FACULTY OF MEDICINE AND HEALTH SCIENCES

The relevance of the muscle fiber typology in sports

Dr. Eline Lievens

Prof. Dr. Wim Derave

GHENT UNIVERSITY

EUROPEAN ATHLETICS
YOUR SPORT FOR LIFE

fwo Research Foundation Flanders
Opening new horizons

CHAPTER I

Muscle physiology

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Muscle physiology

CHAPTER II

Evolution

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Muscle physiology

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CHAPTER III

Measuring muscle typology

CHAPTER I

Muscle physiology

CHAPTER II

Evolution

CHAPTER III

Measuring muscle typology

CHAPTER IV

Relevance in sports

CHAPTER I

Muscle physiology


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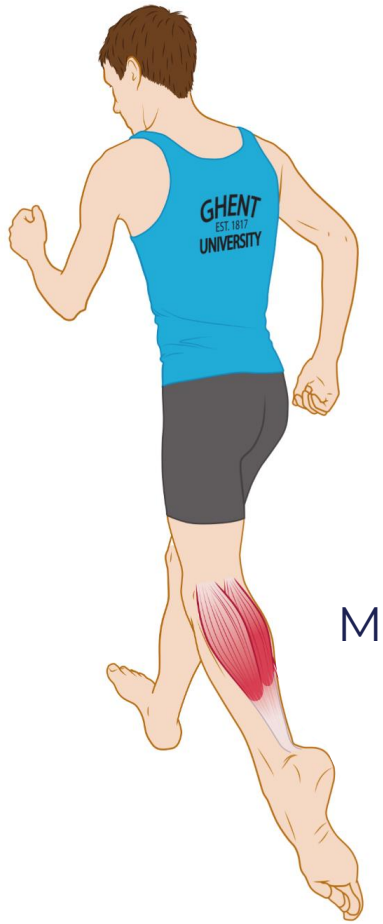

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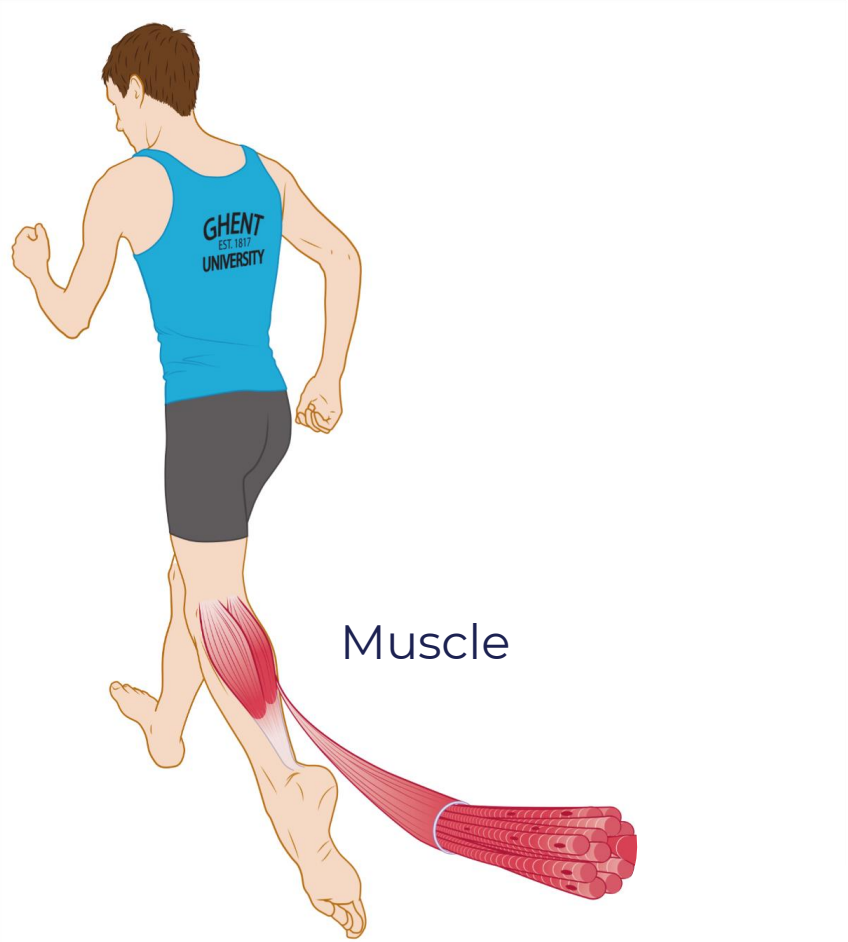
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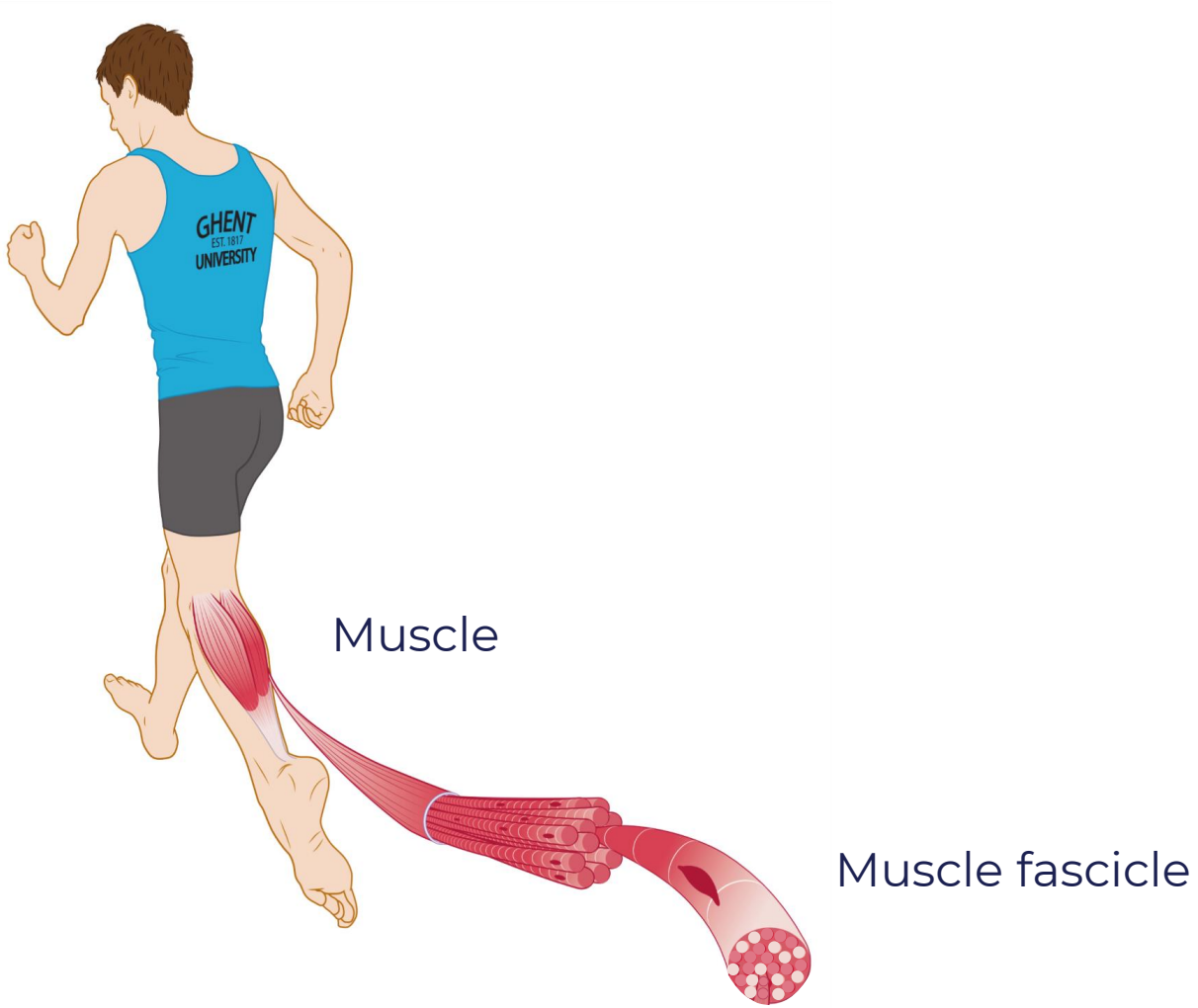
Muscle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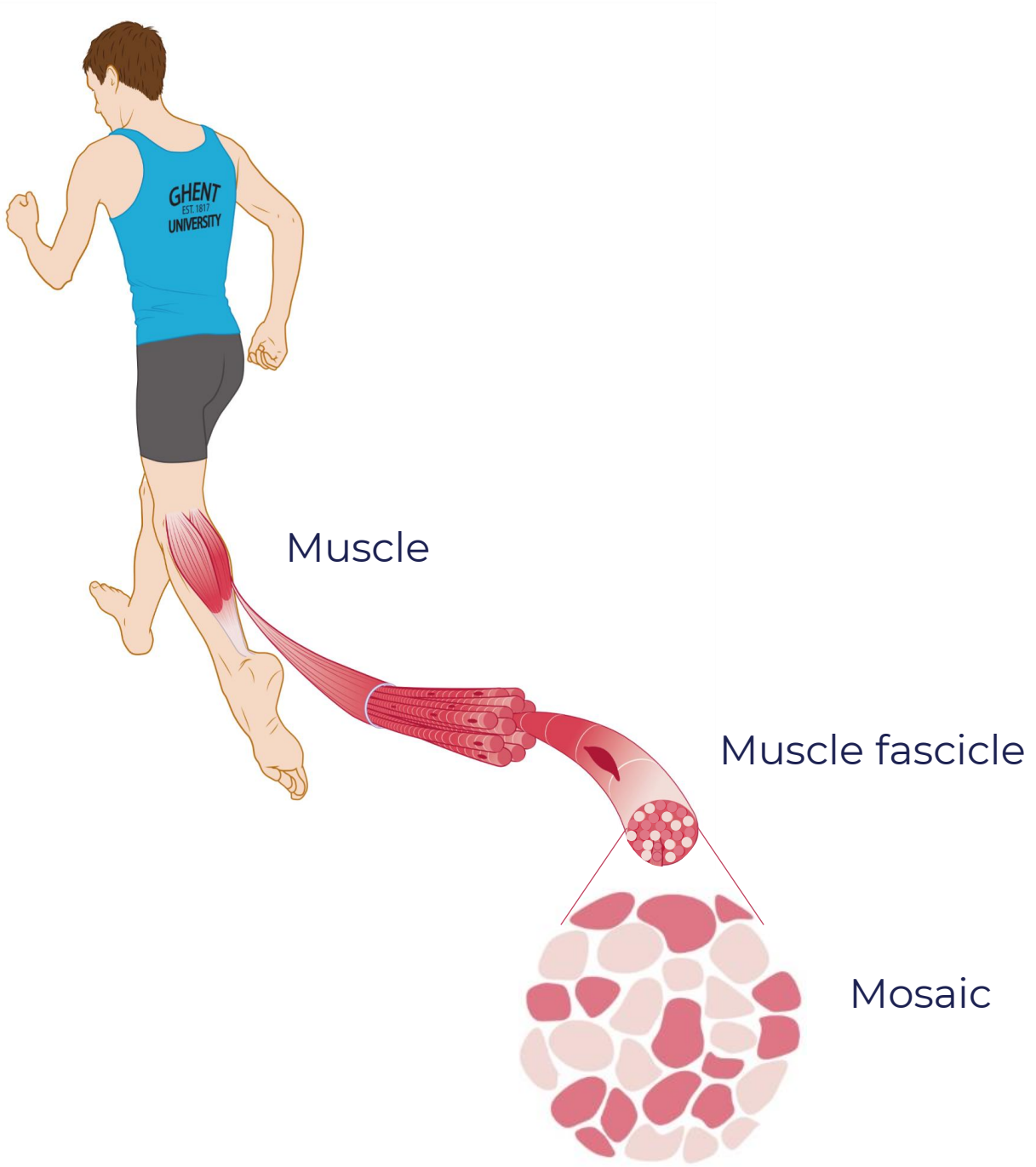
Muscle
Muscle fascicle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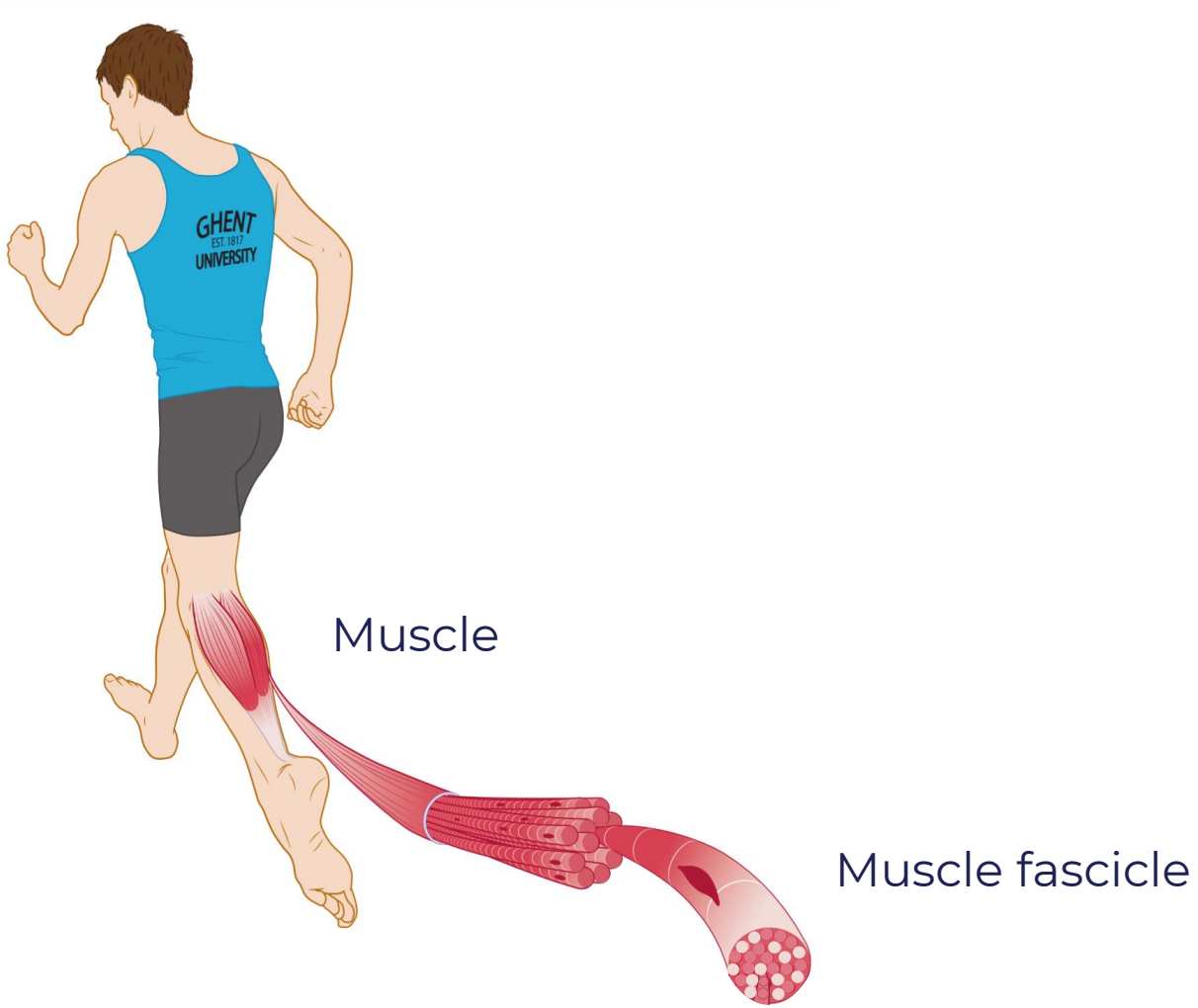
Muscle
Muscle fascicle
Mosaic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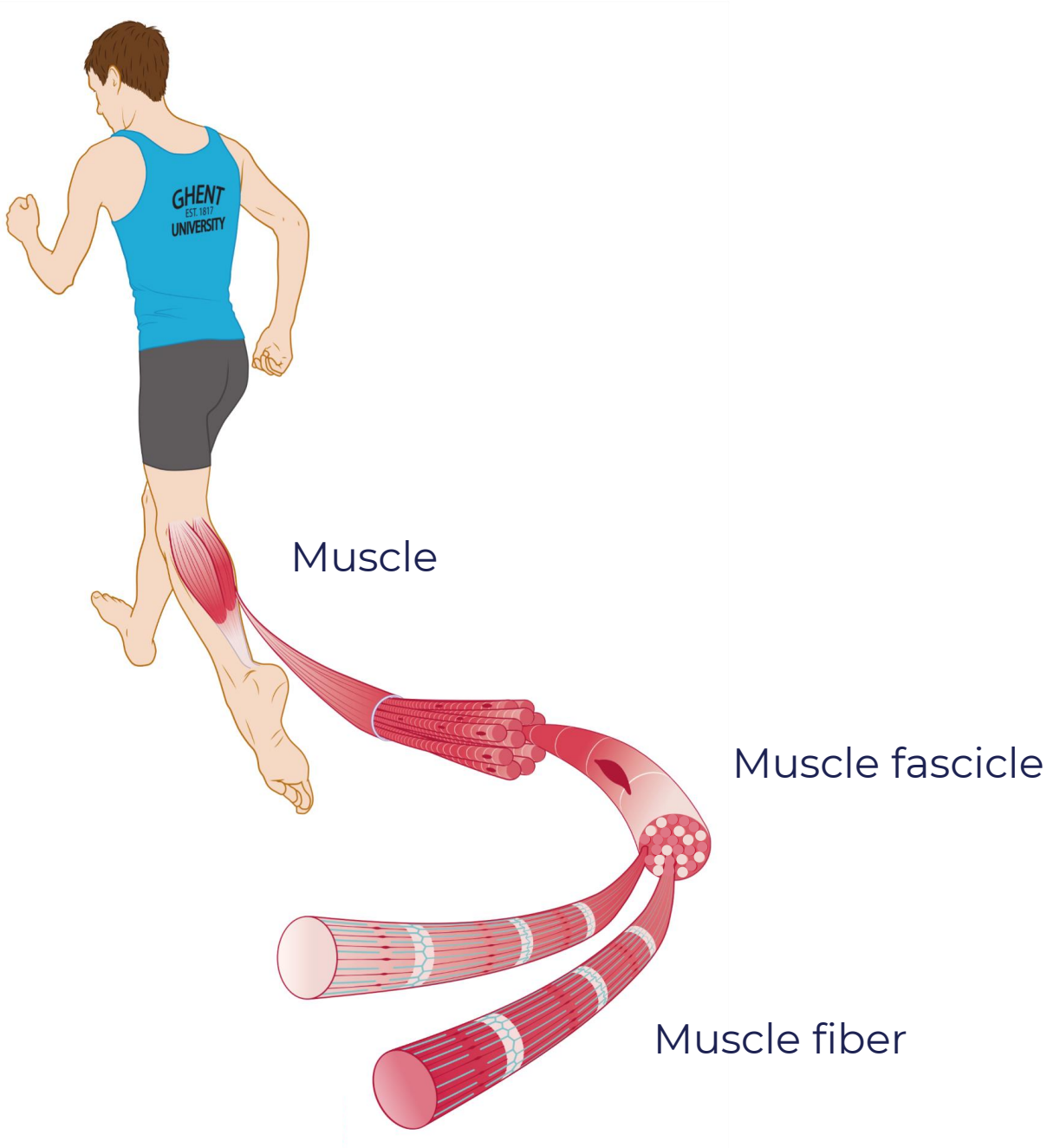
Muscle
Muscle fascicle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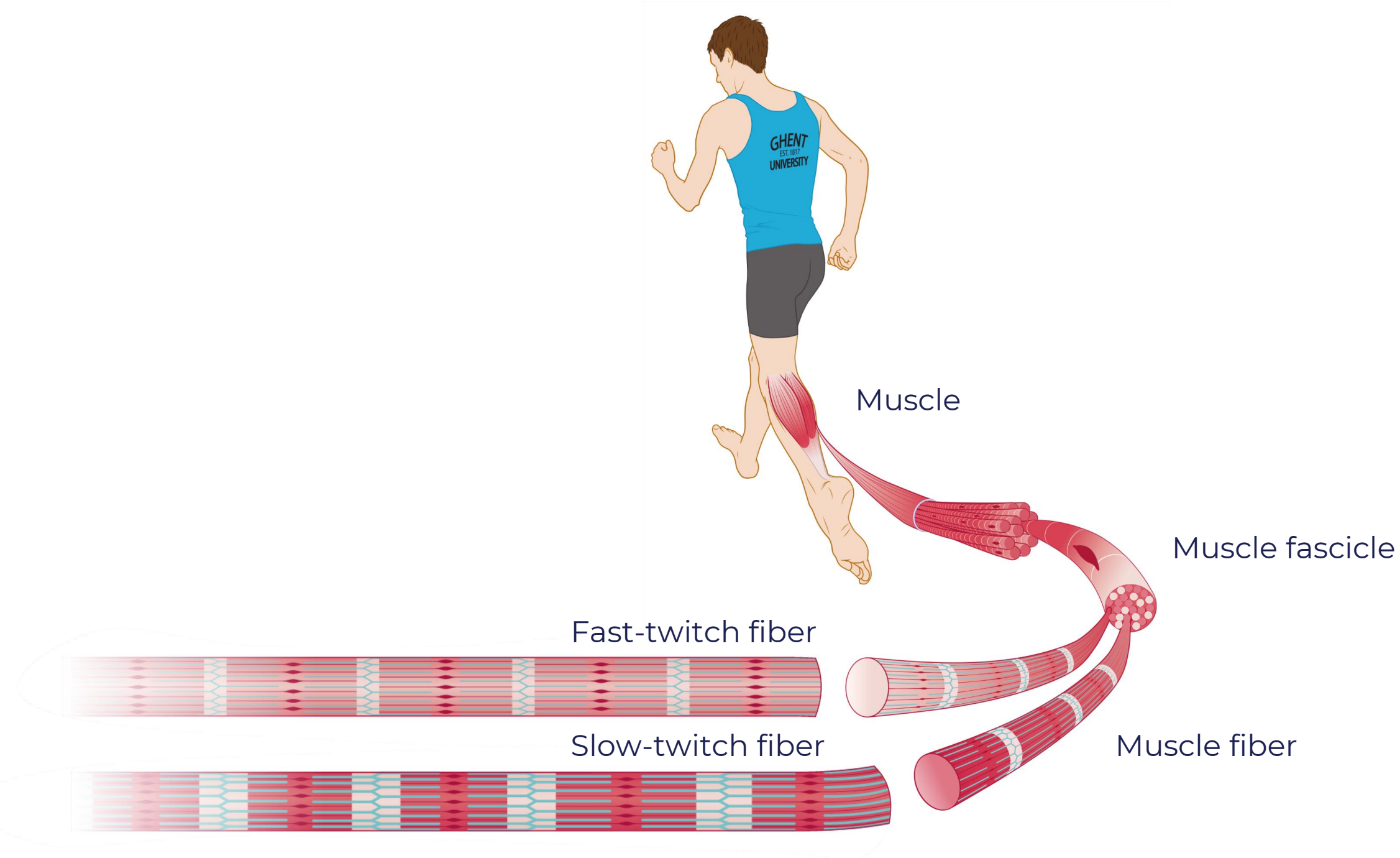
Muscle
Muscle fascicle
Muscle fiber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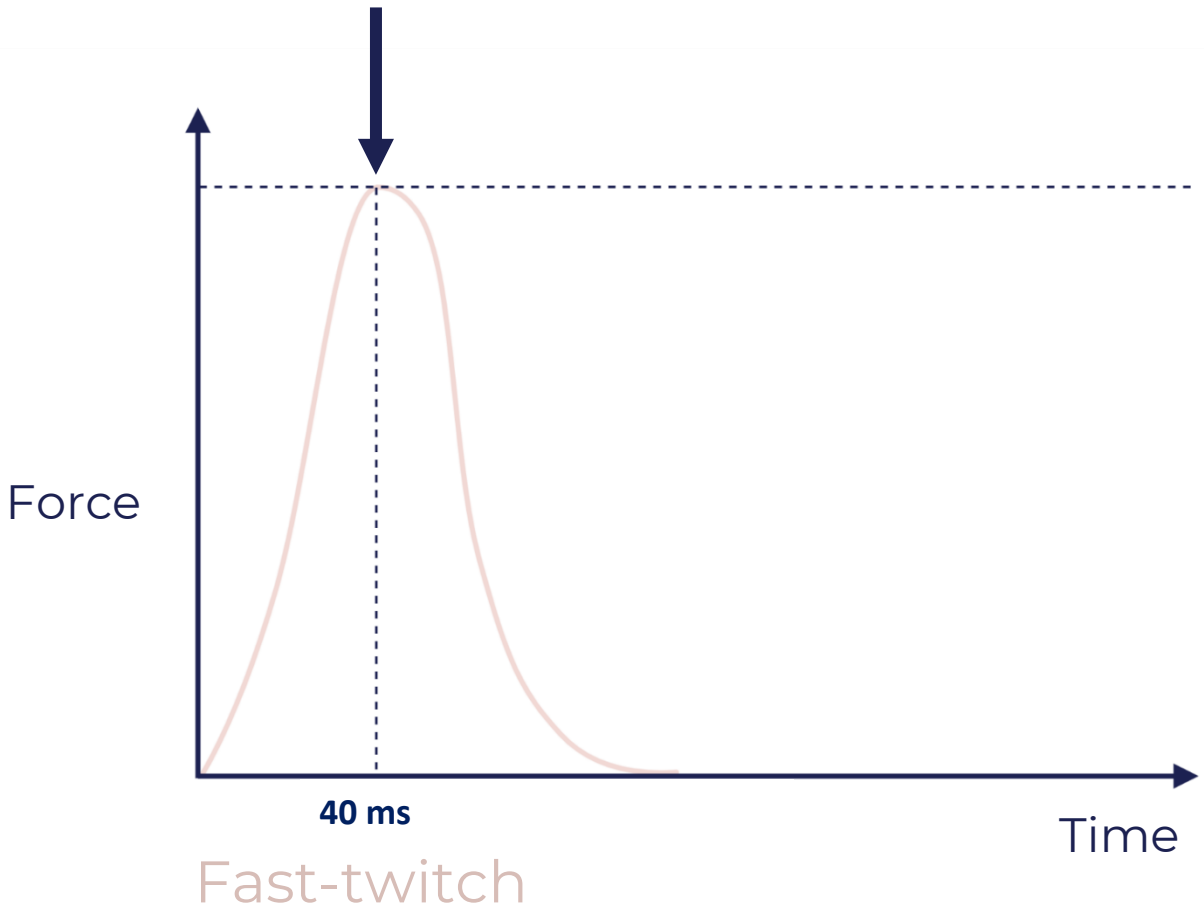
Muscle
Muscle fascicle
Fast-twitch fiber
Slow-twitch fiber
Muscle fiber

1 Fast-twitch fibers are faster



(Bottinelli, J. Physiol., 1996)

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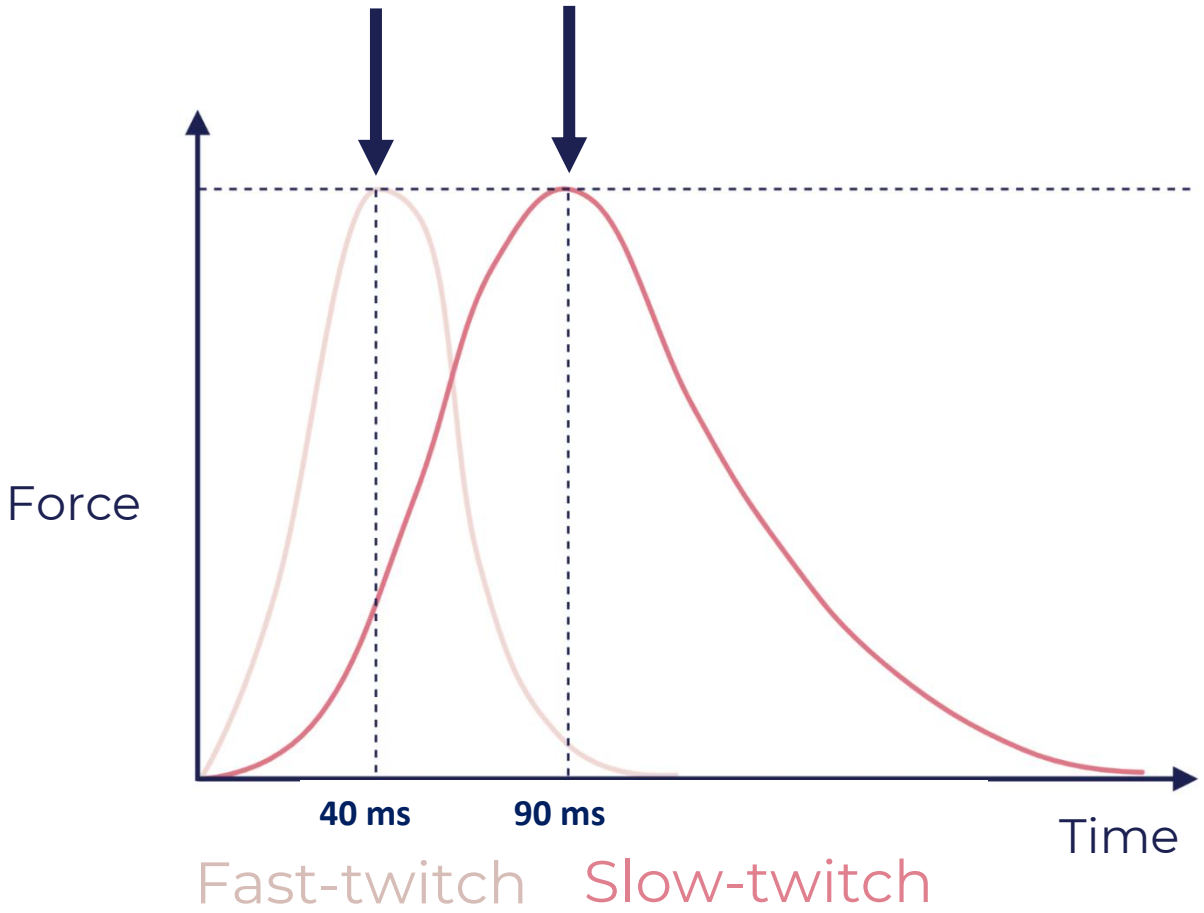

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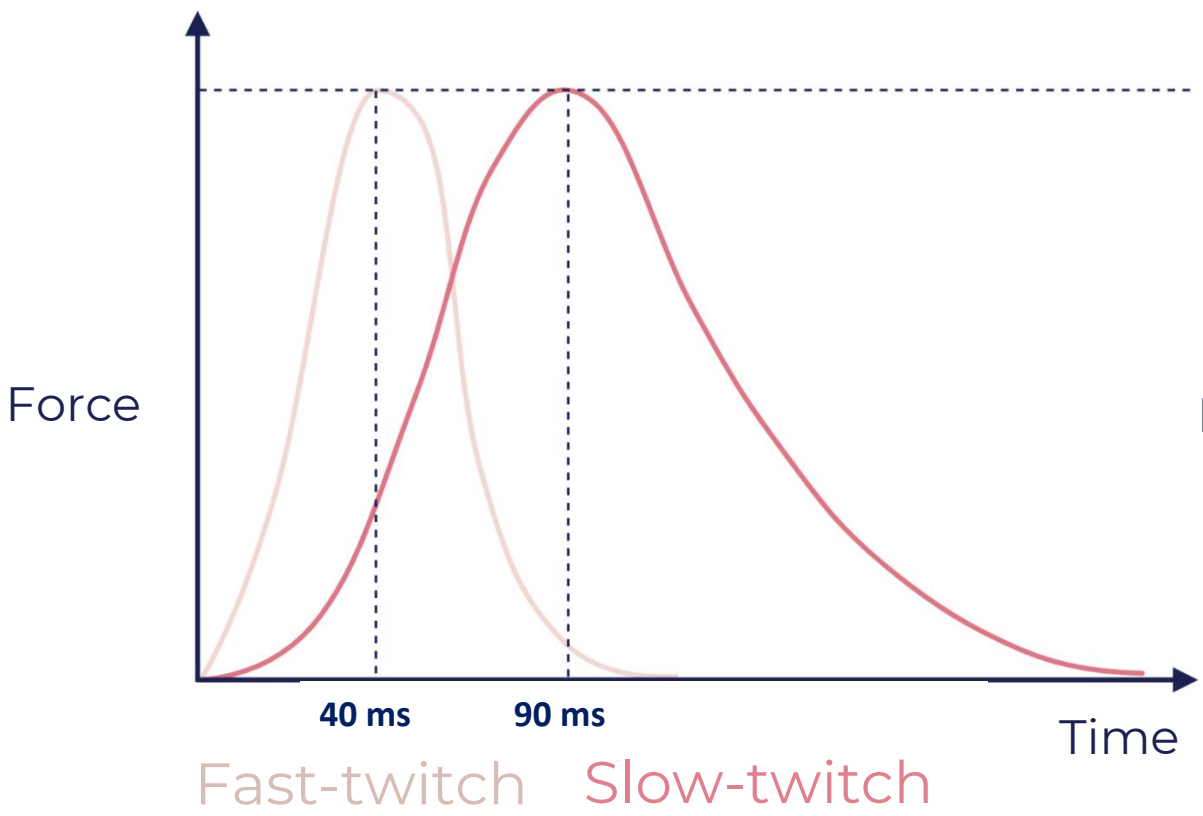

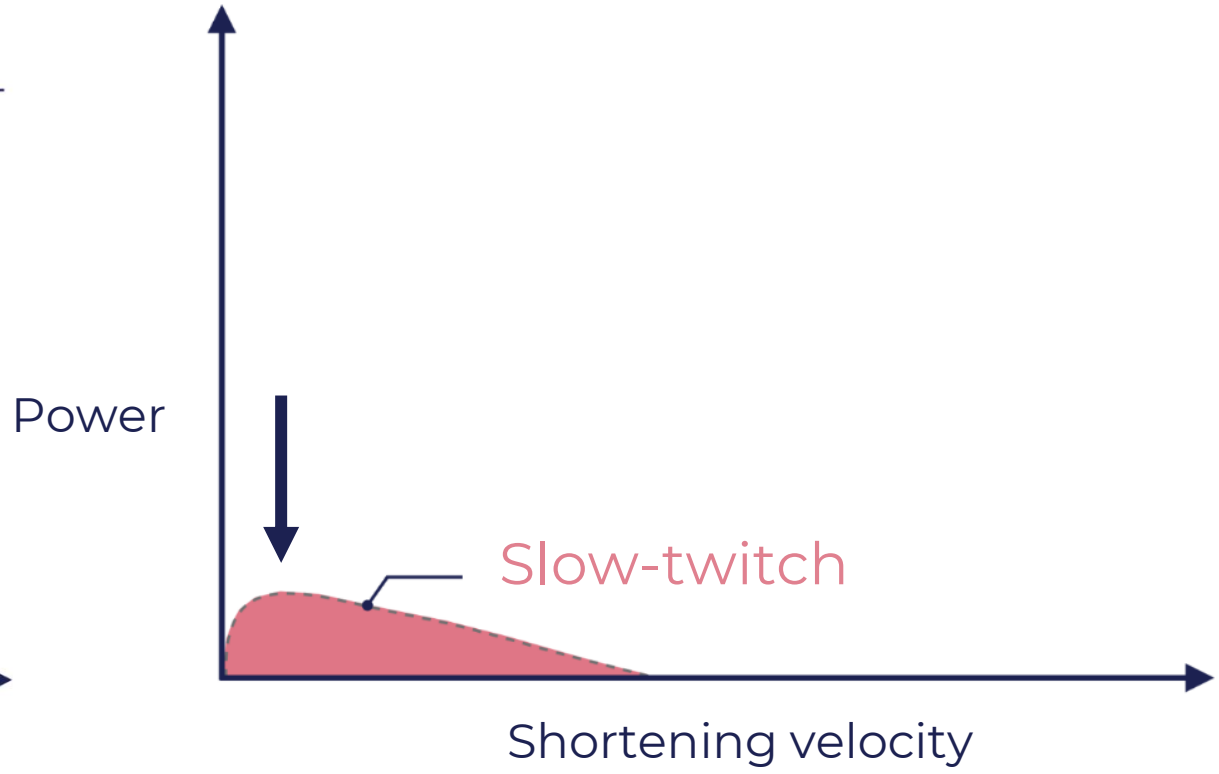

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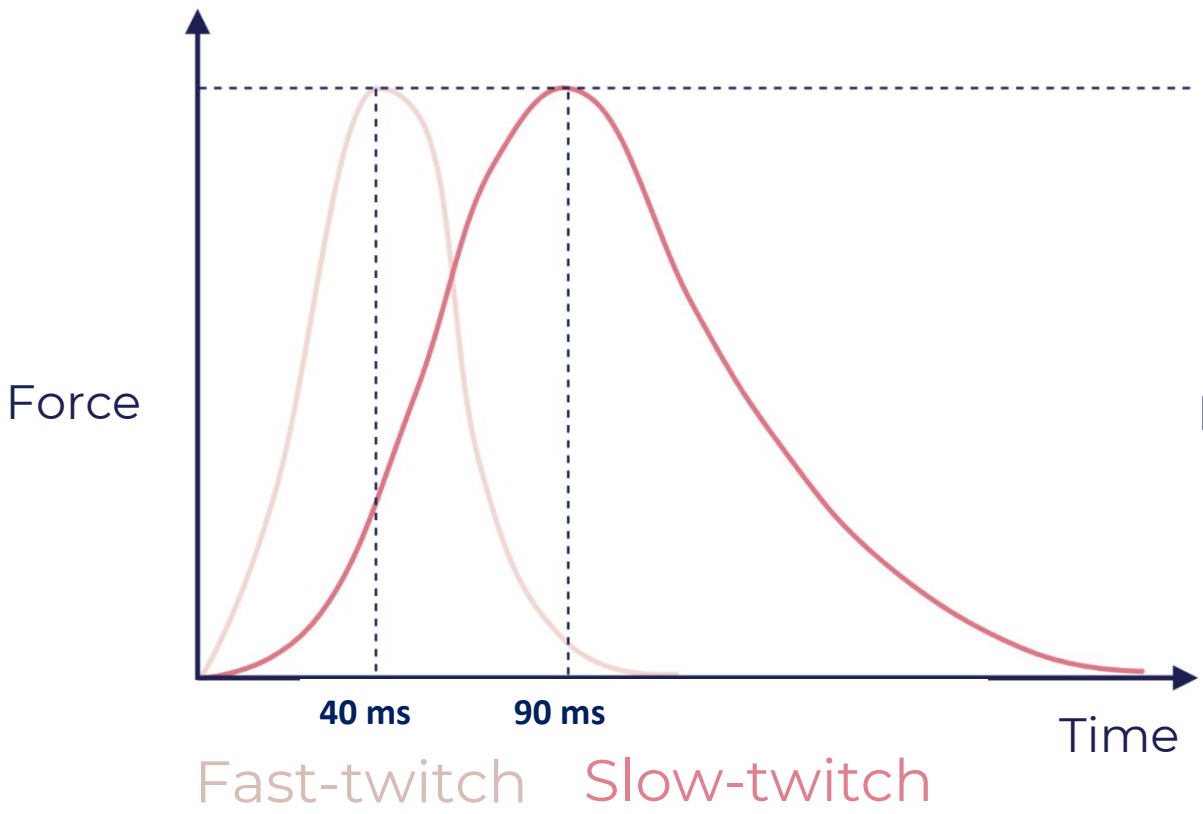
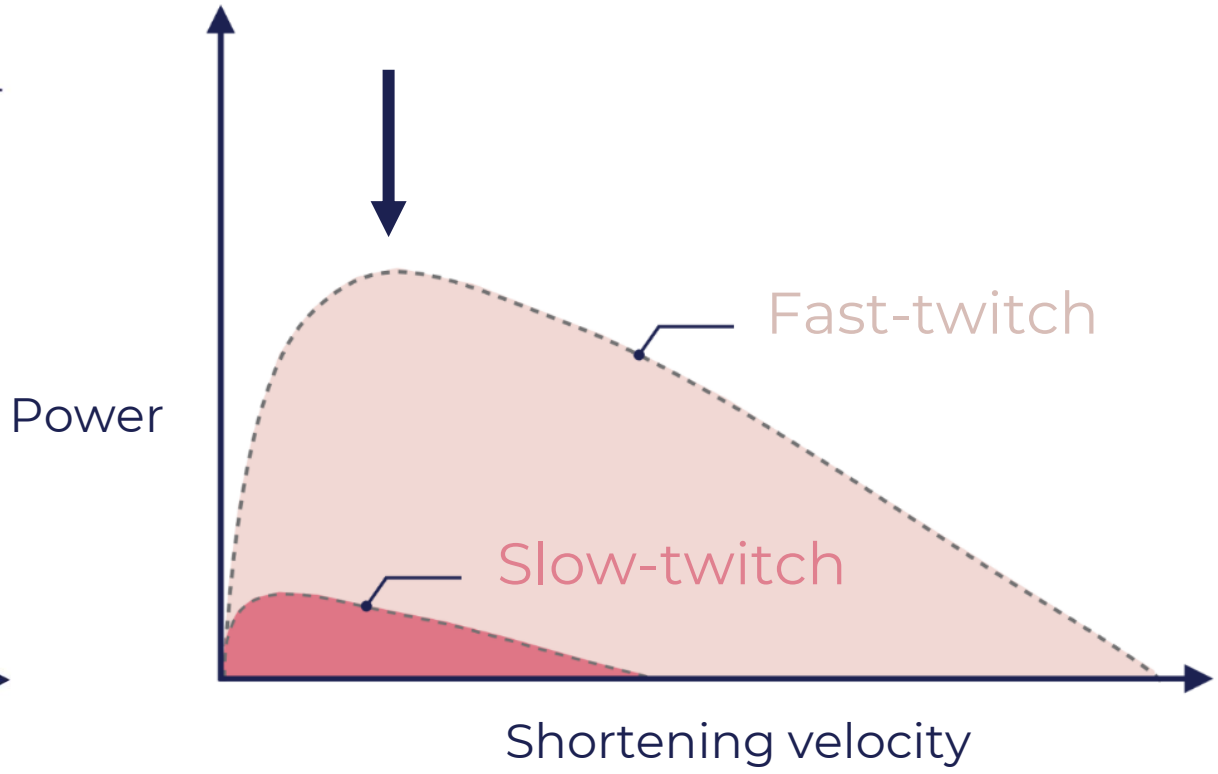
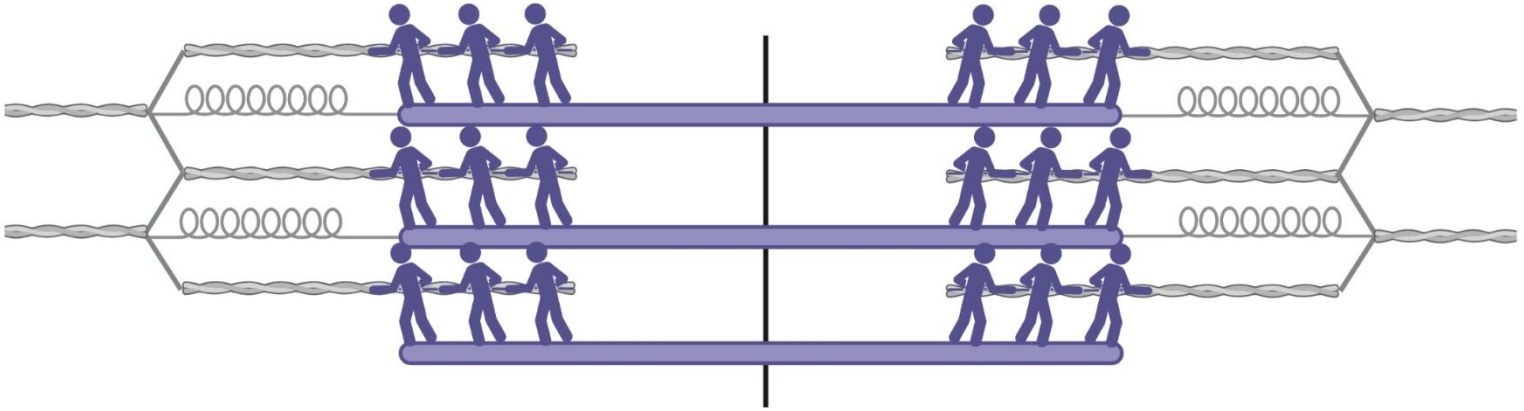




(Bottinelli, J. Physiol., 1996)

2 Slow-twitch fibers are more energy efficient



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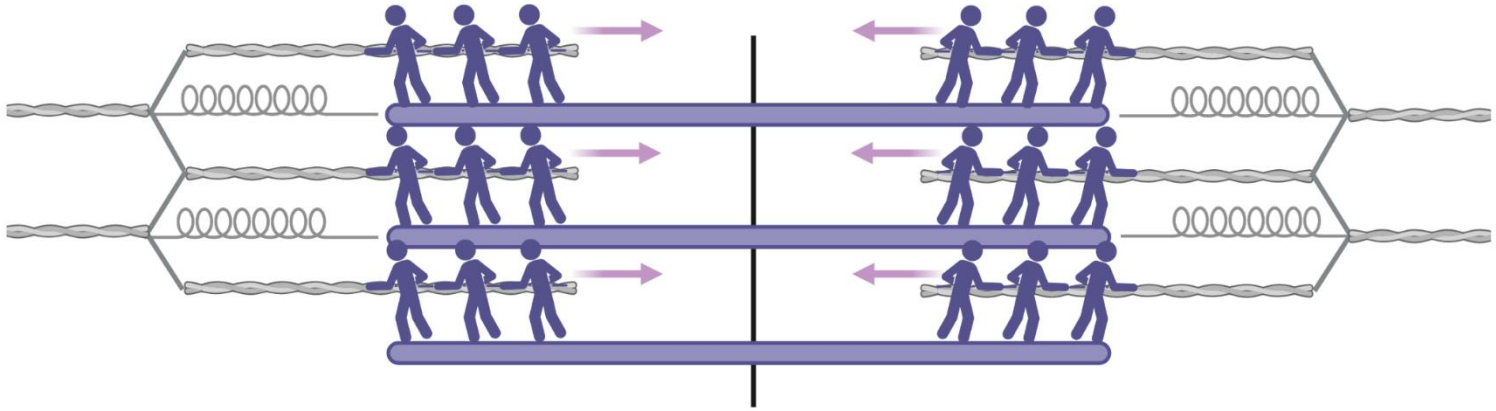
2 Slow-twitch fibers are more energy efficient



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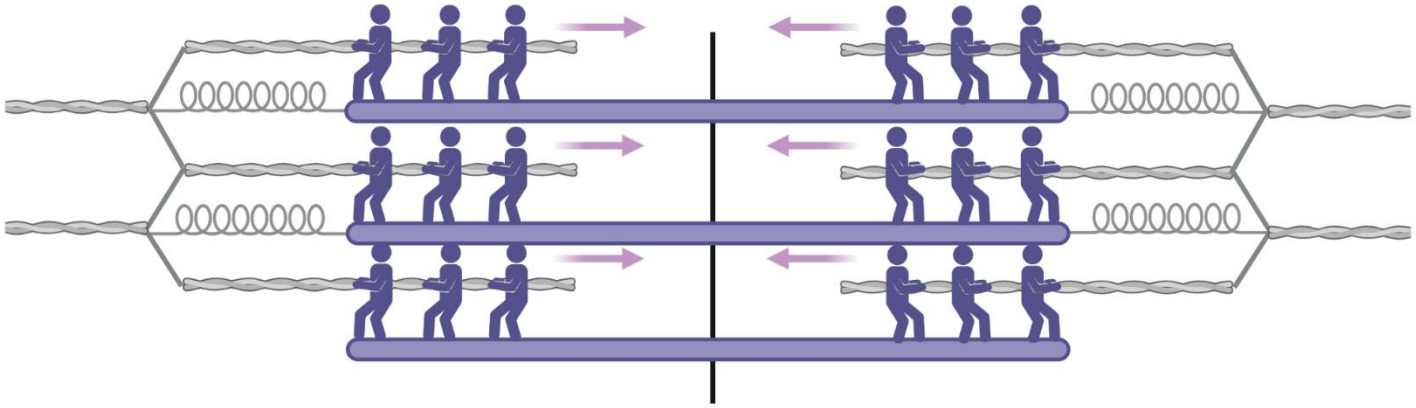

INVOICE:

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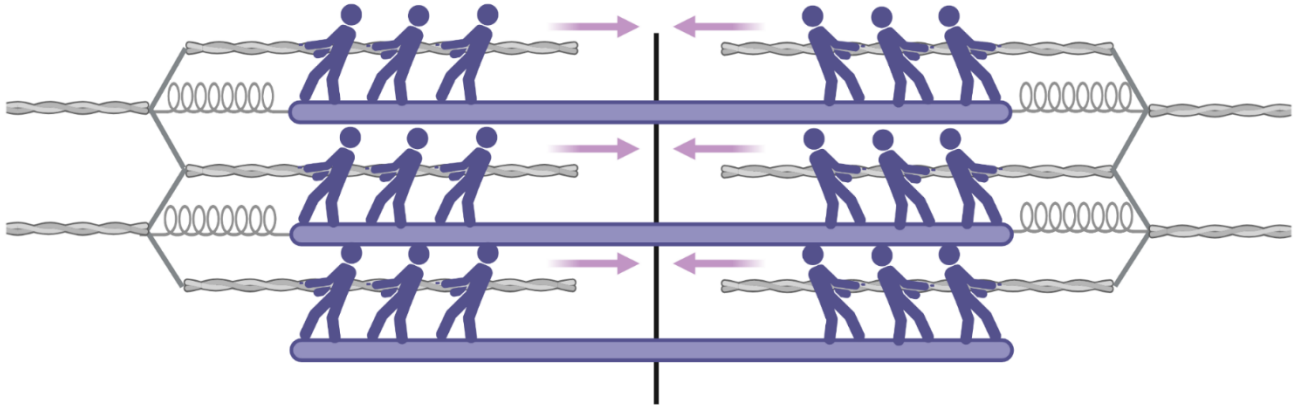

