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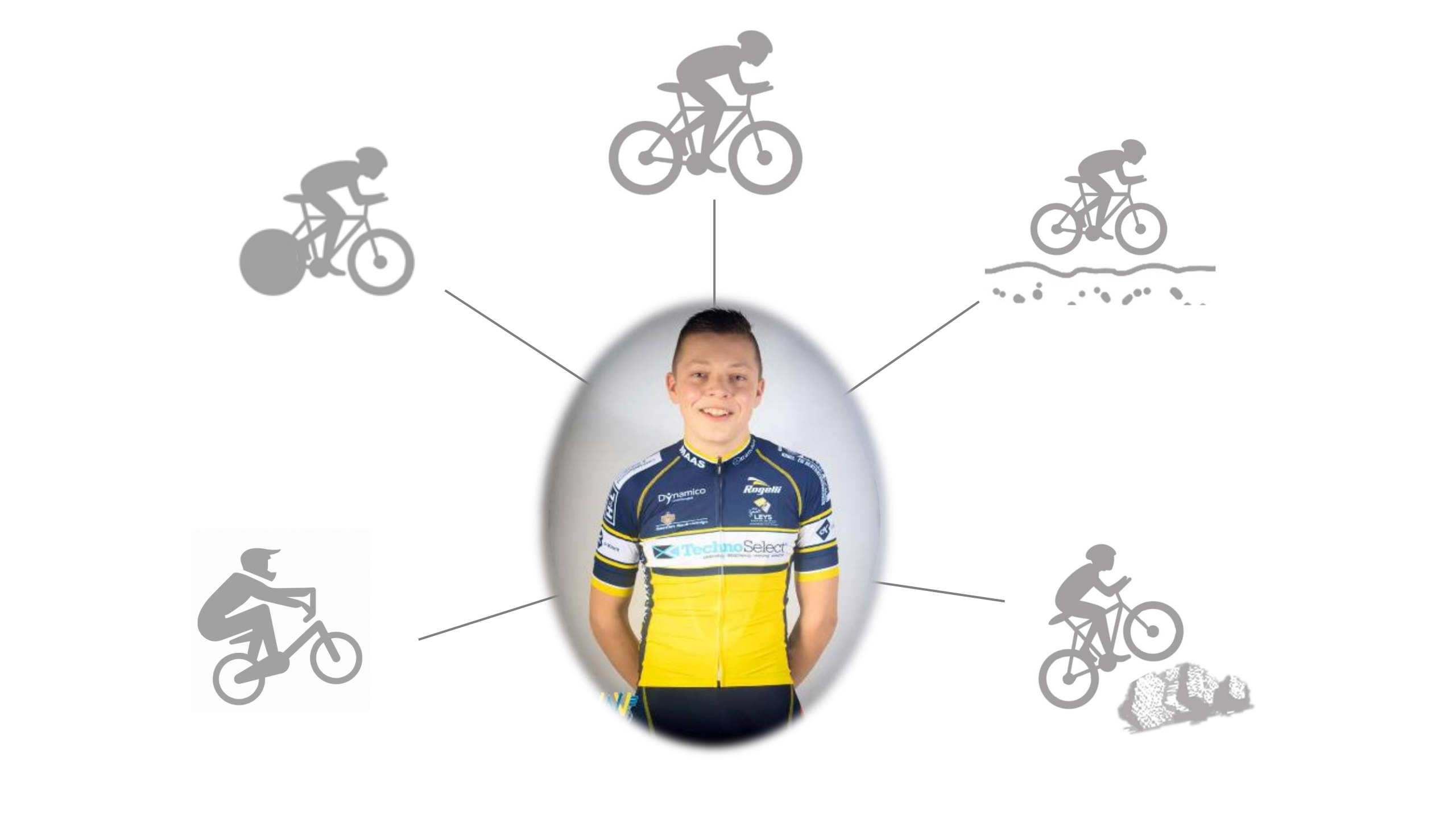
MUSCLE FIBER TYPOLOGIES IN ELITE CYCLING DISCIPLINES

Dr. Eline Lievens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Rogelli
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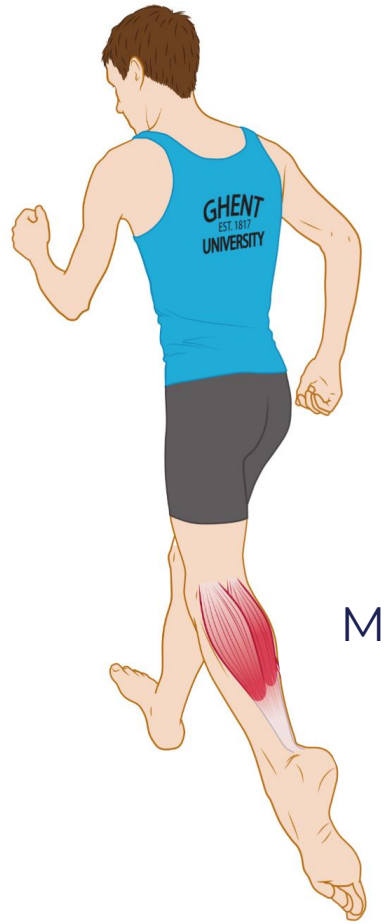
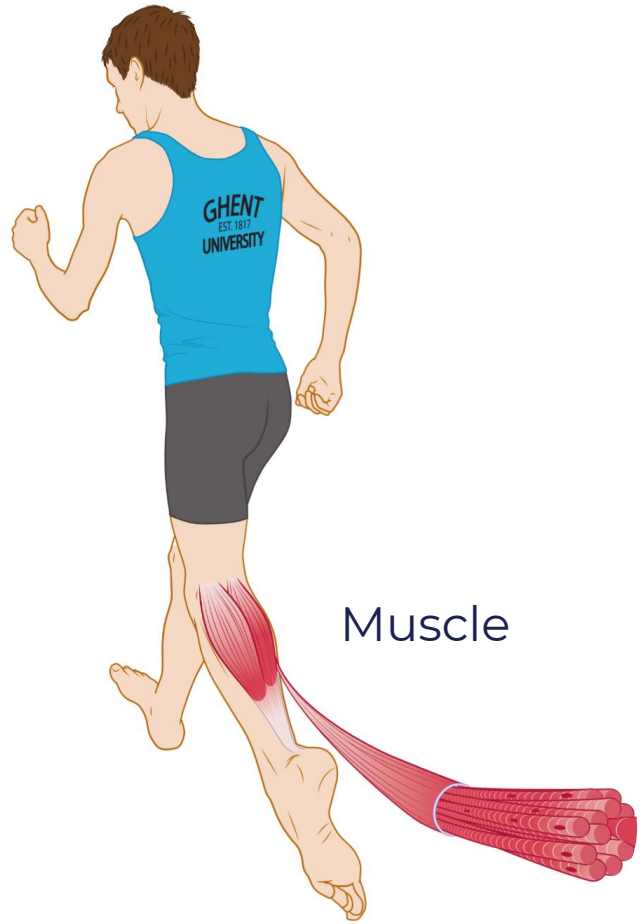
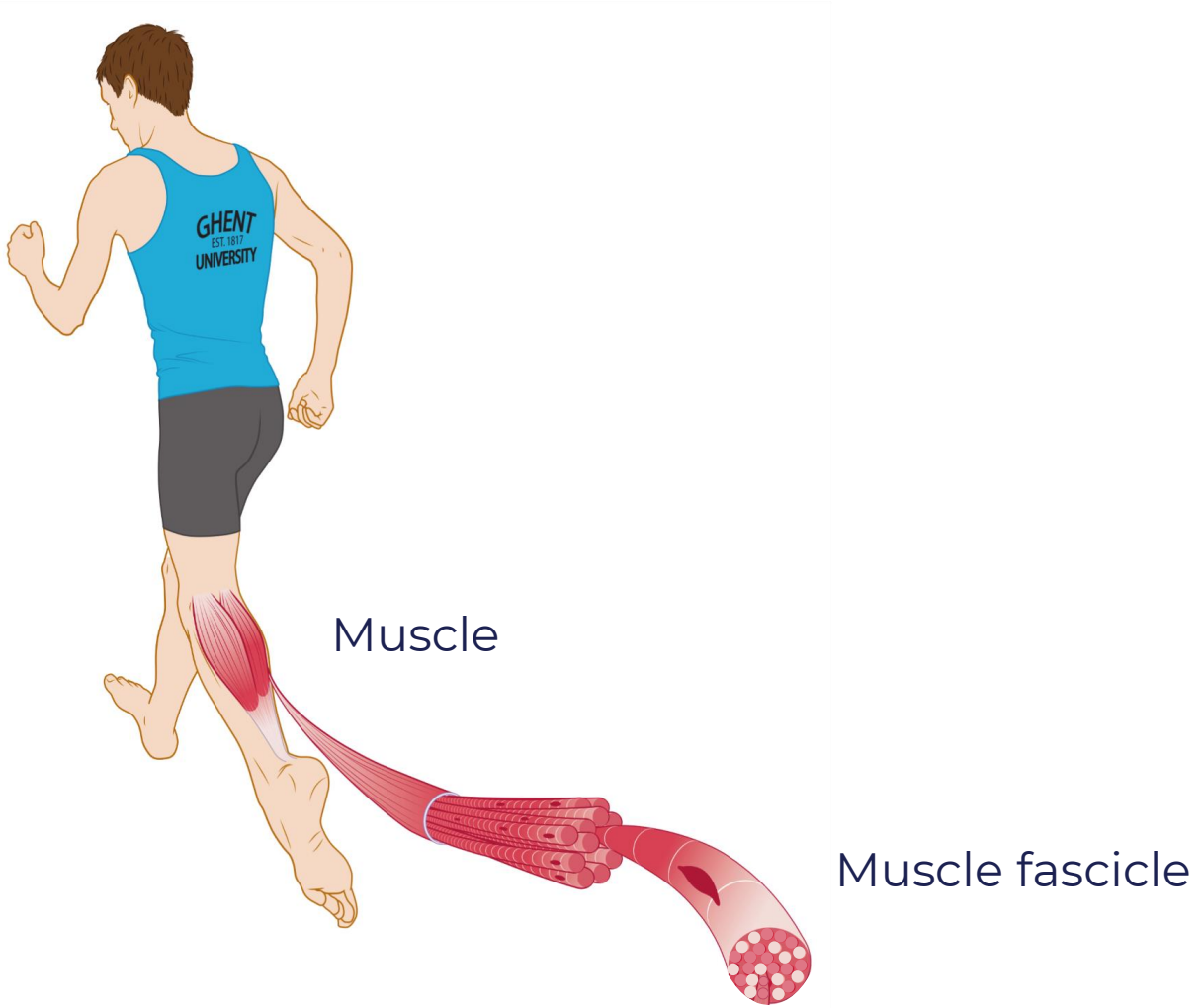


Muscle



Muscle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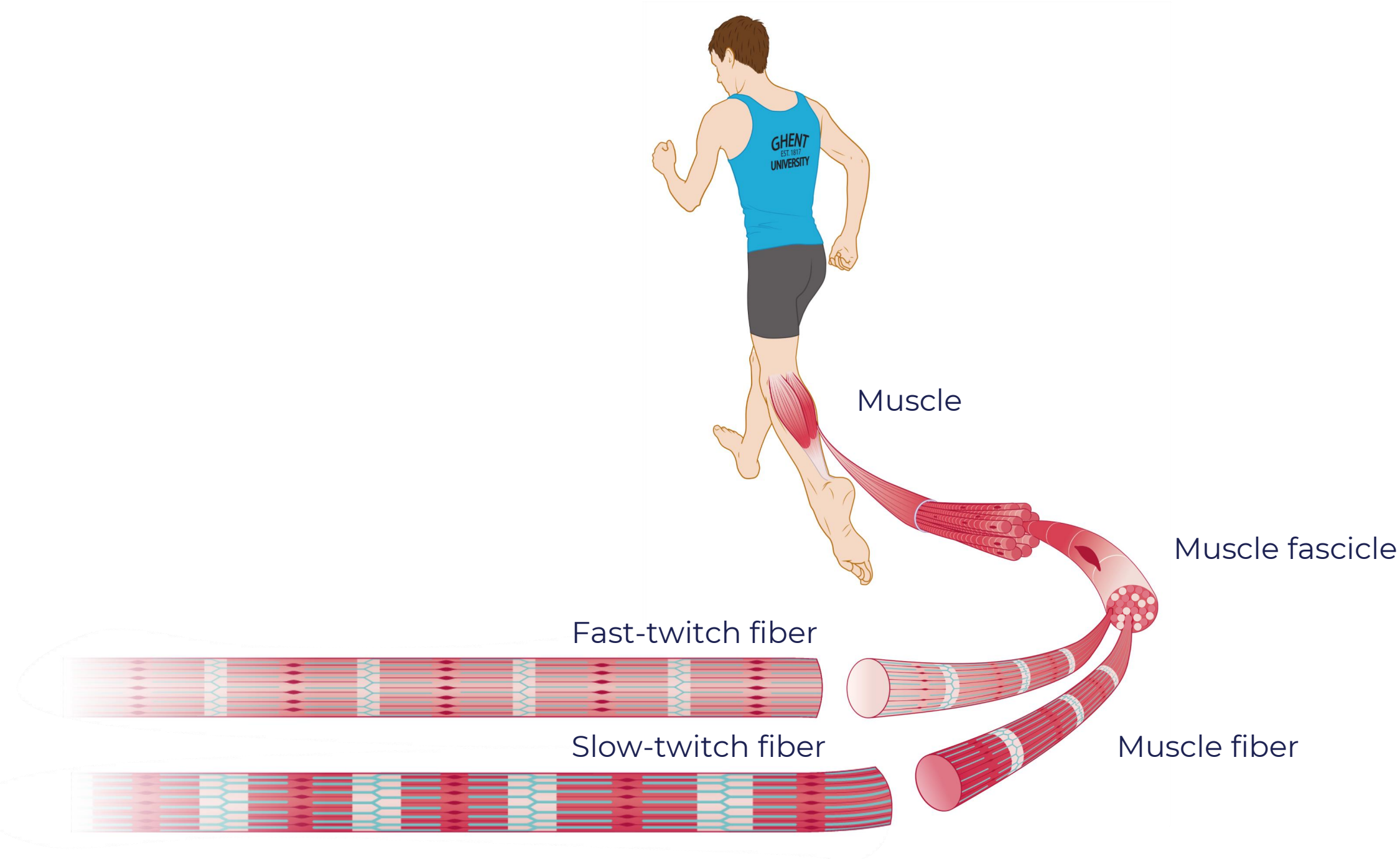
Muscle
Muscle fascicle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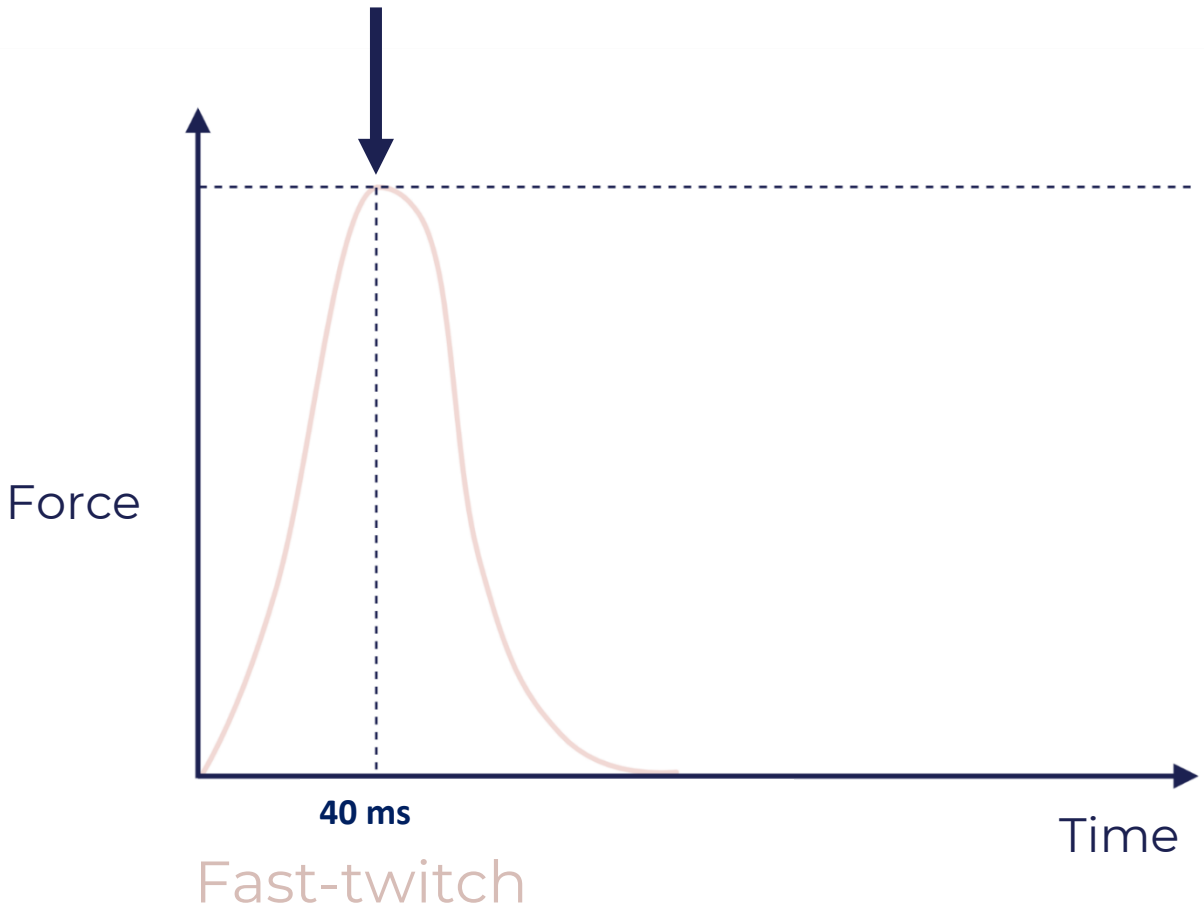
Muscle
Muscle fascicle
Fast-twitch fiber
Slow-twitch fiber
Muscle fiber

1 Fast-twitch fibers are faster



(Bottinelli, J. Physiol., 1996)

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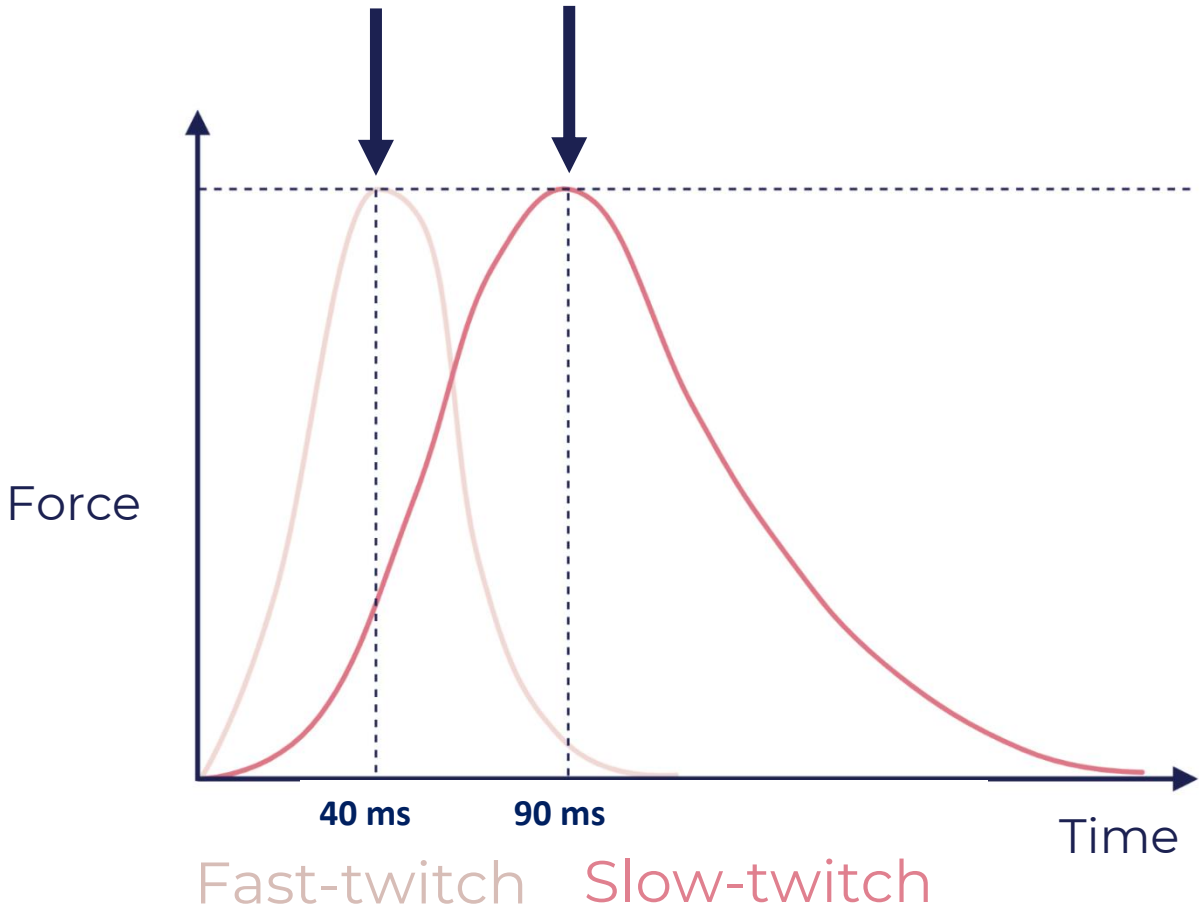

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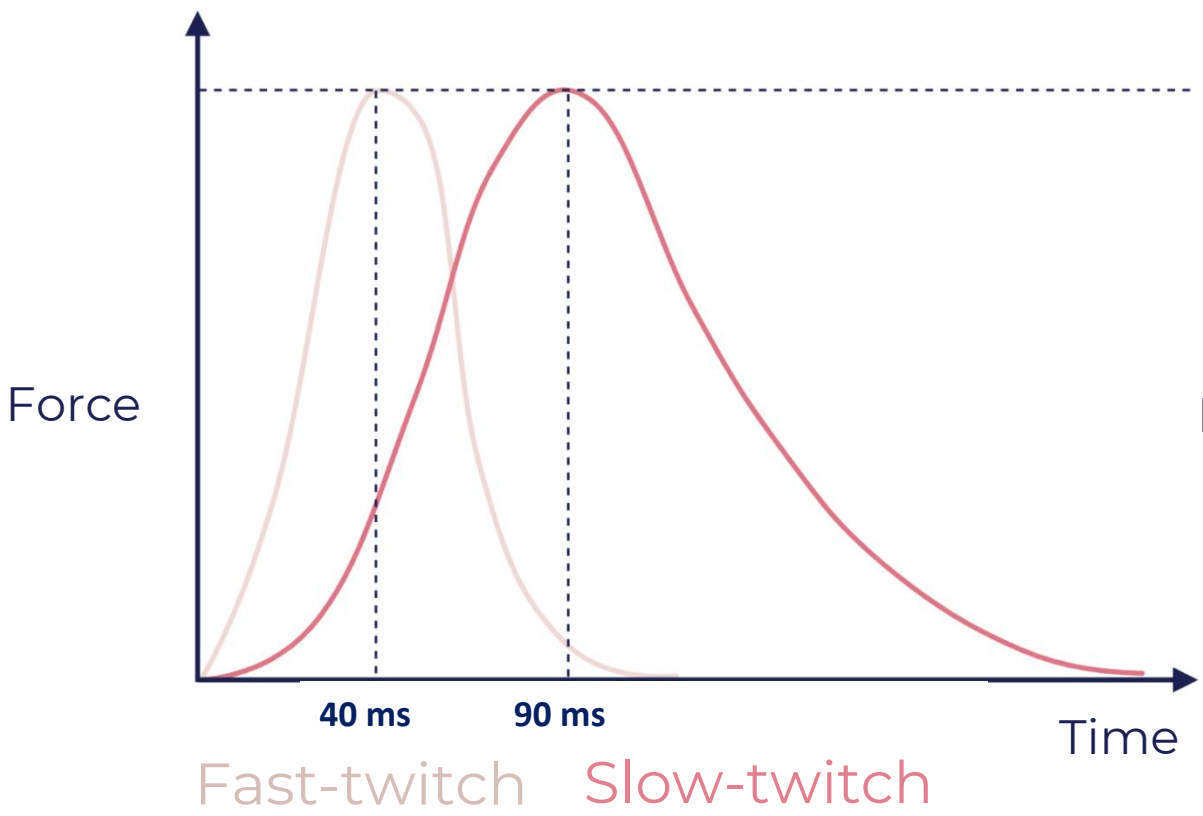
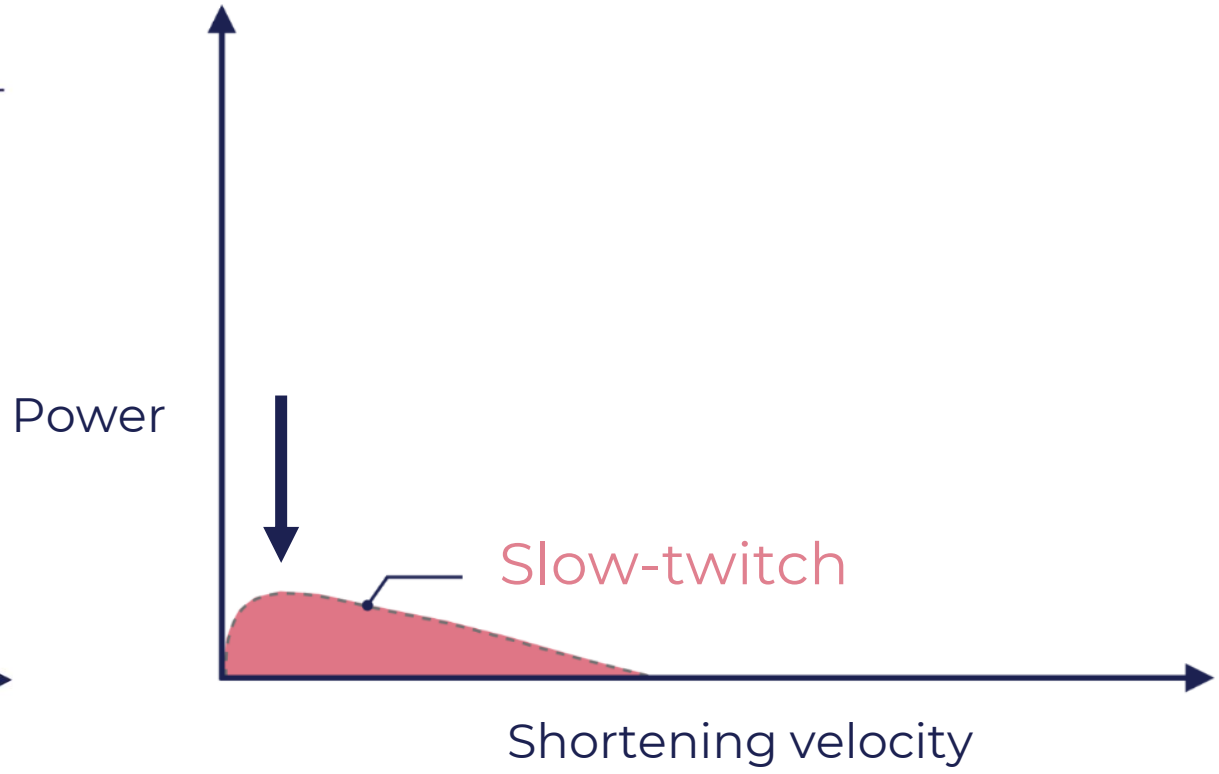
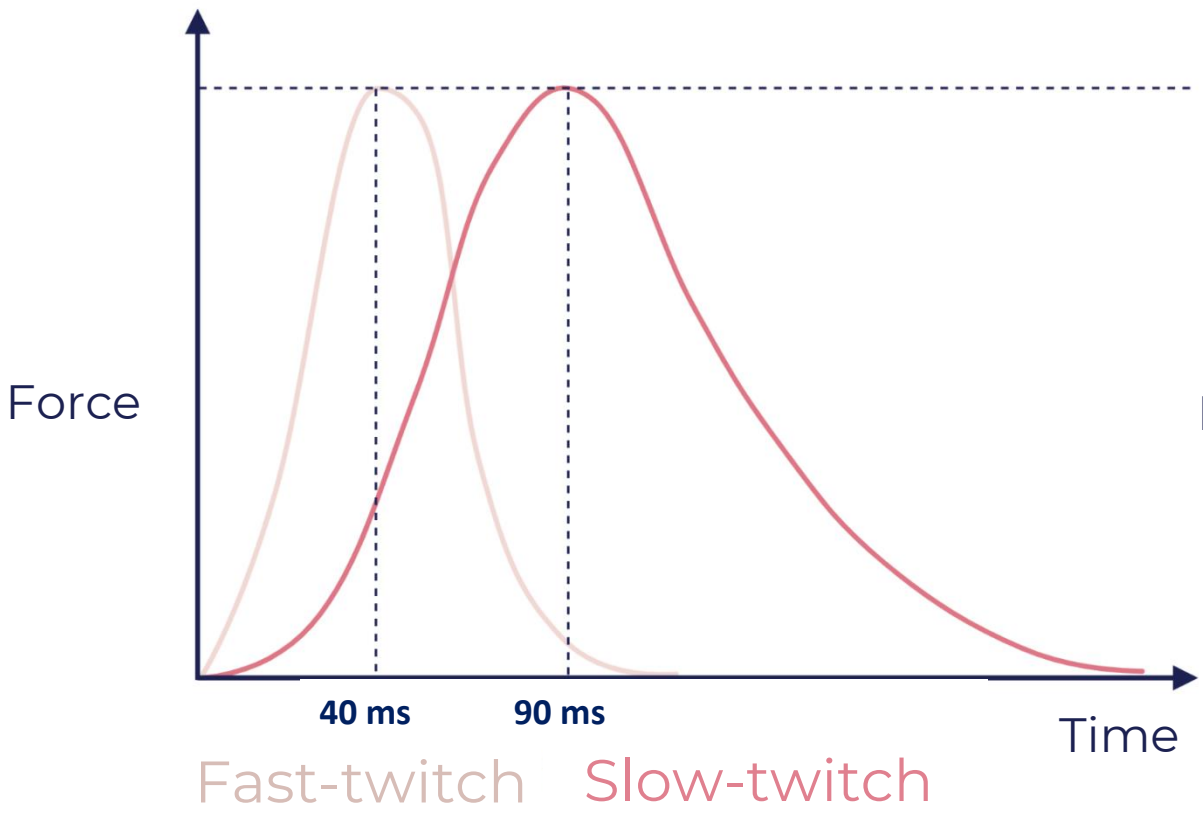
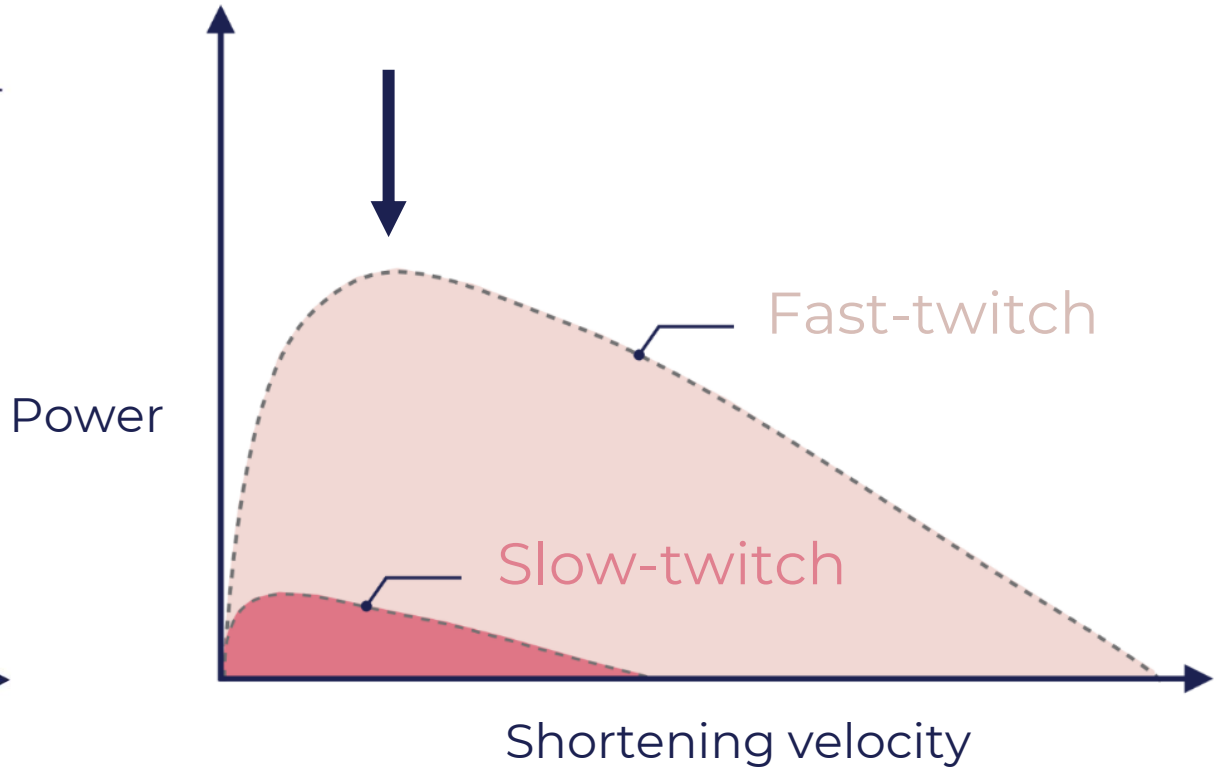




