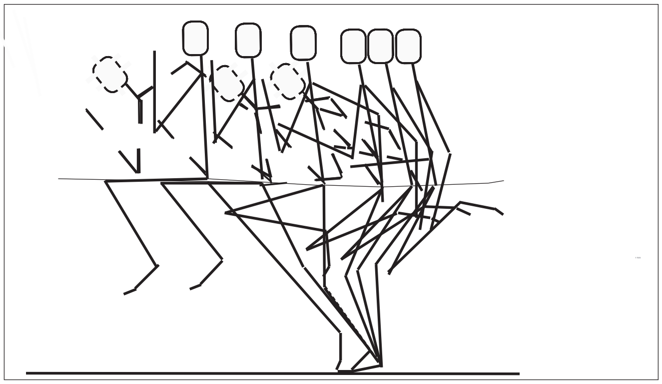


Fig 142 *“Drive pfase” 4-6 step and “Transition phase” 4-6 steps (according to M. Powel -08). Trunk inclination of the first approach step dashed in the figure*

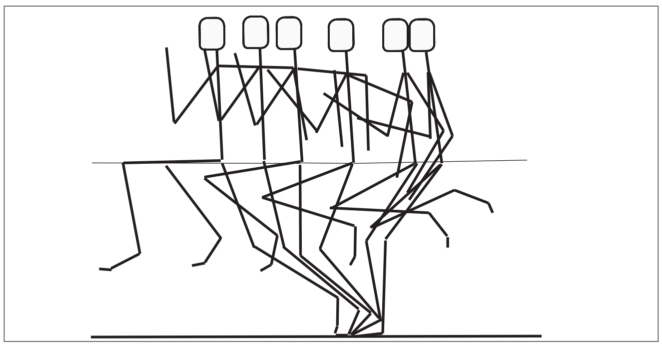


Fig 143 “*Attack phase” 4 steps (M.Powel-08).*

High long jump, last step and take off.

Ground phase of the last approach step, with special technique. We speak of the “penultimate step”, which suggests the technique of an “active” squats. You “pull” the track. Expressions such as “tearing”, “grab” describes the proper touch-down, which can be done in two ways:

A. A clear heel - toe rolling (Fig. 145)
B. Touch down on the front ball of the foot with easy heel contact (Fig. 141)

B. Gives less braking and admits as A further lowering the center of gravity. This is to meet the board in a deep position with the jumping leg at an acute angle to the runway, which is characteristic of the best high long jumpers such as Beomon 1968 and Salodino, 2007 (see p73). Carl Lewis used A. He compensated the braking with greater speed.

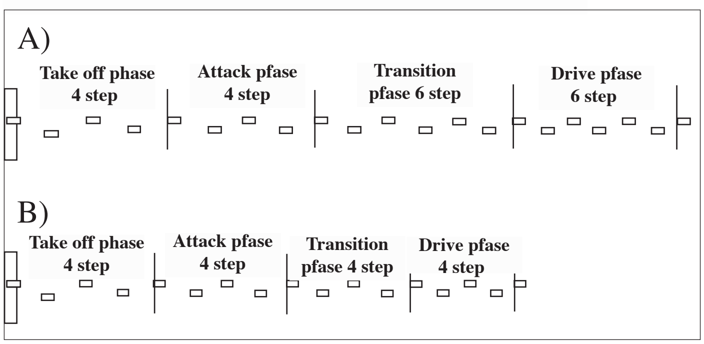


Fig 144 *A) Approach: 20-steps with. 10-“cycle rhythm” of elite jumpers. B) Approach: 16-steps with“. 8 -“cycle rhythm” for youth. (Mike Powel -08 1))*

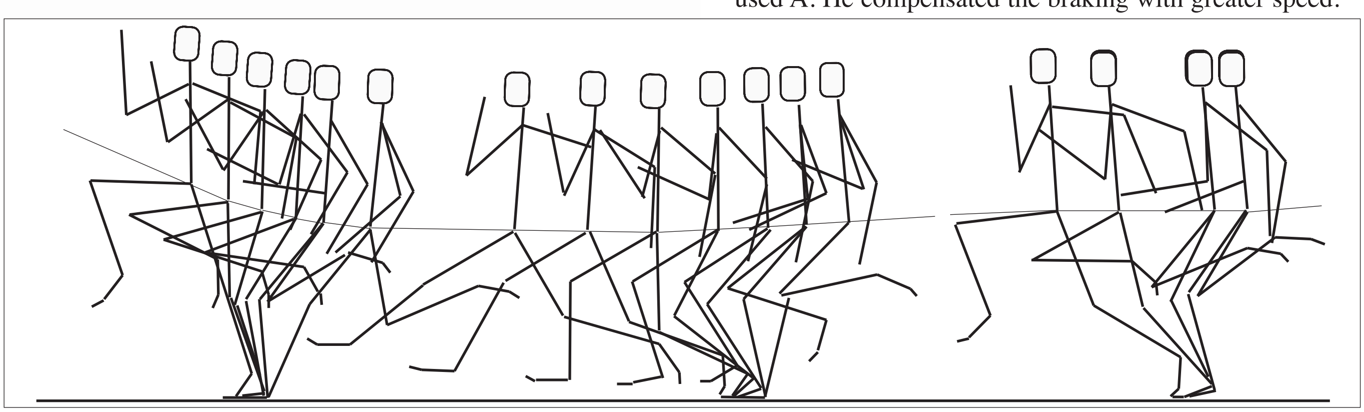


Fig 145 *Take off: The last step is usually shorter* *Penultimate step : Active squats (“pull”). It’s a little longer = CG Lowering*

1) Processed. from one Interviews with Mike Powel (http://trackandfield.about.com/od/longjump/p/powelljumptips.htm)
2) Attack phase with the increased step frequency gives a more “ fluid sprint running”, which seems to be great for sprinter long jump (See page 72, Carl Lewis technologies.

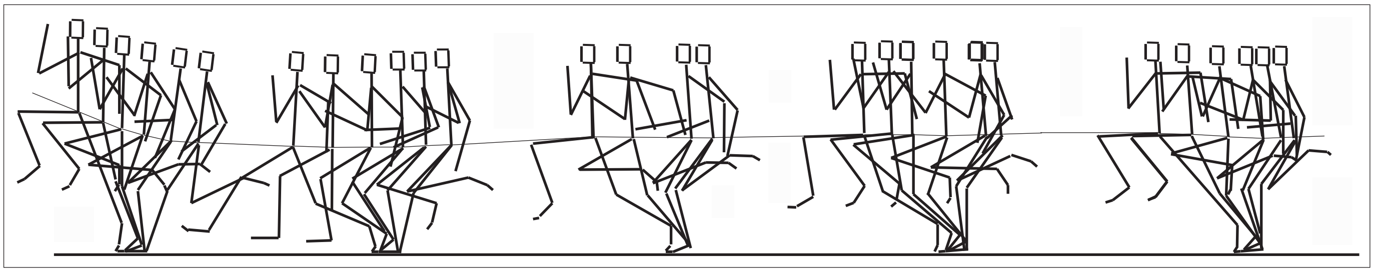


Fig 146 *High long jump. Variant with "lifting" in the last step and a higher position at the board (= "bounce" from the board)*

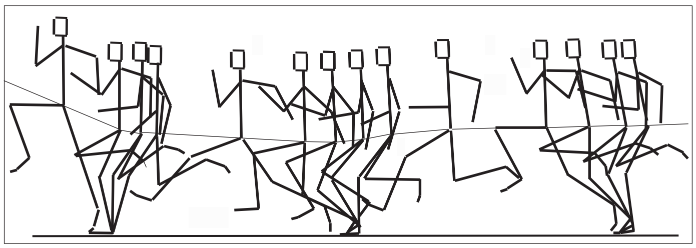


Fig 147 *High Long Jump, variant similar above figure 147*

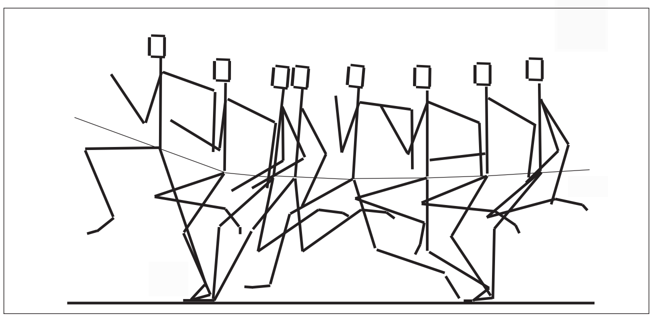


Fig 148 *High long jump, touch down and take off*

Elite = 8.0m	Bob Beamon 8.90m
Va = 10.5m/s	Va = 10.7m/s
Vx = 9.3m/s	Vx = 9.5m/s
Vy = 3.5m/s	Vy = 4.2m/s
α = 21°	α = 24°
γ = 70-75°	γ = 78°
β = 60-65°	β = 60°

High long jump, special variant

High long jump can also be performed with a "lift" in the last step from a deep heel-toe roll in the penultimate step. The take off is then done as a "bounce" in an elevated position with shorter time on the board. The technology can fit explosive jumpers with good jumping capabilities. It reminds of the fast variant of Flop High Jump. See figure 146 and 147.