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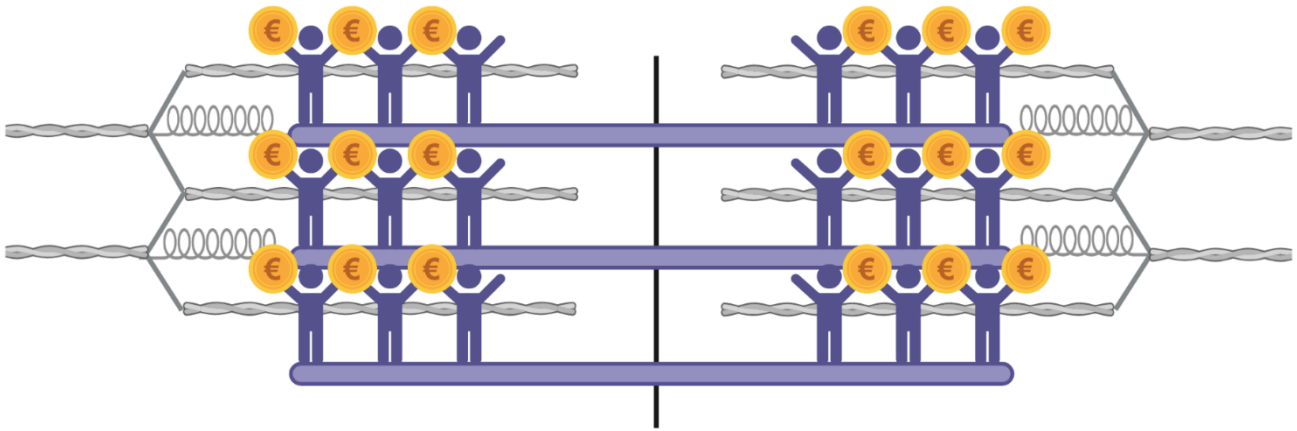

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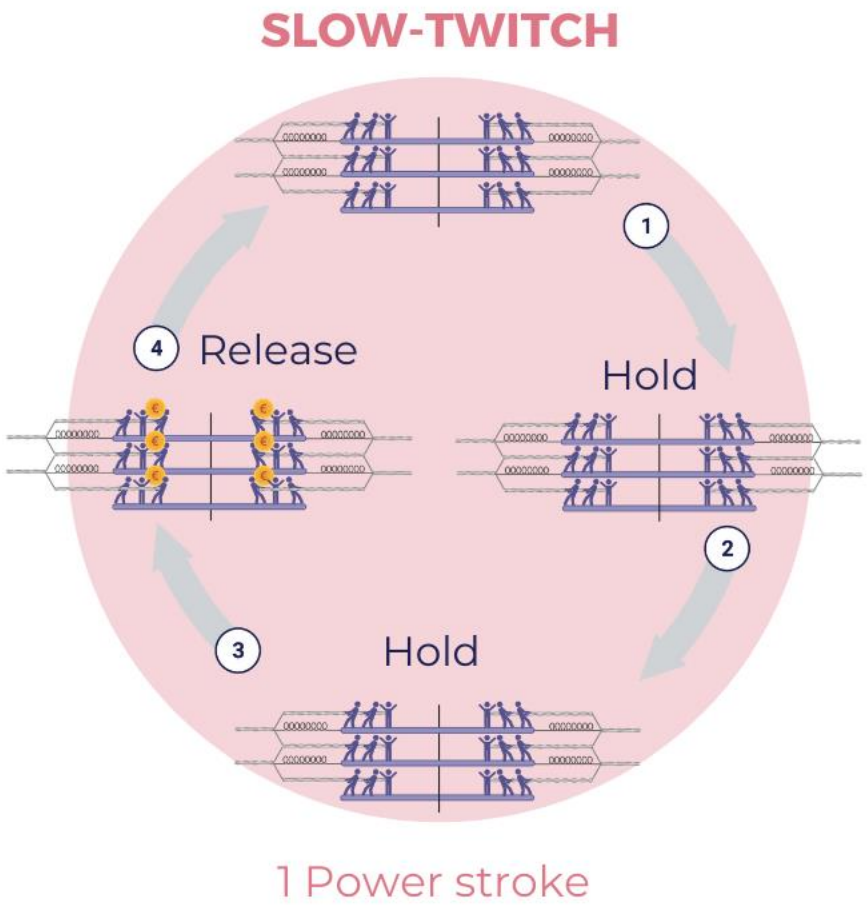

(Stienen, J. Physiol., 1996)

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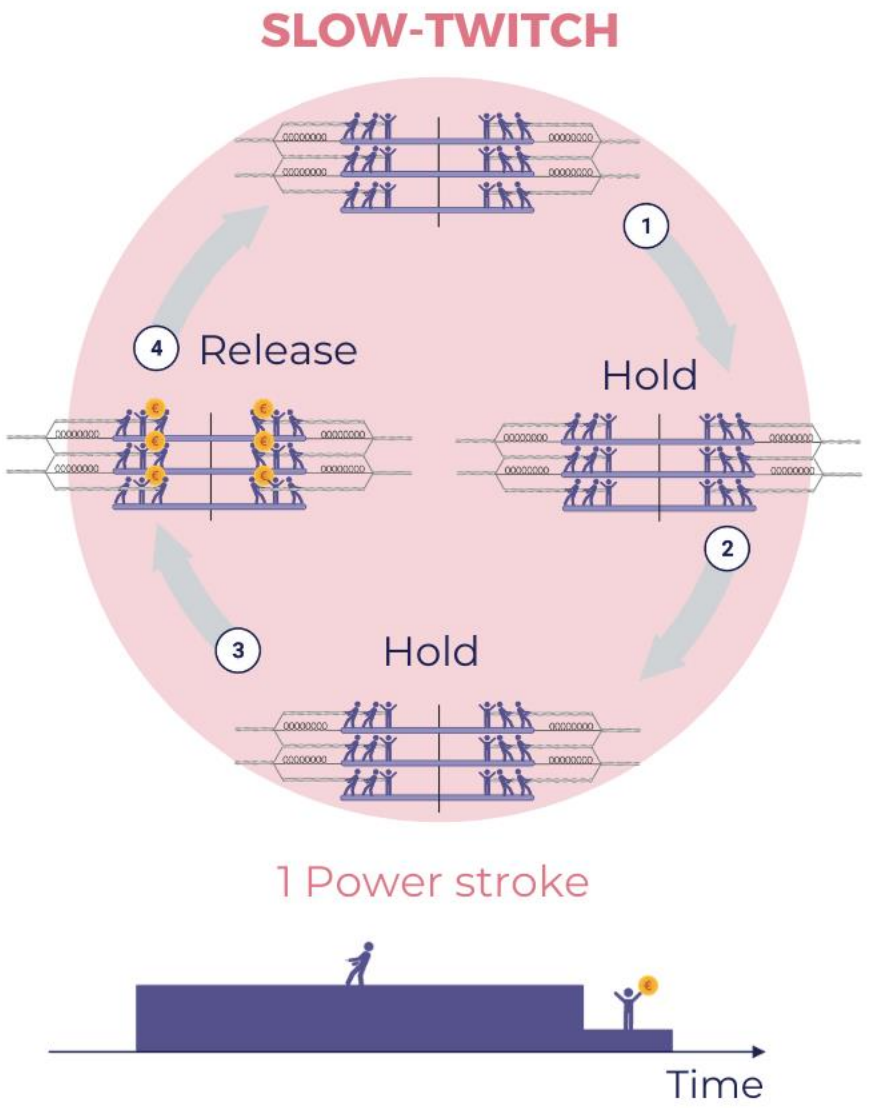

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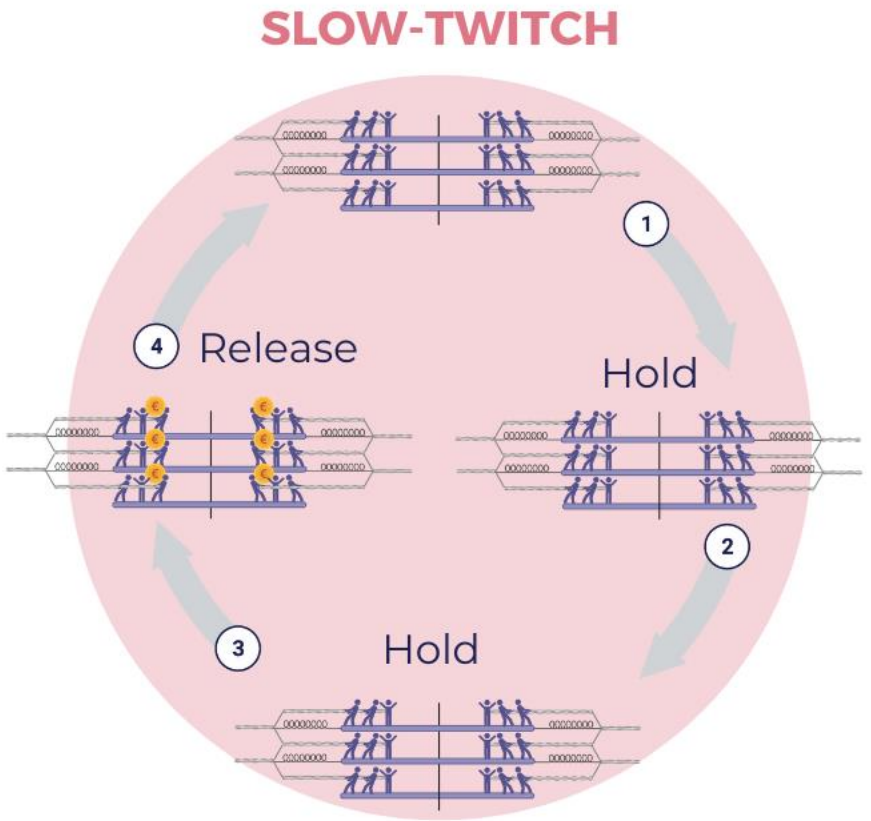
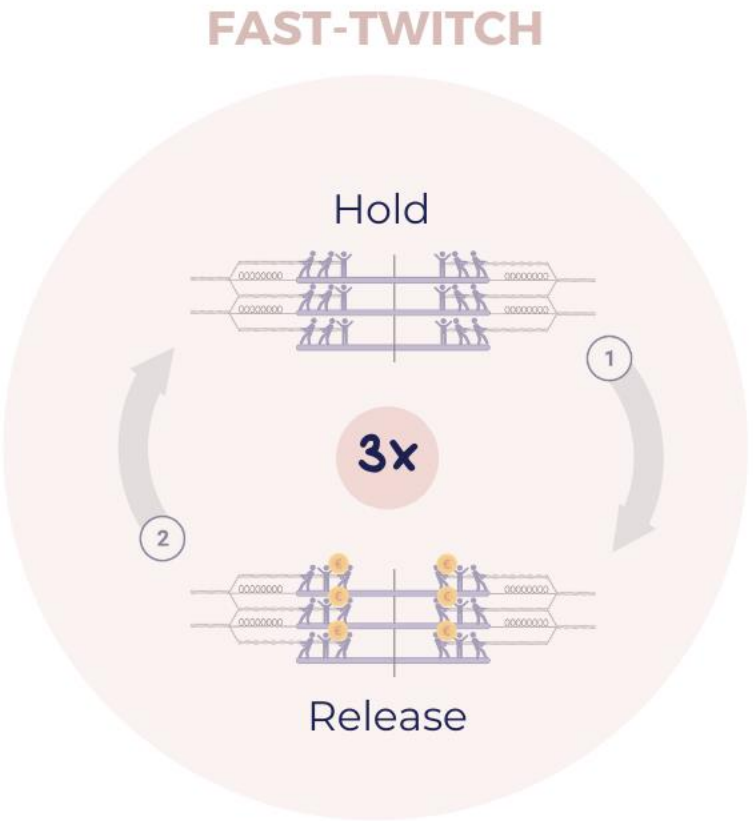
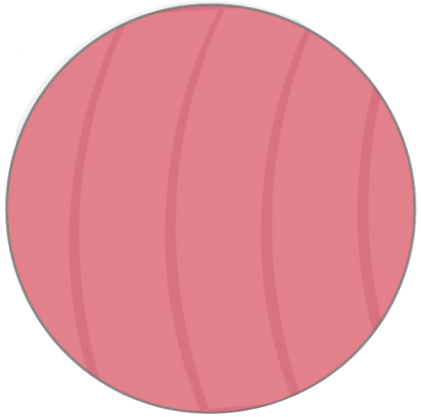




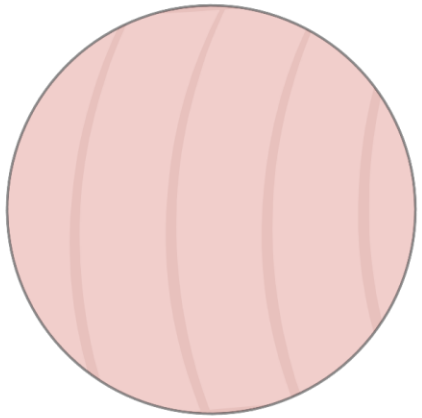
1 Power stroke

3 Power strokes

3 Fiber types use different fuels

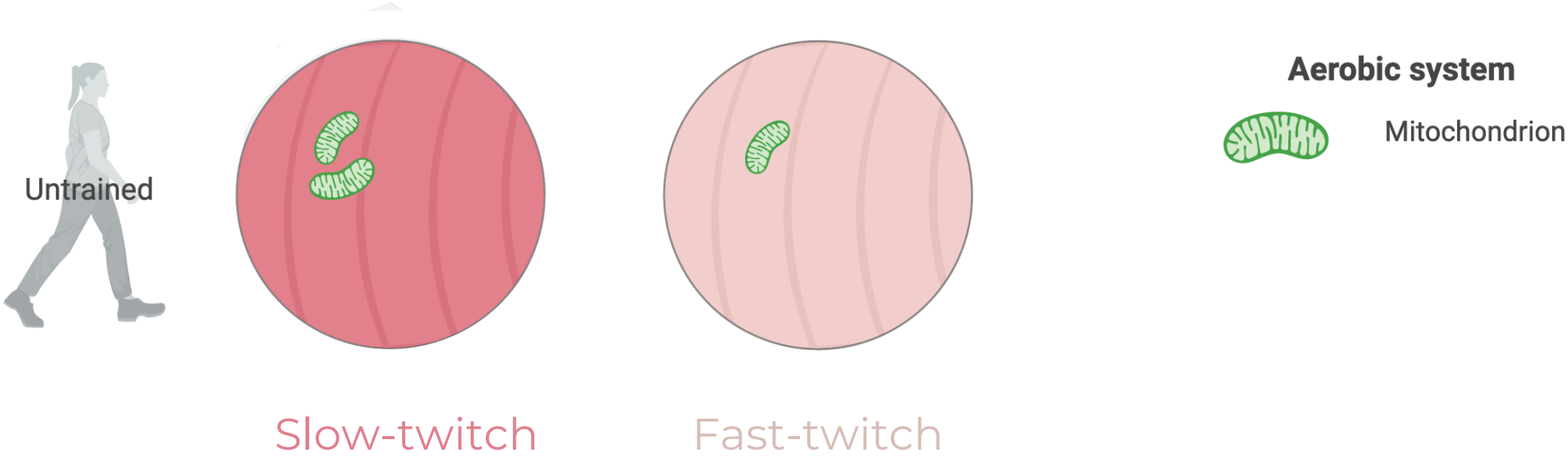


Slow-twitch



Fast-twitch

3 Fiber types use different fuels



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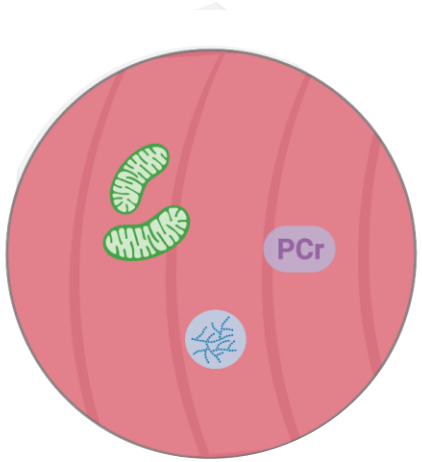
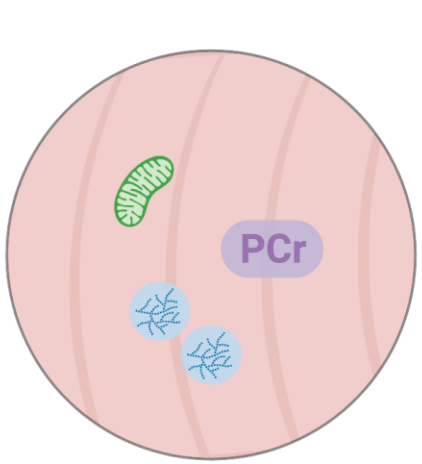


Slow-twitch



Fast-twitch

Aerobic system

Mitochondrion

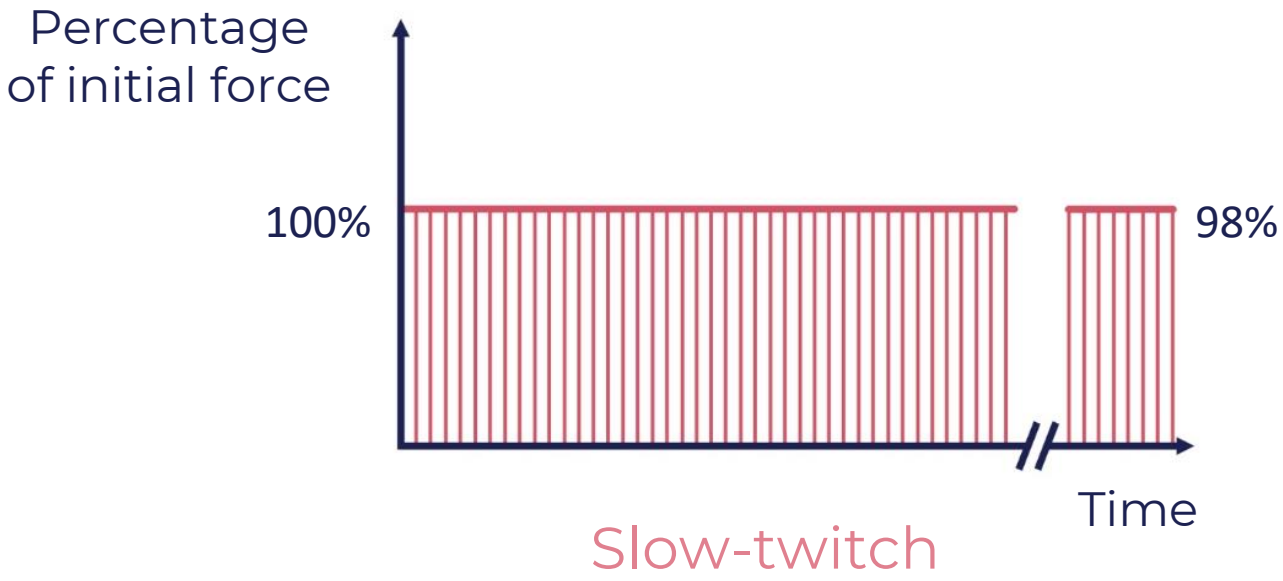
Anaerobic lactic system

Glycogen

Anaerobic alactic system

PCr Creatine phosphate

4 Slow-twitch fibers are more resistant to fatigue



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

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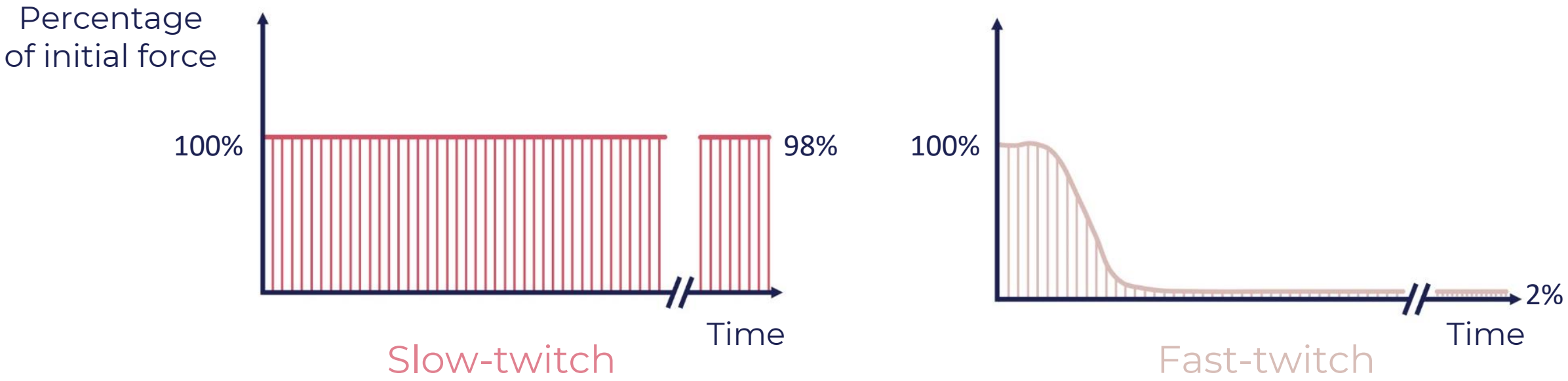

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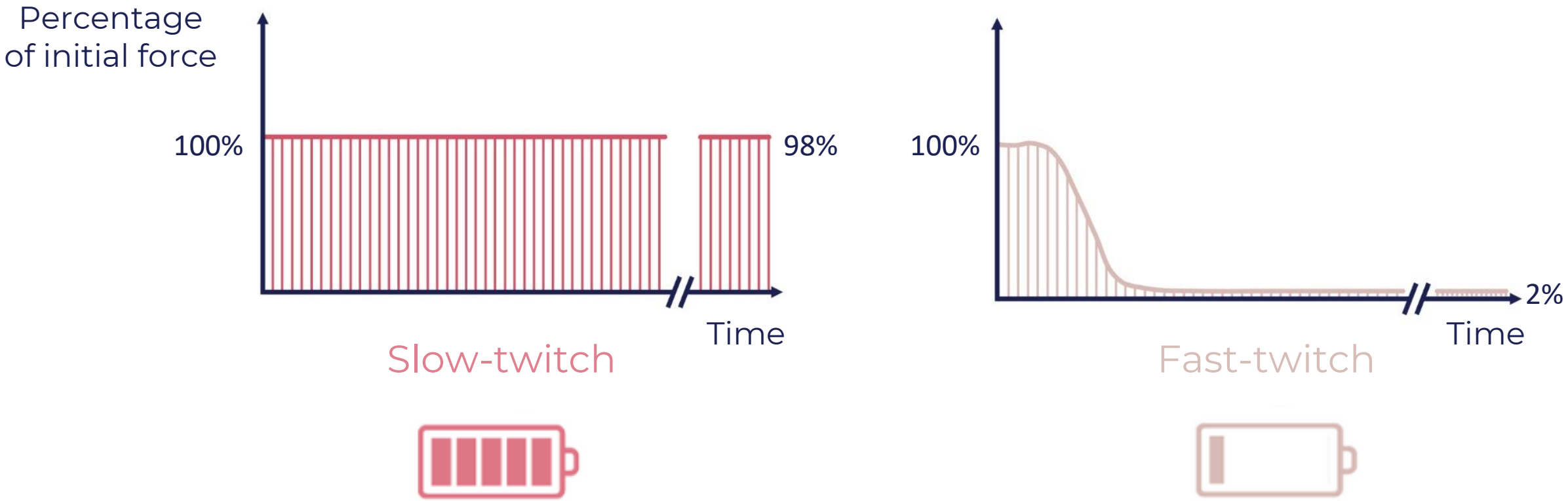

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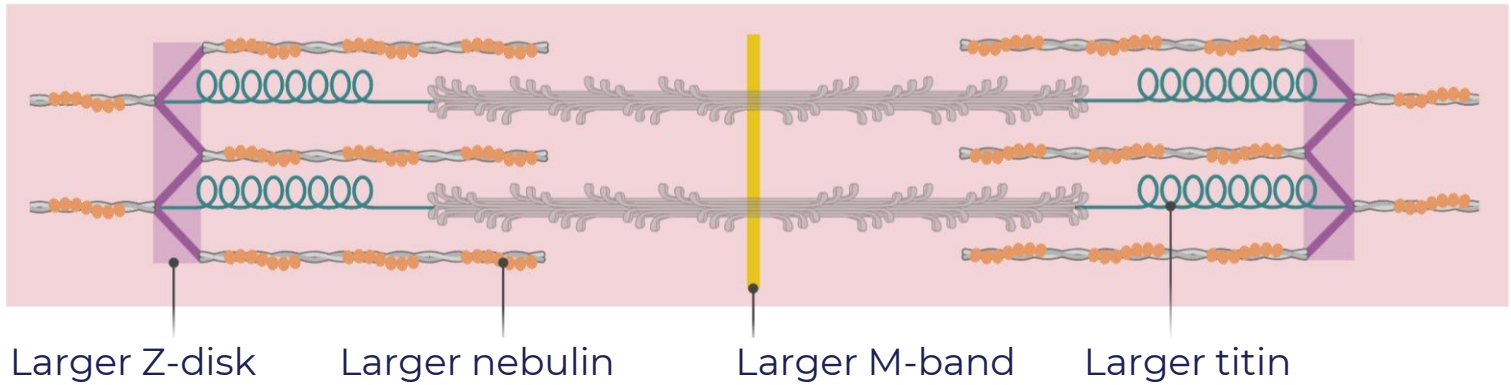
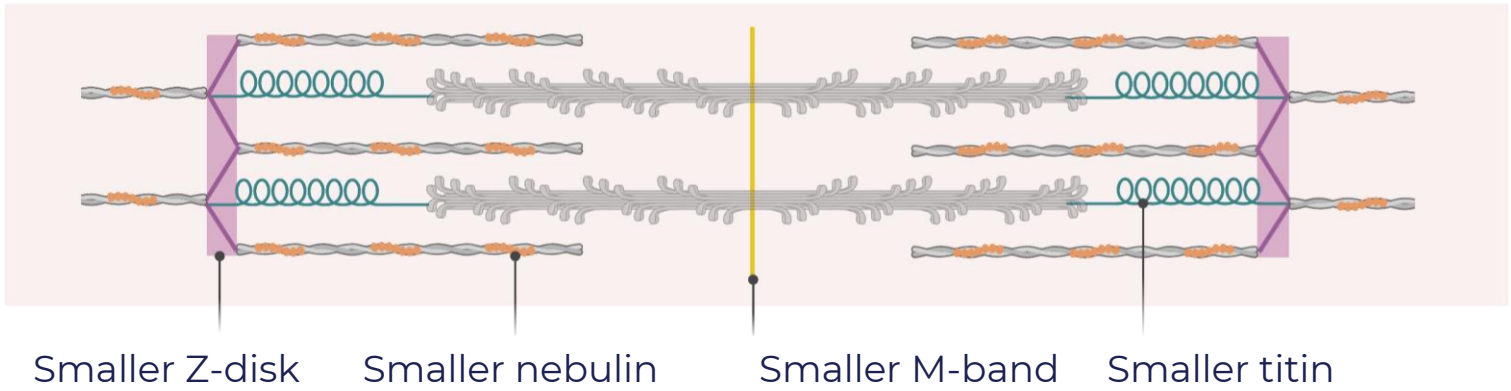
5 Slow-twitch fibers are more robust

Slow-twitch



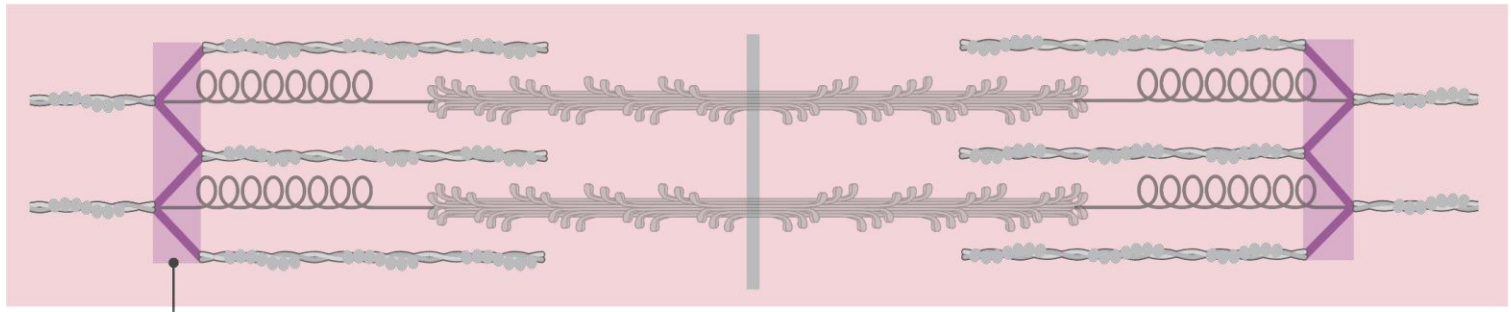
Fast-twitch



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

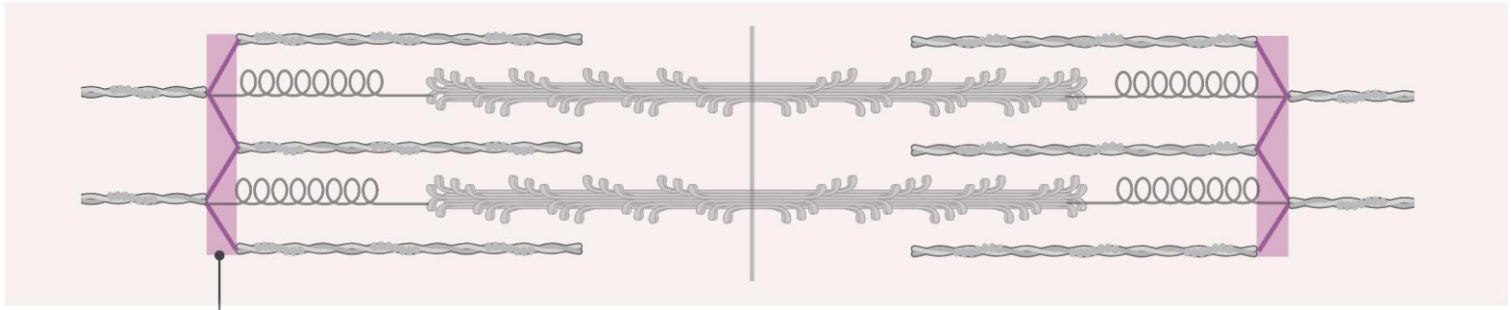
5 Slow-twitch fibers are more robust

Slow-twitch



Larger Z-disk

Fast-twitch



Smaller Z-disk

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

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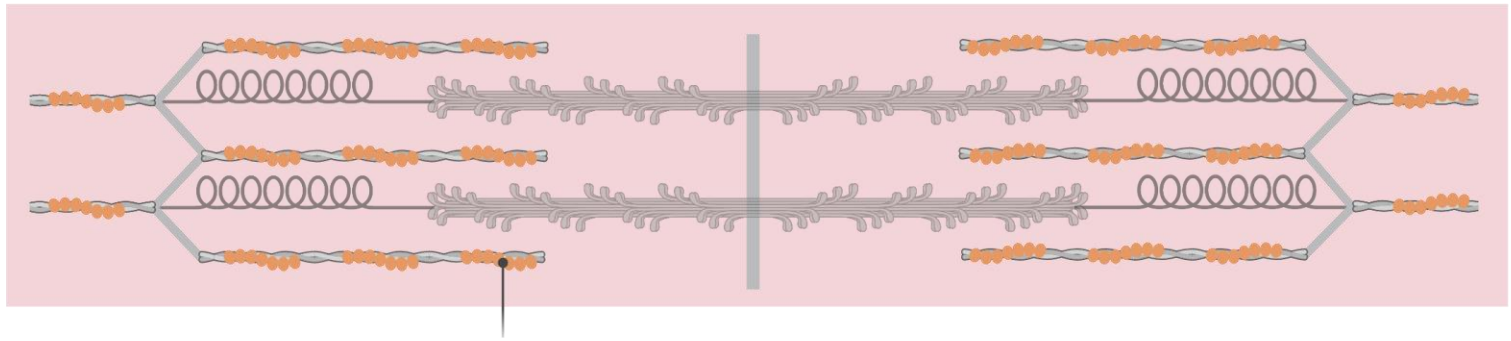
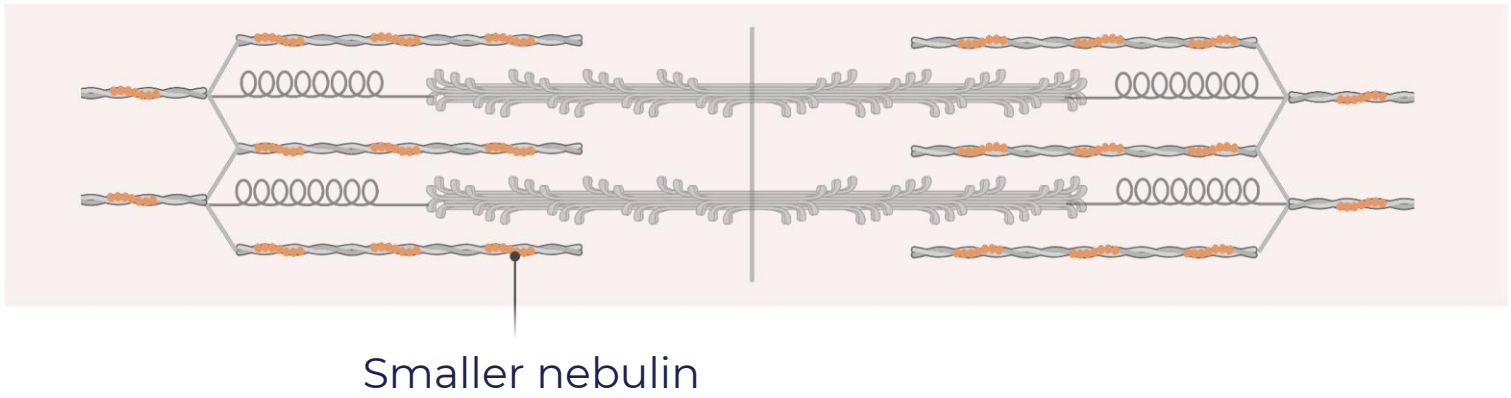
Slow-twitch



Fast-twitch



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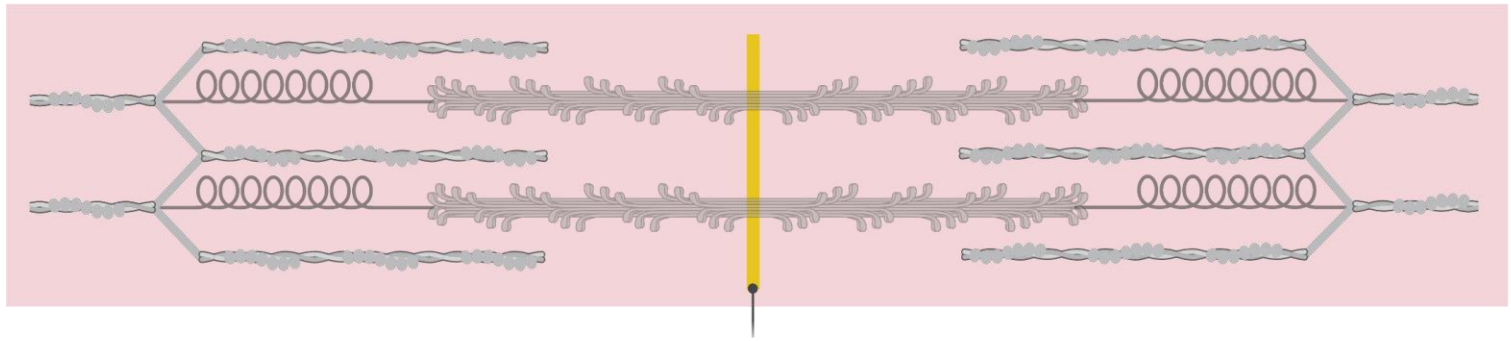
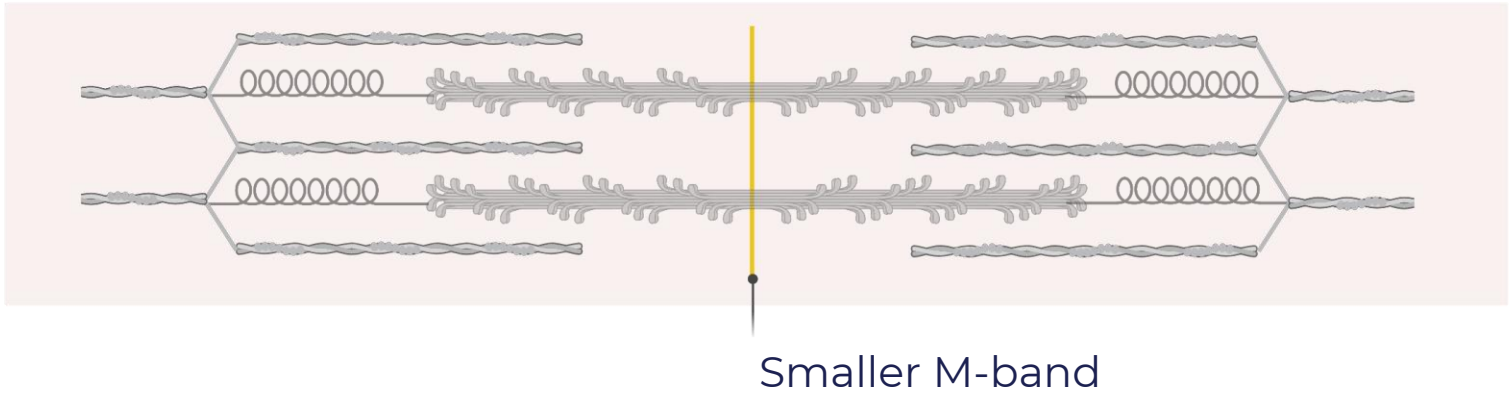
Slow-twitch



Fast-twitch



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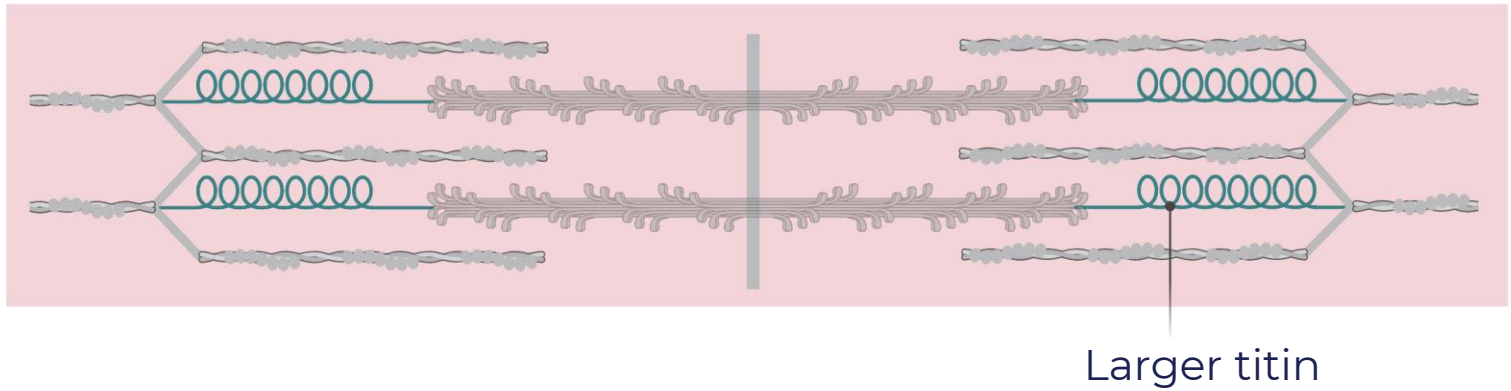
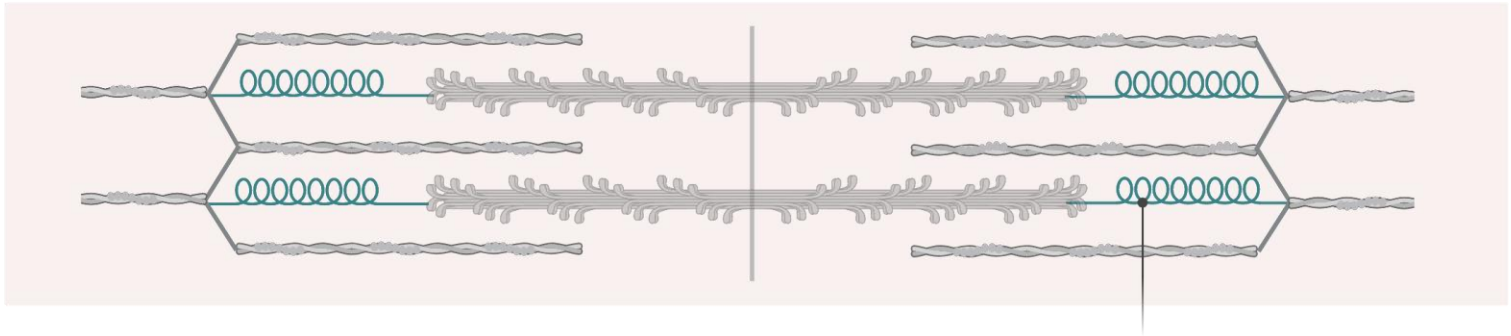
5 Slow-twitch fibers are more robust

Slow-twitch



Fast-twitch



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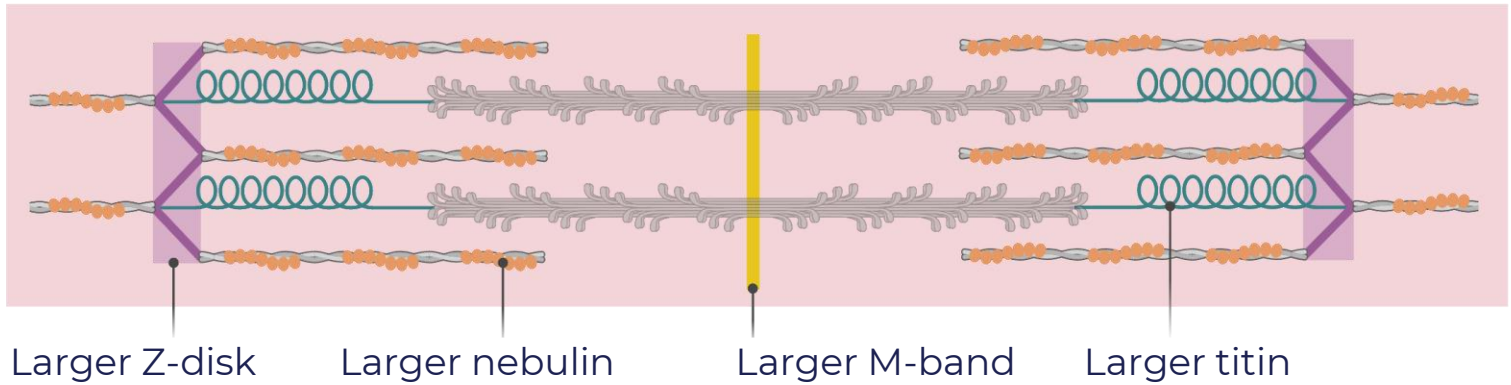
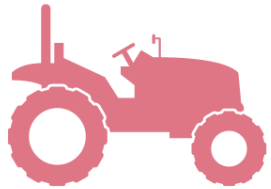
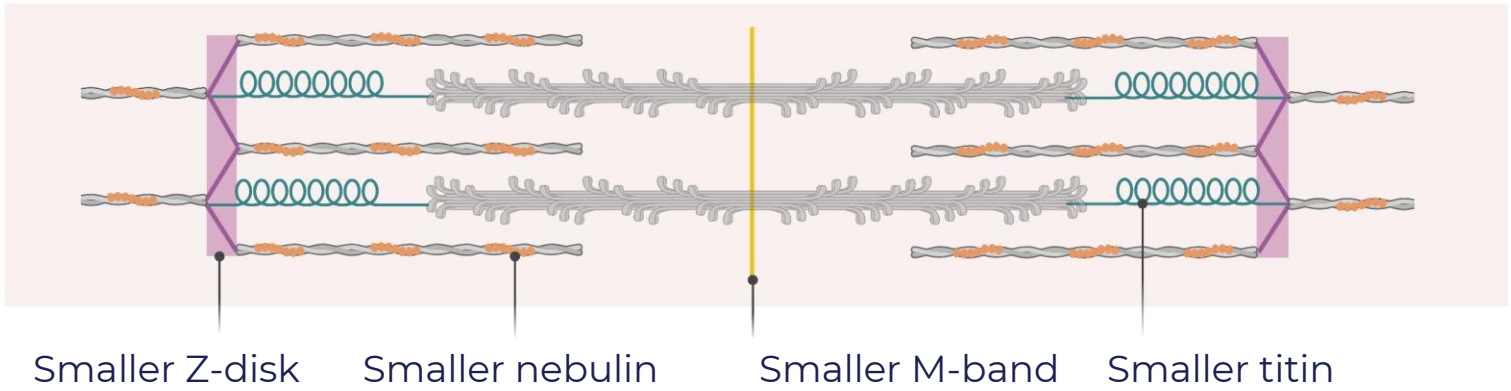
5 Slow-twitch fibers are more robust

Slow-twitch





Fast-twitch



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

INTERMEDIATE SUMMARY

1

2

3

4

5

INTERMEDIATE SUMMARY

SLOW-TWITCH
muscle fiber

FAST-TWITCH
muscle fiber

1. Generate more power
2.
3.
4.
5.

INTERMEDIATE SUMMARY

SLOW-TWITCH
muscle fiber

FAST-TWITCH
muscle fiber

1. Generate more power
2. More efficient
3.
4.
5.

INTERMEDIATE SUMMARY

SLOW-TWITCH
muscle fiber

FAST-TWITCH
muscle fiber

1. Generate more power
2. More efficient
3. Aerobic metabolism
4. Anaerobic metabolism PCr
5.

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	
	5	

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	
Better structural integrity	5	

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	
Better structural integrity	5	

Low-intensity & long-lasting activity

Fast & powerful actions

CHAPTER I

Muscle physiology

CHAPTER II

Evolution

Species

Rat

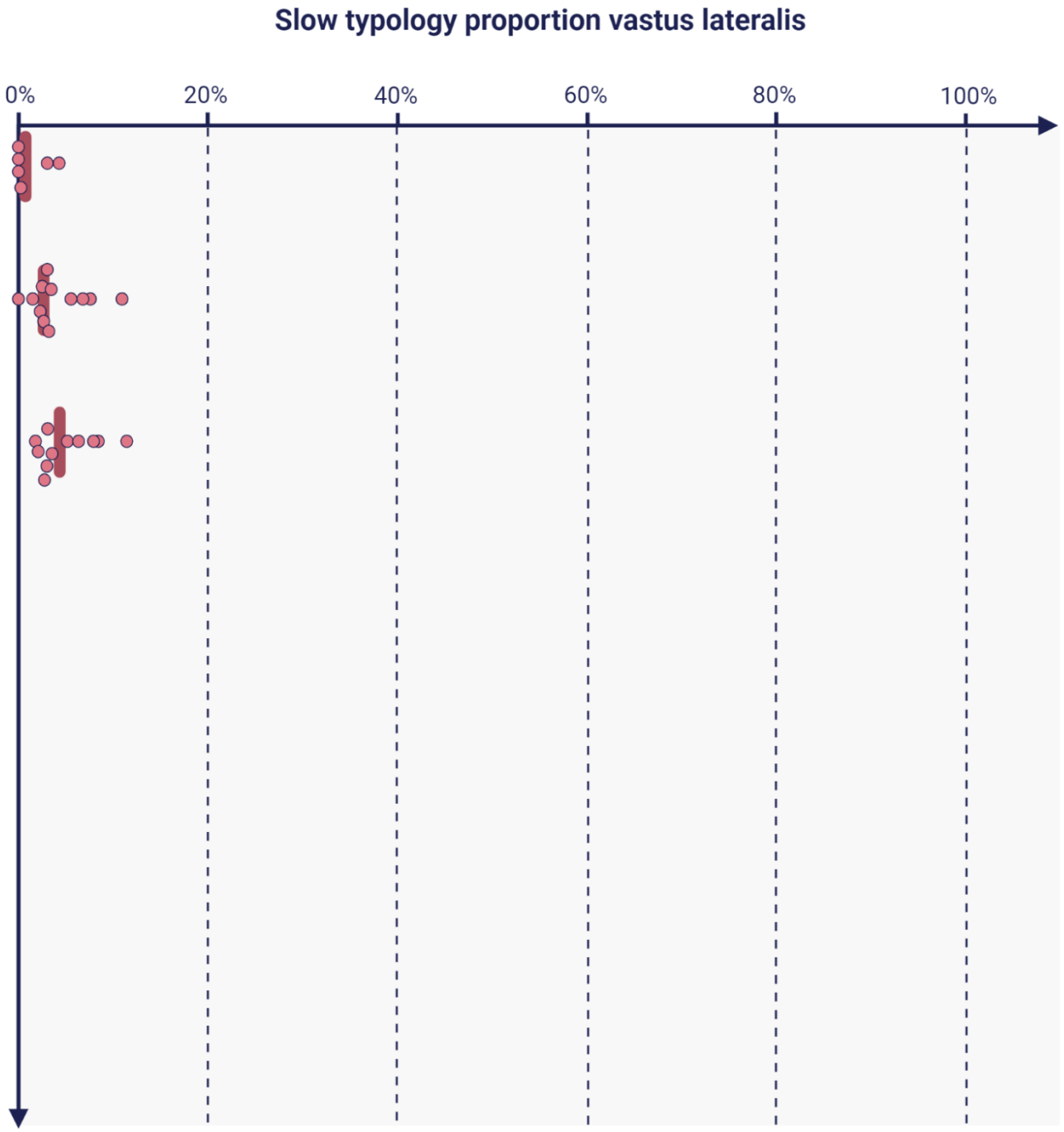
(Eng et al., 2008)

Blesbok

(Kohn, 2014)

Springbok

(Curry et al., 2014)



Species

Rat

(Eng et al., 2008)

Blesbok

(Kohn, 2014)