(Bottinelli, J. Physiol., 1996)

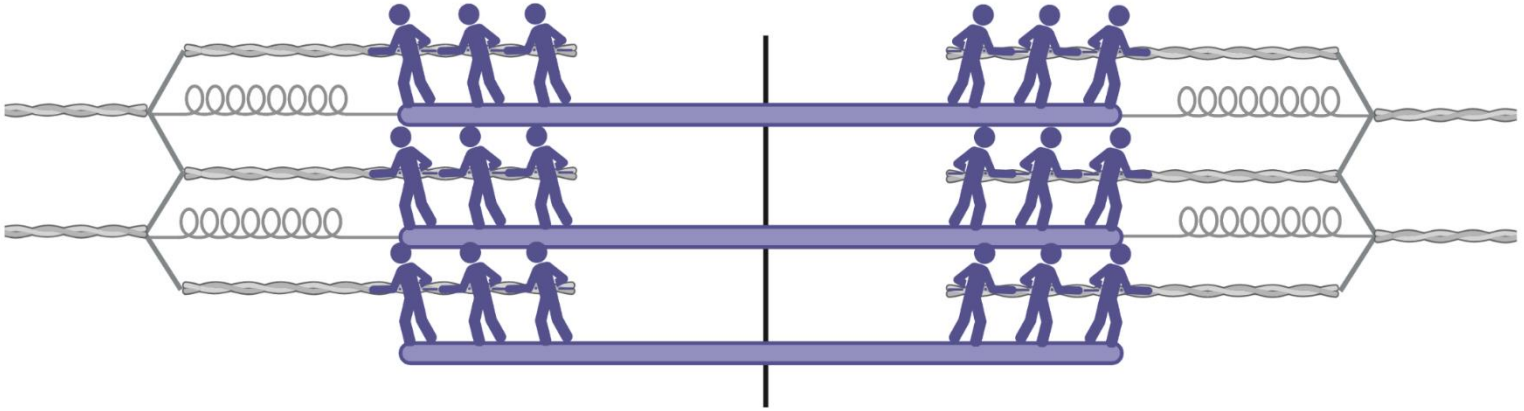
1 Fast-twitch fibers are faster





(Bottinelli, J. Physiol., 1996)

2 Slow-twitch fibers are more energy efficient



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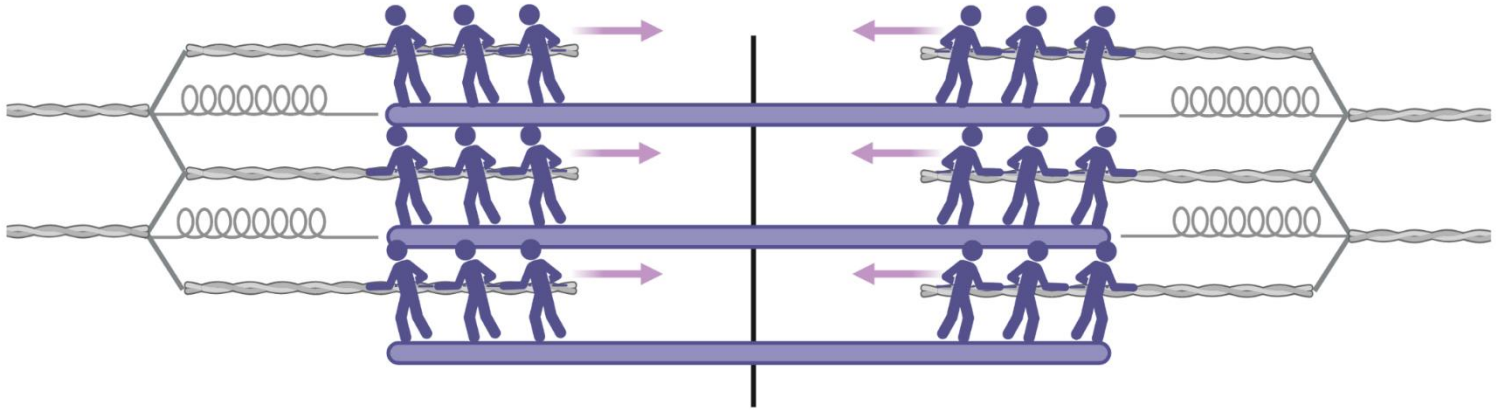
2 Slow-twitch fibers are more energy efficient



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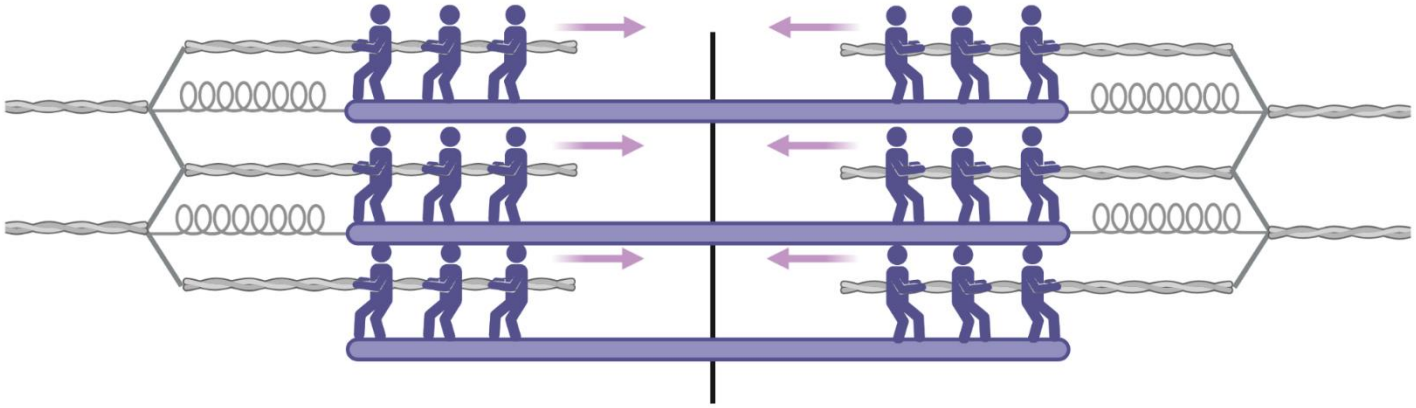

INVOICE:

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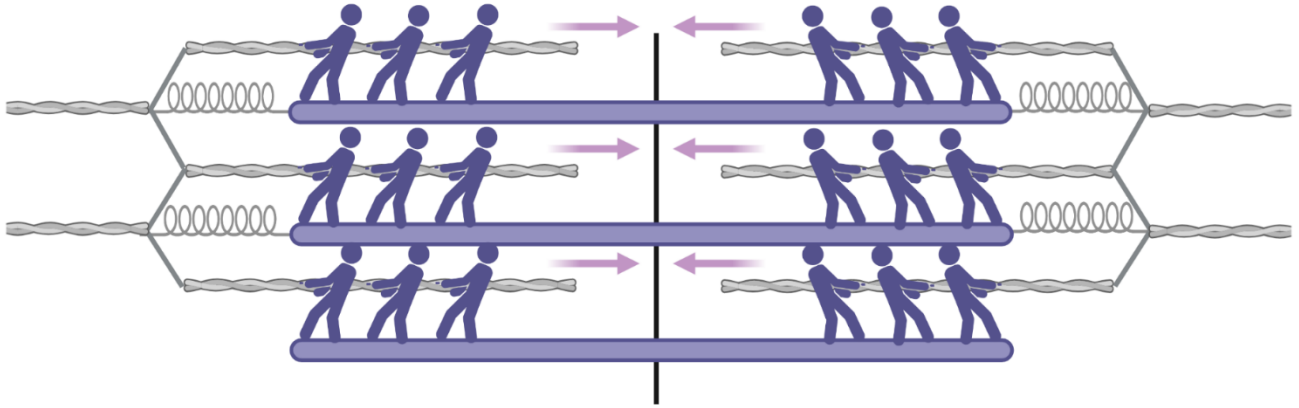

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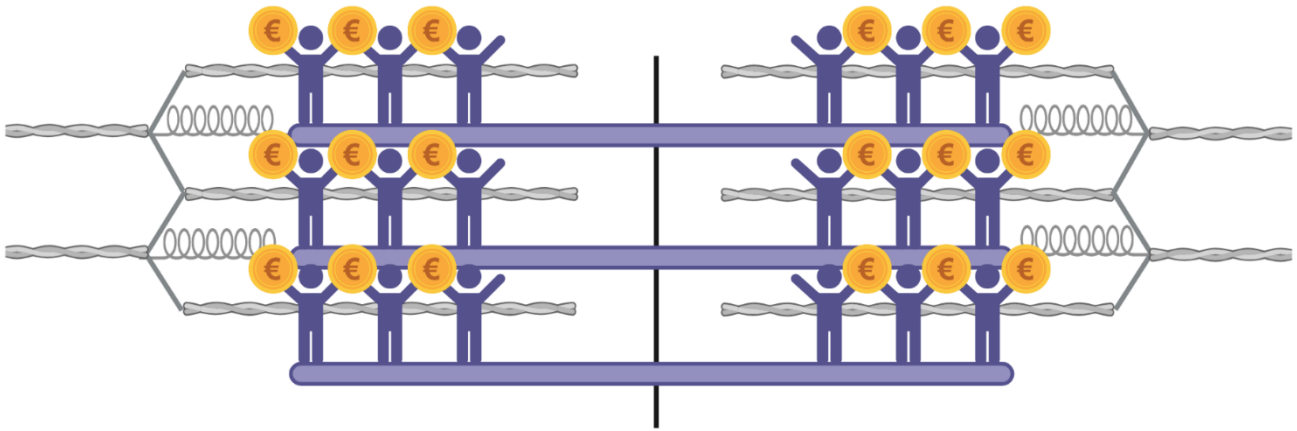

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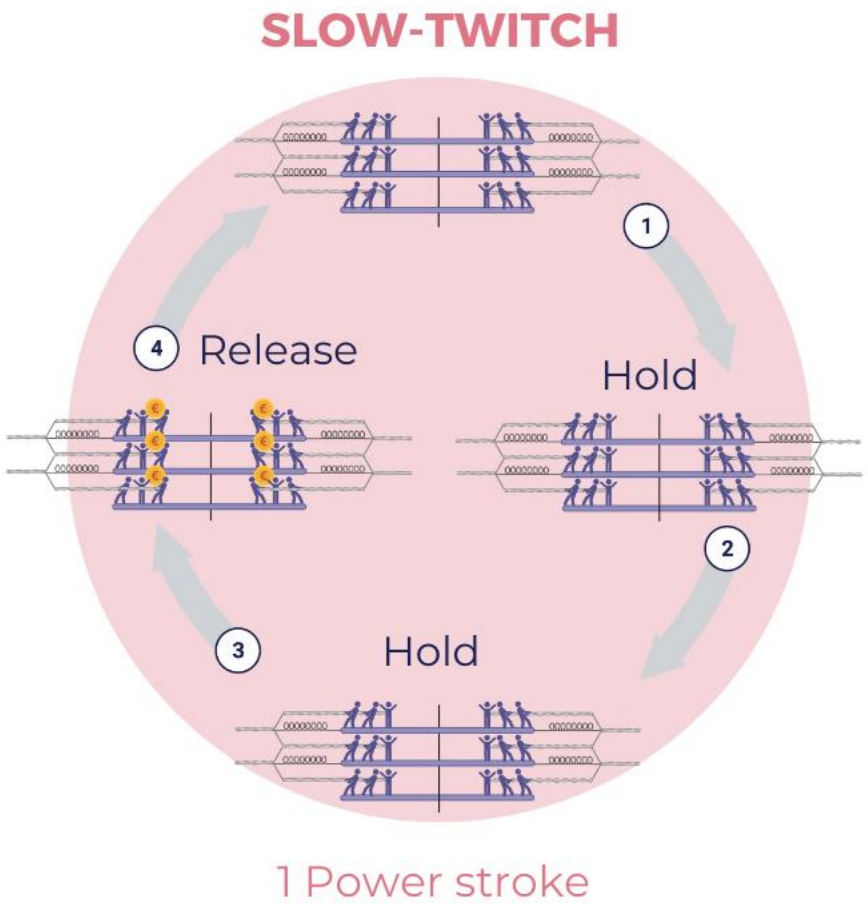
2 Slow-twitch fibers are more energy efficient



(Stienen, J. Physiol., 1996)

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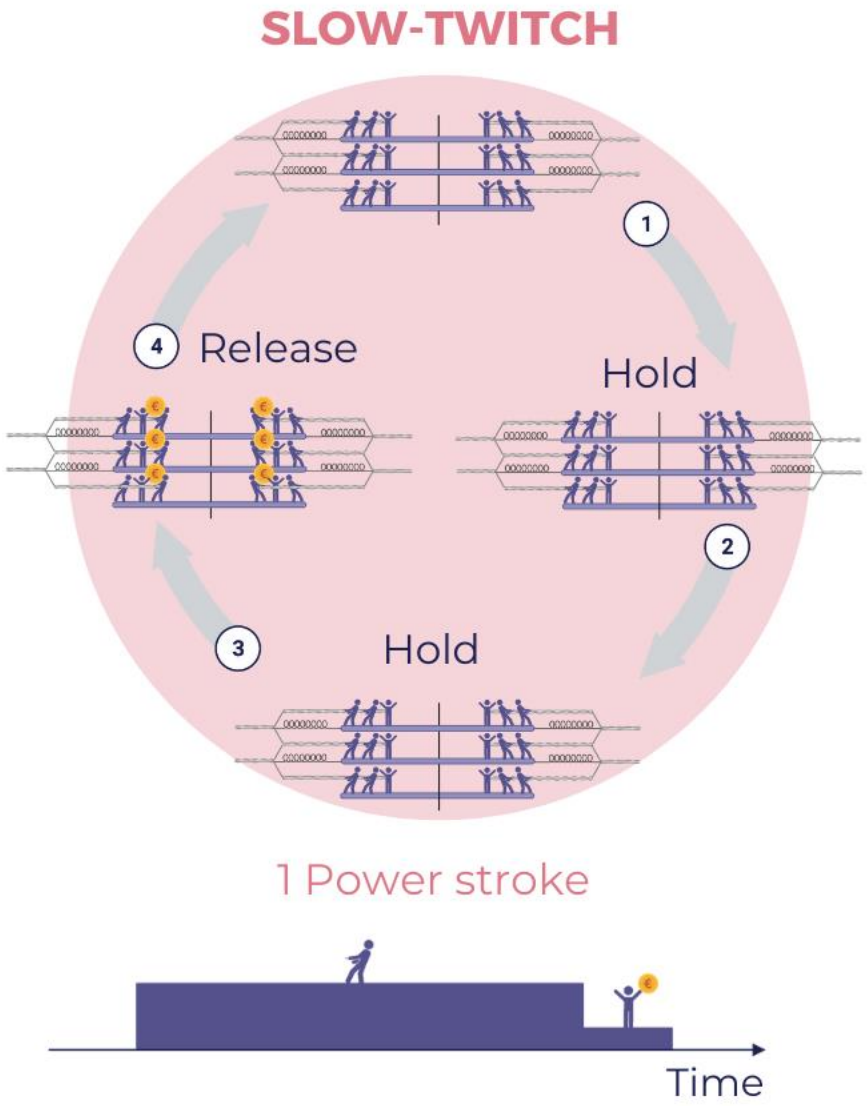

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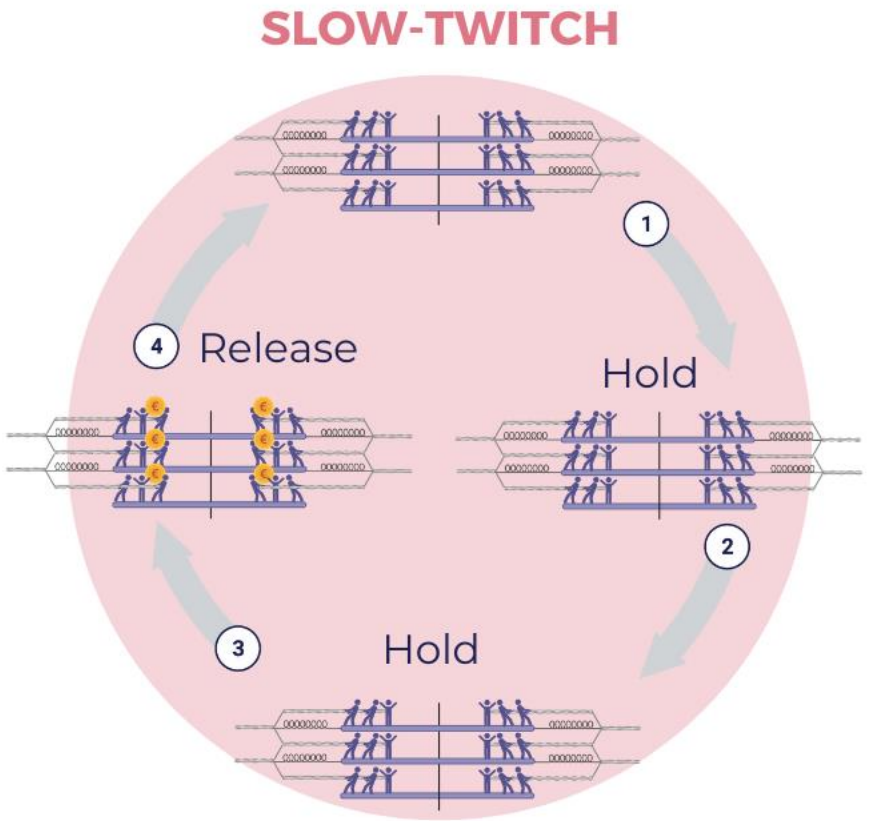
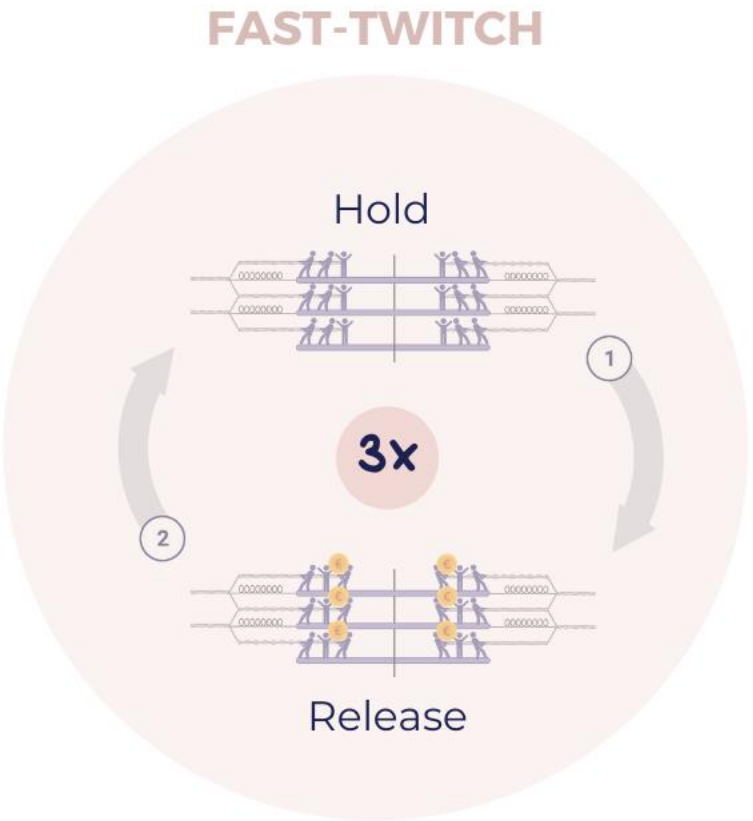
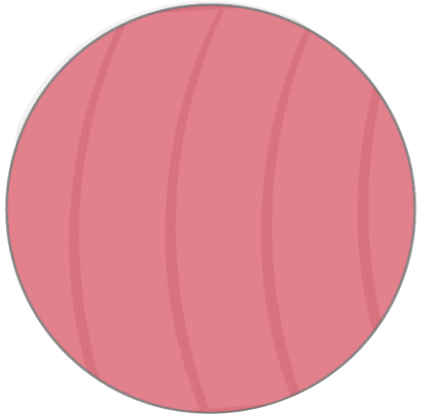


1 Power stroke

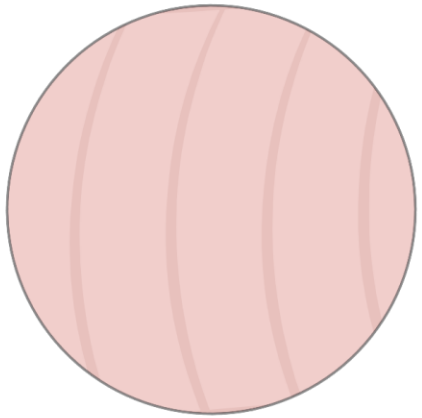


3 Power strokes

3 Fiber types use different fuels

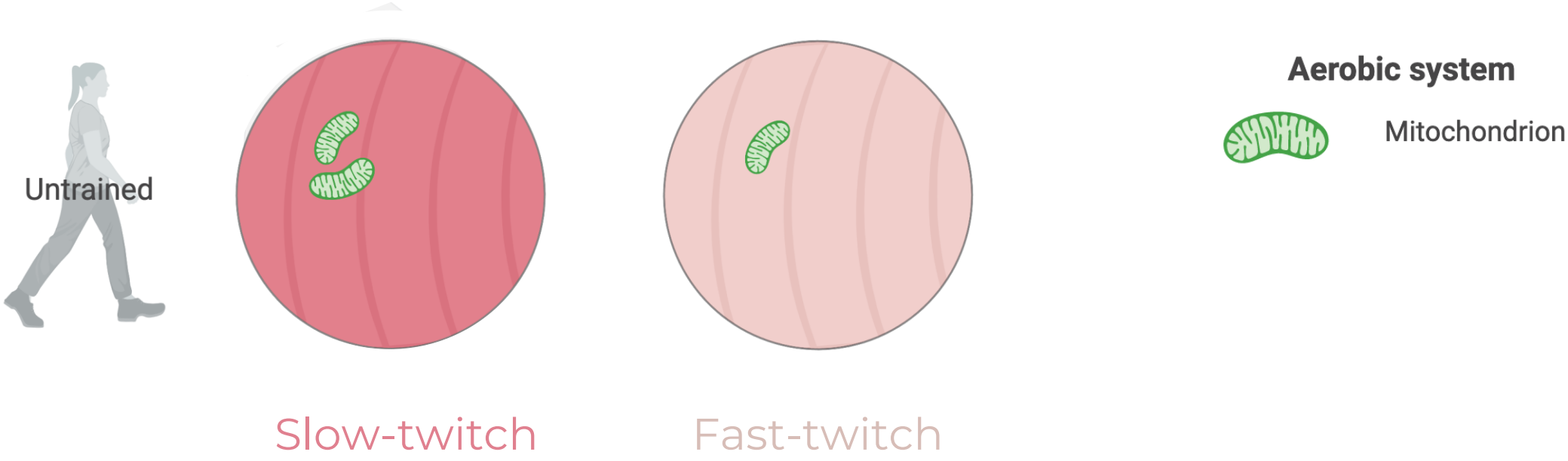


Slow-twitch



Fast-twitch

3 Fiber types use different fuels



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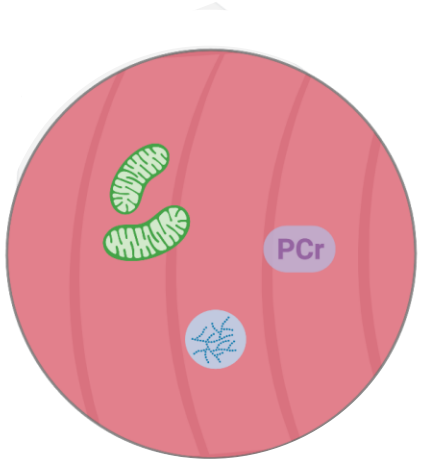
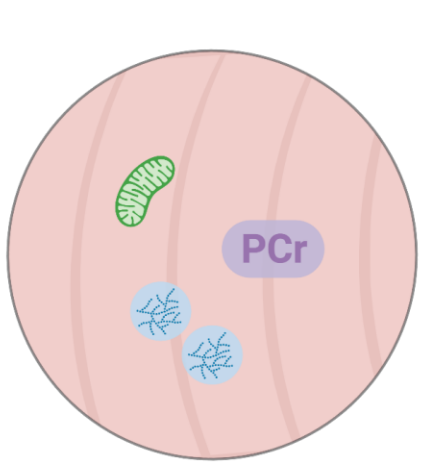


Slow-twitch



Fast-twitch

Aerobic system

Mitochondrion

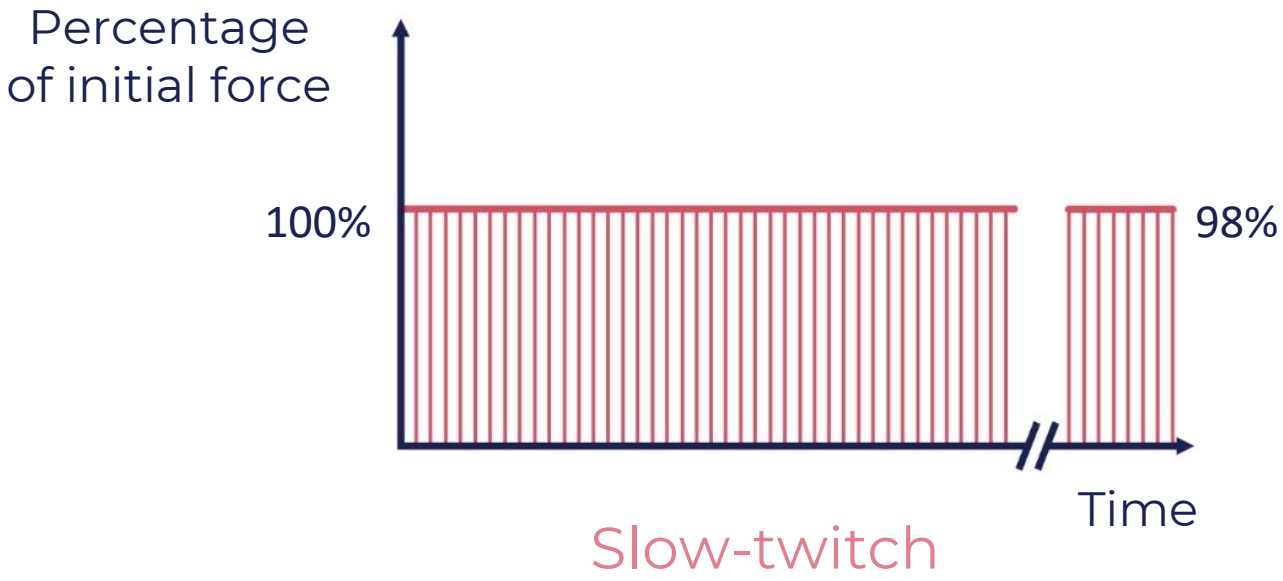
Anaerobic lactic system

Glycogen

Anaerobic alactic system

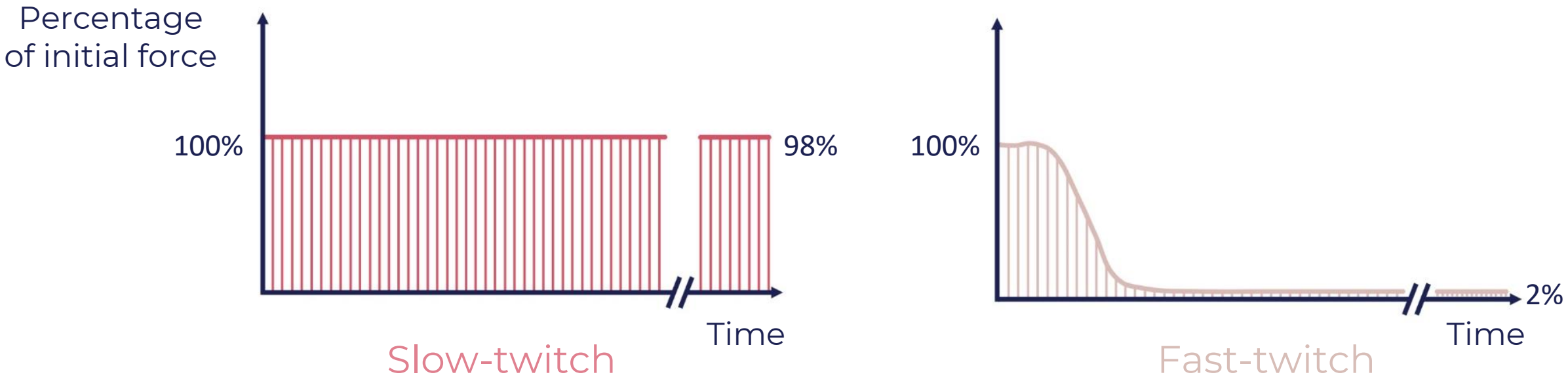
PCr Creatine phosphate

4 Slow-twitch fibers are more resistant to fatigue



(Brurke, J. Exerc. Sport Sci Rev, 1996)

4 Slow-twitch fibers are more resistant to fatigue



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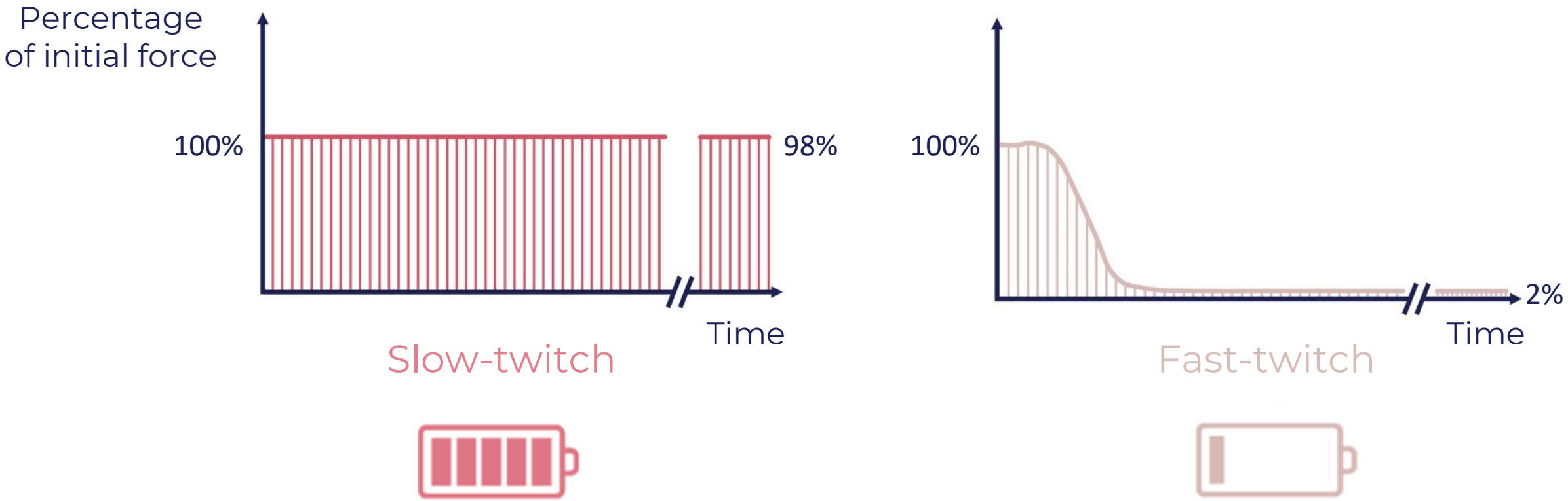


(Brurke, J. Exerc. Sport Sci Rev, 1996)

