

EFFECTS OF MUSCLE GROUP, MUSCLE LENGTH AND METABOLIC PROFILE ON DIFFERENCES IN NEUROMUSCULAR FATIGUE BETWEEN PREPUBERTAL CHILDREN AND ADULTS



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INTRODUCTION



Why studying exercise-induced fatigue in children?

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(A 2, 2007)



Physical



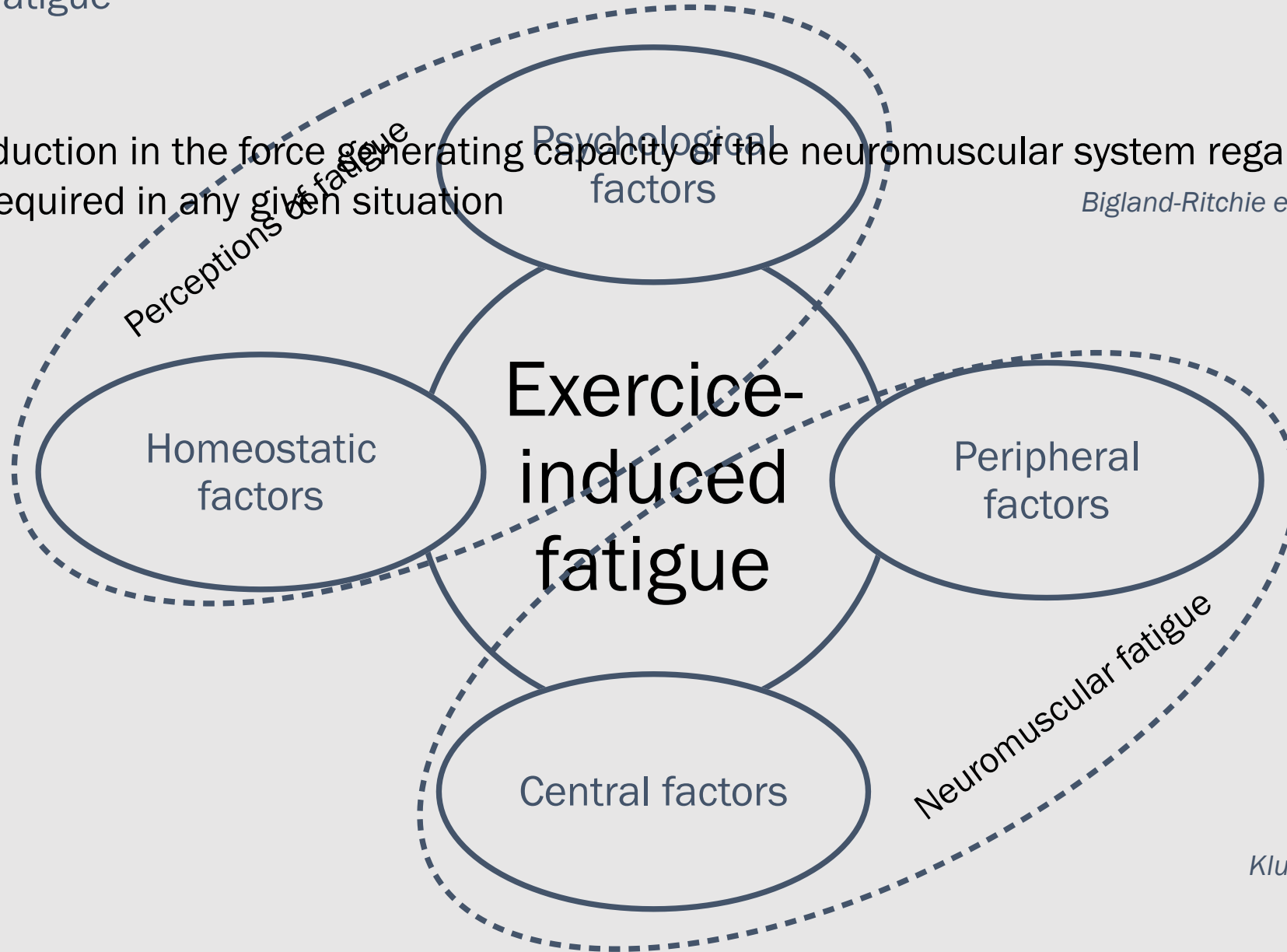
itation

(La science révèle enfin pourquoi les enfants sont inépuisables, Positiv, Axel Leclercq, 26 avril 2018)