Springbok

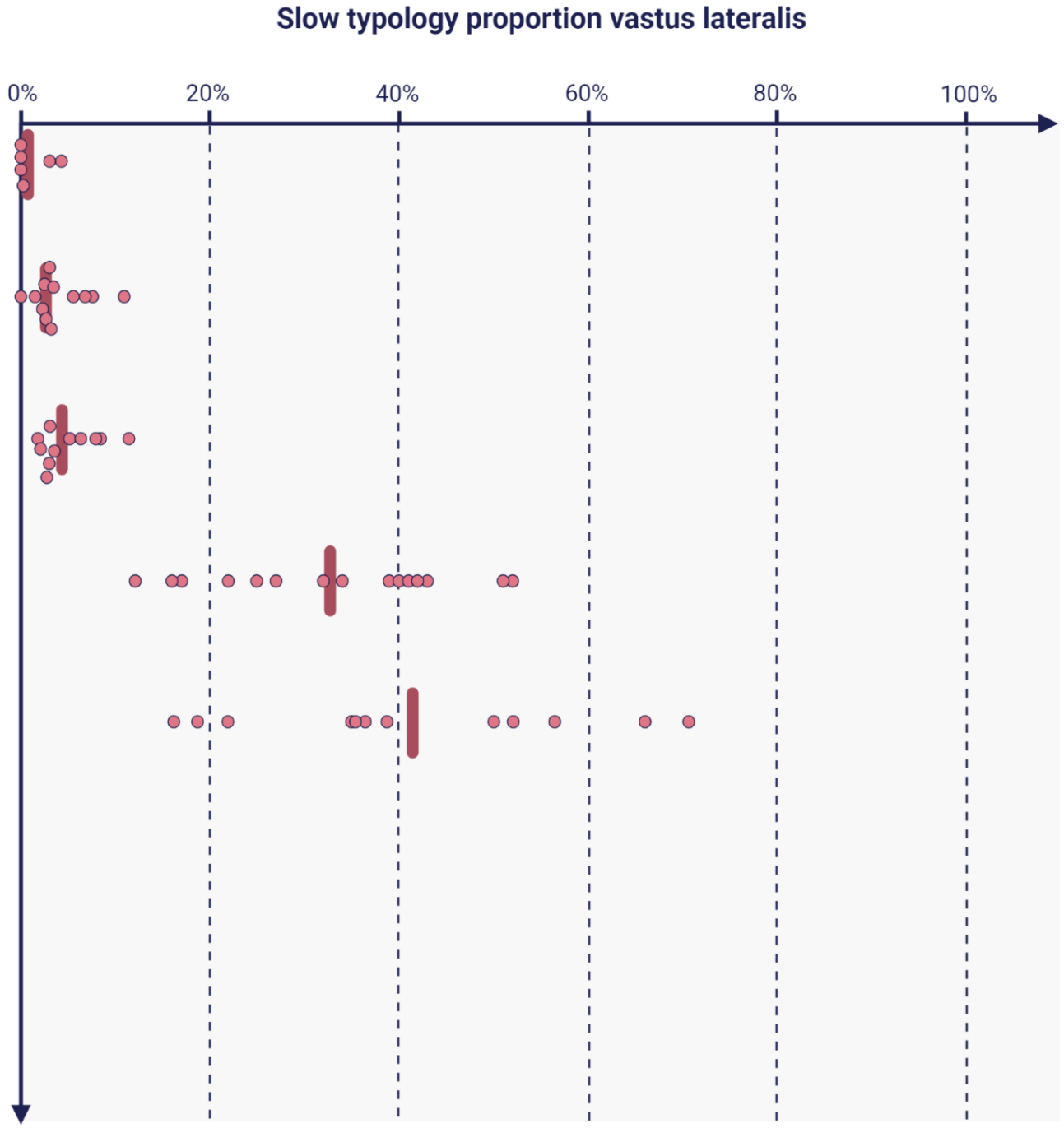
(Curry et al., 2014)

Cape baboon

(Leith et al., 2020)

Chimpanzee

(Bozek et al., 2014;
O'Neill et al., 2017)



Species

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(Eng et al., 2008)

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Cape baboon

(Leith et al., 2020)

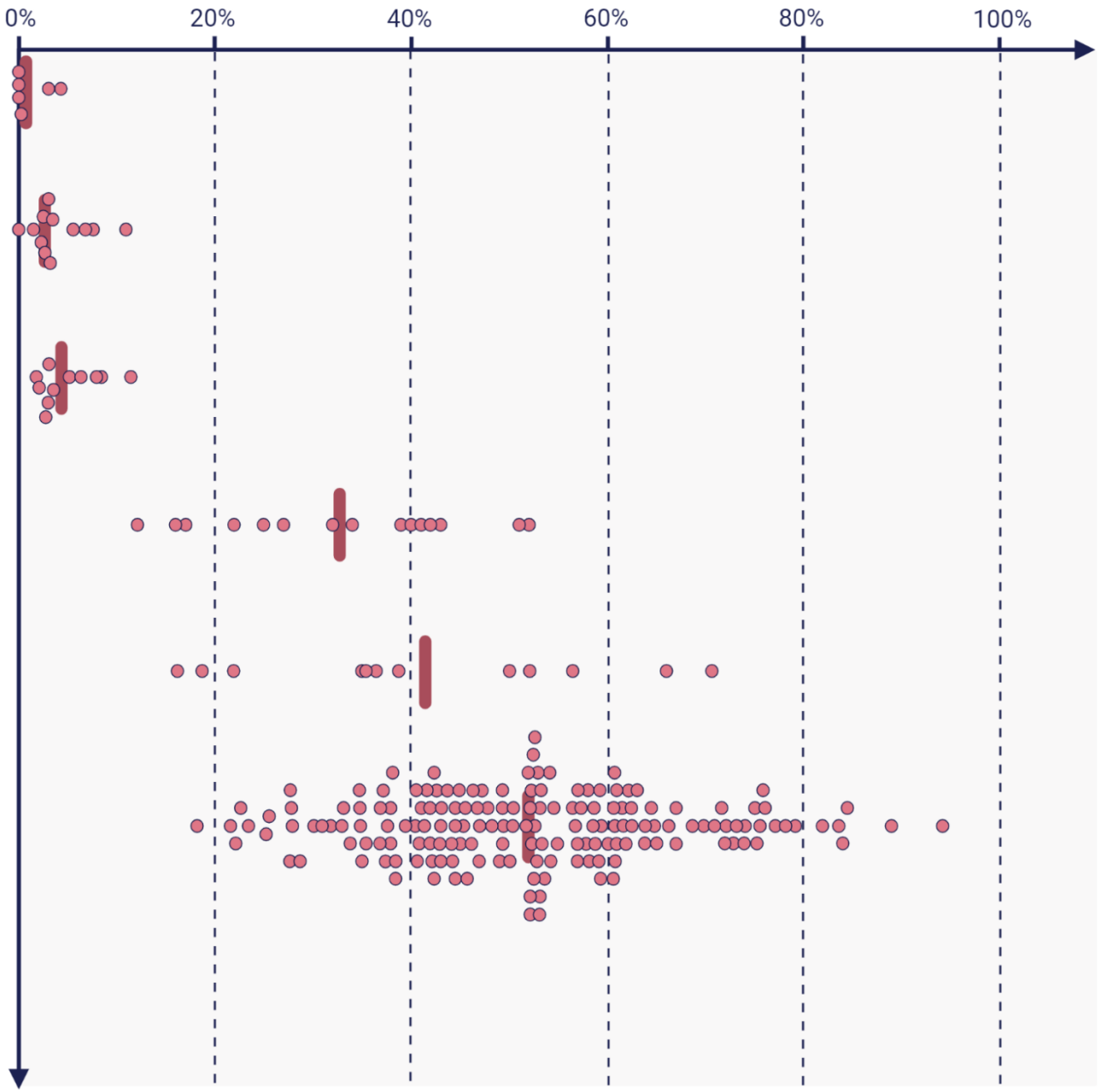
Chimpanzee

(Bozek et al., 2014;
O'Neill et al., 2017)

Human

(Hall et al., 2021)

Slow typology proportion vastus lateralis



Species

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Springbok

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Cape baboon

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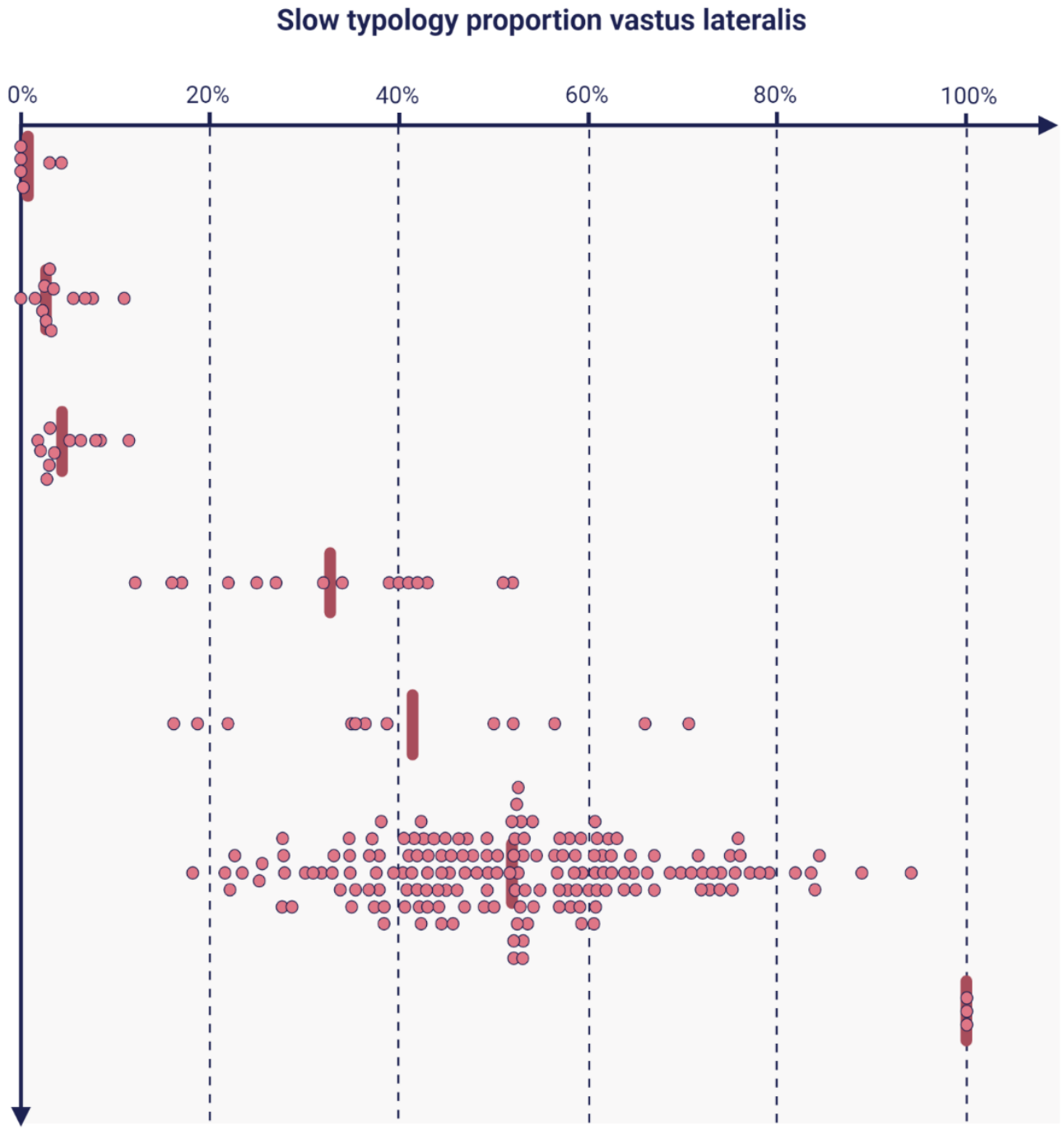
Chimpanzee

(Bozek et al., 2014;
O'Neill et al., 2017)

Human

(Hall et al., 2021)

Sloth
(Spainhower et al., 2021)

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09:00
5 KM


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10KM


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15KM


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12:00
20KM


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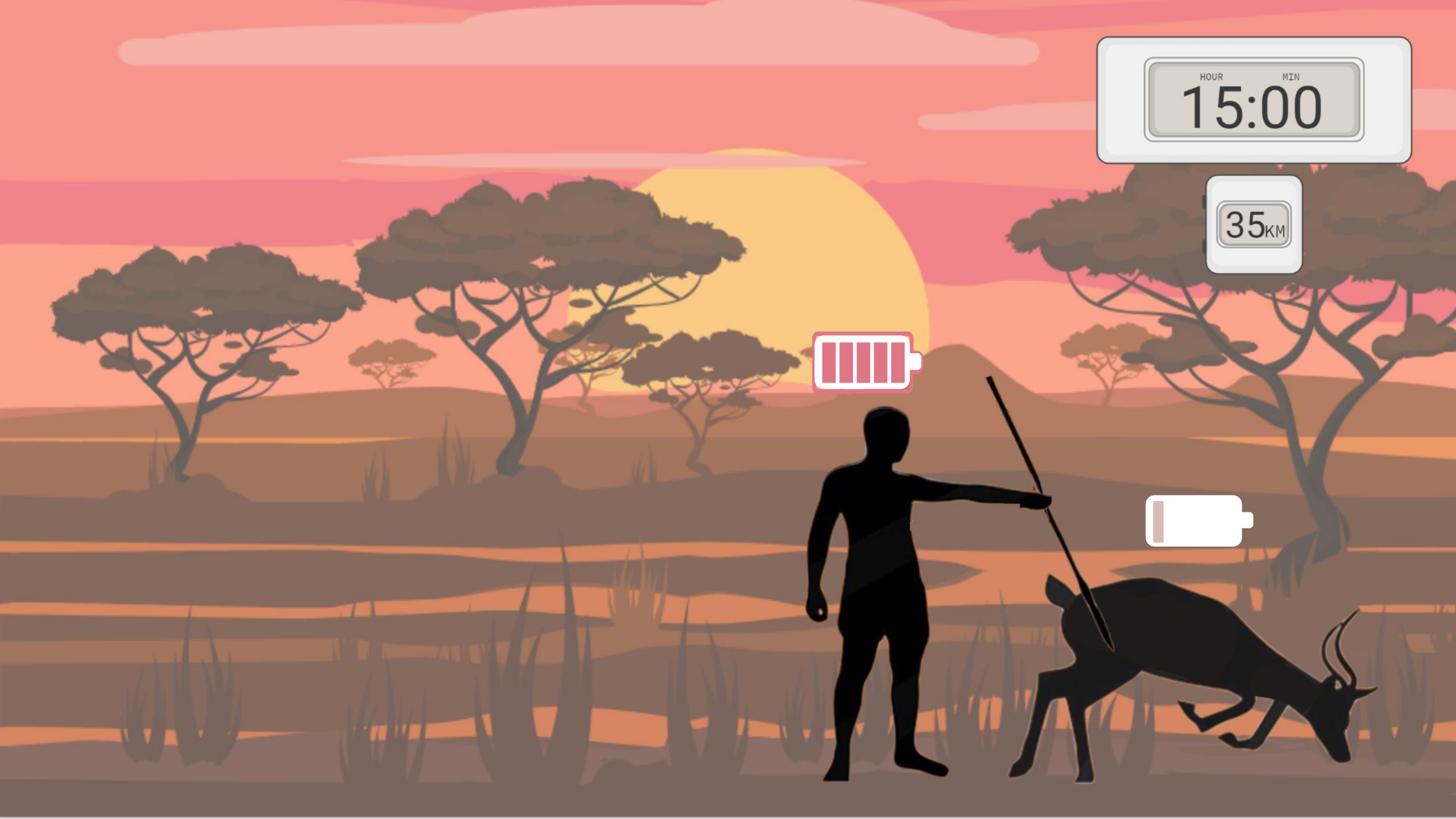
13:00
25KM


HOUR
MIN
14:00
30KM


HOUR
MIN
15:00
35KM

Species

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(Eng et al., 2008)

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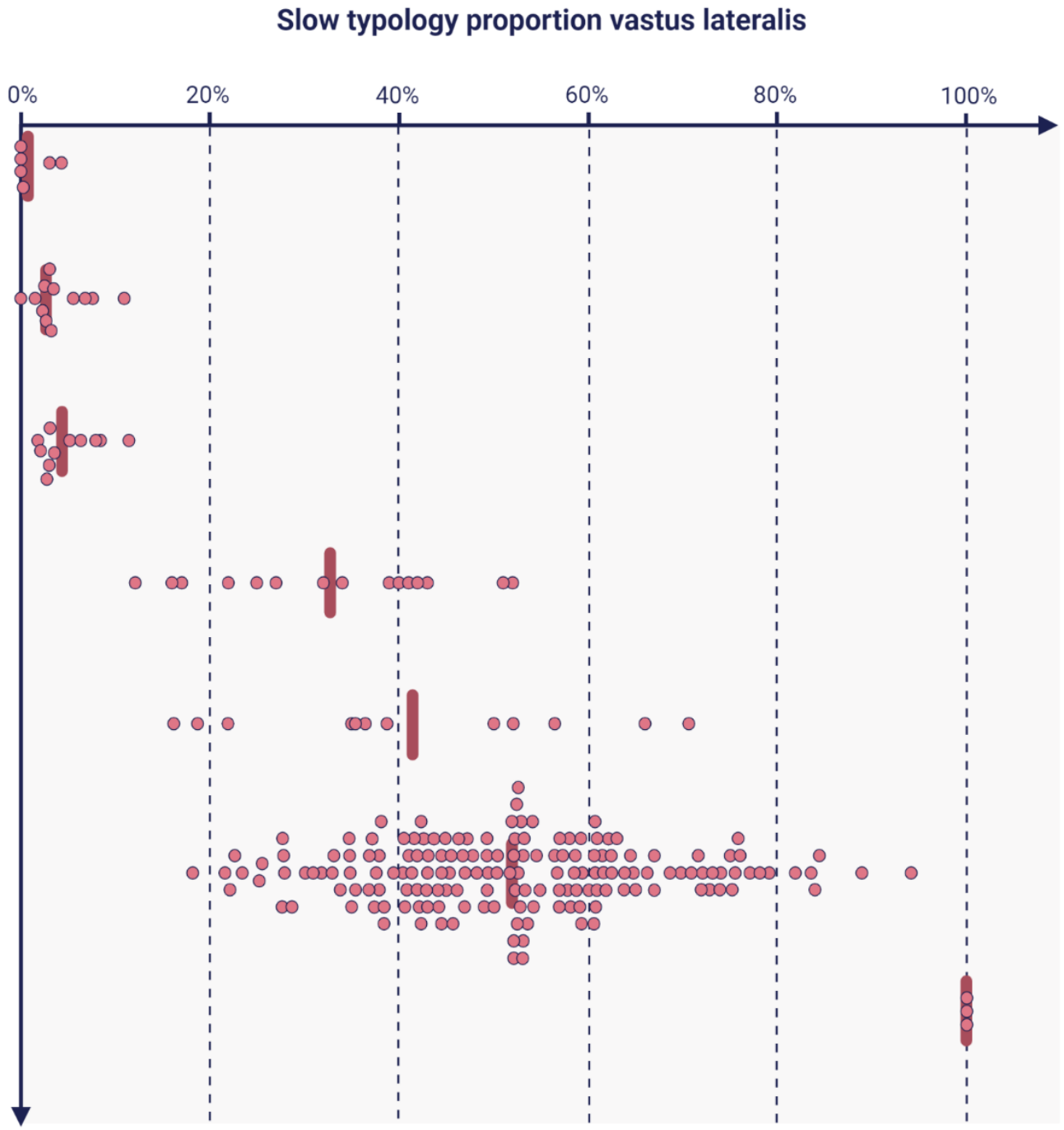
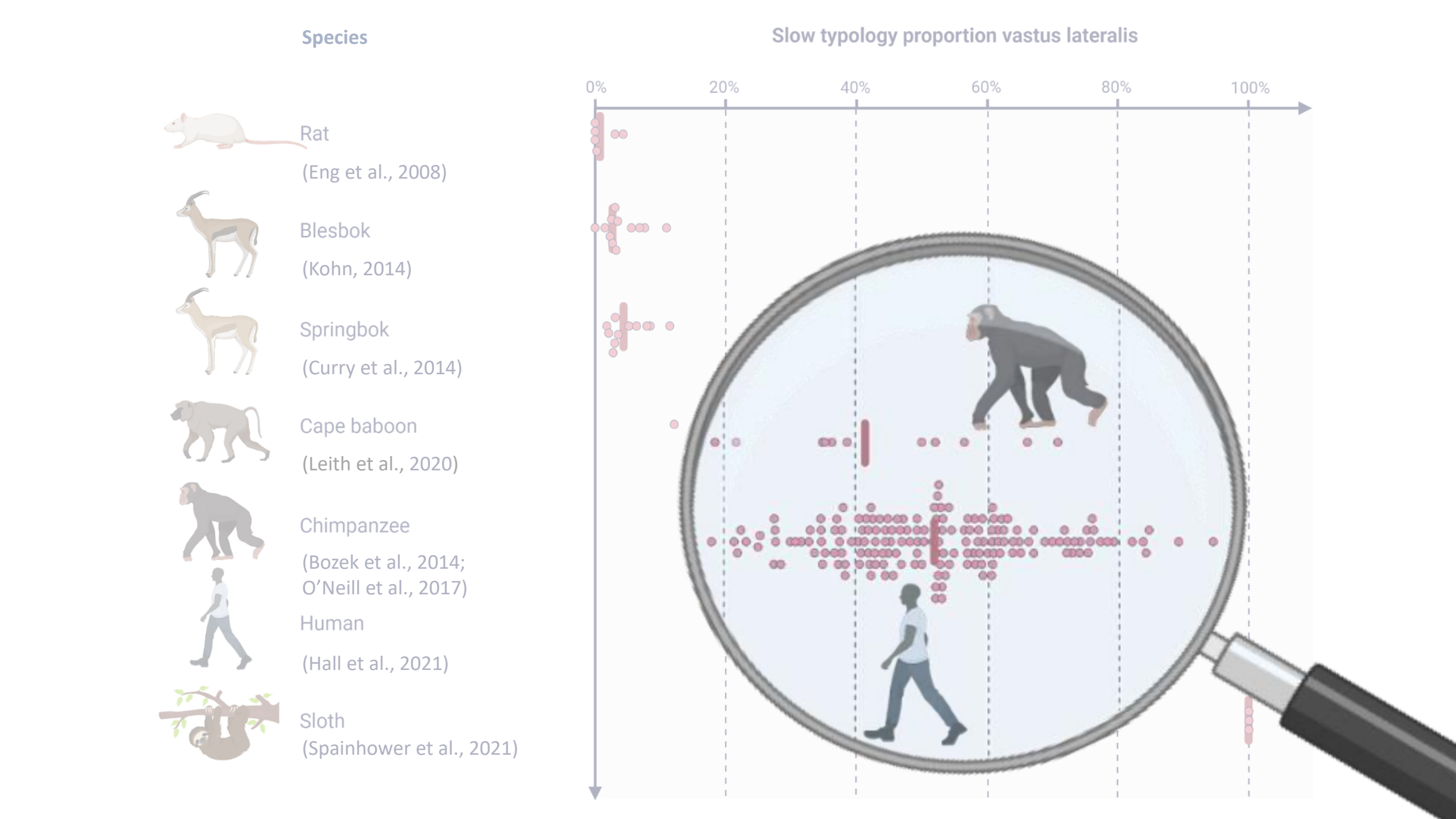
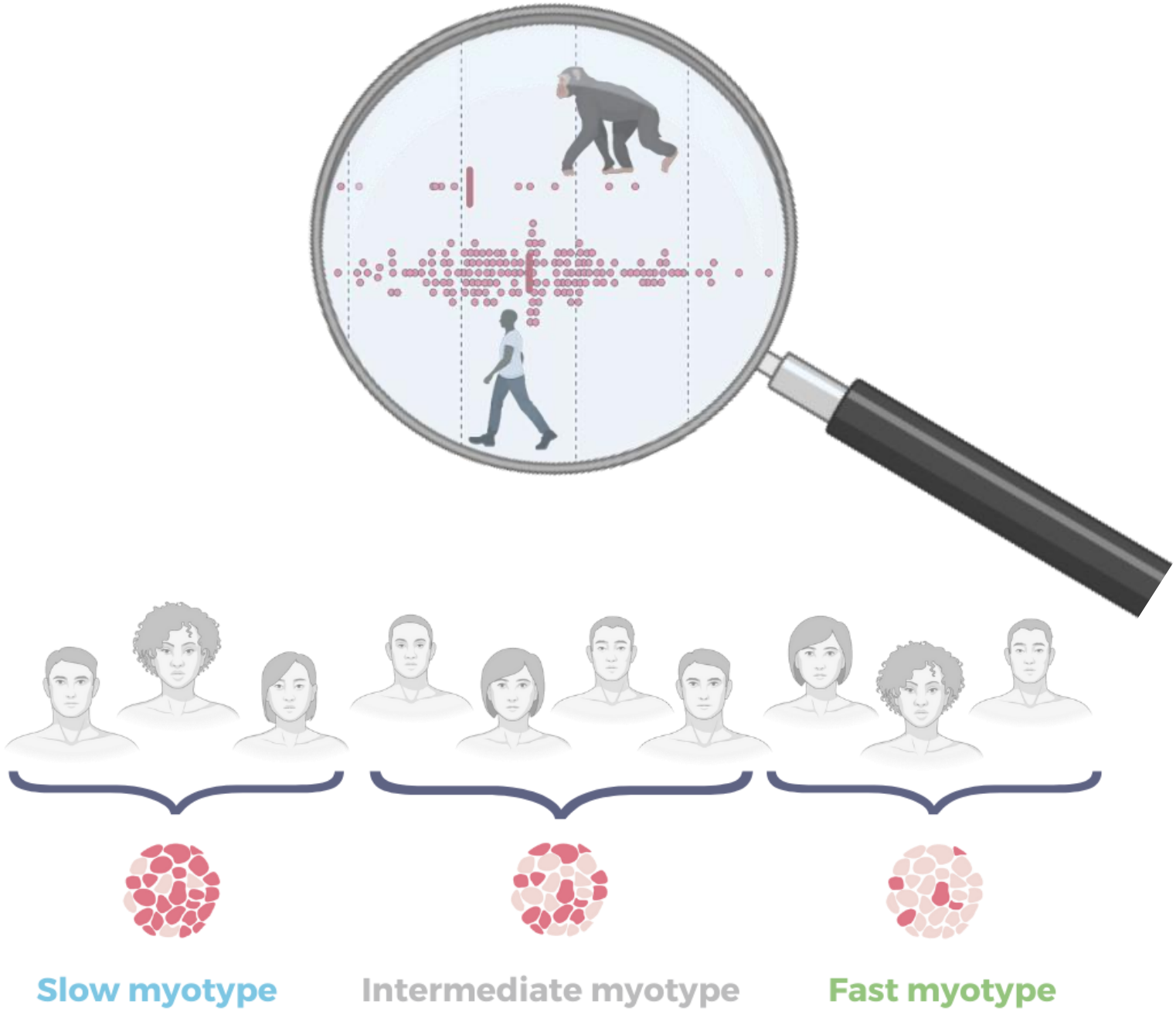
Sloth
(Spainhower et al., 2021)




Species
Slow typology proportion vastus lateralis
0%
20%
40%
60%
80%
100%
Rat
(Eng et al., 2008)
Blesbok
(Kohn, 2014)
Springbok
(Curry et al., 2014)
Cape baboon
(Leith et al., 2020)
Chimpanzee
(Bozek et al., 2014;
O'Neill et al., 2017)
Human
(Hall et al., 2021)
Sloth
(Spainhower et al., 2021)


Slow myotype
Intermediate myotype
Fast myotype

CHAPTER I

Muscle physiology

CHAPTER II

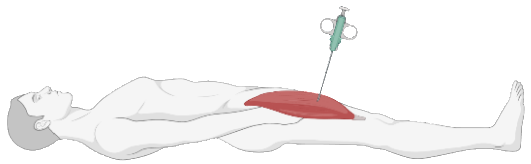
Evolution

CHAPTER III

Measuring muscle typology

1 Invasive method: muscle biopsy

1 Muscle biopsy



1 Invasive method: muscle biopsy

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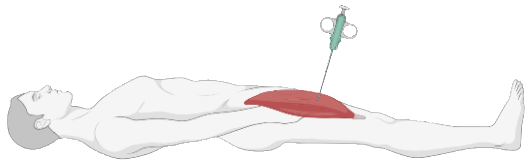
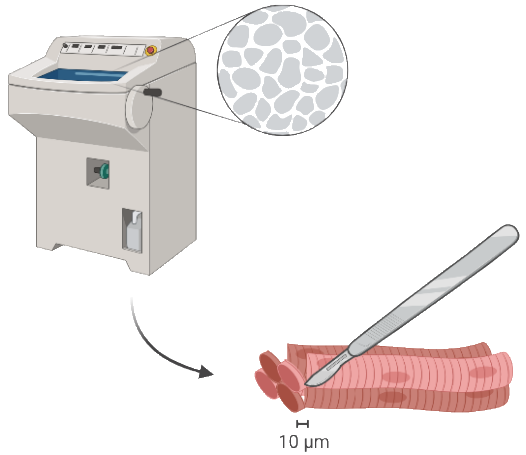


2 Cut muscle tissue



1 Invasive method: muscle biopsy

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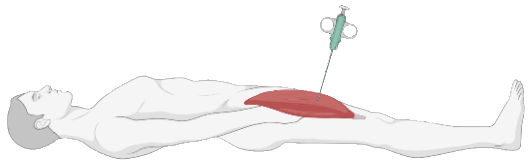
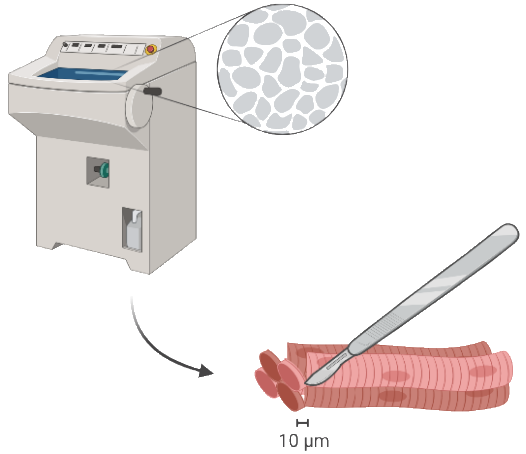
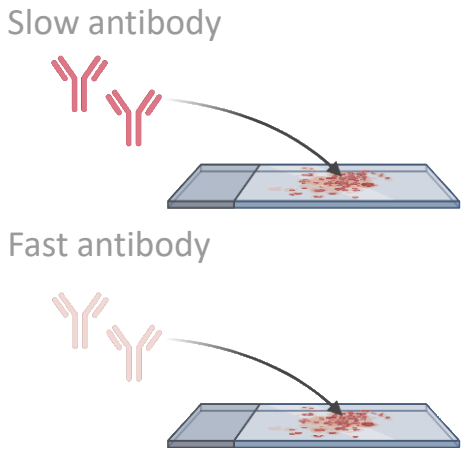


2 Cut muscle tissue



3 Immunohistochemistry



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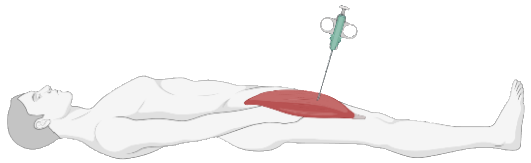

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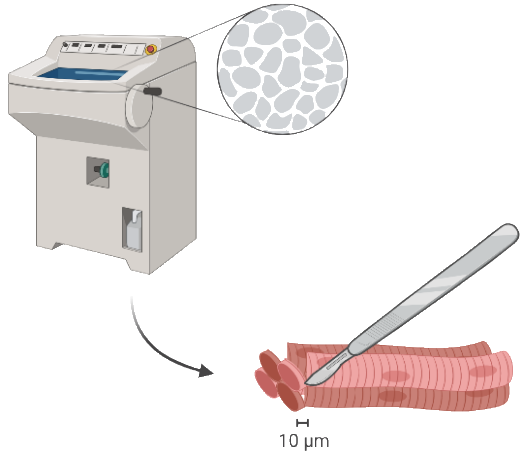
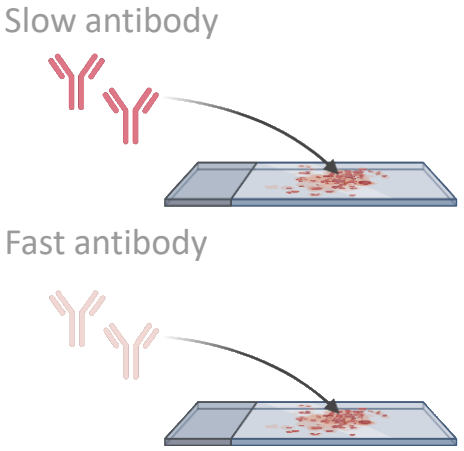
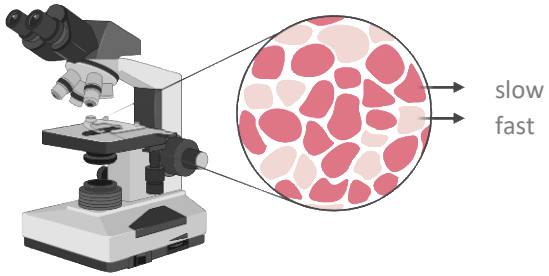


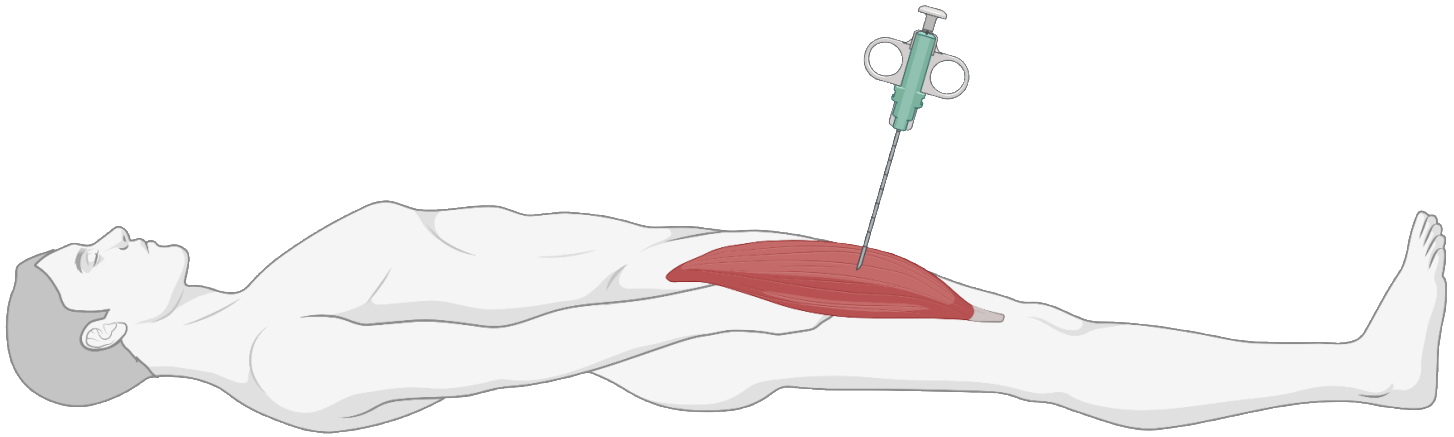
3 Immunohistochemistry



4 Muscle fiber visualization

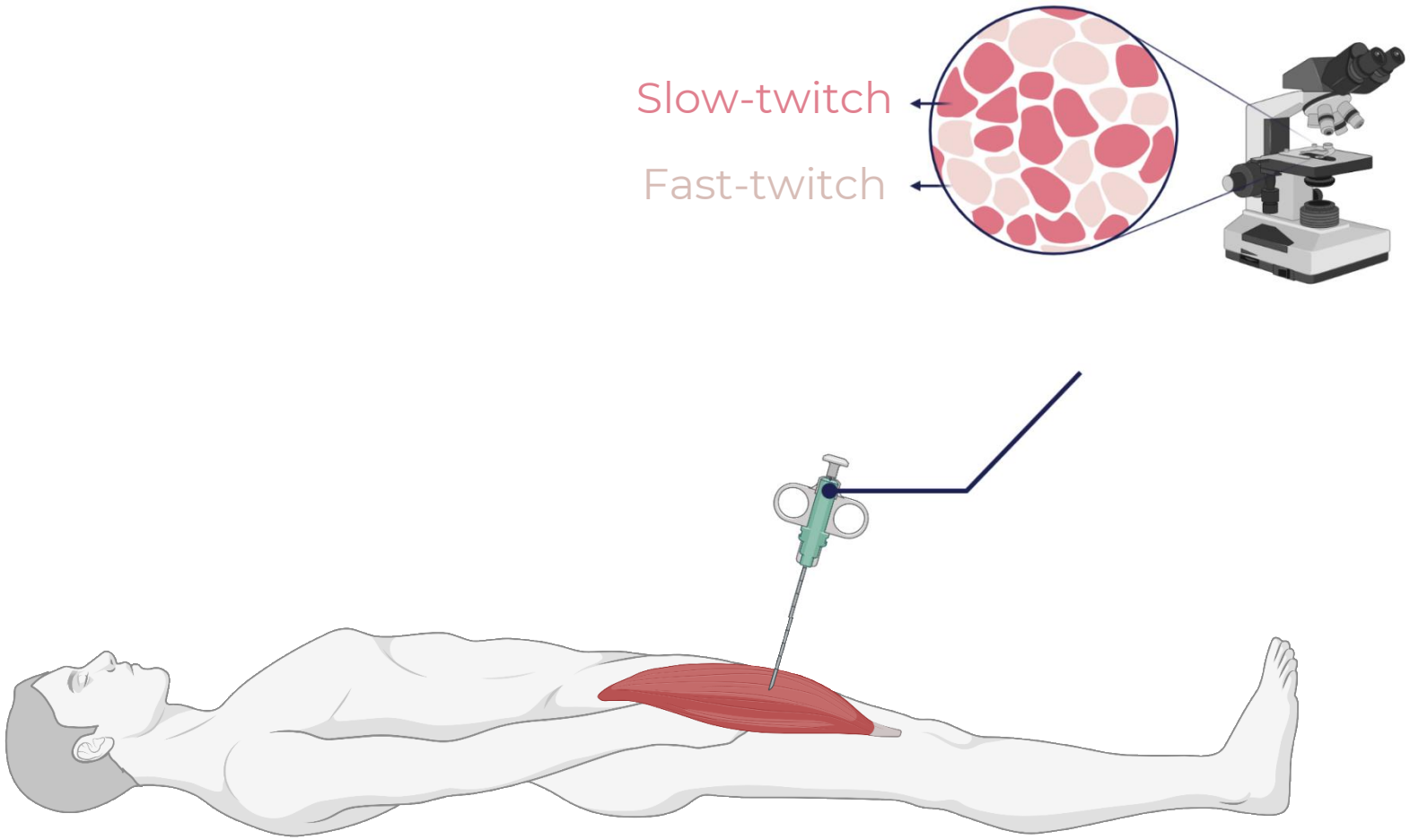


1 Invasive method: high variation



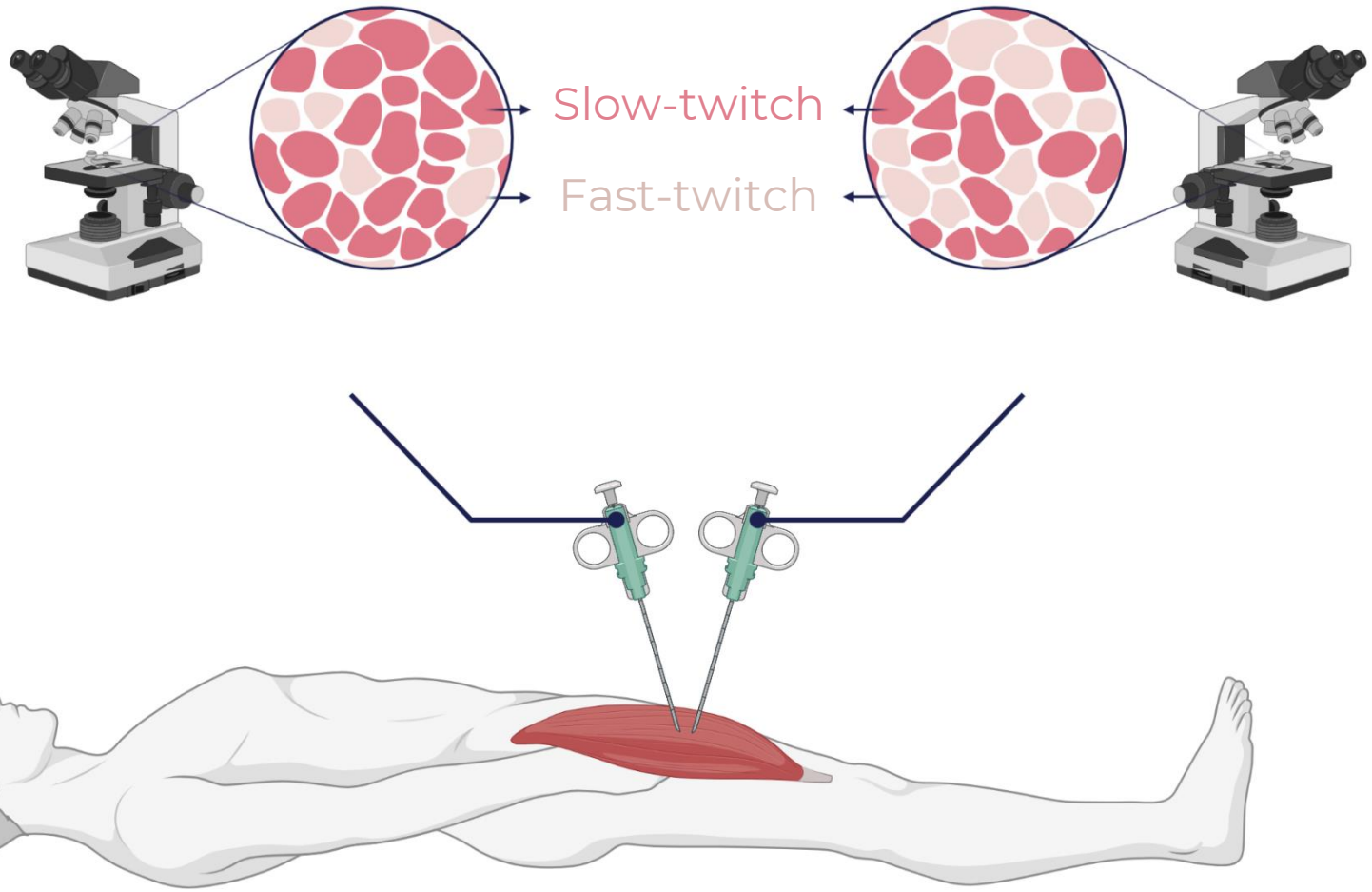
(Horwath et al., JAP, 2021)

1 Invasive method: high variation



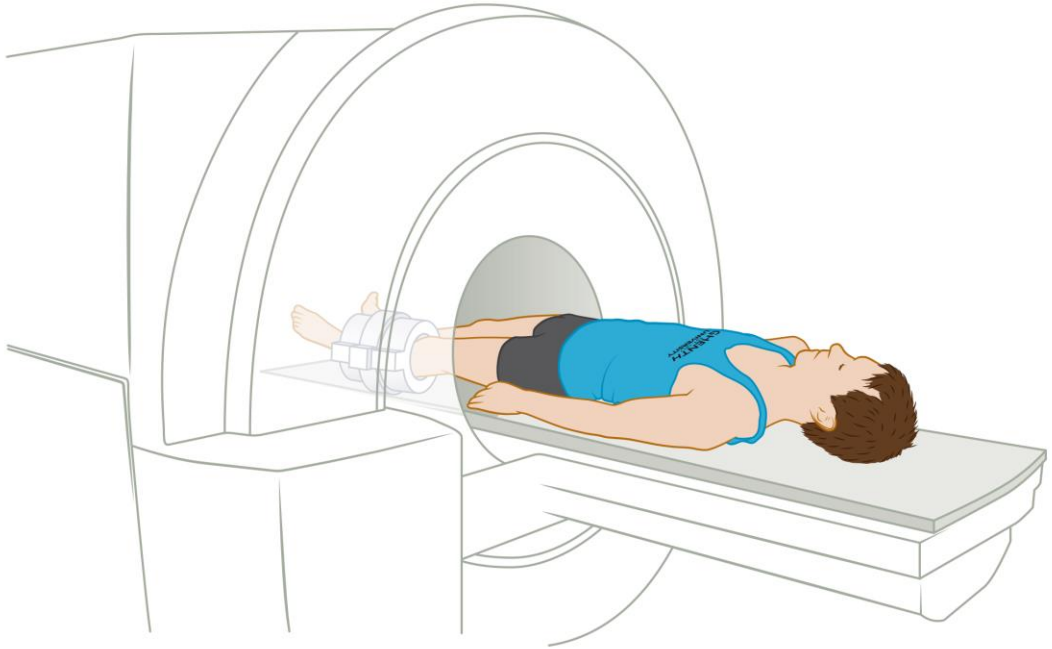
(Horwath et al., JAP, 2021)

1 Invasive method: high variation



(Horwath et al., JAP, 2021)

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



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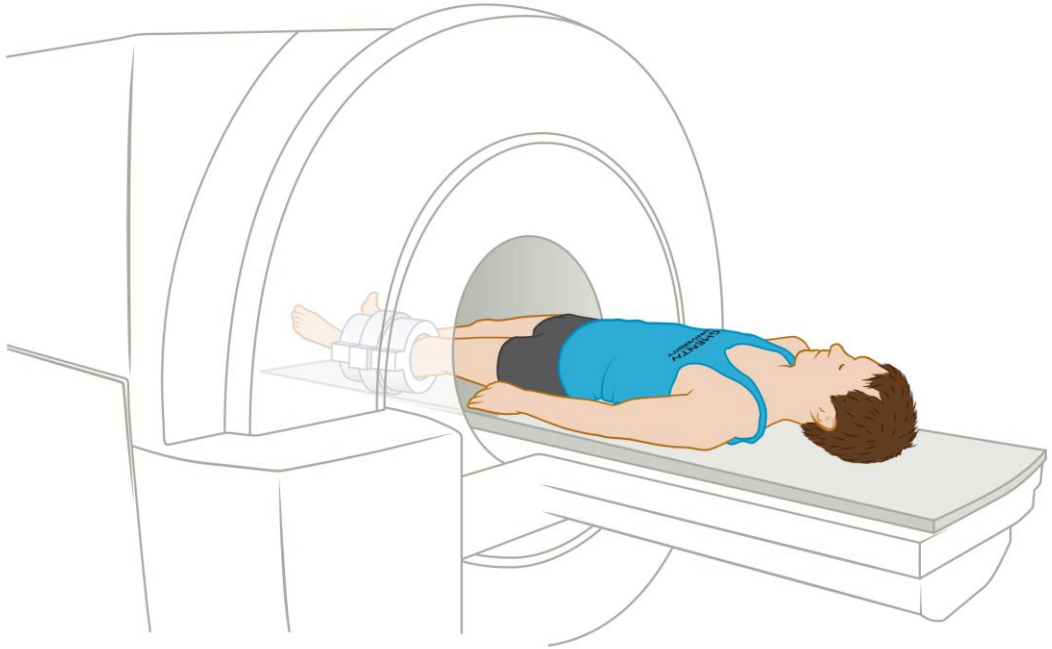

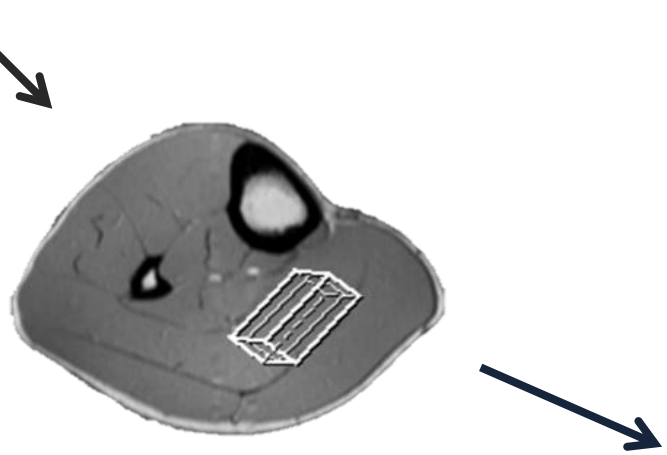

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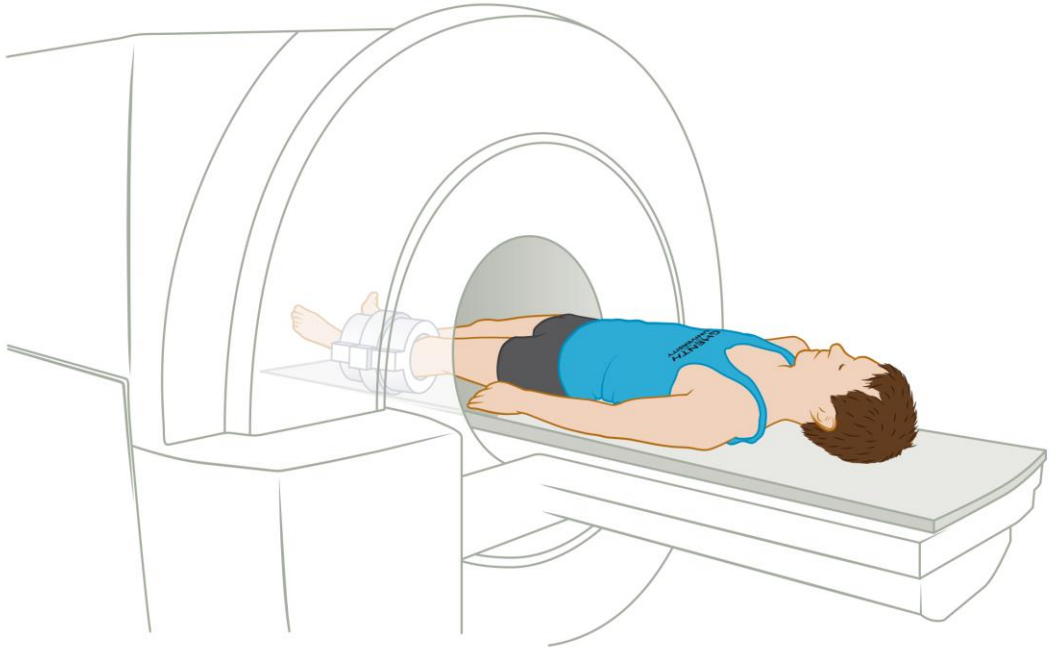

