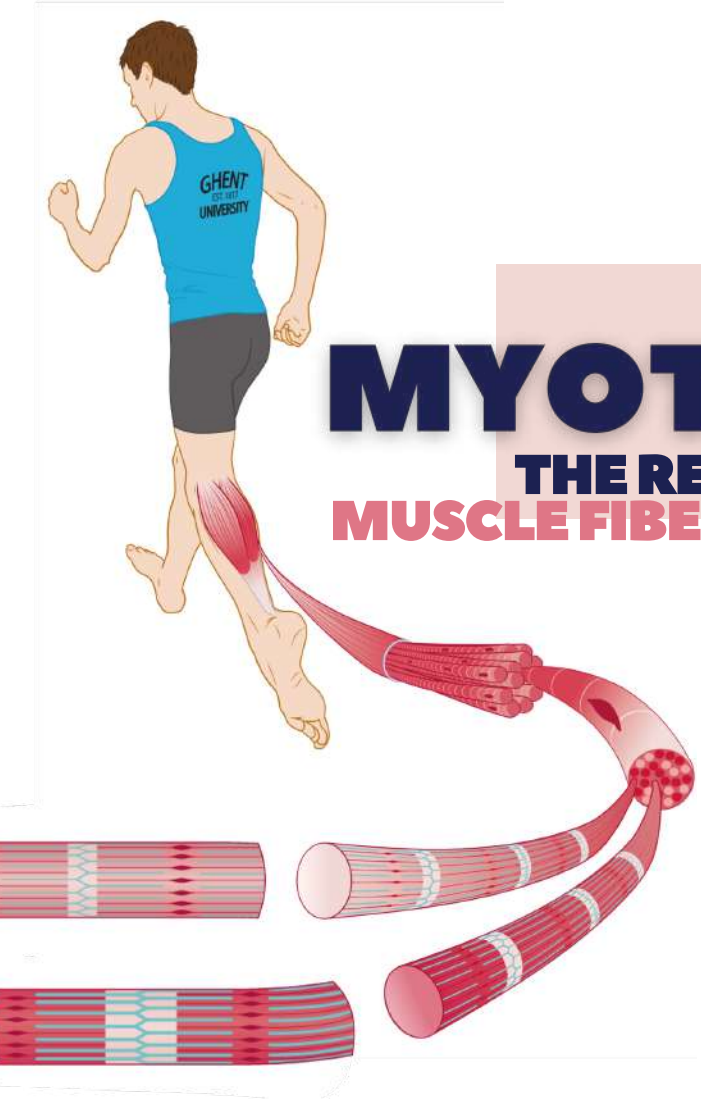


# MYOTYPES

## THE RELEVANCE OF MUSCLE FIBER TYPOLOGY IN SPORTS

Eline Lievens
Flore Stassen
& Wim Derave

ILLUSTRATED GUIDE

# PREFACE

This booklet is a summarized version and practical translation of the PhD thesis of Eline Lievens (2021, Ghent University, Belgium). As an illustrated guide, it depicts the scientific state-of-the-art about the relevance of muscle fiber typology in sports. We aim to make this easily accessible to sport coaches, athletes and everyone who is interested in sports.

This science communication product is freely available. You are welcome to share it with your friends and colleagues, but please respect copyright when reproducing the visuals for your own didactical purposes.

We greatly acknowledge the contribution of the proofreaders. The illustrations are made by Flore in Canva and BioRender.

Enjoy it!

The authors,
Eline, Flore & Wim


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# COLOUR LEGEND

- Slow-twitch fibers
- Fast-twitch fibers
- Slow typology
- Intermediate typology
- Fast typology

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# A BRIEF HISTORY OF RESEARCH ON MUSCLE FIBERS

**1678**
Lorenzini discovers the distinction of 'red' and 'white' muscle fibers for the first time (in the rabbit).

**1952**
Bergström develops a needle biopsy method that allows investigating the muscle fiber typology in human muscle.

**1970**
Brooke & Kaiser identify one slow (I) and two fast (IIa & IIb) fiber types in human skeletal muscle.

**1972-1977**
Classical studies of Saltin, Costill & Gollnick show that the muscle fiber typology is related to athletic performance.

**1979**
First attempt for non-invasive myotyping using jumps & exercise tests.

**SINCE 2000**
Advancements in medical imaging allow non-invasive estimation in muscle at rest (Baguet, 2011).

History shows very intensive scientific research on muscle fiber types around the seventies. We recently picked up on the topic: **THE REVIVAL OF THE MYOTYPES.**

# The coaches' view

- 90% of the coaches would like to use the muscle typology to tailor their training or competitions.
  - → *The relevance of the muscle typology for sports is clear.*
- Only 18.4% of the coaches think that their athletes would be willing to undergo a muscle biopsy.
  - → *We are in need of a robust & easy way to estimate the muscle typology non-invasively.*
- At the moment, coaches are estimating the muscle typology of their athletes based on their own experience, jump or strength tests.
  - → *It is still unclear if these are the best non-invasive strategies to estimate the muscle typology.*
- Coaches currently use the information on the muscle typology to individualize training volume, duration, intensity & frequency, to individualize recovery, to guide athletes in the best discipline/event, to individualize the taper strategy and to decide on pacing strategy.
  - → *Knowledge of the myotype of your athletes might have multiple implications.*

Data based on a survey filled out by 539 coaches of several countries (unpublished)

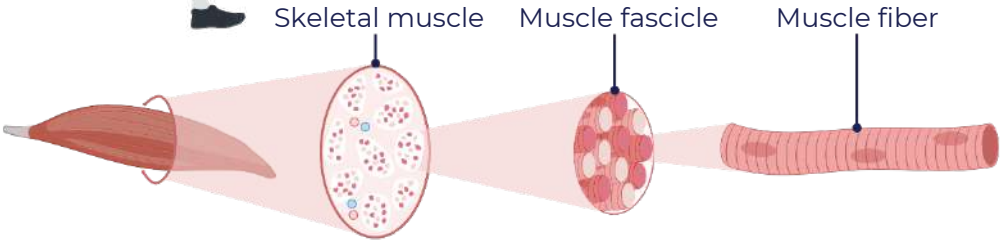
CHAPTER 1

# MUSCLE PHYSIOLOGY

## What will you (re)discover?

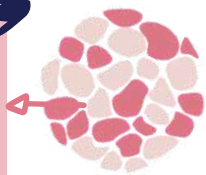
There are two different skeletal muscle fiber types with distinct basic characteristics: contractile properties, energy cost, energy metabolism, fatigue resistance & structural integrity.

# Structure of skeletal muscles




Skeletal muscle is the largest organ of the body and allows us to run, jump, climb, throw, ... and perform in sports. Two different types of muscle fibers are responsible for the production of those movements: slow-twitch and fast-twitch fibers. Both types are present in all muscles, but their proportion differs between individuals.

Mosaic of fibers:



## Type I = SLOW-TWITCH

Type I muscle fibers are slow-twitch fibers because of their slow contraction capabilities. In most animals, slow-twitch fibers have a red colour.

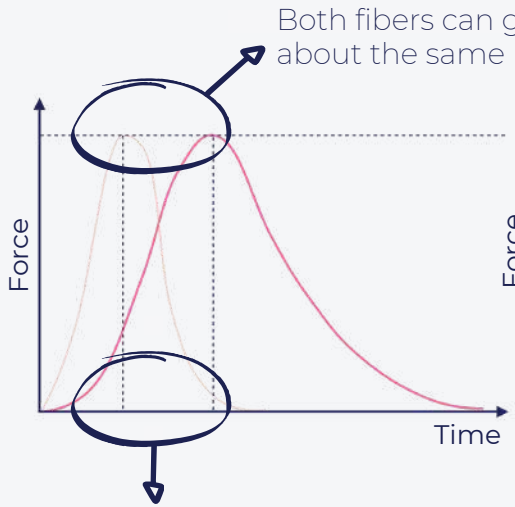
## Type II = FAST-TWITCH

Type II muscle fibers are fast-twitch fibers because of their fast contraction capabilities. In most animals, fast-twitch fibers have a white colour.

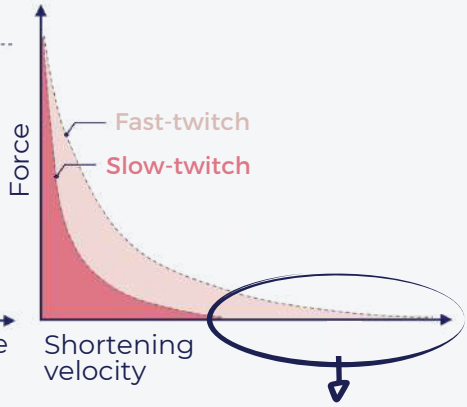
Slow-twitch & fast-twitch fibers have diverse functions, which lead to contrasting properties.

# 1 Fast-twitch fibers are faster

A twitch* is much shorter/faster in fast-twitch fibers, that's how they got their name.




Fast-twitch fibers build up force much faster than slow-twitch fibers (40ms vs. 90ms).

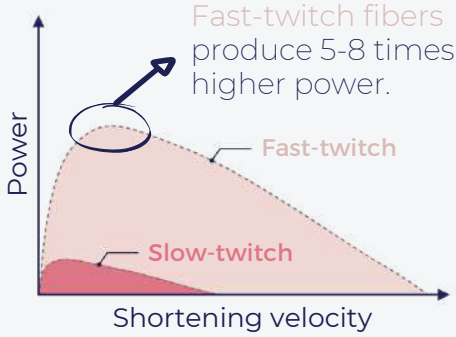



Fast-twitch fibers produce force at higher maximum shortening velocities** than slow-twitch fibers.

Power = force x speed

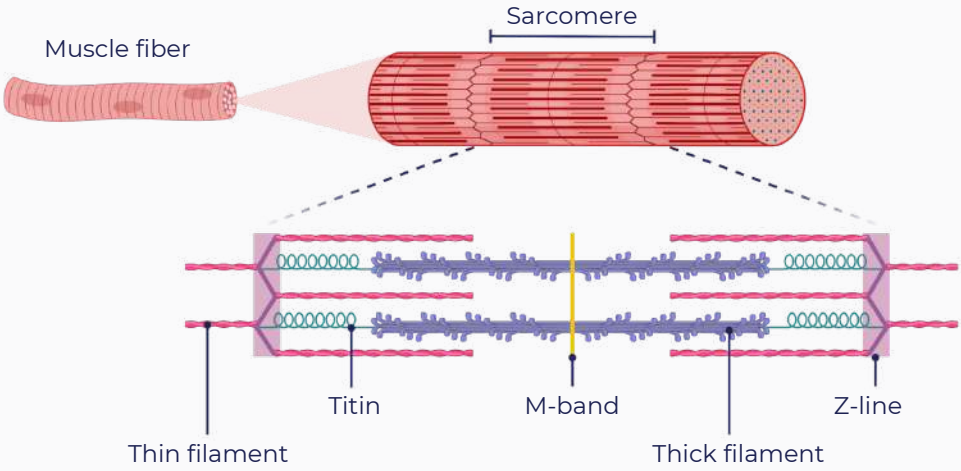
Fast-twitch = slow-twitch

Fast-twitch > slow-twitch

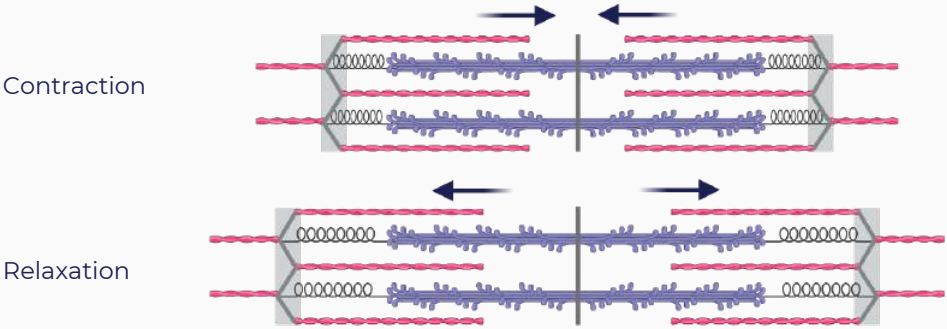



* Force generated in response to a single electrical stimulus.