High long jump, take off. Analysis.

Upphoppstekniken beskrivs i det följande:

1. The foot is moved mostly in a low motion against the board. (T.Tellez: "Just put it down"). The foot finally meets the board relaxed with a downward - rearward movement, which reduces the braking somewhat. The whole sole of the foot is inserted flat, but the heel meets the ground a "microsecond" before. (So that the gluteus damps the pressure author. reflection)
2. For a brief moment (15-20ms) increases the pressure vertical force (see Figure 141). Then the jumper immediately sag in to knee and ankle. It is during this short time mostly of the vertical velocity increase.
3. The jumper now pivots forwards upwards. The motion first becomes flat rising.
4. Finally the "lift" is is performed by quadriceps, gastrocnemius/soleus and the gluteus which are extending completely in all the joints. Great influence comes from the "lead" leg because of its mass. It should perform a short pendulum movement until the thigh is parallel to the ground.

High long jump, discussion

High long jump technique is likely optimal only for the long jumpers of the highest elite (8m-jumpers). It is therefore inappropriate to young people trying to accomplish get height on the jumps by by violently "stomping" the board. Unfortunately, usually the following occur:

- You make technology training with short approach and then tries to jump a long way with the help of a power ful, "springy" stomping take off for height in the jump.
- With a full approach you could possible initially achieve outstanding good performance, but later usually a surprising stagnation occurs.
- Unfortunately, even serious injuries can occur because of too much strain on his leg jumping. (Possible high jump training leads probably to the use of special variant above (author))

In his youth also the 8m-jumper was told från coach:

- "Work long at the board, " "Push through the hips better "," strike the board "clawing".
- Later after many years, coach tell you: "You not seem to increase your approach speed further. Now we must concentrate on a more powerful take off technique.

5.2 Sprinter long jump

Carl Lewis

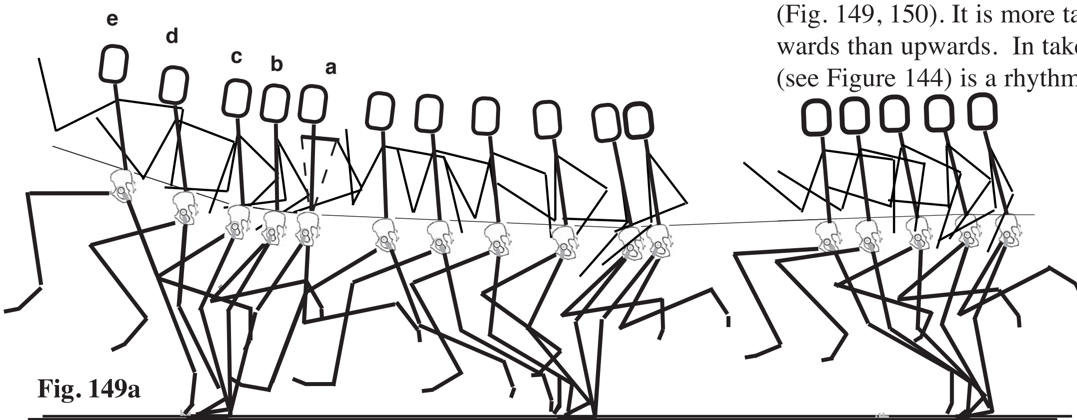


Fig. 149a

Carl Lewis last approach step and take off. Notice the free leg movements. The figure shows a unique optimum coordination between the free leg movements and support phases. From touchdown on a plank, then the femur - the knee is vertically below the hip, the feeling being as a "volley kick" of the foot.

Note: Carl Lewis uses the right leg in his take-off. This drawing shows his technique schematically fairly accurate except that left here is take-off leg

Carl Lewis

It has always existed in the U.S. Long jumpers, who used their pronounced sprinter speed with technology, which completely differs from the high long jump. Such was Carl Lewis (Fig. 149, 150). It is more talk about a jump in direction outwards than upwards. In take off phase the last approach steps (see Figure 144) is a rhythm changing, which gives a first hint of a "lifting" the last step approach. Then the foot is naturally "whipped" in the plank (as an active "gripping), with a very short first heel contact . The jump leg is slightly bent with pretension muscularity. The extremely fast last step occurs along with the pendulum leg, as "cutting motion" and end with the feeling of a "volley foot kick" forward-upward. Already during the attack phase (see page 70), with increased cadence, accentuated pretension (elastic "stiffness", "steel rail") "amortisationen" was prepared (a-b). From position (b) rod force pivots the whole body quickly forward upwards (b-c) followed by the explosive push off (c-e). This while free leg swings up and is blocked at paralell upper leg.The long deep penultimate step with a "lift" in the last step slows you down,but resulting in a less load on the jump leg. This can fit "sprinter runners" which often does not have the pronounced jump strength.

In the approach you sometimes can use a combination of "ATP" - and "PPT- models (Author) (illustrated here and previously on pages 58-59) Often in an alternating step rhythm in harmony with the coordination of the last three strides and take-off.