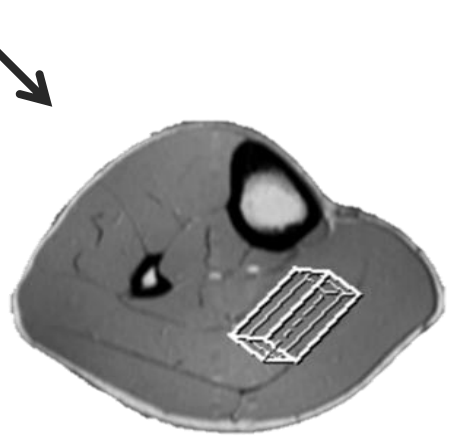

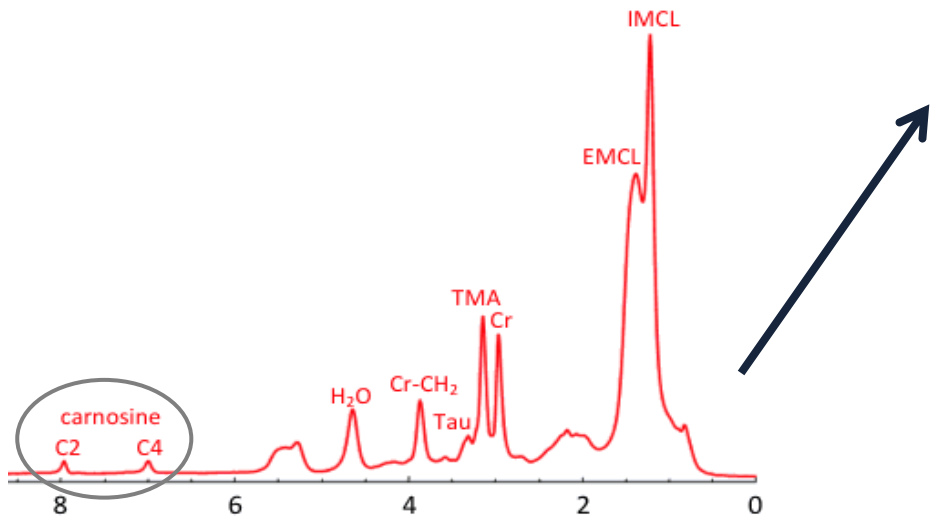

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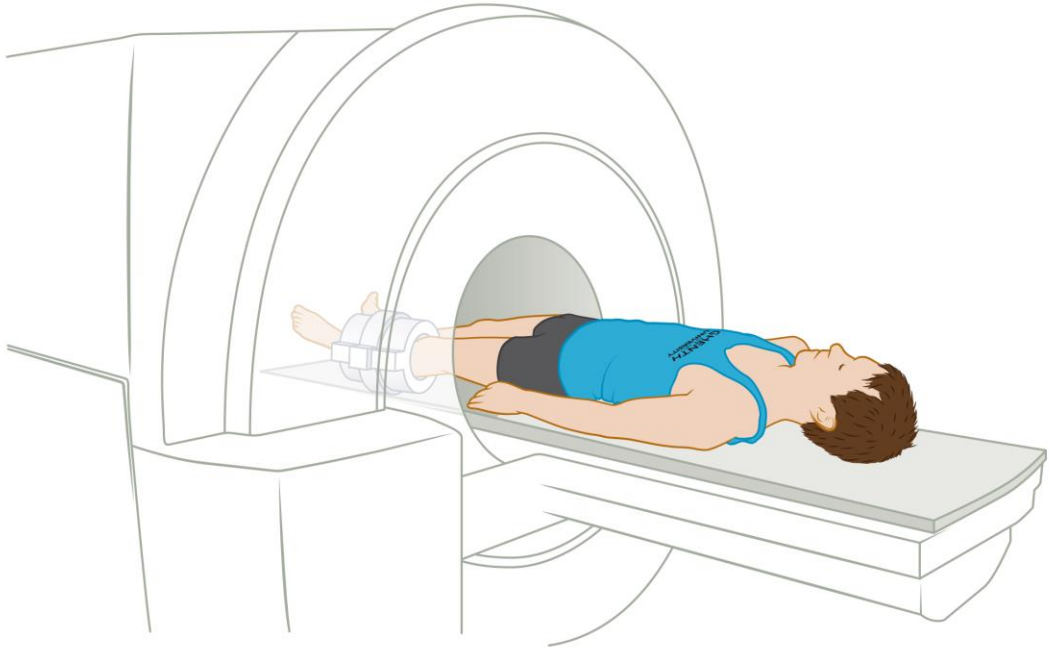
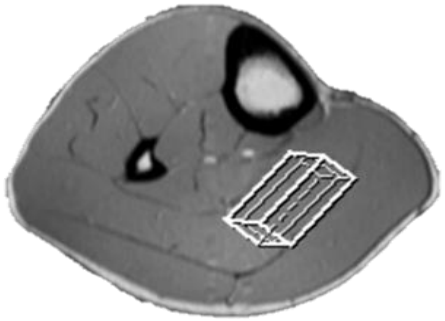
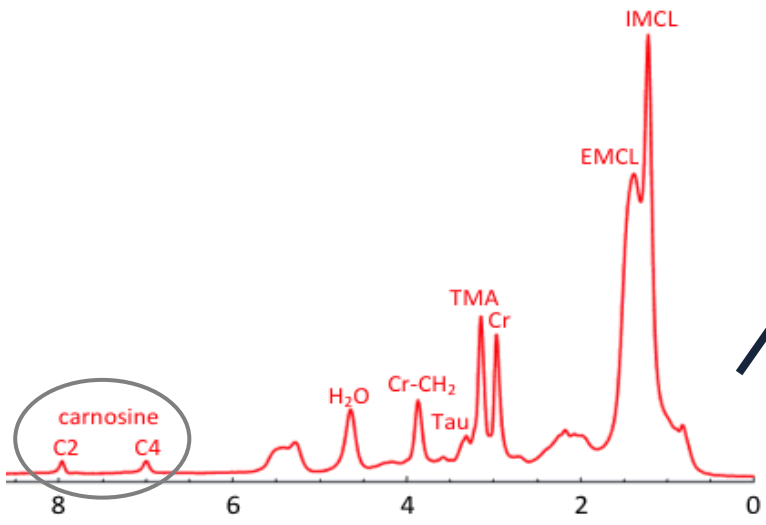
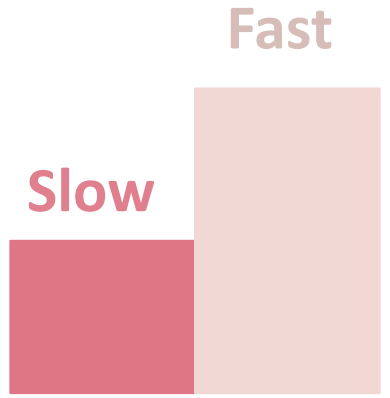




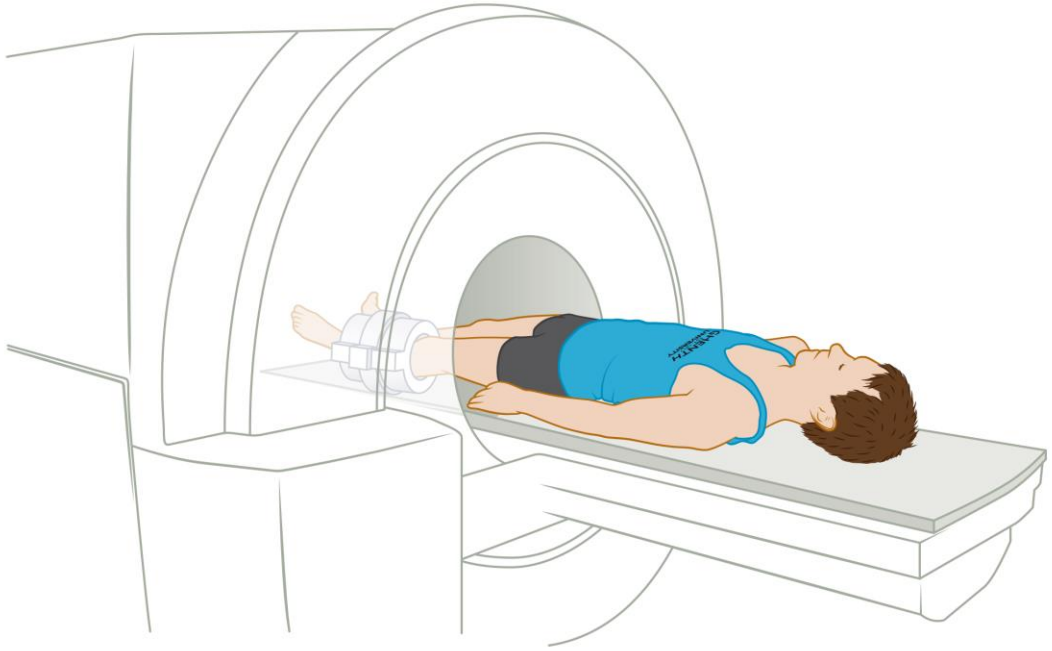




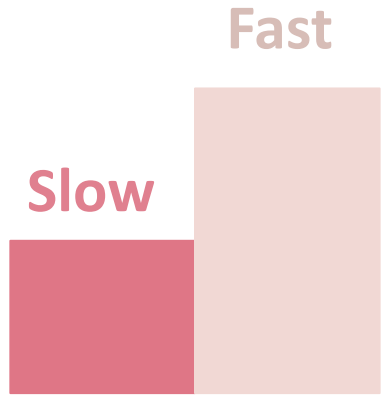
carnosine

(Harris, J Sport Sci, 1998)

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



(Baguet, PLoS One, 2011)



carnosine

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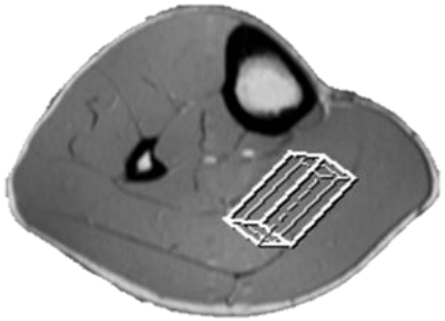
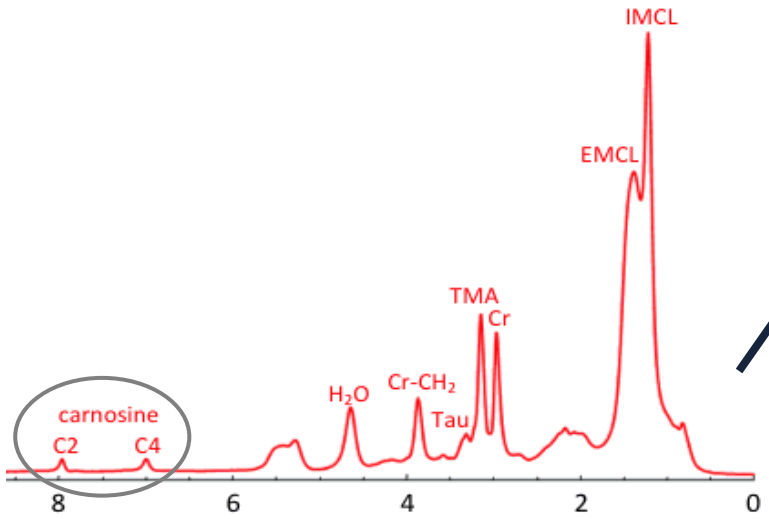
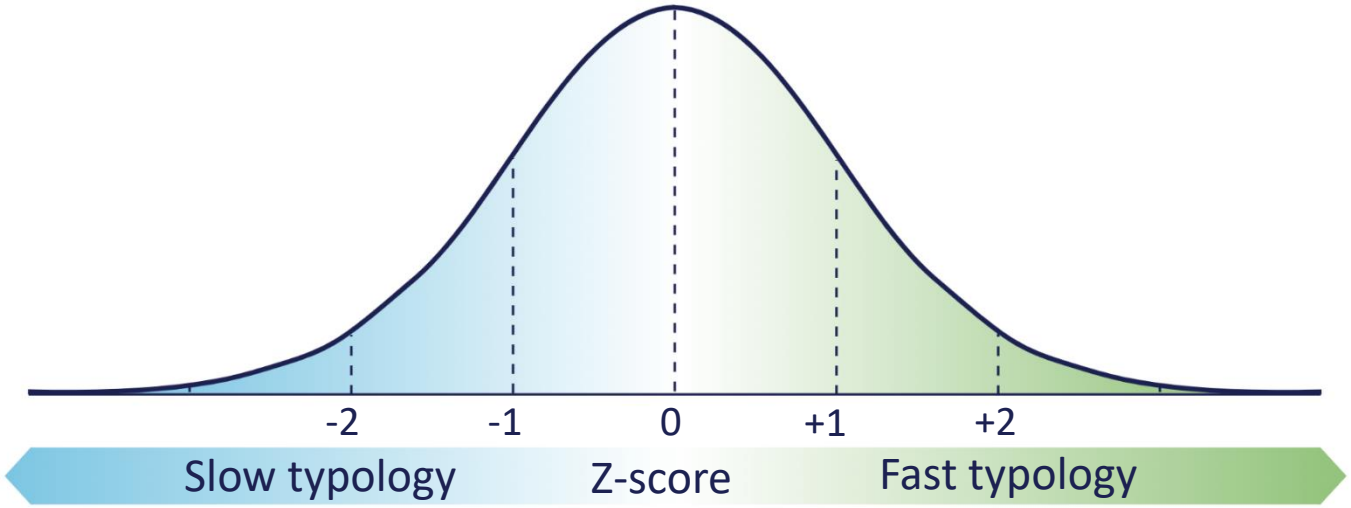


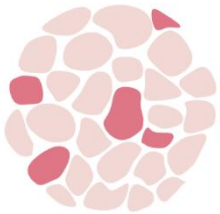


2 Non-invasive method: ^{1}H-MRS of carnosine

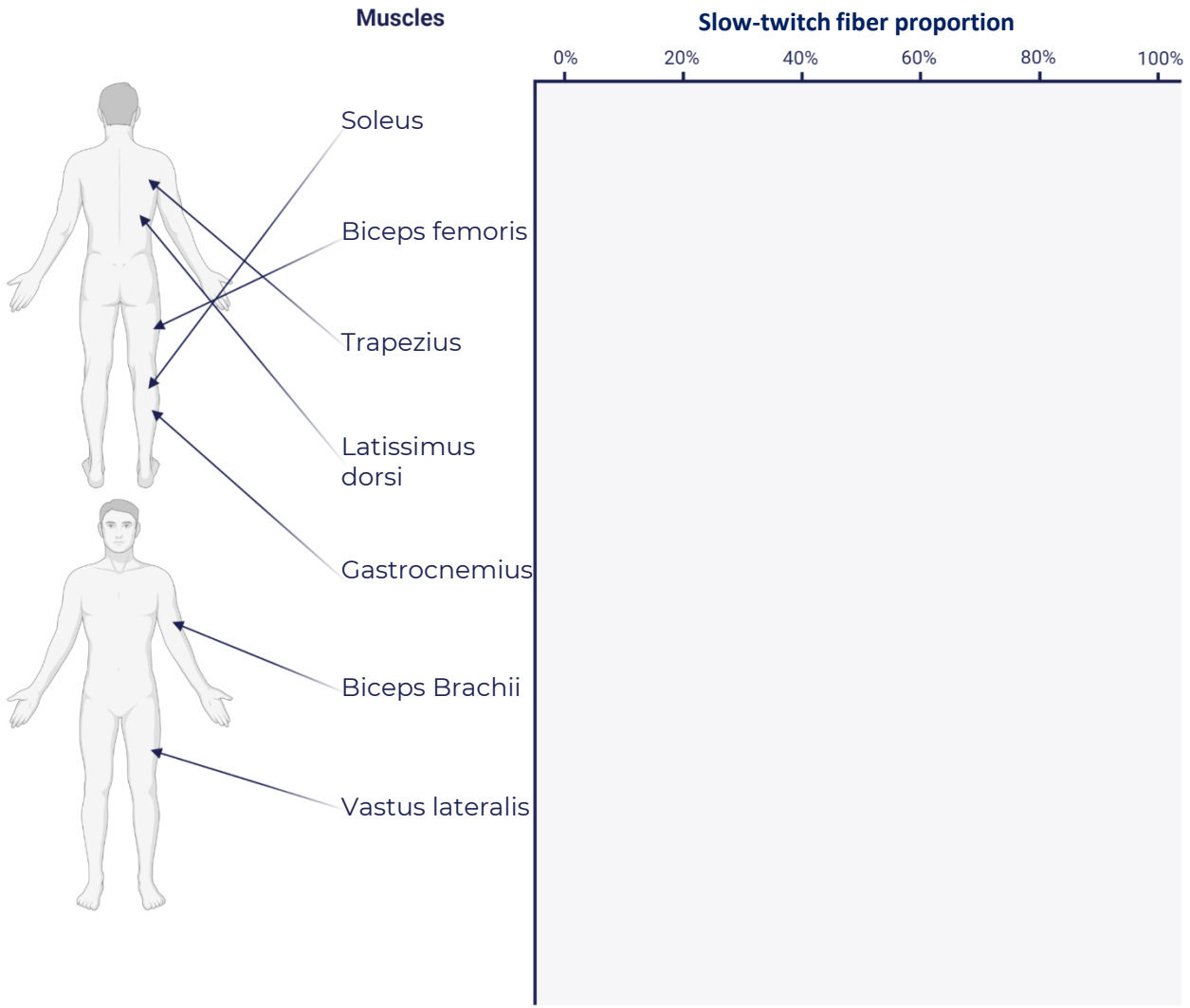
112 women

163 men





3 Across-muscle phenotype



(Vikne, Muscle & Nerve, 2012)

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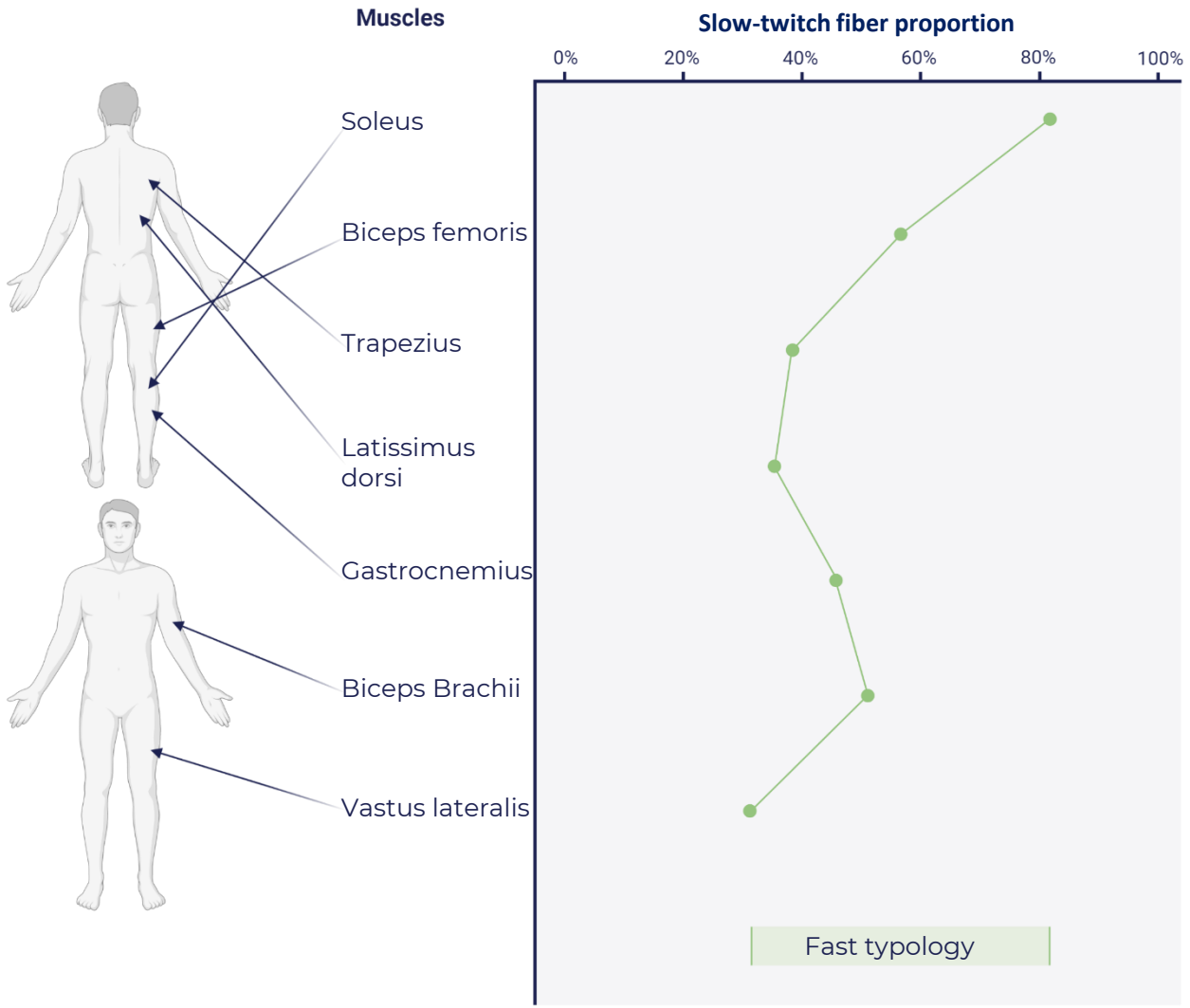

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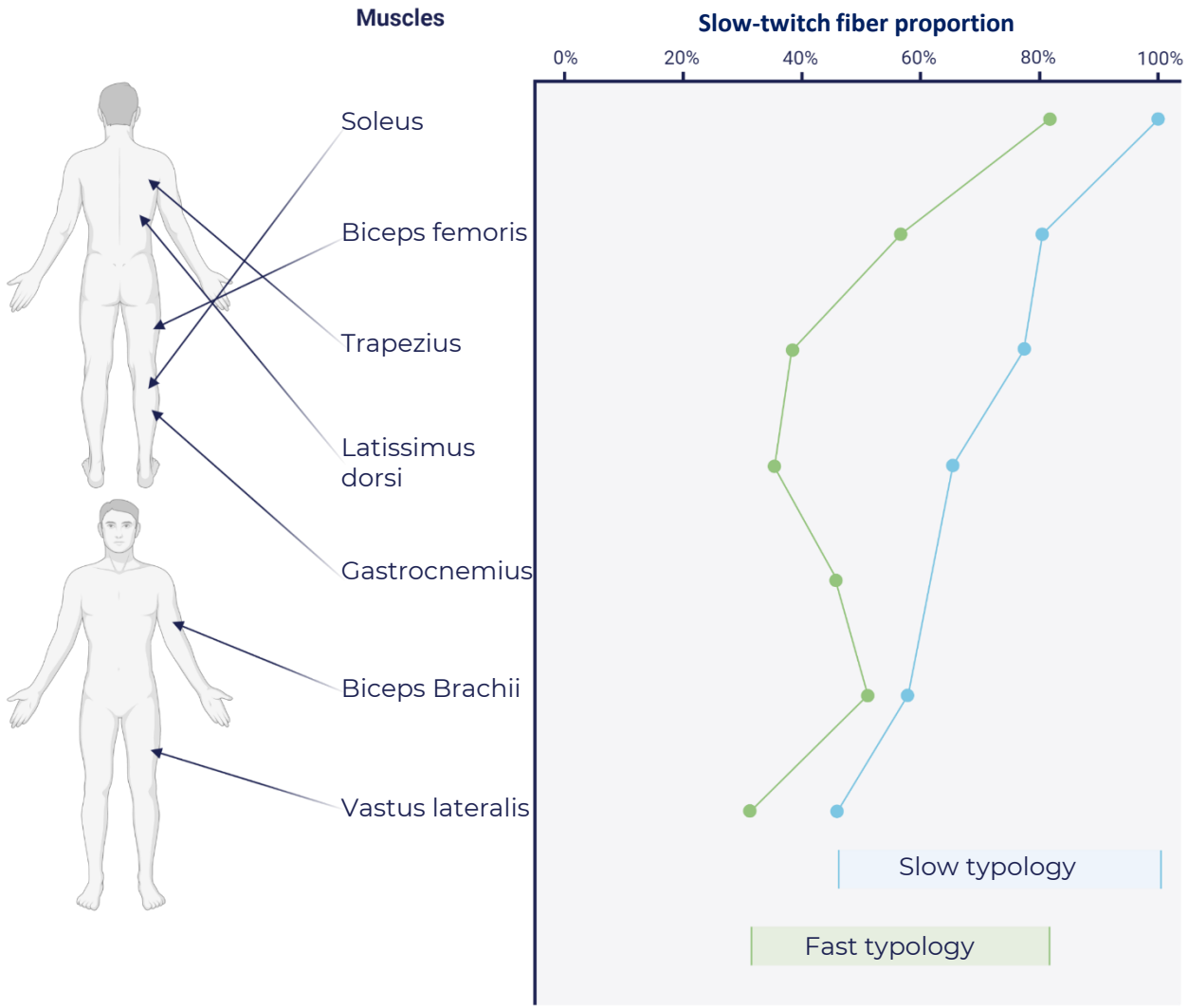
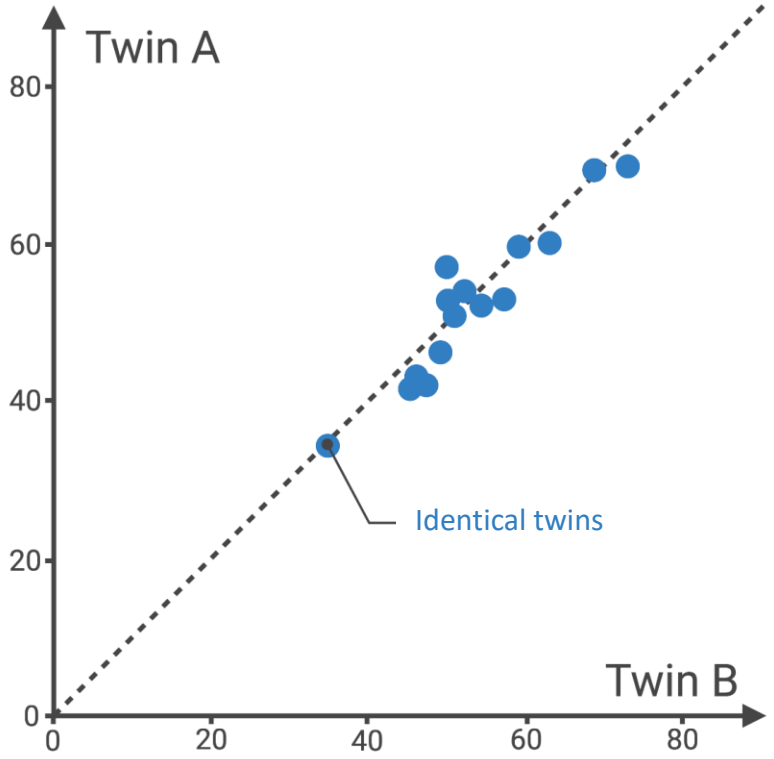


(Vikne, Muscle & Nerve, 2012)

4 Genetically determined

Percentage of slow-twitch fibers

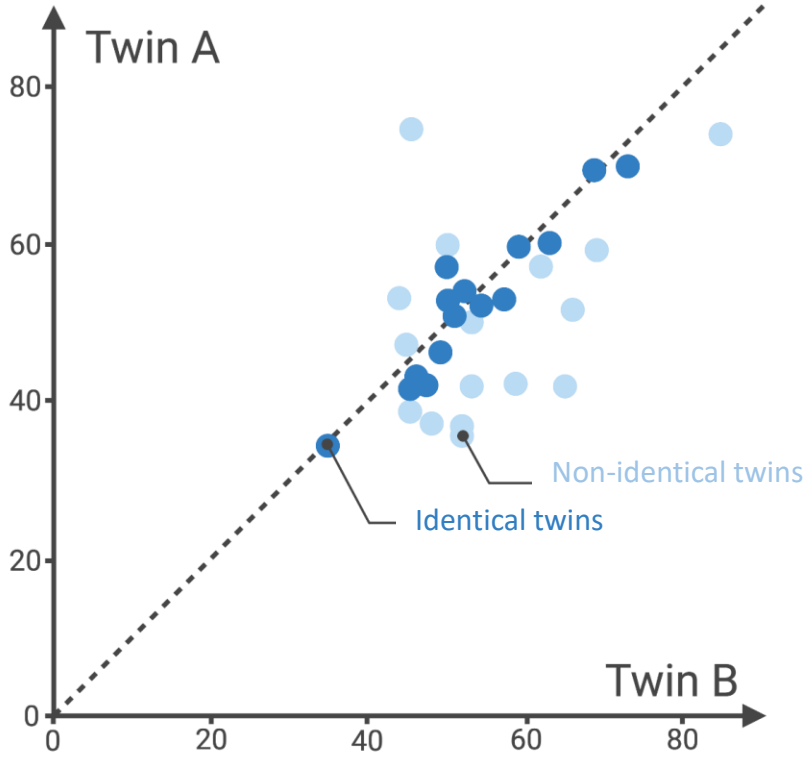


Percentage of slow-twitch fibers

(Komi, Acta Physiologica, 1977)

4 Genetically determined

Percentage of slow-twitch fibers



Percentage of slow-twitch fibers

(Komi, Acta Physiologica, 1977)

CHAPTER I

Muscle physiology

CHAPTER II

Evolution

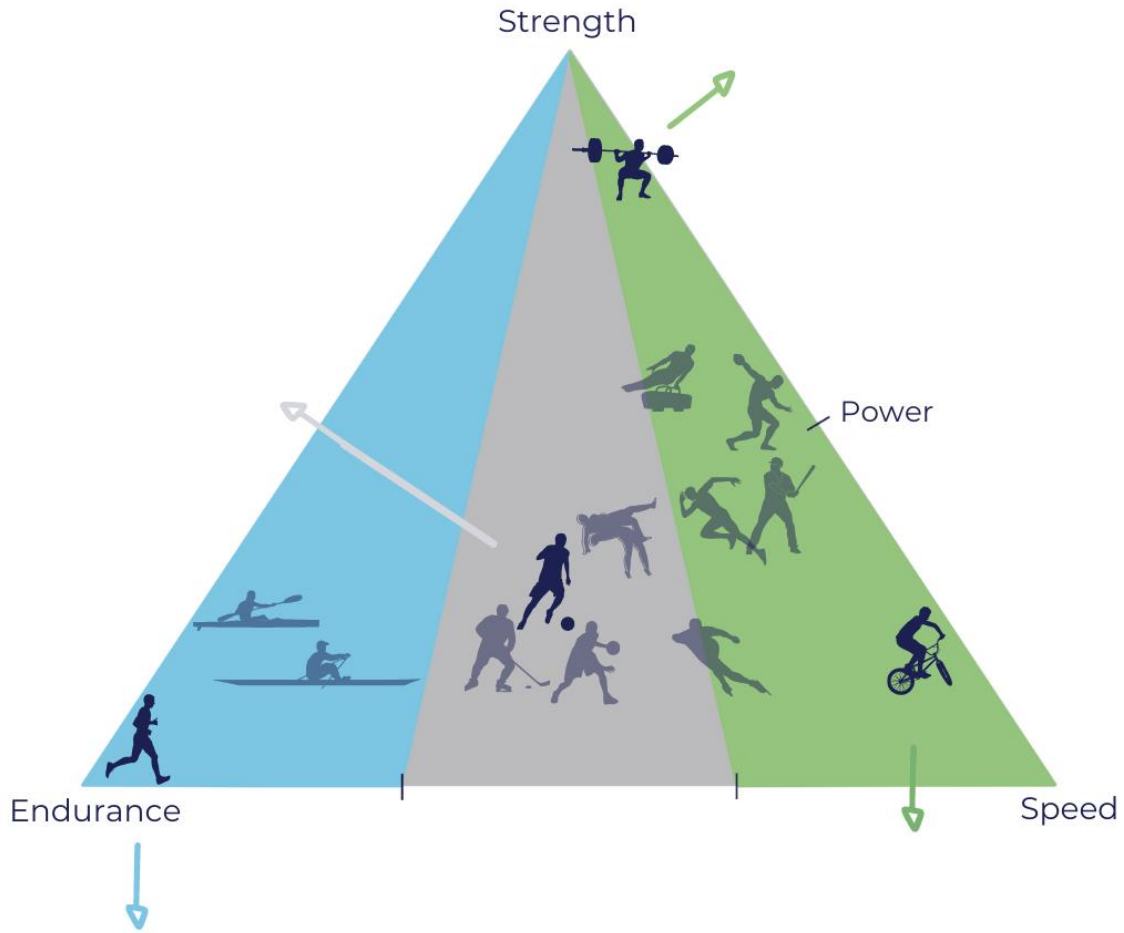
CHAPTER III

Measuring muscle typology

CHAPTER IV

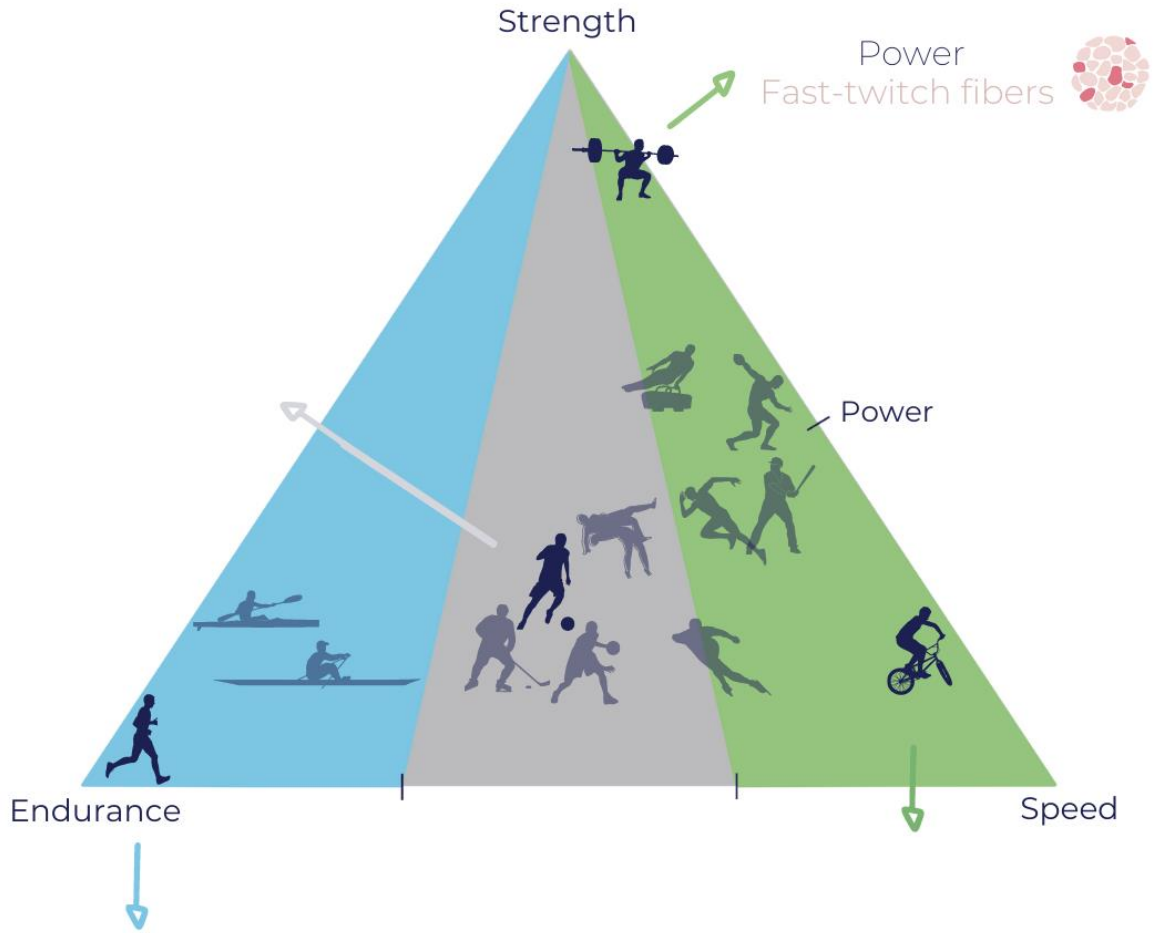
Relevance in sports

1 Is the myotype of importance in your sport?



(Based on bompa, 1996)

1 Is the myotype of importance in your sport?



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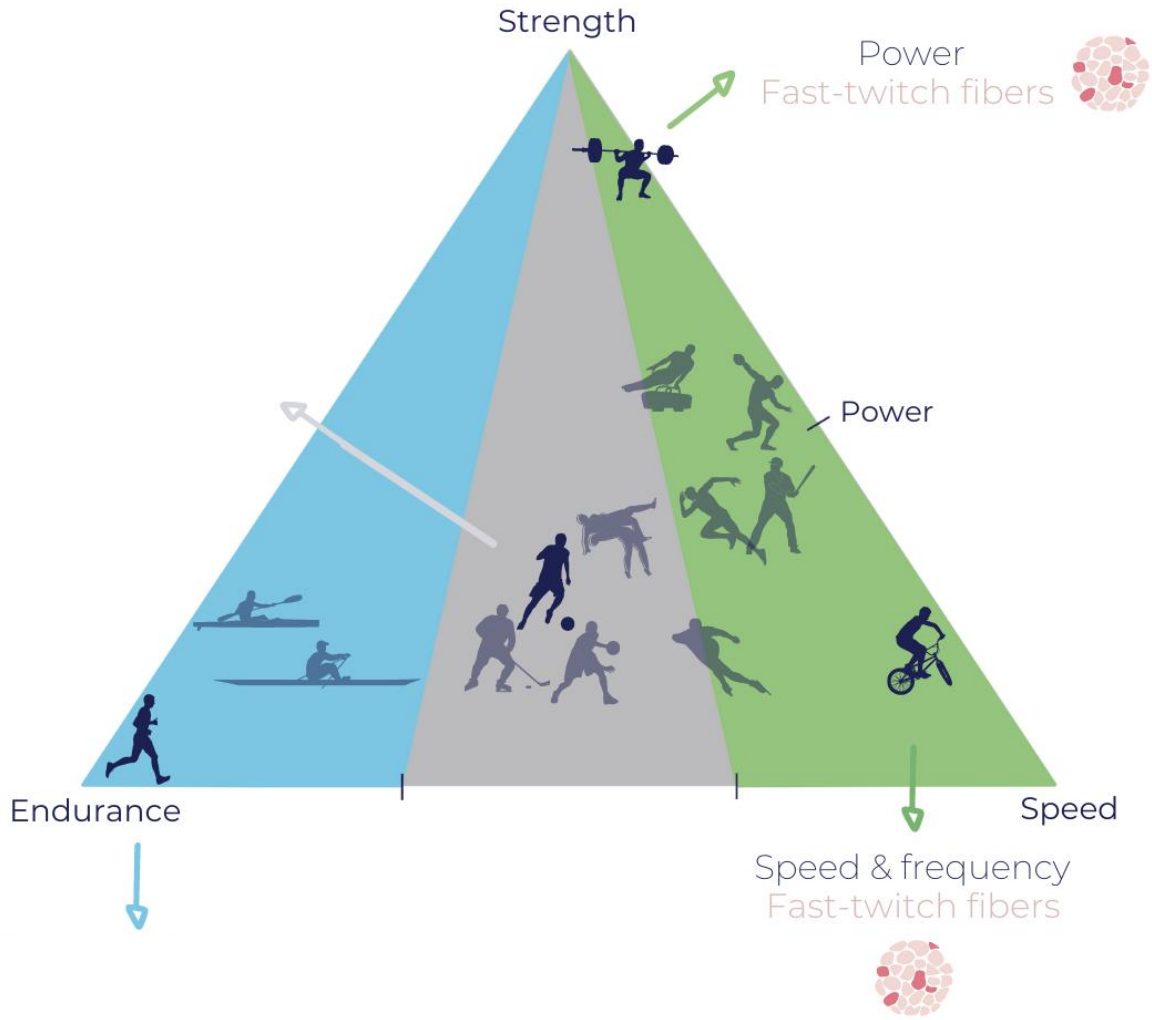

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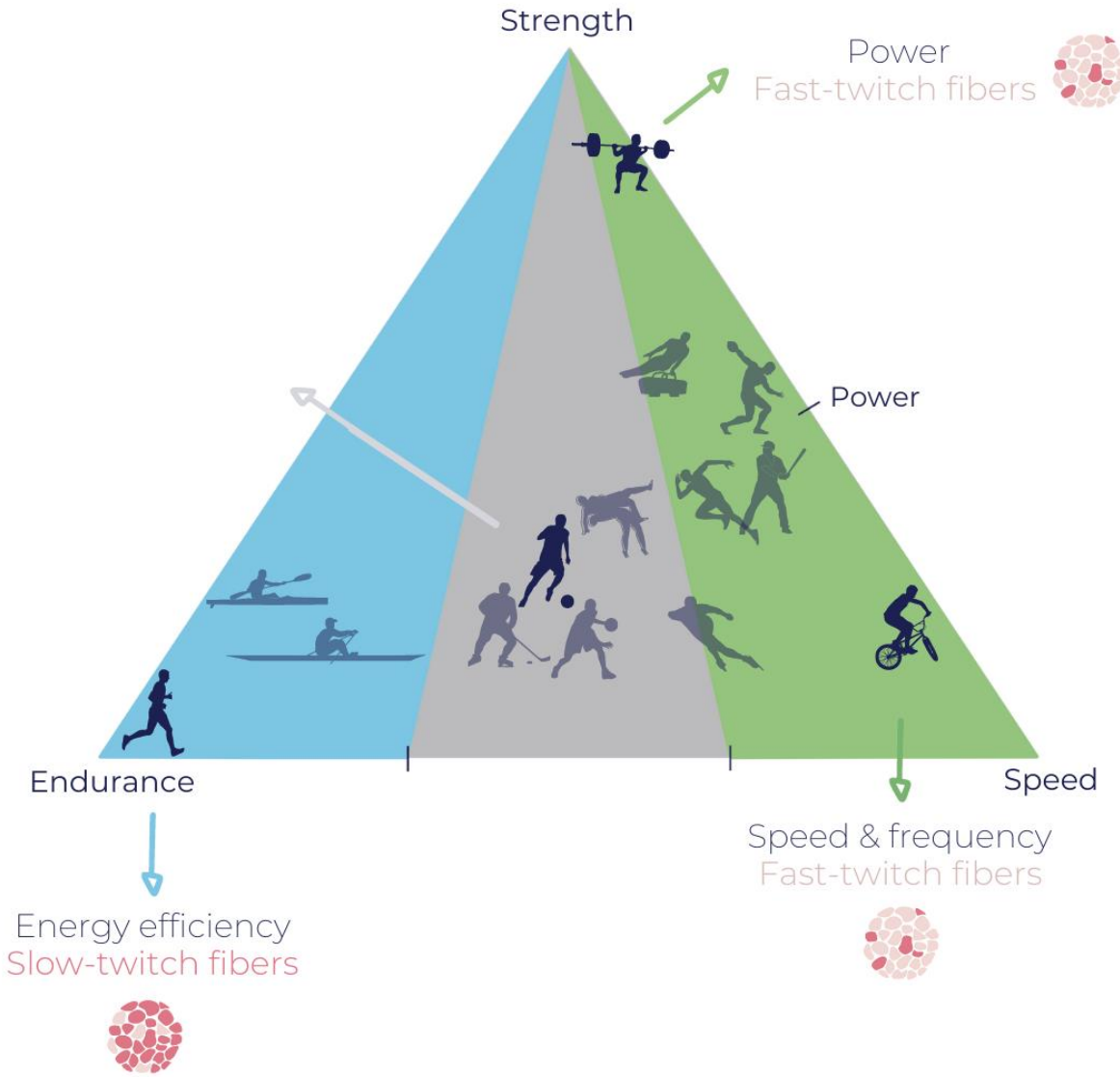

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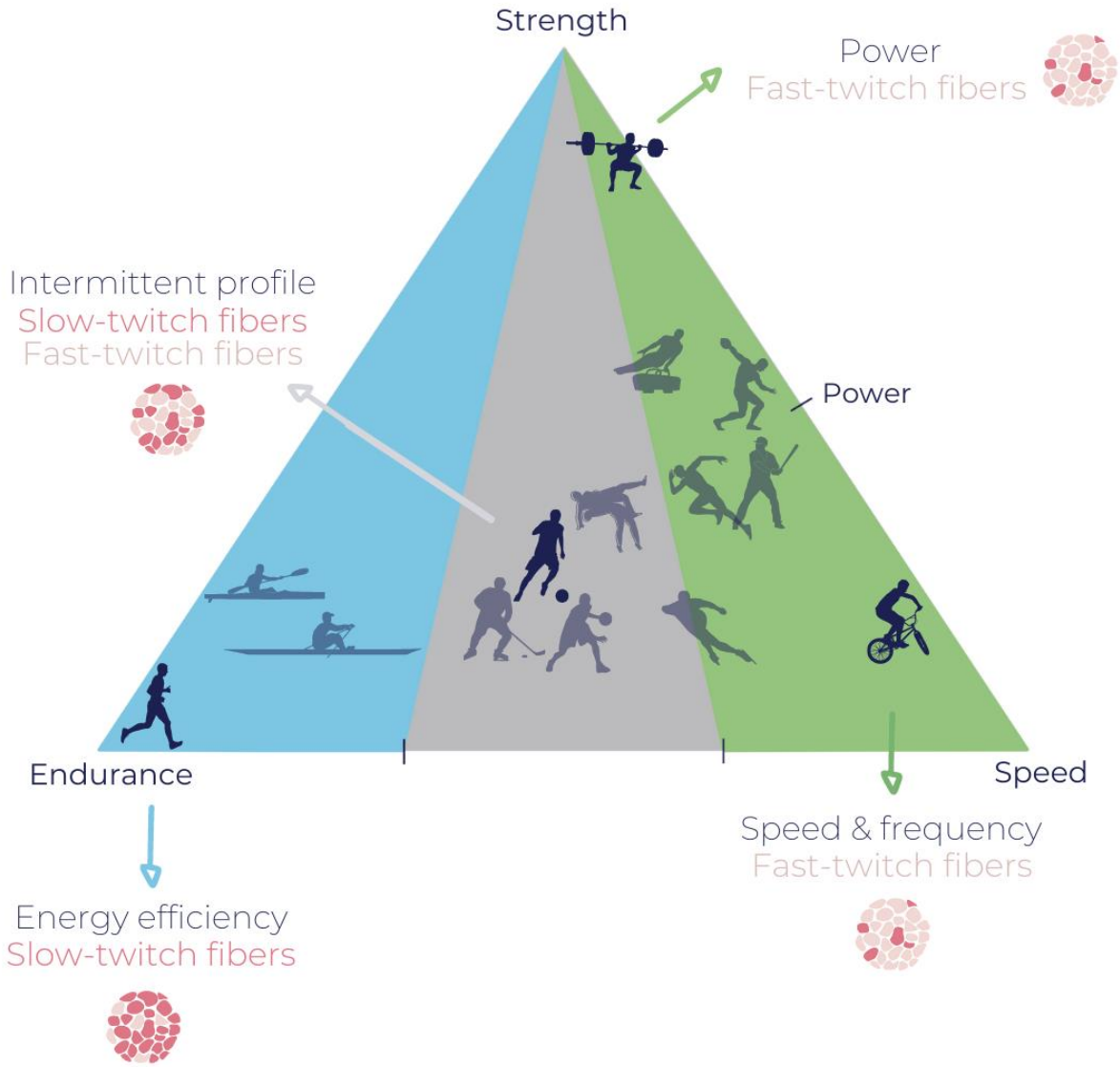


(Based on bompa, 1996)