** Speed at which a muscle changes length during a contraction.



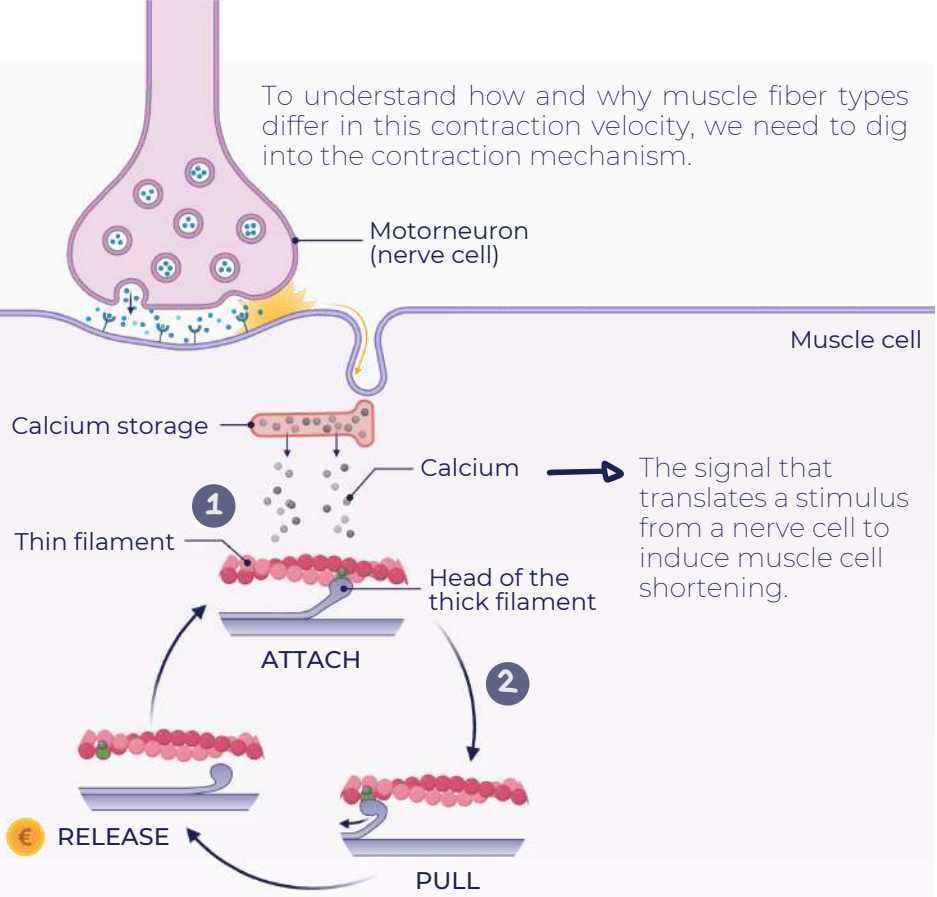

The sarcomere is the basic functional unit of a muscle fiber, and consists of long proteins, which are organized into (myo)filaments.




Muscles contract when the thick filament pulls the thin filament to the center of the sarcomere (= power stroke).

## SARCOMERE STRUCTURE BACKGROUND

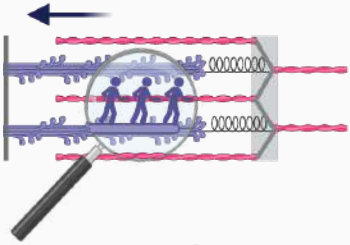
To understand how and why muscle fiber types differ in this contraction velocity, we need to dig into the contraction mechanism.




The signal that translates a stimulus from a nerve cell to induce muscle cell shortening.

1. Fast-twitch fibers can release calcium from its storage sites much faster than slow-twitch fibers.

2. Therefore, the power stroke of the fast-twitch heads of the thick filament is faster.

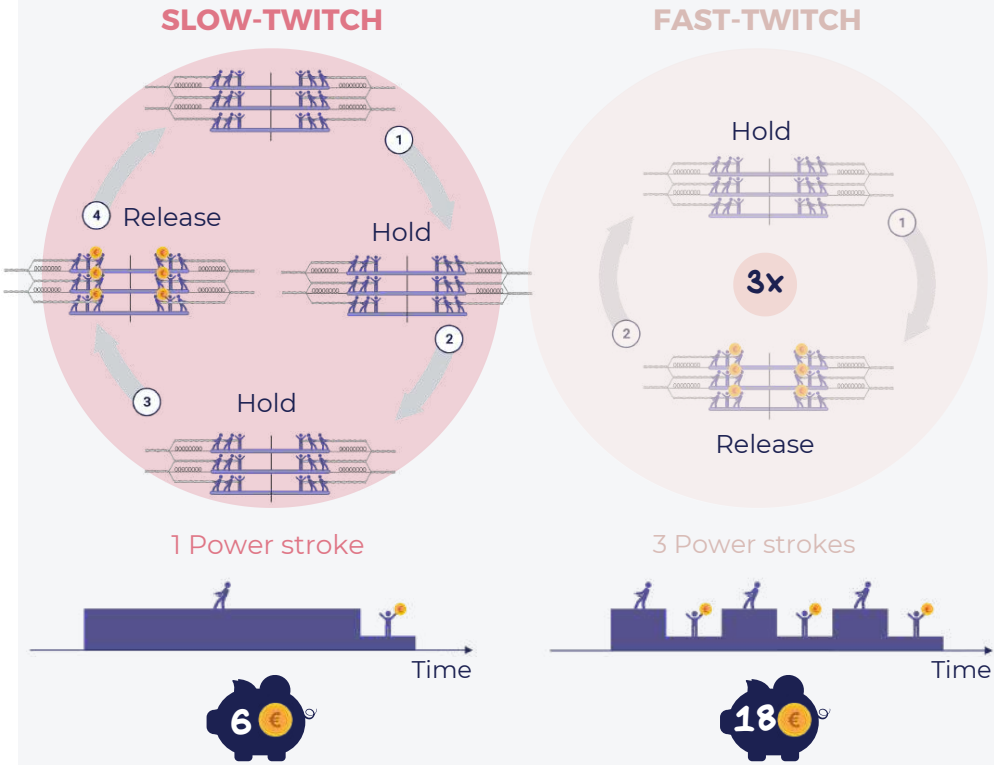


Heads of the thick filament can be visualized as little individuals who pull the thin filament to the center of the sarcomere.

Energy is needed every time a power stroke (= pulling-maneuver) is performed: €.

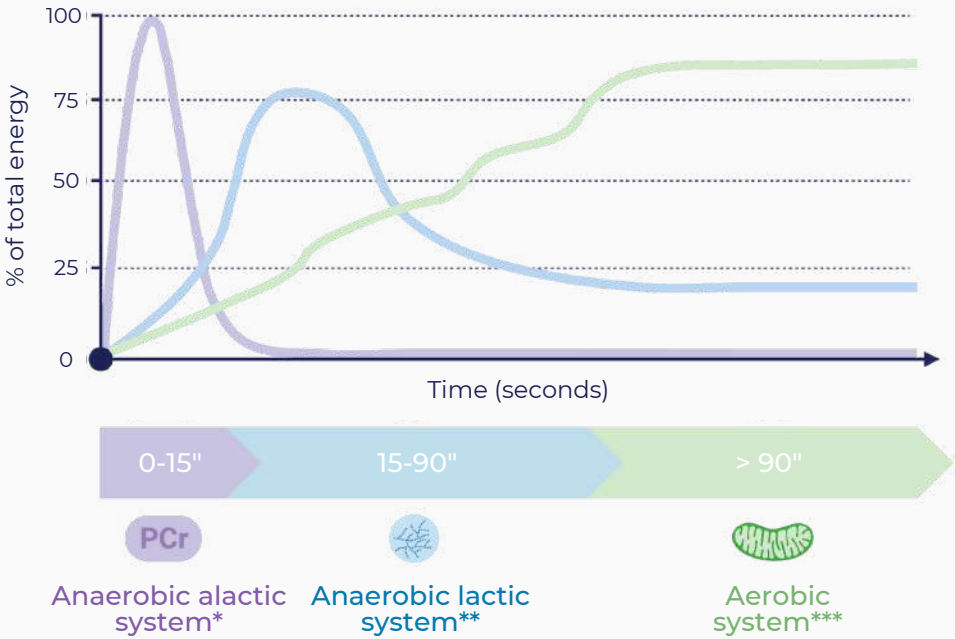


## 2 Slow-twitch fibers are more energy efficient!




The same isometric contraction (no shortening of the muscle) over an equal time interval, costs fast-twitch fibers three times more energy compared to slow-twitch fibers, as their power stroke goes faster and they need to perform 3 power strokes in the time that 1 power stroke is performed in slow-twitch fibers.

When we exercise, energy delivery is crucial. Our body can generate this energy from three different systems, depending on the intensity and the duration of the activity bout.

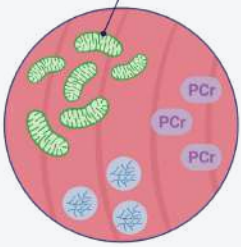


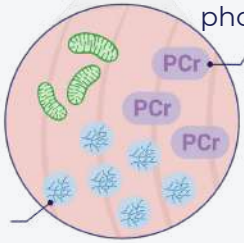

## ENERGY SYSTEMS BACKGROUND

* Energy system in the human body which uses phosphocreatine as fuel. No oxygen is needed for the reaction and no lactate is produced.
** Energy system in the human body which uses glycogen/glucose as fuel. No oxygen is needed for the reaction and lactate is produced.
*** Energy system in the human body which uses glycogen/glucose and fat as fuel. Oxygen is needed for the reaction.

# 3 Fiber types use different fuels

Untrained

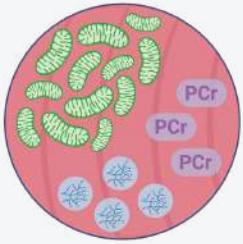


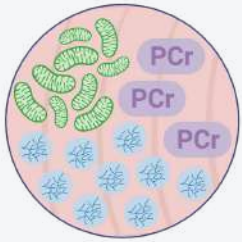




Slow-twitch fibers contain more mitochondria, to generate aerobic energy through oxygen.

Fast-twitch fibers have more glycogen, which results in higher anaerobic activity (without oxygen).

Trained



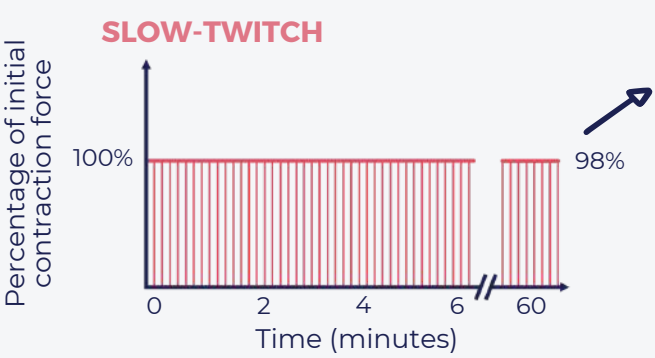

**SLOW-TWITCH** **FAST-TWITCH**

Training can increase the aerobic metabolism to a great extent in both fiber types!

**Did you know...**

*... that training can increase the oxidative capacity of fast-twitch fibers to such extent that they become more oxidative than untrained slow-twitch fibers?*

# 4 Slow-twitch fibers are more resistant to fatigue



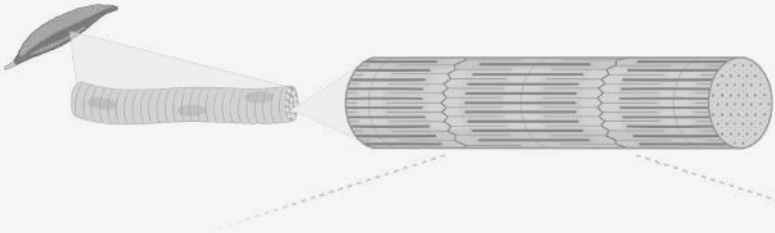

Slow-twitch fibers show hardly any fatigue during exercise of long duration.

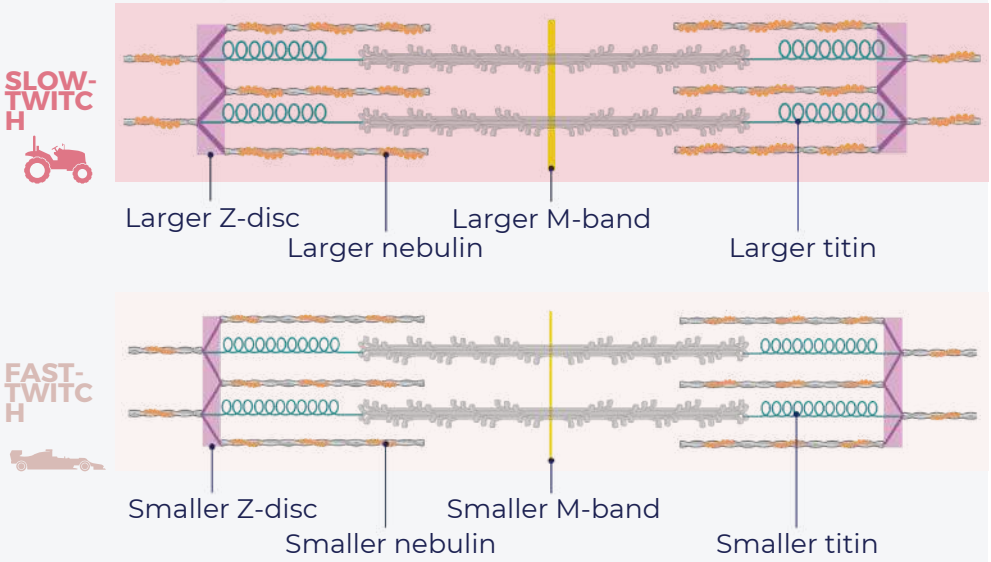

Fast-twitch fibers already display a decline in force during exercise of short duration.

## Did you know...

... that tonic muscles, which are responsible for holding your posture, mostly consist of fatigue resistant slow-twitch fibers, while phasic muscles, which are used for dynamic movements, like jumping, consist of a higher percentage of fast-twitch fibers?

# 5 Slow-twitch fibers are more robust



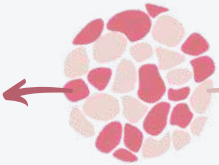



The sarcomere structure of slow-twitch fibers is more robust in comparison to the structure of fast-twitch fibers. Consequently, slow-twitch fibers are better protected against both active and passive elongation and damage.