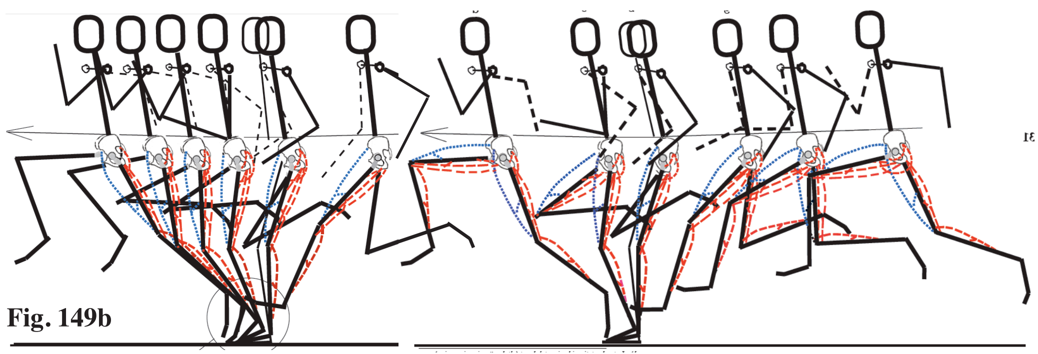


Fig. 149b

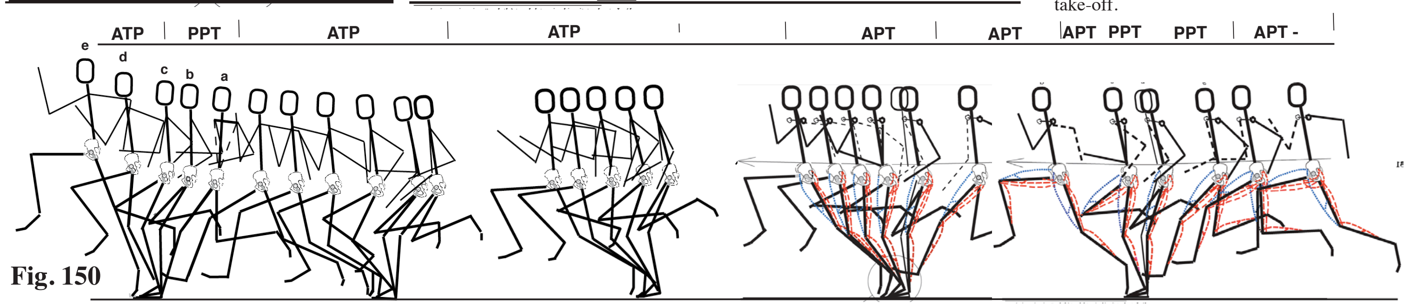
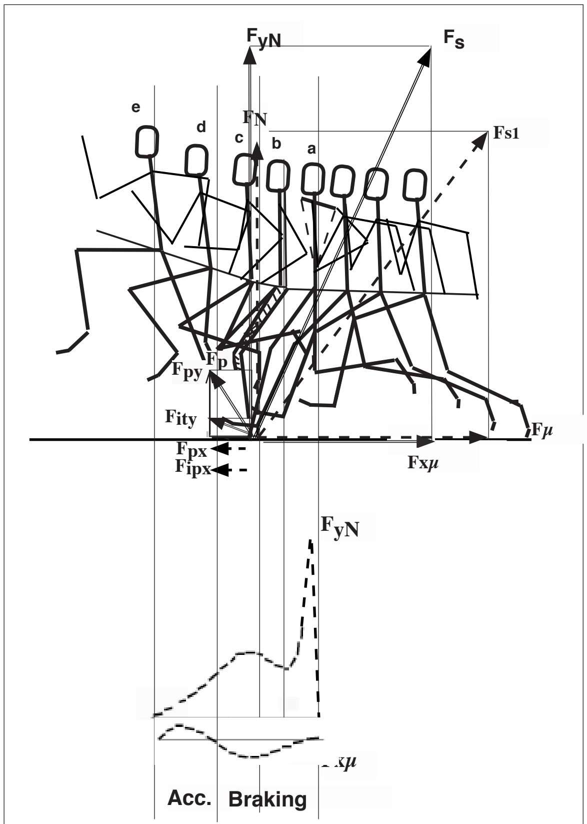


Fig. 150

Step rythm: "short"-"long"-"short" "Feet Runs Underneath the body and then passing" (Auth. talk with Joe Douglas Sthlm -83) *Penultimate step: "Just wait a little"* (Author's. conversation with Tom Tellez -89) *in contact with the ground and landing followed by a deeper ("pull") with a clear heel roll. Lewis performs here also a small side step.* Was recommended author. by Ralph Boston's coach Tom Ecker, Sthlm 1962). *with outward rotation of the foot, followed by a inward rotatin (see page 59). The latter implies a "lateral lift" - a "side-nudge" (Author) with feeling of some relief before touchdown on the plank. Here probably it's also obtained a horizontal-vertical speed boost. A contribution to this first vertical center of gravity increase is also a small "bending forward" and "rise" (See fig.) Jump The foot will now also be placed more in line with the center of gravity resulting in a more efficient take off. The foot touch-down occur with a movement forward-downward with unchanged step rhythm in an arcuate motion at lower altitude just below the knee. The lower leg is brought forward out to slightly as in a sprint stride and "is naturally whipped " in the plank, with a backward gripping motion (with negative velocity). Touchdown is done with the whole ball of the foot, but with an initial brief heel contact. Legs and seat muscles are preloaded for eccentric work during the so called amortisation phase* **a-b.** *This pretension is accentuated, as mentioned earlier, already in attack phase. The"springy rod" force is rotating the jumper forward upwards* **b-c**, *followed by the explosive push off* **c-e**. *An interesting techniques detail - his right arm and shoulder is kept back in a low position at touchdown. It then occurs an elastic stretch of the hip side (which immediately is stretched, "as a rubber strap"* (Author's talks with Valeri Bunin at an international training course in the long jump -94, "a secret behind the Russian long- and triple- jumpers") *Another detail is that Lewis performs an "outwards rotation over the toe", probably with using adductors with higher force in the push off (See also page 75)*

Lewis = 8.91m	Powel = 8.95m
Va = 11.06m/s	Va = 11m/s
Vx = 9.72m/s	Vx = 9.09m/s
Vy = 3.22m/s	Vy = 3.70m/s
α = 18.3°	α = 22.1°
γ = 67.5°	γ = 73.9°
β = 77°	β = 71.8°
L1 = 1.88	L1 = 2.28
L2 = 2.70	L2 = 2.74
L3 = 2.23	L3 = 2.40

Analysis of Carl Lewis sprinter long jump. Data Comparison, Mike Powel - a more typical hight long jumper.



F_t = Reaction force at touchdown
F_p = Reaction force from pendulum leg
F_N = Normal force
$F\mu$ = Braking horizontal friction force
Fy_N = Force component, vertical
($Fy_N = F_{N} + F_{py} + F_{ty}$)
$Fx\mu$ = Braking component, horizontal
($Fx\mu = F\mu - F_{px} - F_{tx}$).
($Fx\mu$ brakes therefore less than $F\mu$)
Fs = Force at touchdown, resultant
Fs1 = Force resultant to $F\mu$ and F_N
(Without Fp and Ft could mean large torsional moment about the body's center of gravity. The jumper then will have a great forward rotation.)

Fig 151 *Biomechanical analysis of the sprinter long jump*

Sprinter longjump, mechanics, muscle work.

We have also previously in sprinter technology-section used the natural "foot strike" naming the touch down. Put down the foot with a quick sweeping arcuate motion against the board, with slightly bent jump leg, in harmony with the free leg swing movement forward-upward. As in sprinter running the leg's muscles are in pre tension to cope "amortisationen". We shall now describe in more detail what happens**:**

Take off

The pretensioned leg and buttocks muscles at touchdown means that foot and knee are fixed ("locked"). The pelvis is backward tilted, with isomet- rically working gluteus and rectus femoris. At touchdown the leg is forming with the upper body, through the pre- tensed muscles a pretty solid unit, which is like a rod. When its lower end (foot) are trapped in the ground, the top (upperbody), gets an increased speed. The rod will thus rotate around its support point in the ground. This is what is meant by the rod - principle. By the rod seems a force. Fig 151 shows the forces during take off using a schematic pressure diagram. Force $\mathbf{F_s}$, consisting of a braking component $\mathbf{Fx\mu}$ in the horizontal direction and the accelerating component of $\mathbf{Fy_N}$ in the vertical direction, grows rapidly to a high value of up to 10 times the body weight of elite jumpers. The force operate with a high pressure at the board a very short time. Already after about 15ms, the pressure reached its maximum. (**b**) and then diminishes rapidly.

During touchdown **a - c** there is also the reaction force $\mathbf{F_p+F_t}$ in the jump (running) direction from the ground. The jumper should increase this force, and with an active ("strike") $\mathbf{F_t}$ ("gripping") and with a "swung- full" bone pendulum $\mathbf{F_p}$. The braking is then reduced. Another positive effect by $\mathbf{F_p}$ and $\mathbf{F_t}$ is that force $\mathbf{F_s}$,will be directed more through the body's center of gravity (Fig. 151). The torque around the center of gravity is then zero, so the jumper will be in better balance in the air with little forward rotation. Then one can jump great also with simple techniques in the air as hangstile. An important fact is that without the sum of Fp and Fip a dangerous force Fs1 would be produced and partly severely damage the jumper (Note: Serious bone fractures have occurred in long jump) and the jumper would get too strong forward rotation which would frustrate the proper technique in the landing.

In position **c** the pressure diagram shows that $\mathbf{Fy_N}$ again has risen to about 1/3 of $\mathbf{F_s}$ value. From here then the push off is completed **c - e**, as a powerful sprinter step, but in a more upward direction. Just before **d** correspond to the point where the vertical line from the body's center of gravity is passing just above the foot. $\mathbf{Fx\mu}$ then is changed to acceleration in the horizontal direction.

Heiki Drechler was a female representative for sprinter long jump. In Figure 152 displays vertical and horizontal reactive forces in the two training jumps with the same jump length at different approach speeds. Interestingly, at higher speed she needs significantly less vertical force, which incidentally seems extremely short-lived. At World Cup 1991 jumps Heiki 7.29m with only angle 18.3 ° and compared to the other competitors (see table on page 73), with a significantly lower vertical jump speed.