1 Can I discover talent in athletics?

68

Long distance

22

Middle distance

23

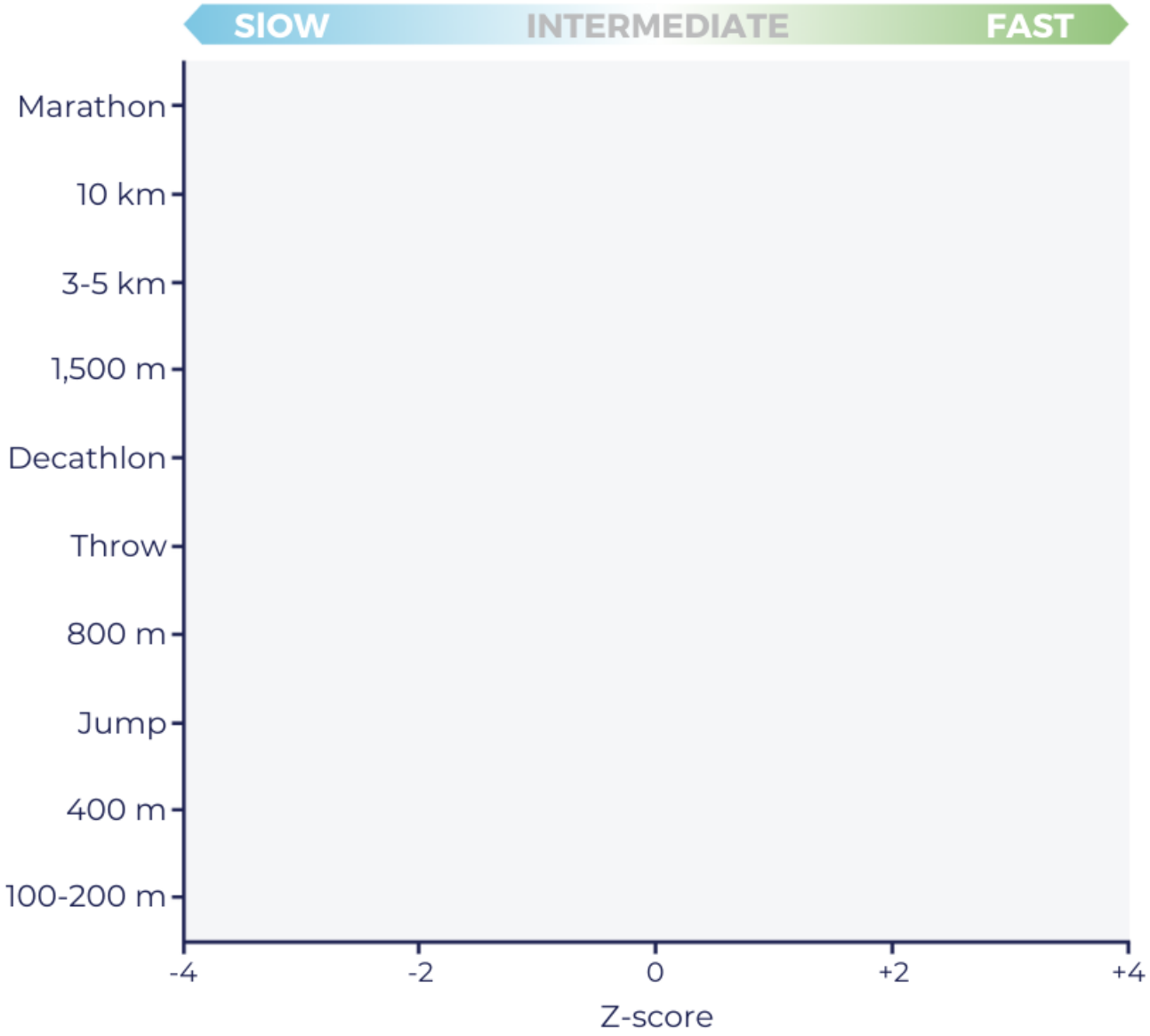
Sprint

23

2 Olympic medalists
3 World medalists

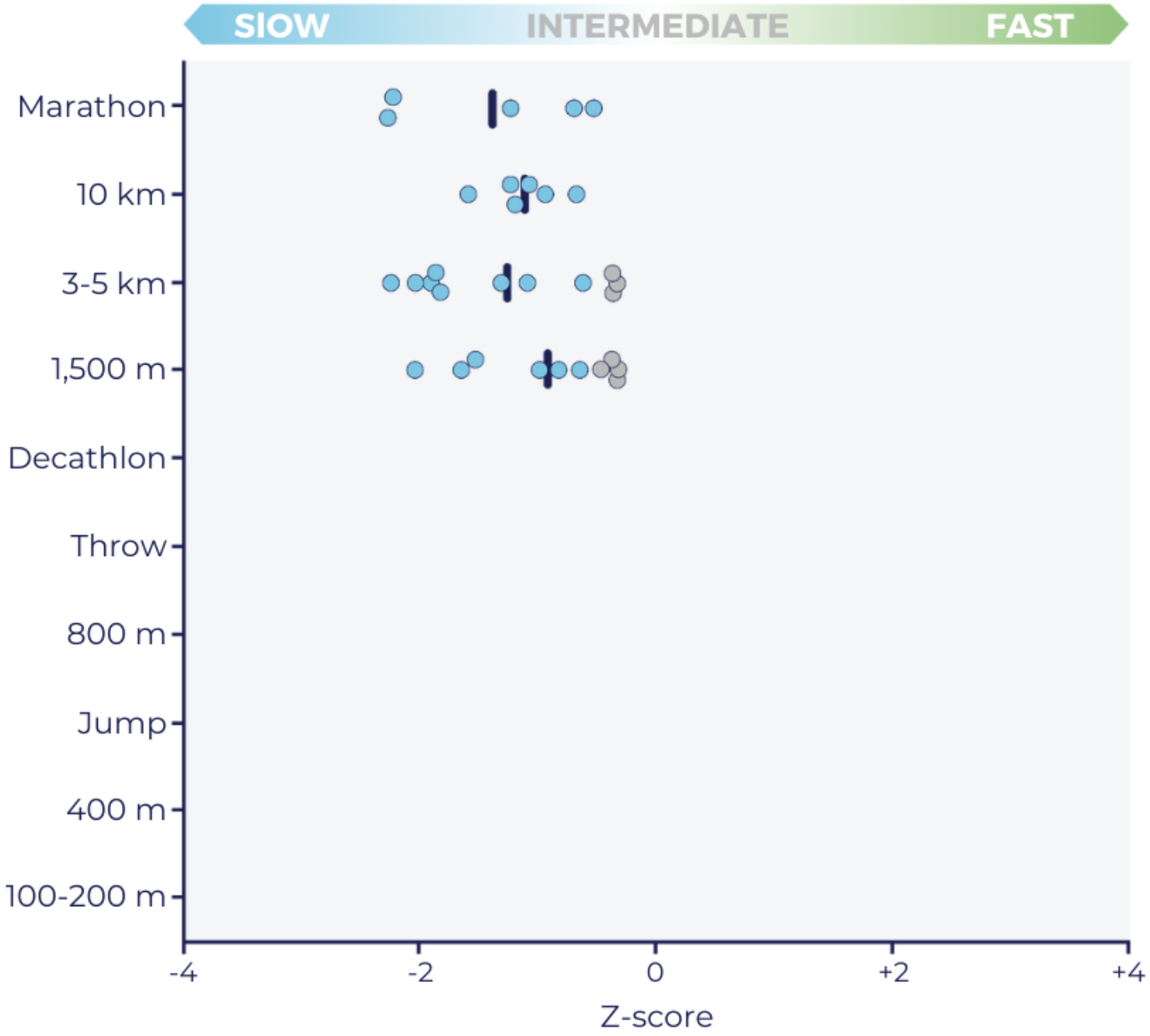
(Baguet, PLoS One, 2011; Bex, scand J Med sci sports, 2017)

1 Can I discover talent in athletics?



(Baguet, 2011; Bex, 2017)

1 Can I discover talent in athletics?



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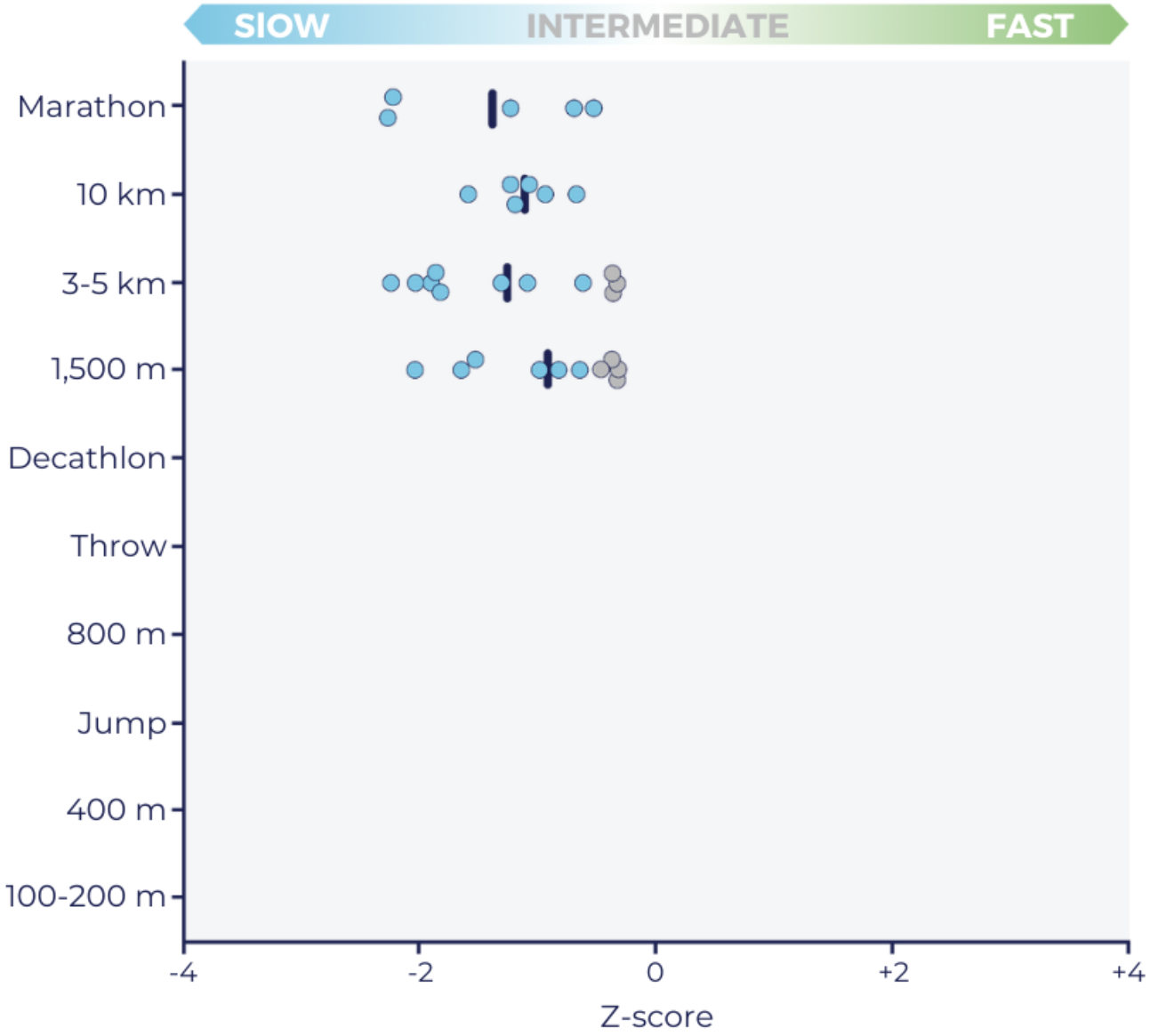

More efficient

More resistant to fatigue

(Baguet, 2011;
Bex, 2017)

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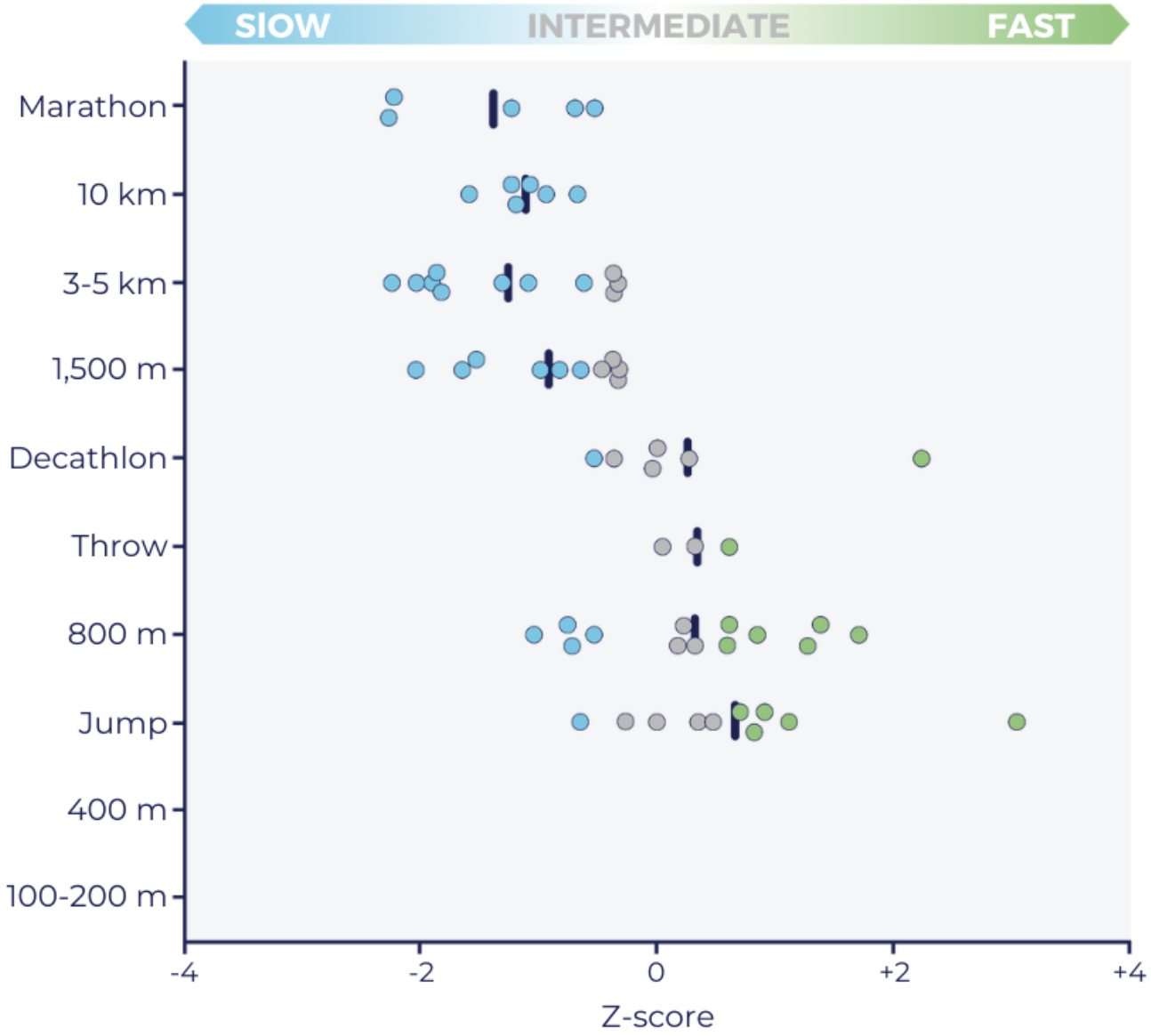

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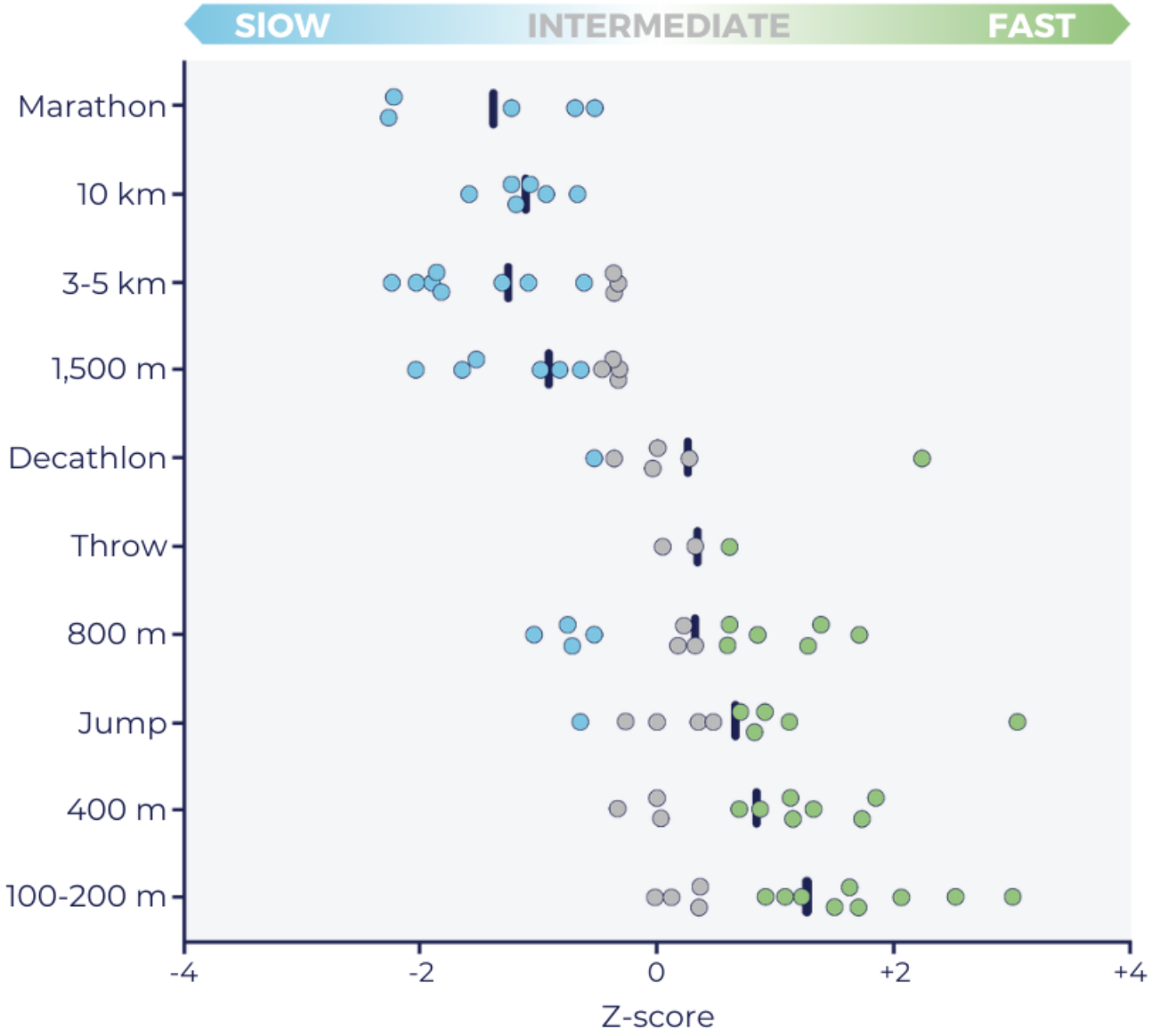


More efficient

More resistant to fatigue

Generate power

High movement frequencies

(Baguet, 2011;
Bex, 2017)

1 Can I discover talent in cycling?

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?

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

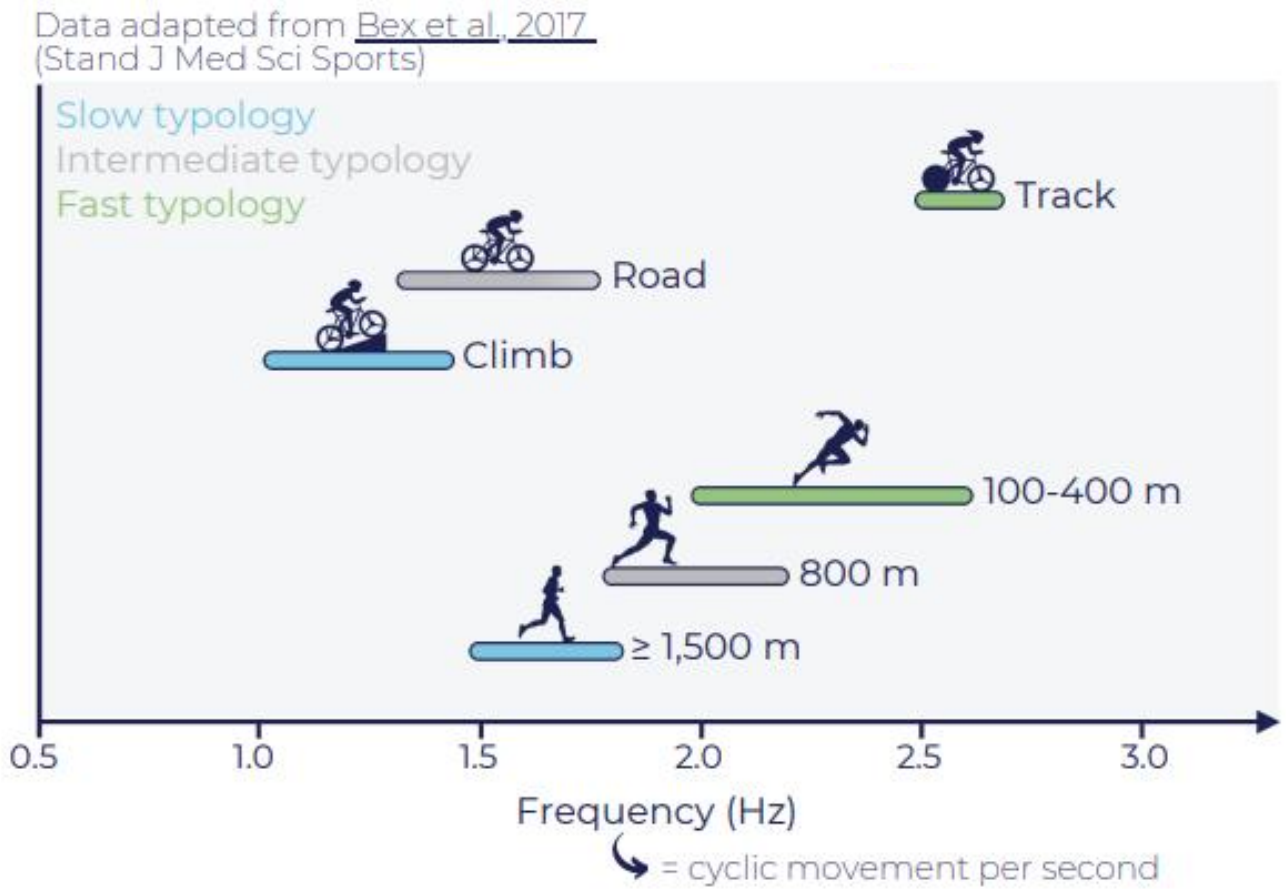
More resistant to fatigue

Generate power

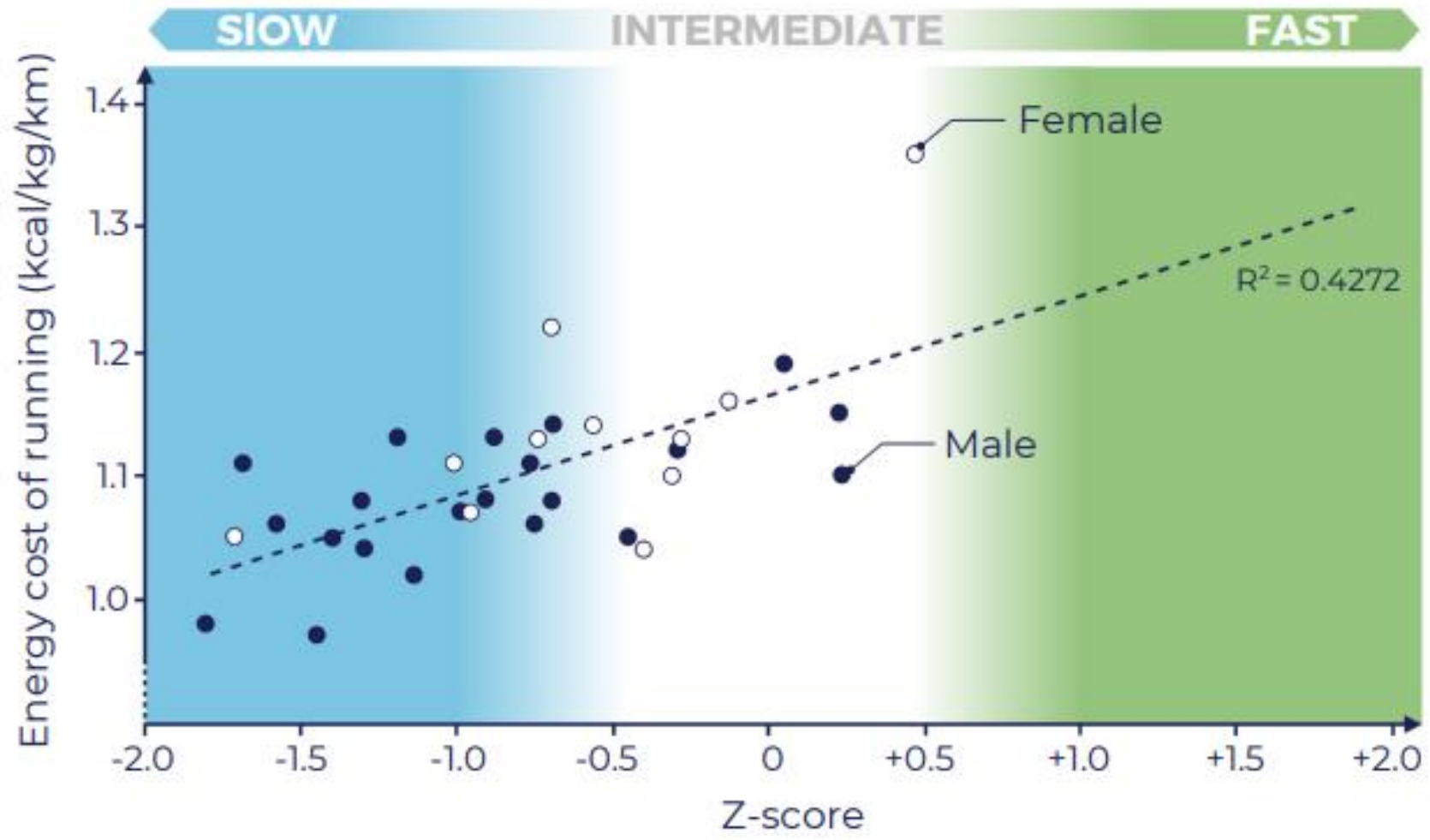
High movement frequencies

(Lievens & Bellinger, MSSE, 2021)

1 Why are fast fibers needed?



1 Why are slow fibers needed?

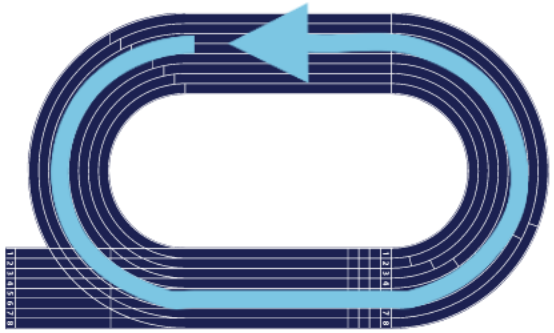


(Bellinger, EJAP, 2020)

2 Can I adapt my competition strategy?

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

Slow typology



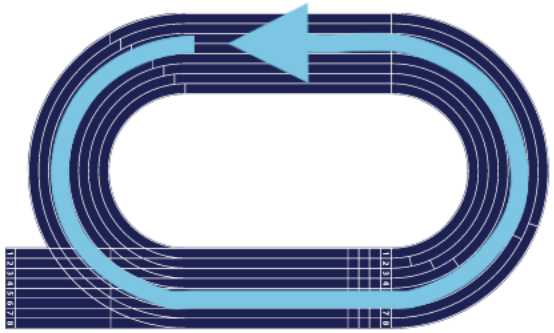
Even-paced

(Bellinger et al., EJAP & MSSE, 2021; Mallett et al., Int. J. Sports Physiol Perform, 2021)

2 Can I adapt my competition strategy?

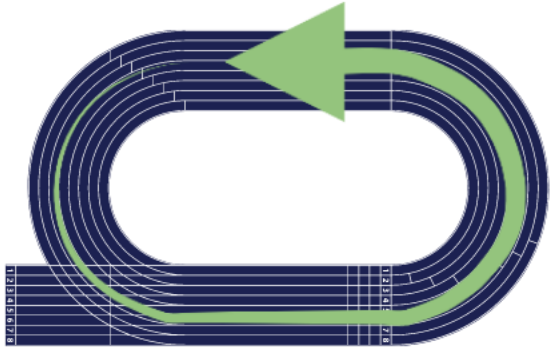
- ATHLETICS (1,500 m & 800 m):

Slow typology



Even-paced

Fast typology

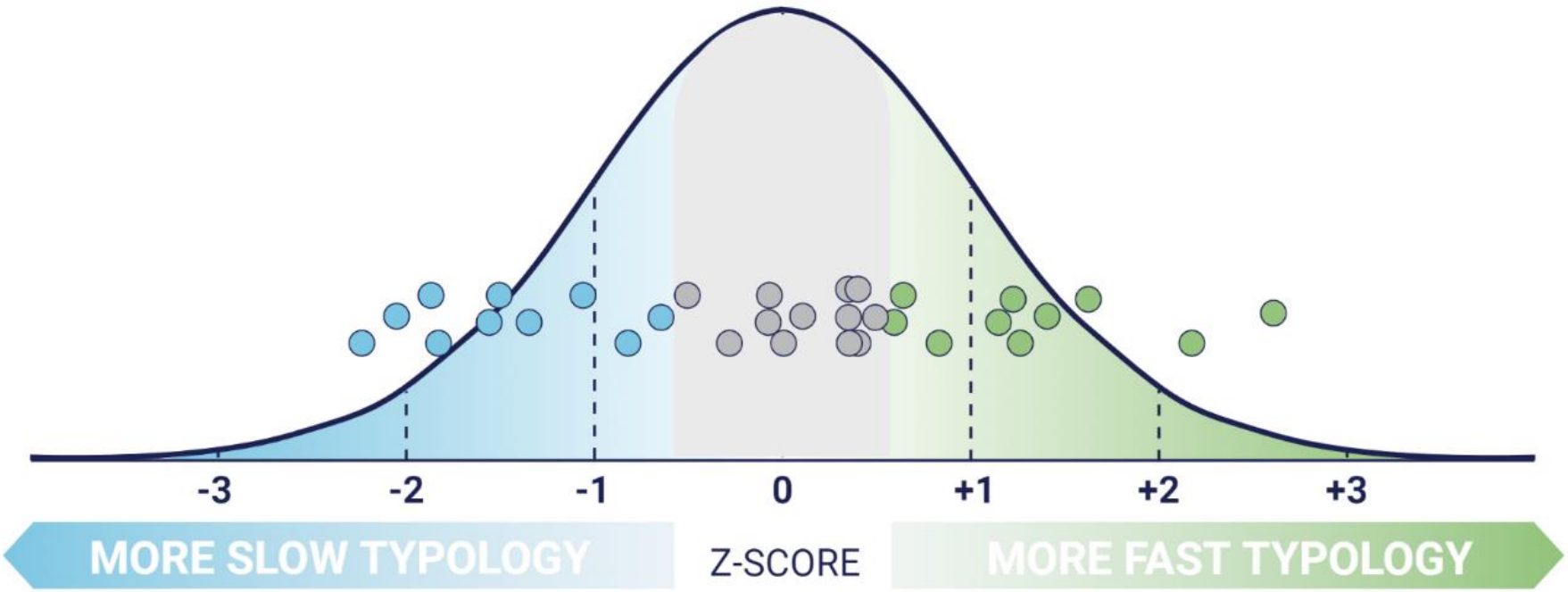


Slow start & fast end

(Bellinger et al., EJAP & MSSE, 2021; Mallett et al., Int. J. Sports Physiol Perform, 2021)

3 Can I adapt my training program?

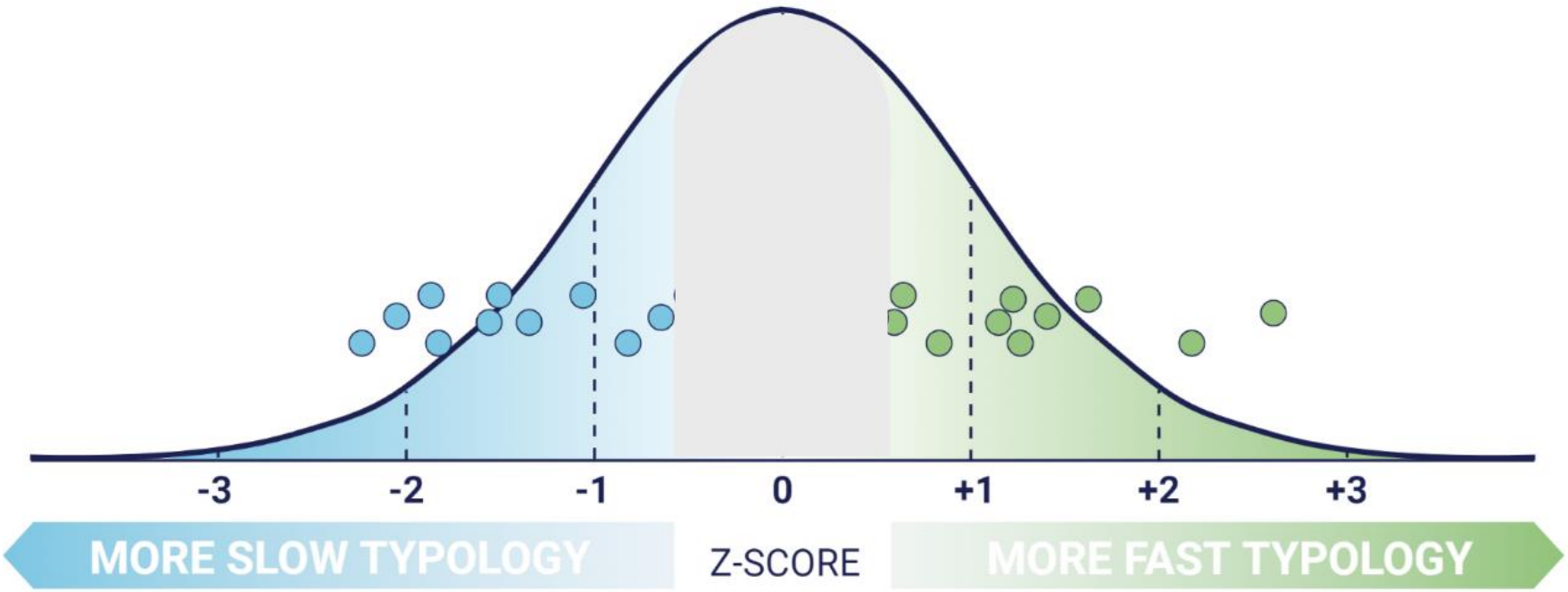
- **Single training session**



Lievens et al., JAP, 2021

3 Can I adapt my training program?

- **Single training session**



Lievens et al., JAP, 2021

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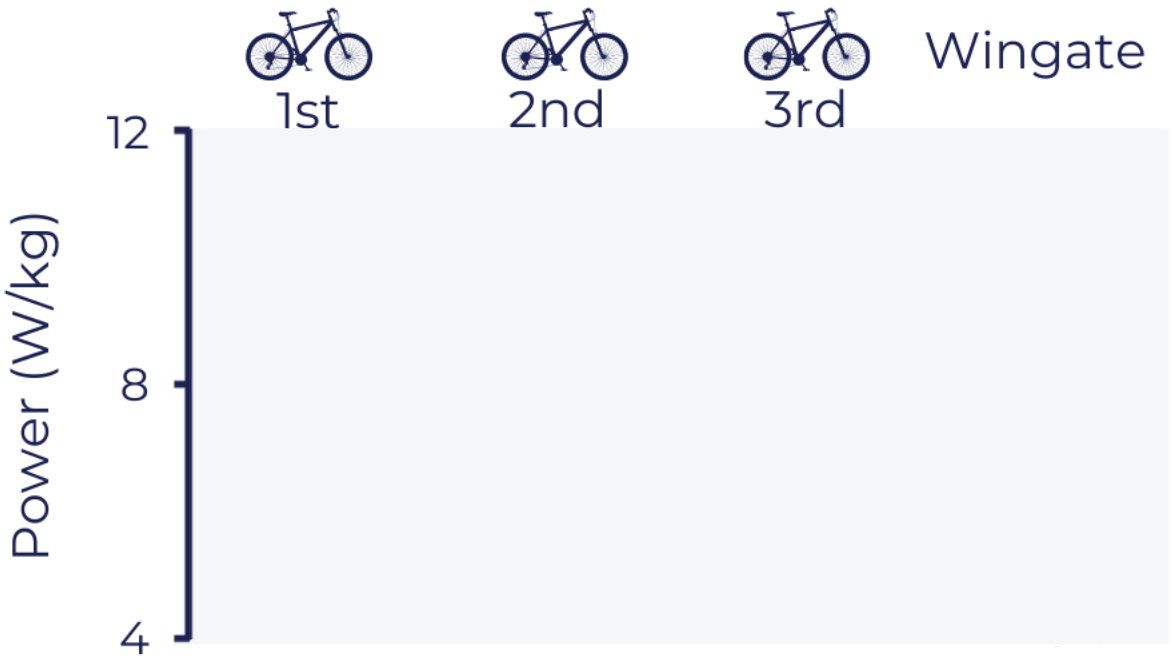

Lievens et al., JAP, 2021

3 Can I adapt my training program?

- **Single training session**

- Slow typology
- Fast typology

Lievens et al., JAP, 2021

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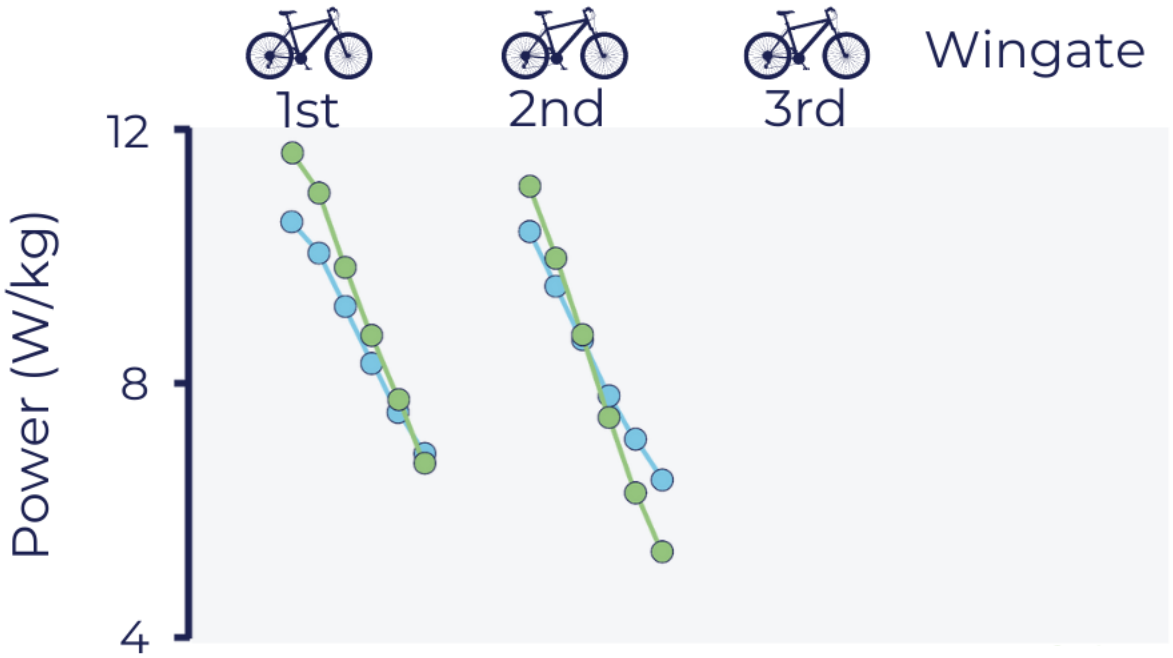

- Slow typology
- Fast typology

Lievens et al., JAP, 2021

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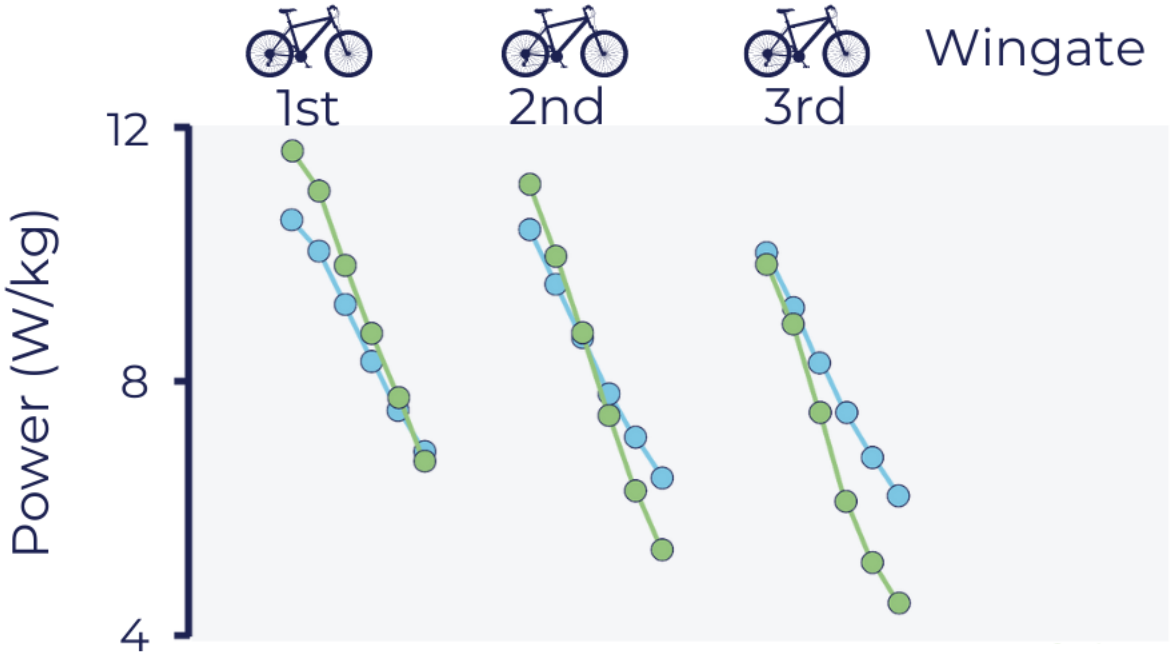

- Slow typology
- Fast typology

Lievens et al., JAP, 2021

3 Can I adapt my training program?

- **Single training session**

Lievens et al., JAP, 2021

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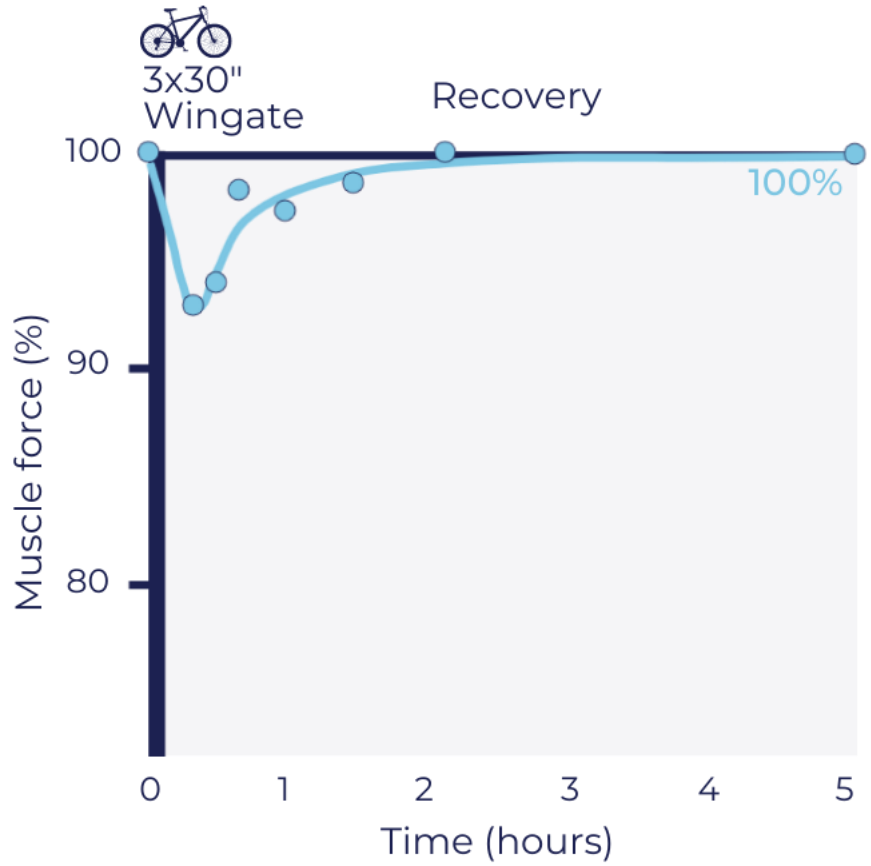

(Lievens et al., JAP, 2021)

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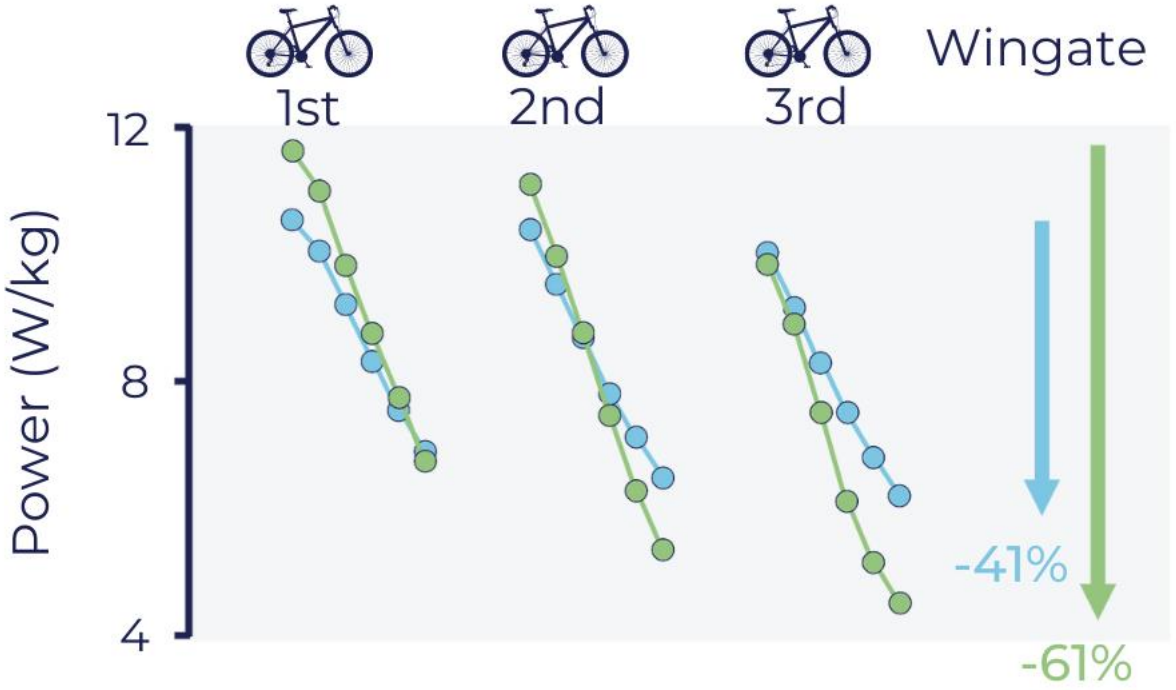
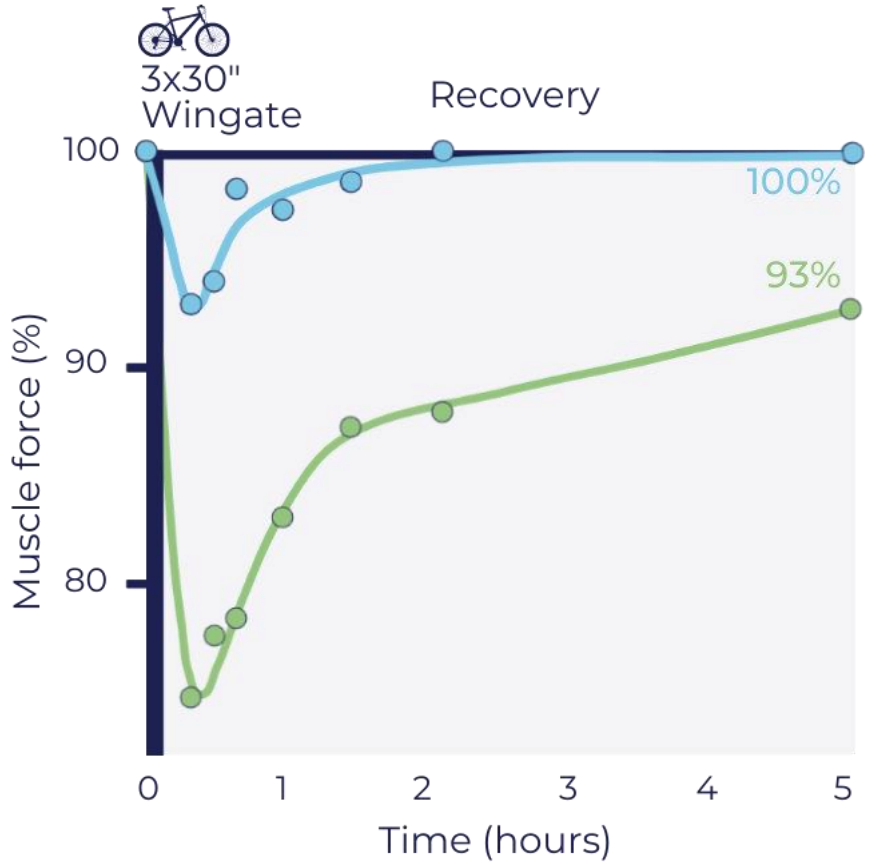


- Slow typology
- Fast typology



(Lievens et al., JAP, 2021)

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- **Multiple training sessions**

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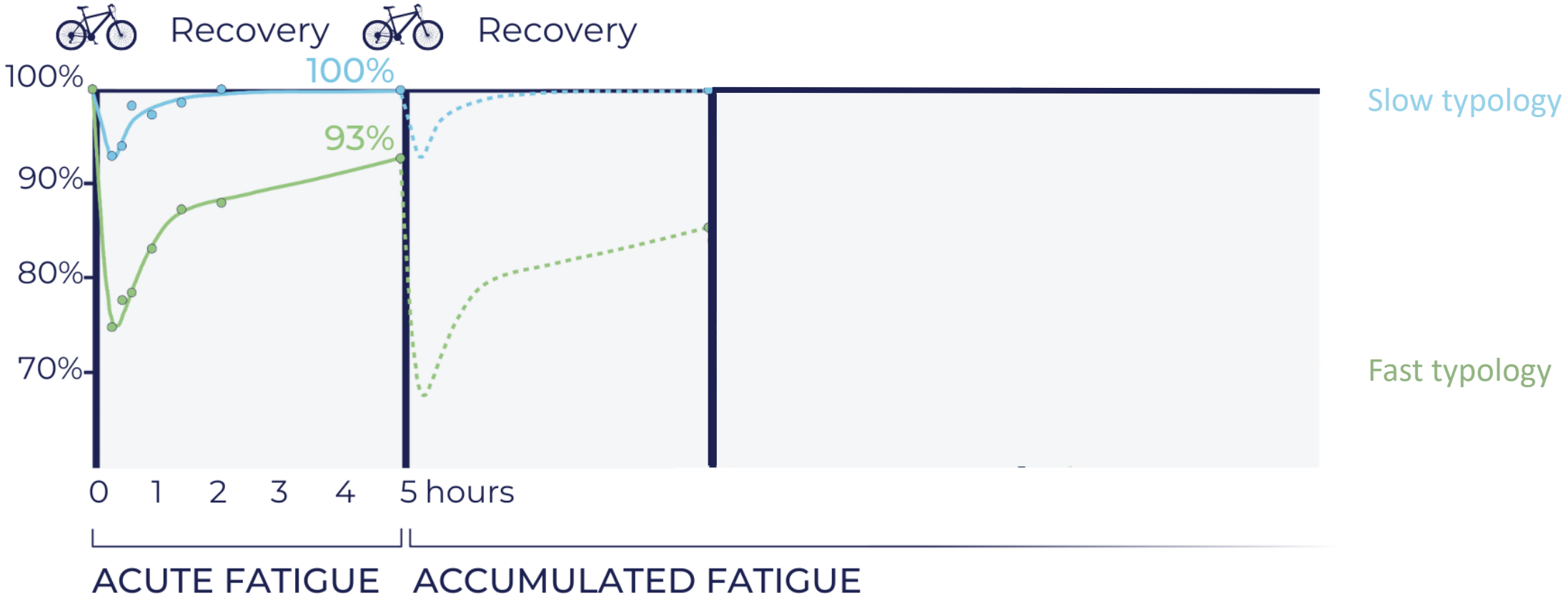