Exercise-induced fatigue

Définition:

Any reduction in the force generating capacity of the neuromuscular system regardless of the force required in any given situation
Bigland-Ritchie et Woods (1984)



Kluger et al. (2013)

Differences in neuromuscular fatigue between prepubertal children and adults

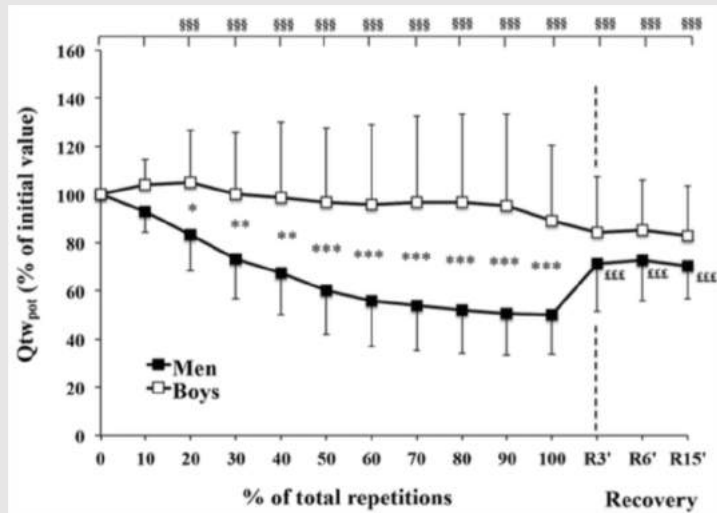
During maximal voluntary contraction (MVC)

Fatigability

Children <<< Adults



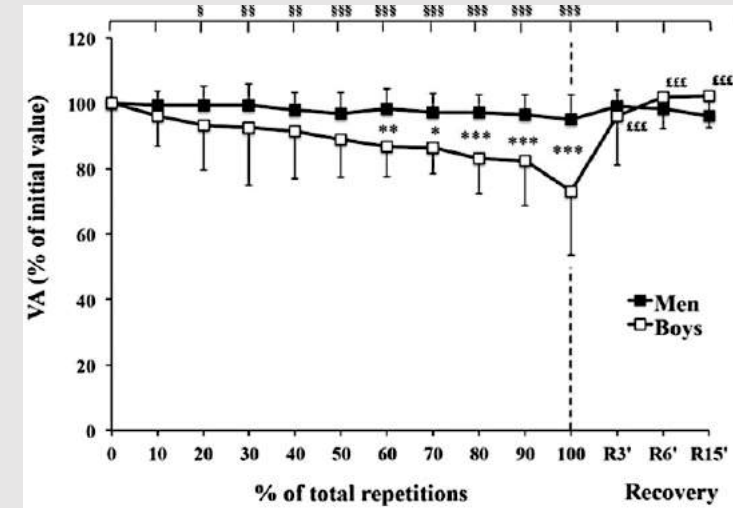
Peripheral fatigue
Children <<< Adults



Qtw_{pot} : Potentiated single twitch



Central fatigue
Children >>> Adults



VA : Voluntary activation level

Ratel et al. 2015

Mechanisms underpinning differences between children and adults

Difference in torque level

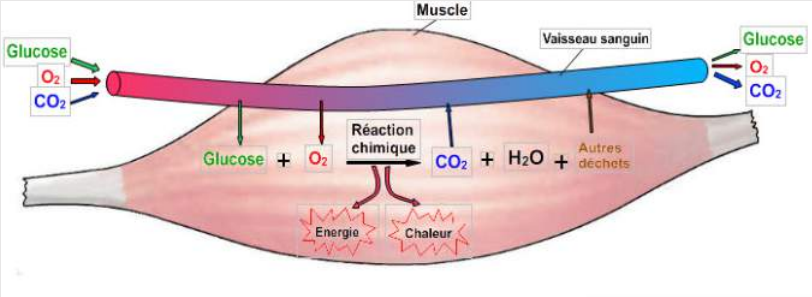
Ratel et al. (2015)