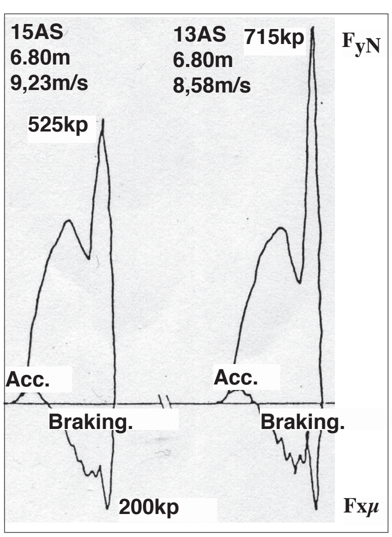


Fig 152
Heiki Drechslers vertical and horizontal reactive forces in the two jumps with the same jump length 6.80m at different number of approach steps (AS) approach speeds 8:58 respectively. 9.23 m / s [1]

1) Modif. from Die Lehre der Leichtathletic nunber 22 -93

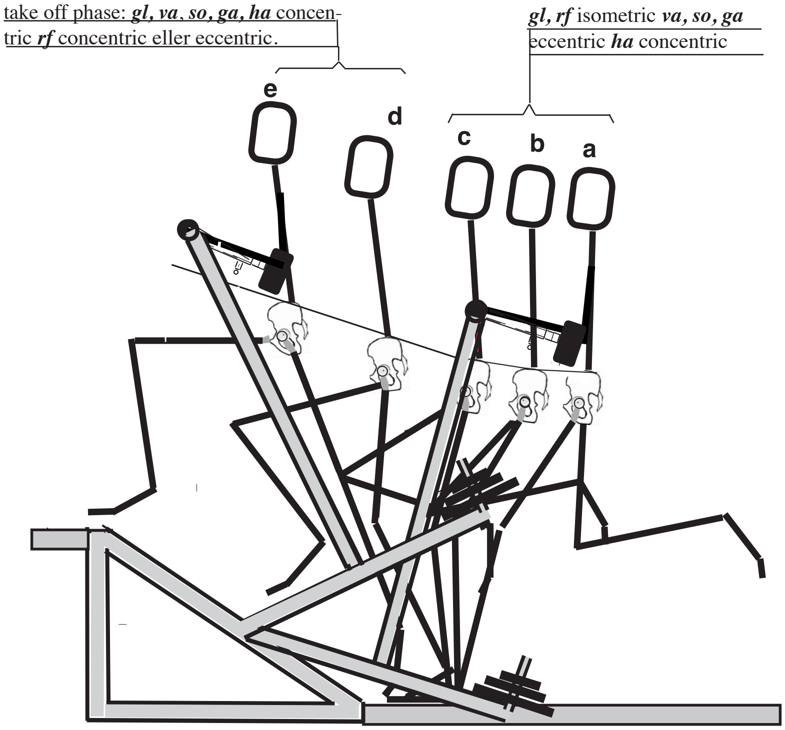


Fig 153 *Muscle work at take off for a typical sprinter long jump 1)*
Here specifik Powersprint strength training

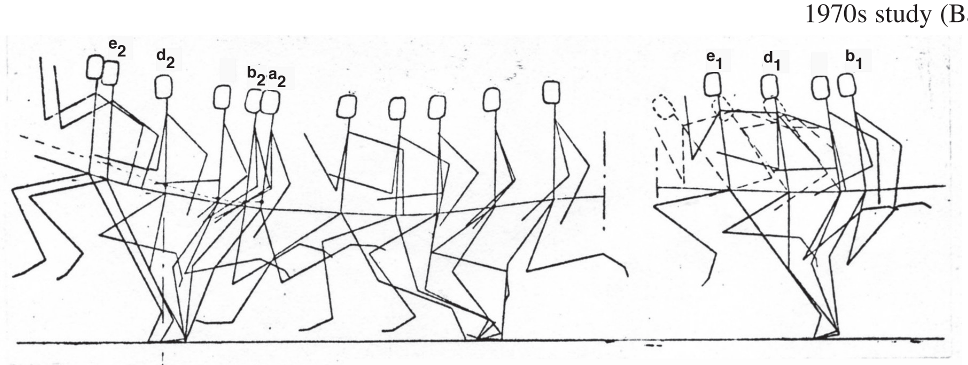
Muscle work

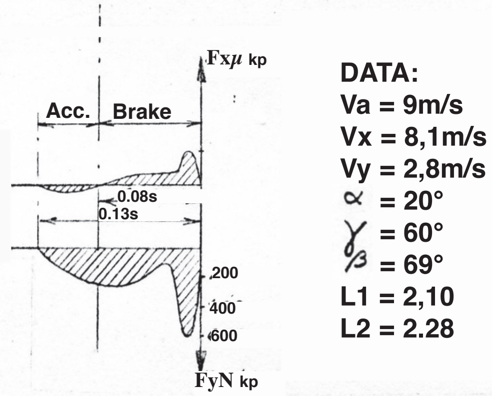
Study the schematic illustration in fig.153 with ***r**ectus **f**emoris, **va**stus lateralis, **gl**uteus, **ga**strocnemius, **so**leus* och ***ha**mstring*. Muscle work happens as follows:

a_1 - c_2: ***gl, rf*** isometric. ***va, so, ga*** eccentric. ***ha*** concentric.
c_2 - e_2: ***gl, va, so, ga, ha*** concentric. ***rf*** concentric. or eccentric.[1]

Sprinter Long jump, beginner and intermediate level jumpers (6.50-7,20)

These data with illustrations (author.) is based on an early 1970s study (Ballreich). It was scientifically carefully made and may was well worth to be presented even today. Reason for that this group of jumpers (20 males with jump lengths 6:50 - 7:20m with an average of 6.80m), can be included in the category of sprint long jumpers depends on the relatively flat take off angle 20 ° with a low braking of horizontal speed. A speed reduction of only 0.9 m / s.-

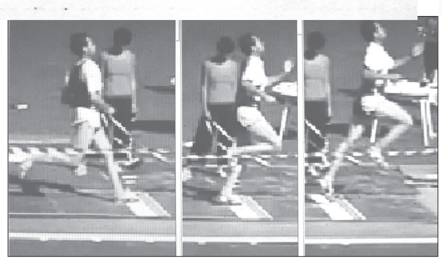




154 *Analysis of long jump by an early 1970s study (Ballreich)*

Properties:

- The "Lift" in the last step relieves the load on the jumpleg. After the active touchdown, jumper can easily "float out" in the jump with a delayed ankle extension.
- The jumper is here totally focused on extension of hip, but less on the knee lift and trunk stability. The trunk "rocks" back slightly (typically for beginners eager to enter the hang-style directly in the jump, the author. refl.). The technology is probably optimal for this long jumpers capacity.



Kent Nygren a swedish veteran world champion, here in a 6.50m jump, can be a good representative for this style. He, however, manage just fine with trunk stability

1) Authors study of this article: The EMG activity and mechanics of the running jump as a function of take off angle. W. Kakihana, S. Suzuki (Journal of Electromyography and Kinesiology 11 (2001, 365-372)
Processed data also from Biomechanics of the long jump, Nicholas P. Linthorne

Biomechanical study of the long jump 2007

In conjunction with the World Championships in Osaka in 2007, a biomechanical survey[1] was made in respect of the best long jumper's properties (see table below). It was found three types of jumpers. Depending on velocities in the jumps, one could divide the jumpers into three groups:

1. Large vertical and horizontal velocity
   (First Salodino, 2nd Howe, 3rd Phillips)

2. Large vertical and small horizontal velocity:
   (4th Lukashevych, 5th Mokoena)
   In these two groups we have our "High Long Jumpers" (author)

3. A small vertical and large horizontal velocity
   (6th Beckford, 5th Badji 6th Marzouq)
   These two jumpers could be considered "sprint jumpers, " but far from Carl Lewis capacity (Author.)