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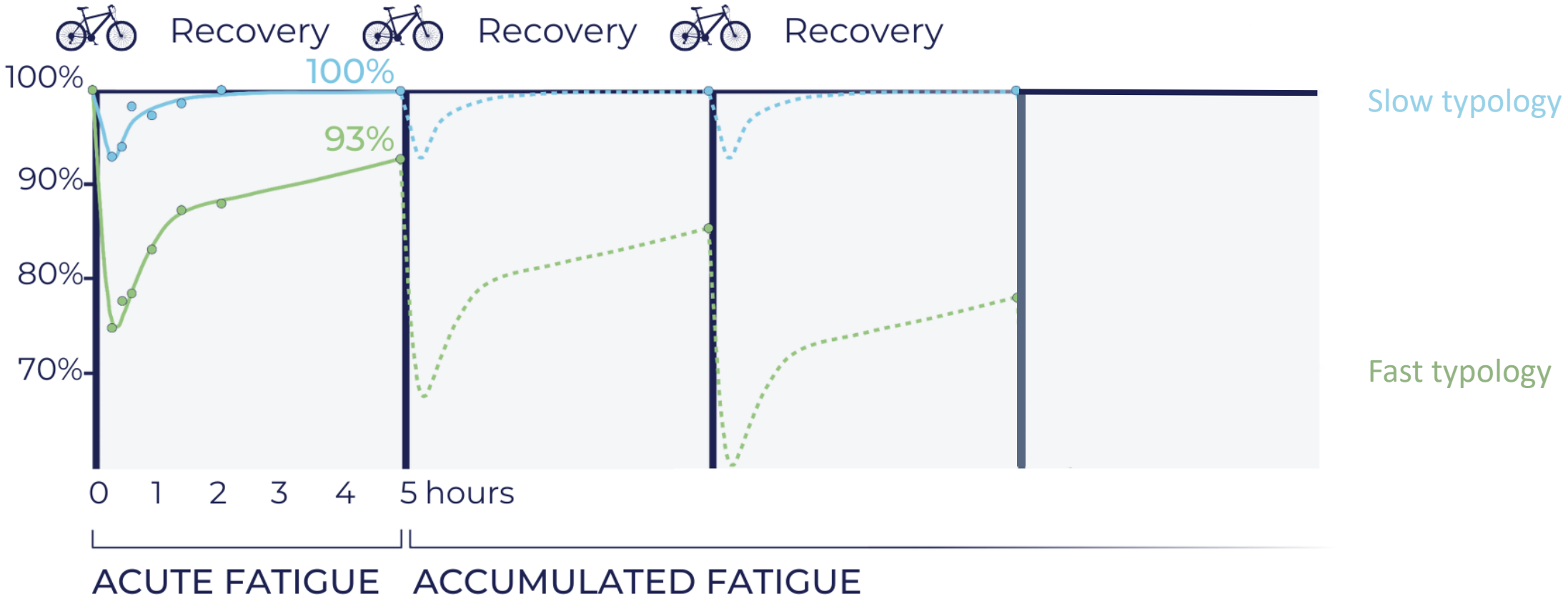

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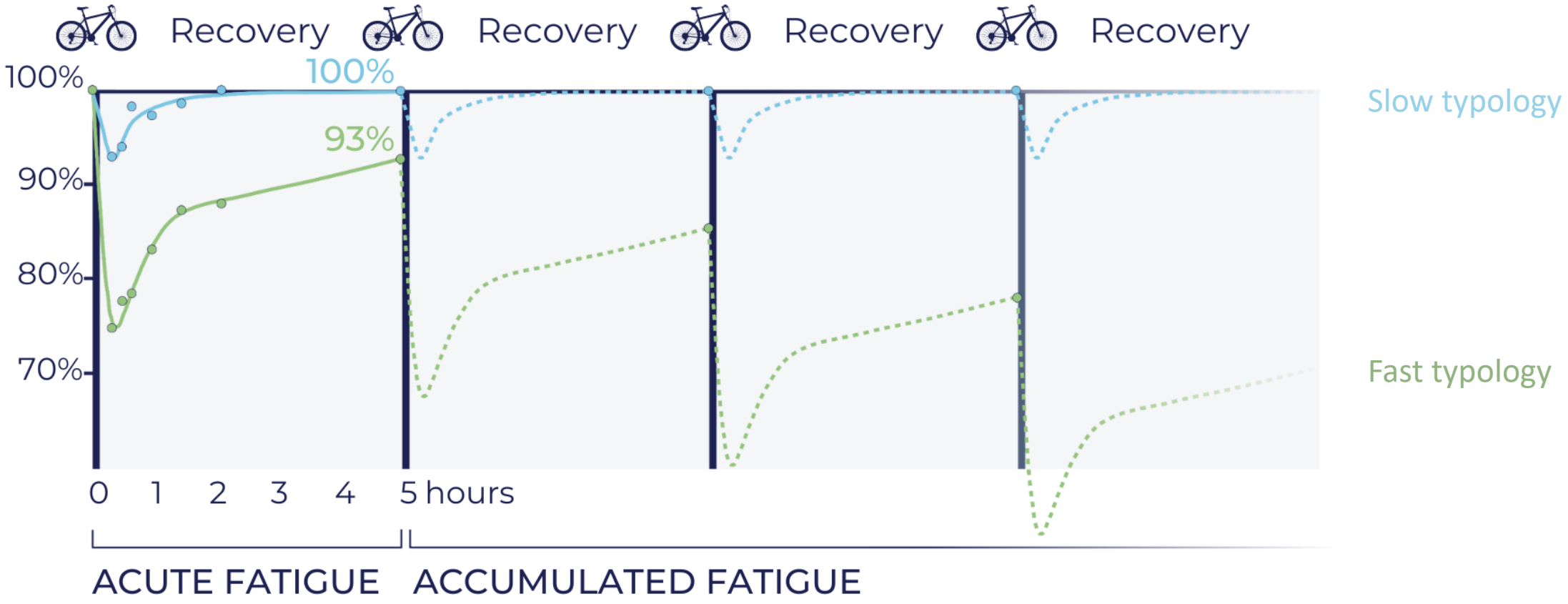

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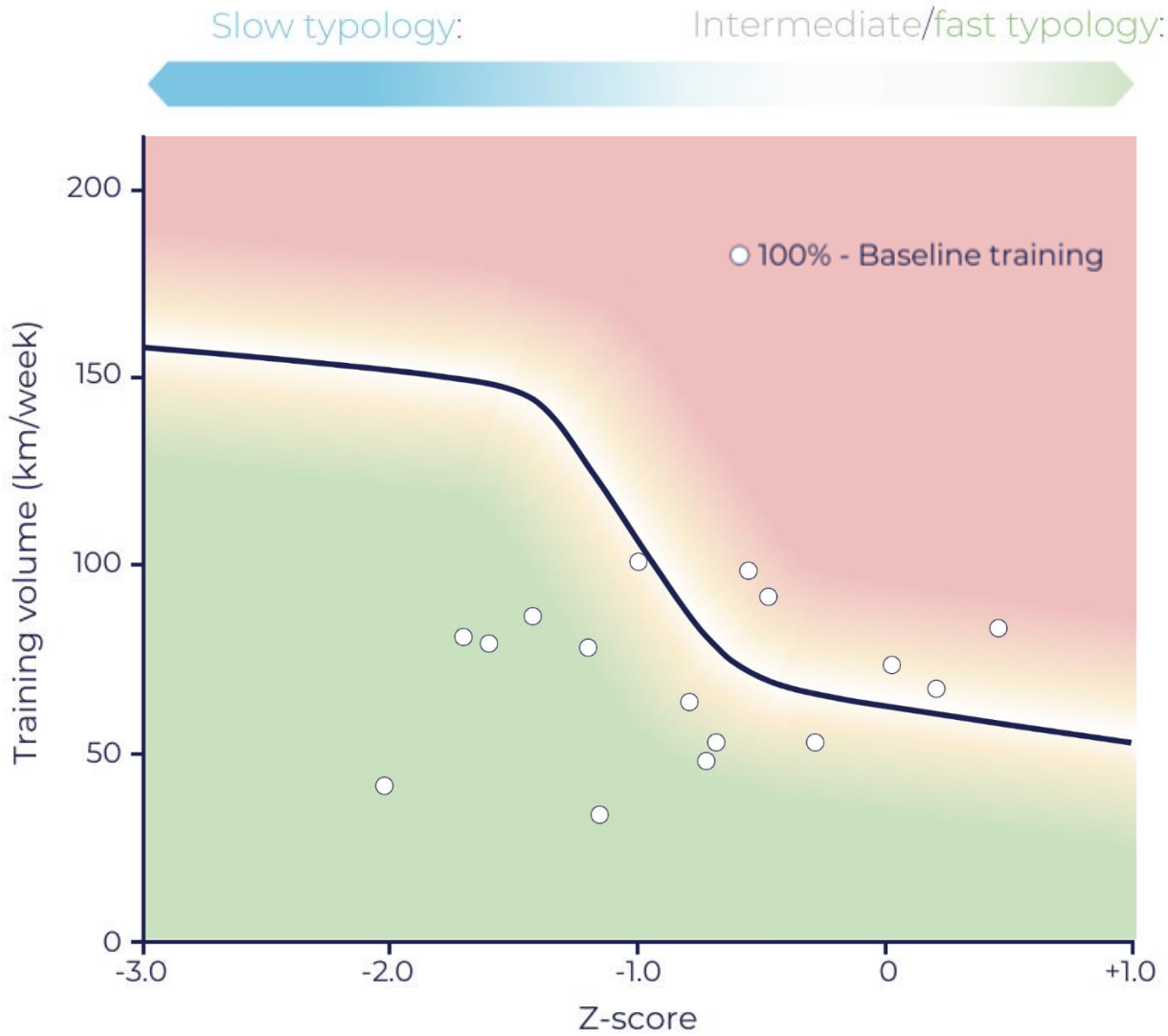

(Bellinger et al., JAP, 2021)

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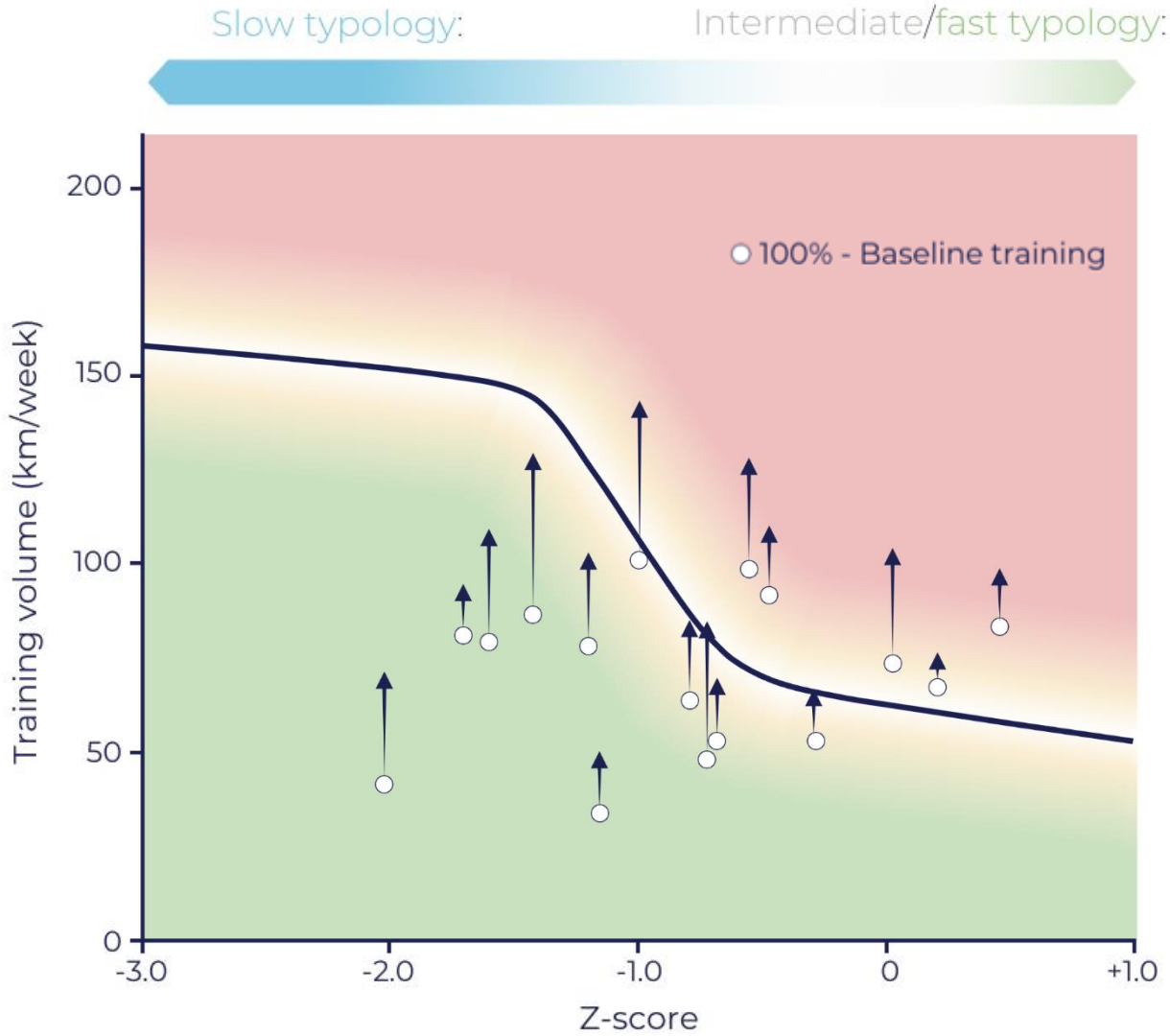

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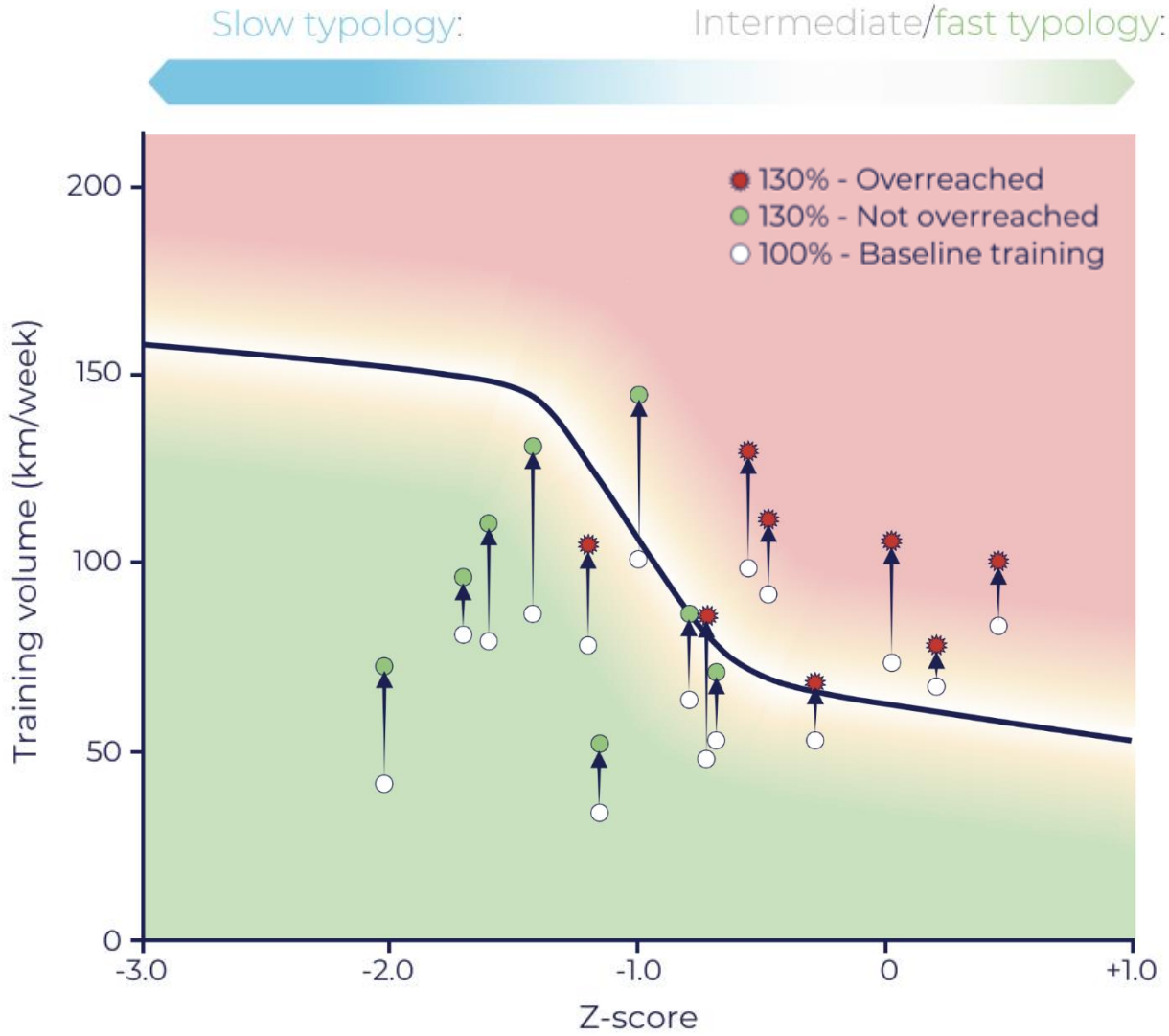

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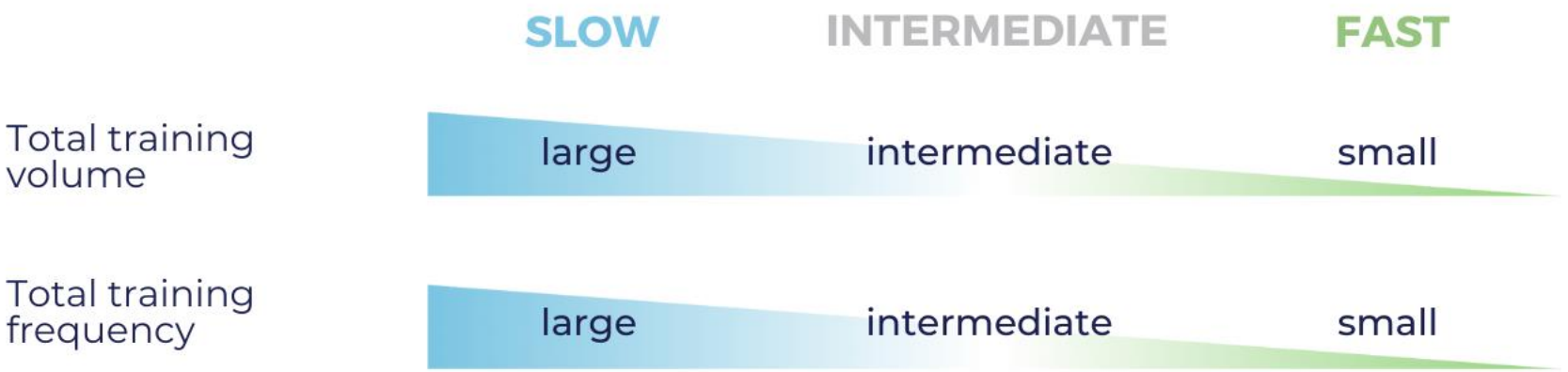

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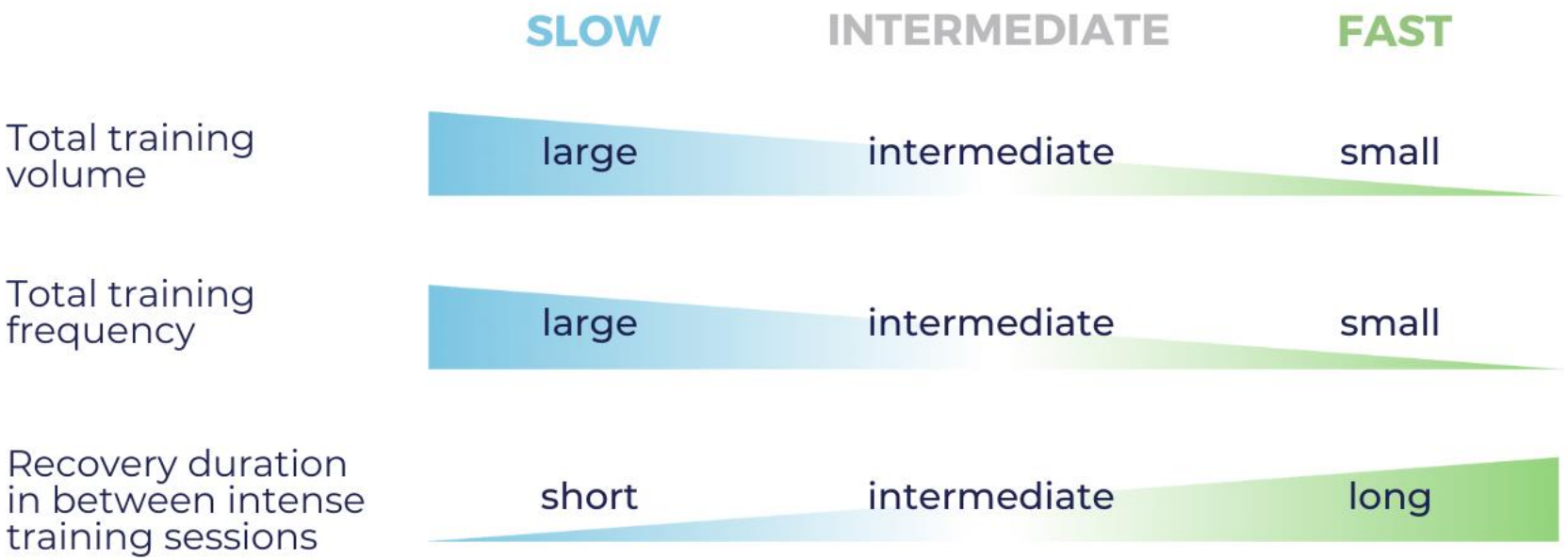

4 Can I estimate injury risk?

Lievens et al., Sports Med, 2021

4 How does the muscle typology looks like in football?

118

Gent
Club Brugge
Zulte-Waregem
Kortrijk

Goal keeper

15

Defender

38

Midfielder

37

Striker

28

Lievens et al., Sports Med, 2021

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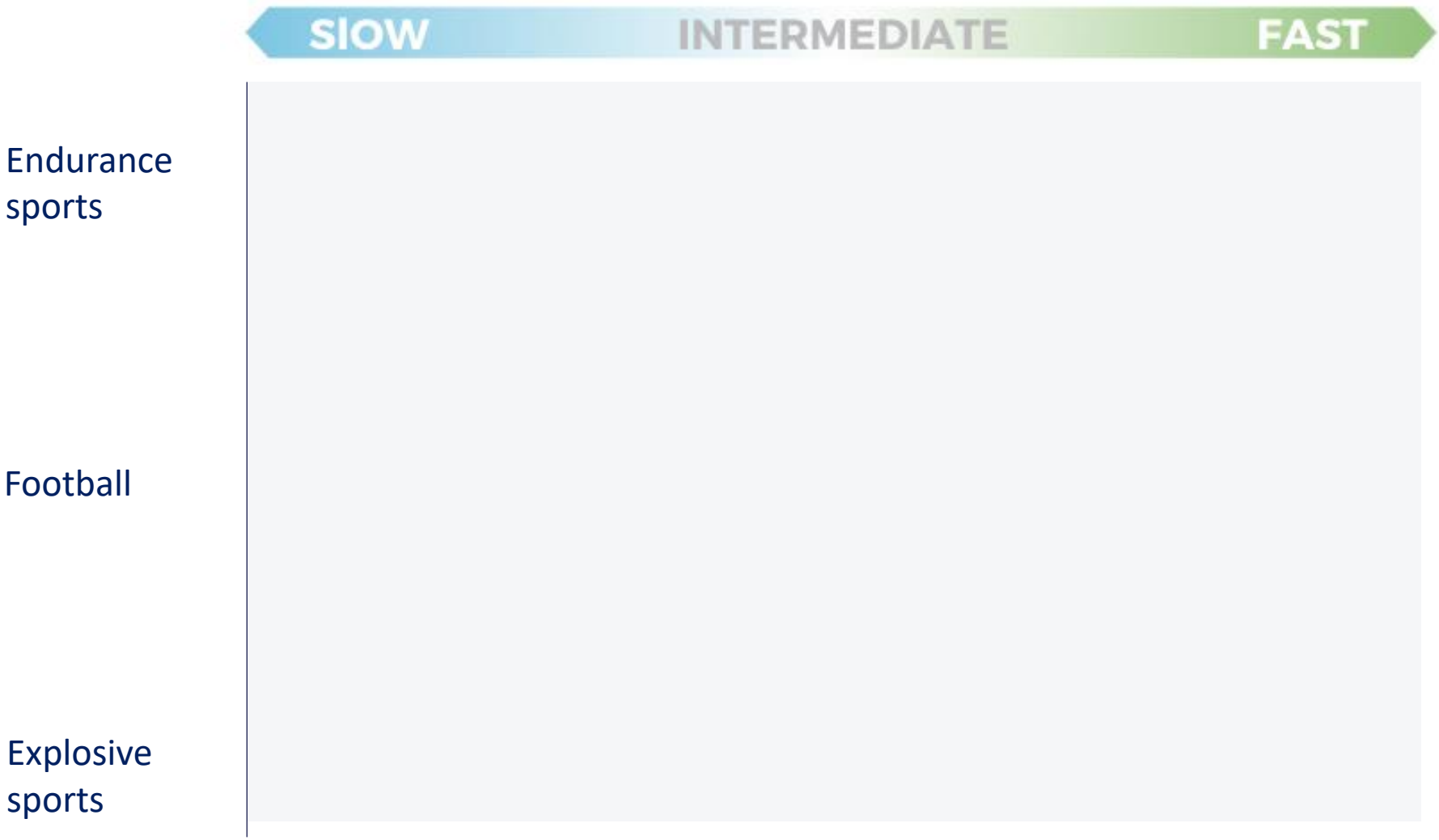

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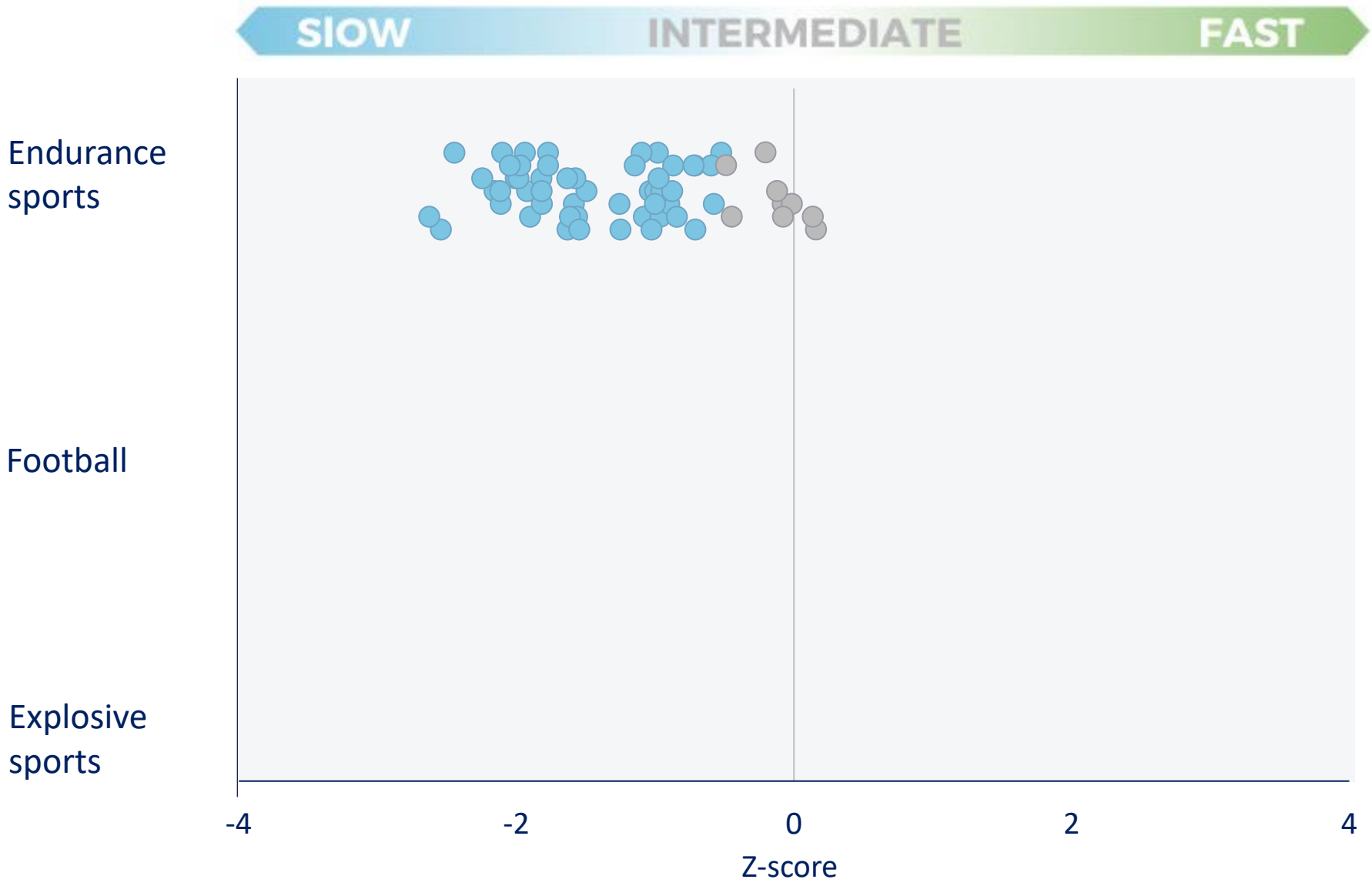

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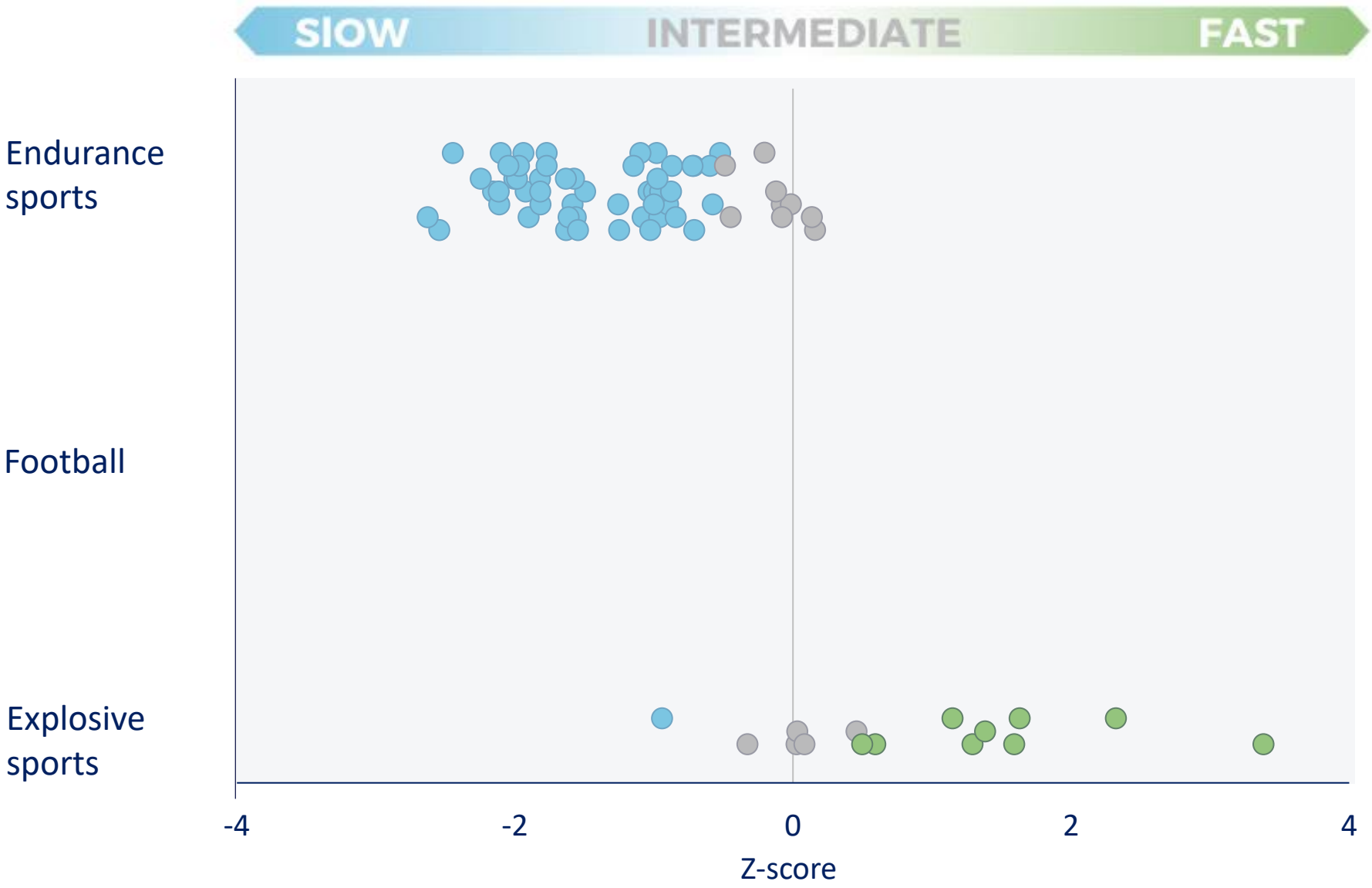

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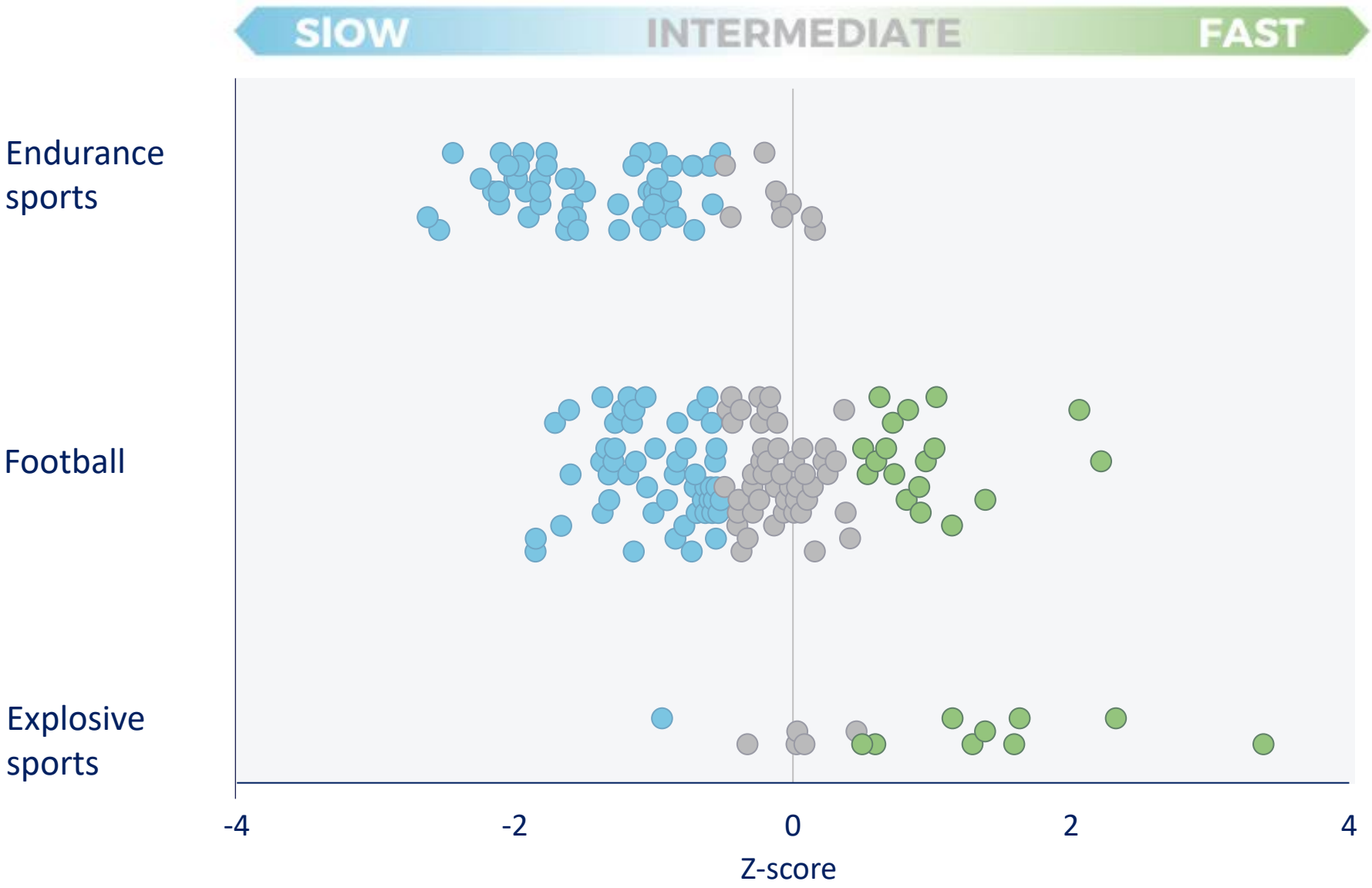

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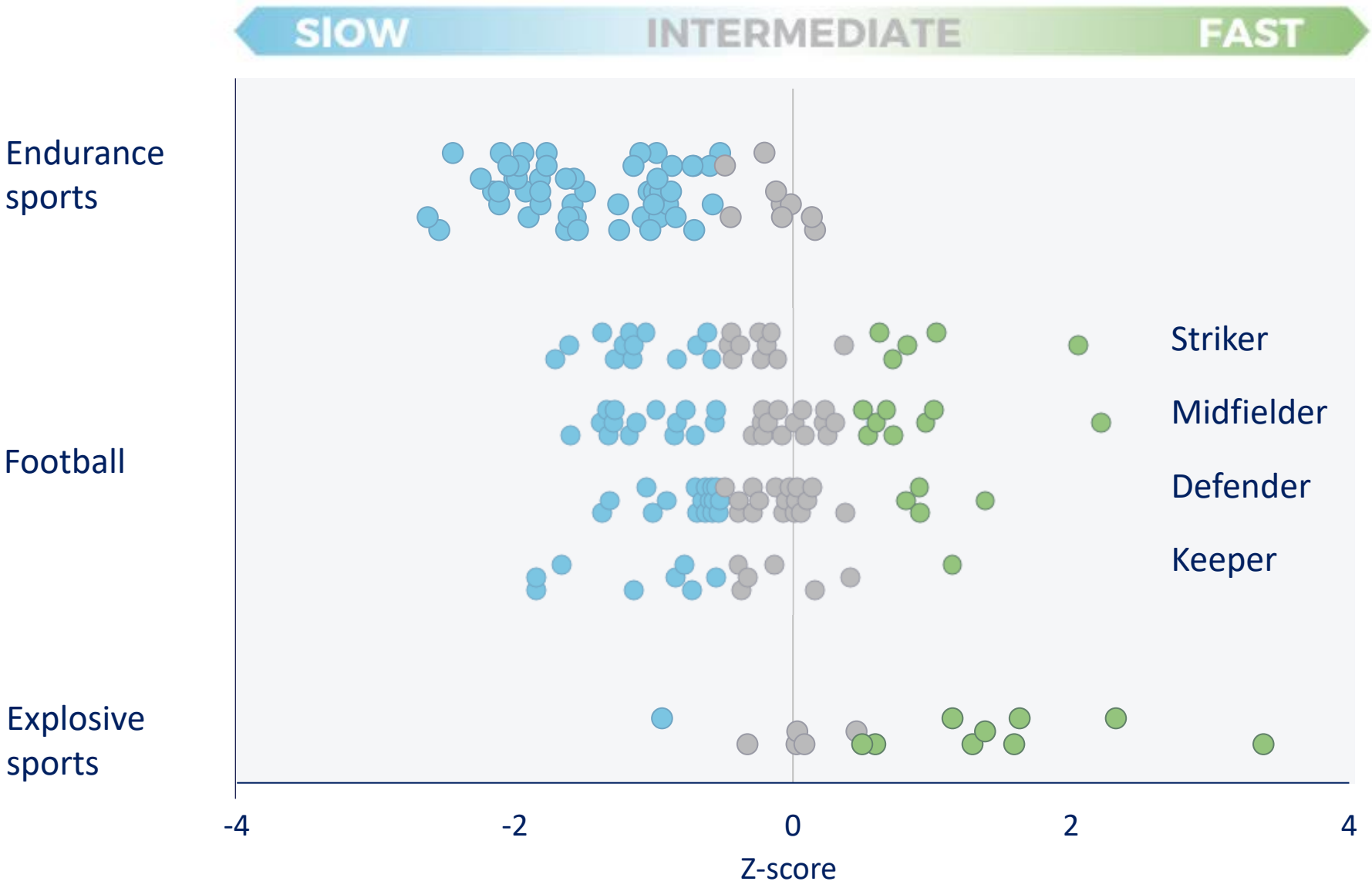

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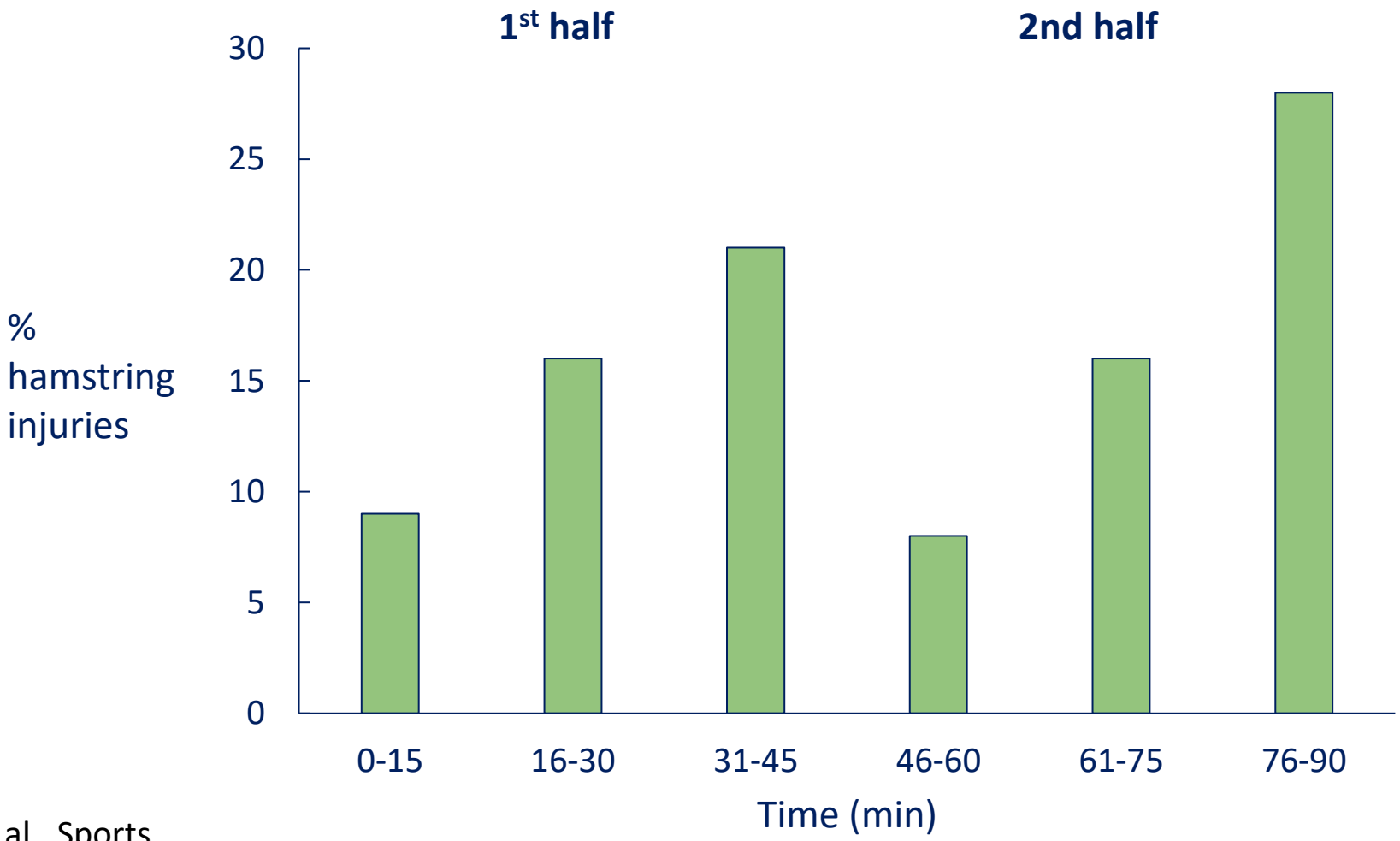
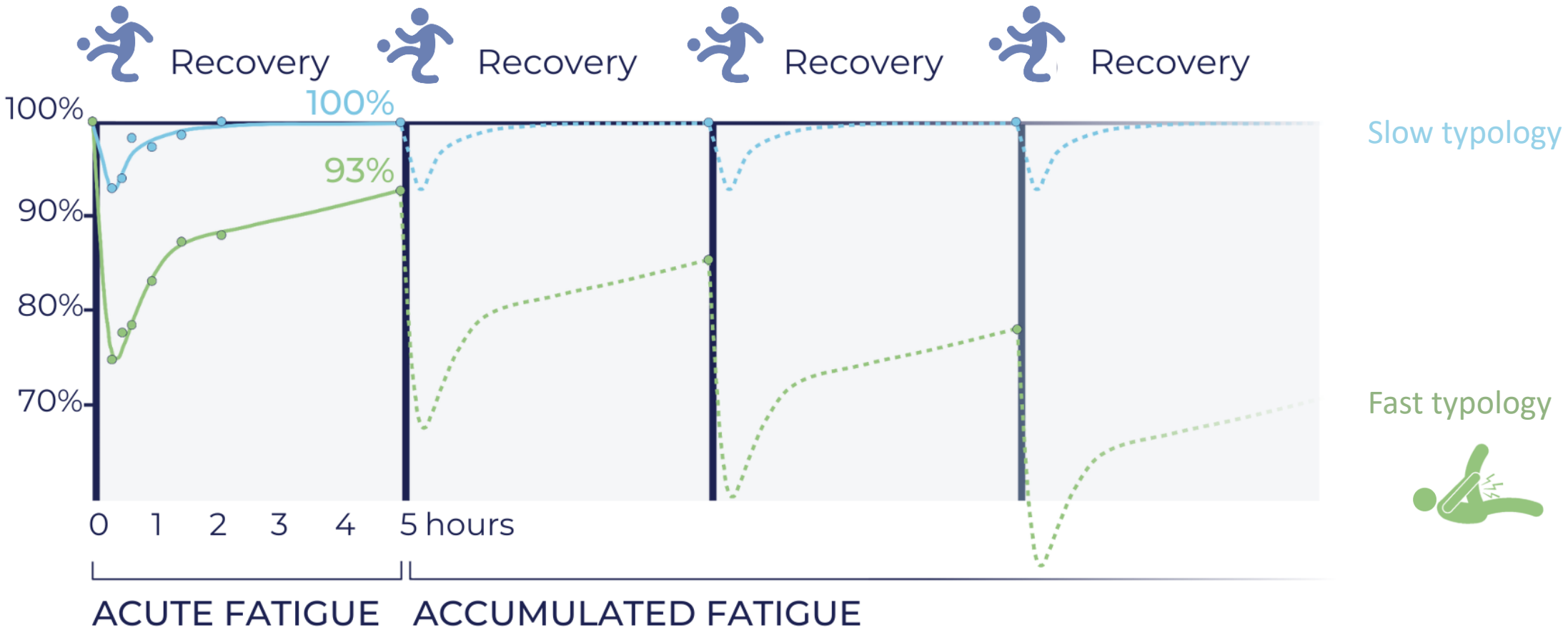