INTERMEDIATE SUMMARY

1

2

3

4

INTERMEDIATE SUMMARY

SLOW-TWITCH
muscle fiber

FAST-TWITCH
muscle fiber

1. Generate more power 
2.
3.
4.

INTERMEDIATE SUMMARY

SLOW-TWITCH
muscle fiber

FAST-TWITCH
muscle fiber

1. Generate more power
2. More efficient
3.
4.

INTERMEDIATE SUMMARY

SLOW-TWITCH
muscle fiber

FAST-TWITCH
muscle fiber

1. Generate more power
2. More efficient
3. Aerobic metabolism
4. Anaerobic metabolism PCr

INTERMEDIATE SUMMARY

SLOW-TWITCH muscle fiber		FAST-TWITCH muscle fiber
	1	Generate more power
More efficient	2	
Aerobic metabolism	3	Anaerobic metabolism PCr
More resistant to fatigue	4	

INTERMEDIATE SUMMARY

SLOW-TWITCH muscle fiber		FAST-TWITCH muscle fiber
	1	Generate more power
More efficient	2	
Aerobic metabolism	3	Anaerobic metabolism PCr
More resistant to fatigue	4	

Low-intensity & long-lasting activity

Fast & powerful actions

PART I

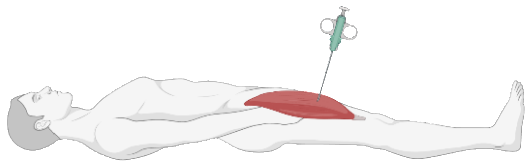
Muscle physiology

PART II

Methodology

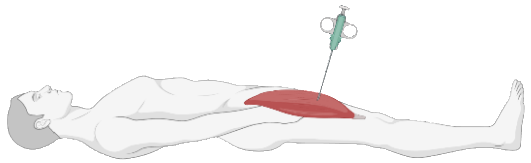
1 Invasive method: muscle biopsy

1 Muscle biopsy

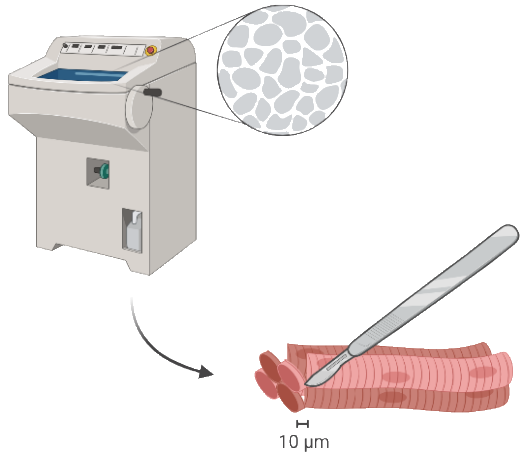


1 Invasive method: muscle biopsy

1 Muscle biopsy

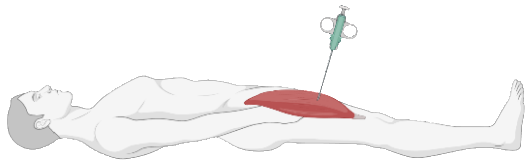


2 Cut muscle tissue

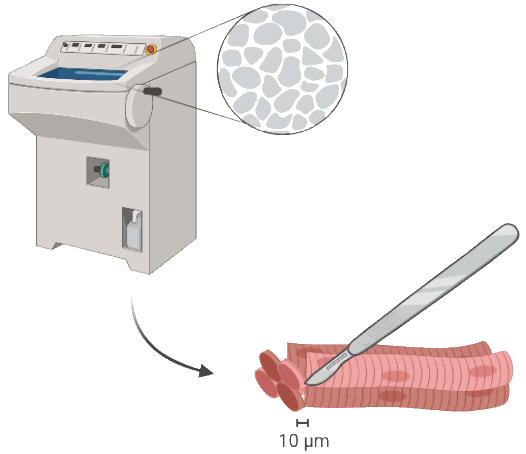


1 Invasive method: muscle biopsy

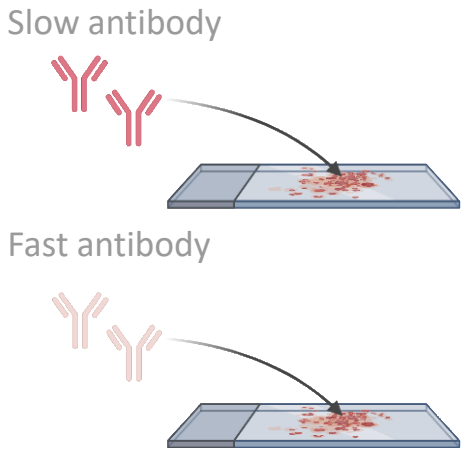
1 **Muscle biopsy**



2 **Cut muscle tissue**

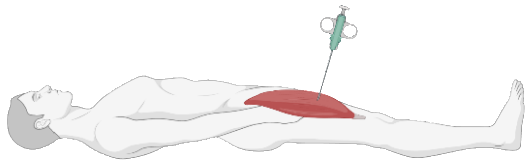


3 **Immunohistochemistry**



1 Invasive method: muscle biopsy

1 Muscle biopsy



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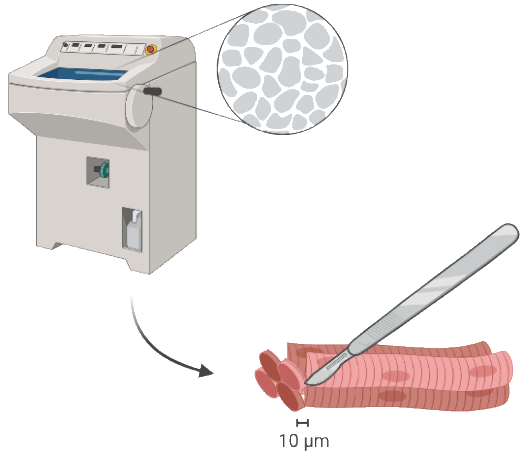
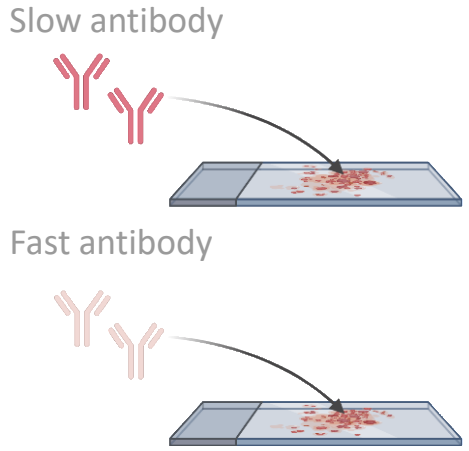
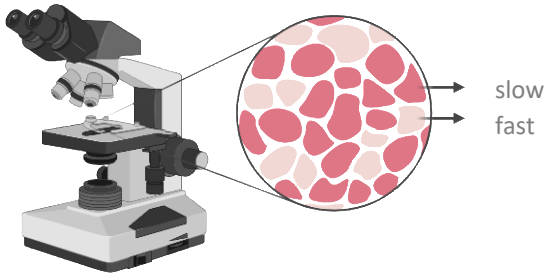


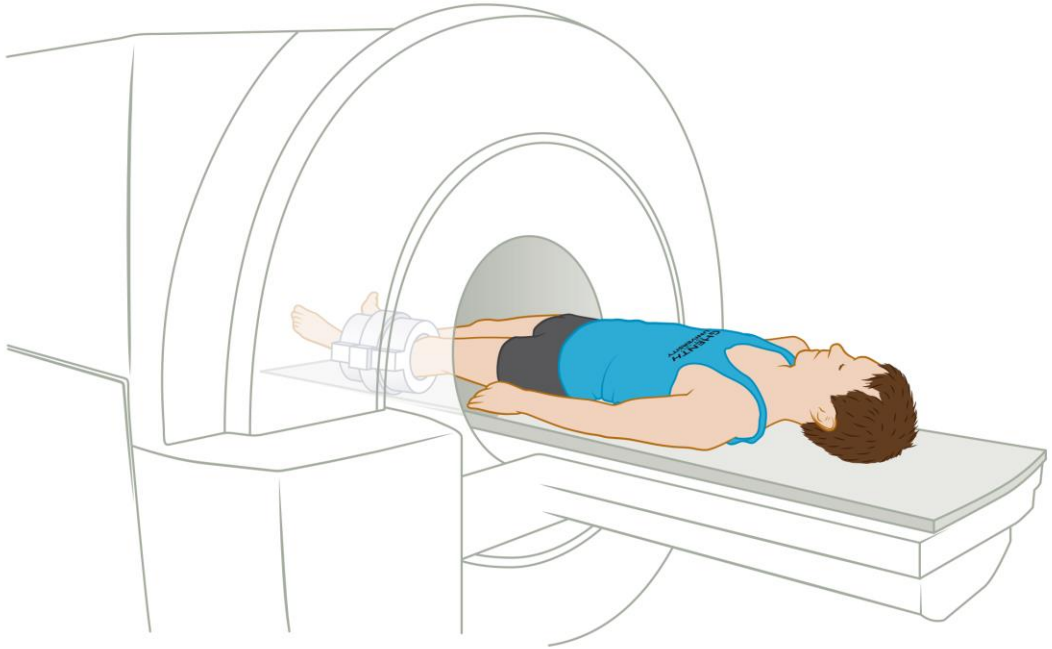
3 Immunohistochemistry



4 Muscle fiber visualization



2 Non-invasive method: ^{1}H-MRS of carnosine



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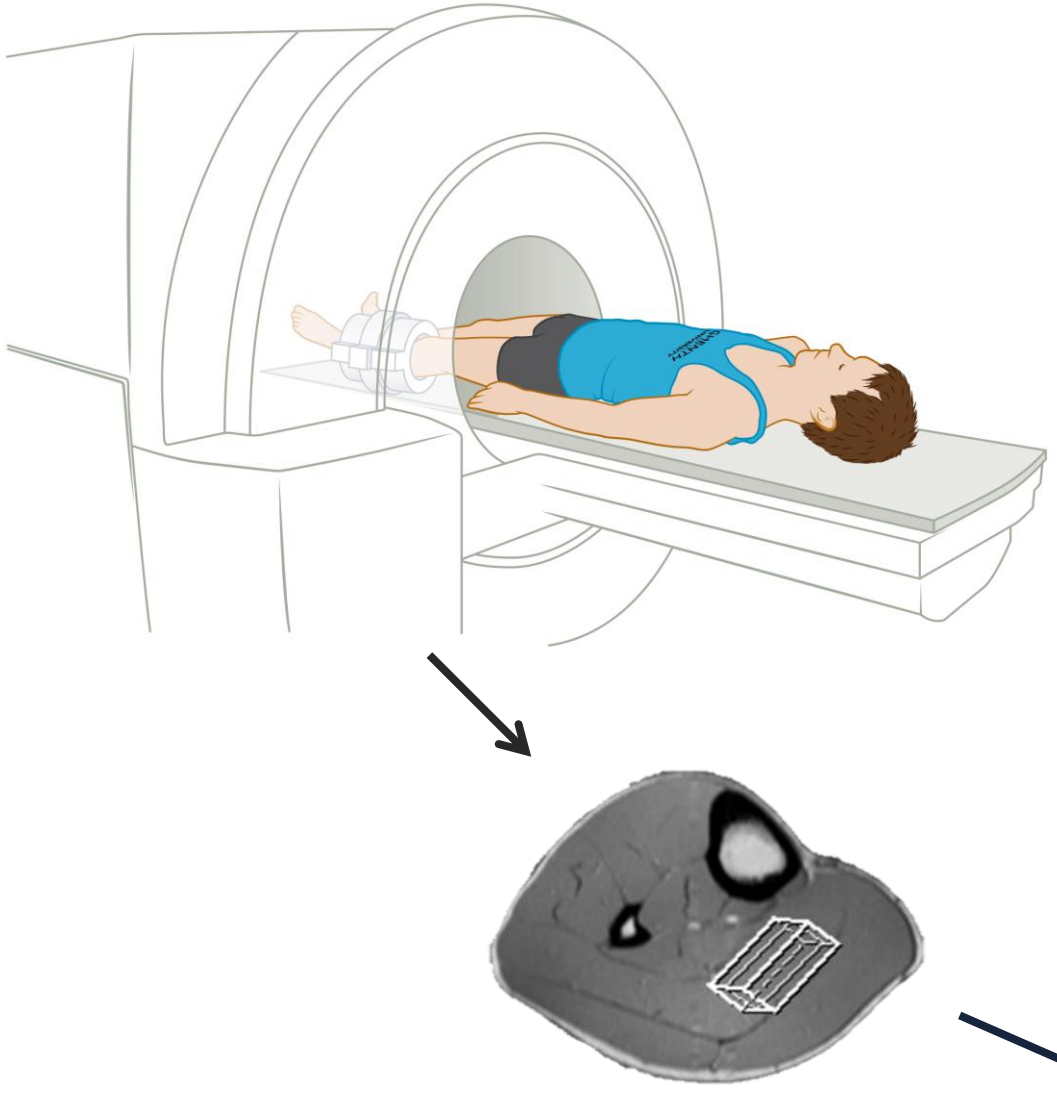

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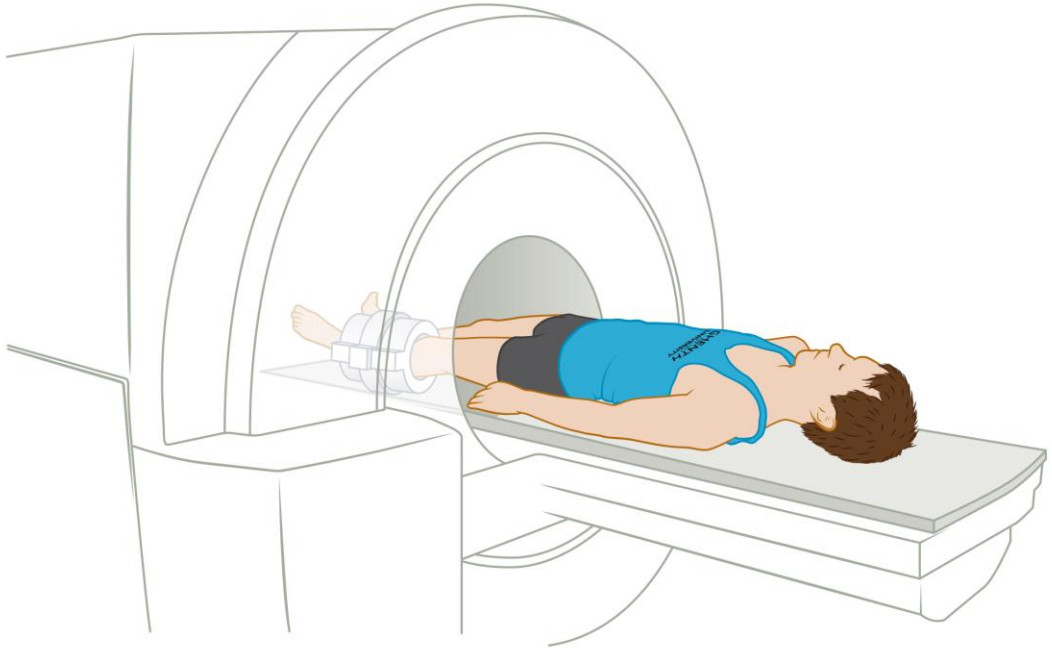

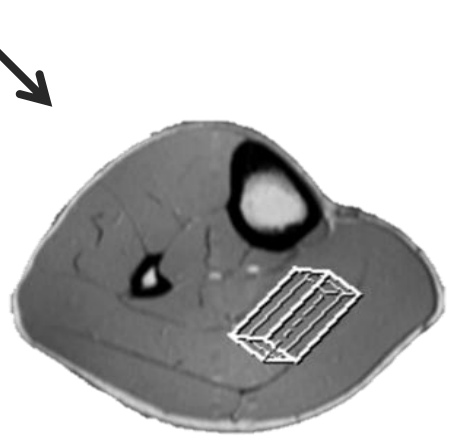

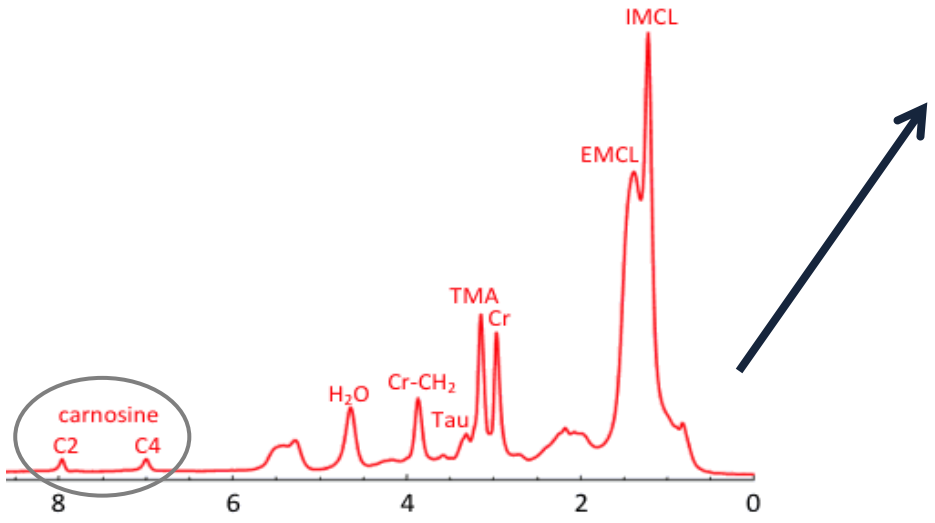

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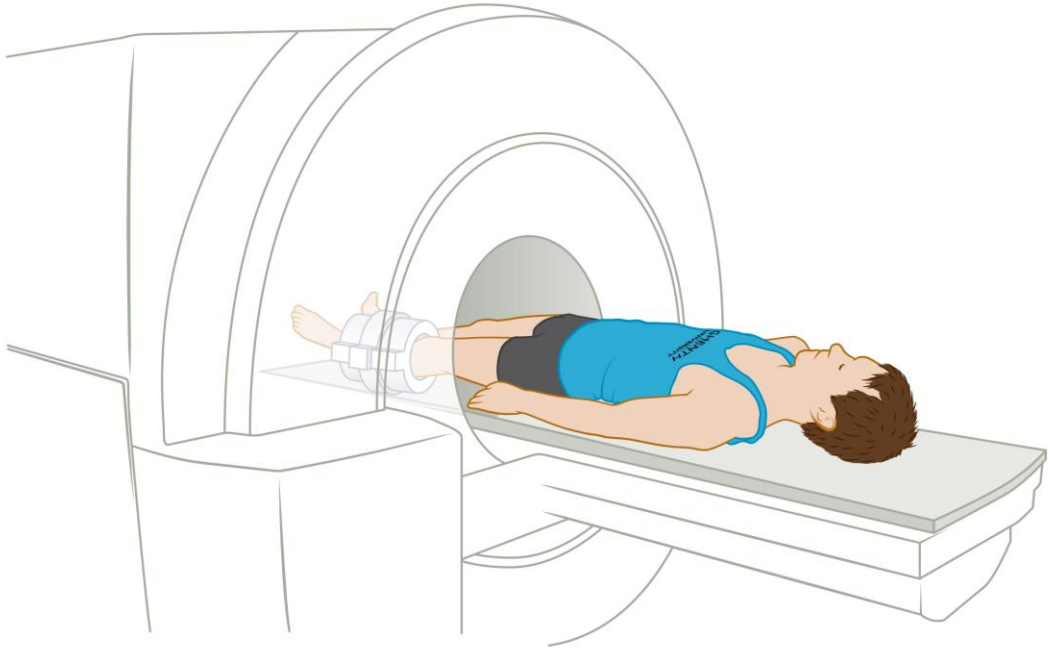
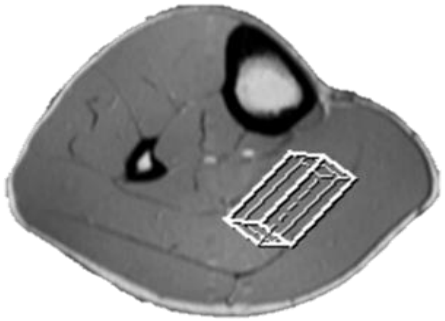
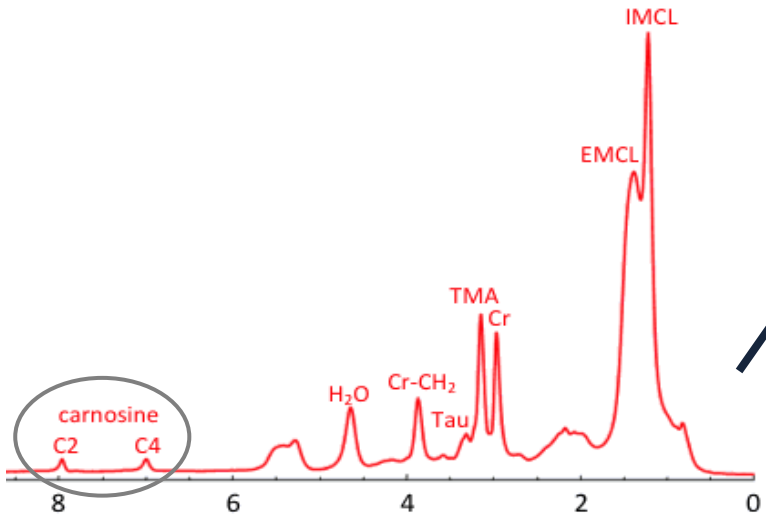
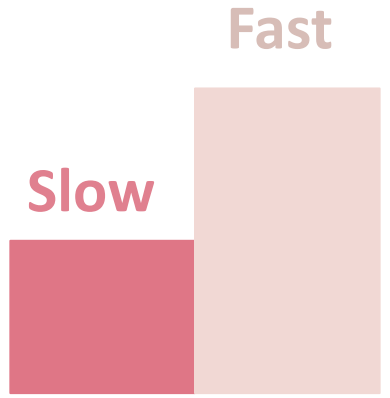




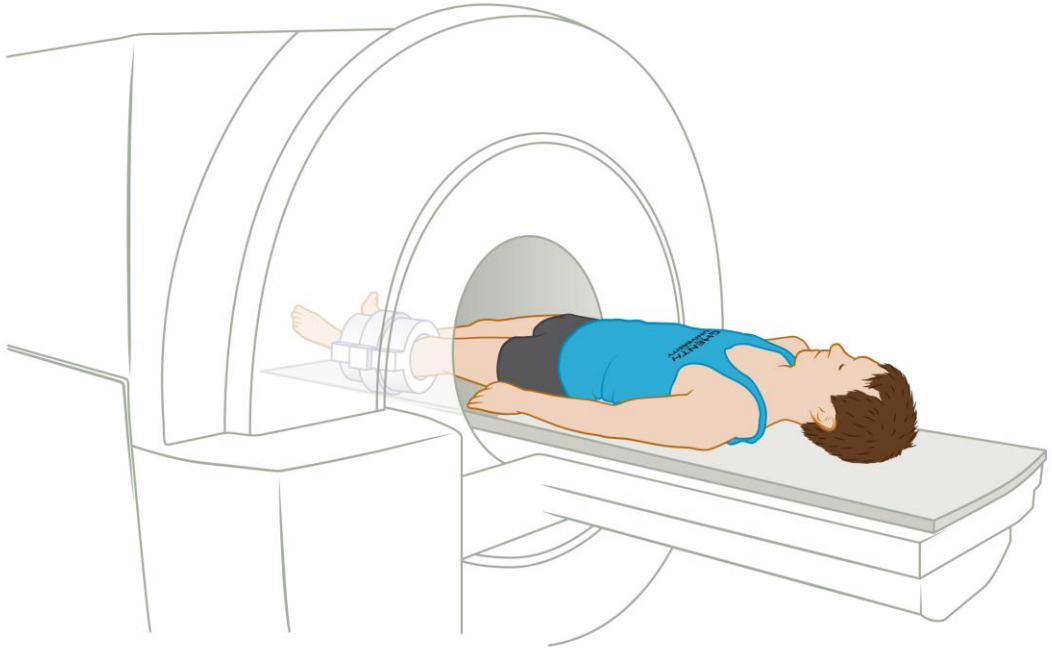




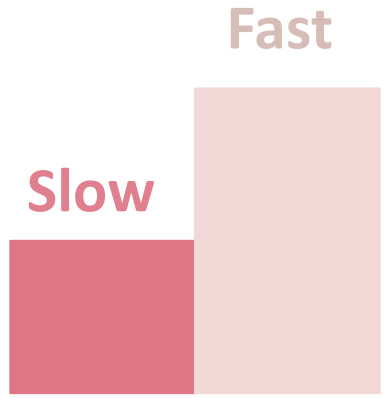
carnosine

(Harris, J Sport Sci, 1998)

2 Non-invasive method: ^{1}H-MRS of carnosine



(Baguet, PLoS One, 2011)



carnosine

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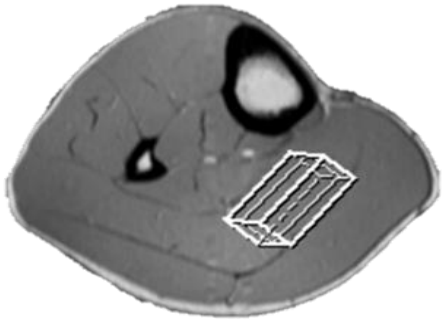
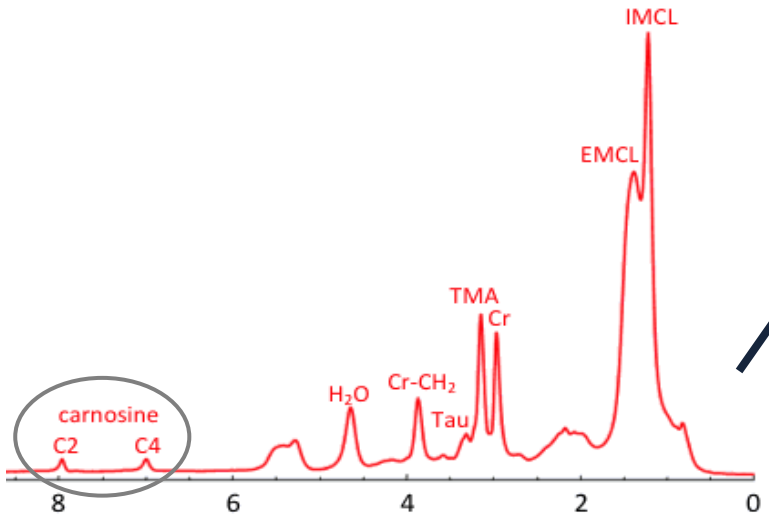
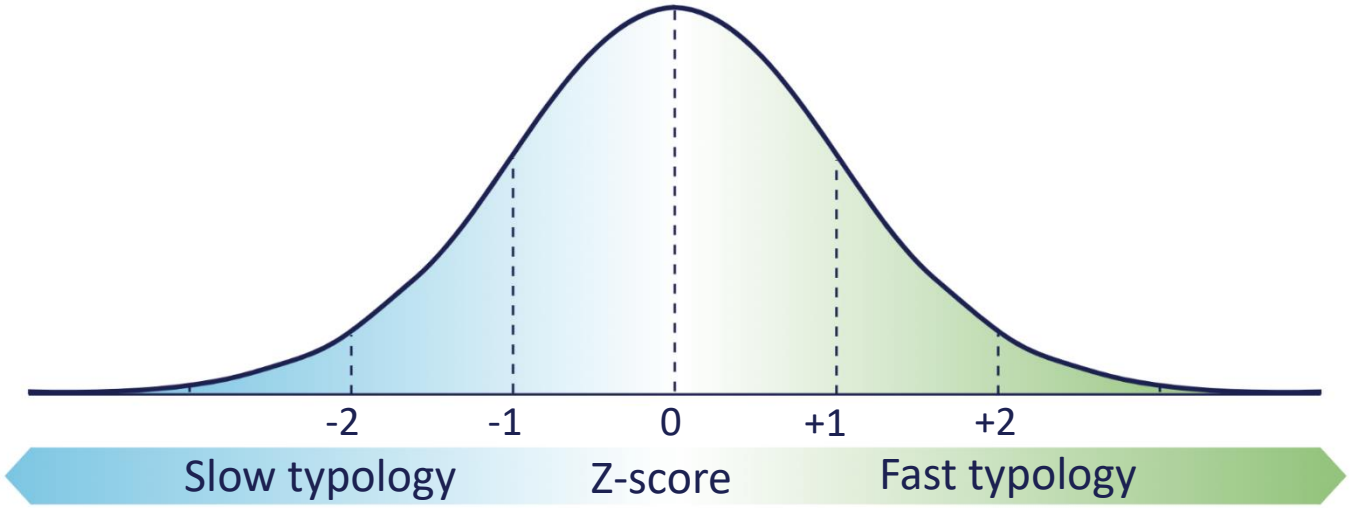


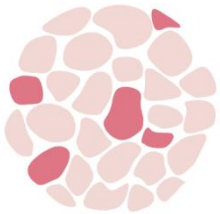


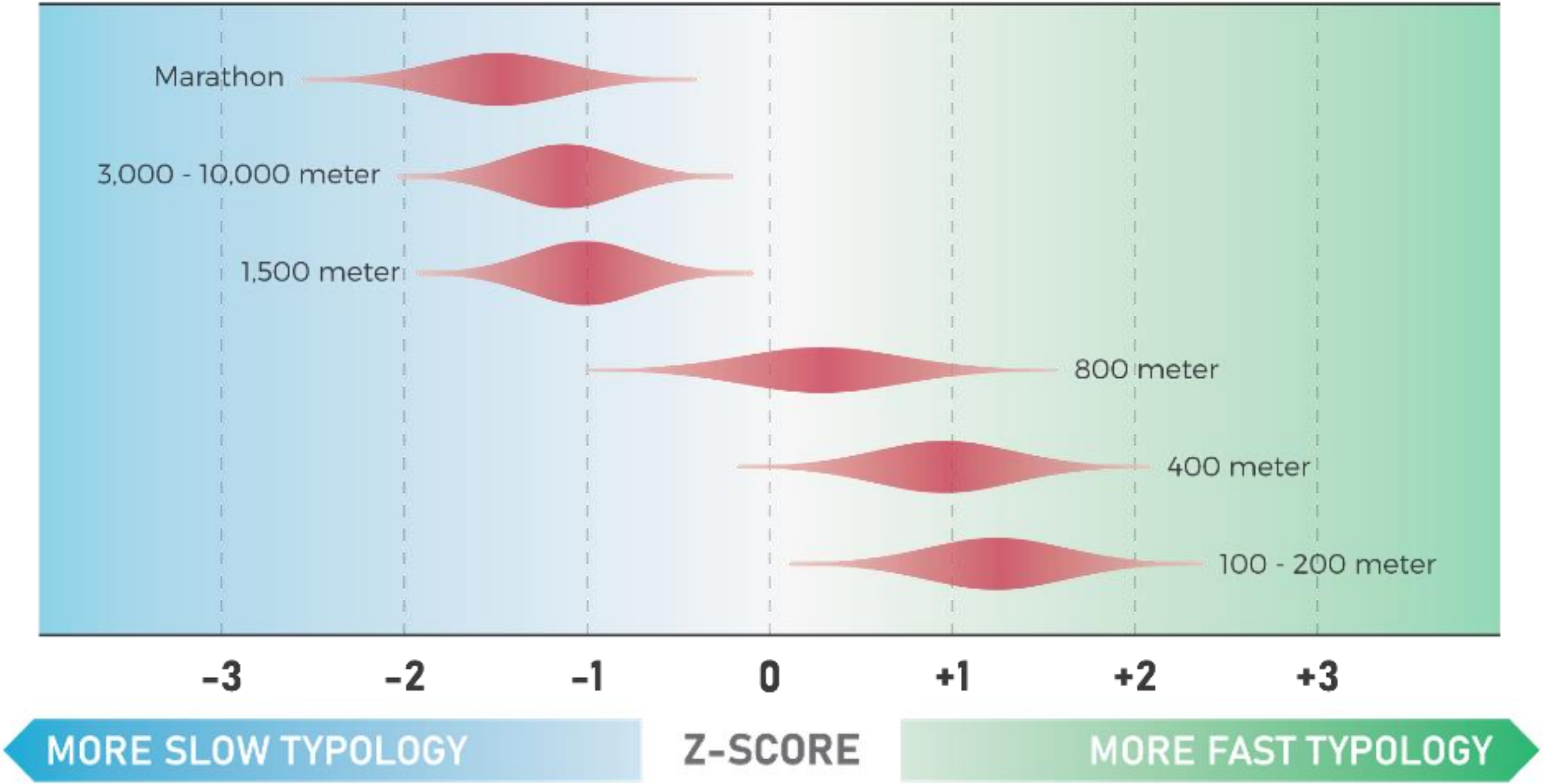
2 Non-invasive method: ^{1}H-MRS of carnosine

112 women

163 men







(Baguet, PLoS One, 2011)

PART I

Muscle physiology

PART II

Methodology

PART III

Relevance for cycling

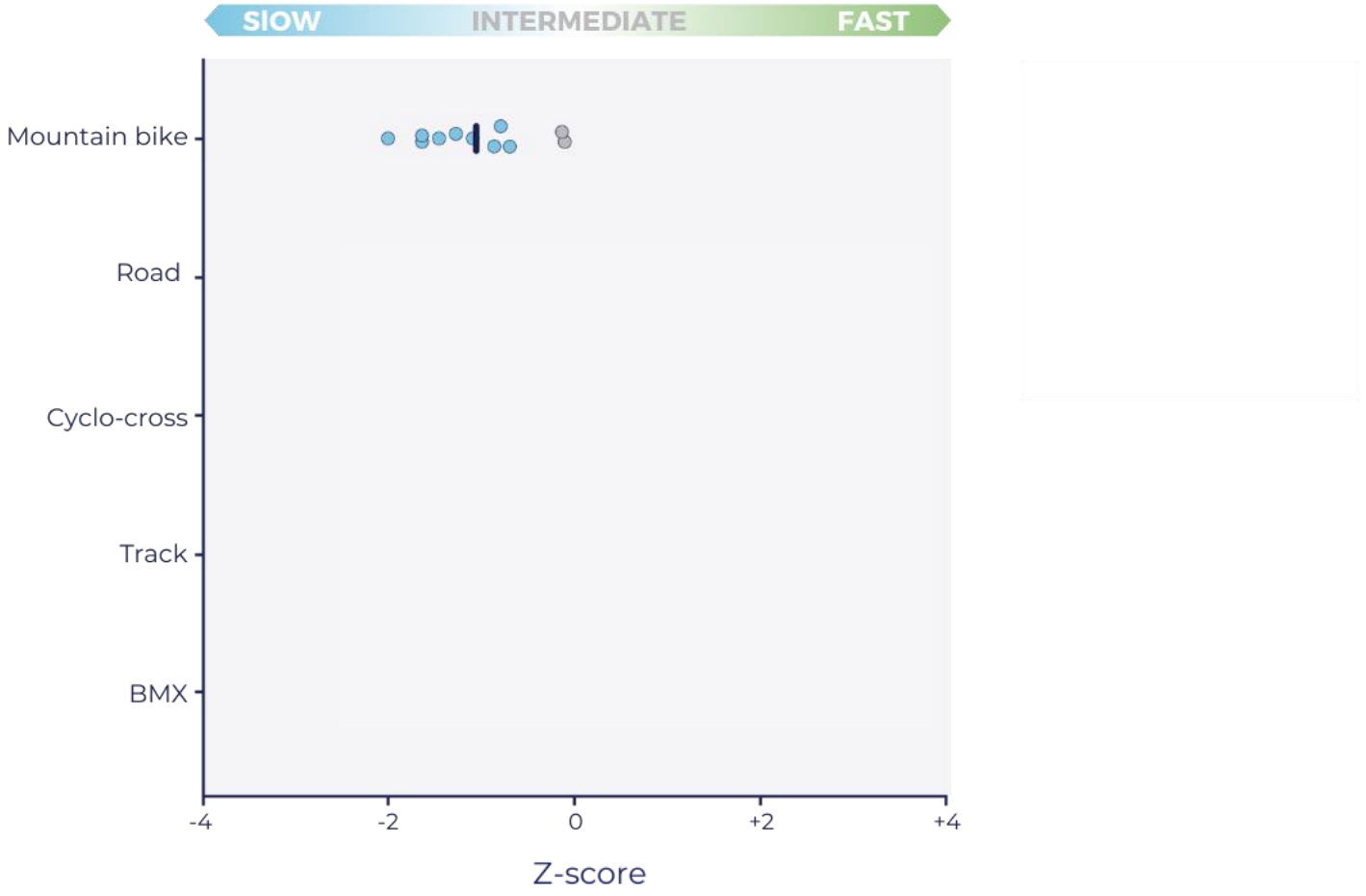
1 Can I discover talent in cycling?