	Salodino	Howe	Philips	Lukashevych	Mokoena	Beckford	Badji	Marzouq	Övriga
	8.58m	8.47m	8,50	8,25	8,28	8.20	8.09	8,04	8.15+-0.17
Va	10.52m/s	10.87m/s	10.38m/s	9,97m/s	10,12m/s	10,63m/s	10,16m/s	10.22m/s	10.65+-0.19
Vx	8.90m/s	9.26m/s	8.96m/s	8,27m/s	8,33m/s	9.05m/s	8.83m/s	9,03m/s	8.77+-0.22
Vy	3.75m/s	3.46m/s	3.67m/s	3.78m/s	3.71m/s	3.25m/s	3.17m/s	3.01m/s	3.42+- 0.26
∝	22.9°	20.5°	22.3°	24.6°	24.0°	19.8°	19.8°	18.4°	21.3°+- 1.5

From the table below with female Long jumpers from Osaka and Tokyo World Championships we have:

High long jumpers: Lebedeva and J.J Kersee
Sprint long jumpers: H Drechsler and Kotov (Author)

	Osaka VM 2007			Tokyo VM 1991		
	Lebedeva	Kolchanova	Kotova	JJ.Kersee	H. Drechsler	Övriga
	7.03m	6.92m	6.90m	7.32	7.29	6.95+-0.43
Va	9,37m/s	9.13m/s	9.08m/s	9.85m/s	9.86m/s	9.53+-0.11
Vx	7.73m/s	7.73m/s	8,14m/s	8.09m/s	8.49m/s	7.92+-0.31
Vy	3.50m/s	3.23m/s	3.18m/s	3.46m/s	2.80m/s	3.05+- 0.24
∝	24.4°	22.7°	21.3°	23.2°	18.3°	21.1°+- 2.0

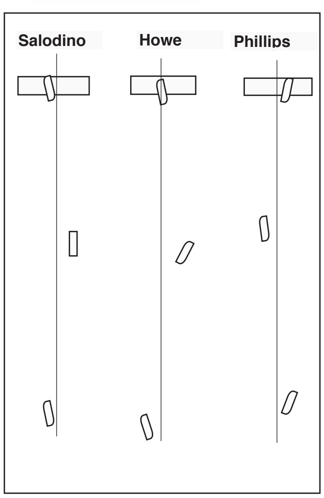
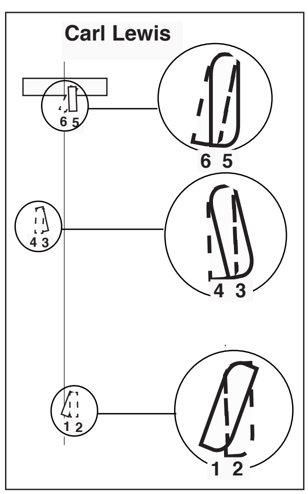


Fig. 155a *Touch downs, the last two approach steps and on the board. The three best long jumpers. in Osaka World Championships 2007*



155b *Carl Lewis footwork, schematically drawed from above with leg* inward rotated *(p. 59), 1-2, 3-4 and in the take-off " outwards rotation"5-6.*

They filmed the touch downs and came to what here is described in point 1-3. (see Figure 155a):

1. In the penultimate step the touchdown is slightly from midline, about 10-20cm. This "slide-step " was already used by Jesse Owen but mainly by Carl Lewis (Author).
2. Touchdown on the board is on the center line with the leg slightly tilted inwards. The researchers then concluded that the jumpers effective use abductors (gl.medius, gl.minimus, tensor fasciae lata) and extend the hip side.(Compare page 38 Figure 77 with the text "rubber-strap "(V. Bunin)).
3. Salodini had a large shoulder rotation, which coordinates with the stretching of the hip side in accordance with above point 2. See also p.70, fig 149a. Carl Lewis pulls hastily back shoulder before the touch down and this is resulting in a elastic stretching of the hip side. (Author refl.)

In the penultimate stage Carl Lewis has a "slide-step" [1] after a typical inward rotated leg 1-2 and in the touch down also a well-accented inward rotated 3-4. The foot is put in a straight line on the board followed by an outwards rotatation 5-6, ie. Outward rotation of the sole of the foot over the big toe during simultaneous inward-turning of the heel over middle line.[2] Muscularly it's likely adductor magnus and vastus medialis, which primarily is engaged for Carl Lewis push off. This will prolong and enhance the accelerating force in the take off.[2]

1) Modif. ur KINEMATICS OF TAKEOFF MOTION OF THE WORLD ELITE LONGJUMPERS
Hiroyuki Koyama1, Yuya Muraki2, Megumi Takamoto2, and Michiyoshi Ae1
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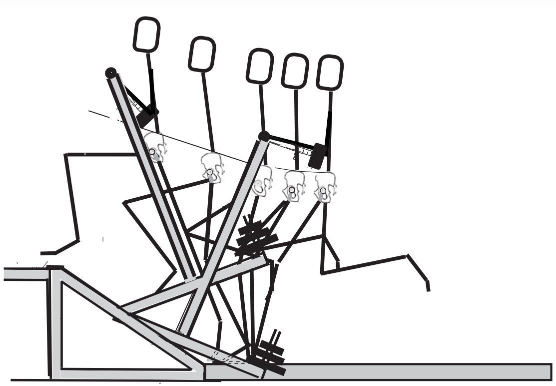
1)Author. 2) Magnus Warfvinge from filmstudies -2014

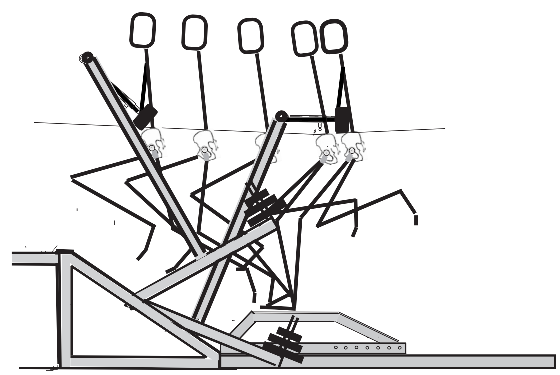
Sprint long jump, Brittney Reese 2016.
"Heel-toe" rolling och center of gravity lift in last step. (Author tells at page 75)

Brittney Reese five approach steps and take-off. Photo montage from filmclip [1].

Last approach step short "lifting". Small but clear upward movement of the center of gravity in order to reduce the load of the jump leg.

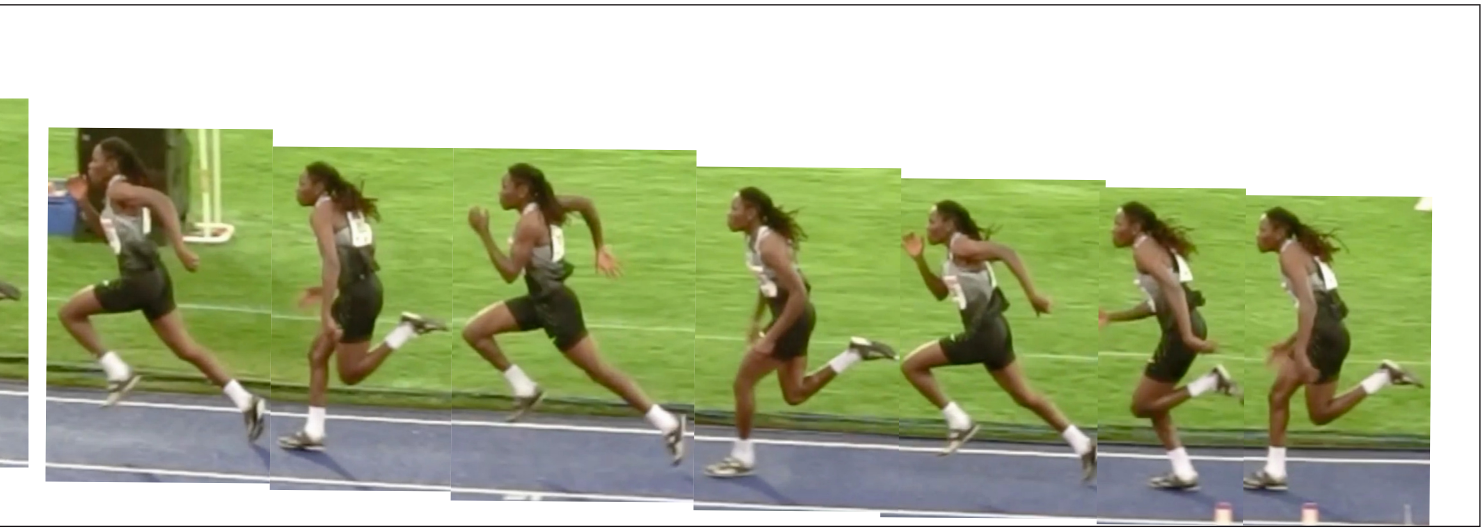


Muscle-specific exercise with Powersprint machine. Take-off with a "drive" upwards and out from the board. Focus on the hipextensors.



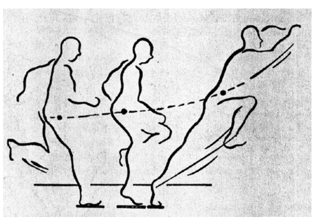
Muscle-specific exercise with Powersprint machine. The Penultimate step: Landing with a gripping "heel-toe rolling" and an inward leg rotation. Big muscular effort by hamstring and gluteus and a small but still a certain lift of the center of gravity in last step.