Lievens et al., Sports Med, 2021

4 Can I estimate injury risk?

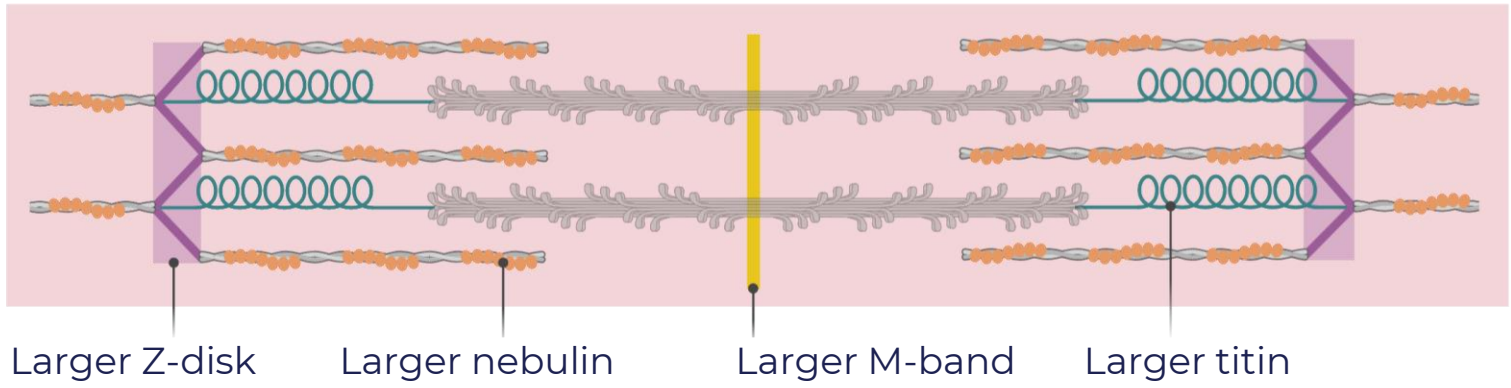
- **Modifiable risk**

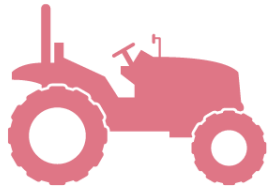


4 Can I estimate injury risk?

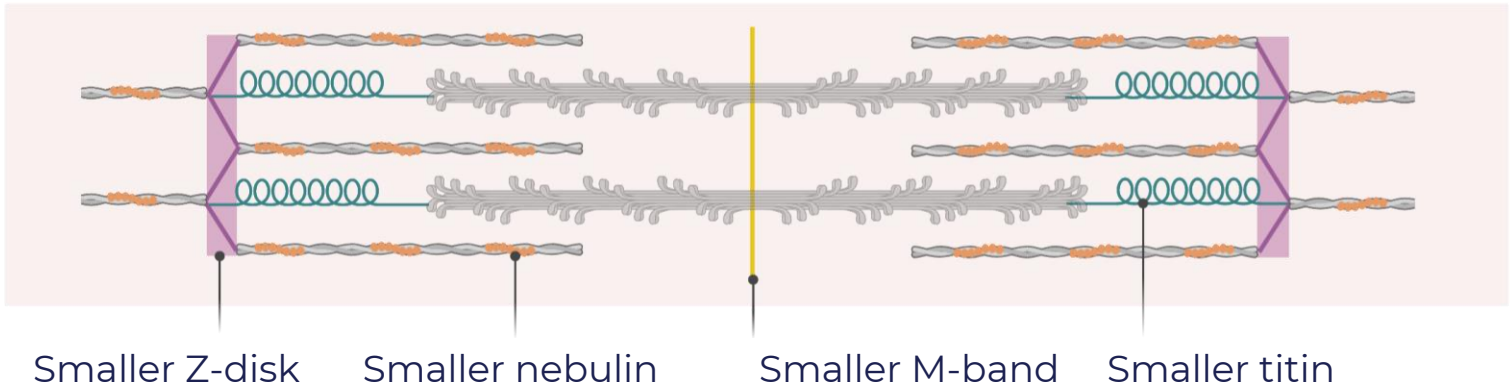
- **Non-modifiable risk**

Slow-twitch





Fast-twitch



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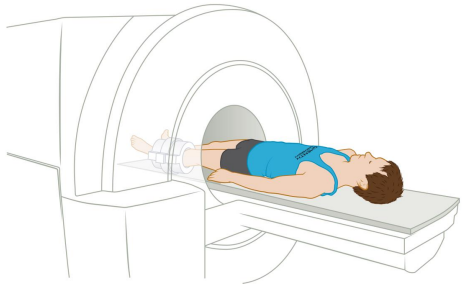
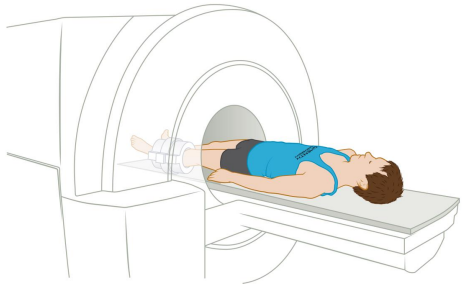


Jupiler Pro League n=118

Premier League n=47

Lievens et al., Sports Med, 2021

4 Can I estimate injury risk?

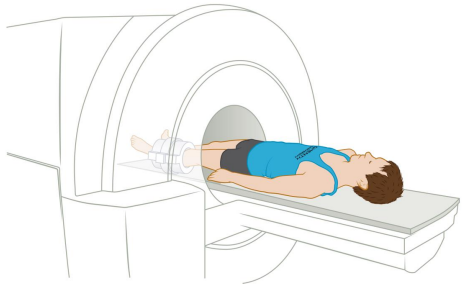


Jupiler Pro League n=118 → 61

Premier League n=47→ 34

Lievens et al., Sports Med, 2021

4 Can I estimate injury risk?



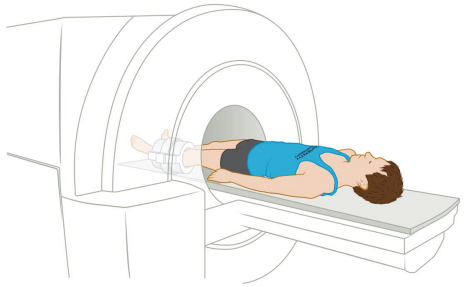
3 seasons

Jupiler Pro League n=118 → 61

Premier League n=47→ 34

Lievens et al., Sports Med, 2021

4 Can I estimate injury risk?



3 seasons

Jupiler Pro League	n=118 → 61	n=14
Premier League	n=47→ 34	n=13

Lievens et al., Sports Med, 2021

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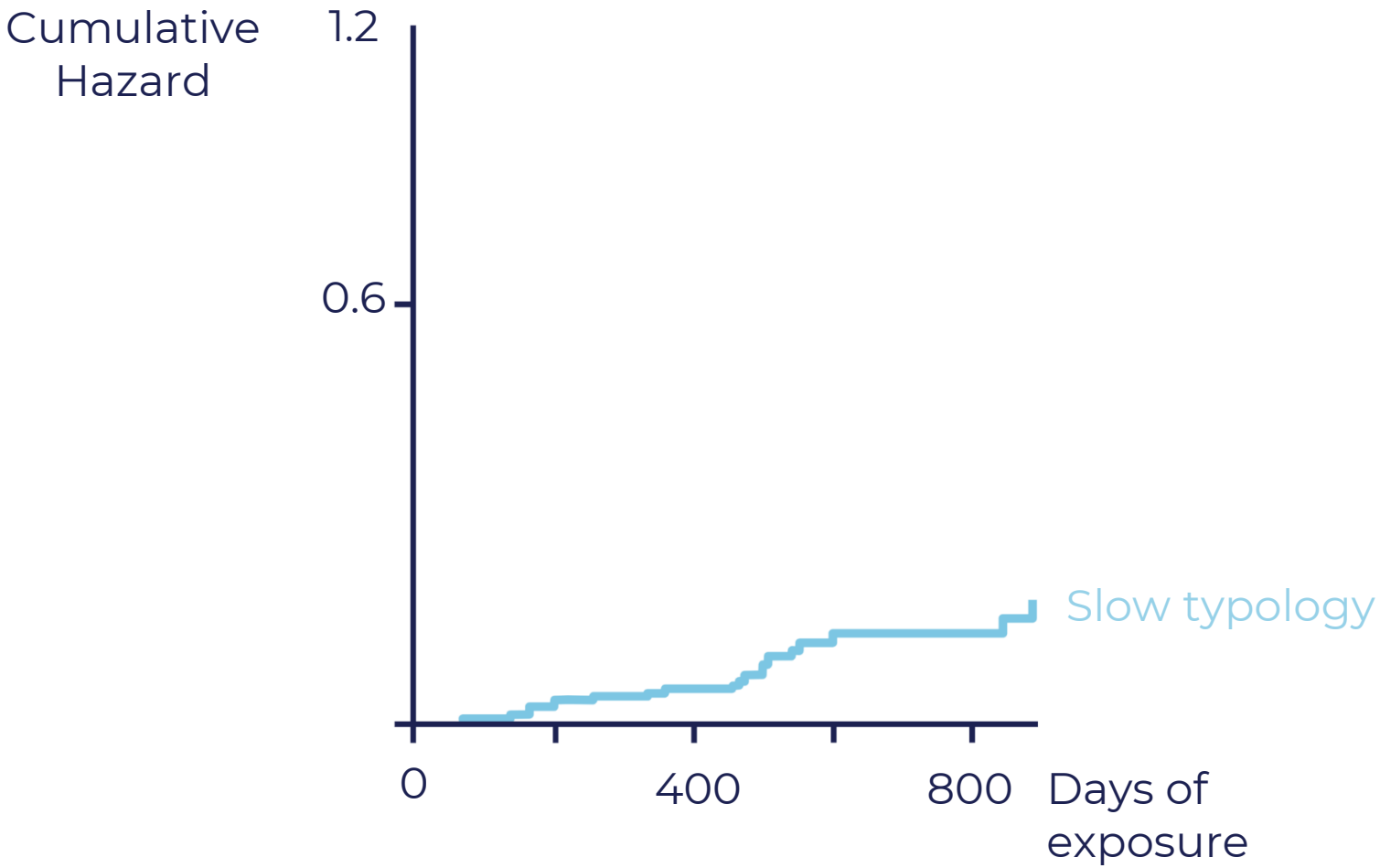

(Lievens et al., Sports Med, 2021)

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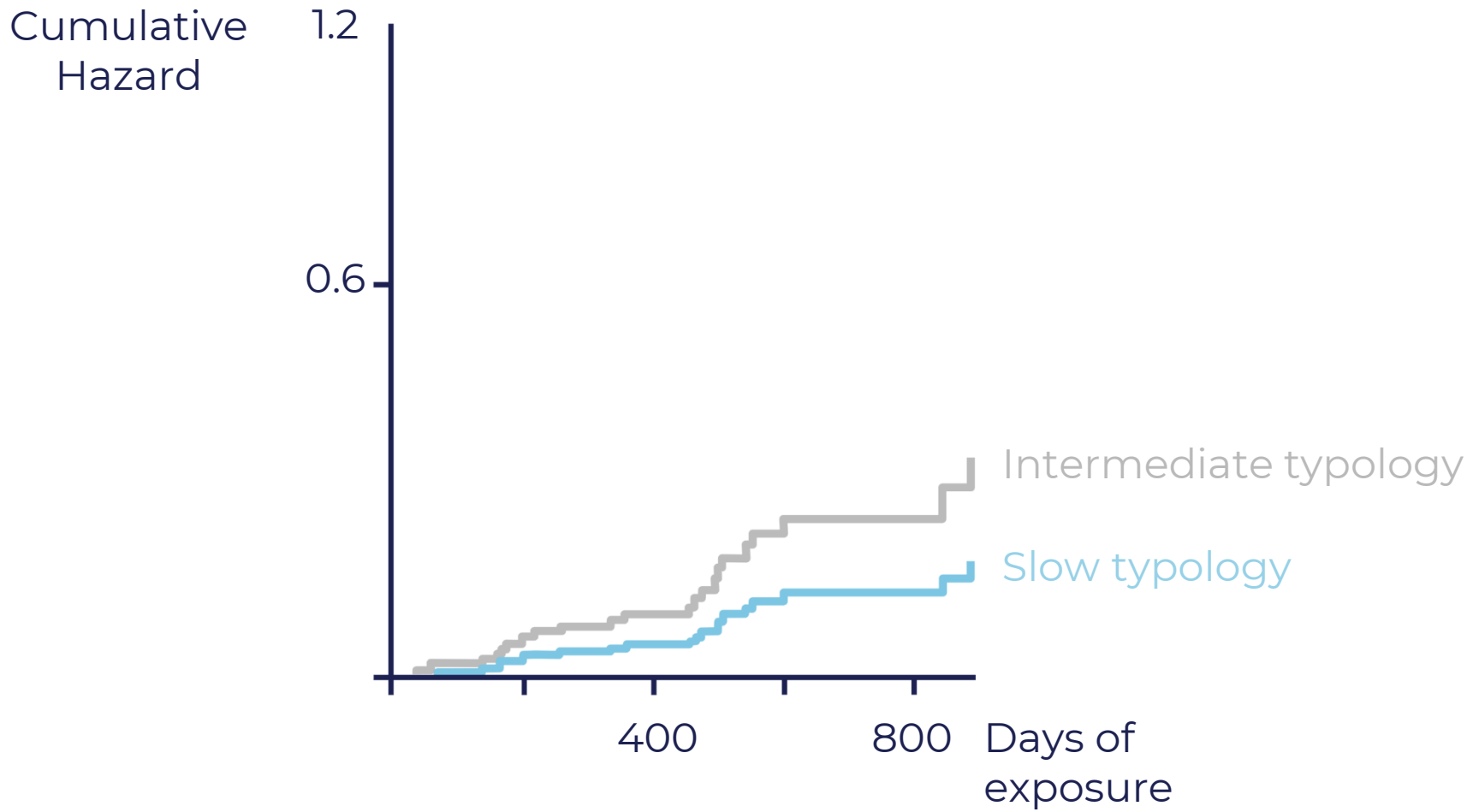

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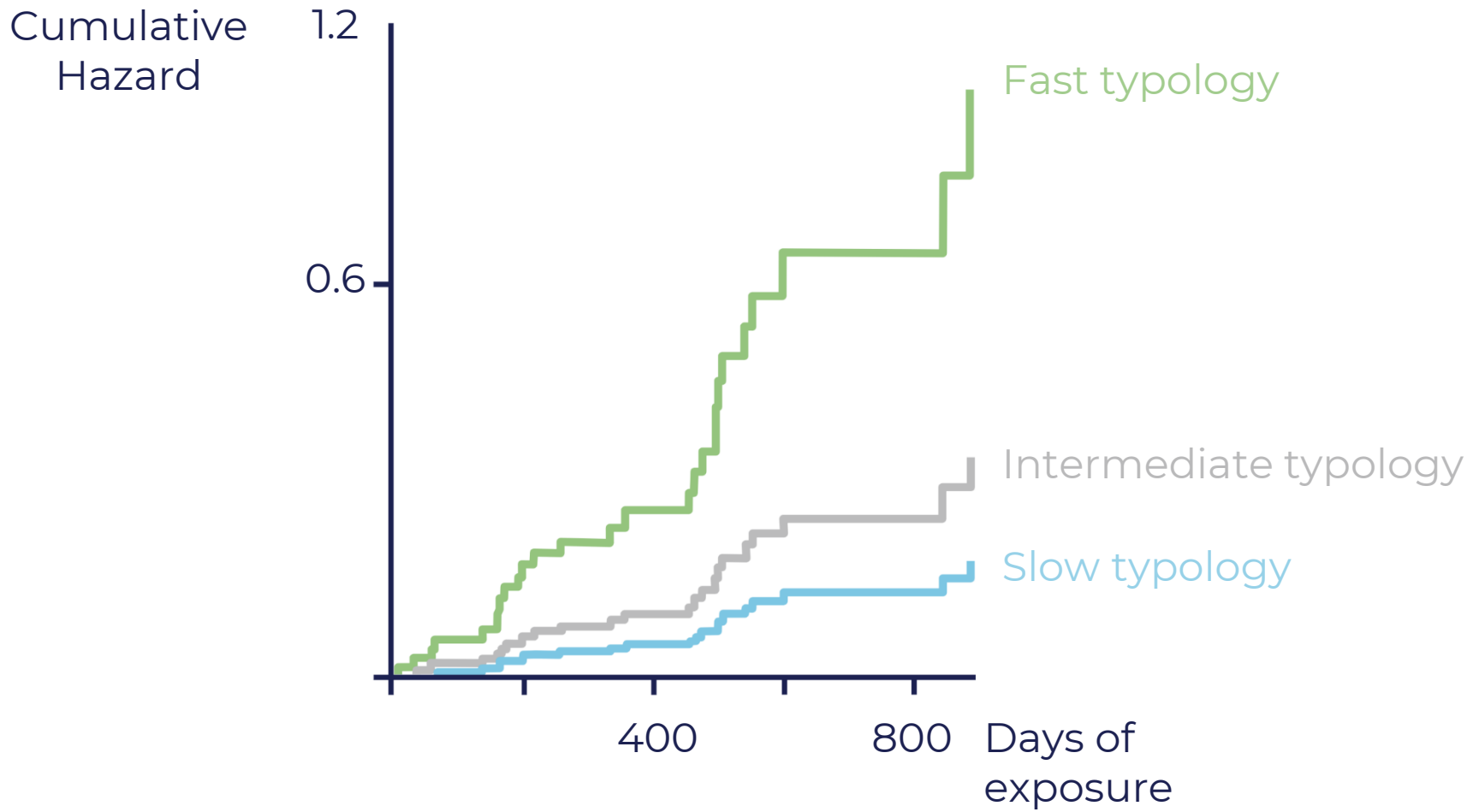

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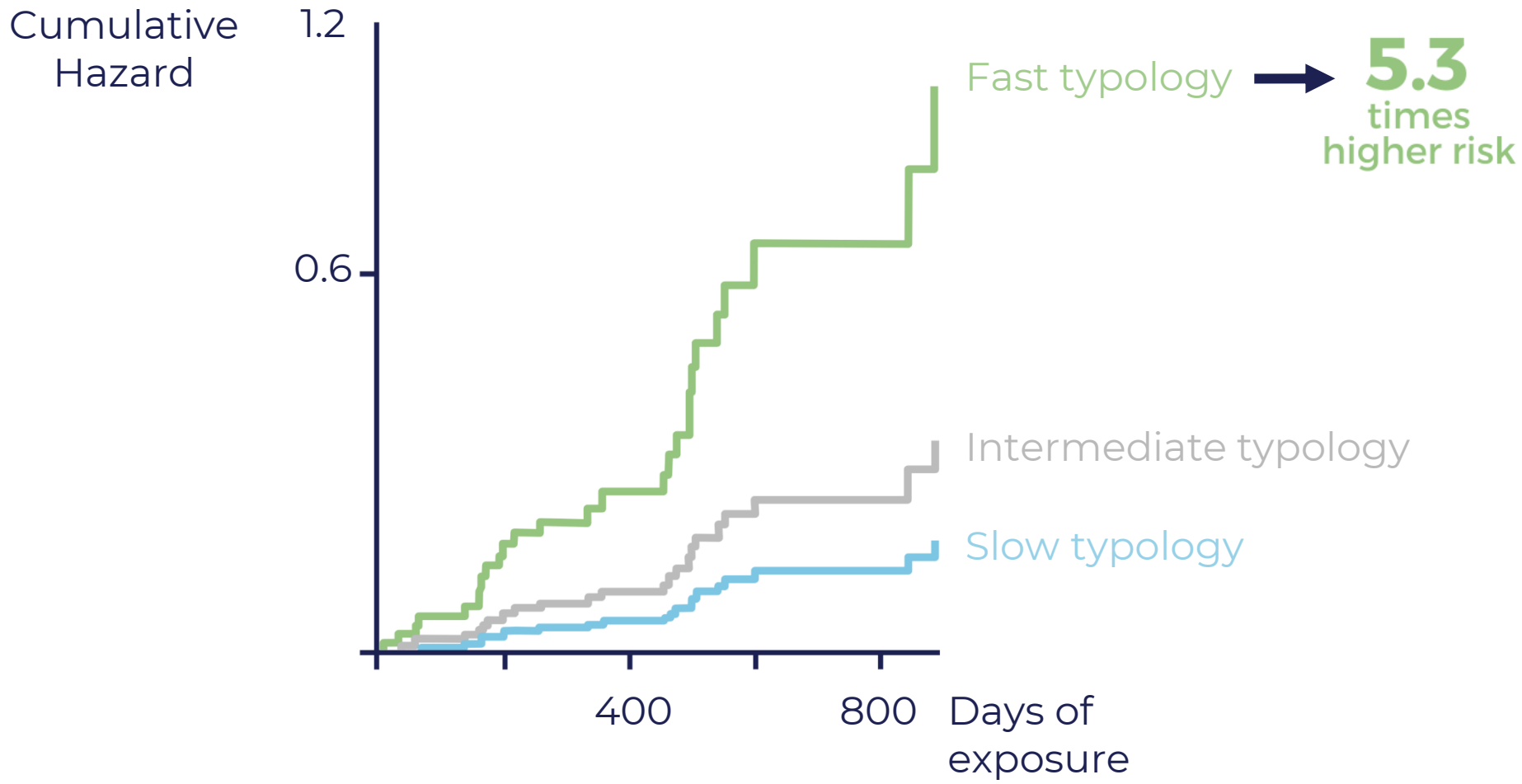
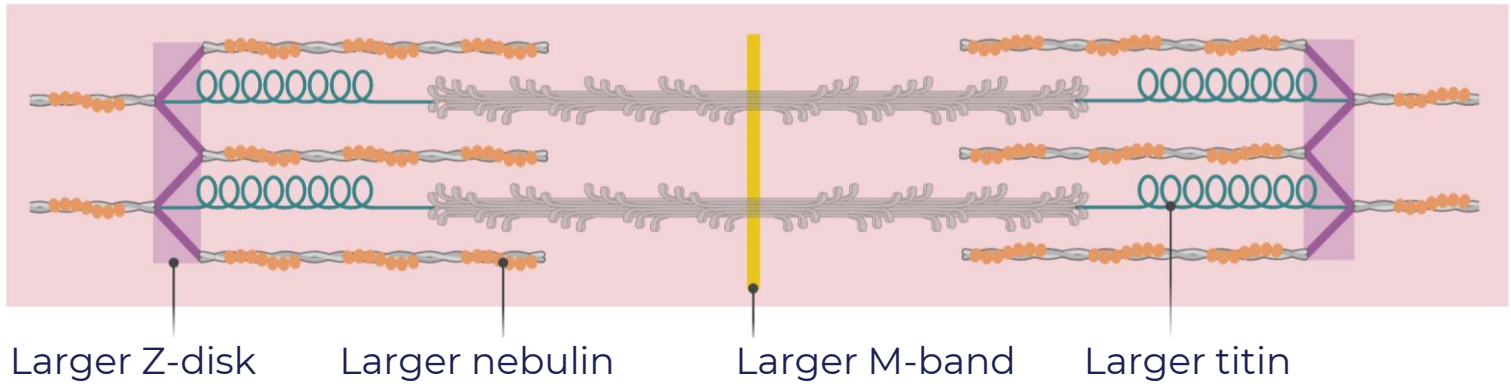


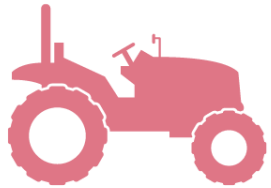
(Lievens et al., Sports Med, 2021)

4 Can I estimate injury risk?

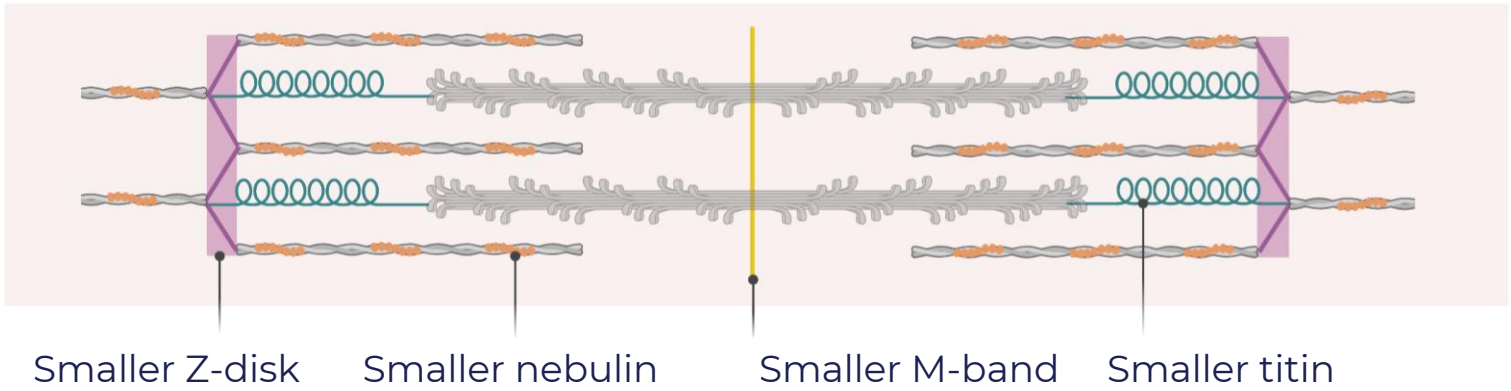
- **Non-modifiable risk**

Slow-twitch



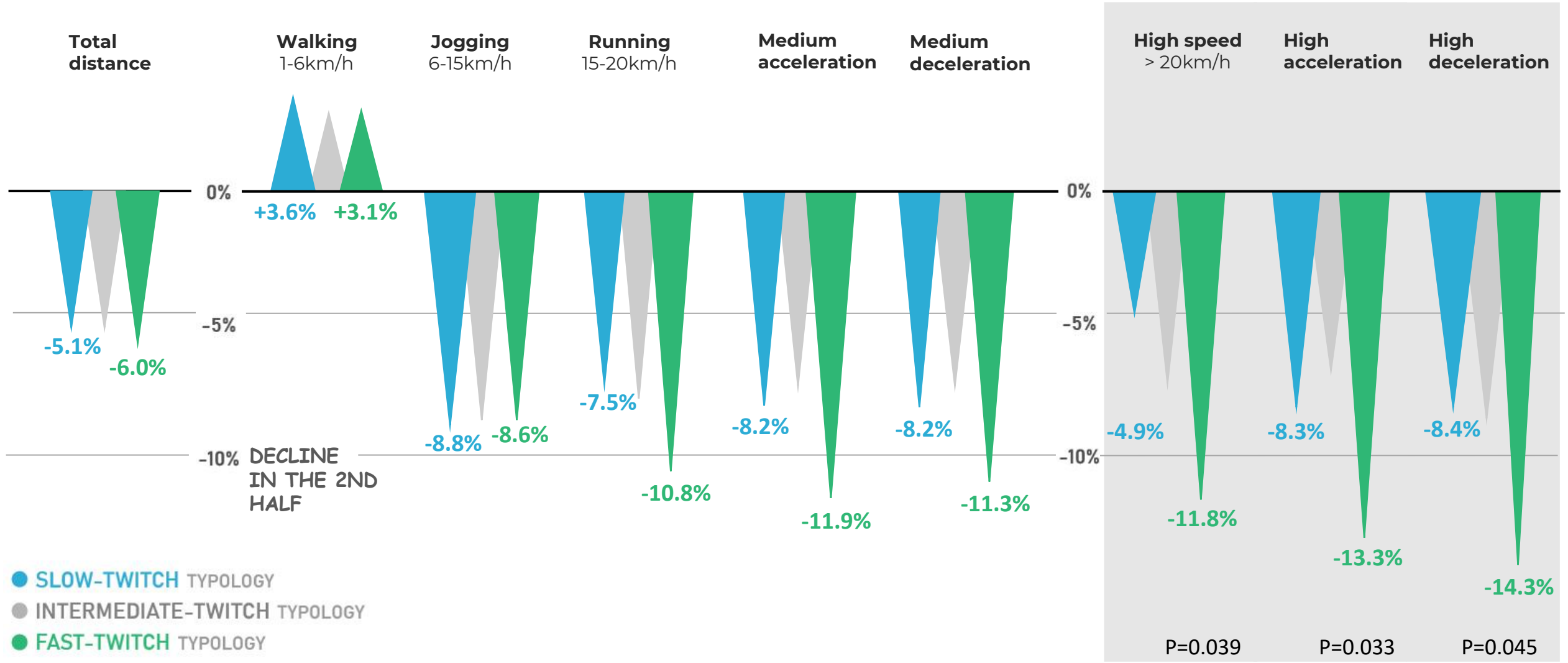


Fast-twitch



4 Can I estimate injury risk?

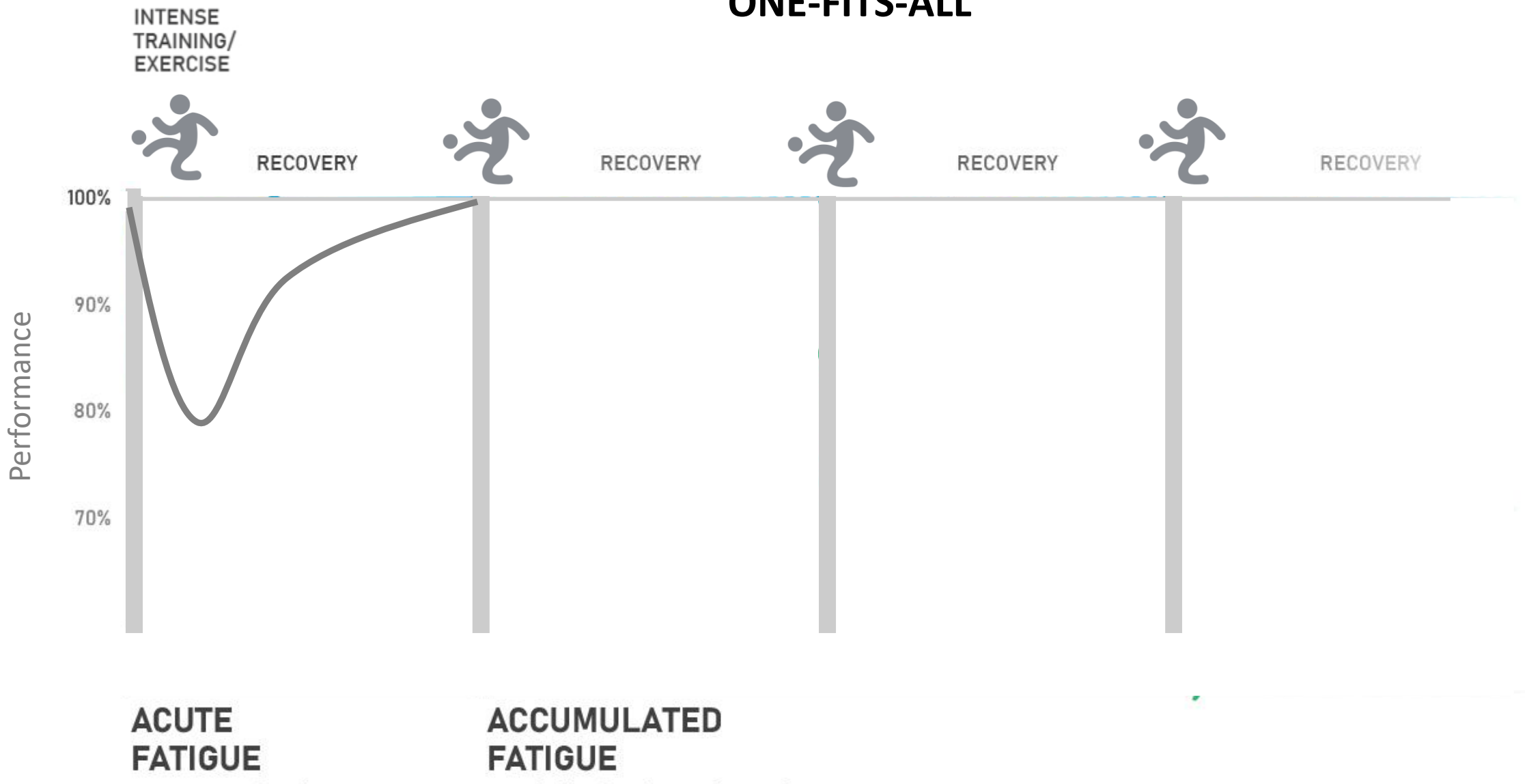
- **Modifiable risk**



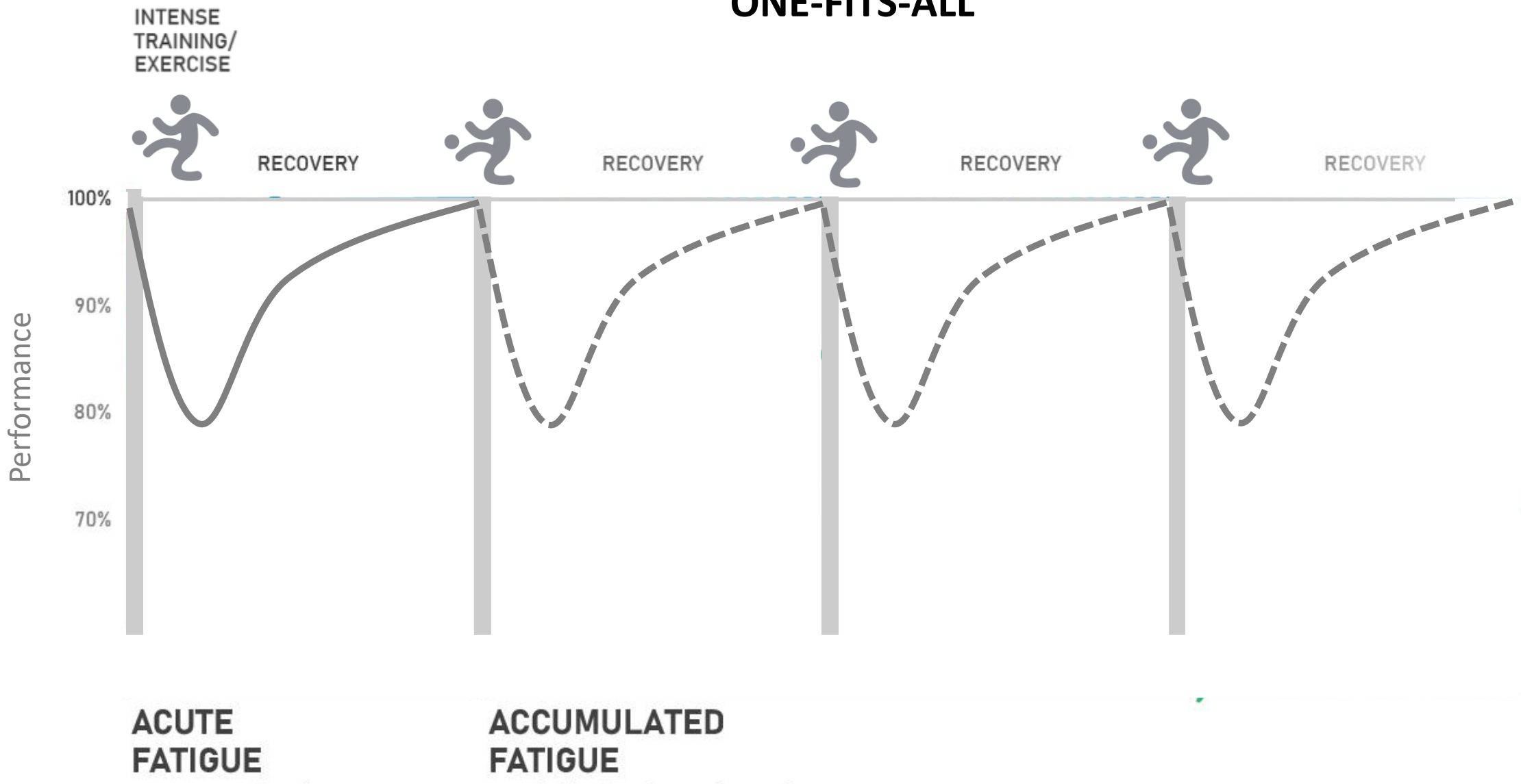
4 Can we prevent injuries?

ONE-FITS-ALL

ONE-FITS-ALL


INTENSE TRAINING/ EXERCISE
RECOVERY
RECOVERY
RECOVERY
RECOVERY
100%
90%
80%
70%
Performance
ACUTE FATIGUE
ACCUMULATED FATIGUE

ONE-FITS-ALL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ONE-DOES-NOT-FIT-ALL

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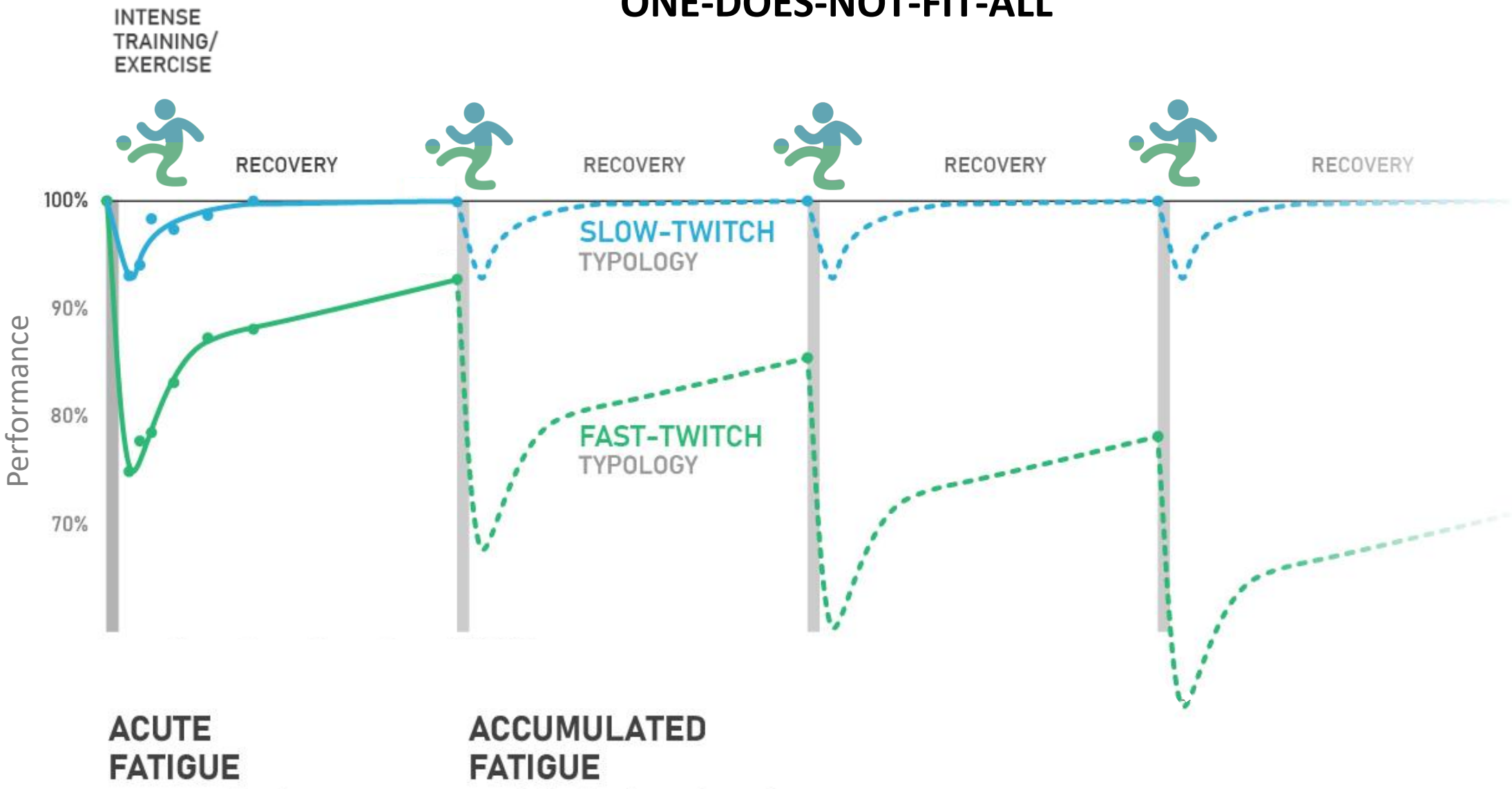

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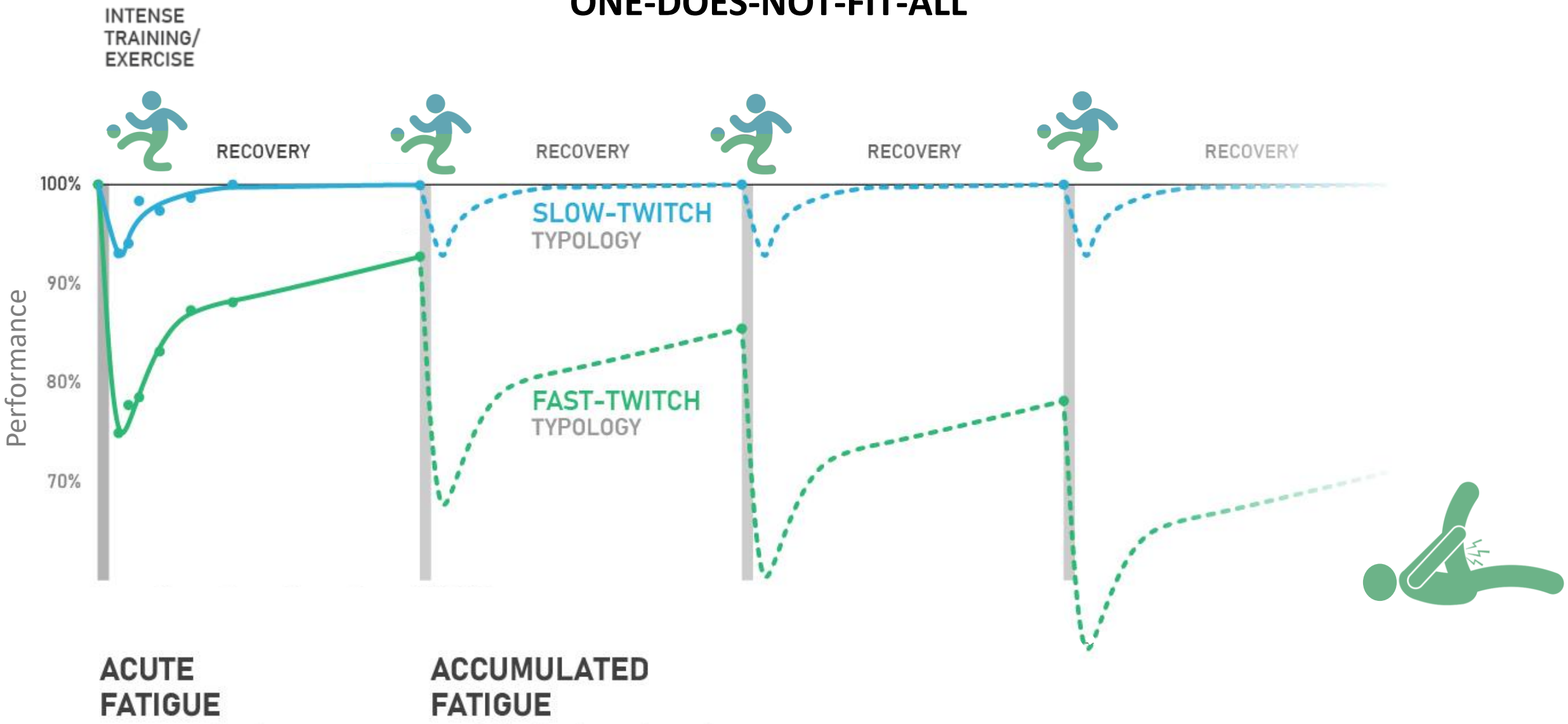
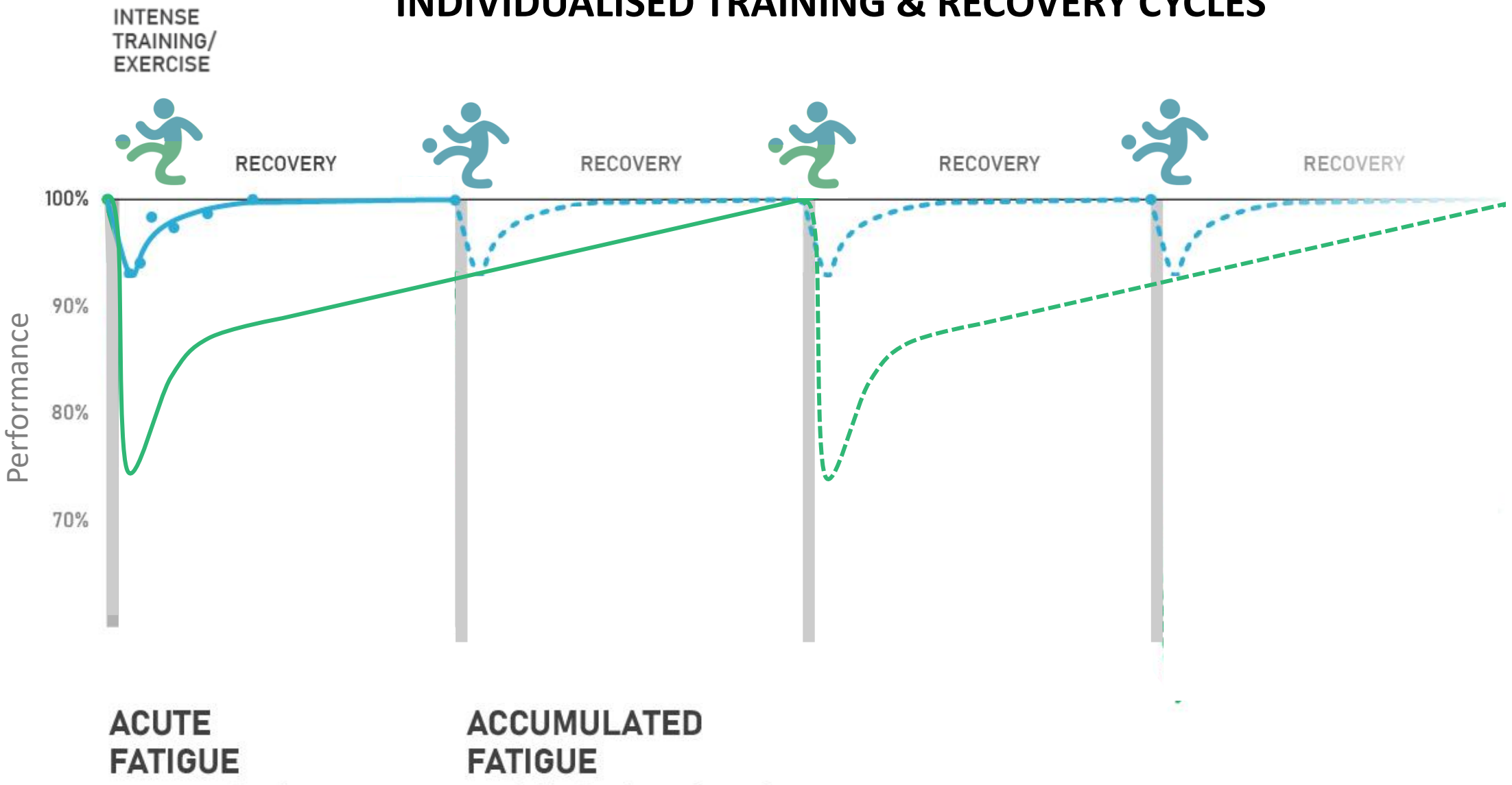


INDIVIDUALISED TRAINING & RECOVERY CYCLES



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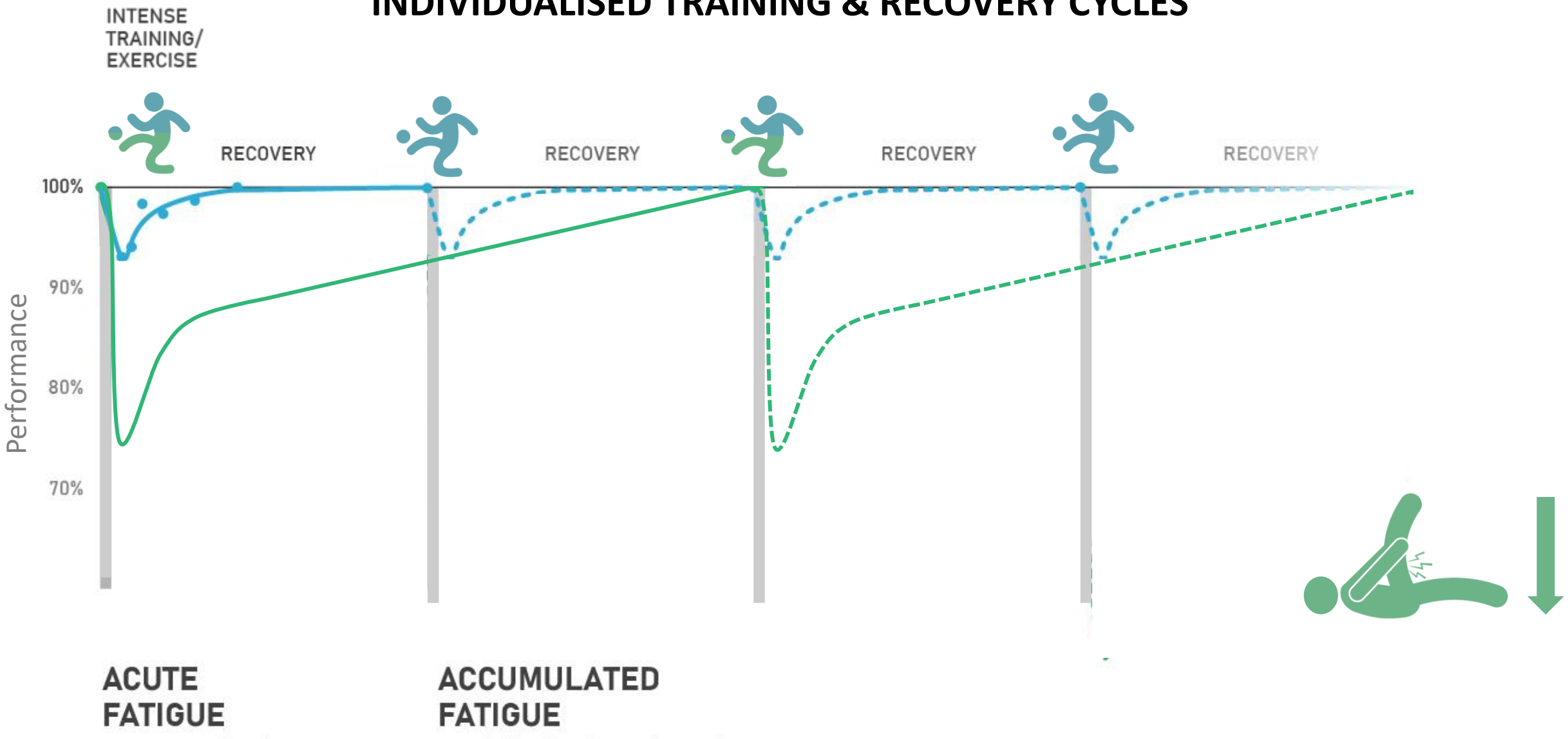
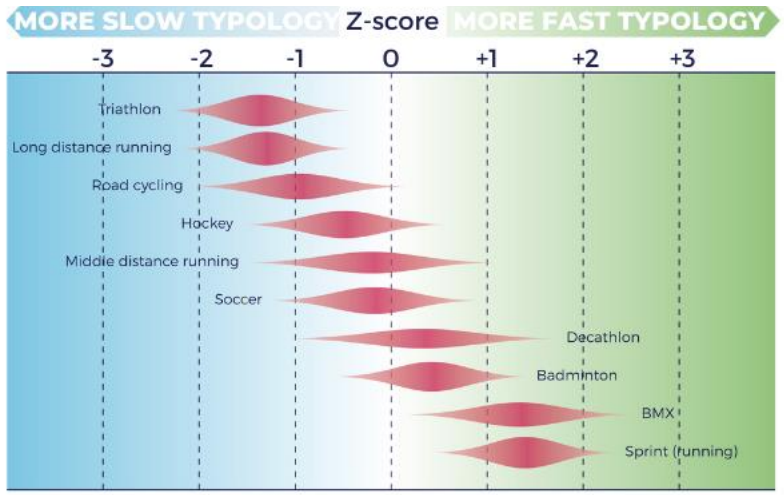


TAKE HOME MESSAGE:

1 **Talent identification**



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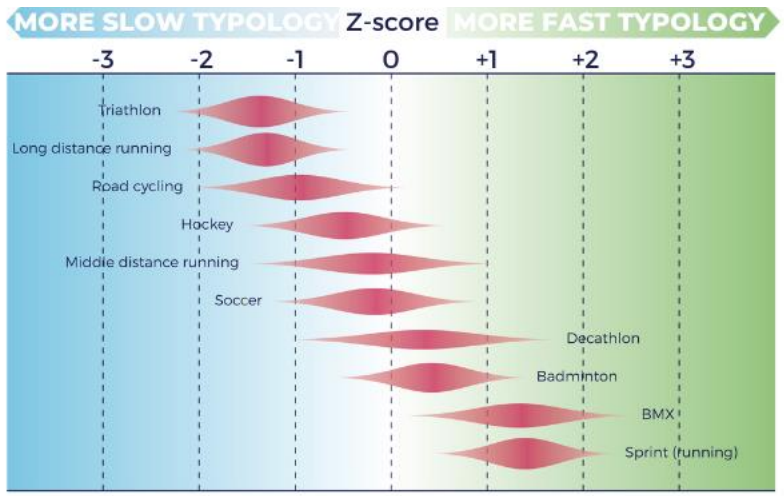
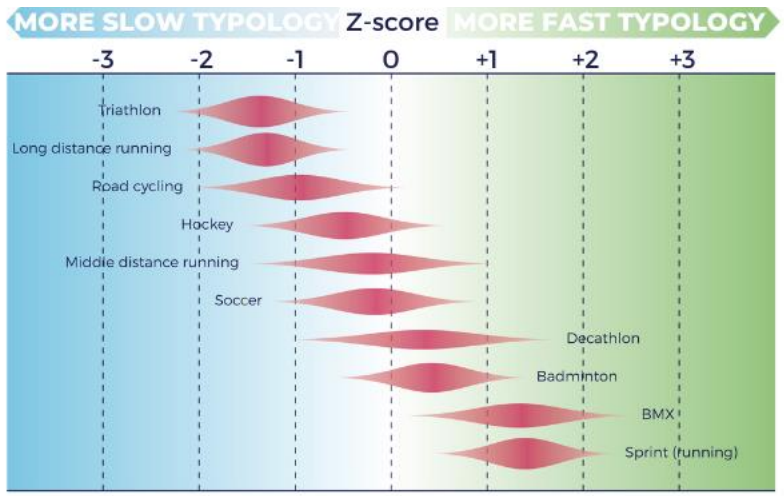


2 **Training prescription**

Total training volume	large	intermediate	small
Total training frequency	large	intermediate	small
Recovery duration in between intense training sessions	short	intermediate	long

TAKE HOME MESSAGE:

1 **Talent identification**



2 **Training prescription**

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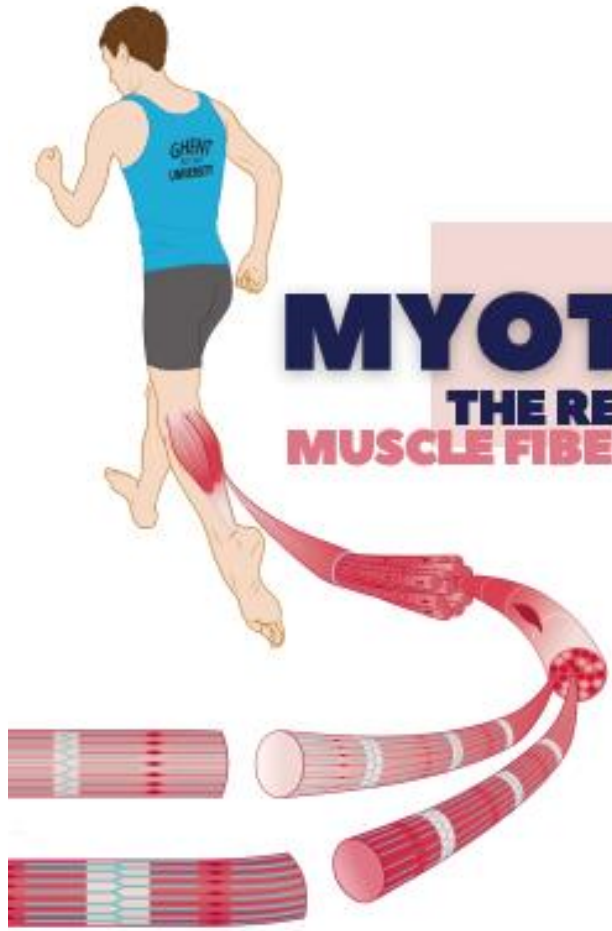
3 **Injury risk**



MYOTYPES

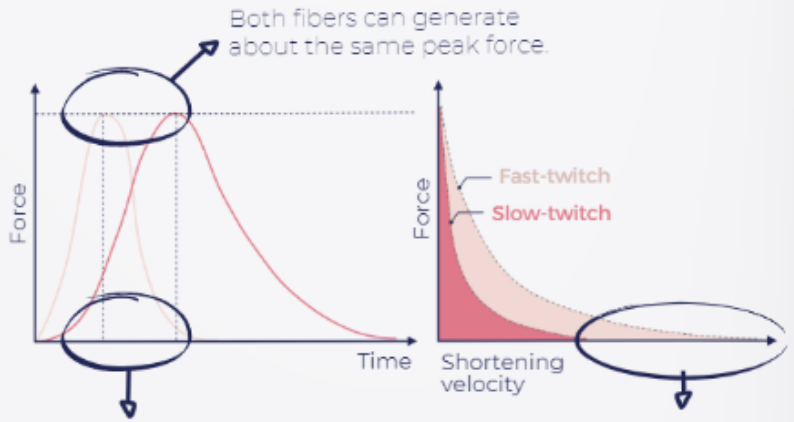
THE RELEVANCE OF MUSCLE FIBER TYPOLOGY IN SPORTS

Eline Lievens
Flore Stassen
& Wim Derave

ILLUSTRATED GUIDE

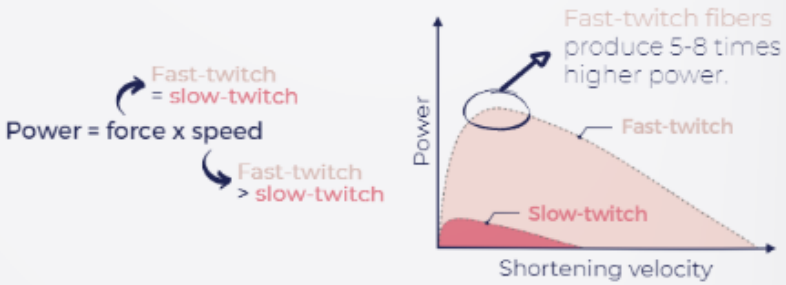
1 Fast-twitch fibers are faster

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

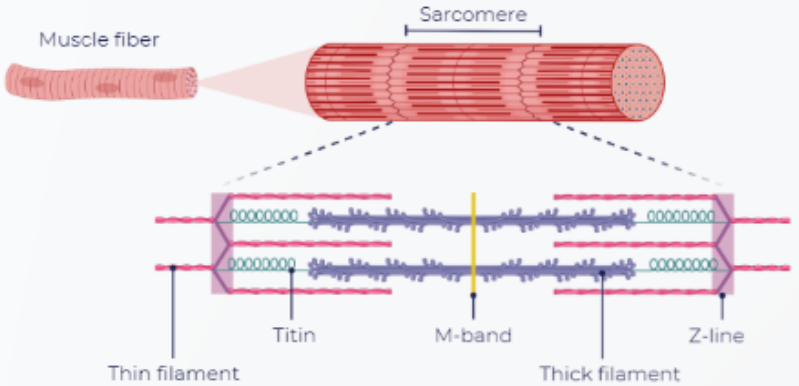


Fast-twitch fibers build up force much faster than slow-twitch fibers (40ms vs. 90ms).