80

BMX	Track	Road	MTB	Cyclo-cross
				
4	33	24	11	8

4 Olympic medalists
24 World medalists

1 Can I discover talent in cycling?



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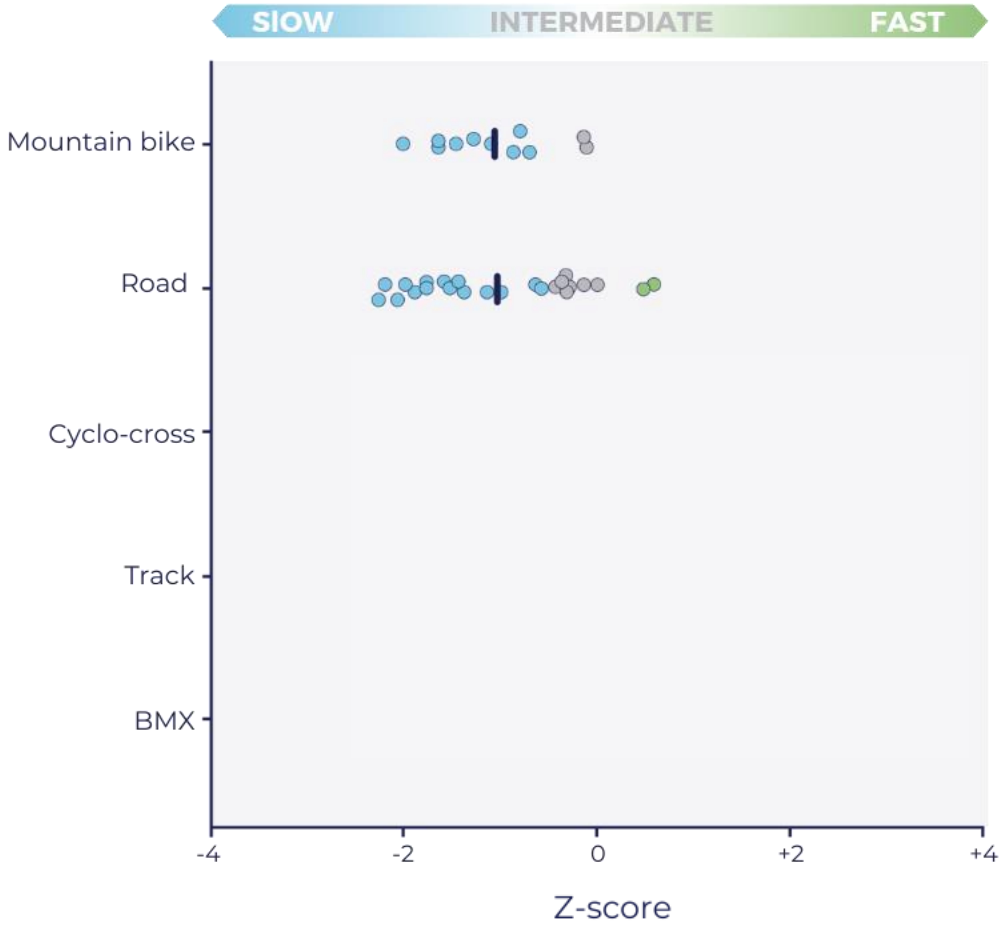

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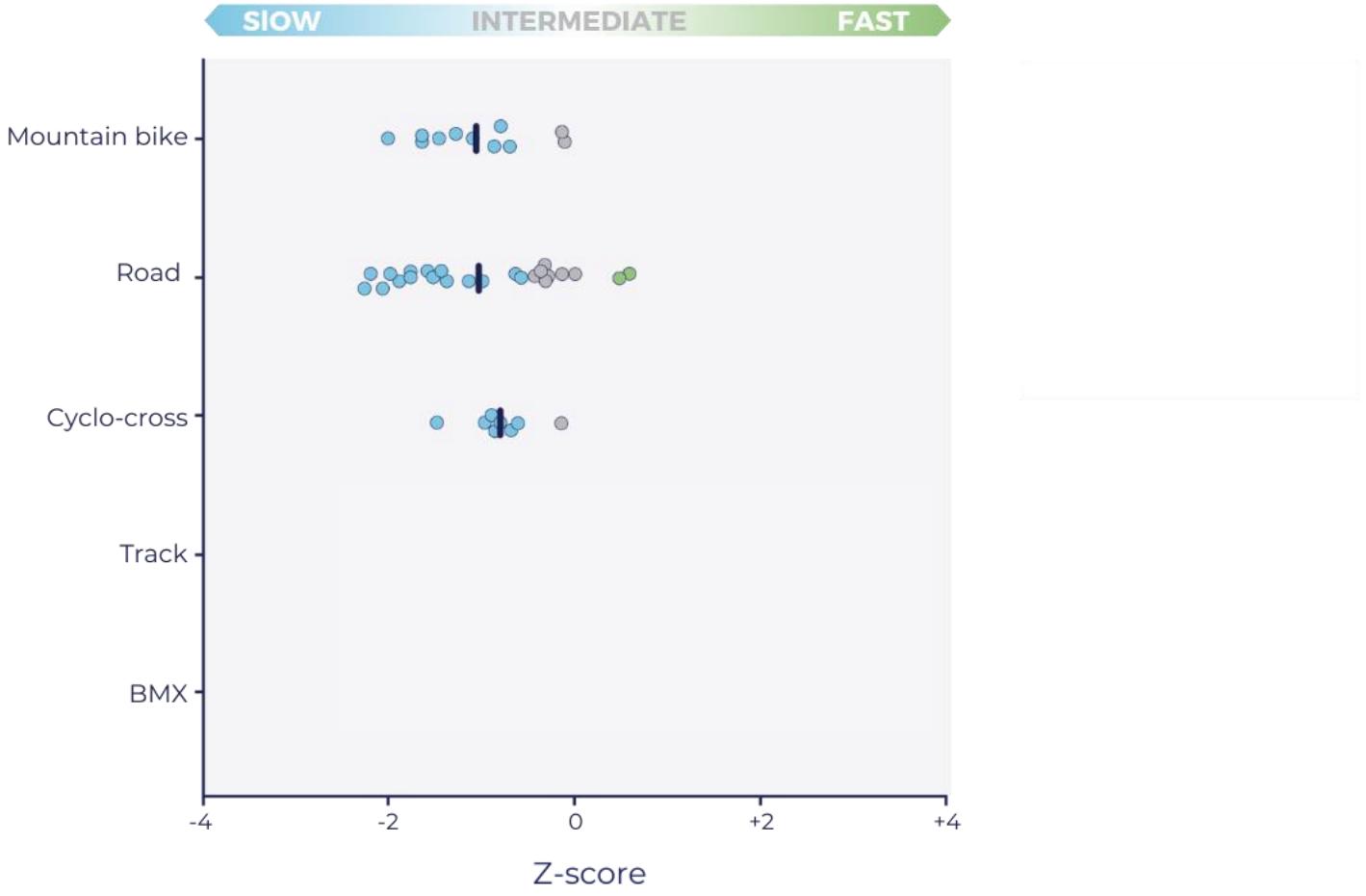

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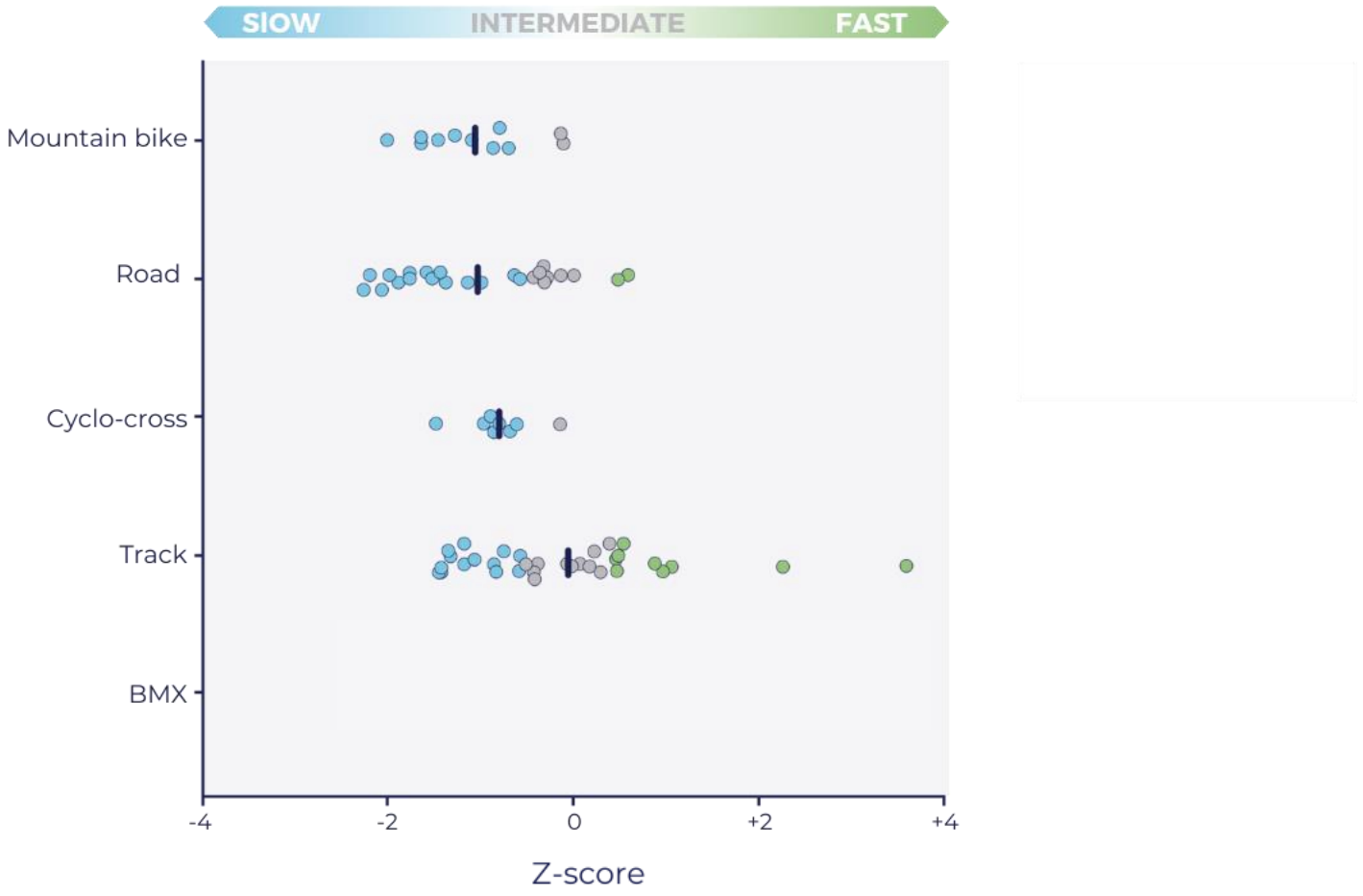

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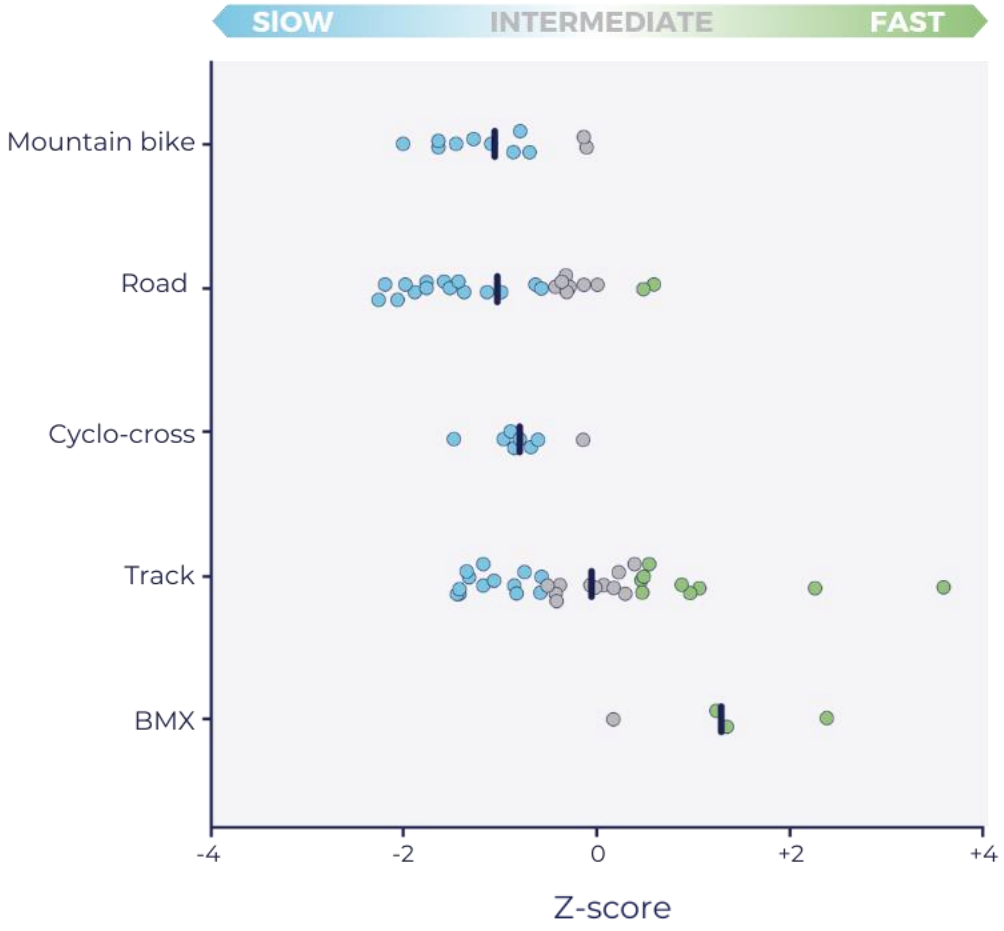

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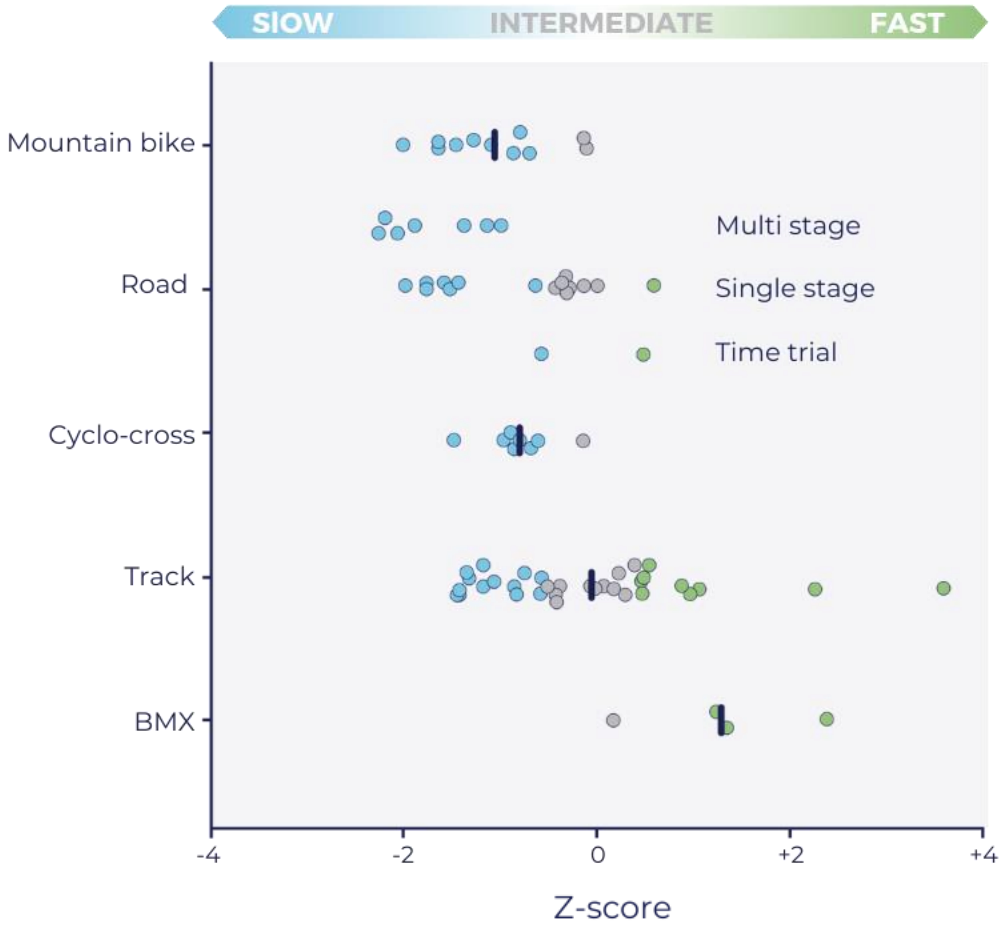

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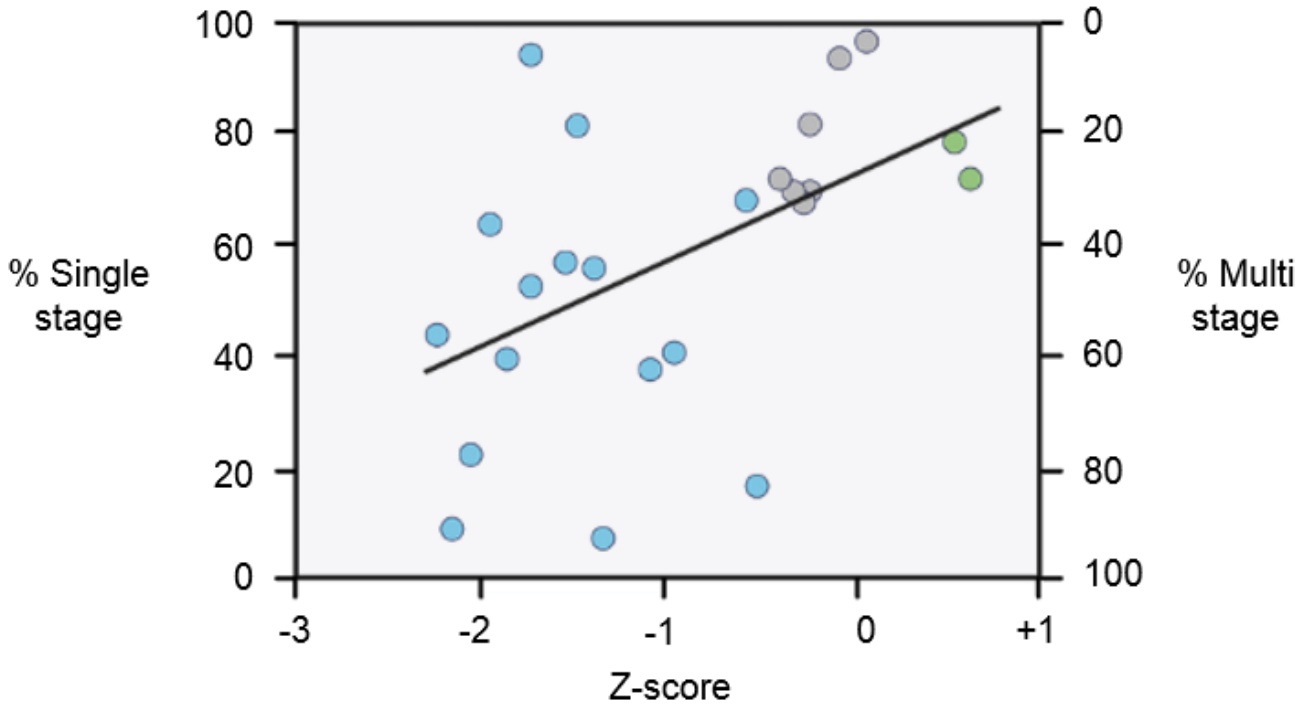
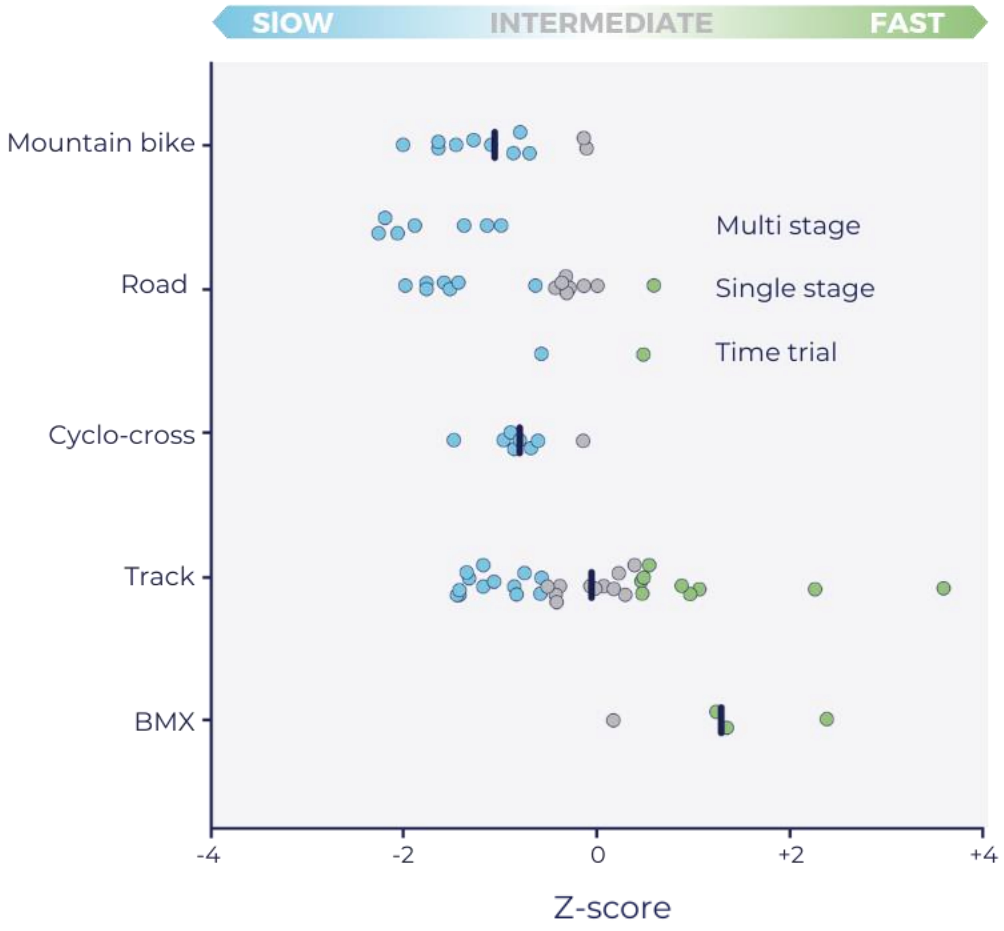
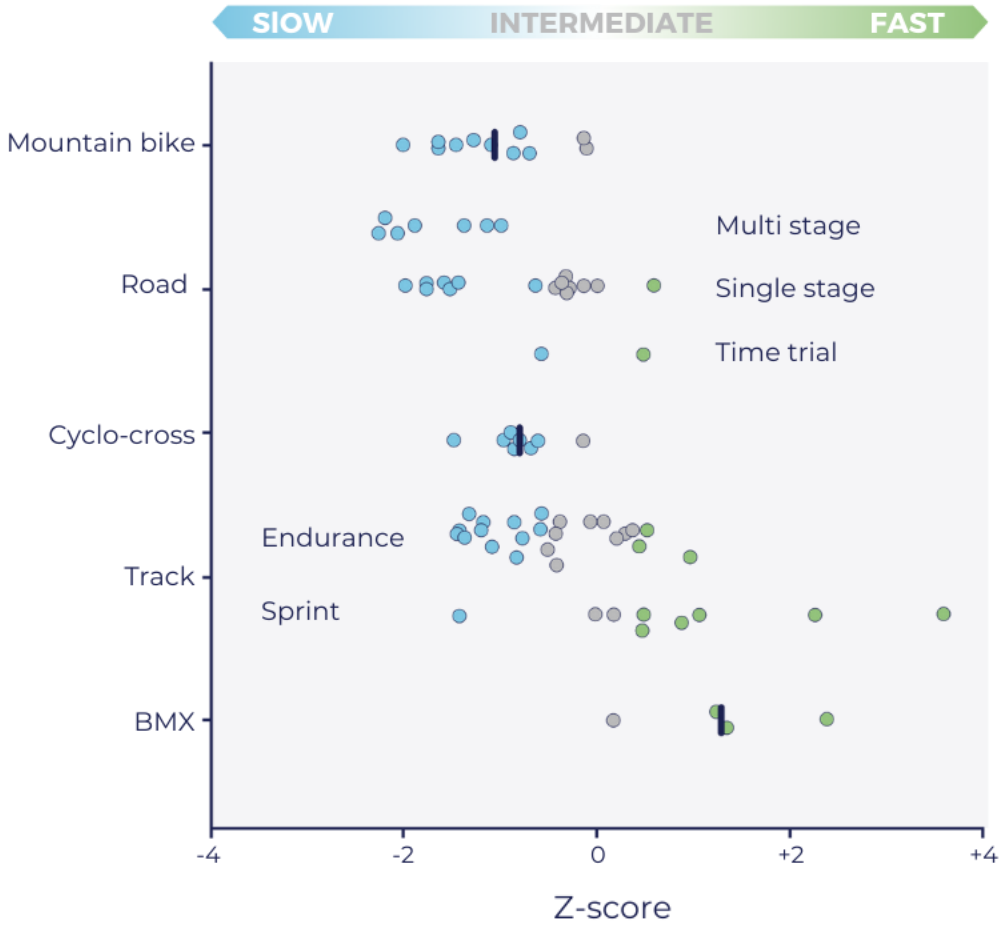


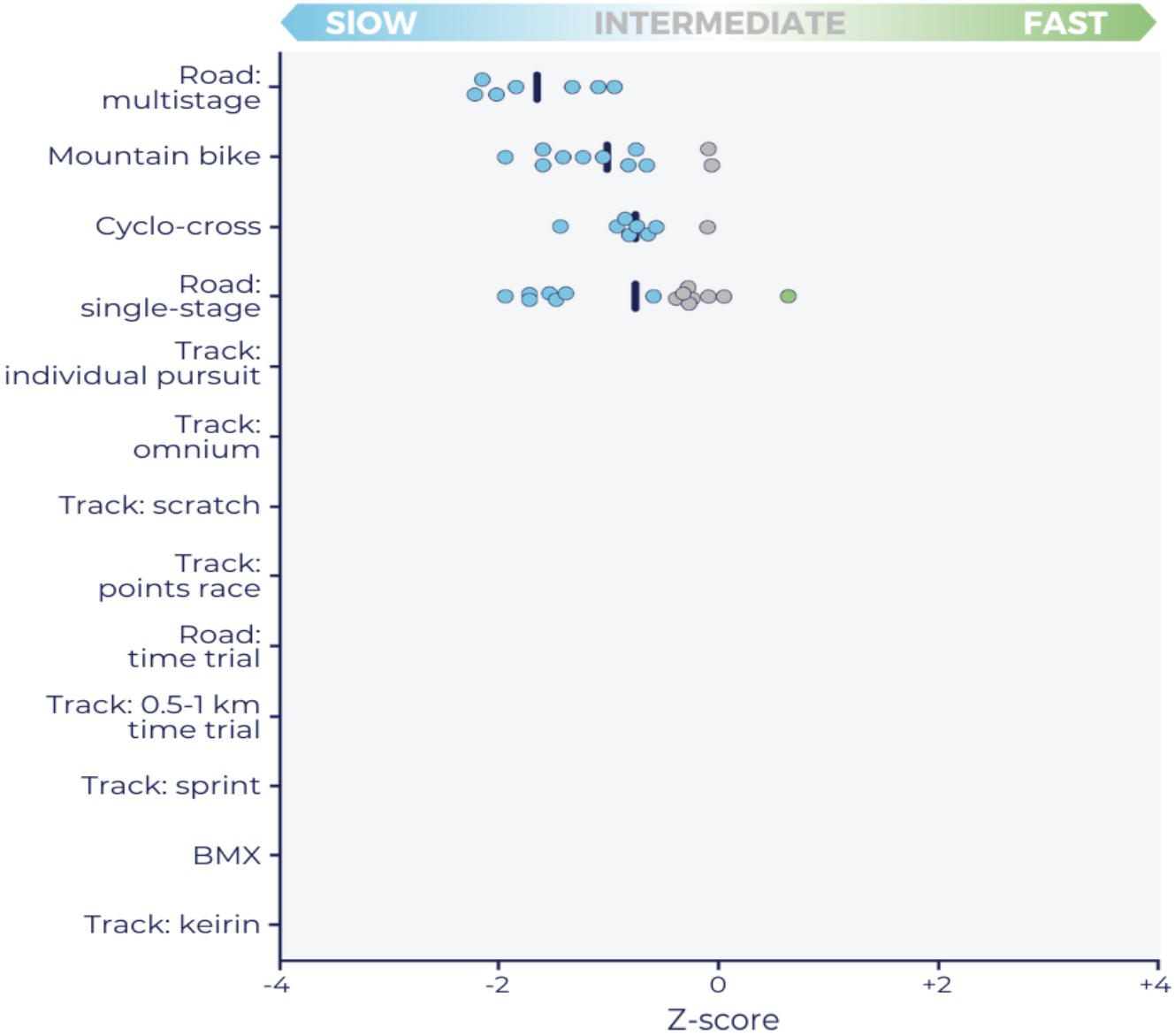
1 Can I discover talent in cycling?