1) Filmclip Peter Hornebrant 2016

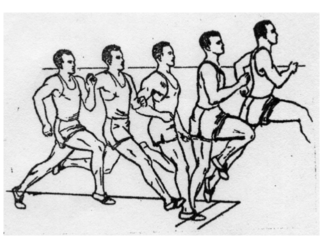


The photo montage by Brittney Reese shows here a unique optimized technology that leads my mind to Houston in 1999. The Swedish Henrik Olausson, trained by Tom Tellez, had conveyed my visit. Generously, opportunities were offered for interesting questions about Carl Lewis technology. When I, as a Master, tried some easy jumps with a short approch, Tom Tellez criticized my penultimate and last step. He eagerly showed me the technique with deeper "heel-toe rolling"[1] into a short last step. The jump then felt immediately easier to perform. This technical feature, used by Carl Lewis and Brittney Reese, can be crucial for an optimally performed sprint length jump for the following reasons:

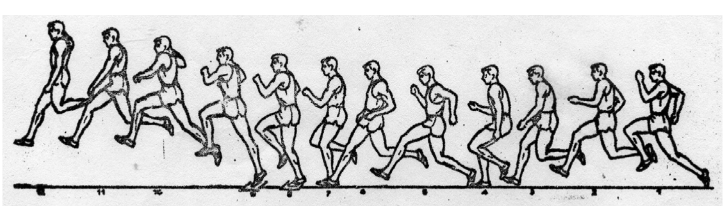
1. A small center of gravity elevation ("lifting") in the final step allows an active gripping movement to "drive" up and out in take-off with sprint technique and then with a high power insert from the hip extensors.
2. The speed loss with this "heel-toe" rolling is compensated by a faster speed in the approach and also by a less velocity brake in the take-off. The latter should also reduce the risk of injury.



Larry Schneider Jesse Owen's coach: "The center of gravity must be ahead of the take-off foot" after a shortened last step and upright posture. This old schematic drawing, is showing this a bit exaggerating. This drawing is Interesting in comparison to Brittney Reese energetic forward inclination of trunk still until the last step. This is also clearly seen in old movie clips of Jesse Owen.



"Jesse Owen seemed to just running out in the take-off". This drawing from the 40's show Jesse Owens upright posture with foot insertion after a short last step.



Ter-Ovanesjan 1967 World Record Holder, High Long Jumper with a characteristic jumping with a powerful braking vertical force using the jumping leg as a springy rod.

High- / Sprint long jumping. Summary and discussion:

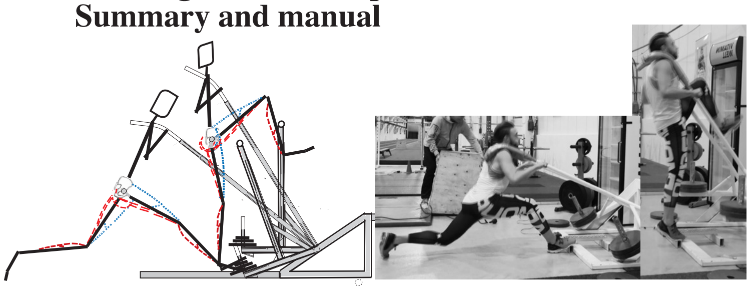
High long jump technique can of course lead to excellent performances (Beamin, Powell, Salodino et al.), but always involve considerable injury risk due to higher vertical force. A sprint long jump requires better speed, but also a necessary special advanced technique in the penultimate and the last step of the approach according to describing above. It should be noted that the most successful long jumper without a comparing is Carl Lewis with his four Olympic gold in four Olympic Games. Therefore, sprint long jump technique should be considered more serious than the case today.

Many coaches from the past argue that: "A good jumping technique is characterized primarily by a smooth transition between the approach speed and the take-off".

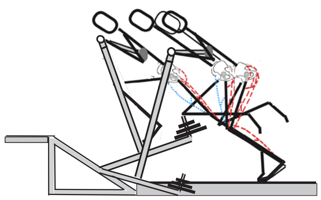
A recipe that Jesse Owen used already 80 years ago.

1) Also applies with the "inward rotation" of leg which was not mentioned at this occasion. Later movie studies shown this. (see page 70 and 73)

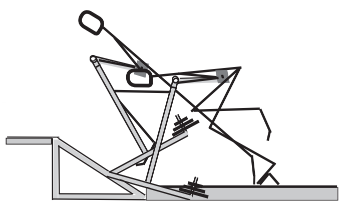
5.4 Training with Powersprint® Summary and manual



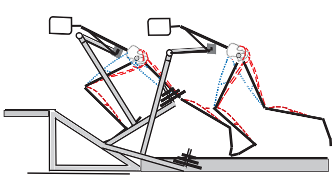
Powersprint®. with leverage mechanism
As an accessory. General overall exercise for hamstring and gluteus. The picture: Tom-Kling Baptist



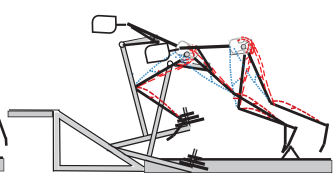
Acc I, first two steps



Block start

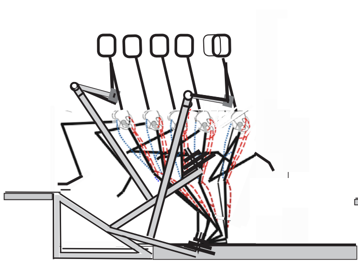


Acc I, first two steps

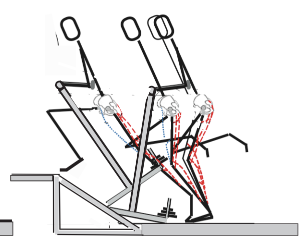


Block start

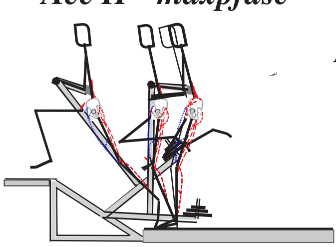
Advanced "super elite" start with Powersprint training



Acc II - maxpfase



Acc I, higher position



Max pfase.
Powersprint machine, the original, with rotation-shoulder axis which proved to be the optimal specific sprint design

Manual for Powersprint:
1. Grip with the palm upward ("Curlfattning") and pull gently against the body so that the support plate is in contact with abdominals.
2. The support plate should lightly touch the belly.
3. The pressure should be distributed on several points. Use not only the support plate, but to work actively with the upper body. Feel the pressure is distributed on abdominal, chest muscles, shoulder and back muscles. Try also on the feels good to angle the elbows slightly against the oblique abdominal muscles.
4. You must build a platform (120x500x1400, (height, width length)) by wood dressed with a rubber mat

General strength training .

Basic exercise for hip extensors and mainly gluteus and hamstring. The exercise may seen as a simple "Step-up" but can now be done with extra high security, and you get hamstring to take part in the total movement, which occurs as a very big motion from extended position. Performed in a lever mechanism which can be connected to the powersprint machine (can be ordered as an accessory). The padded levers is resting on the shoulders and the back are held straight during the whole movement.

Speedstrength and explosive maximum strength Acceleration I Blockstart

The exercises for accelerate I are training explosive maximum strength and speed strength for the technology of the starting steps. The exercise for block-start is a specific technique training where you perfect could use a start-block. Is used primarily as a speed strength exercises. Still possible for both specific explosive maximum and speed strength of the quadriceps, hamstrings and the gluteus, but also for extending the ankle with soleus and the gastrocnemius. In the acceleration I in addition is also training hip side and adductors. (See text and graphics on pages. 58-59). The posture and movements of Pelvis is very much a secret of sprint running (Author). Mainly the quadriceps and gluteus are engaged, but for driving the body forward flat, hamstring is required to "resist against". ie according to Wieman hamstring then is working isometric ((See p. 49 Fig. 109). The machine need a a platform (ramp) which you easily could built of wood and dressed with a rubber mat