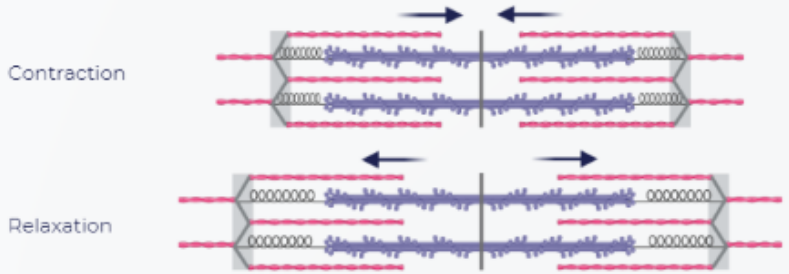
Fast-twitch fibers produce force at higher maximum shortening velocities** than slow-twitch fibers.



* 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.

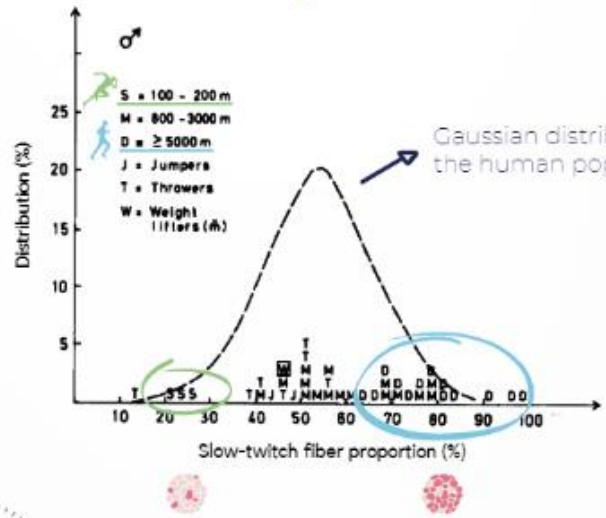


Muscles contract when the thick filament pulls the thin filament to the center of the sarcomere (= power stroke).

SARCOMERE STRUCTURE BACKGROUND

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.

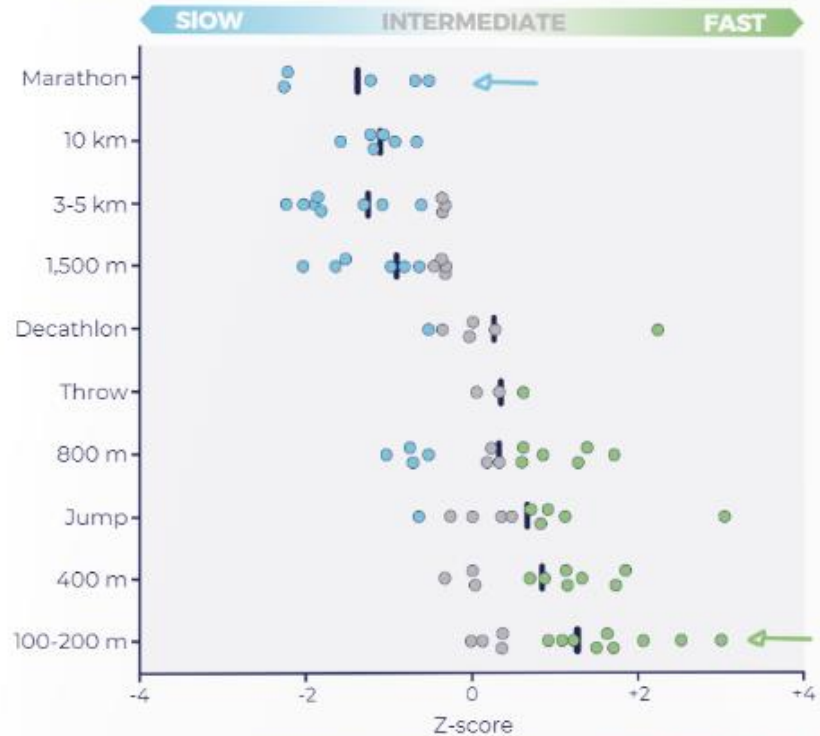
Did you know... *that in the seventies, muscle biopsies were taken from absolute world class athletes to determine their myotype? One of them was Frank Shorter, the 1972 Olympic champion in marathon running. His biopsy showed a tremendously high number of slow-twitch fibers (> 90%) and very few fast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

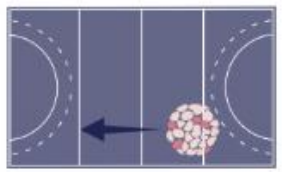
Data adapted from Baguet et al. 2011 (PLOS ONE), Rex et al. 2017 & unpublished data

Can I adapt my game strategy?

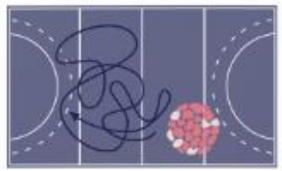
The myotype of your players might be relevant for tactical game decisions. It might influence:

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.

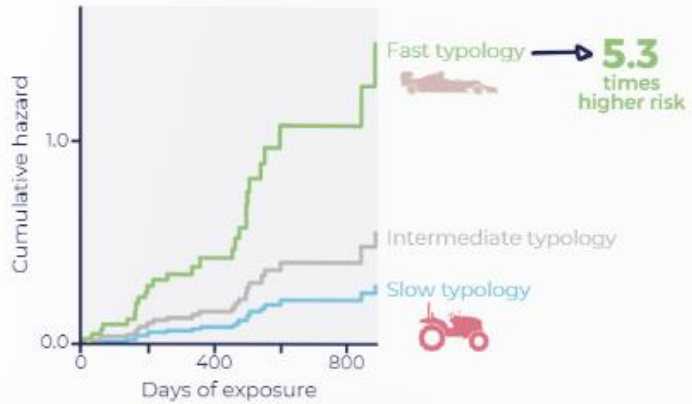
However, the effect of these myotype-based tactical decisions on game performance has not been confirmed yet.

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)

What is next?

Eline Lievens/Kim Van Vossel/Freek Van de Casteele

Department of Movement & Sports Sciences
Ghent University, Belgium

Is the muscle typology important for your progress?

Eline Lievens/Kim Van Vossel

Department of Movement & Sports Sciences
Ghent University, Belgium

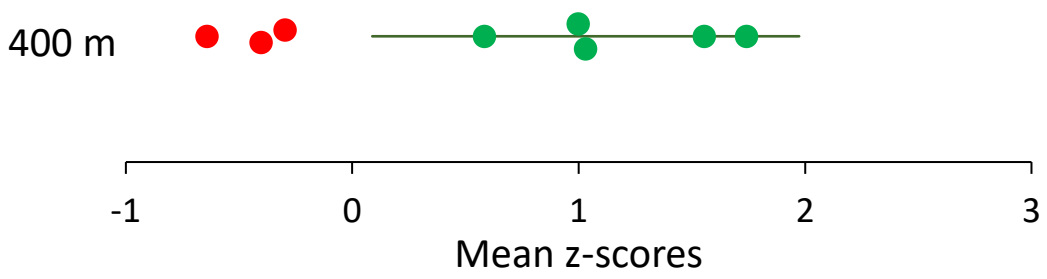
Study aims

99 elites => reference (IAAF>1050)

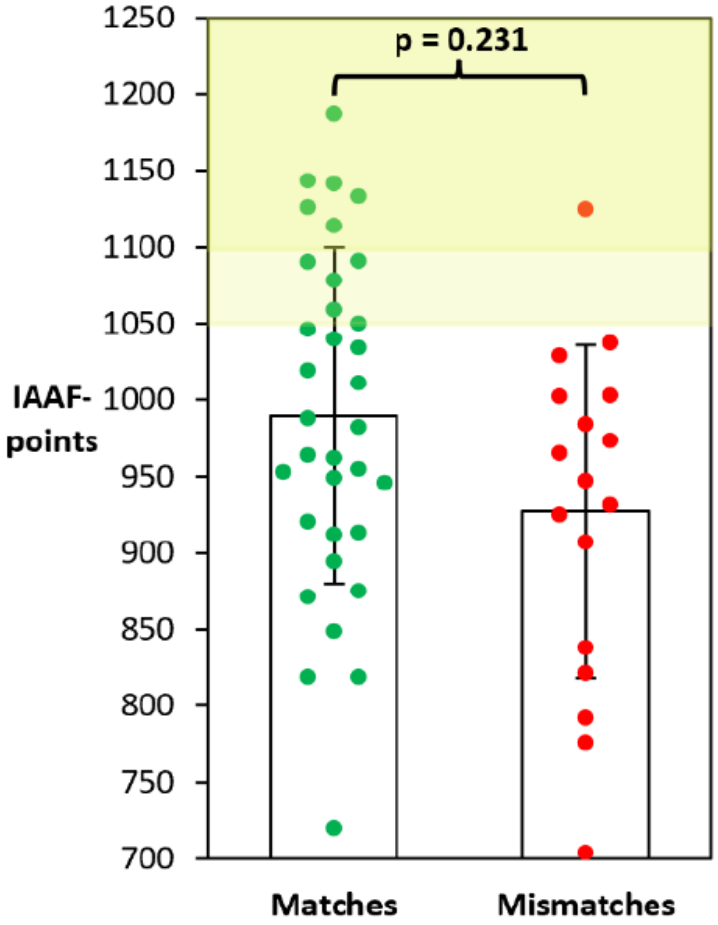
- Range of mean ± SD

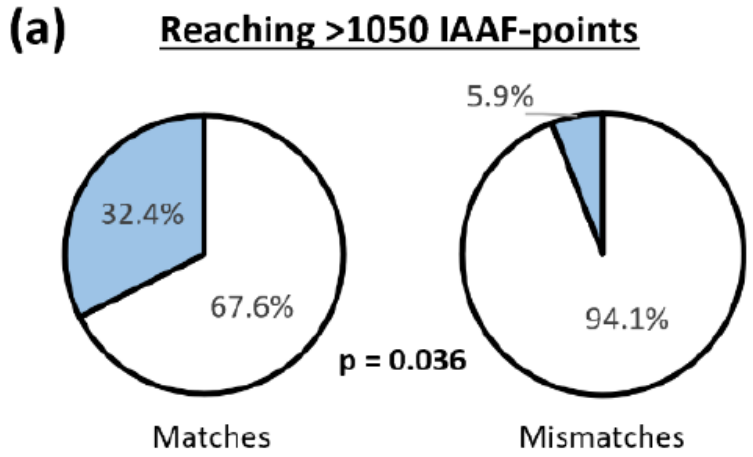
51 young athletes

- 34 matches
- 17 mismatches



Current results





Are there other non-invasive techniques?

Freek Van de Casteele

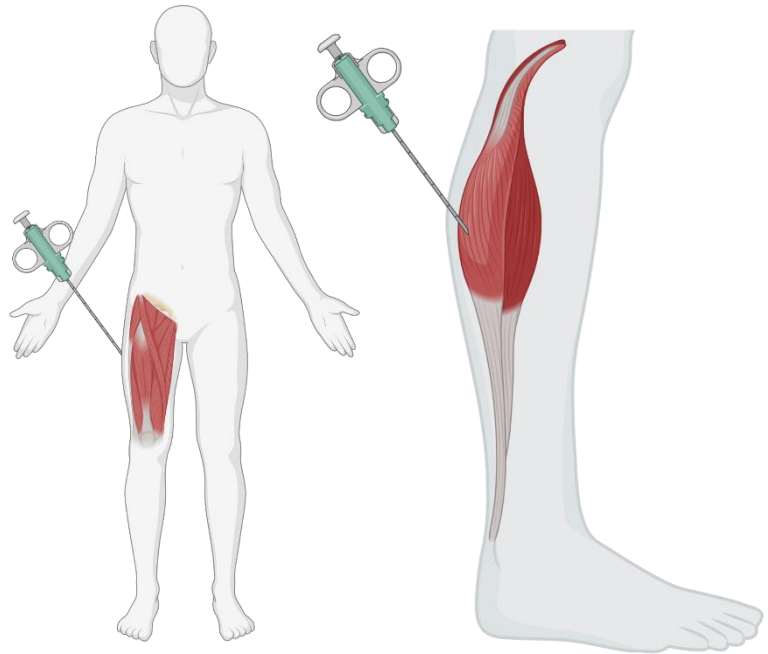
Department of Movement & Sports Sciences
Ghent University, Belgium

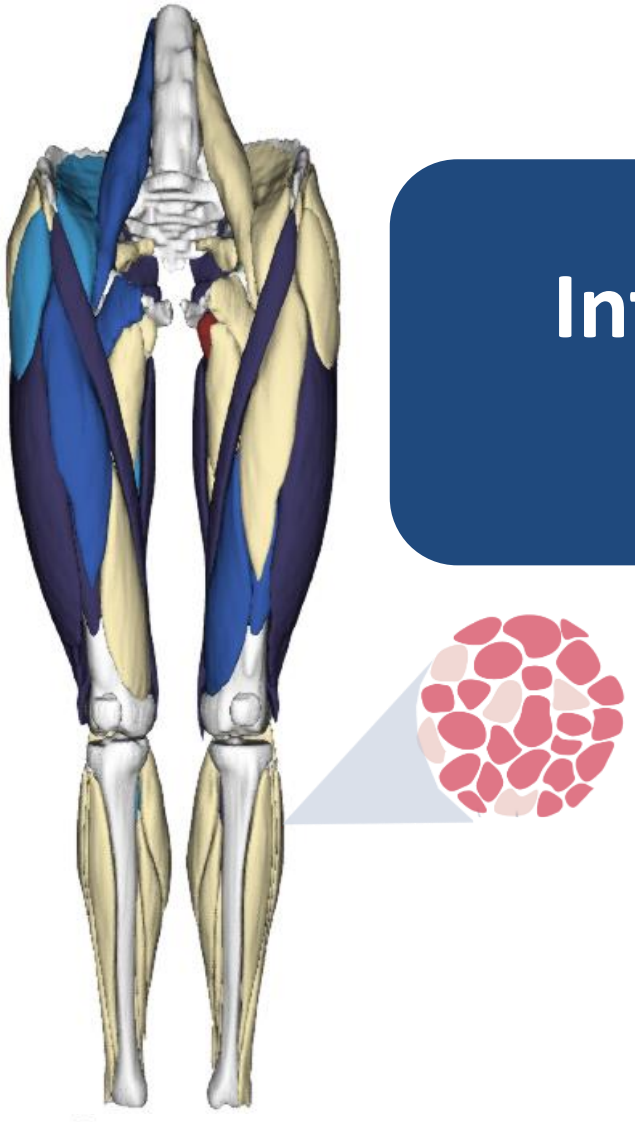
The coaches' view

- 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)

Study aims





Influence of muscle typology on resistance training adaptations

Kim Van Vossel

Department of Movement & Sports Sciences
Ghent University, Belgium

Study aims

Aim 1

Aim 2

Muscle strength

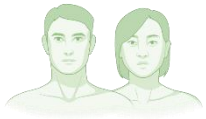
Muscle volume

Frequency & volume

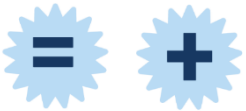
Hypothesis

Slow typology

VS



Fast typology



Slow typology

VS

Fast typology

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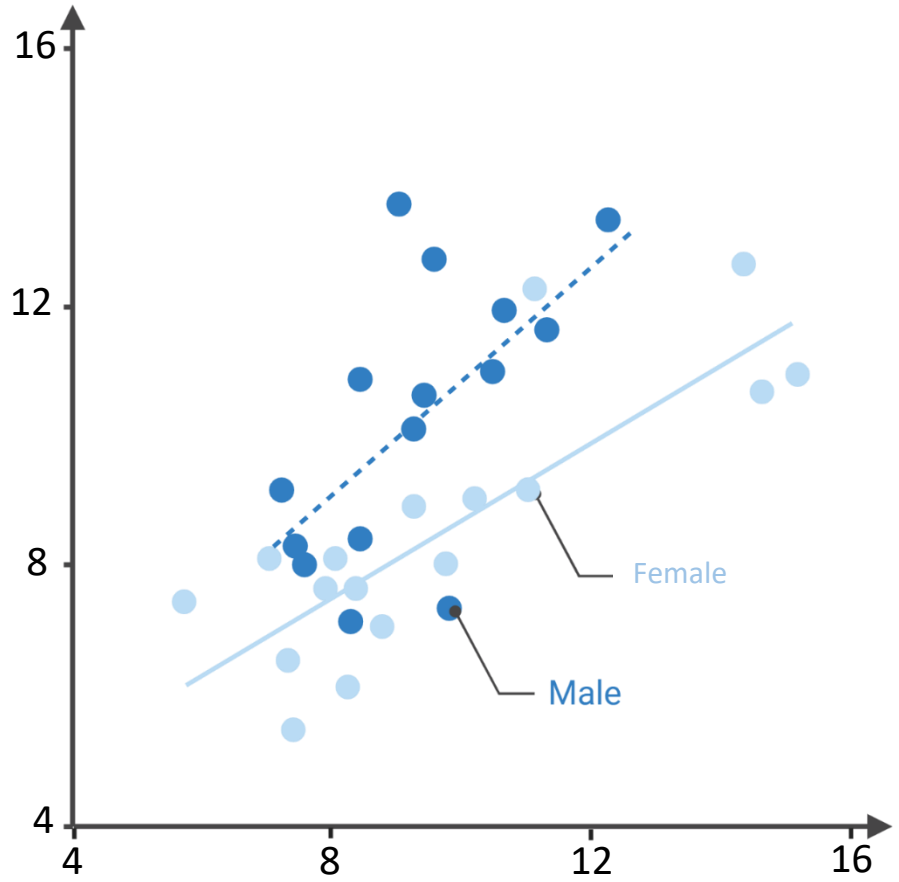
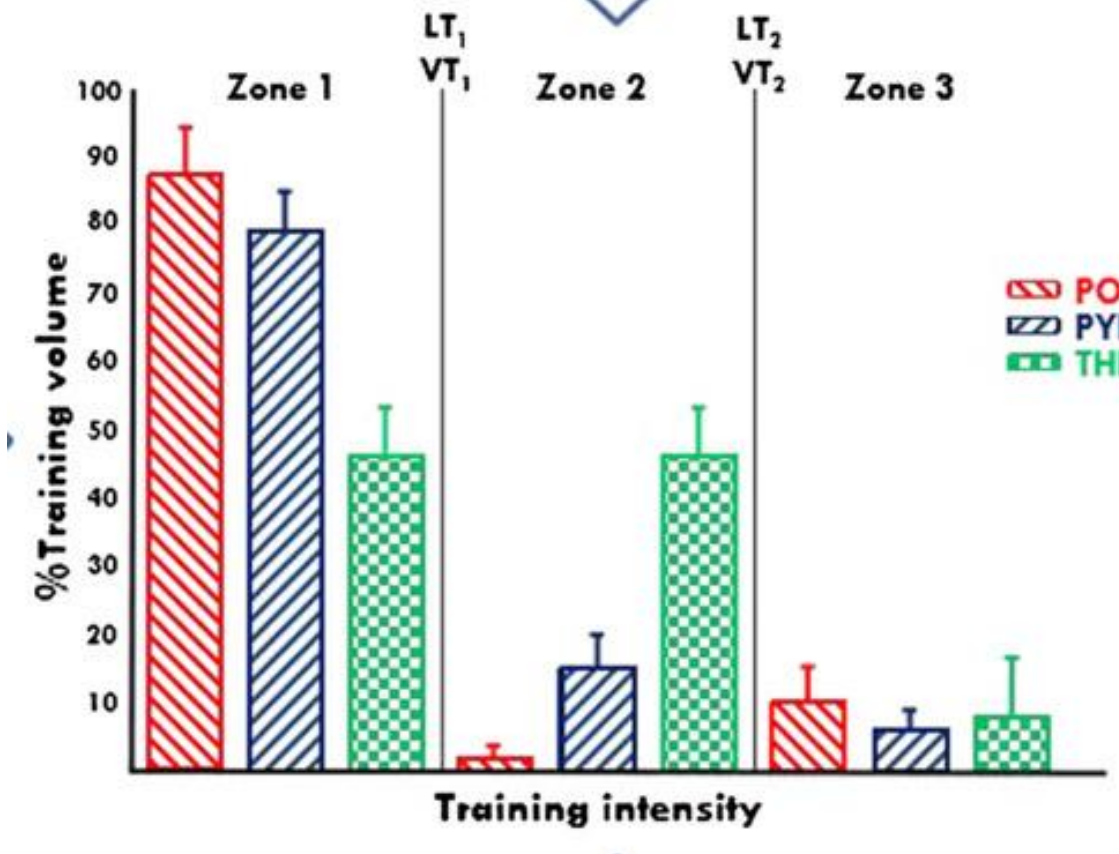
5 Scans can be performed before puberty



(Lievens et al., JAP, 2021)

Profile of the sports discipline

- Biomechanical: eg, generated forces by muscles and joints, movement frequency, changes in direction, technique
- Physiological: eg, race duration, cardiorespiratory and vascular load, metabolic load, contribution of different metabolic processes, muscle fiber recruitment



Type I oriented endurance athletes

Type II oriented endurance athletes

1 Can I discover talent in swimming?

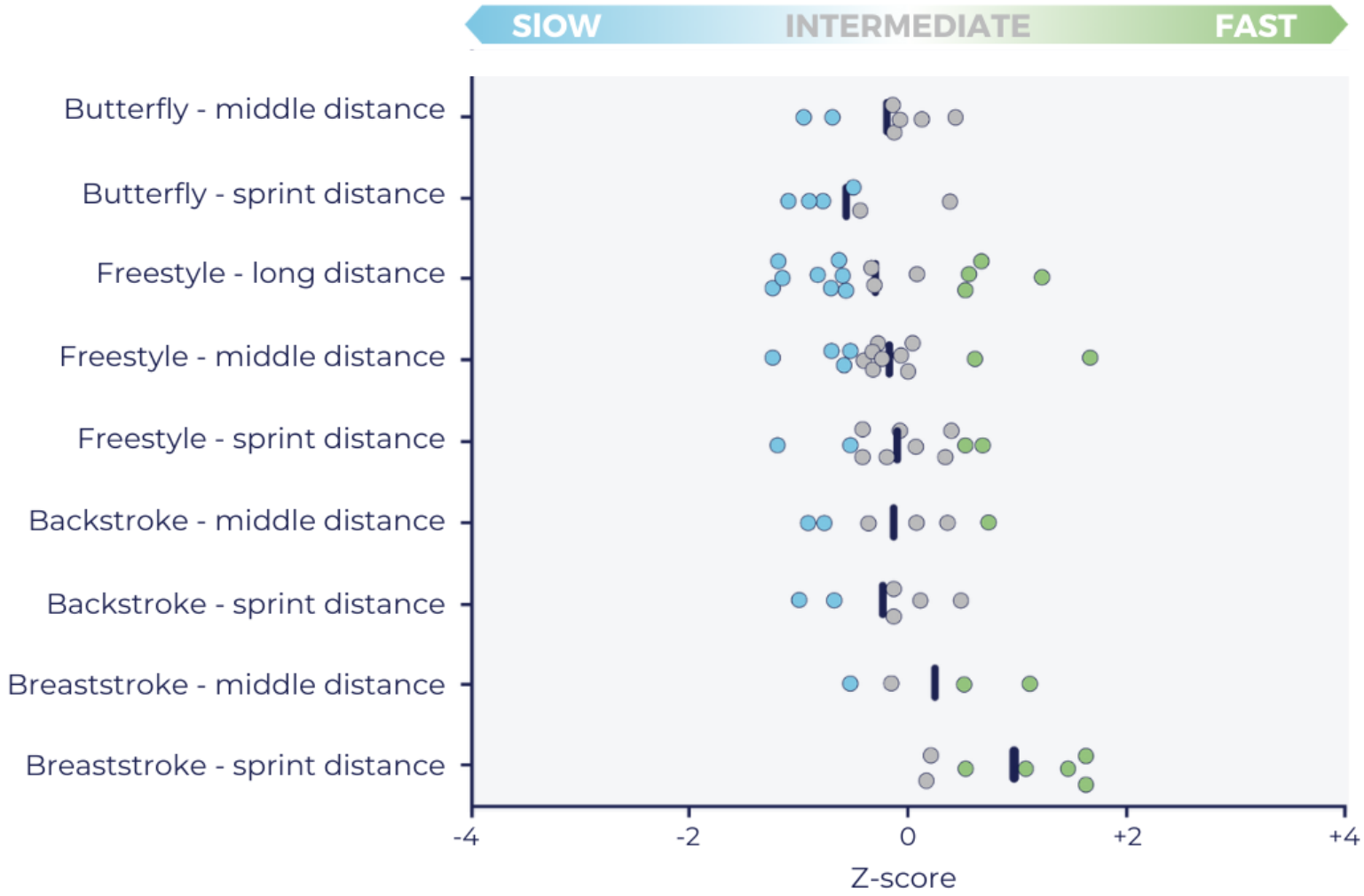
73

Freestyl	Breaststroke	Butterfly	Backstroke
			
39	11	12	11

14 Olympic medalists
24 World medalists

Bellinger & Lievens,
Unpublished

1 Can I discover talent in swimming?

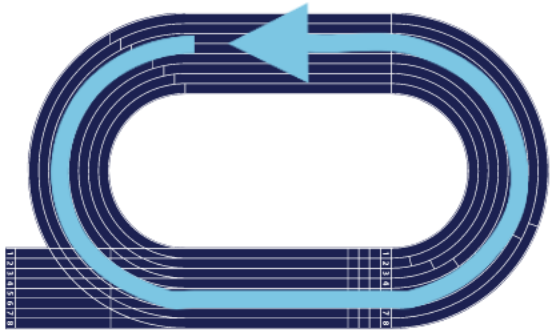


(Bellinger & Lievens Upublished)

2 Can I adapt my competition strategy?

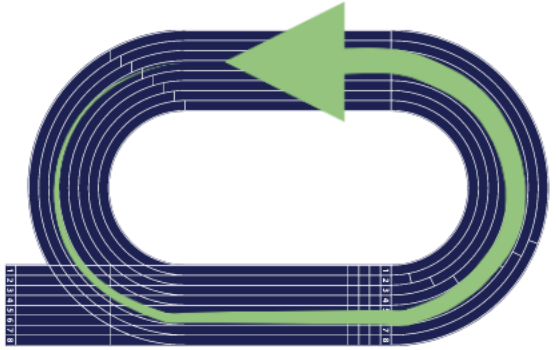
- **ATHLETICS (1,500 m & 800 m):**

Slow typology



Even-paced

Fast typology



Slow start & fast end

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

Slow typology

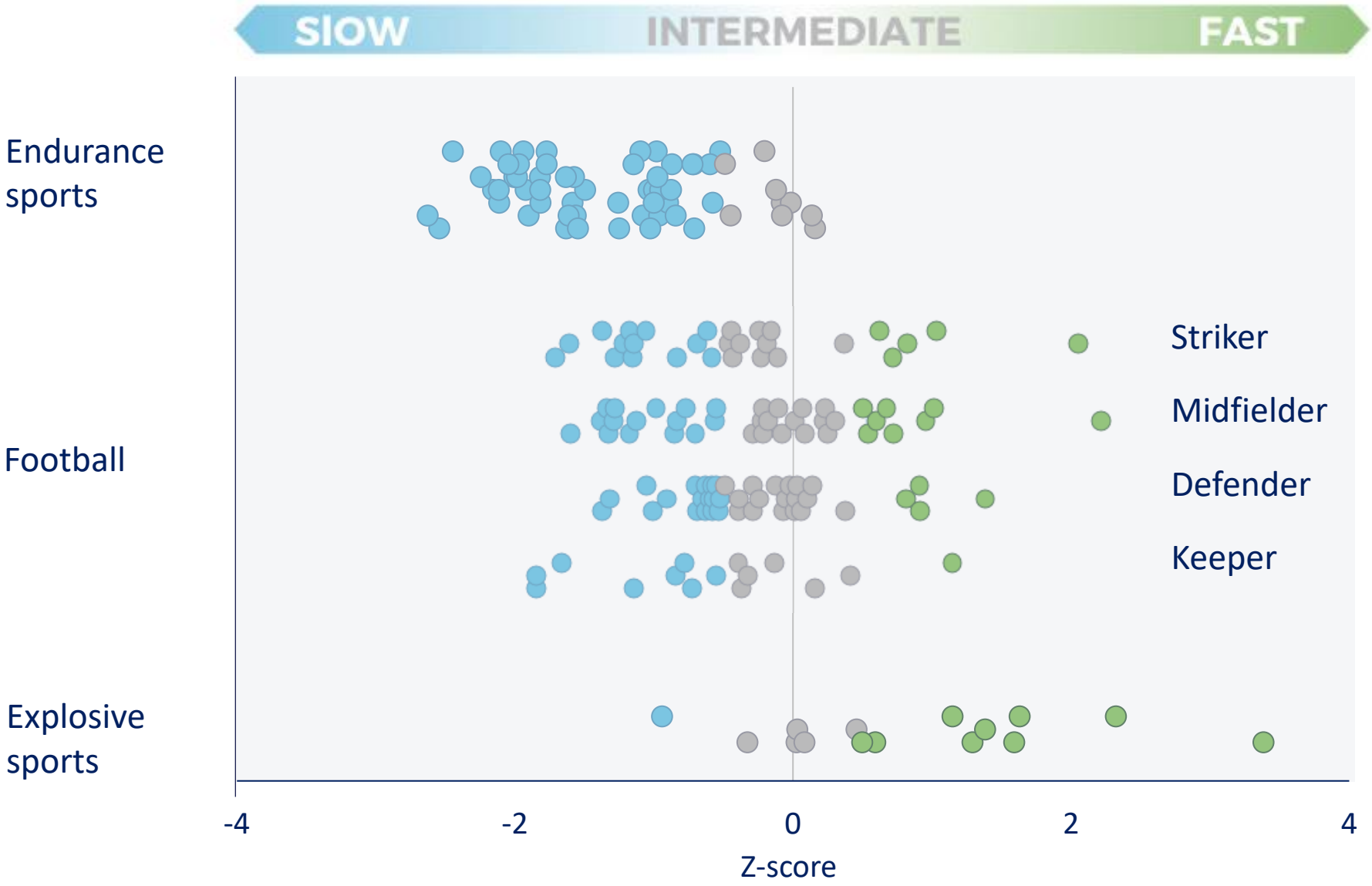
Even-paced

Fast typology

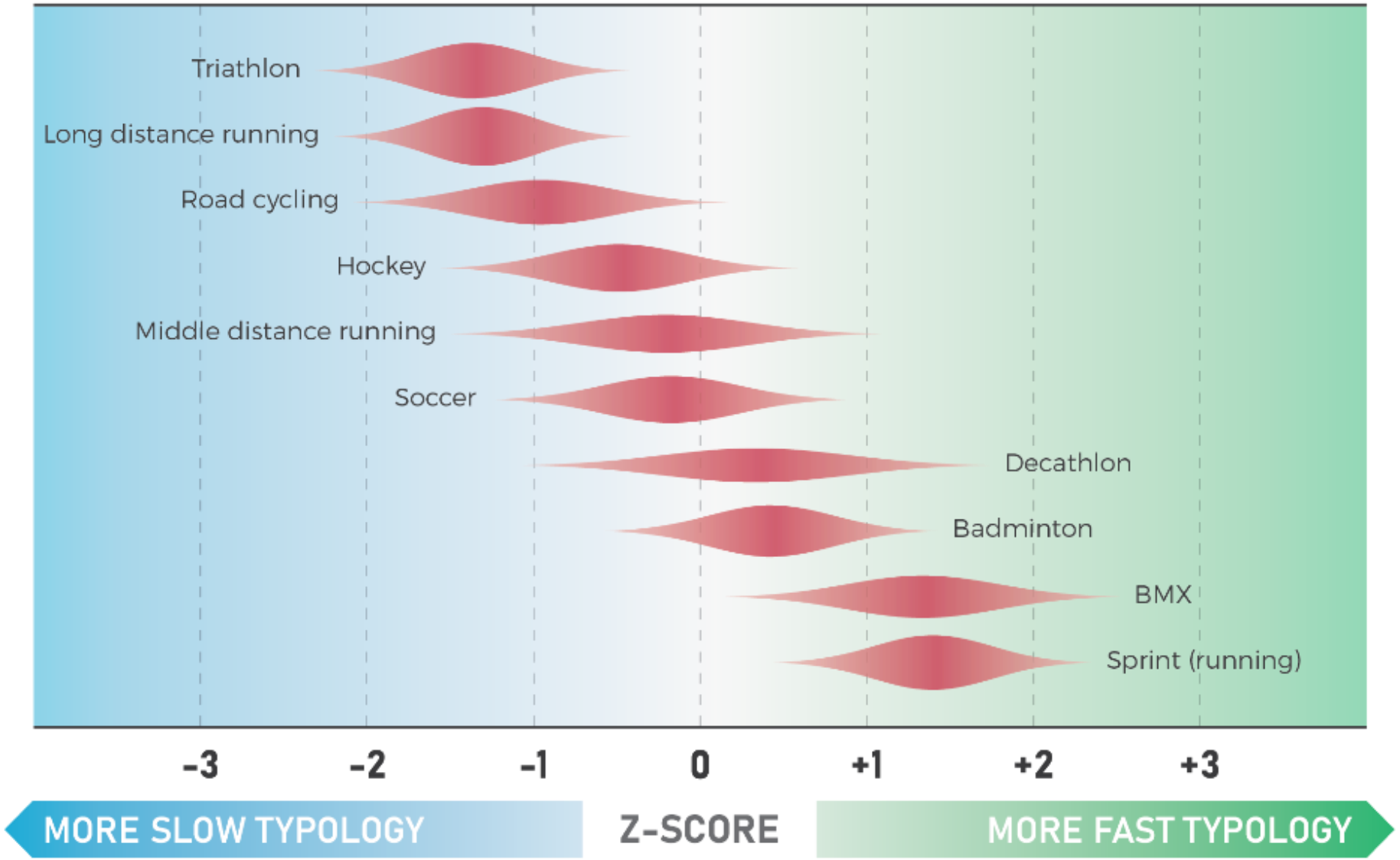
Slow start & fast end

(Bellinger et al., EJAP & MSSE, 2021; Mallett et al., Int. J. Sports Physiol Perform, 2021)

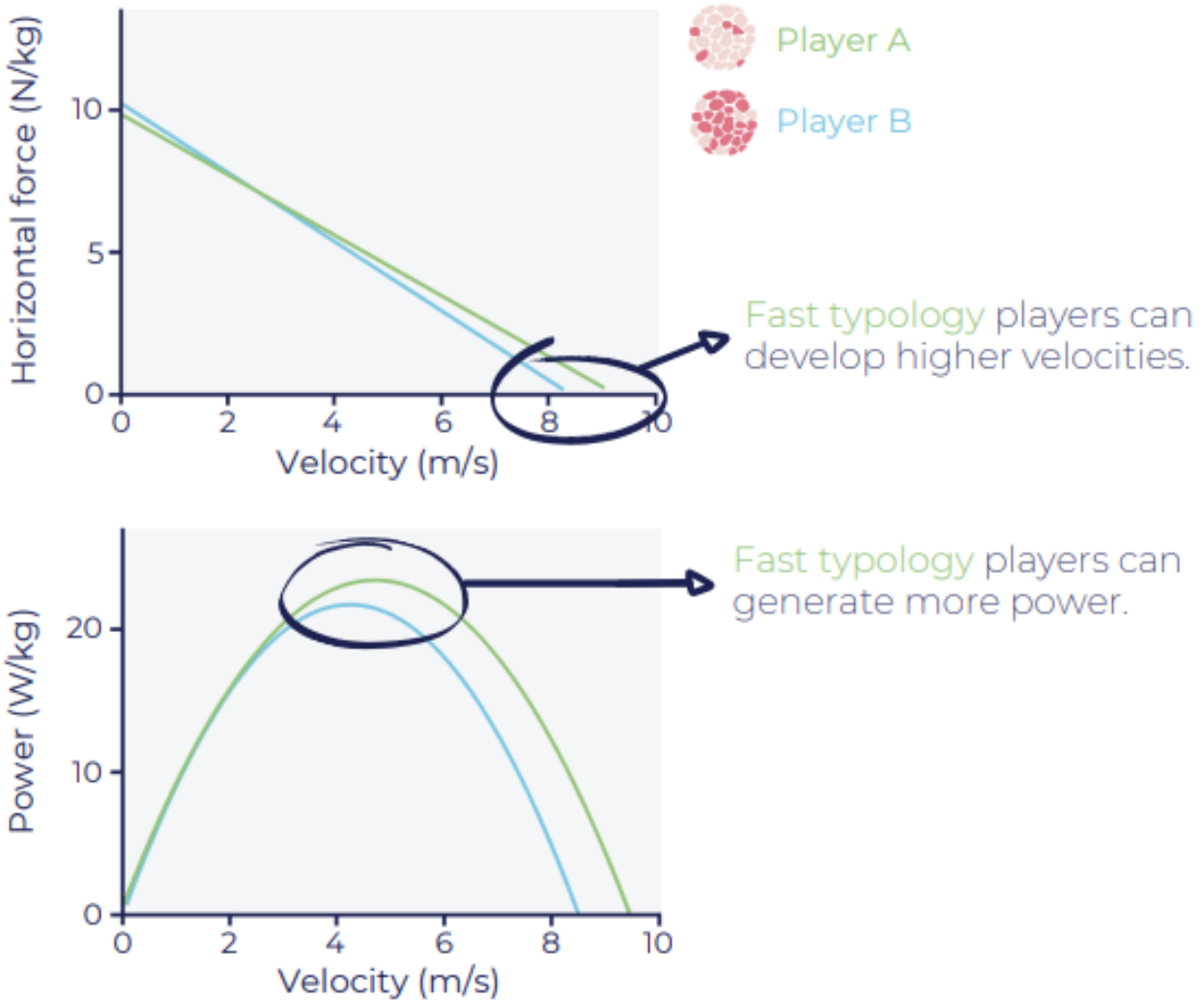
1 How does the muscle typology looks like in football?



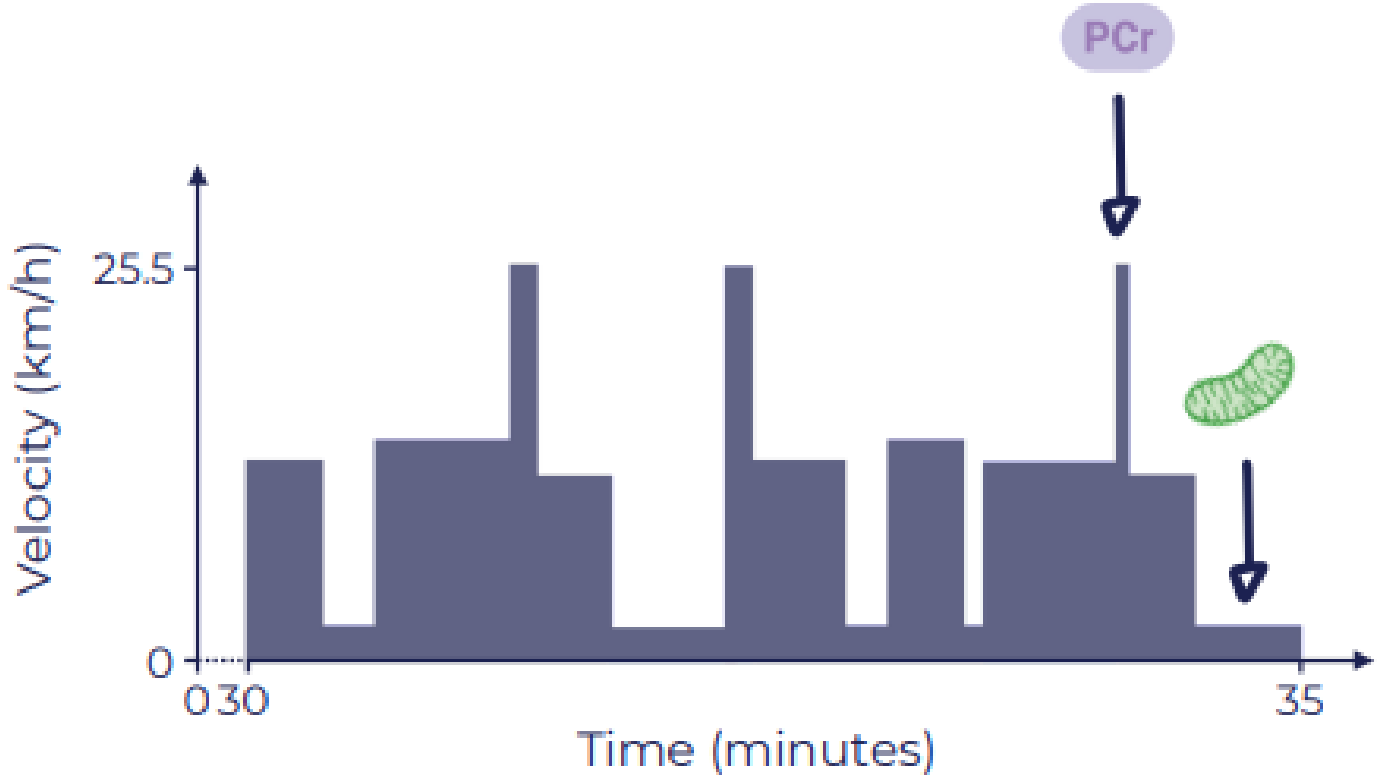
1 Other sports?



1 Why are fast fibers needed?

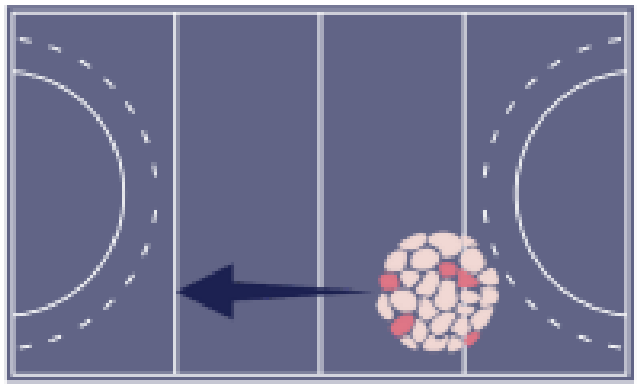


1 Why are slow fibers needed?



(Bellinger, EJAP, 2020)

2 Can I adapt my competition strategy?



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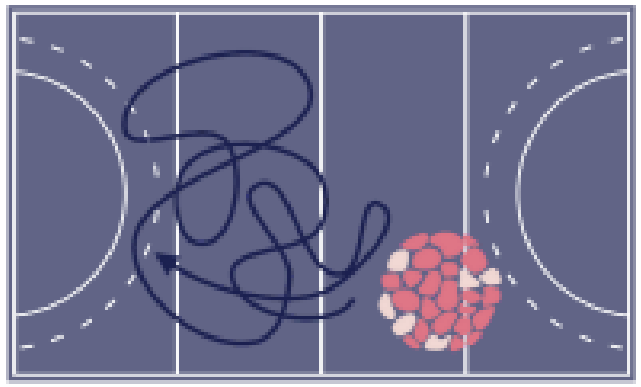

Slow typology players might be ideal because of their fatigue resistance.