*It seems contra-intuitive that fast-twitch fibers have a lower integrity since those fibers work with higher forces. The fact that those fibers are less robust might be the reason why fast-twitch fibers are more vulnerable to damage than slow-twitch fibers.*

***Just as in cars, faster does not always mean more robust!***

# TAKE HOME MESSAGE:



**SLOW-TWITCH**
**muscle fiber**

**FAST-TWITCH**
**muscle fiber**

| | | |
|---|---|---|
| | 1 | Generate more power |
| More efficient | 2 | |
| Aerobic metabolism | 3 | Anaerobic metabolism |
| More resistant to fatigue | 4 | |
| Better structural integrity | 5 | |

PCr

**Low-intensity & long-lasting activity**

**Fast & powerful actions**

## Key references:


Sciaffino & Reggiani, 2011

*Extensive review on mammalian skeletal muscle fiber types describing the diversity in muscle fiber types, their functional compartments, and its relation to species, sex and development.*

Bottinelli, 1996

*Investigation of the force-velocity properties on a large group (n = 151) of human skinned skeletal muscle fibers.*

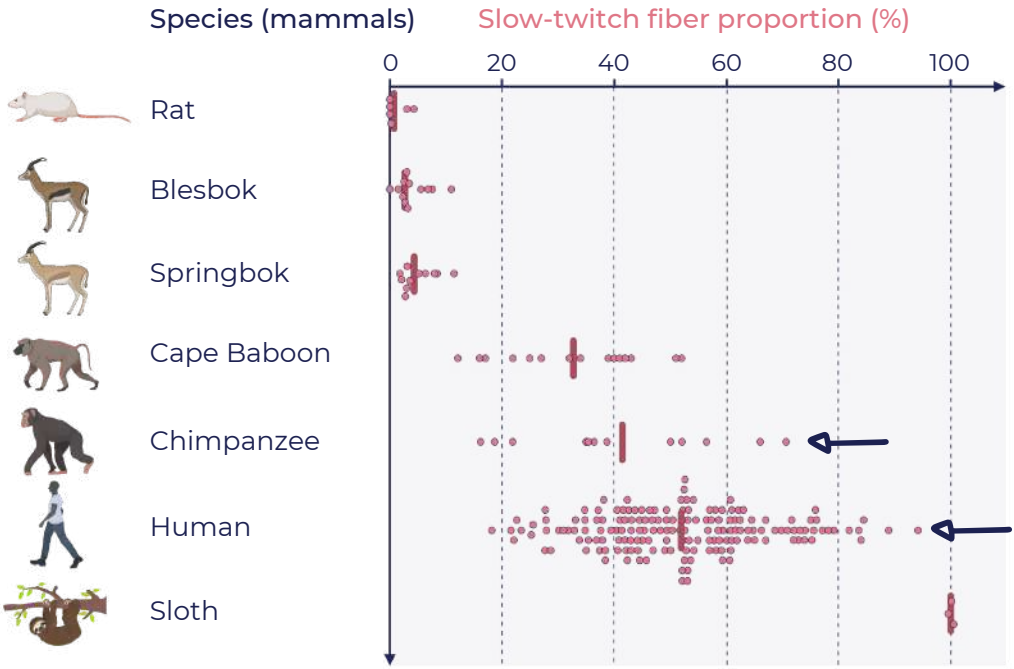
CHAPTER 2

# DIVERSITY IN MYOTYPES

## What will you discover?

Both muscle fiber types are present in all mammalian muscles, but in different proportions. Primates show a big diversity in their muscle fiber typology, which introduces the need to divide humans in different groups based on their muscle fiber type composition.

# Evolution




Both slow-twitch fibers and fast-twitch fibers are present in our muscles. Nevertheless, evolution shows that we (humans) and chimpanzees (our closest primate) evolved to a more slow-twitch composition than most mammals.

**Did you know...**

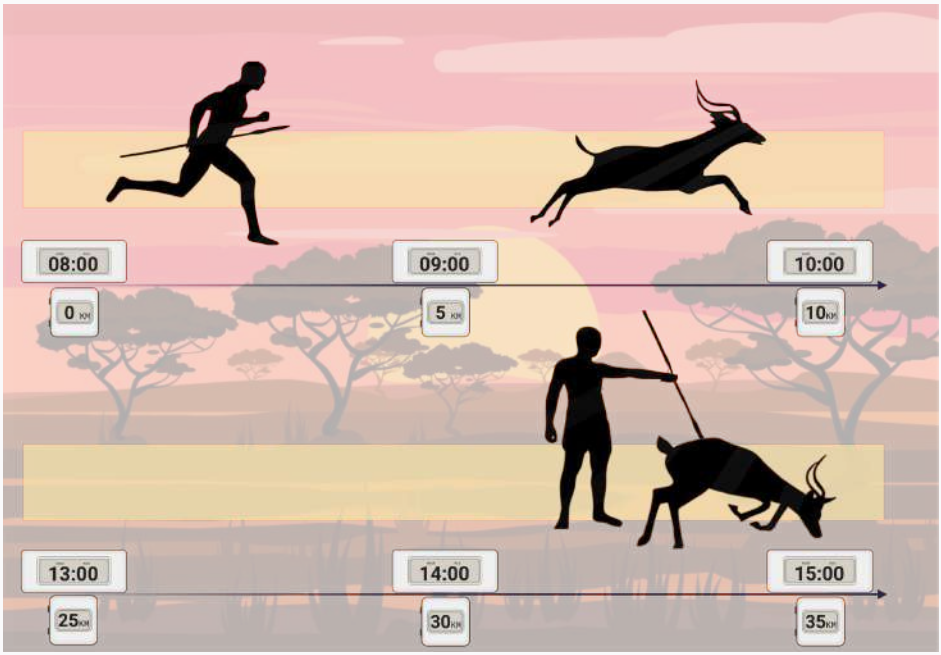
*... that humans have developed endurance running as a hunting strategy and slow-twitch muscle as a weapon (see 'persistence hunting' overleaf p.16)?*

Data from Eng et al., 2008; Curry et al., 2012; Bozek et al., 2014; Kohn, 2014; O'Neill et al., 2017; Leith et al., 2020; Hall et al., 2021; Spainhower et al., 2021

## Can persistence hunting explain why we transitioned toward a more endurance-based profile?

**Humans (hunters)** **VS.** **Quadrupedal mammals**

Humans can run and chase long distances, but do not fatigue easily. While mammals need to gallop, resulting in fatigue and overheating.

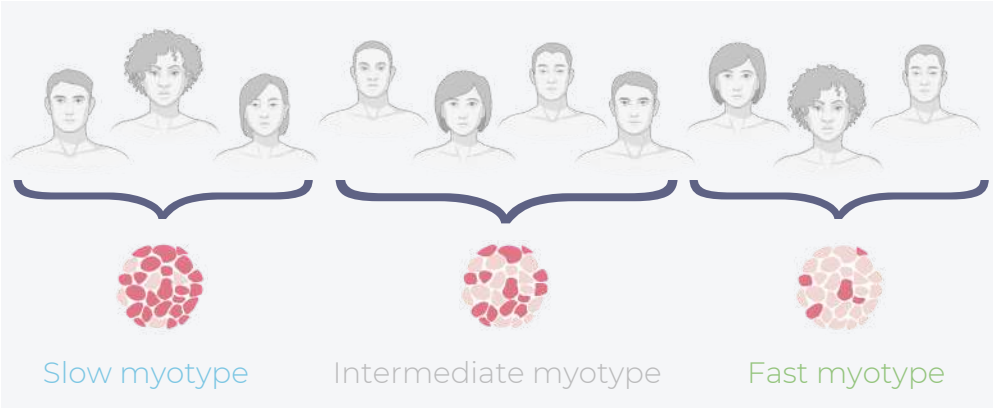



Therefore, humans can kill the animal while it has to stop to rest and cool down.

# Diversity

When we zoom in on the graph on page 15, a big diversity is found in the muscle fiber typology of humans & chimpanzees.

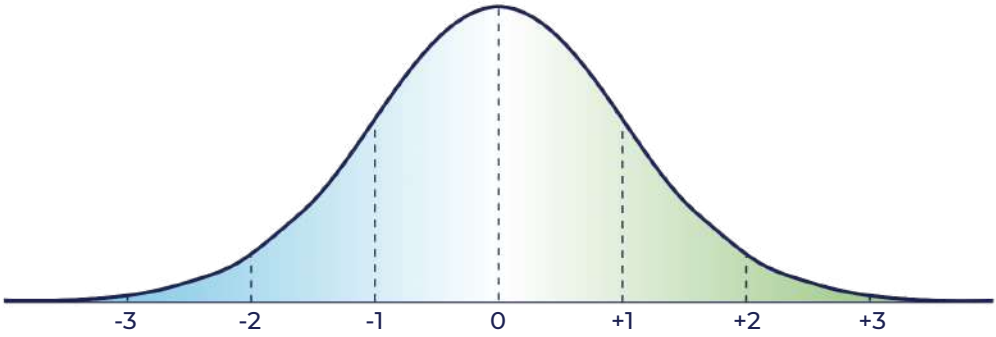
The muscle fiber distribution of athletes can be divided into three myotypes, which are based on the distribution of the athlete's slow-twitch and fast-twitch skeletal muscle fibers:




*We hypothesize that since the Homo erectus, differences between roles in the complex network of human society might have appeared in which some humans needed to have more slow-twitch fibers (endurance tasks: persistence hunting) and others needed to have more fast-twitch fibers (explosive tasks: to produce fast and accurate throws).*

# What's your myotype? Albatross, ape or cheetah?

The myotype is presented by a Gaussian distribution, indicating that most people are intermediate (50% slow-twitch and 50% fast-twitch fibers) but some are dominantly slow and others dominantly fast.




| MORE SLOW TYPOLOGY | Z-score* | MORE FAST TYPOLOGY |
|---|---|---|
| < -0.5 | [-0.5 ; +0.5] | > +0.5 |

These myotypes will be presented by three different animals:

## SLOW MYOTYPE

### Albatross

Champion in long-distance migration (travels around the world in 1.5 months). Can fly 15,000 km without landing.

Energy efficient & resistant to fatigue.

! Slow-twitch fibers

## INTERMEDIATE MYOTYPE

### Ape

Diversity of tasks (jumping, sprinting, tree climbing & gathering food).

Need a mixture of muscle fiber types.

! Slow-twitch fibers
Fast-twitch fibers

## FAST MYOTYPE

### Cheetah

Able to run speeds of 100 km/h, but can only sustain this for a few seconds.
Leads to fatigue & prolonged recovery periods.
Can generate a lot of power.

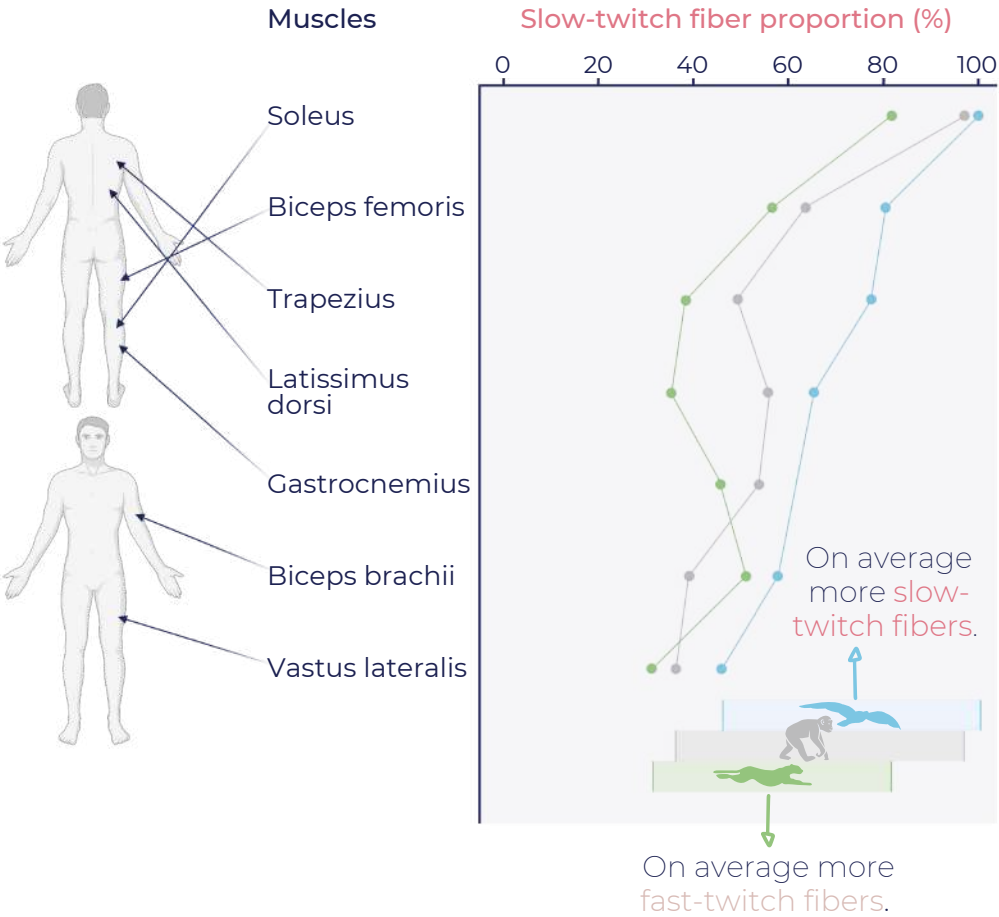
! Fast-twitch fibers

* Describes a value's relationship to the mean and the variation of a reference group.

# Does your myotype apply to every muscle in the body?

**YES!**

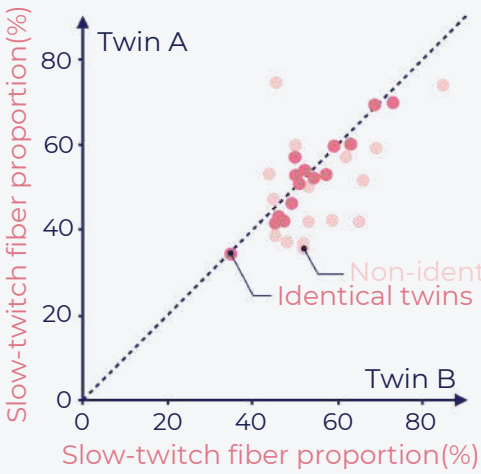
Not all muscles in the human body have a population average of 50% slow-twitch and 50% fast-twitch fibers. Some muscles, like the soleus, are dominantly slow, while other muscles, like the triceps, are dominantly fast. But if you are more slow-twitch in one muscle (Hey, albatross), you will be more slow-twitch than the average population in all of your muscles (blue line).