Explosive maximum strength and speed strength Acc II and Maximum phase

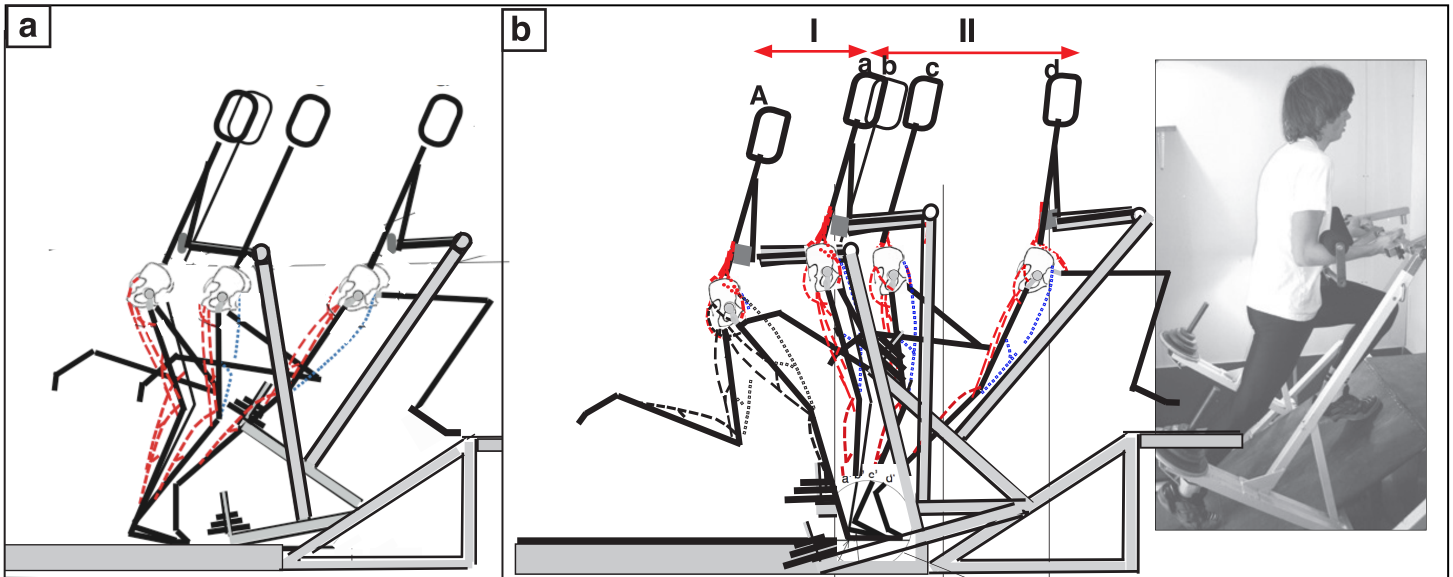
Training of technical details for the Acceleration II and the various individual max phase sprint models (see pages 58-59 can be done as a basic exercise, but is primarily used to train explosive maximum strength (NMC "explosive") and speed strength. Might as well as other exercises, such as take-off (see page 72, fig 153) for the long jump, strongly contributing to improved technology.advantage).

Total muscle specific exersices for maximum phase

Again, we describe this here, probably the best exercise. On the next page 79 this shows the "total" way to use Powersprint.

Alt. A: Use combination of acceleration I from deeper positions (upper fig. a) with maximum phase, where this is starting with the powersprint machine in an uplifted position (upper fig b (**II**)). Now the most criti cal movement is taking place in max speed sprinter running. With a bouncing explosive started acceleration, one can probably come very close to the pressure diagram data (see page 79)

Alt. B: You could also exercise the leg's movement as an elastic rod striking the ground (upper and bottom fig. b (**II**). This in combination with maximum support phase (upper and bottom fig. b (**II**)).
I and **II** could be done as one movement eventually with a small concentration before the explosive support phase **II.**

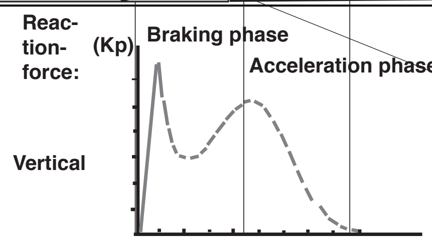


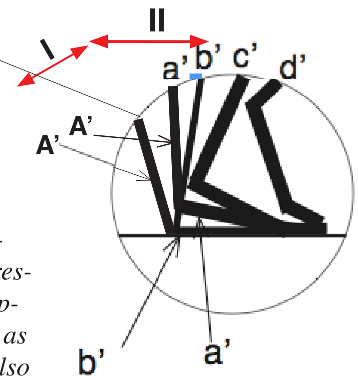
Total muscle specifik ways to use Powersprint.

Alternativ:

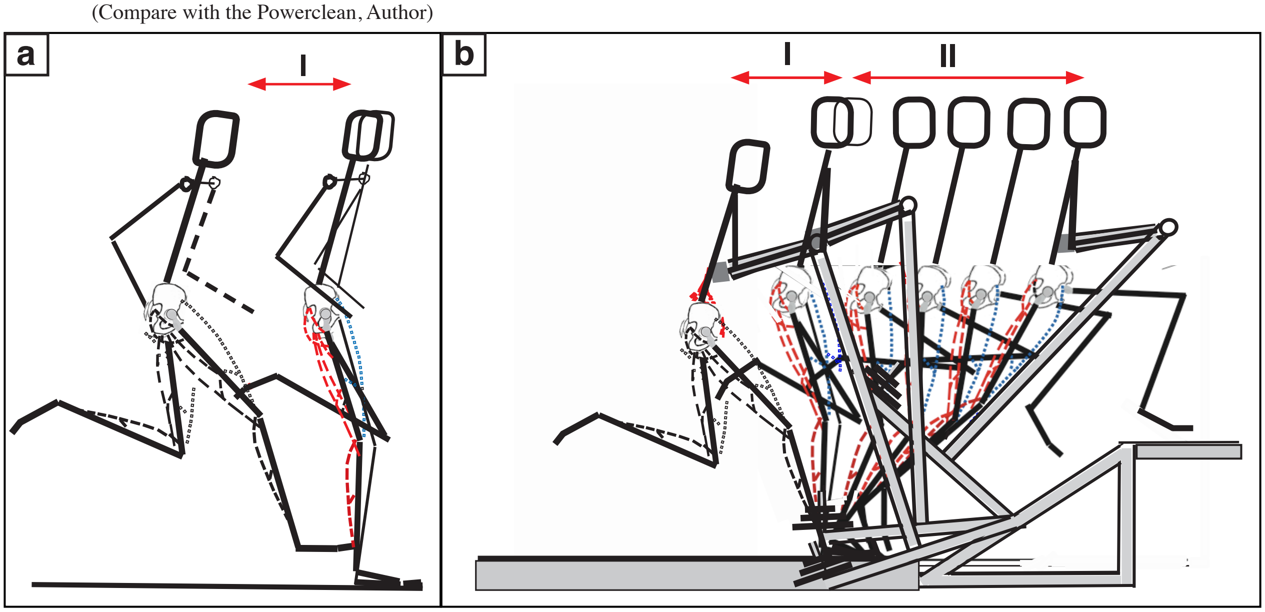
A: *See upper fig*. a. *Powersprint accelerations I .Then work as another exercise directly from the uplifted position as upper fig*. b **II** *is showing*.

B: *See bottom fig*. b **I.** *Simulating the leg's movement as an elastic rod striking the ground (fig. a)*
See upper fig b **II** *Maximum phase"Model PPT-APT "short rotation in the hip"(Also called " Front mechanics")*.
See bottom fig b **II** *Maximum phase"Model APT "long rotation in the hip". Movement is started from uplifted position of the machine*. **I.** *and* **II** *can also be performed, as a single movement only with a brief moment of "focus" on the explosion* **II.**
(Compare with the Powerclean, Author)



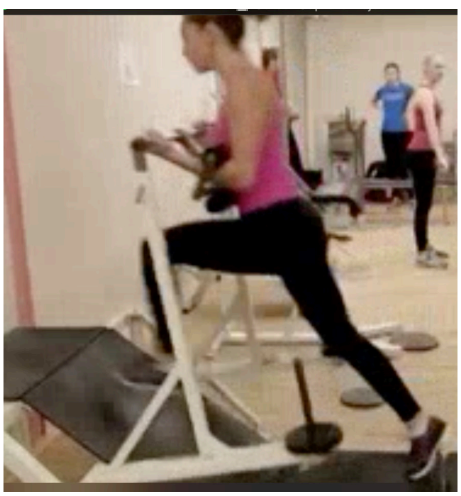


If the atack against the load of the Powersprint machine is explosive certainly a pressure diagram should be similary to the supportphase in sprinting. When here the leg as an elastic rod is rotating in the hip joint also the vertical force will be high. s(Hope to get a reserching about this sometime, (Author)) Note the platform. (high: 135-140mm)