1 Can I discover talent in cycling?



1 Can I discover talent in cycling?



More efficient

More resistant to fatigue

(Lievens & Bellinger, MSSE, 2021)

1 Can I discover talent in cycling?

More efficient

More resistant to fatigue

(Lievens & Bellinger, MSSE, 2021)

1 Can I discover talent in cycling?

More efficient

More resistant to fatigue

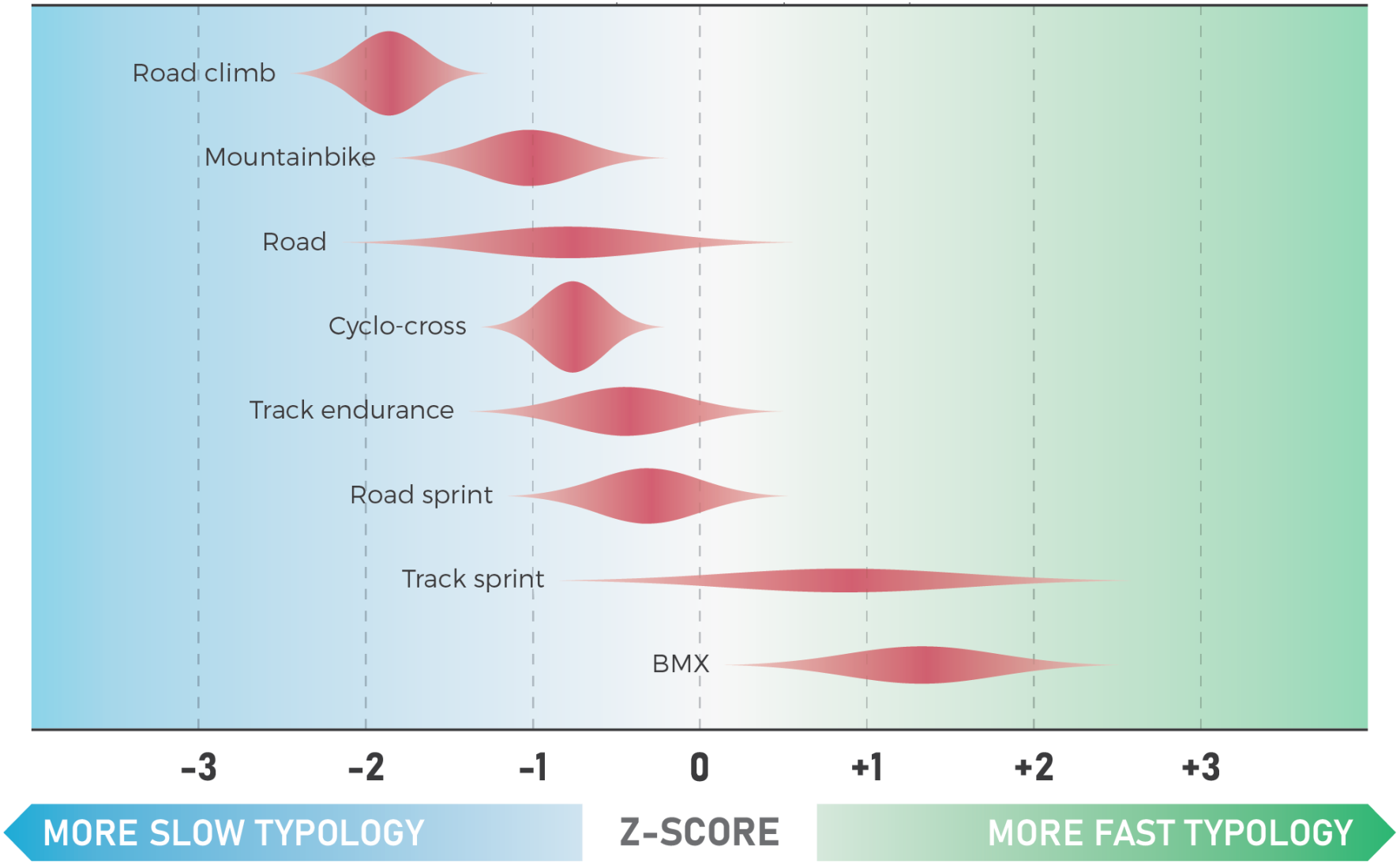
Generate power

High movement frequencies

(Lievens & Bellinger, MSSE, 2021)

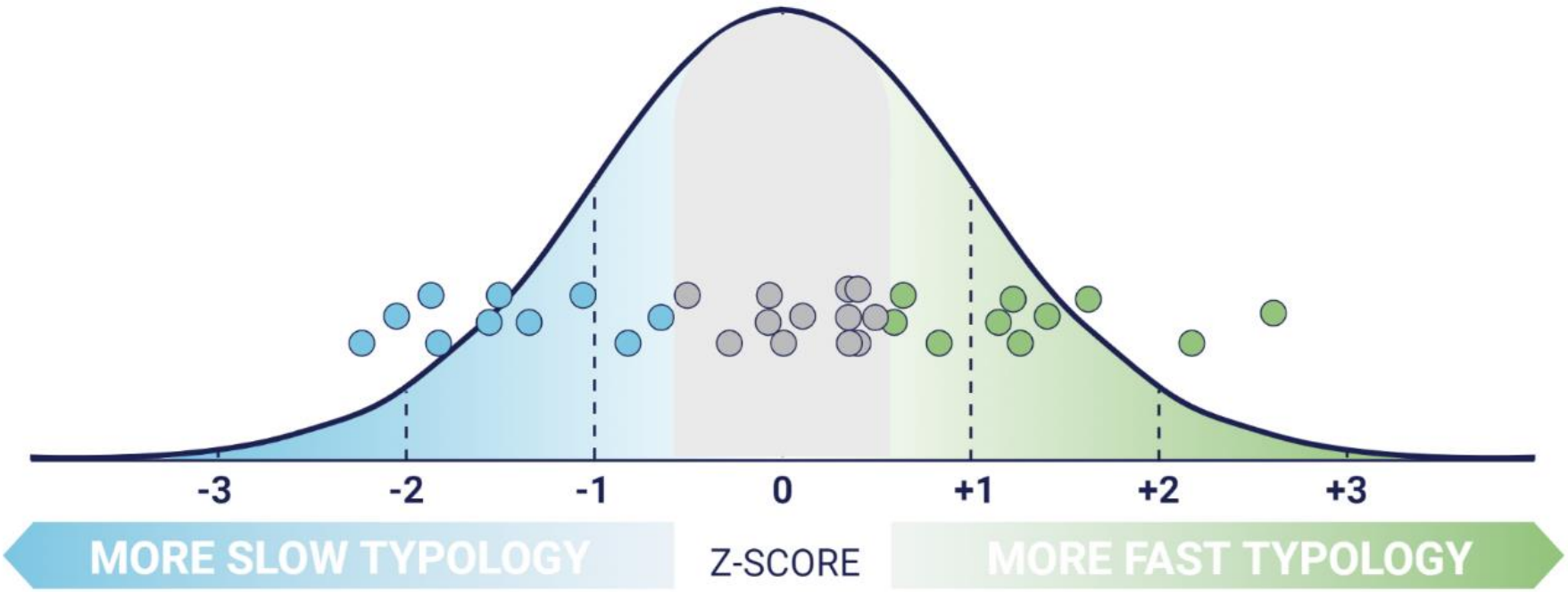
2 Relevance for elite cyclists?

2 Talent transfer



2 Can I adapt my training program?

- **Single training session**



Lievens et al., JAP, 2021

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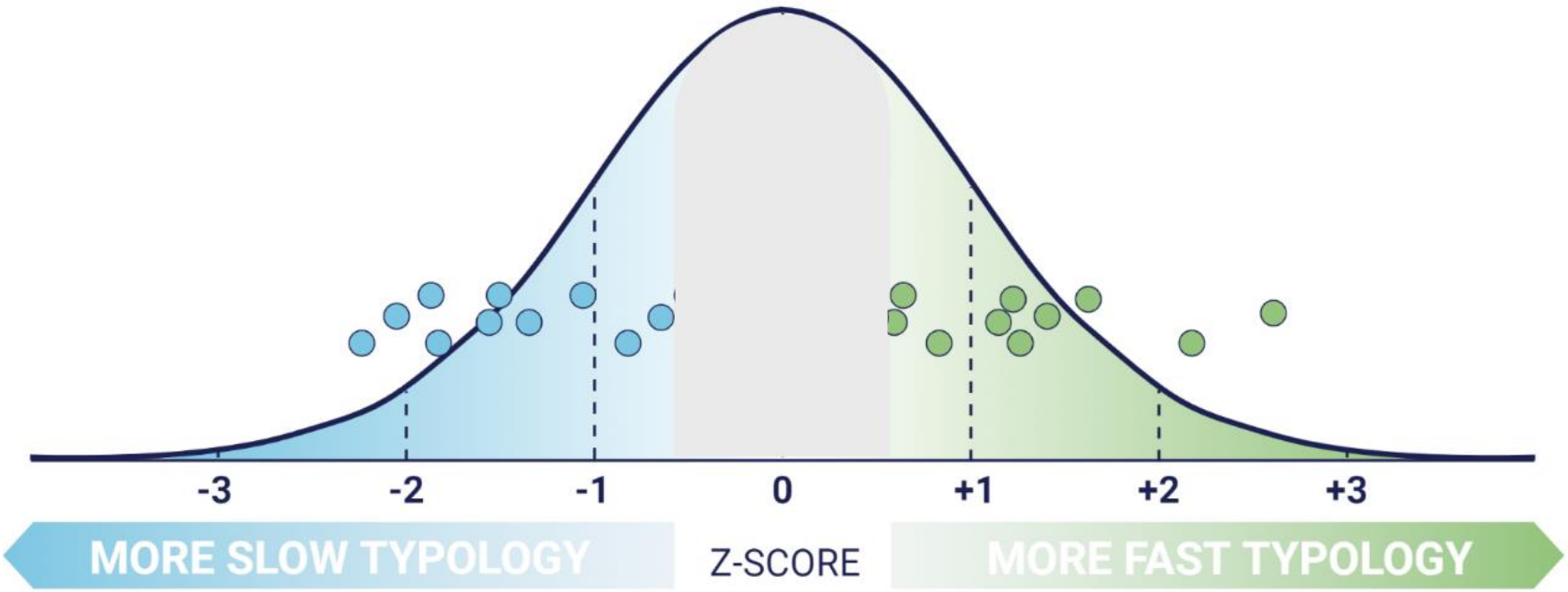

Lievens et al., JAP, 2021

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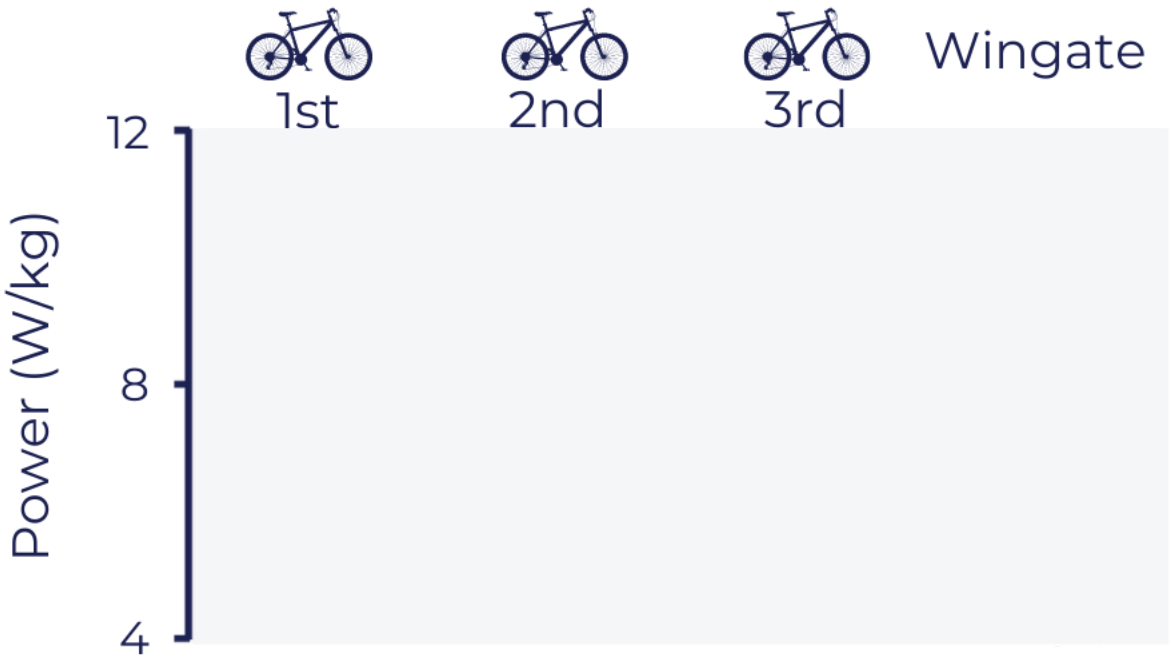


Lievens et al., JAP, 2021

2 Can I adapt my training program?

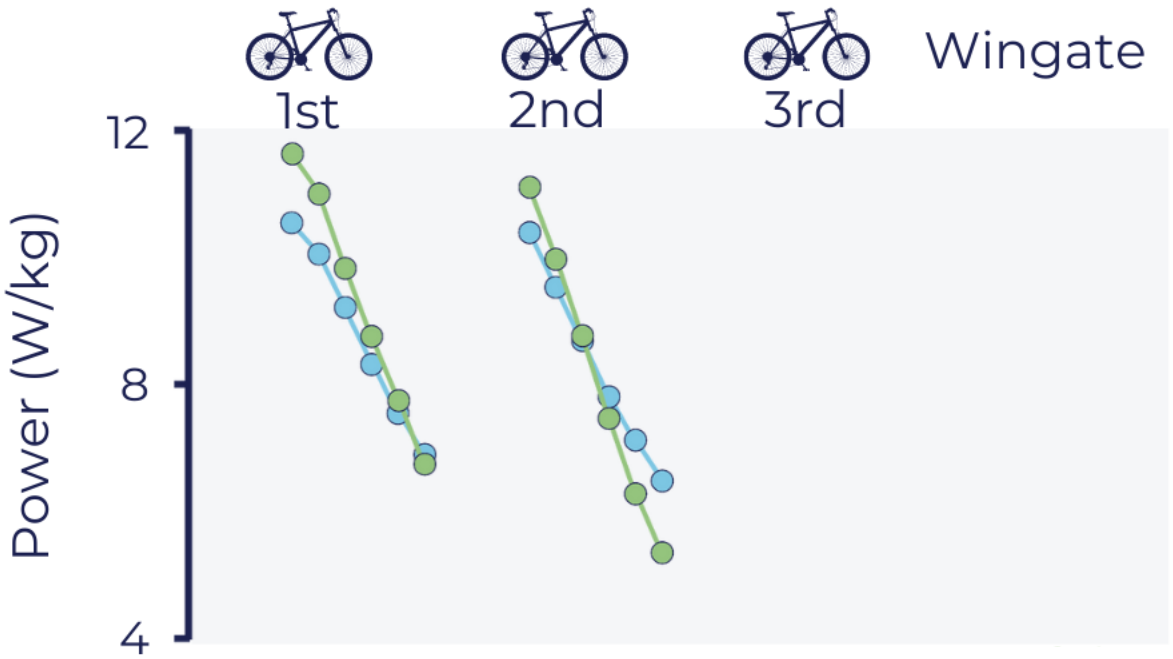
- **Single training session**

- Slow typology
- Fast typology

Lievens et al., JAP, 2021

2 Can I adapt my training program?

- **Single training session**

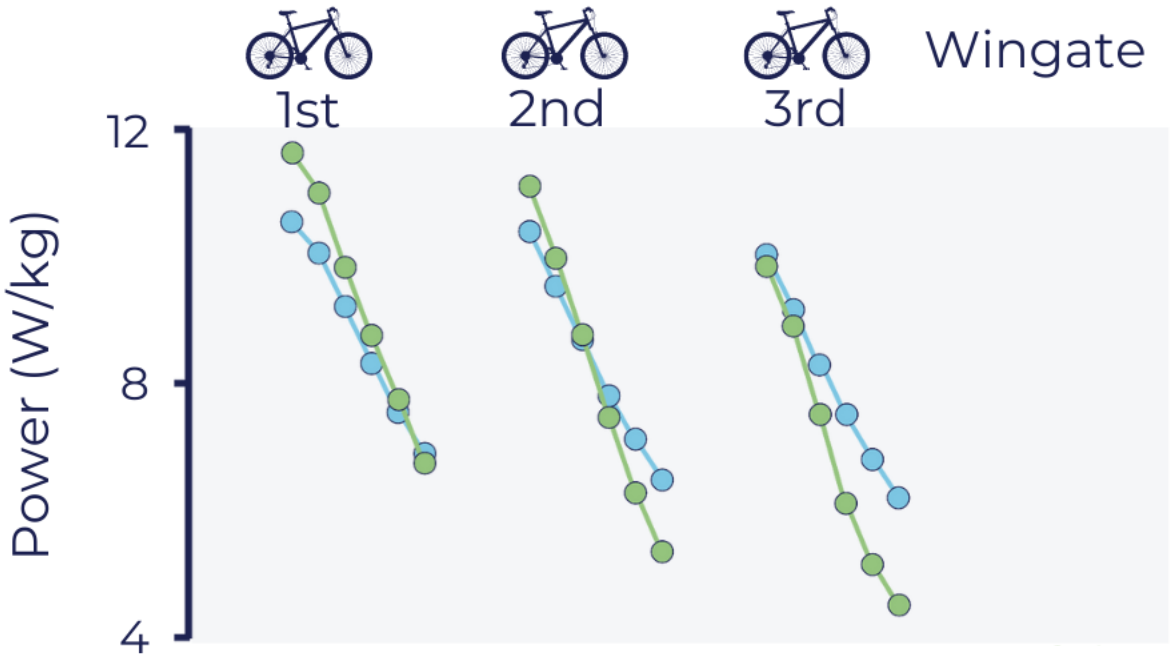


- Slow typology
- Fast typology

Lievens et al., JAP, 2021

2 Can I adapt my training program?

- **Single training session**



- Slow typology
- Fast typology

Lievens et al., JAP, 2021

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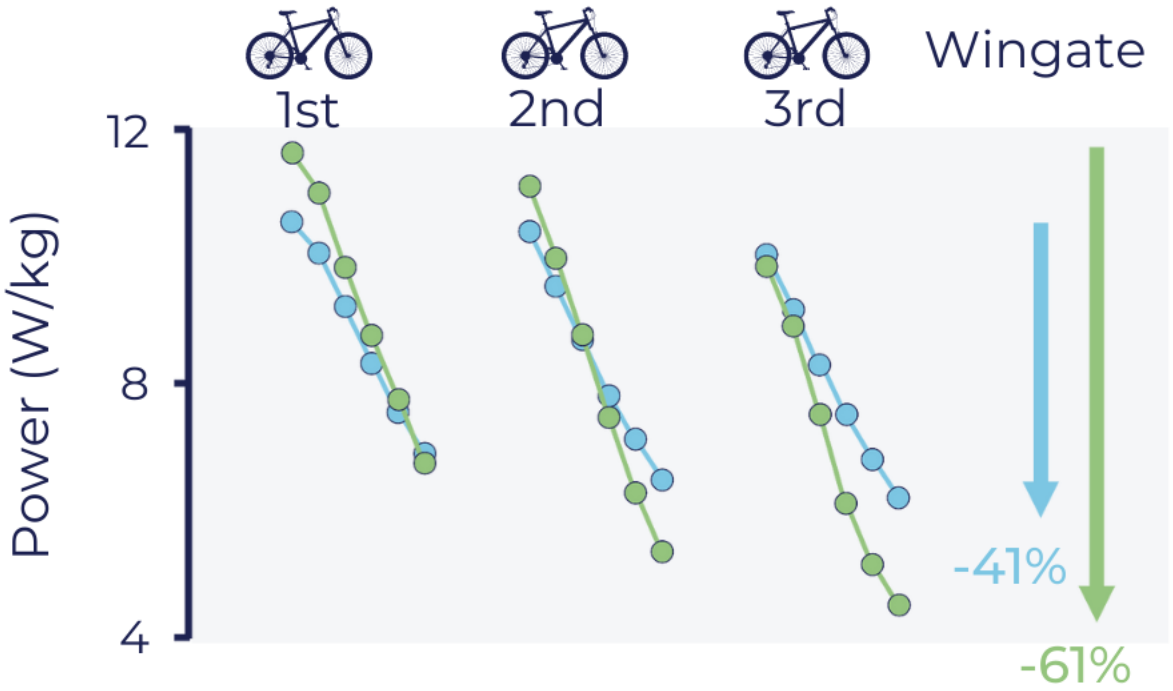

Lievens et al., JAP, 2021

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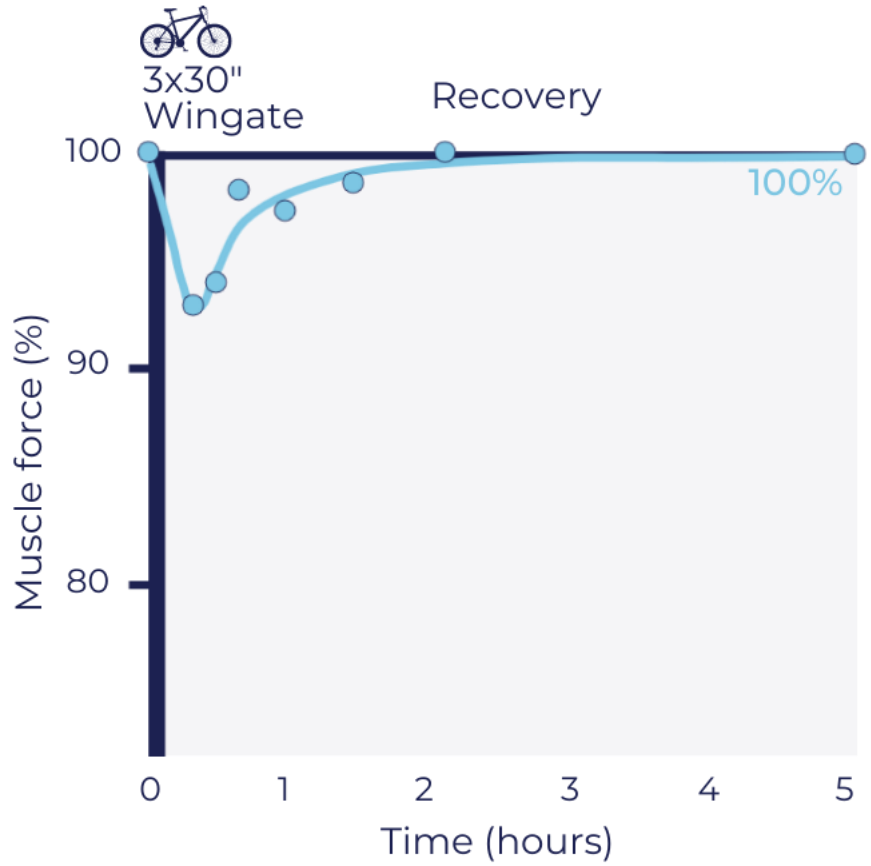
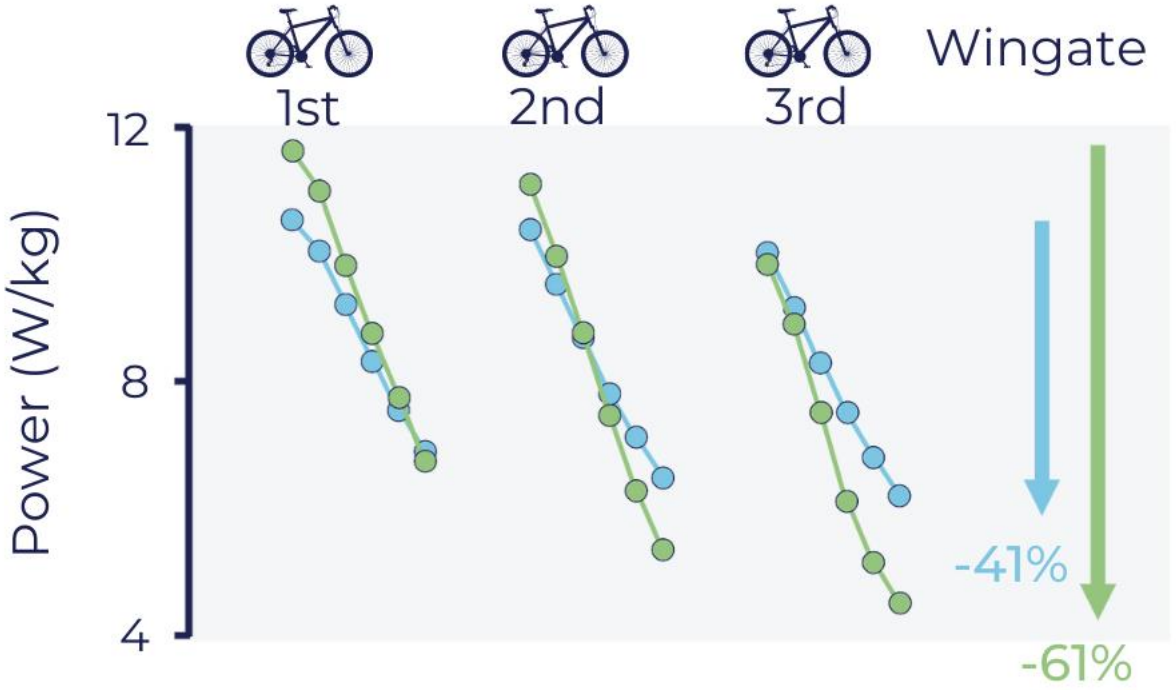


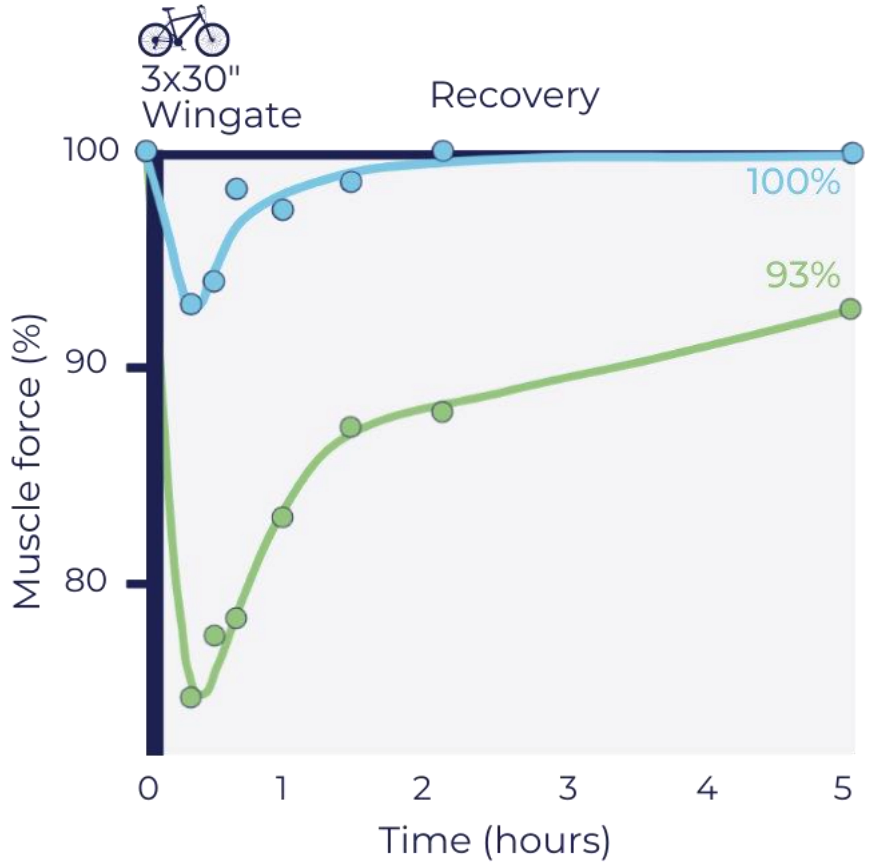
(Lievens et al., JAP, 2021)

2 Can I adapt my training program?

- **Single training session**



- Slow typology
- Fast typology



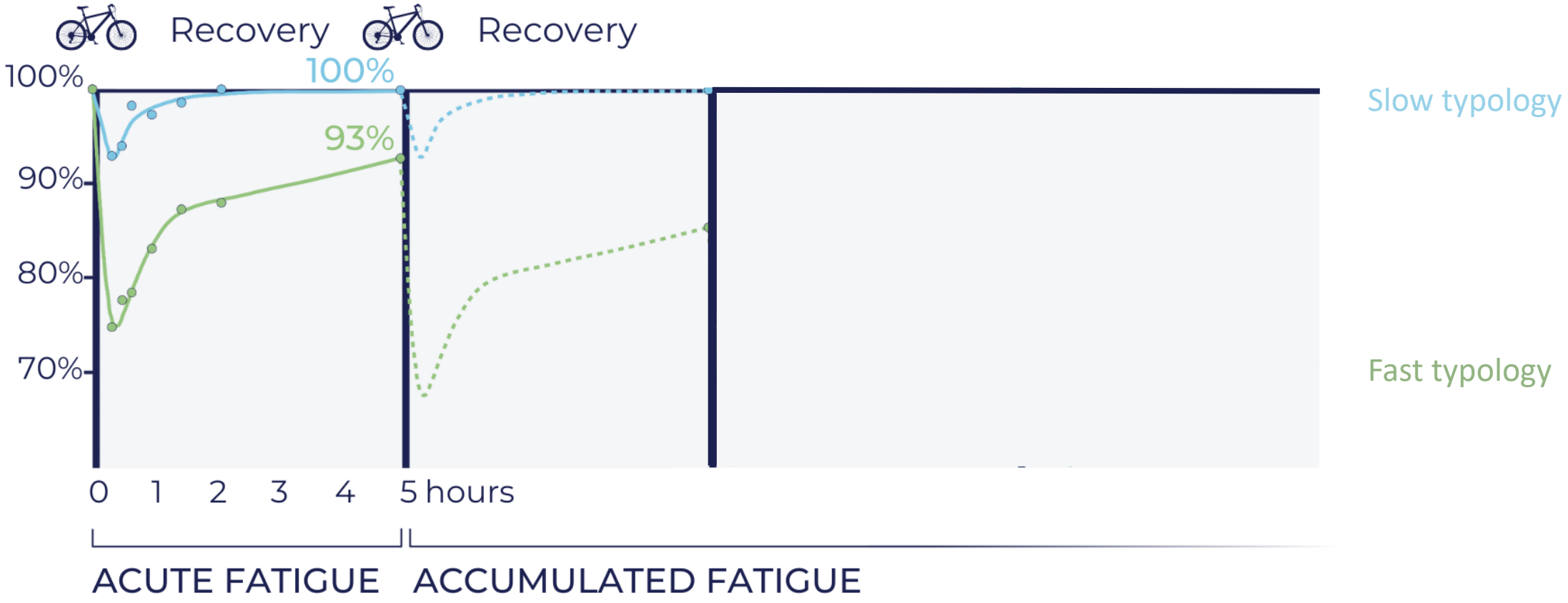
(Lievens et al., JAP, 2021)

2 Can I adapt my training program?

- **Multiple training sessions**

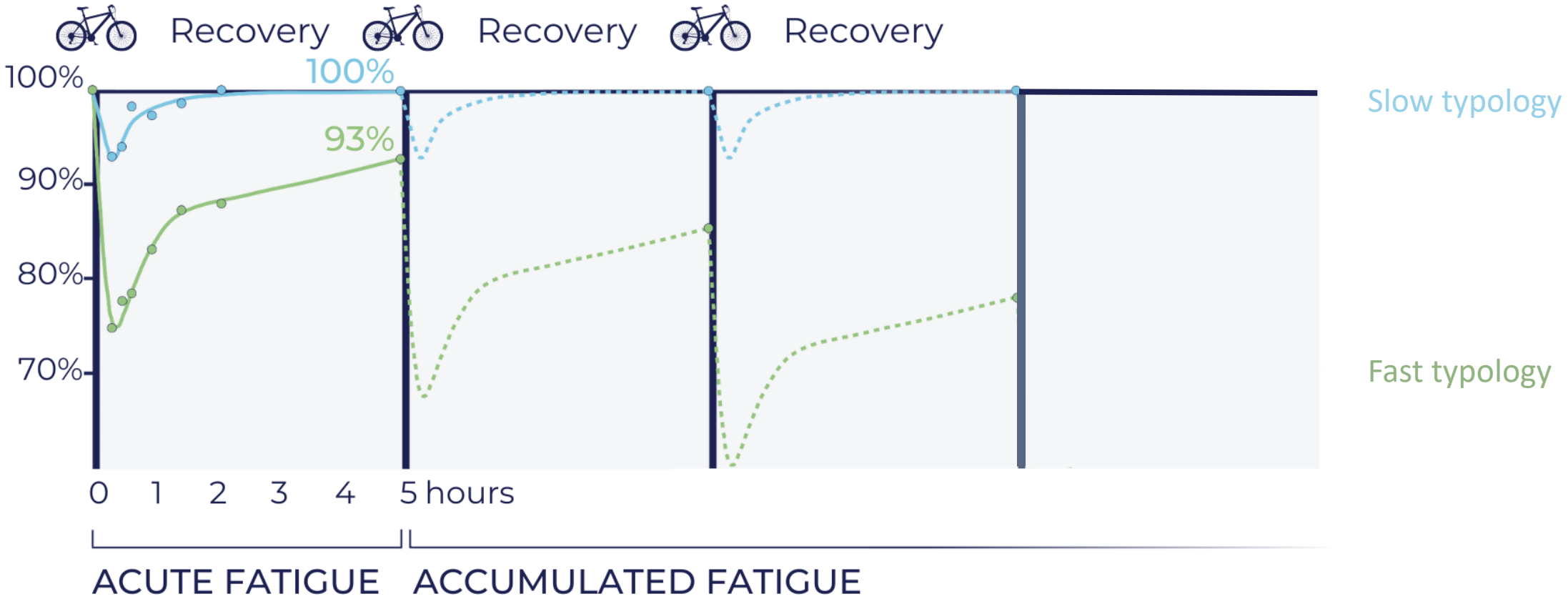
2 Can I adapt my training program?