Data adapted from Vikne et al., 2012

# Are you born with a fixed myotype or can it be changed by training?

Some studies established that fiber type composition is mainly genetically determined.

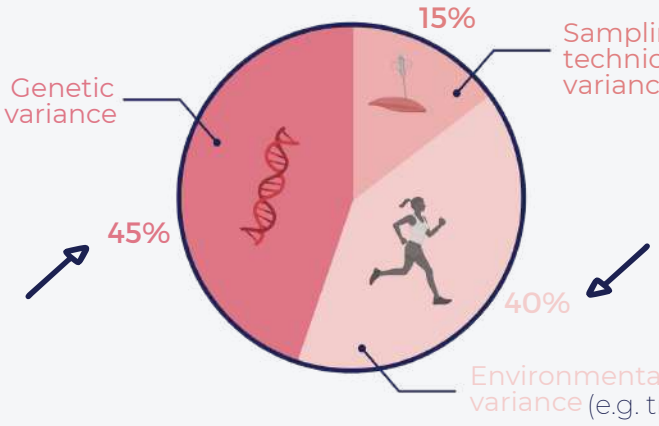



Identical twins have almost the same percentages of slow-twitch fibers. Heritability estimates are therefore very high.

Heritability: ♂: 99.5%
♀: 92.8%

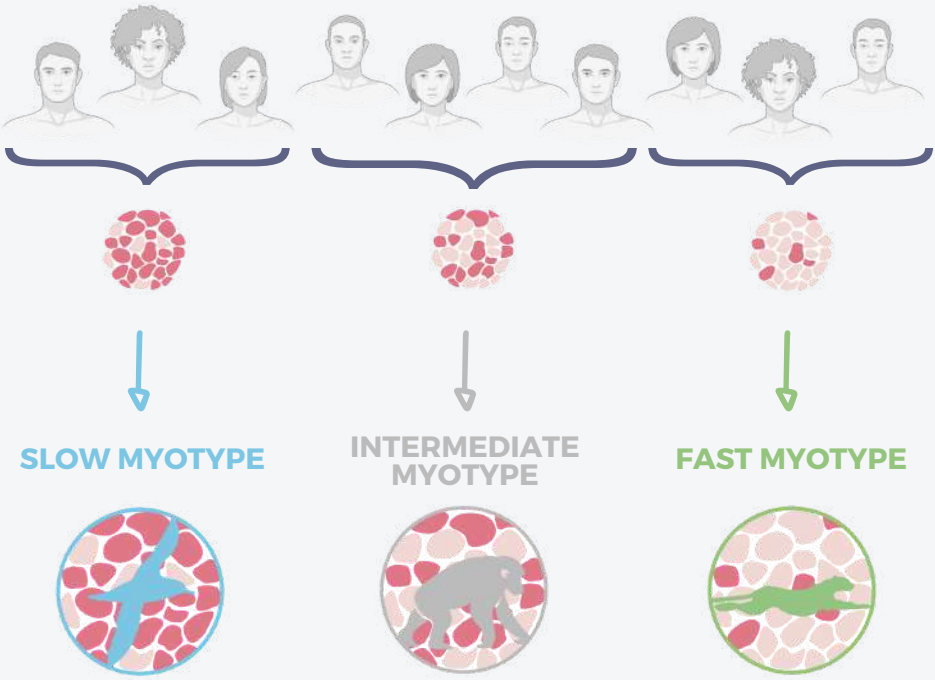
Data adapted from Komi et al., 1977

Other researchers suggest that muscle fiber type composition can still change by environmental factors, like training.




Data adapted from Simoneau et al., 1995

# TAKE HOME MESSAGE:




The big diversity in muscle fiber typology in humans led to the introduction of the three myotypes (a slow, an intermediate and a fast myotype), which will have its consequence for multiple aspects of sports: talent identification, fatigue, recovery, training response & susceptibility to injury.

Simoneau & Bouchard, 1995

*Paper investigating the genetic determinism of fiber type proportion in human skeletal muscle.*

Vikne et al., 2012

*Research determining the inter muscular relationship of human muscle fiber type proportions in multiple datasets.*

CHAPTER 3

# RELEVANCE OF MYOTYPES IN SPORTS

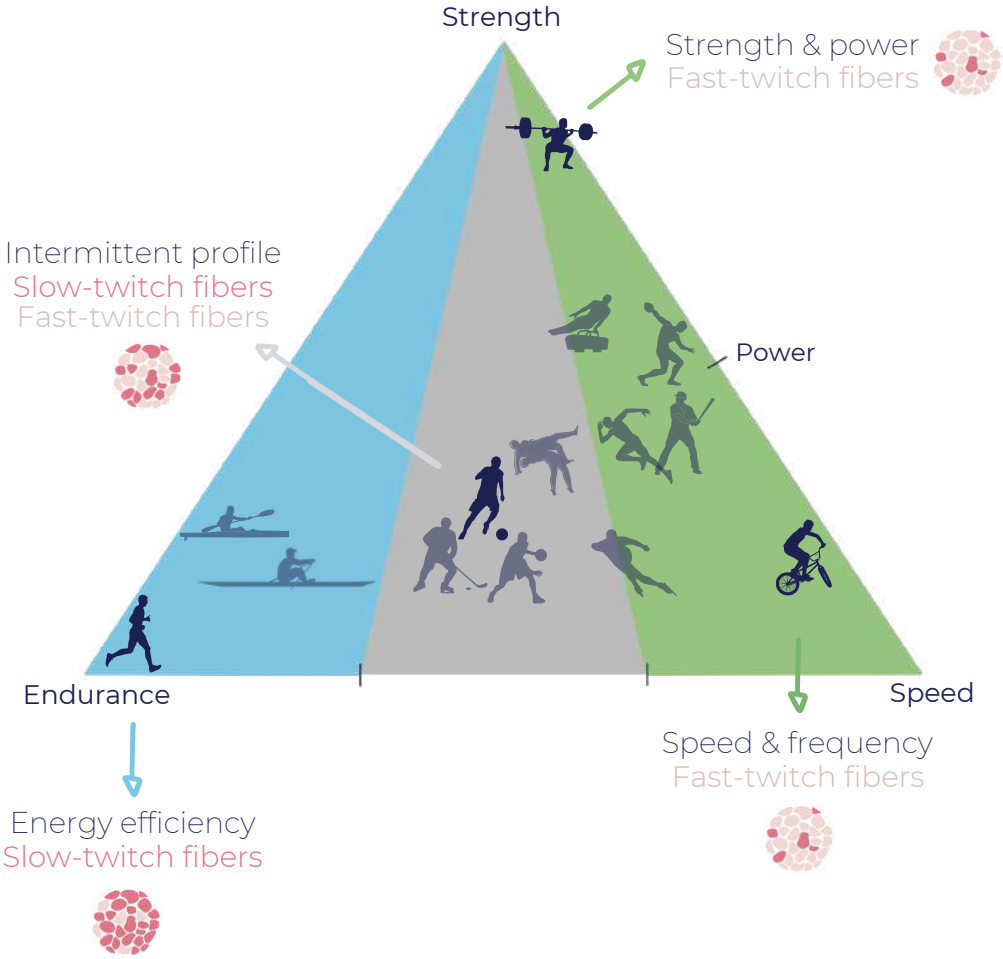
## What will you discover?

Different muscle fiber types introduce advantages for sports. Therefore, the muscle typology might have practical applications for coaches.

# Is the myotype of importance in my sport?

Strength, speed and endurance are important physical capabilities for successful sports performance. Every sport has its own dominant characteristics and requirements.

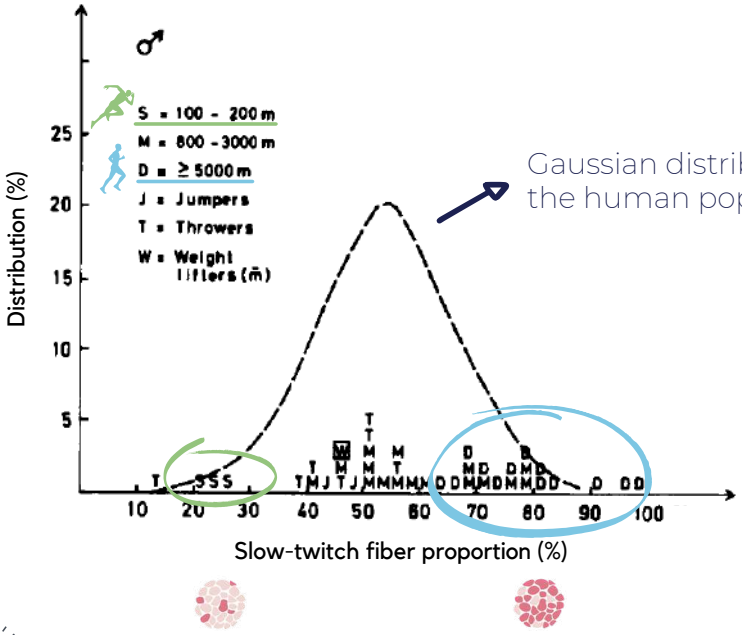
These physical capabilities may be closely related to muscle typology:




Based on Bompa, 1990

# INDIVIDUAL SPORTS

The classical studies in the seventies of Saltin, Costill & Gollnick showed for the first time that myotypes play an important role in sports, especially in athletics.




Gaussian distribution in the human population.

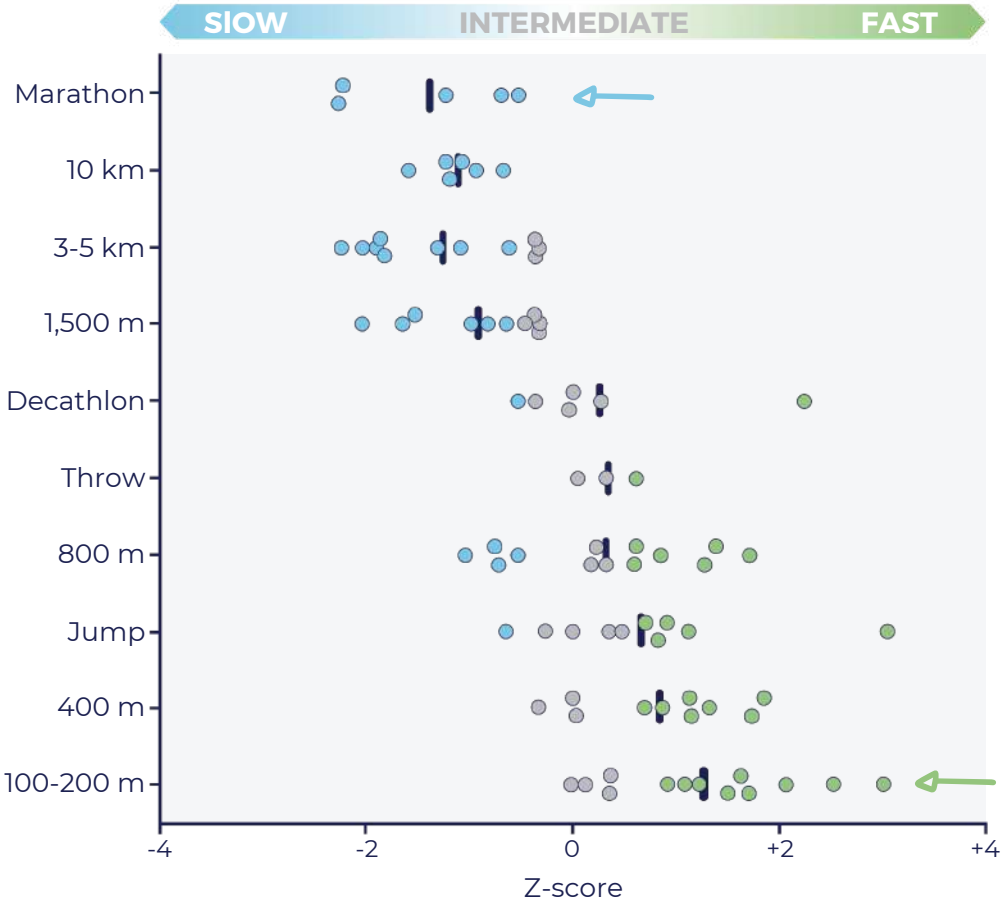
**Did you know...** *that in the seventies, muscle biopsies were taken from absolute world class athletes to determine their myotype? One of them was Frank Shorter, the 1972 Olympic champion in marathon running. His biopsy showed a tremendously high number of slow-twitch fibers (> 90%) and very few fast fibers. More recent findings on endurance runners do not confirm such an extreme slow myotype anymore.*

Figure adapted from Saltin et al., 1977

# Can I discover talent?

Recently, those classical studies were confirmed and expanded with data in elite athletes of athletics and cycling.