Difference in metabolic profile

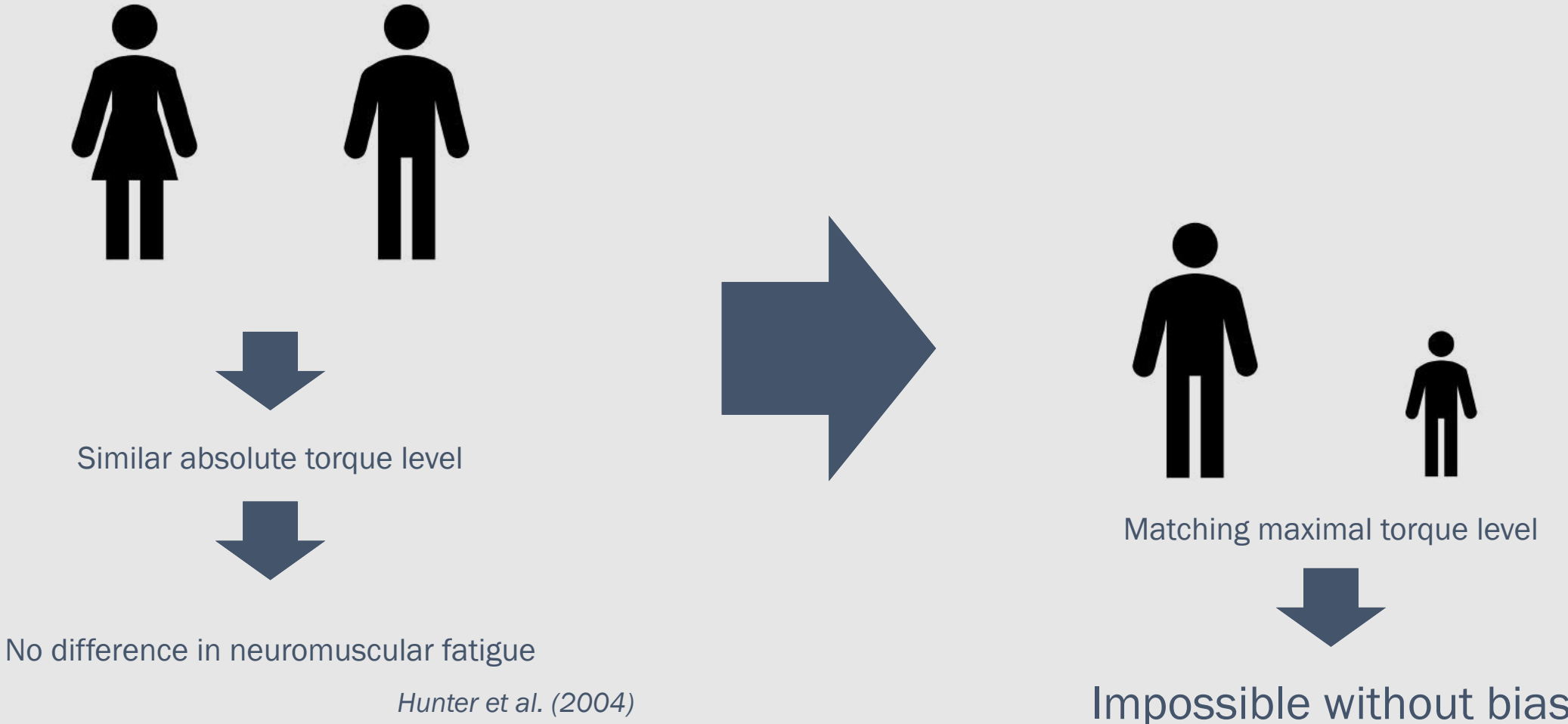
Ratel & Blazevich (2017)



Difference in neuromuscular fatigue between children and adults

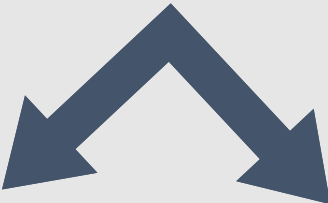


How to evaluate the effect of torque level difference ?

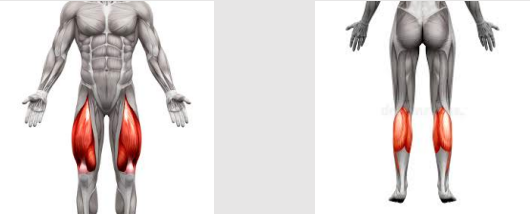


How to evaluate the effect of torque level difference ?

Vary difference in torque level between children and adults



Muscle group effect



Muscle length effect



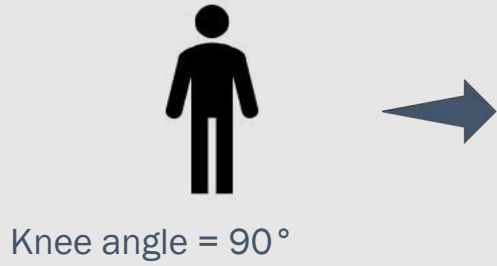
How to evaluate the effect of difference in torque level?