- **Multiple training sessions**



2 Can I adapt my training program?

- **Multiple training sessions**



2 Can I adapt my training program?

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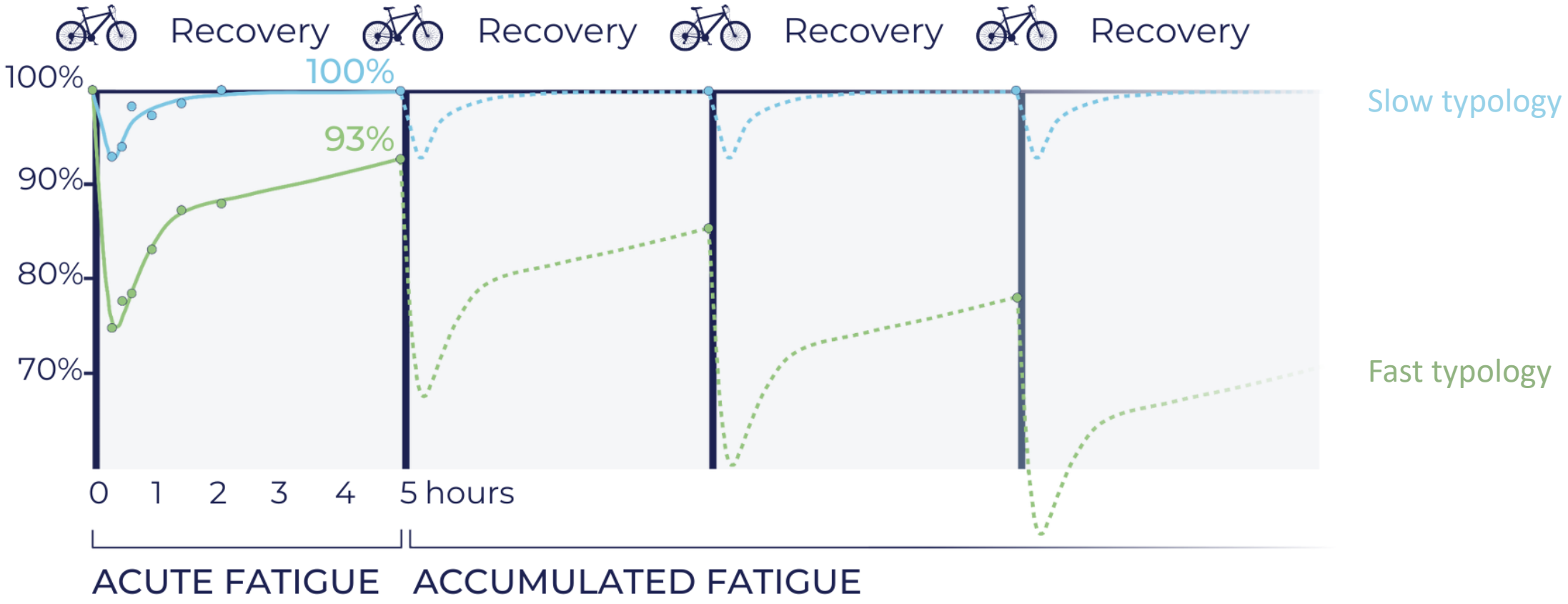

(Bellinger et al., JAP, 2021)

2 Can I adapt my training program?

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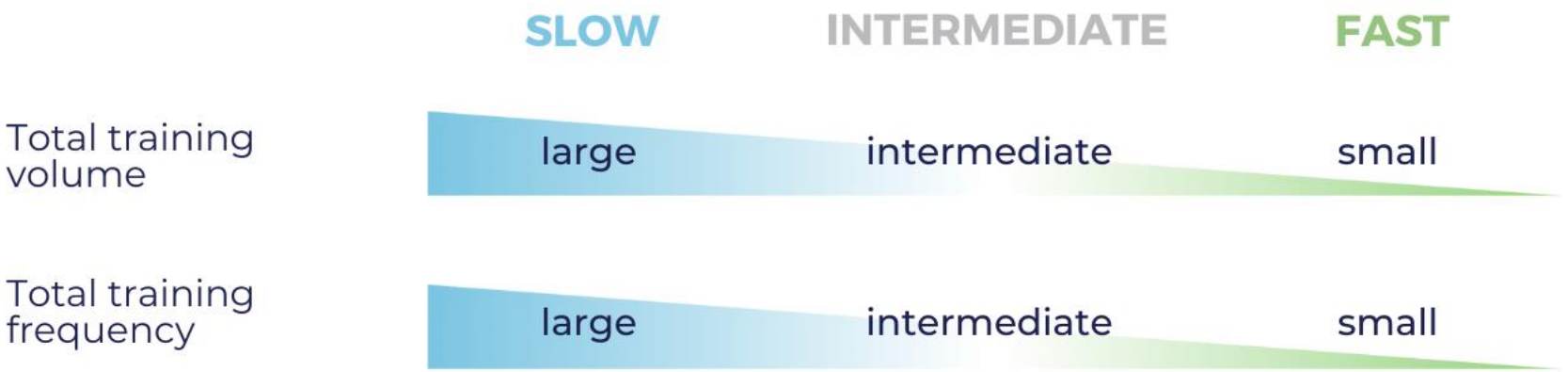

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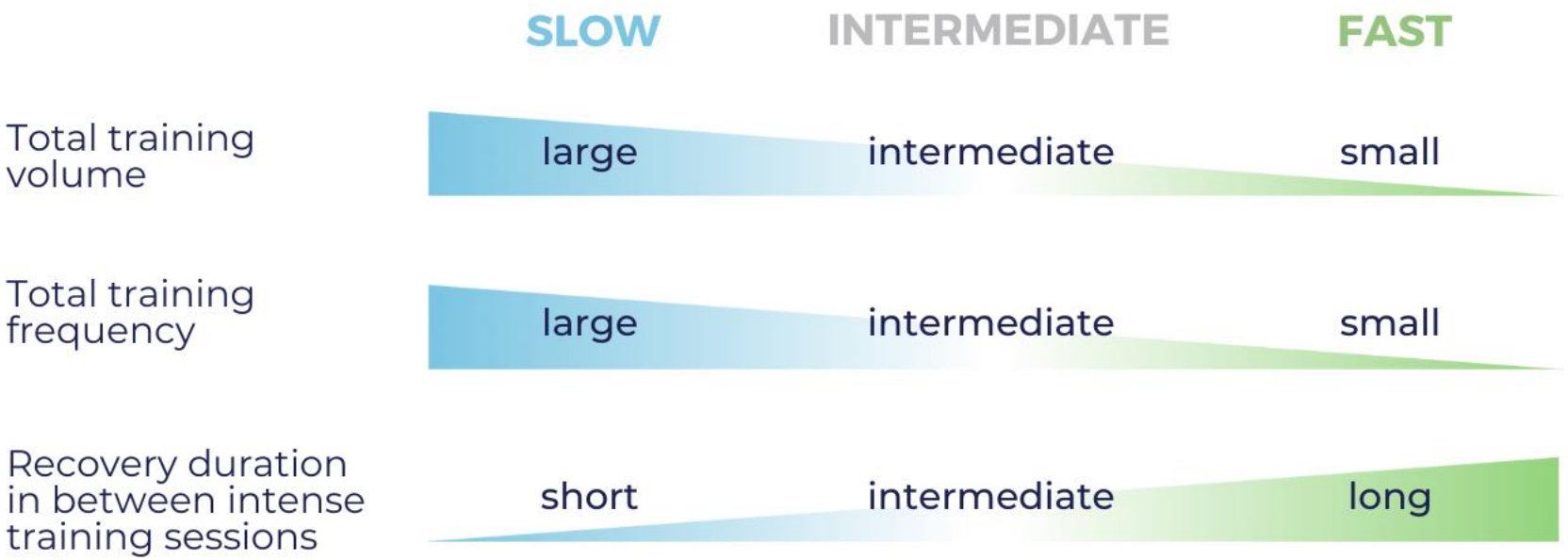


PART I

Muscle physiology

PART II

Methodology

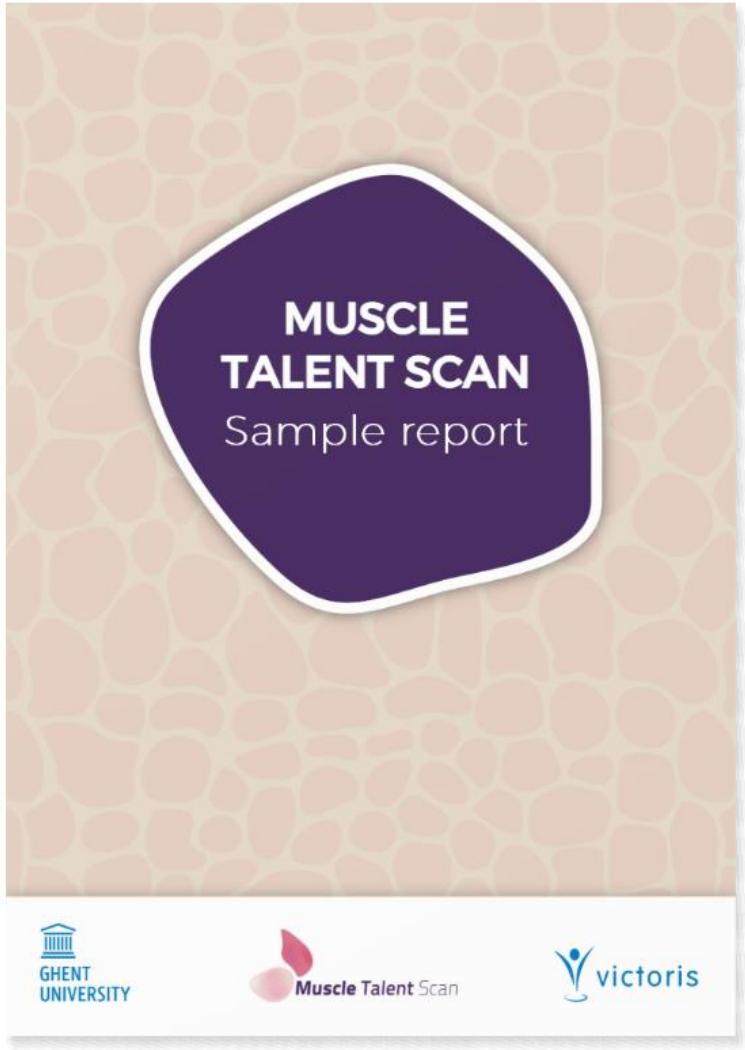
PART III

Relevance for cycling

PART IV

Interested?

1 Can I scan my athletes?



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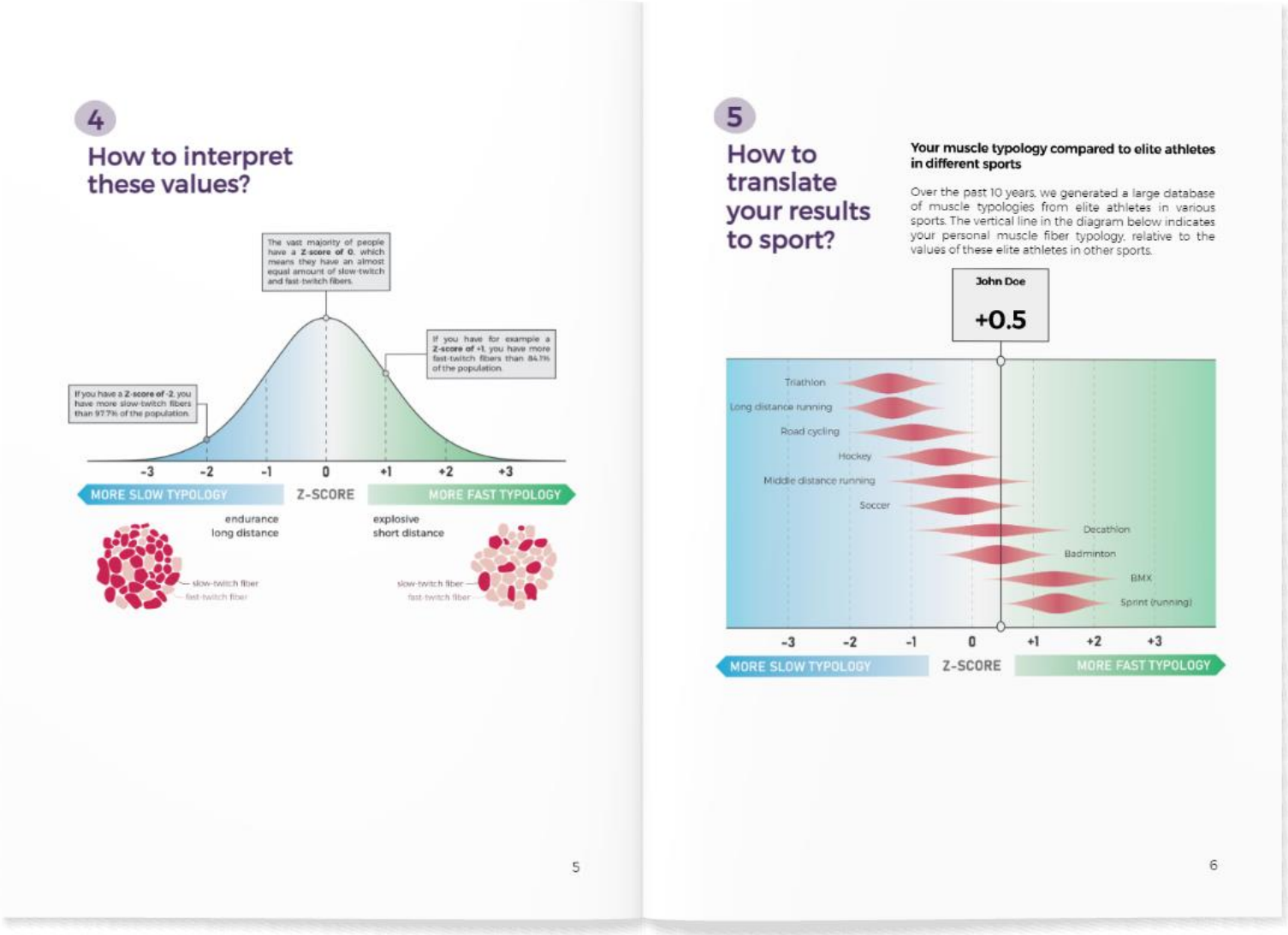


4

How to interpret these values?

The vast majority of people have a **Z-score of 0**, which means they have an almost equal amount of slow-twitch and fast-twitch fibers.

If you have for example a **Z-score of +1**, you have more fast-twitch fibers than 84.1% of the population.

If you have a **Z-score of -2**, you have more slow-twitch fibers than 97.7% of the population.

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

MORE SLOW TYPOLOGY | Z-SCORE | MORE FAST TYPOLOGY

endurance
long distance

explosive
short distance

slow-twitch fiber
fast-twitch fiber

5

6

How to translate your results to sport?

Your muscle typology compared to elite athletes in different sports

Over the past 10 years, we generated a large database of muscle typologies from elite athletes in various sports. The vertical line in the diagram below indicates your personal muscle fiber typology, relative to the values of these elite athletes in other sports.

John Doe
+0.5

Triathlon
Long distance running
Road cycling
Hockey
Middle distance running
Soccer
Decathlon
Badminton
BMX
Sprint (running)

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

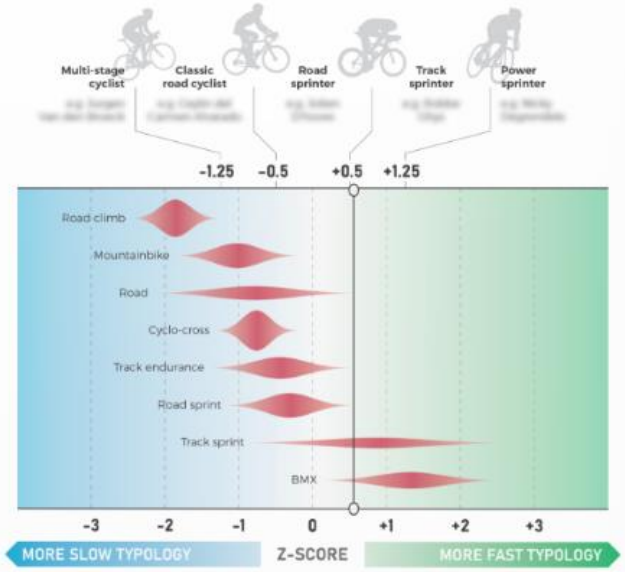
MORE SLOW TYPOLOGY | Z-SCORE | MORE FAST TYPOLOGY

1 Can I scan my athletes?

Your muscle typology compared to elite athletes in cycling

Below you can compare your own score to the elite athletes from the different disciplines within cycling. At the moment we haven't scanned a lot of cyclo-cross riders. Based on the comparison with our database, your ideal other discipline in cycling would be:

Track Sprint



Lievens et al. (2020). Muscle Typology of World-Class Cyclists across Various Disciplines and Events. *Medicine and Science in Sports and Exercise*

6

How can this information help to individualize training?

When three athletes with divergent typologies would be exposed to exactly the same training and recovery regime, they would each experience this very differently. If it is ideal for one athlete, it will not be ideal for the two others. It is therefore advised to take muscle typology into account as one of the parameters upon which to design individualized training and recovery cycles.

	SLOW TYPOLOGY (negative score)	INTERMEDIATE TYPOLOGY (score around 0)	FAST TYPOLOGY (positive score)
Total training volume (hours or kilometers per week)	large	intermediate	small
Recovery duration in between intense training sessions	short	intermediate	long
Recovery duration between intense exercises within training sessions[2]	short	intermediate	long

Whether certain types of training (threshold training, high-intensity interval training,...) are better suitable for certain muscle typologies, is currently unknown and is subject to further scientific research.

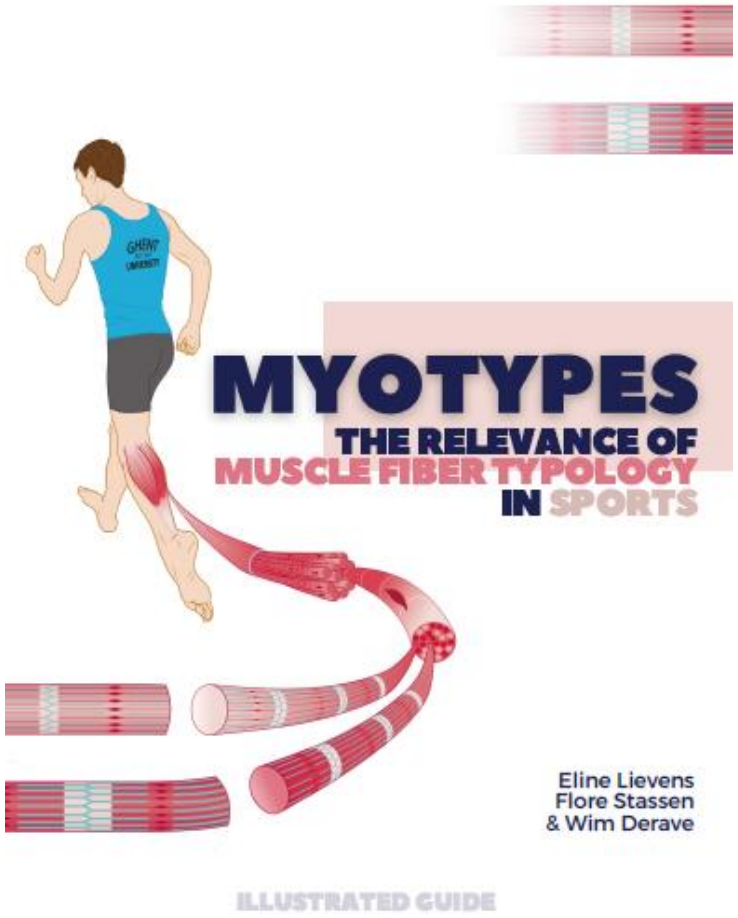
For more information contact
info@muscletalentscan.com

or

www.muscletalentscan.com

[2]Lievens, E. (2020). Muscle fiber typology substantially influences time to recover from high-intensity exercise. *Journal of Applied Physiology*

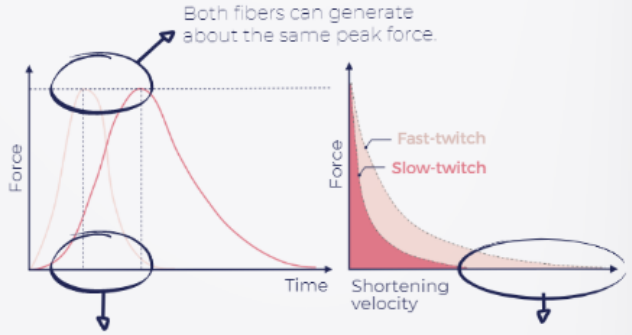
2 Want to know more?



2 Want to know more?

1 Fast-twitch fibers are faster

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



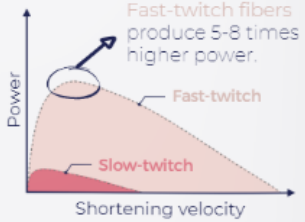
Fast-twitch fibers build up force much faster than slow-twitch fibers (40ms vs. 90ms).

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

Power = force x speed

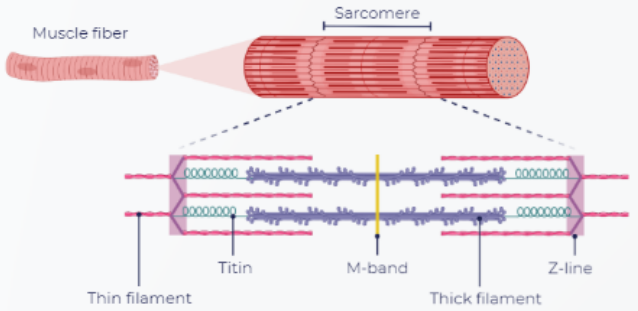
Fast-twitch = slow-twitch

Fast-twitch > slow-twitch

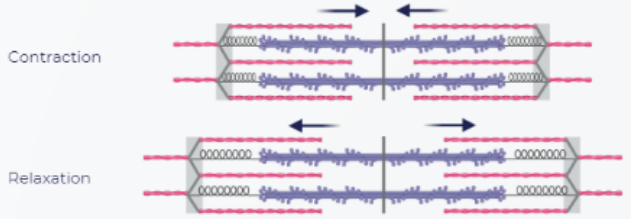


Fast-twitch fibers produce 5-8 times higher power.

* 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.



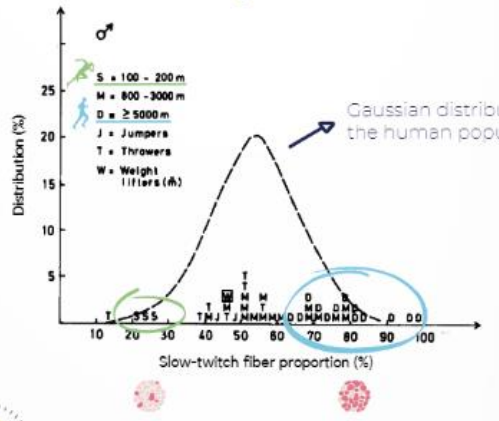
Muscles contract when the thick filament pulls the thin filament to the center of the sarcomere (= power stroke).

SARCOMERE STRUCTURE BACKGROUND

2 Want to know more?

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.

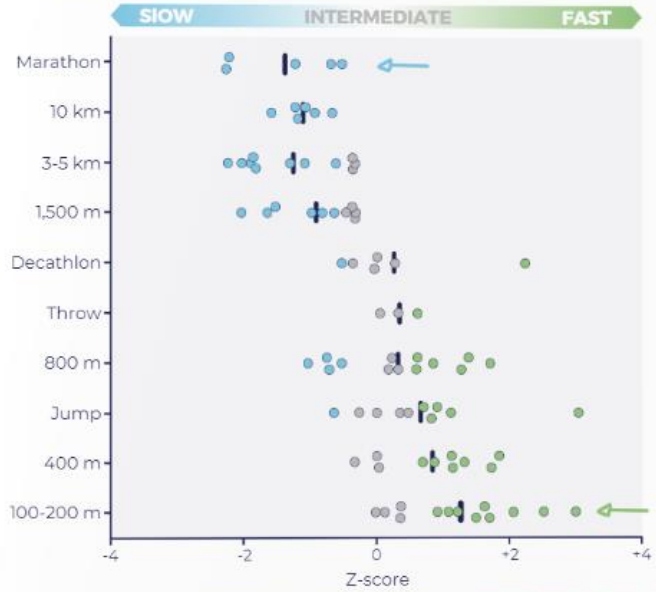
Did you know... *that in the seventies, muscle biopsies were taken from absolute world class athletes to determine their myotype? One of them was Frank Shorter, the 1972 Olympic champion in marathon running. His biopsy showed a tremendously high number of slow-twitch fibers (> 90%) and very few fast 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 Ragueb et al. 2011 (PLOS ONE), Rex et al. 2017 & unpublished data

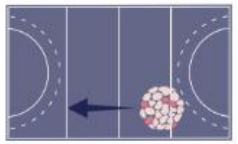
2 Want to know more?

Can I adapt my game strategy?

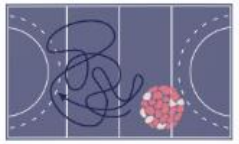
The myotype of your players might be relevant for tactical game decisions. It might influence:

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.

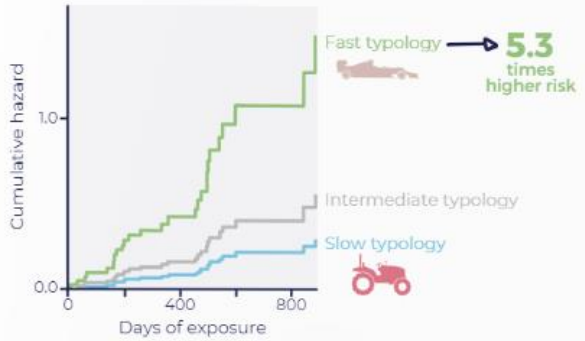
However, the effect of these myotype-based tactical decisions on game performance has not been confirmed yet.

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)

Interested?
www.muscletalentscan.com

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Colleagues & collaborators:
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Freek Van de Castelle
Dr. Phil Bellinger
Prof. Clare Minahan

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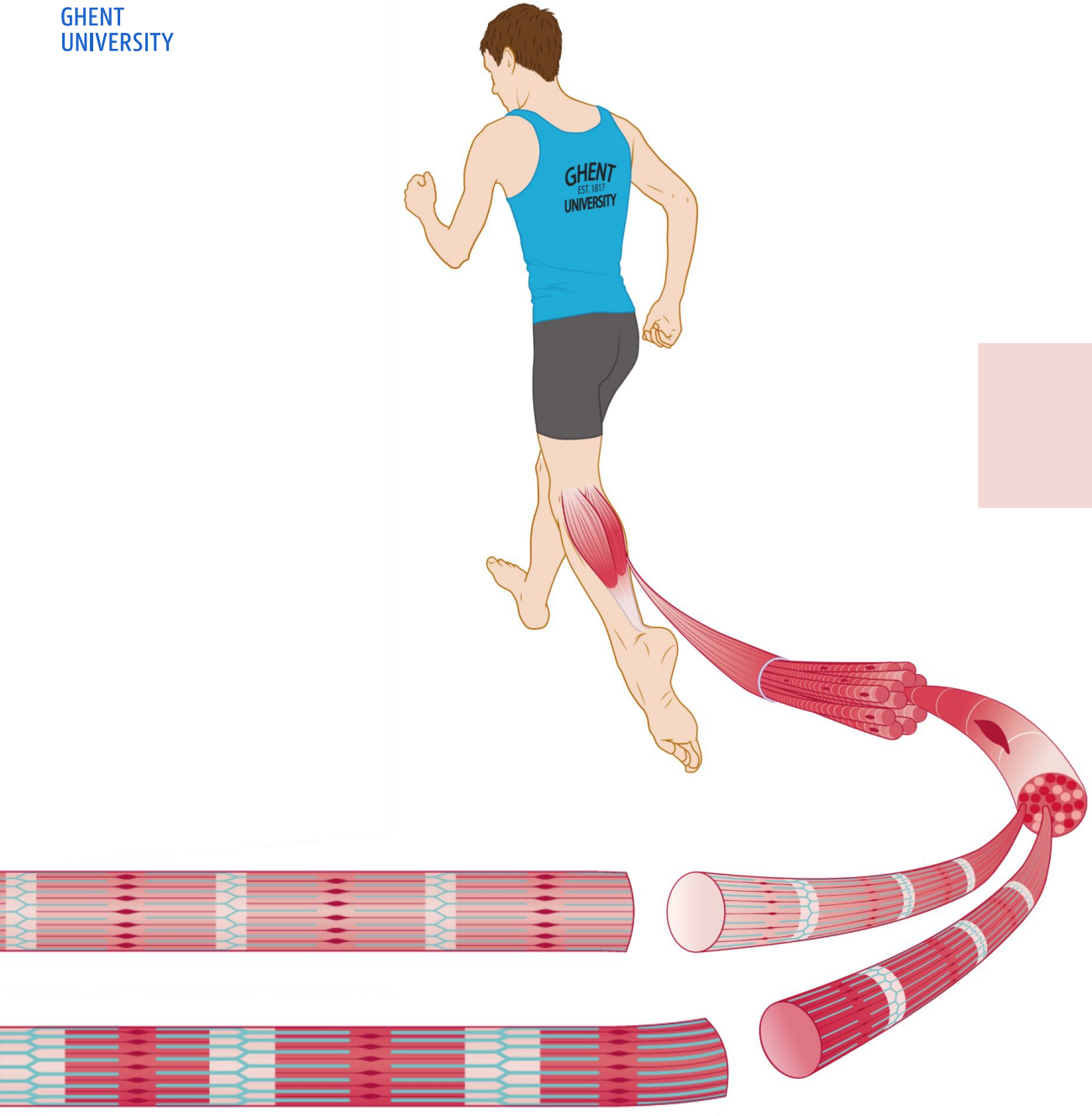

Extra slides

Dr. Eline Lievens

5 Scans can be performed before puberty

Lievens et al., JAP, 2021

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(Lievens et al., JAP, 2021)