- **ATHLETICS:**

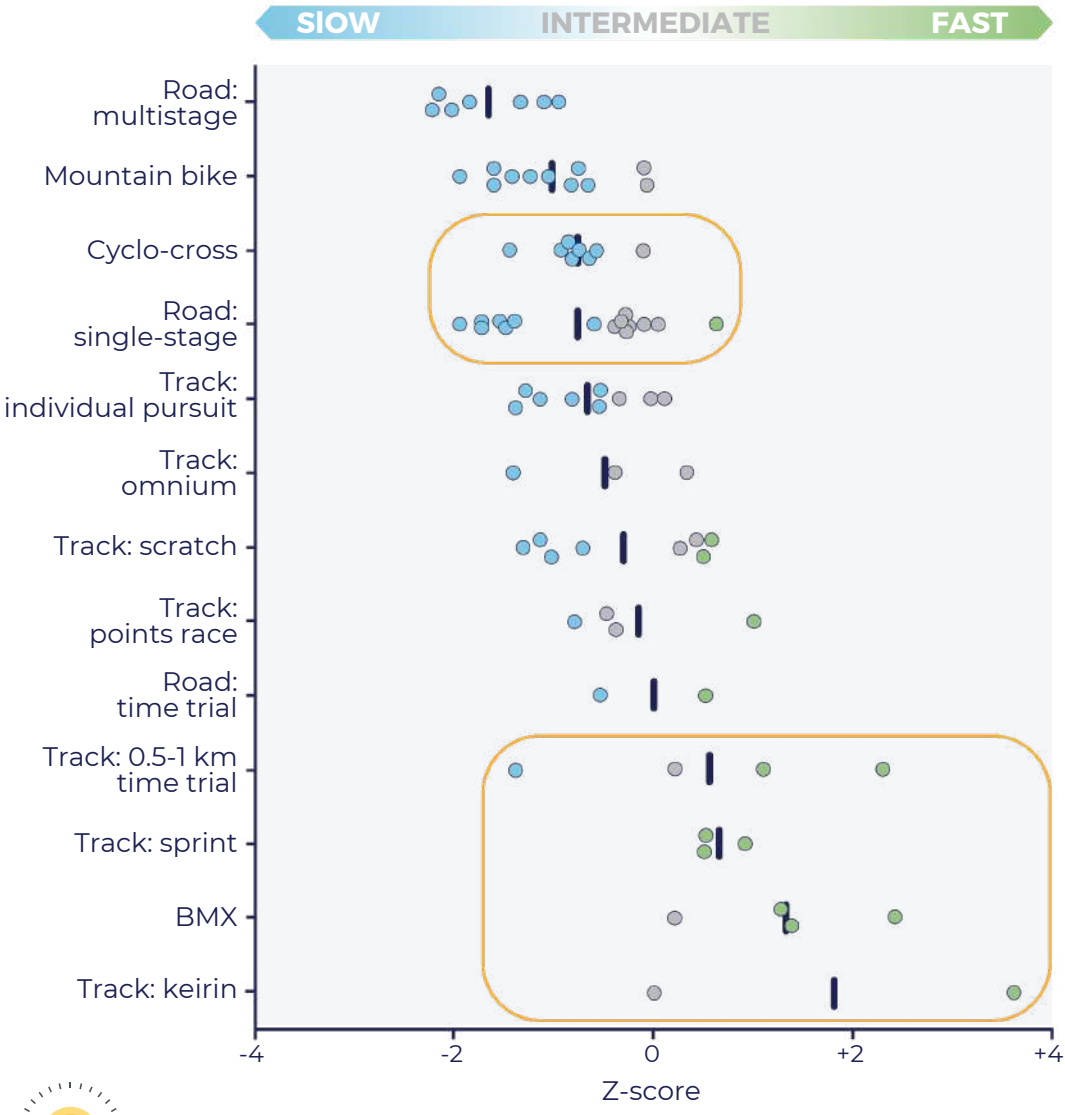



To run a marathon, characteristics of slow-twitch fibers (like energy efficiency and aerobic metabolism) are a must, so distance runners can be advantaged by a slow typology.

Sprint will need characteristics of fast-twitch fibers (like power and anaerobic metabolism) and sprinters are therefore favored with a fast typology.

Data adapted from Baguet et al., 2011 (PLOS ONE); Bex et al., 2017 & unpublished data

- **CYCLING:**




**Did you know...** *that a talent transfer from cyclo-cross to road cycling is likely to succeed based on similar muscle typology requirements? Same for BMX and track sprint cycling.*

Data adapted from Lievens et al., 2021 (Med Sci Sports Exercise)

# Can I discover talent?

YES!

To summarize, muscle fiber type seems to be an important parameter within most individual sports. Therefore, determining the myotype of athletes can be relevant to decide upon which discipline to choose. This type of information can also be used for succesful transfer between disciplines (and sports).

**A slow myotype might be favorable for endurance disciplines in individual sports.**

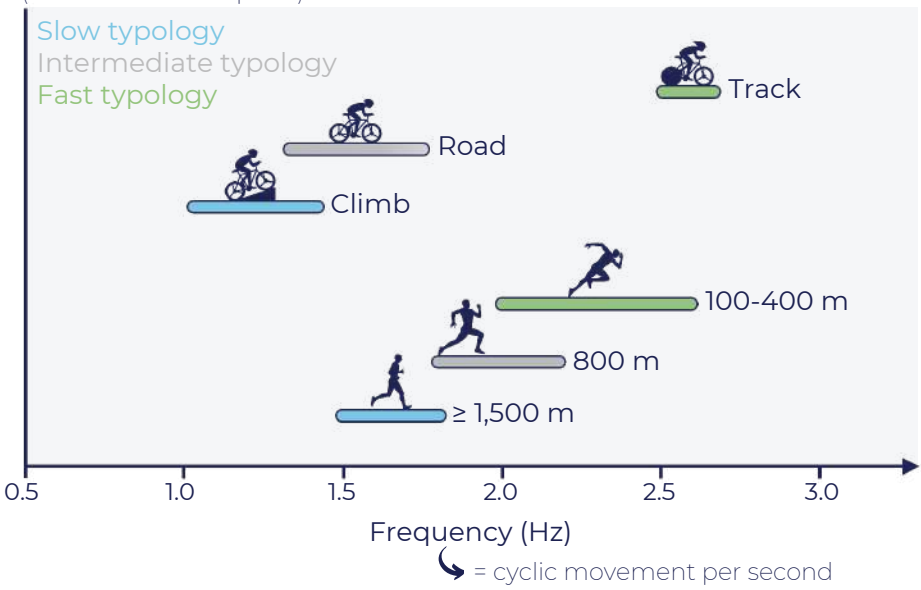
**A fast myotype might be favorable for explosive disciplines in individual sports.**

## Why are fast-twitch fibers needed during individual sports?

- To produce high amounts of power.
- To develop high movement frequencies.

The link between movement frequency & muscle typology has been confirmed: a fast typology is correlated with a high movement frequency.

Data adapted from Bex et al., 2017 (Stand J Med Sci Sports)

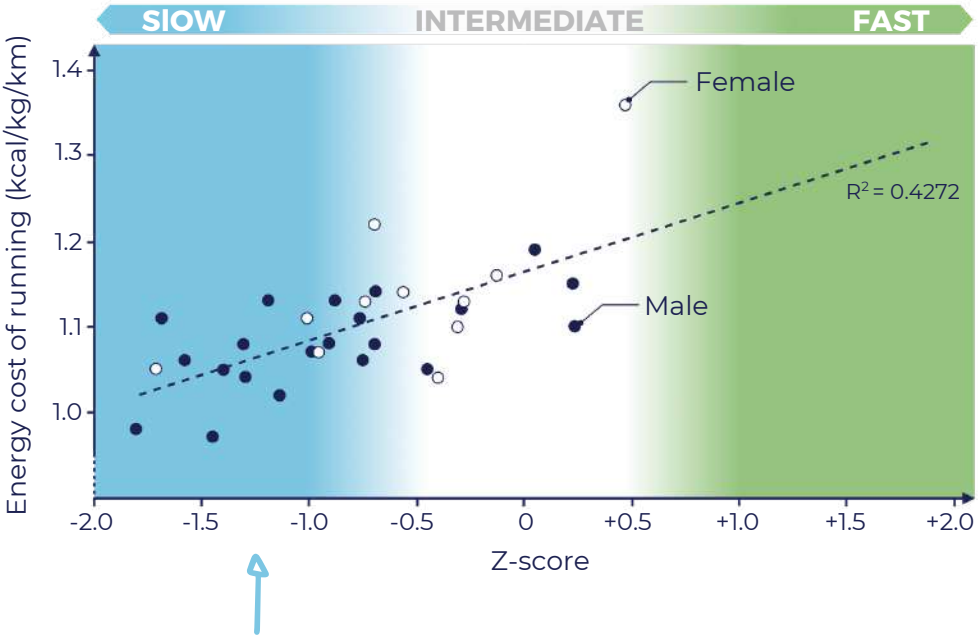



**A fast myotype might be important to generate maximal power and frequency.**

**Did you know...** *that the winner of the Berlin marathon 2019 (Kenenisa Bekele, world record of 2:01:41) generated an average power of almost 900 Watt at a speed of 20.7 km/h? In comparison, Usain Bolt sprinted toward his world record of 9.58 (100 m) in 2009 at a peak power of ± 2600 Watt.*

## Why are slow-twitch fibers needed during individual sports?

- To sustain the duration of a long event.
- Probably because of their relationship with the running economy*:




The better the running economy, the lower the energy cost of running at a certain intensity. This is probably related to the fact that slow-twitch fibers use their energy more efficiently during isometric exercise (see p. 7).

**A slow myotype might be important to run more efficiently.**

* Measure of how much oxygen your body requires to run at a certain intensity.

Data adapted from Bellinger et al., 2020 (EJAP)

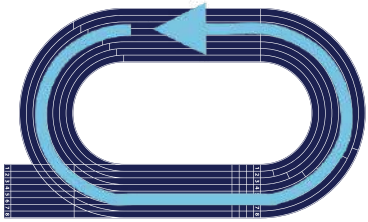
# Can I adapt my competition strategy?

In individual sports, the myotype of your athlete might decide on the ideal pacing strategy (athletic tactic of spreading one's effort over the race) to enlarge the chances of winning.

**YES!**

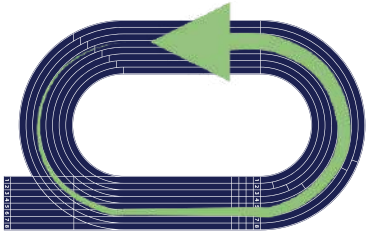
- **ATHLETICS (1,500 m & 800 m):**

Slow myotype



Even-paced

Fast myotype



Slow start & fast end

- **SWIMMING (200 m freestyle):**

Slow myotype

Even-paced

Fast myotype

Slow start & fast end

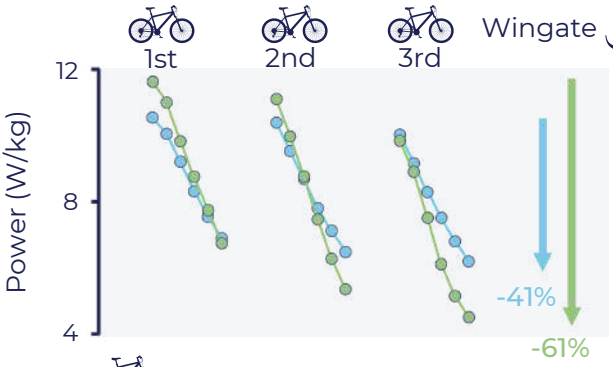
**Athletes with a slow typology may be best suited to use an even-paced racing strategy to take advantage of their superior running economy.**

**Athletes with a fast typology may be best suited for races with a slow start, to take advantage of their superior last lap speed (last lap kick).**

Data adapted from Bellinger et al., 2021 (EJAP); Mallett et al., 2021 (Int J Sports Physiol Perform)

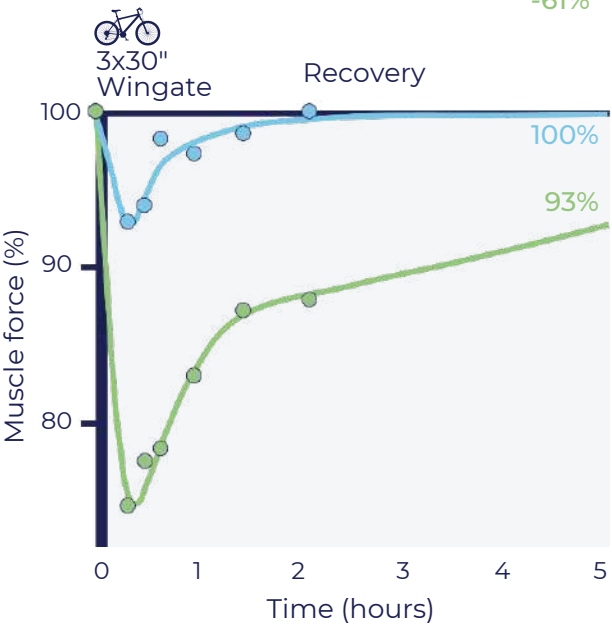
# Can I adapt my training program?