Muscle groups

Child-adult difference in torque level



Kluka et al. (2015)



297 ± 67 N.m



93 ± 31 N.m

204 N.m

+



Kluka et al. (2016)



89 ± 19 N.m



45 ± 18 N.m

44 N.m

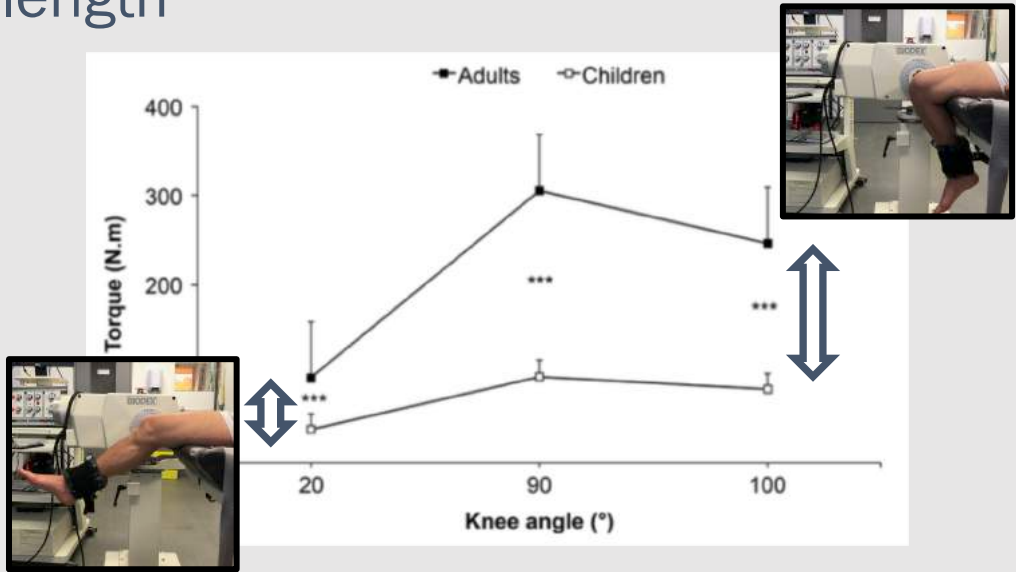
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How to evaluate the effect of torque level difference ?

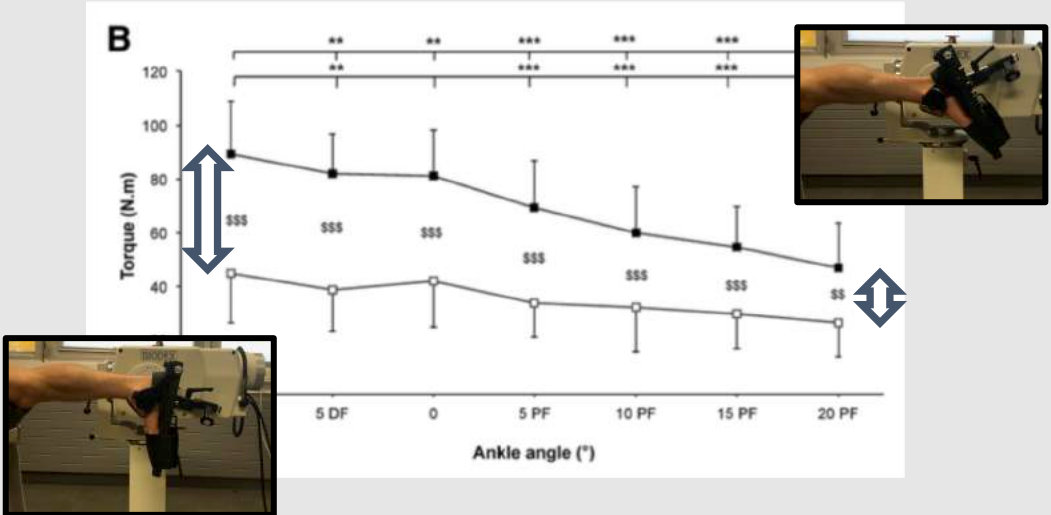
Muscle length



Kluka et al. (2015)