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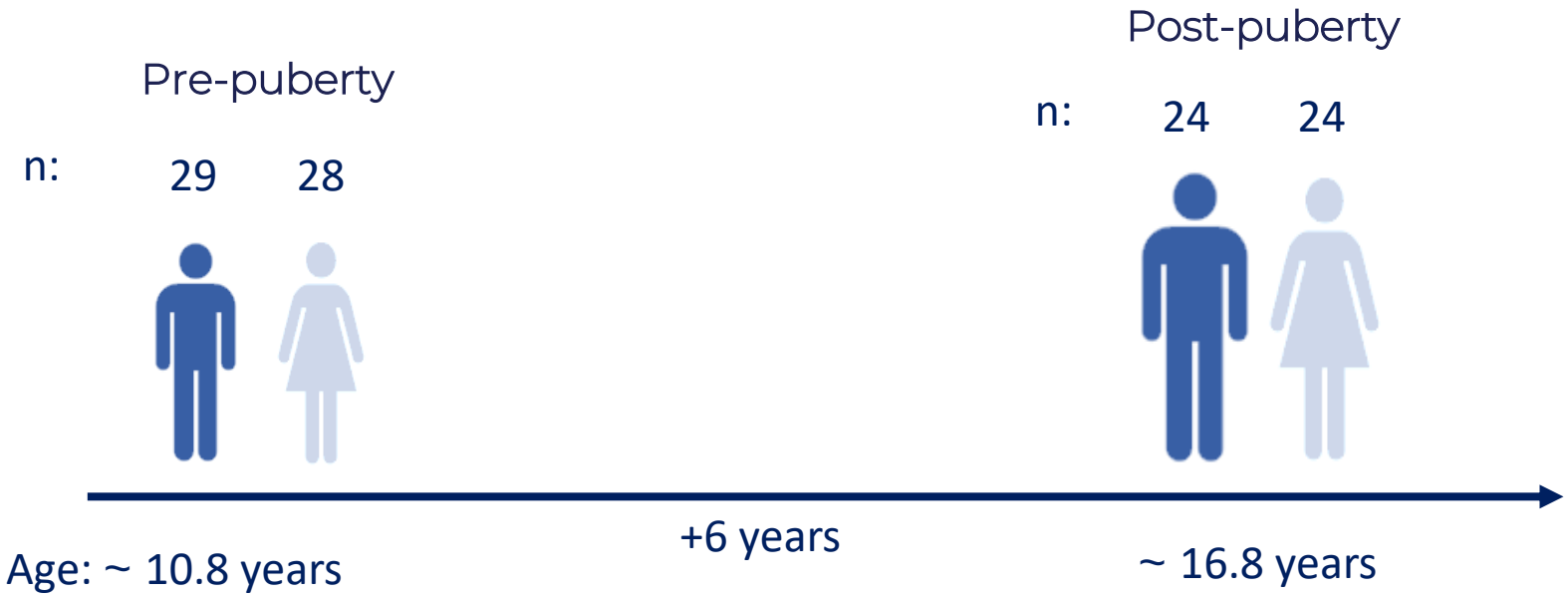

(Lievens et al., JAP, 2021)

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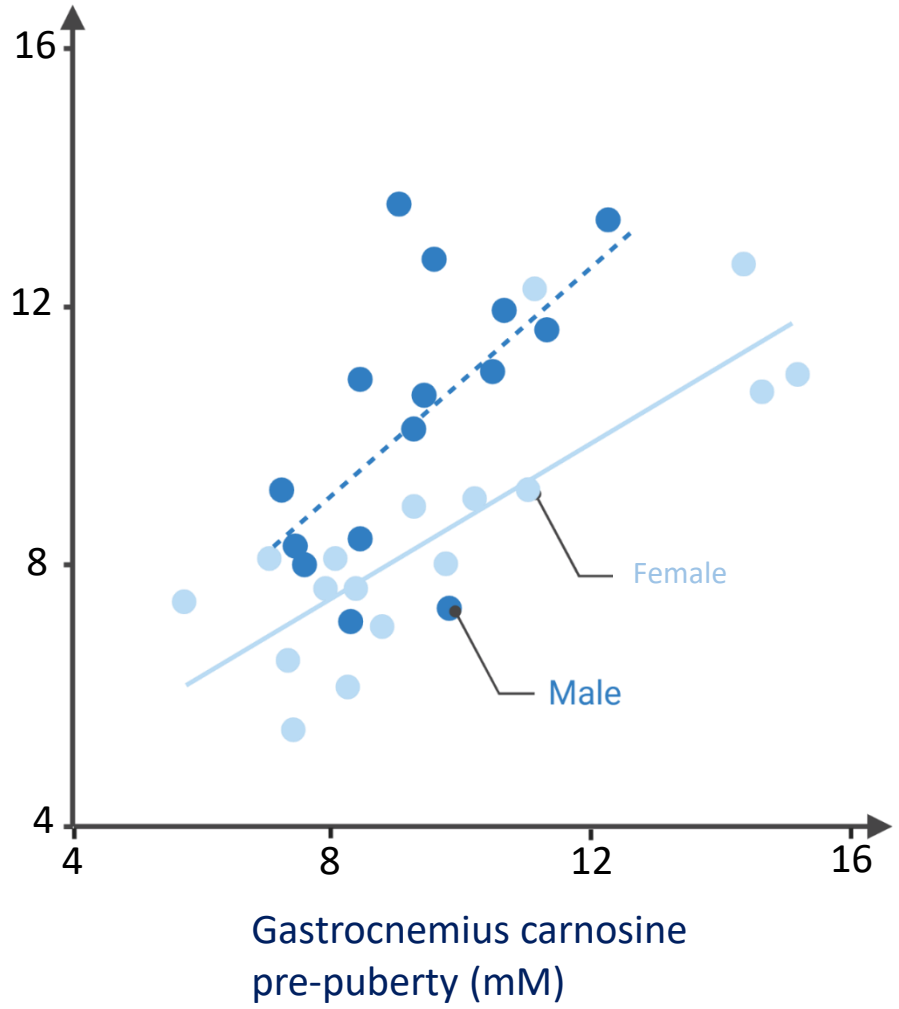
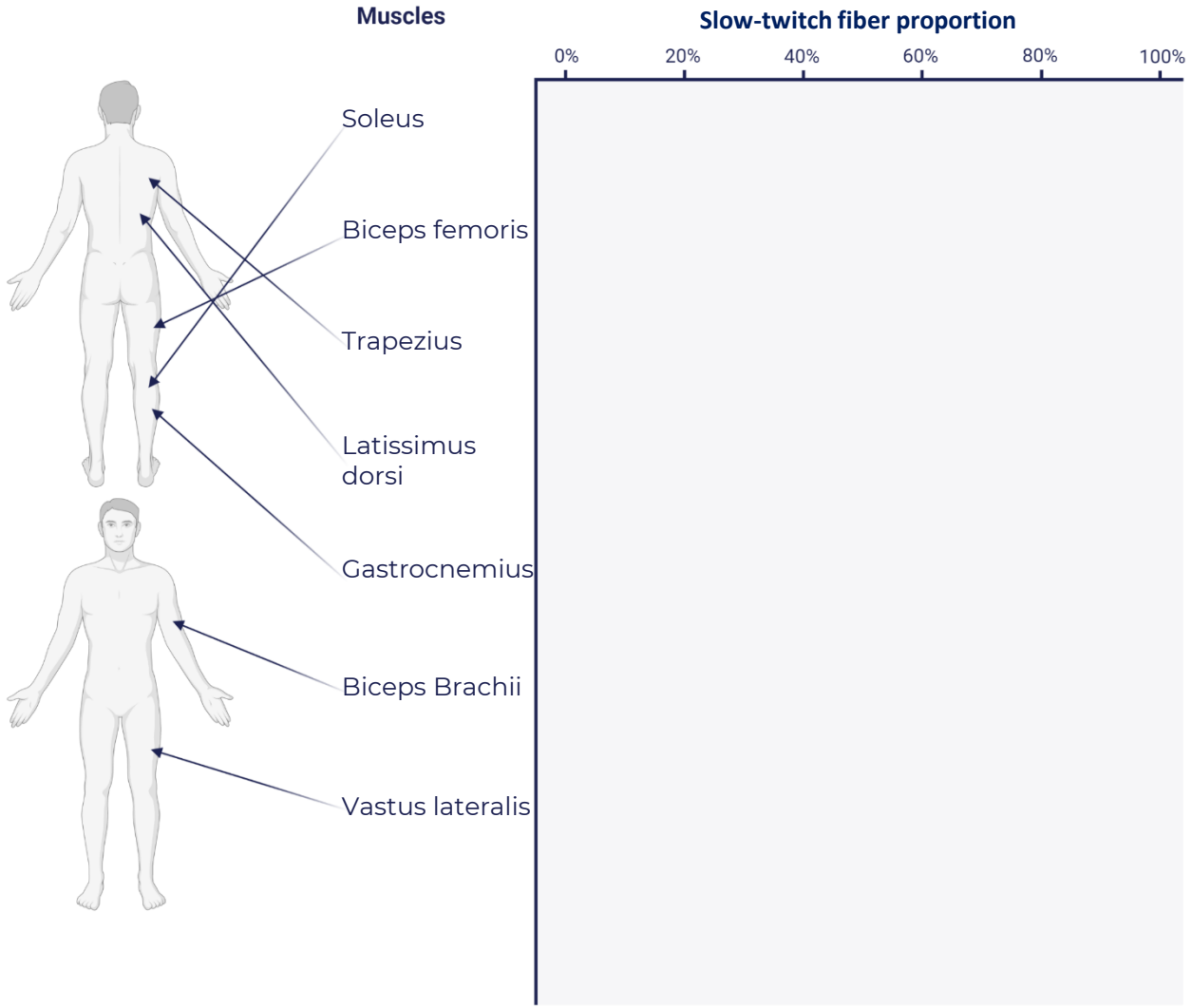


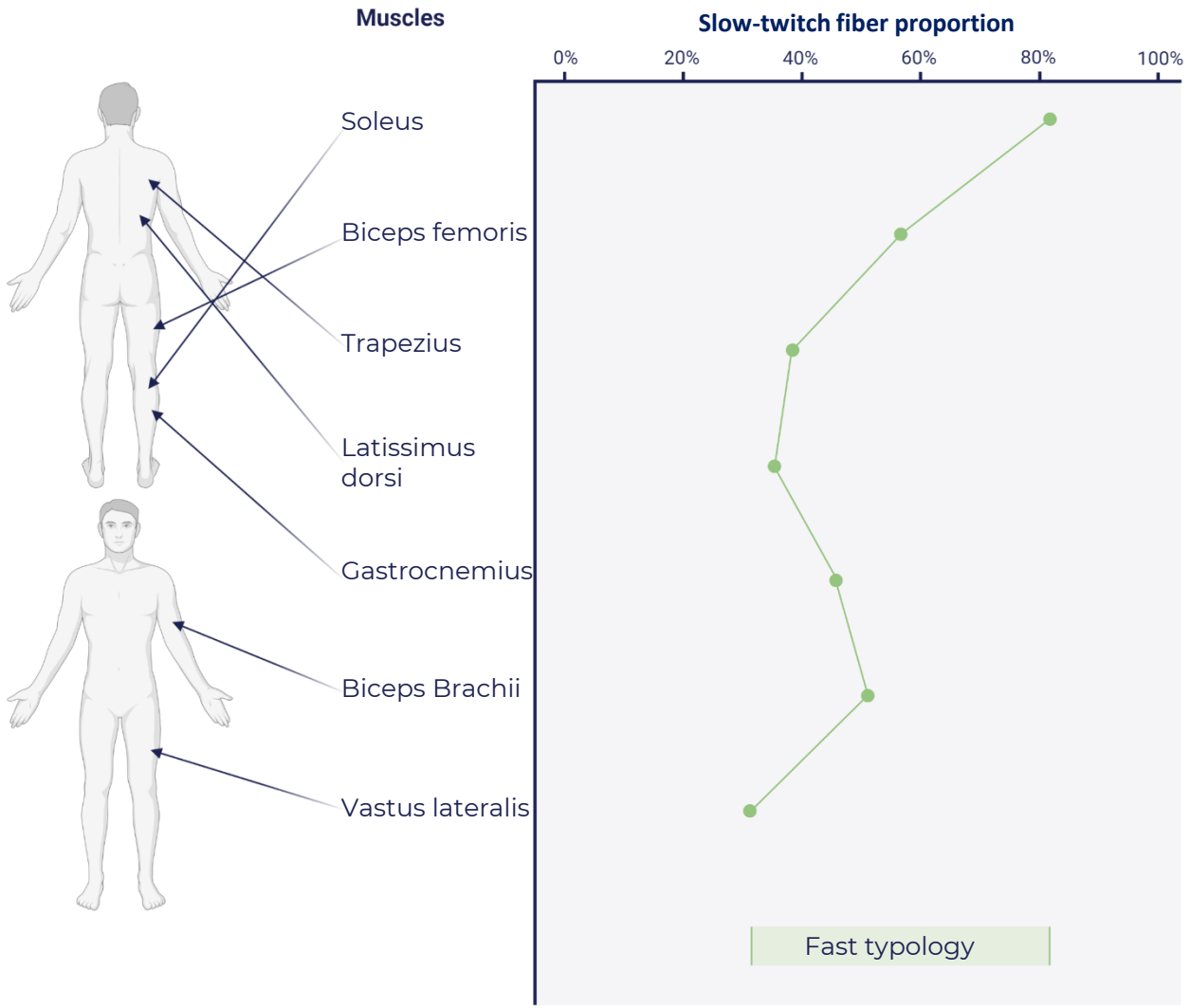
(Lievens et al., JAP, 2021)

3 Across-muscle phenotype



(Vikne, Muscle & Nerve, 2012)

3 Across-muscle phenotype



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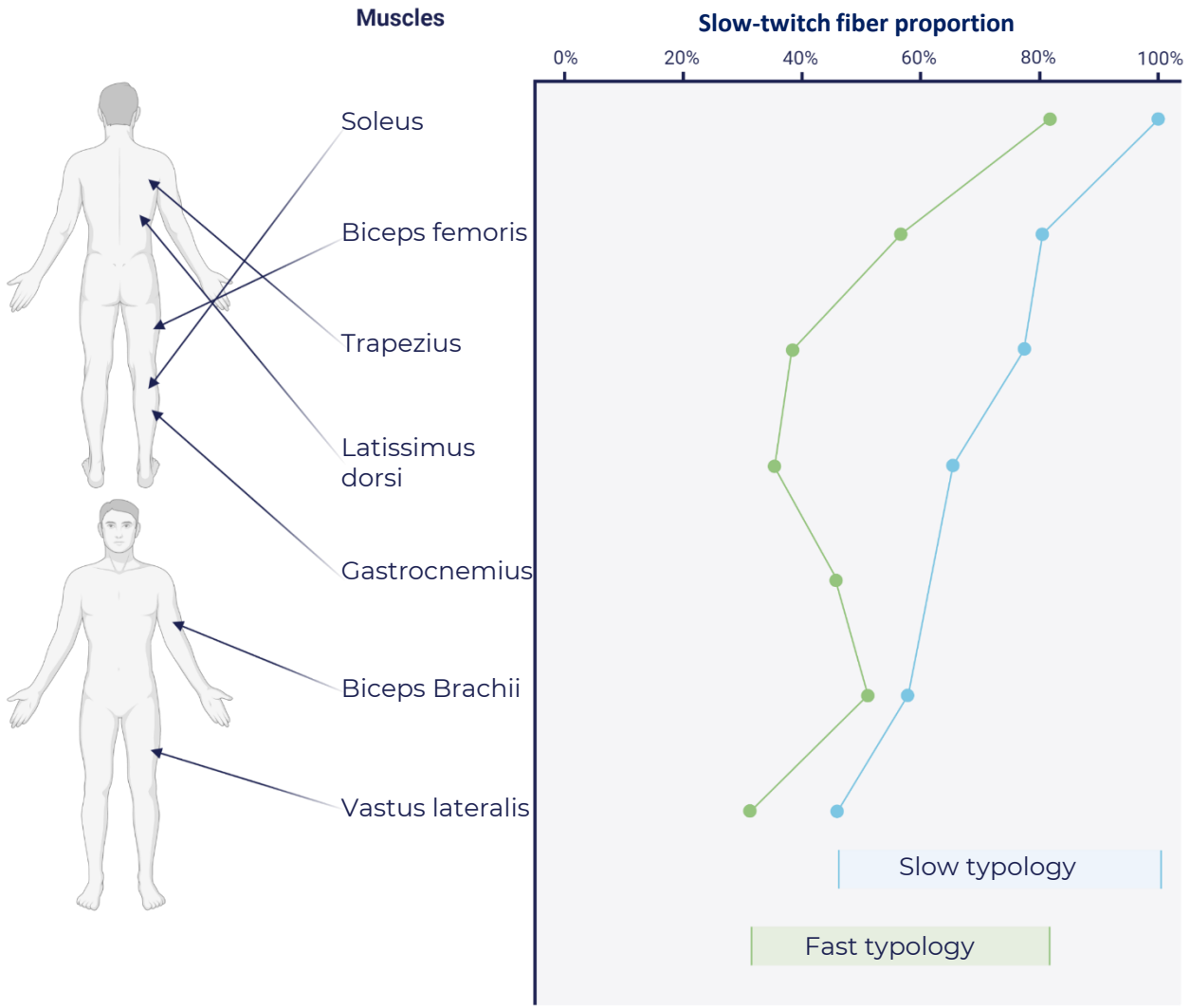
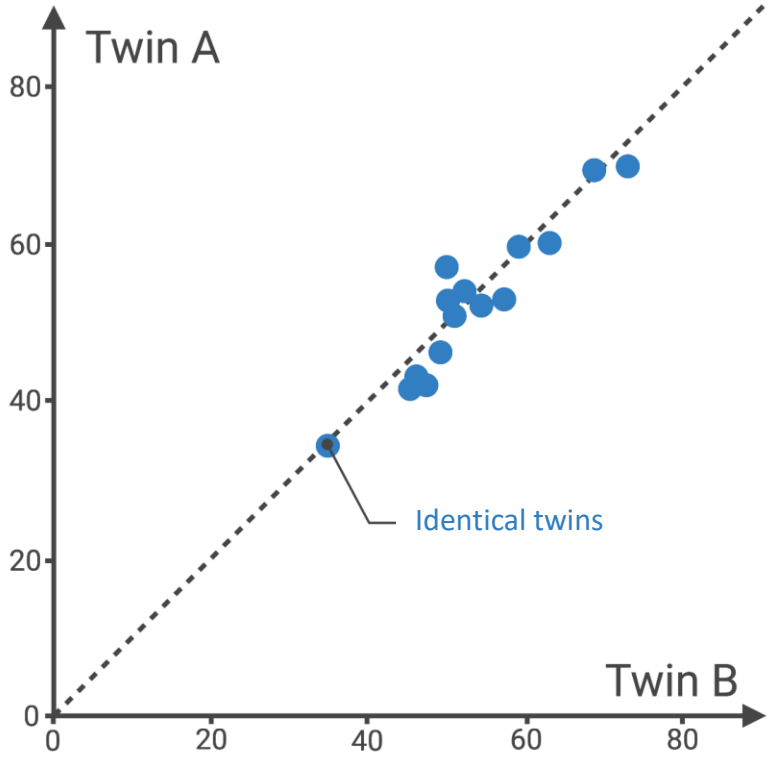


(Vikne, Muscle & Nerve, 2012)

4 Genetically determined

Percentage of slow-twitch fibers



Percentage of slow-twitch fibers

(Komi, Acta Physiologica, 1977)

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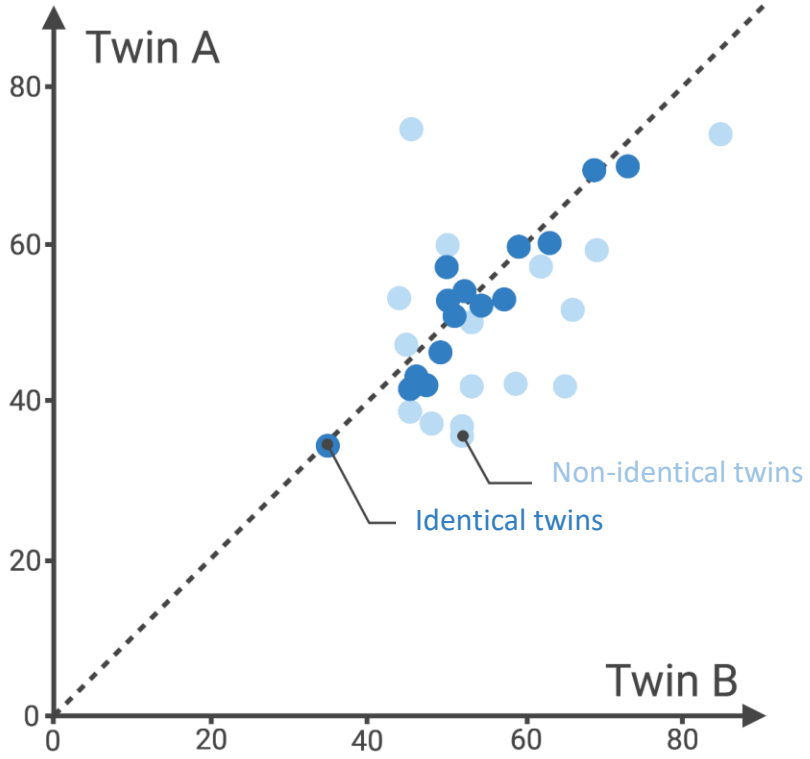
Percentage of slow-twitch fibers

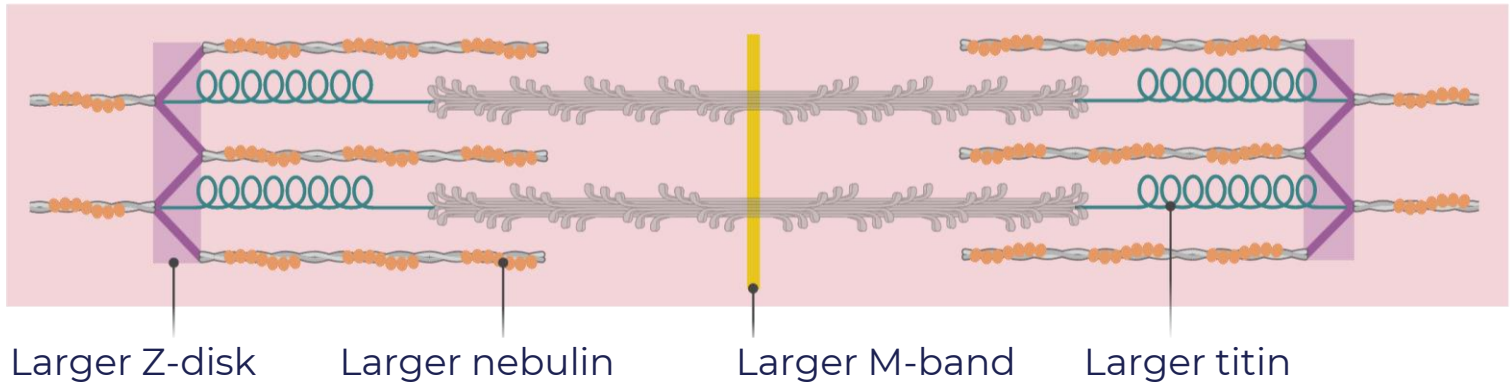


Percentage of slow-twitch fibers

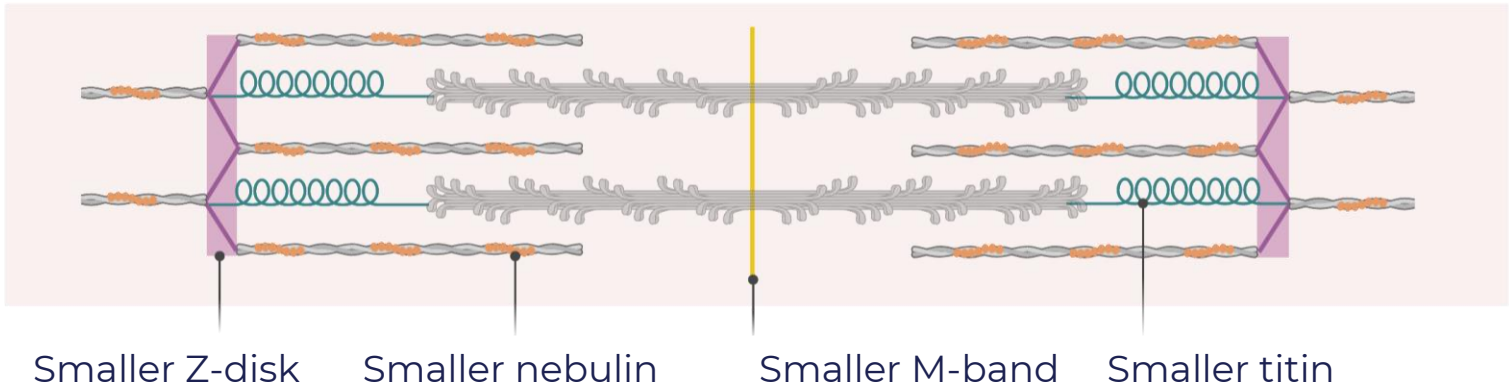
(Komi, Acta Physiologica, 1977)

5 Slow-twitch fibers are more robust

Slow-twitch



Fast-twitch



(Qaisar, J. Free Radic. Biol. Med., 2016)

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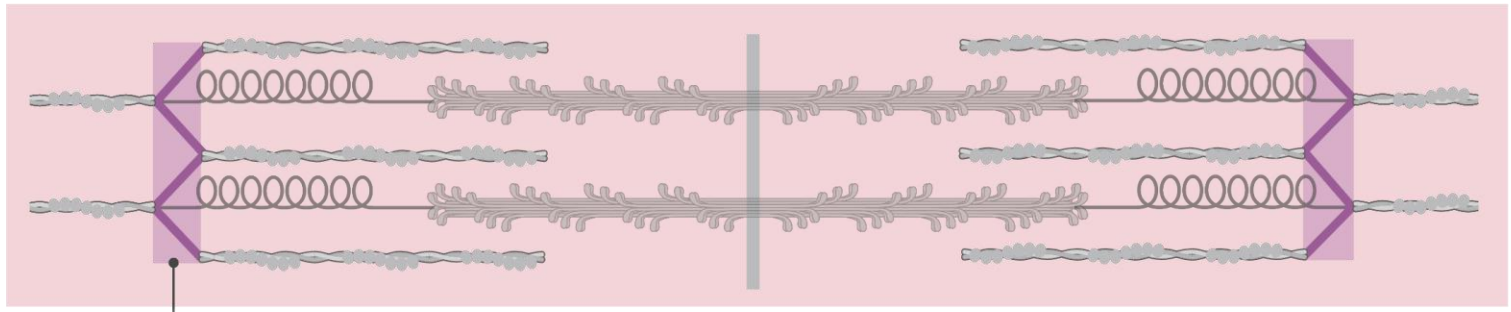
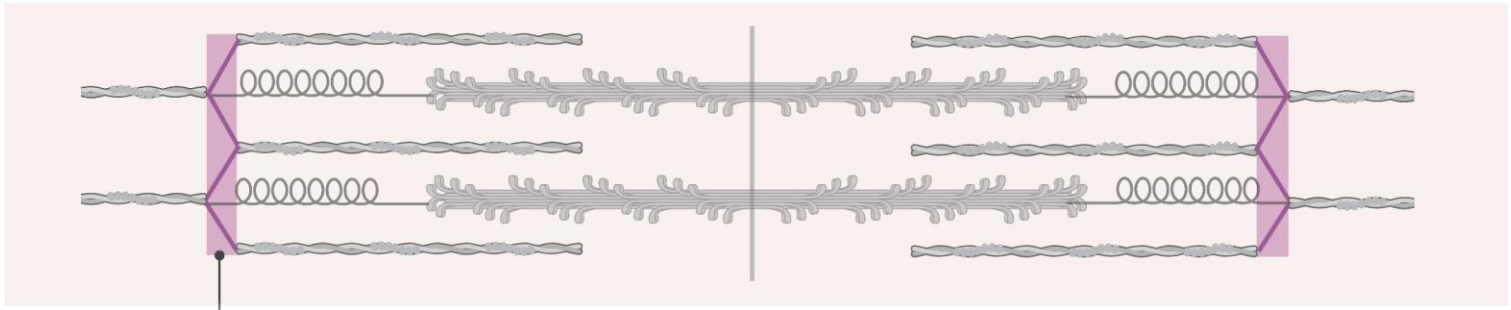
Slow-twitch



Larger Z-disk

Fast-twitch



Smaller Z-disk

(Qaisar, J. Free Radic. Biol. Med., 2016)

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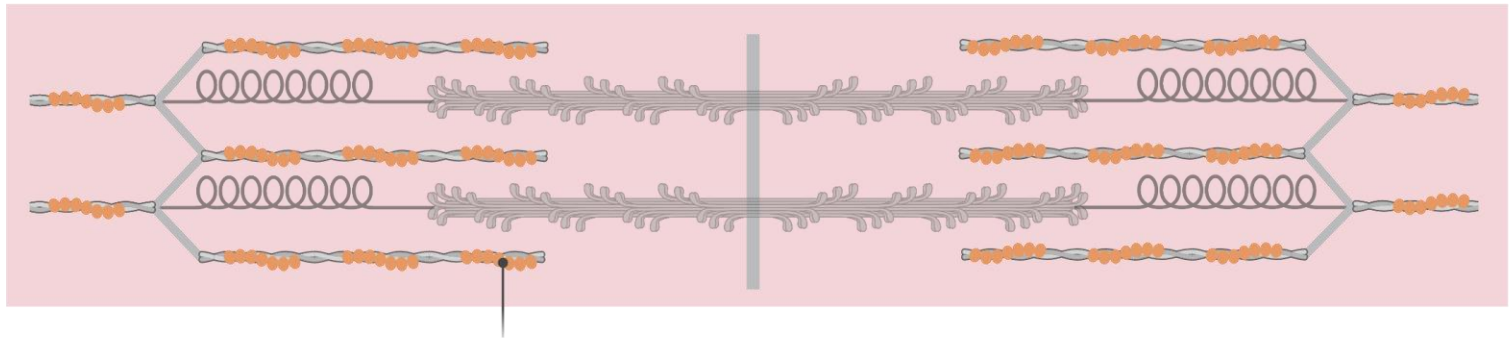
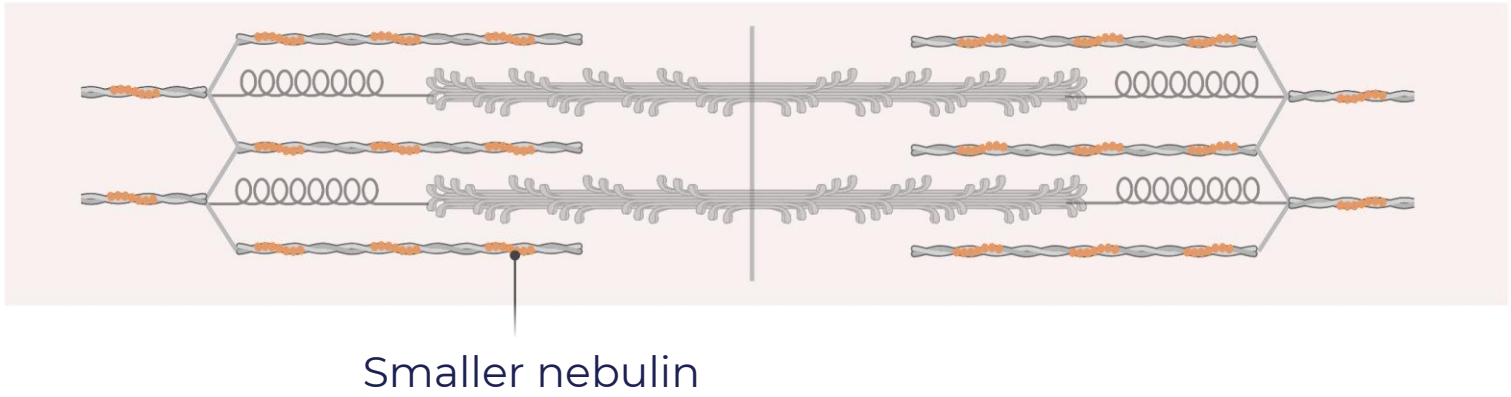
Slow-twitch