- **Acute training leads to different degree of fatigue:**




- Fatigue accumulated during tests:

Slow typology: low power drop
Fast typology: high power drop




- Recovery after tests:

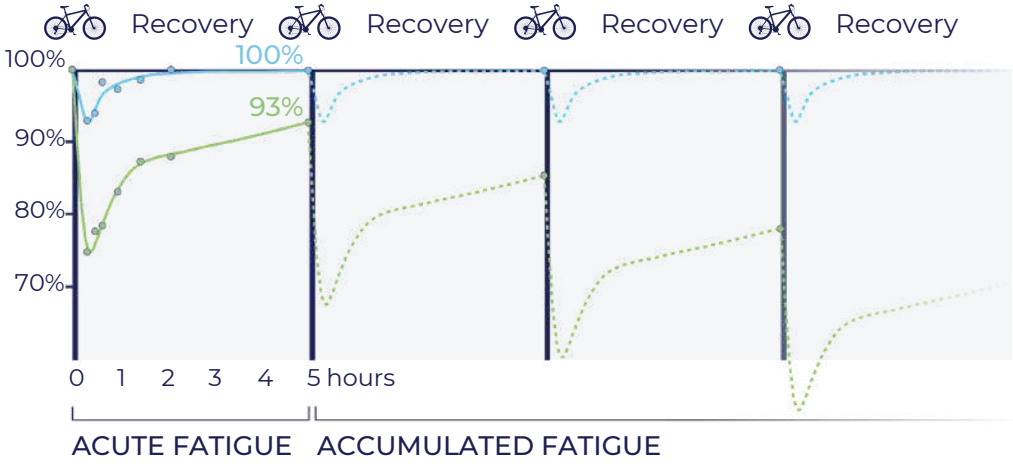
Slow typology: 20 minutes
Fast typology: > 5 hours!

Data adapted from Lievens et al., 2020 (JAP)

**Athletes with a fast typology might accumulate more fatigue during training, especially when training sessions follow each other quickly, as their recovery from every single training takes longer.**
Thus, it may be important that the training sessions of your athletes with a fast typology are planned less frequently in comparison to their colleagues with a slow myotype.

- **Accumulation of acute fatigue leads to chronic fatigue**

If big differences exist in fatigue and recovery after an acute training session, you might expect that this fatigue accumulates during a training period:

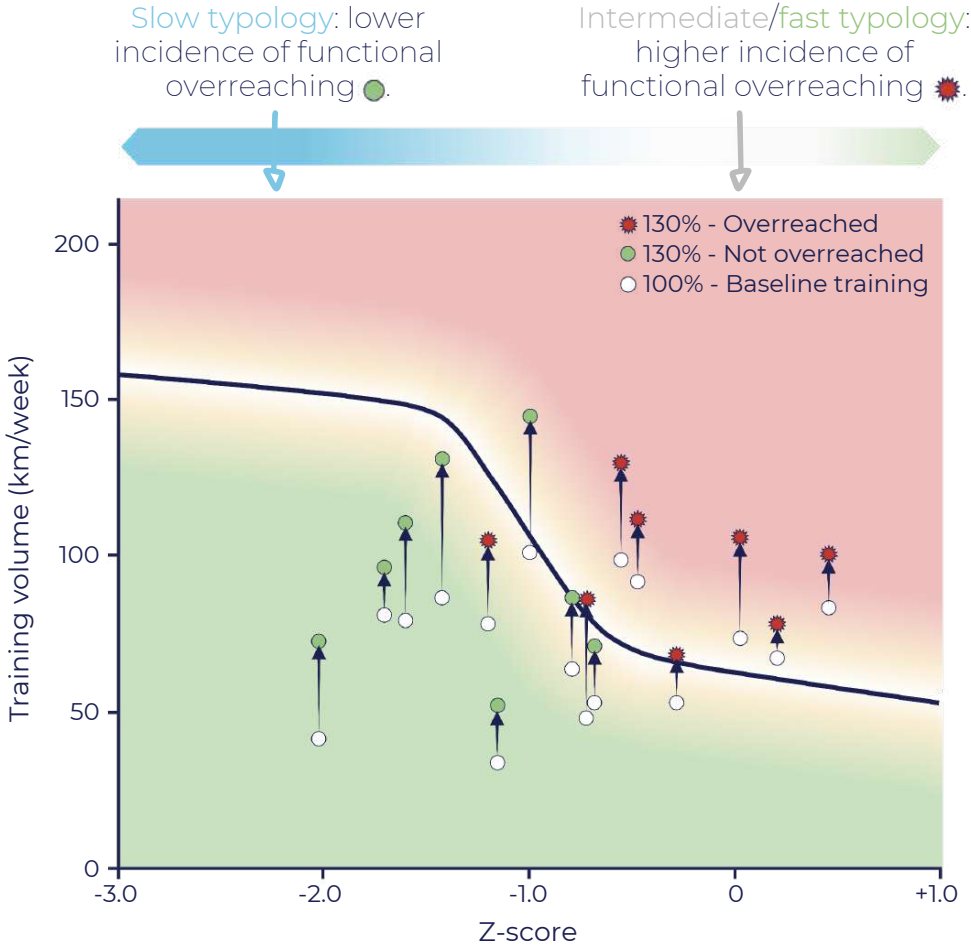



Performance might decline substantially in athletes with a fast typology due to the accumulation of fatigue.

**Did you know...** *that even athletes performing in the same discipline (e.g. 100 m sprint running), may still differ in myotype and therefore need individualized training load and recovery for optimal performance? Pierre-Jean Vazel reconstructed the story of two Italian sprinters with diverging myotypes and accompanied training requirements (Le Monde, 20/3/'15).*

- **Fast myotype predisposes for overreaching**

In a recent study, highly trained middle-distance runners (1,500 m) performed a volume overload training program of three weeks. Compared to their normal training volume (100%), some runners became overreached by the overload training (130%) and others did not.

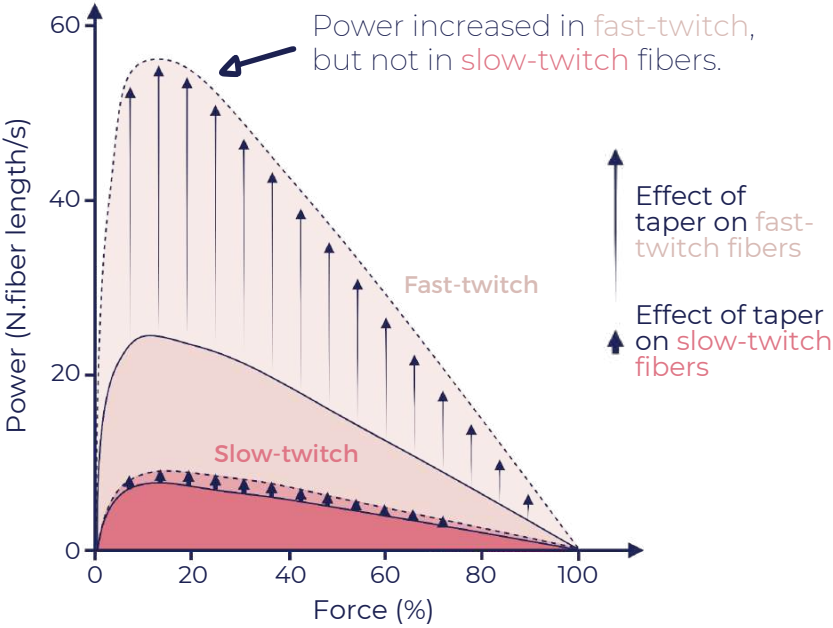



Data adapted from Bellinger et al., 2020 (JAP)

**The myotype of runners probably defines the upper tolerable limit of training volume (depicted as the dark line), but more research is still needed on this topic.**

- **Taper according to myotype**

A taper (gradual reduction in the volume/intensity of an athlete's workout the days before an important race or competition) has been repeatedly shown to target fast-twitch fibers by increasing their size, with no influence on the size of the slow-twitch fibers.




In order to optimize the response of a taper on the single fast-twitch fiber level, it is important to lower the volume but maintain the exercise intensity.

**Anecdotal evidence suggests that athletes with a fast myotype might need a longer taper period as they recover more slowly.**

**Athletes with a slow typology might perform better after a shorter taper period.**

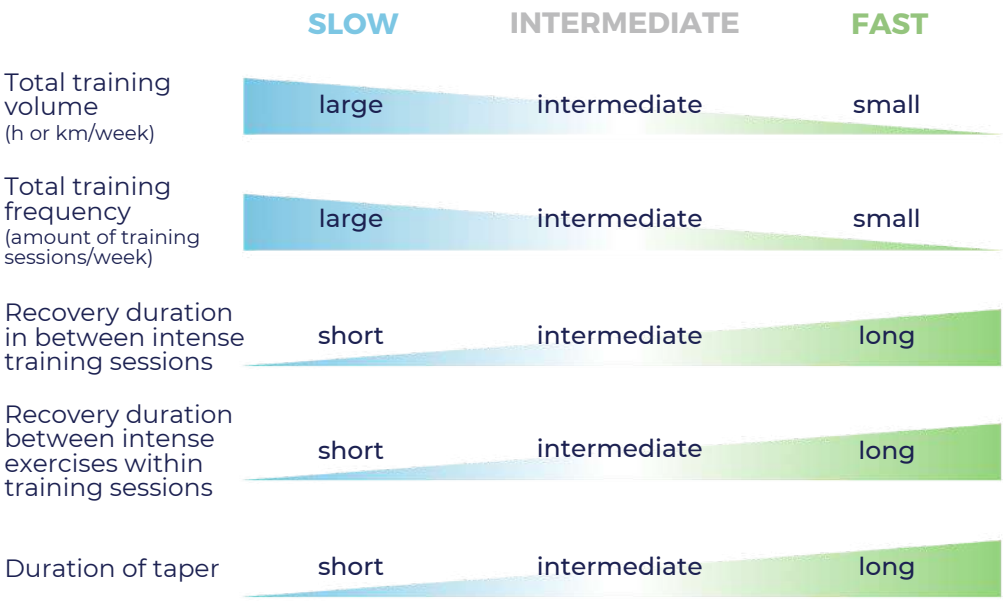
**But no strong scientific evidence is available at present.**



Data adapted from Trappe, 2001

# Can I adapt my training program?

**Emerging evidence suggests that training prescription can be individualized according to myotypes for the following training characteristics:**



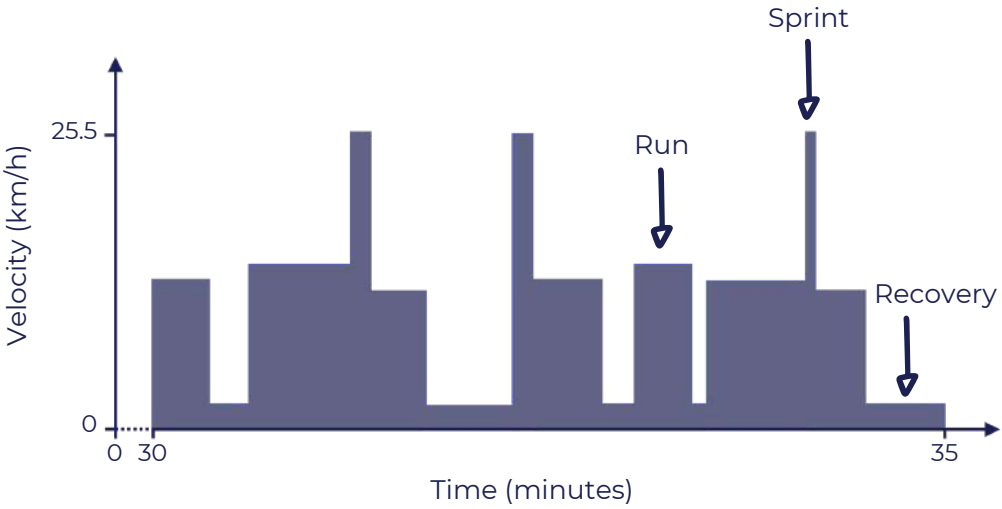

*There's a list of factors that can be taken into account when individualizing training, the myotype seems to be one of them. Training individualization may not only be important to optimize performance, but also to reduce injury risk (see p. 43).*

# TEAM SPORTS

Most team sports (football, basketball, hockey, ...) have an intermittent exercise profile. High-intensity actions (where fast-twitch fibers mainly determine performance) are interspersed with lower-intensity periods (e.g. walking, jogging) and recovery, for which slow-twitch fibers are more suitable.

↳ Optimal myotype is less clear.

**Time-motion analysis football (soccer):**




| | | |
|---|---|---|
| Total distance: | ± 11 km | → Slow-twitch fibers are needed |
| Sprint distance (> 25 km/h): | ± 350 m | → Fast-twitch fibers are needed |

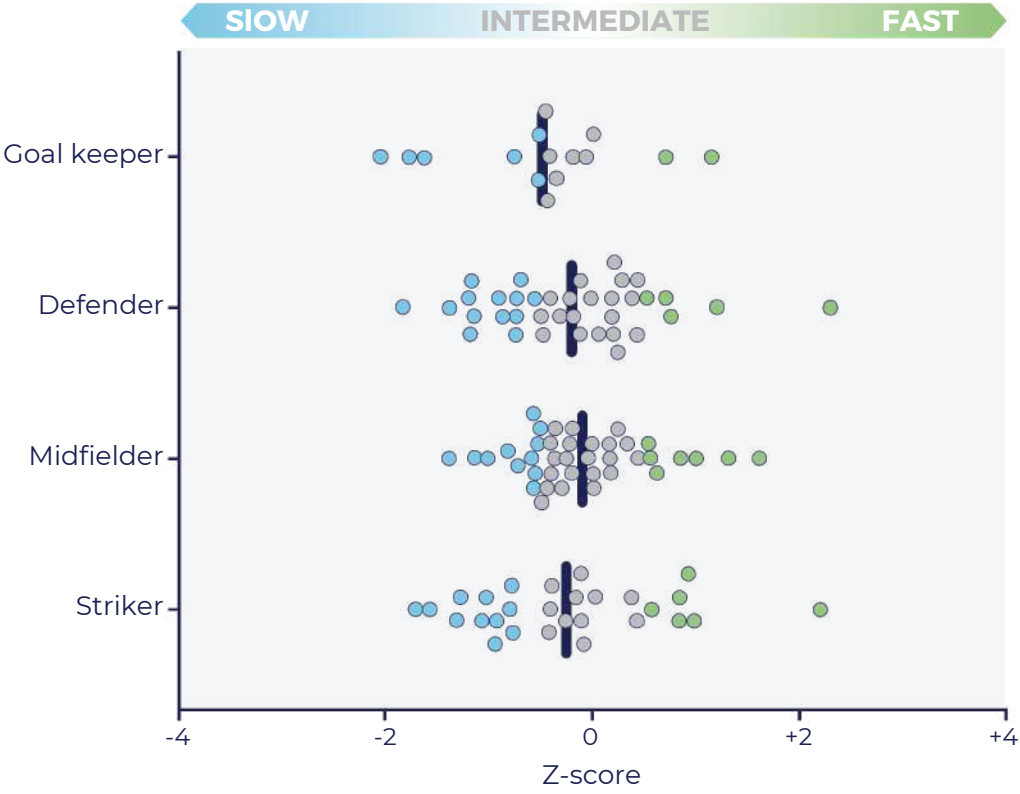
↳ Most data show that team sports players have on average an intermediate myotype. In football, there is even a slight dominance of slow-twitch fibers.