*a. The figure shows the the leg's striking the nere the ground (***I***) with locked knee.*
*b. Acceleration II - Maximum phase, Model ATP "long rotation in the hip". Here simulating the leg's movement as an elastic rod striking the ground (***I***). The support phase (***II***) is then started with the ma chine in an uplifted position.*

1995 author gave drawings for a powersprint-machine to Hakan Anders-son. He would, however, have the load on the shoulders and the move-ment more like a regular "step-up" with an upright posture with the skill of being able to make the ascension with a relatively straight leg. The result was a "cruel" exercise for hamstring that certainly contributed to the successes of Håkan's all sprinters: Torbjörn Eriksson, Peter Karls-son, Stefan Tärnhuvud and Tom-Kling Baptist (here in picture)

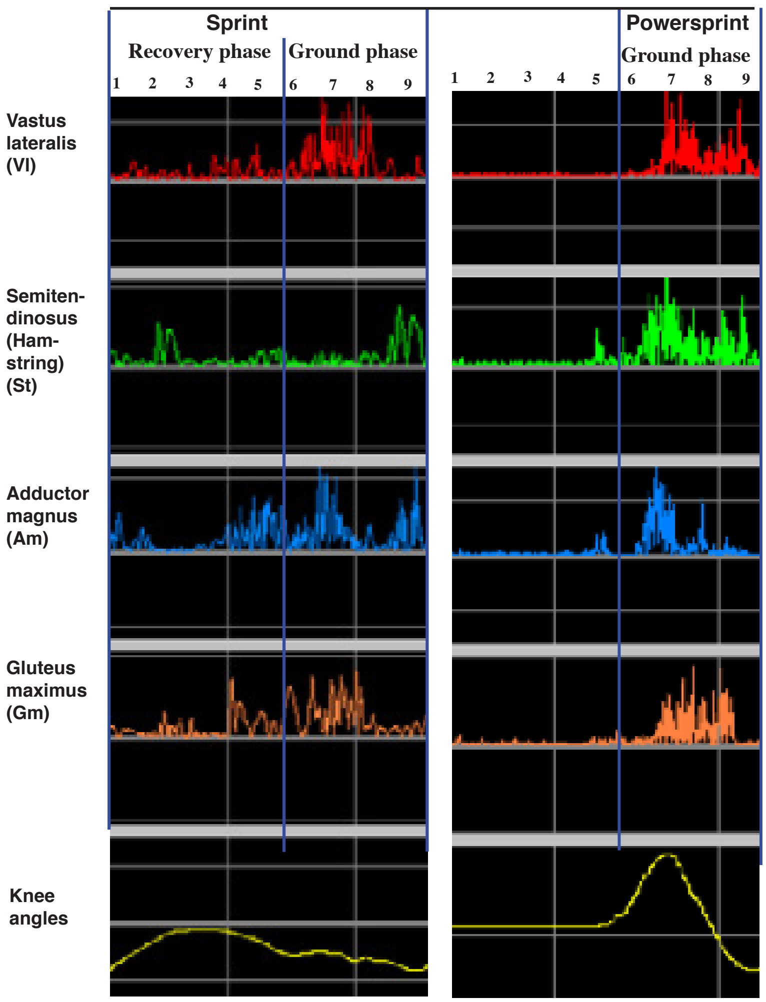


Lisa Warfvinge has used Powersprint, as a supplement in her training, since 14 years of age. As 16 she became Swedish youth champion in short sprint and long jump. At 18, she got silver at 60m at Indoor junior Swedish Cham-pionship. After a break due to injury, she became the year after, although after a short training, 4th at Indoor junior Swedish Championship in the long jump. Lisa has really shown such talent that there are good conditions for a great future sports career. *(See also page 79)*

Powersprint also suitable for Masters.
Here author is training max pfase sprint.

5.5 New swedish comparative EMG analysis of sprint with Powersprint (2016)

EMG electrode placement (right leg).



EMG-data
Mean EMG Activity

Powersprint (Konc.)	10kg	14kg	32kg
Vl	0,157	0,174	0,179
Am	0,078	0,069	0,078
St	0,588	0,555	0,378
Gm	0,217	0,230	0,212

	Sprint	Reactive-jumps	Squats	Lunges	Clean and jerk	Snatch 35kg	Clean 55kg
Vl	0,178	0,113	0,119	0,188	0,144	0,157	0,200
Am	0,129	0,084	0,049	0,061	0,054	0,073	0,073
St	0,248	0,392	0,047	0,073	0,17	0,236	0,210
Gm	0,261	0,244	0,082	0,080	0,175	0,196	0,210

EMG test studying muscular effort during sprint and Powersprint. The test was performed on a Swedish female junior elite sprinter. Analyzed data received from the test is presented below. [1]

SPRINT

Recovery phase 1-3:
Activity from Semitendinosus (St)* in the beginning of the recovery phase. Biceps femoris might also be activated*

Recovery phase 4-5:
Activity from Adductor magnus **(Am)** and Gluteus maximus **(Gm)** just before the foot strike. **St** and **Vl** are pre activated with subtle isometric muscle tonus.*

Ground contact phase 6-8: activity from **Gm** and **Vl** working hard to resist great vertical forces. **Am** is activated during the rotational movement of the forefoot after foot strike (see page 59)

Ground contact phase 8-9: St and **Am** activation shows that the muscles are working hard in the final stage of the push off. This is probably typical for the Sprint model PPT-ATP mode. "Short-long rotation in the hip"*.(Page 59). This corresponding to the Wiemann-Tidow study.

POWERSPRINT

Ground contact phase 6:
Activation mainly from **St** and **Am** showing great response in the beginning of the movement. **St** is the main muscle working during the "clawing" movement over the surface. **Am** is activated during the rotational movement of the forefoot after foot strike (see page 59)

Ground contact phase 7:
Activity from **Gm** and **Vl** working hard to resist great vertical forces. The knee is slightly angled, either active or by vertical load forces.

Ground phase 8-9:
Activation from **St** might be an expression that **St** either extends the knee or perform an isometric exercise* probably in this case isometric as an antagonist, while **Vl** extend the knee and hip, described at page 59. The final alternative correspond to the sprint model PPT-APT-mode Quadriceps dominance, Hamstring, isometric* antagonistic function. **Gm** is not involved in the push-off similar to what sprint EMG showed. **St** is active near the end of the ground phase making complete knee extension impossible.

Powersprint EMG data table. In comparison with conventional exercises for sprinters.

As an exercise machine designed to improve sprint and speed, the data from this EMG study shows that compared to the most commonly used strength exercises in this area the Powersprint is a fantastic alternative. Semitendinosus (St) in the hamstring group* seems to be much better activated in Powersprint than in Olympic lifting. Powersprint shows equal muscle activity as Olympic lifting concerning the other measured muscle groups in this study.

By studying this EMG data you will notice that the Powersprint is a versatile super tool to improve sprint and speed. next page 80 shows the test person in the studied exercises.[1]

*) NOTE: The electrodes were placed over the semitendinosus. However, the risk of crosstalk. Statement: Is there reference which prove this?

1) The authors text reviewed and processed by Magnus Warfvinge.

Powersprint®-. strength training even for youth. Right in the picture here Lisa Warfvinge Varberg GIF, who was EMG-tested in the powerprint in 2018, also in comparison with conventional strength training for sprinters, including Olympic lift (see below).

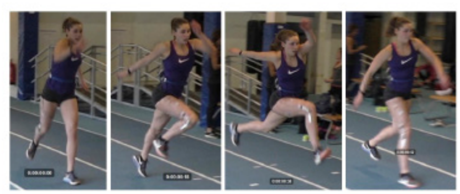
Powersprint, maximum pfase

Here and the following picture Lisa Warfvinge during EMG-testing

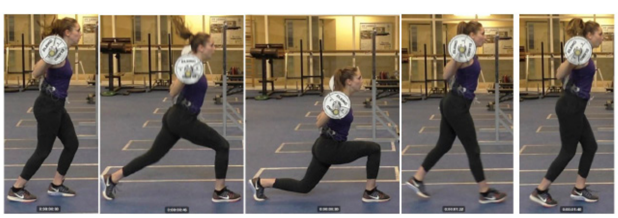
Sprint, maxpfase

Squats

Reactive jumps



Lunges



Clean and jerk

Cleans

Snatch

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