Fast-twitch



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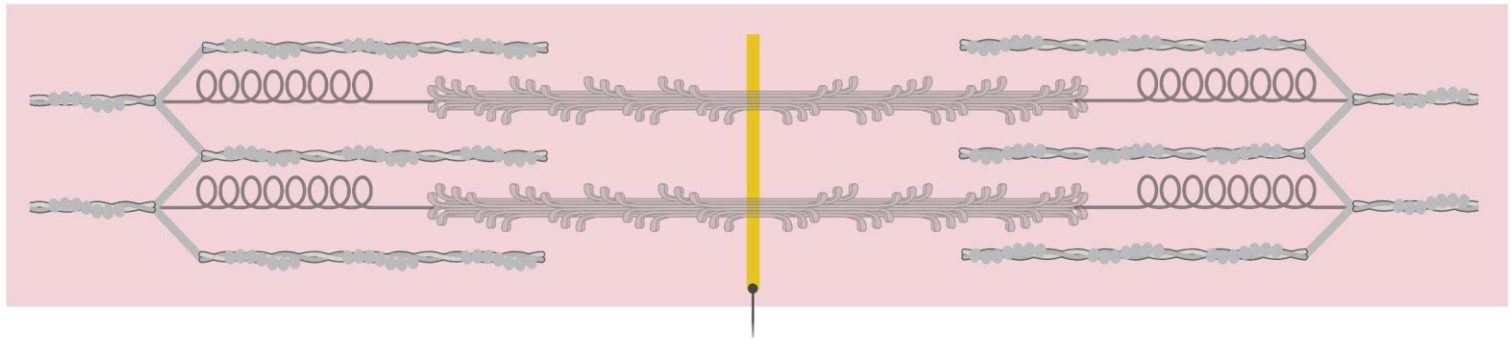
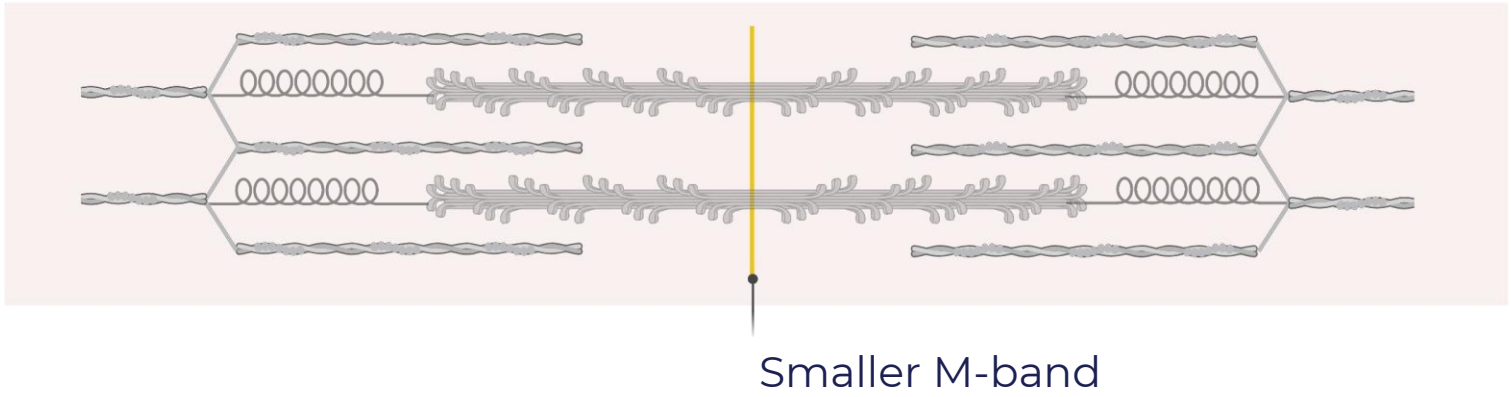


Fast-twitch



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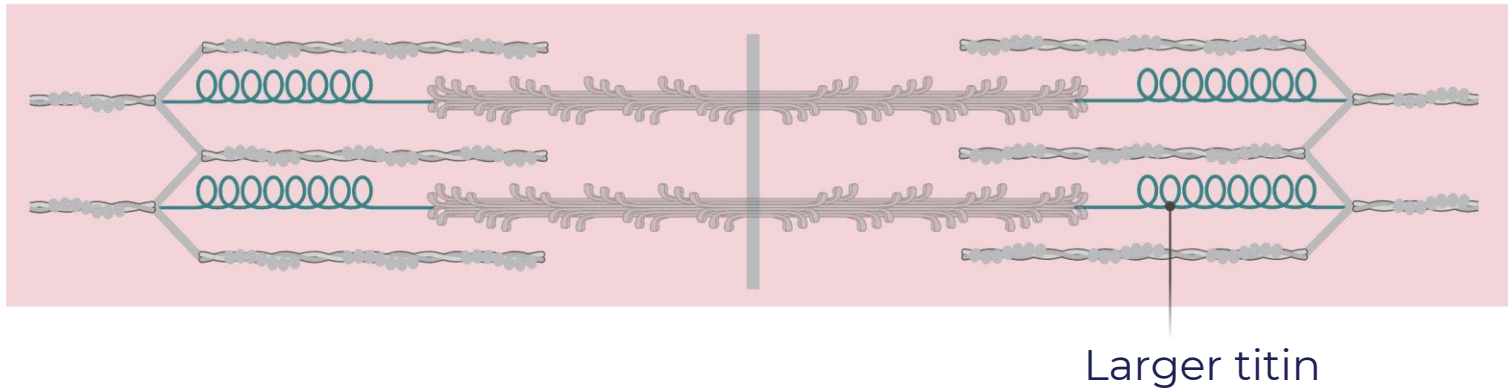
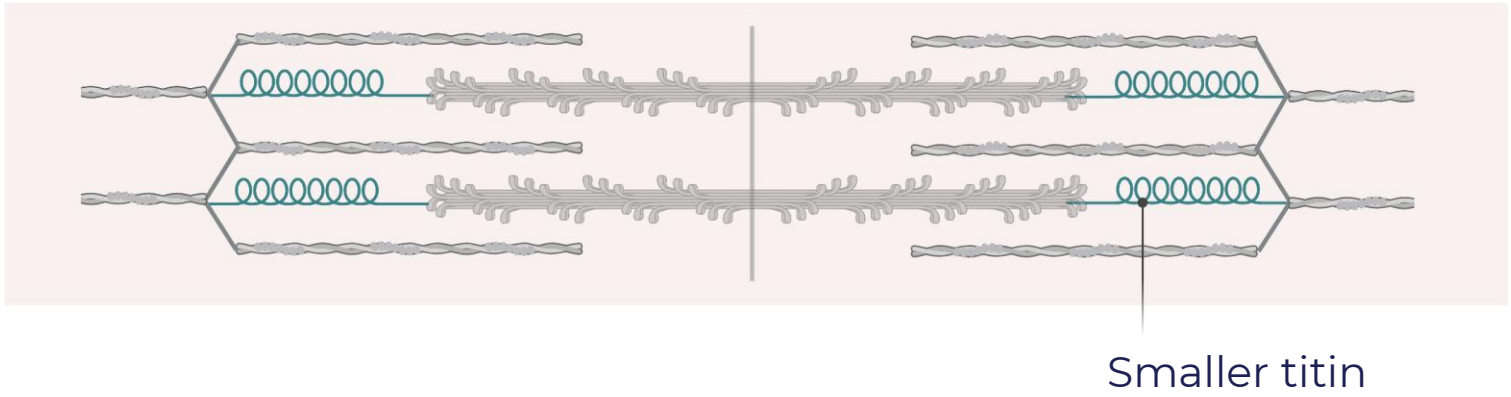


Fast-twitch



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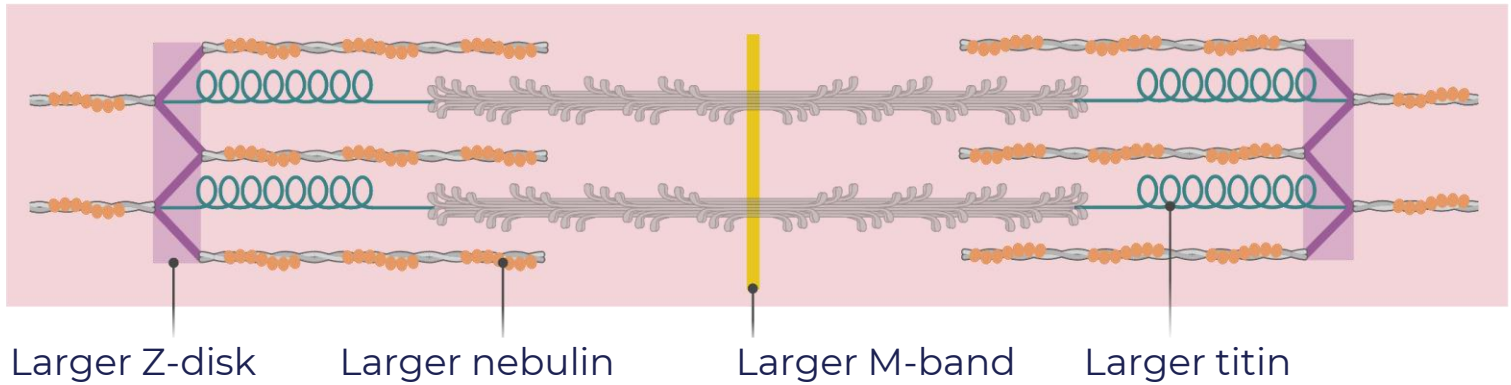

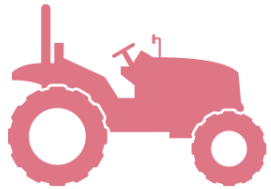

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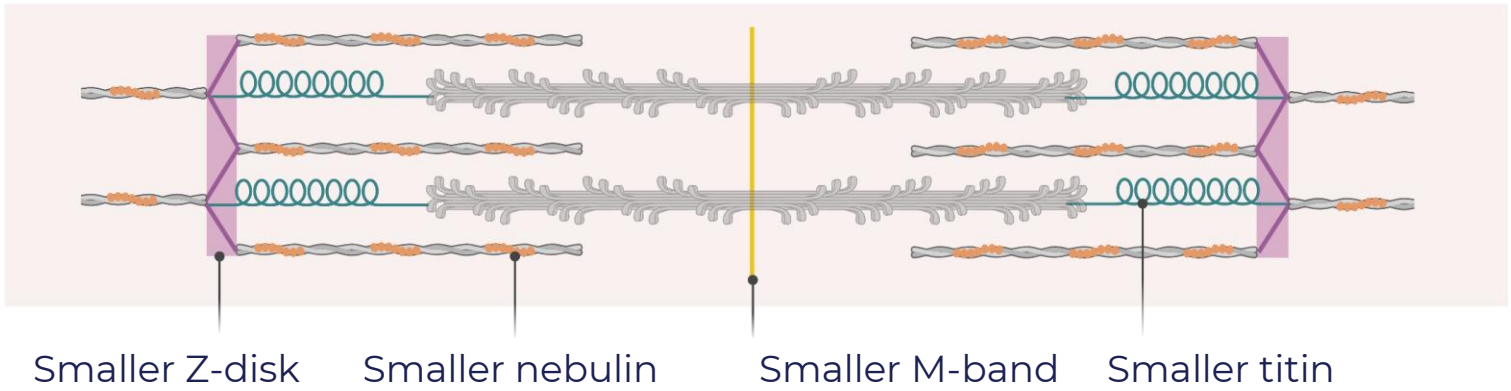
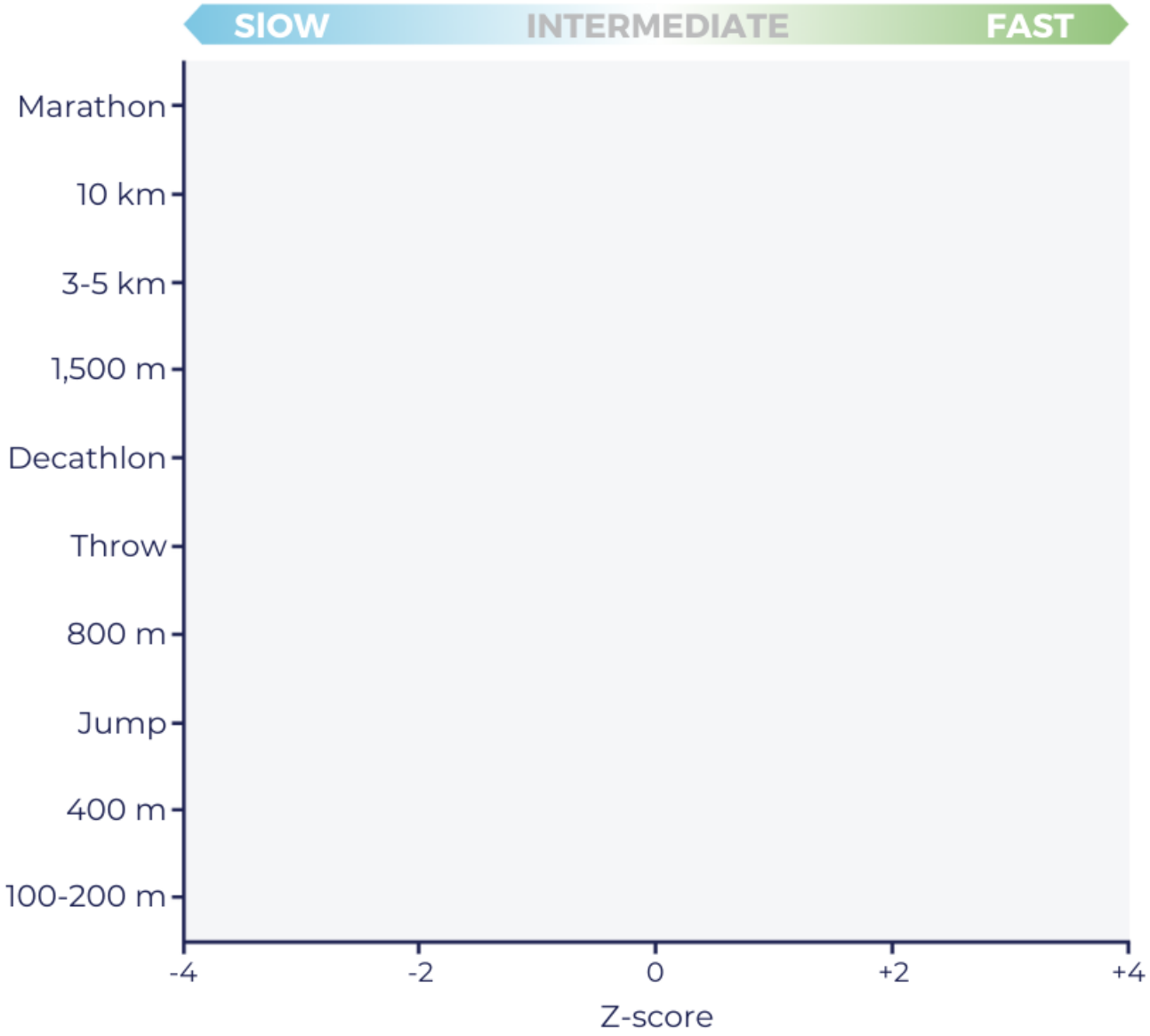


(Qaisar, J. Free Radic. Biol. Med., 2016)

1 Can I discover talent in athletics?



(Baguet, 2011; Bex, 2017)

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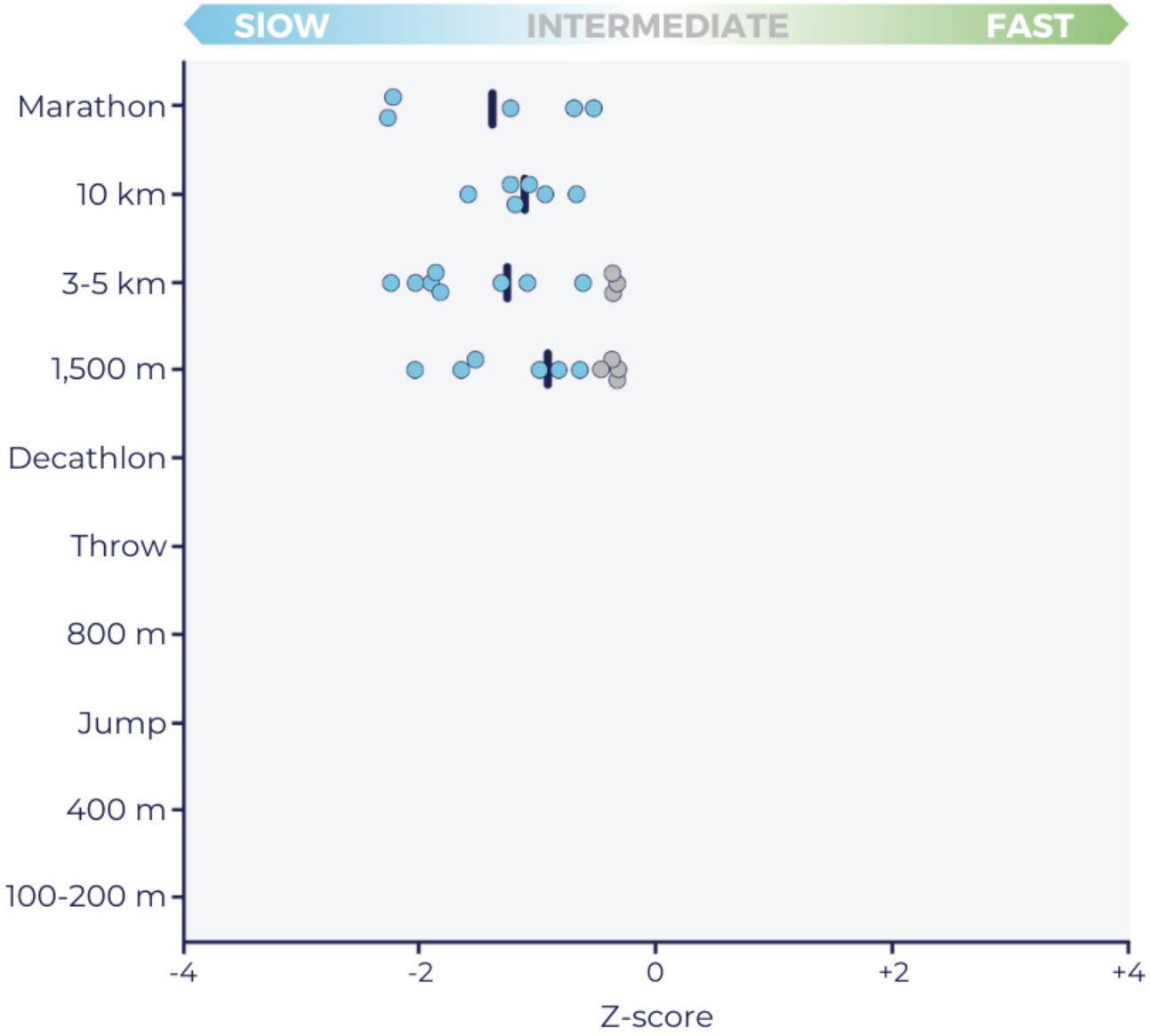

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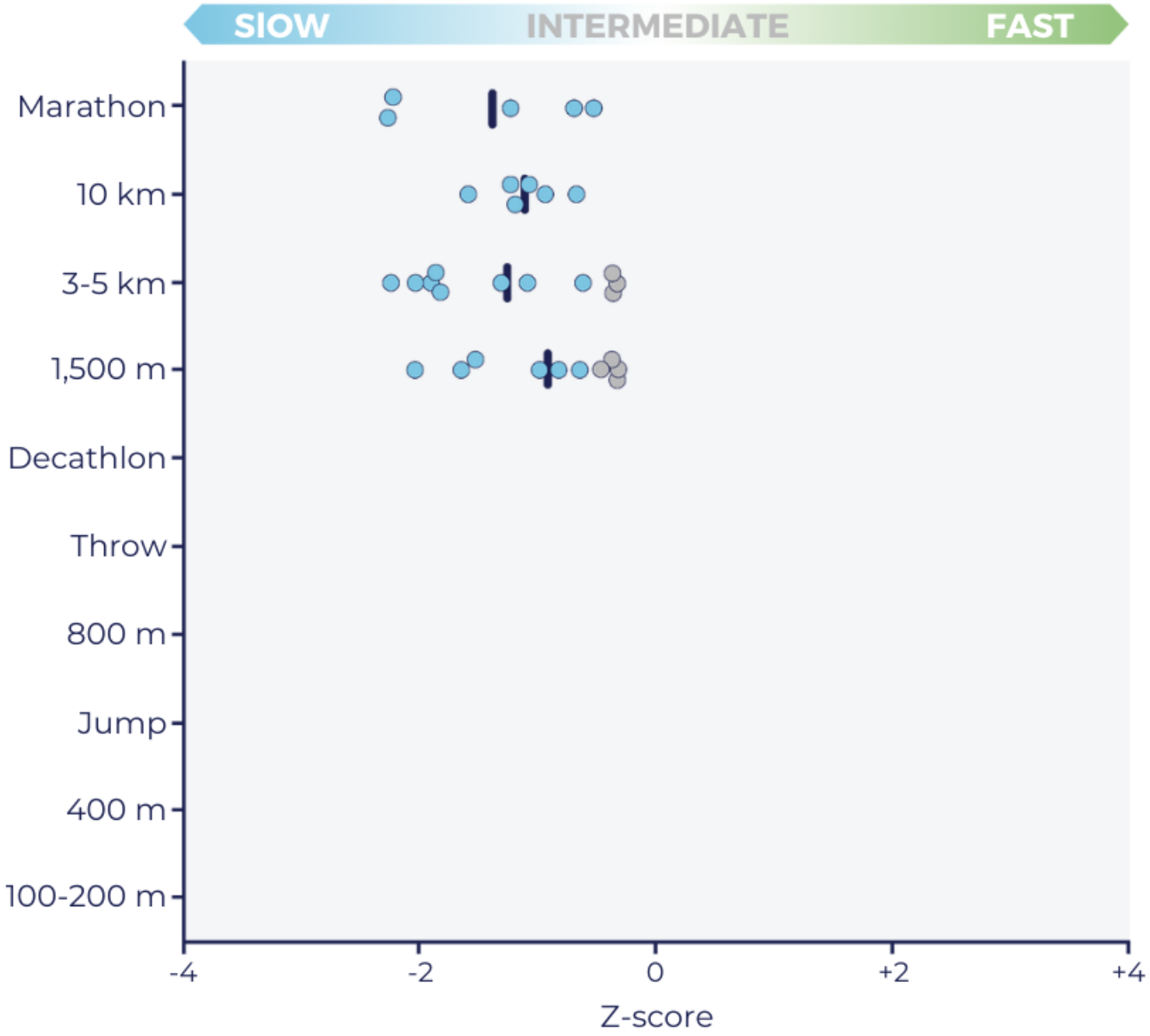

More efficient

More resistant to fatigue

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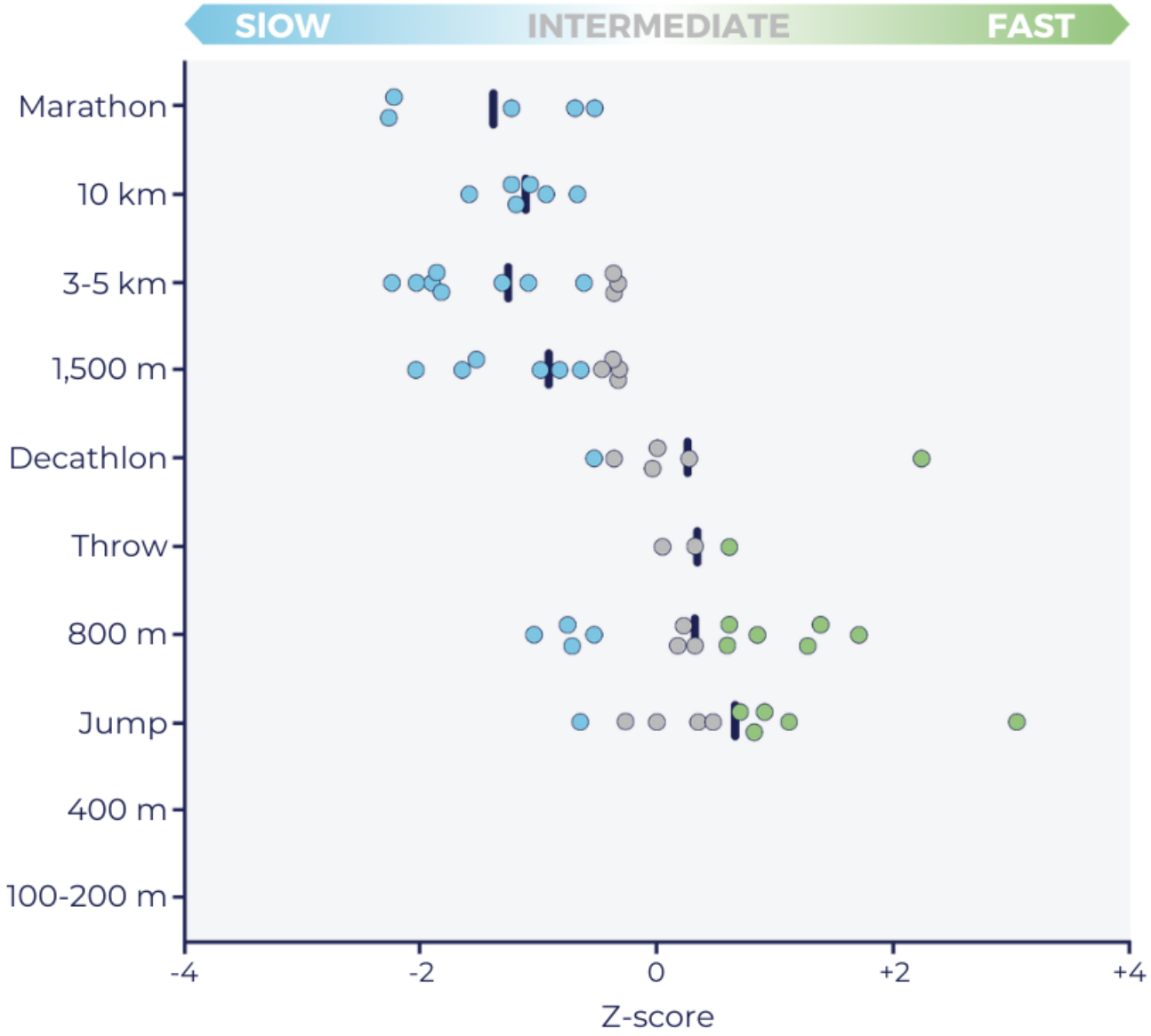

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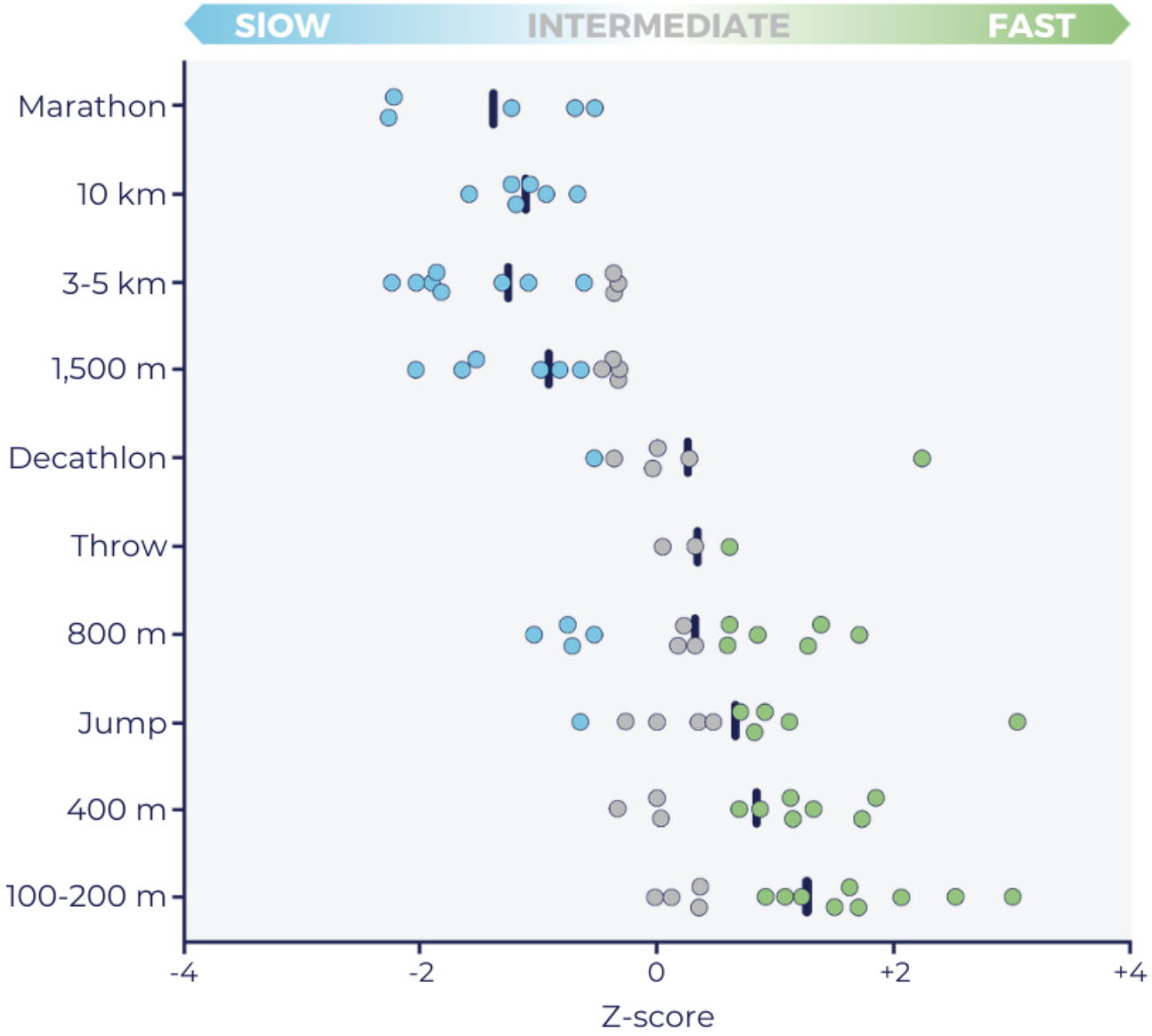


More efficient

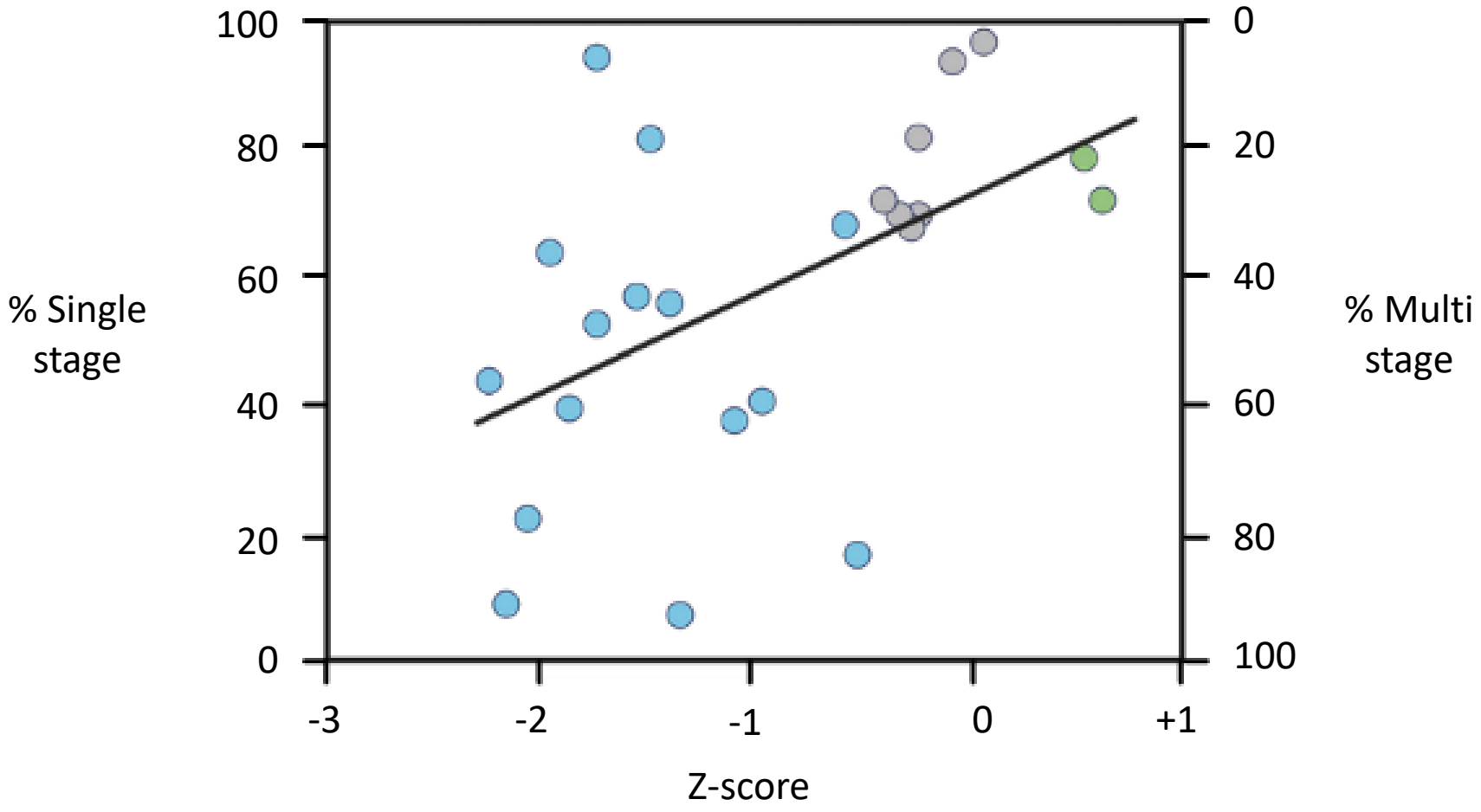
More resistant to fatigue

Generate power

High movement frequencies

(Baguet, 2011;
Bex, 2017)

1 Can I discover talent in cycling?



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