# Can I discover talent?

PROBABLY NOT

- **FOOTBALL:**

Recent evidence on > 100 professional football players documents a very high diversity within a team, with slow, intermediate and fast myotype players, all competing at the highest level.




**No specific myotype is needed to excel in football, and myotypes can not be used to determine the position of your players.**
More research is required to generalize this finding on other team sports.

\+ You probably cannot be born with the 'wrong' myotype to play football at a high level.

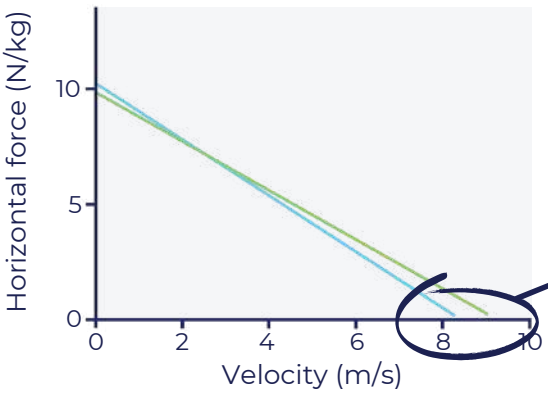
\- This high diversity between players requires vastly different training load and recovery regimes (see p. 37).

 Data adapted from Lievens et al., 2021

## Why are fast-twitch fibers needed during team sports?

- For explosive actions (jumping and sprinting).

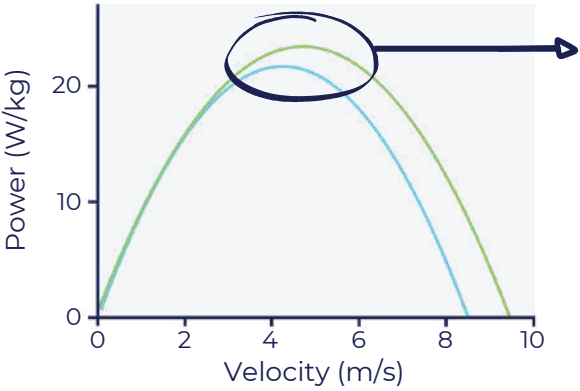
A study in 19 sub-elite male rugby players showed that muscle fiber composition is a key determinant in jumping and sprinting:




Player A

Player B

Fast typology players can develop higher velocities.




Fast typology players can generate more power.

**Did you know...** *that next to fast-twitch fibers, a high muscle volume can also positively influence power?*

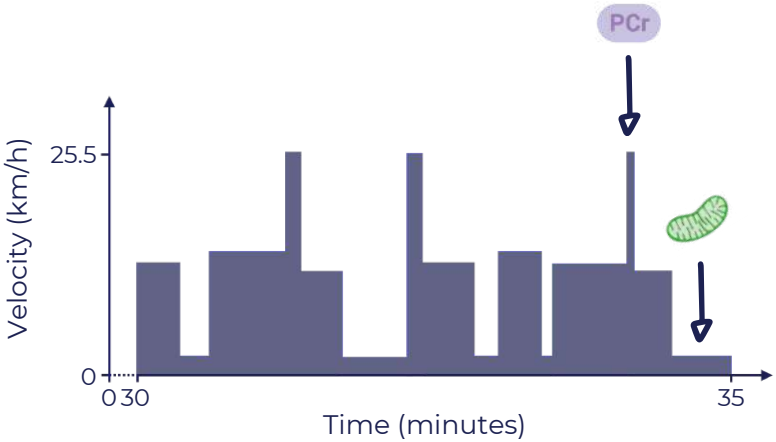
**If a player has more fast-twitch fibers, he/she may generate more power and might therefore jump higher & sprint faster.**

Data adapted from Bellinger et al., 2021 (MSSE)

## Why are slow-twitch fibers needed during team sports?

- To sustain the long duration and intensity of a game, due to their higher fatigue resistance.

- To optimize recovery in between intermittent sprints:




A developed aerobic system will give the anaerobic alactic system (needed for explosive tasks) the time to recover and to perform again.

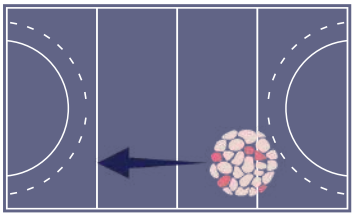
**If a player has more slow-twitch fibers, he/she may be more resistant to fatigue, which might prevent a decline in performance during high-intensity actions at the end of the game.**

# Can I adapt my game strategy?

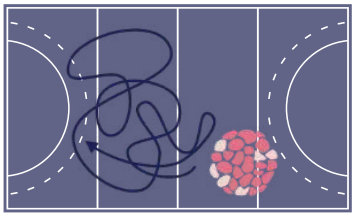
The myotype of your players might be relevant for tactical game decisions. It might influence:

**POSSIBLY**

- **The tactical positional decision:**



Fast typology players might be ideal because of their higher sprint capacity.



Slow typology players might be ideal because of their fatigue resistance.

- **The choice of your starting team depending on your game calendar:**

  Slow typology players might be of value during fixture congestion periods, when multiple games are played during one week.

- **The choice of your substitutions:**

  As players with a fast typology are less fatigue resistant, they might fatigue earlier in the game.

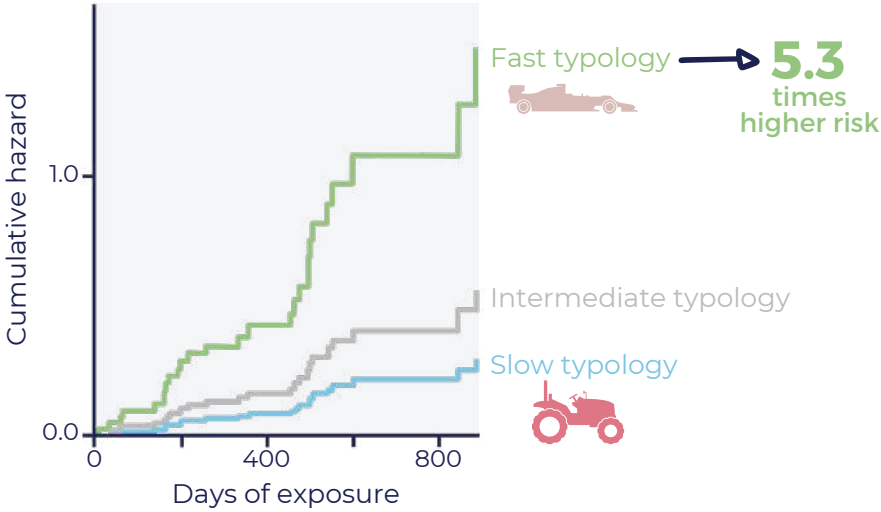
However, the effect of these myotype-based tactical decisions on game performance has not been confirmed yet.

*As the substitutions in e.g. basketball are not fixed, it might be valuable to substitute a fast typology player after a short intensive period, to prevent the player from accumulating fatigue and probably also injuries.*

# Can I estimate injury risk?

YES!

A study in elite soccer players demonstrated the importance of myotypes on the risk of getting a hamstring strain injury:




As athletes with a fast myotype:

- accumulate more fatigue,
- recover more slowly,
- have lower integrity of the sarcomeres (less robust, higher vulnerability due to the imbalance between higher load and the lower load capacity in fast-twitch fibers).

Muscle fiber typology might be a risk factor of injuries:

**Athletes with a fast typology may have a higher risk of muscle injuries.**

*You can prevent injuries by individualizing the training program of your team based on the muscle fiber typology of your players (see p. 37).*

Data adapted from Lievens et al., 2021 (Sports Med)

# SUMMARY

The myotype is relevant for talent identification, performance characteristics, race tactics, training prescription & injury risk.

## Key references:

Bellinger et al., 2020 (JAP)

*Investigation showing that muscle fiber typology is related to the incidence of overreaching following increased training volume.*

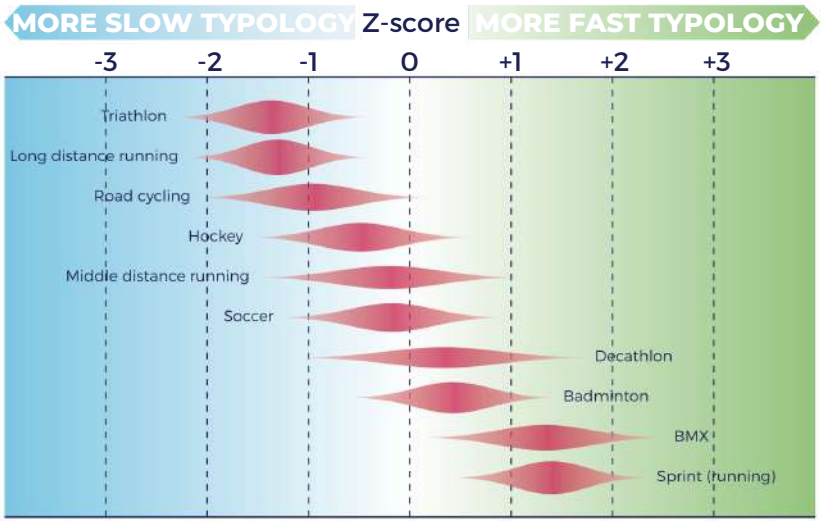
Lievens et al., 2021 (Sports Med)

*Investigation determining the muscle fibre typology as a novel risk factor for hamstring strain injuries in professional football.*

PhD thesis Eline Lievens, 2021

*The relevance of muscle typology in sports.*
*The extended version of this booklet.*

## Talent identification




## Performance characteristics

Energy efficiency

Maximal power & frequency

## Race tactics

Running economy

Even paced

Sprint capacity

Slow start
fast lap kick



MORE SLOW TYPOLOGY | Z-score | MORE FAST TYPOLOGY

-3 -2 -1 0 +1 +2 +3

## Training prescription

| | | | |
|---|---|---|---|
| Total training volume (h or km/week) | large | intermediate | small |
| Total training frequency (amount of training sessions /week) | large | intermediate | small |
| Recovery duration in between intense training sessions | short | intermediate | long |
| Recovery duration between intense exercises within training sessions | short | intermediate | long |
| Duration of taper | short | intermediate | long |

**Injury risk**




CHAPTER 4

# MEASURING MYOTYPES

## What will you discover?

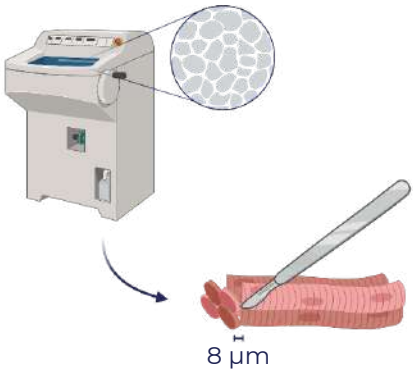
Myotypes have a considerable relevance in sports. Before you can apply the conclusions on your athletes, you have to determine their muscle fiber type distribution. But how can you do this?

# The invasive method by a muscle biopsy

The invasive method is a surgical procedure where a small part of muscle tissue is taken with a biopsy needle under local anaesthesia. It is then analyzed by biochemical methods and visually counted under a microscope.

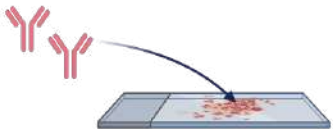
## 1 Muscle biopsy

## 2 Cut muscle tissue

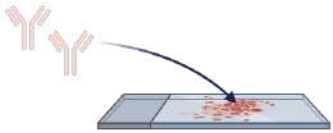



## 3 Immunohistochemistry

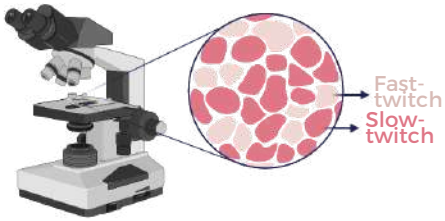
Slow-twitch fiber antibody



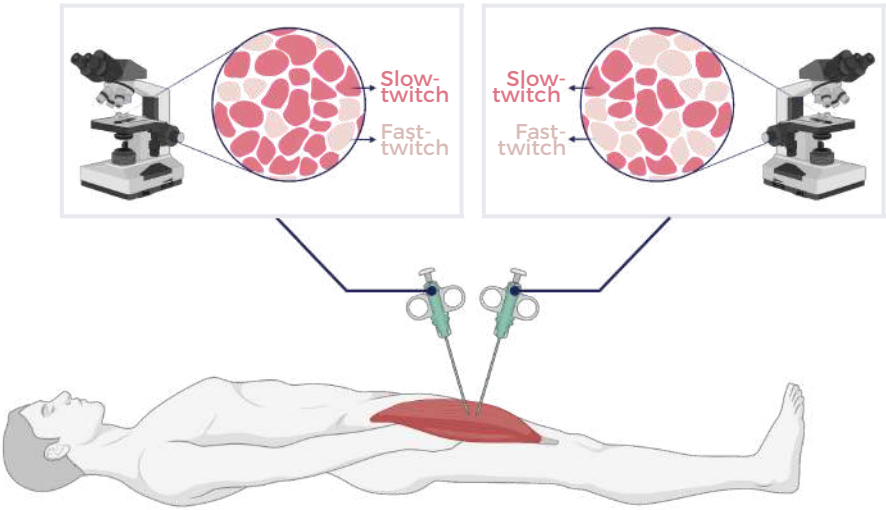
Fast-twitch fiber antibody



## 4 Muscle fiber visualization



- Gold standard
- Been used in many studies
- Invasive (difficult to perform on athletes)
- Analyzes small part of the whole muscle (< 0.1%)
- High variation between repeated biopsies



# Non-invasive methods

As the muscle biopsy falls short for the estimation on the muscle typology in sports, multiple non-invasive measurements have been investigated:

- **Isokinetic knee-extensions** 
  = 50 repeated isokinetic knee-extensions
  Decline in force (fatiguability) → % fast-twitch fibers

- **Wingate test** 
  = 30 seconds all-out
  Anaerobic power performance & fatiguability
  → % fast-twitch fibers

- **60" jump test** 
  = 60 seconds continuous maximal vertical jumping
  Anaerobic power performance & fatiguability
  → % fast-twitch fibers

- **Sprint & run** 
  = 40 m sprint & 2 km run
  Anaerobic performance capacity → % fast-twitch fibers
  Aerobic performance capacity → % slow-twitch fibers

- **...**


Non-invasive


Require performance of the muscle
↳ can be variable (dependent on technique, training, recovery, nutritional status, ...)

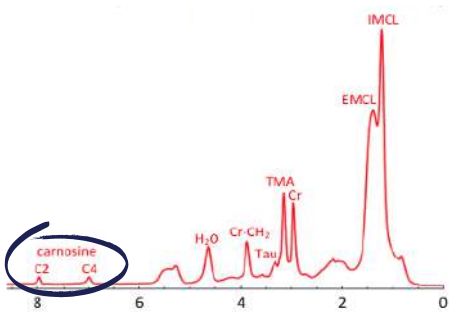
# Non-invasive method using the Muscle Talent Scan

To overcome these pitfalls, measurements in rest can be executed with the Muscle Talent Scan, a non-invasive method based on an MRI-scan. The calf of an athlete is scanned in order to determine the carnosine (muscle pH buffer) concentration (visualized by a spectrum and indicative for the amount of fast-twitch fibers). This concentration is then related to the carnosine concentration of the general population and transformed into a z-score. (Baguet et al., 2011; PLoS One)

**1** $^{1}$H-MRS

**2** Image of the calf

**3** Spectrum




**4** Z-score vs. reference

- Non-invasive (no radiation & easy to perform on athletes)
- Analyzes big part of the whole muscle (± 5%)
- Not influenced by training or acute nutritional changes (except beta-alanine supplementation & long term vegetarism)
- Measurement is based on the relationship between muscle fiber proportion and one metabolite (carnosine)
- Highly technical & relatively high cost

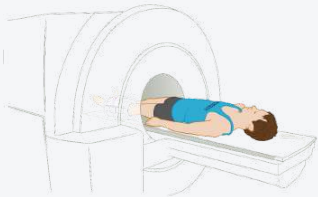
# TAKE HOME MESSAGE:

Despite the fact that 50 years of research has shown that the muscle fiber typology is important for sports practice, it is currently not used in the daily guidance of athletes.

### Invasive methods

Not ideal for athletes

### Non-invasive methods
**in action & in rest**



Possible to perform on athletes

Showing the relevance of myotypes in sports

## Key references:


Inbar, 1981

*Relationship between the muscle fiber type distribution and aerobic & anaerobic performance capacities.*

Bosco, 1979

*Relationship between the muscle fiber type distribution and squat & counter-movement jump.*

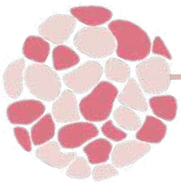
CHAPTER 5

# FAQ'S

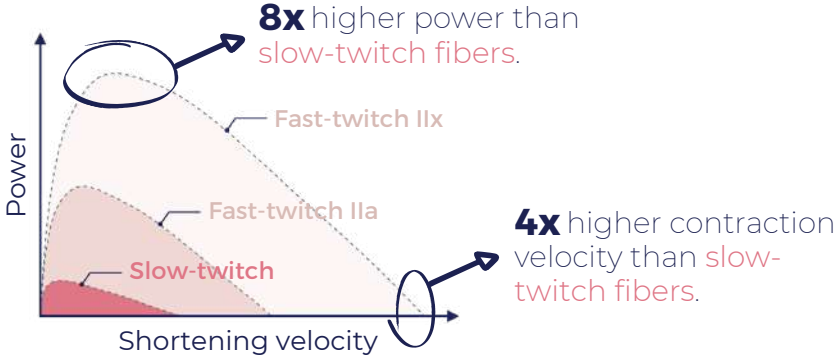
## Frequently asked questions

There is a lot more to learn about muscle fiber typology. Here you will find the answer on several frequently asked questions of coaches and researchers with regard to muscle fibers and myotypes and their relevance in sports.

# What are type IIx fibers? Are they relevant for sports?



FAST-TWITCH → Fast oxidative glycolytic fibers (IIa)
FAST-TWITCH → Fast glycolytic fibers (IIx)




- In general, these fibers are not frequently found in most athletes.

  IIx fibers (formerly known as IIb fibers) might not play an important role for sports performance in most sports.

- In some cases, for example in a world champion 60 m hurdles, 24% of the fibers was found to be type IIx.

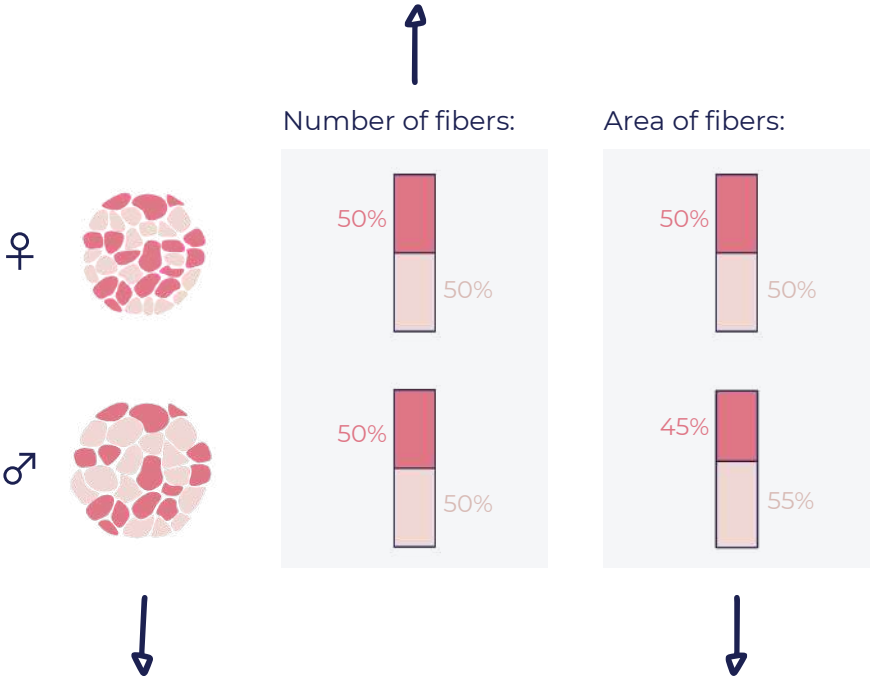
  IIx fibers might be performance determining in some specific sprint disciplines.

However, it is important to note that the distinction between type IIa and type IIx is often difficult to make.

**Despite some exceptions, the low abundance of type IIx fibers in athletes results in a limited influence on performance.**

# What about sex?

If you count the number of slow-twitch and fast-twitch fibers in men and women, we don't see consistent differences.




Men have bigger fibers compared to women. Moreover, fast-twitch fibers are generally larger in men than slow-twitch fibers.

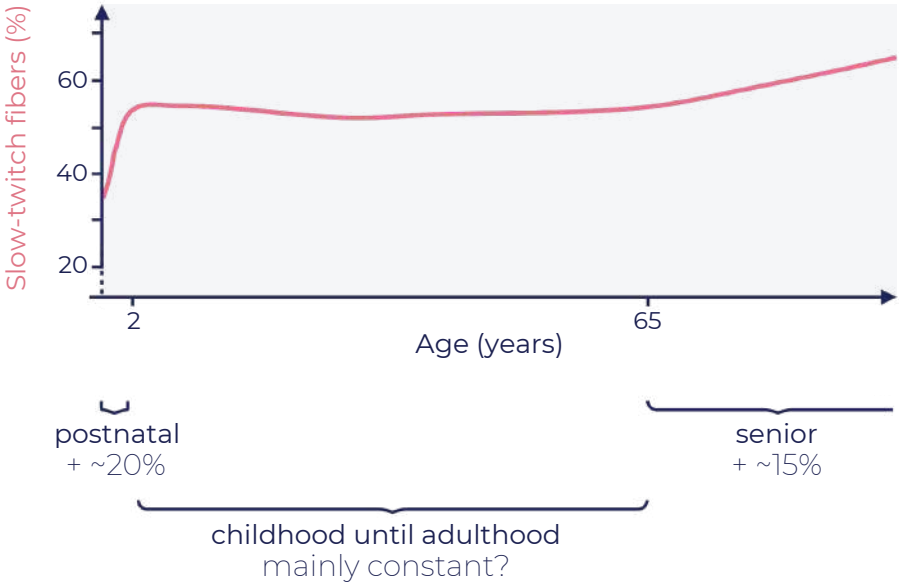
The muscle consists of a higher relative area of fast-twitch fibers in men.

**The number of fibers is indifferent between men and women, while the surface of fast-twitch fibers is somewhat higher in men.**

Data adapted from Saltin et al., 1977; Simoneau & Bouchard, 1989; Staron et al., 2000

# Muscle typology across the human lifespan

- In the early years of life, there is an increase in the amount of slow-twitch fibers.
- From childhood to adulthood, the muscle fiber distribution remains fairly constant.
- During aging, the amount of slow-twitch fibers increases again.



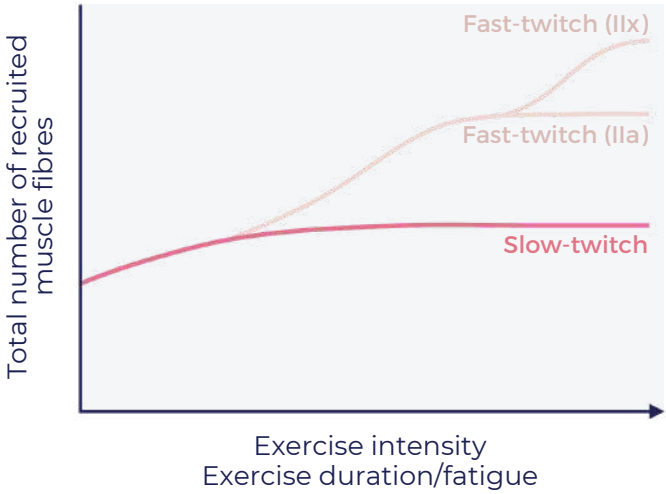

**Despite data are still scarce, muscle fiber type distribution remains more or less constant when peak performances are delivered in sports.**

Data adapted from Oertel, 1988; Lexell et al., 1992

# When are slow-/fast-twitch fibers recruited?

During submaximal muscle effort, some fibers are activated (= recruited) and others are not. The amount and type of the muscle fibers which are recruited, depends on:

- Exercise intensity: the harder the training (higher loads), the more fast-twitch fibers are recruited.
- Exercise duration/fatigue: the longer the training lasts and fatigue appears, the more fast-twitch fibers are recruited.




**Did you know...** *that if you would like to increase the size of your fast-twitch fibers (hypertrophy) through resistance training, you can either train with high loads or train until fatigue?*

**The recruitment of muscle fibers increases with exercise intensity and duration. Slow-twitch fibers are activated first, followed by fast-twitch fibers.**

# FINAL NOTE

Throughout this booklet, we aimed to scientifically explain and document why the muscle fiber type composition is an important characteristic of an athlete in both individual and team sports.
The goal of this illustrated guide is to advise and promote the practical use of the myotype in sports.

We hope you enjoyed reading this work. If you have suggestions for improvement, please contact us (see contact details on the next page).

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This booklet can be downloaded on
ugent.be & muscletalentscan.com
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Muscle Talent Scan

victoris

SPORT SCIENCE LABORATORY
Jacques Rogge

This booklet is a summarized version and practical translation of the PhD thesis of Eline Lievens (2021, Ghent University, Belgium). As an illustrated guide, it depicts the scientific state-of-the-art about the relevance of muscle fiber typology in sports. It aims to make this easily accessible to sport coaches, athletes and everyone who is interested in sports.

Why do fiber types matter? Every individual has a unique composition of two muscle fiber types: slow and fast fibers. Based on the ratio of these fiber types, we can divide the population into three distinct muscle fiber typology groups: the myotypes. Your own myotype is relevant for multiple aspects of sports, such as talent identification, race characteristics, training prescription & injury risk. Understanding the basics of these myotypes is therefore useful for every sports practitioner.

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