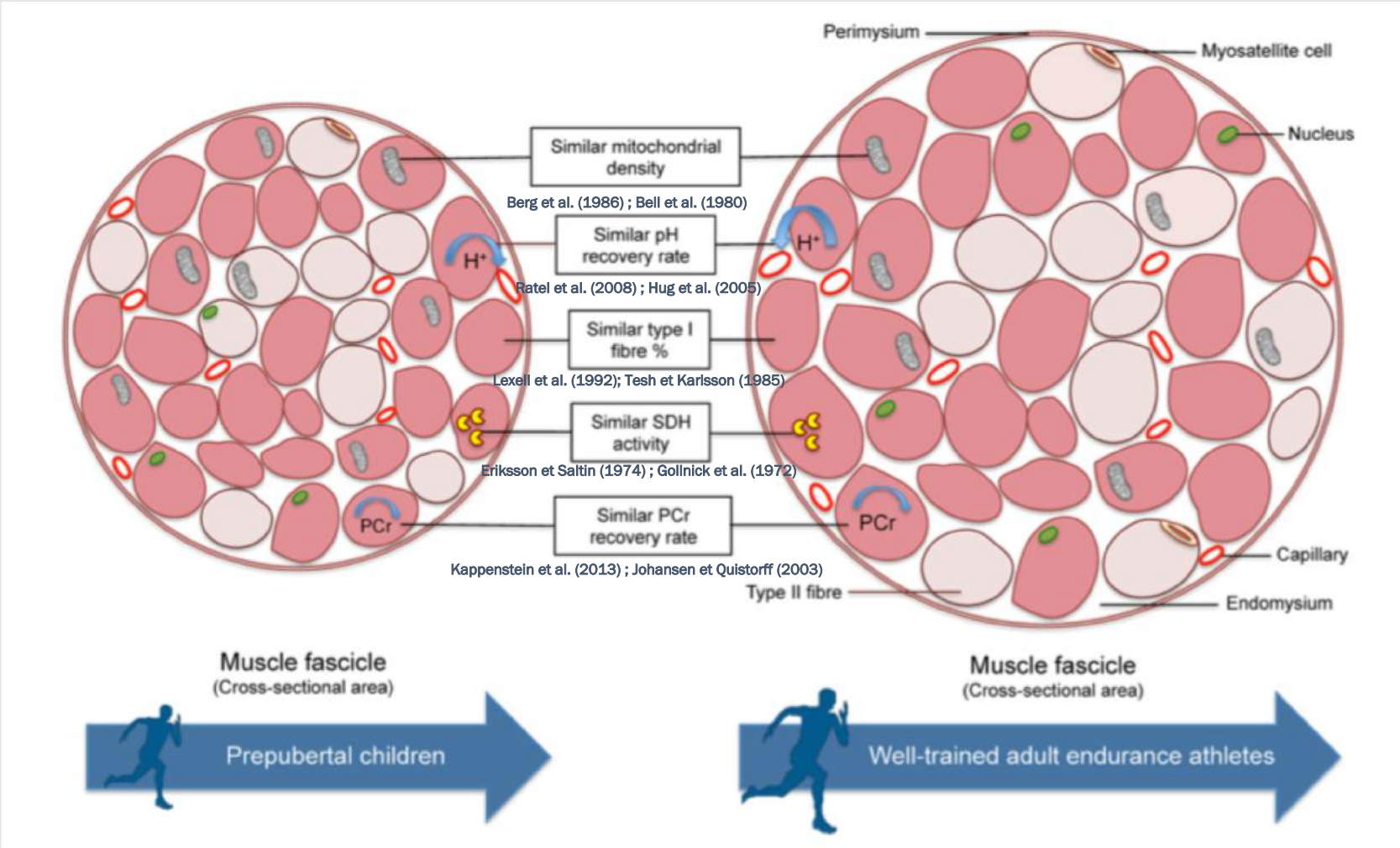


Kluka et al. (2016)



How to evaluate the effect of metabolic profile difference ?

Hypothesis: Children and endurance athletes seem to be metabolically comparable



Ratel et Blazevich (2017)



METHODS



Populations



8-10 yr
(n = 25)



18-30 yr
(n = 25)



21-45 yr
(n = 13)

< 4h PA/week

> 6x /week

Performance:
10 000 m between 28 & 33'

Fatigue protocol



MVC & MVC_{anta} : Maximal voluntary contraction of agonist muscles and antagonist muscle, respectively.

Knee extensor muscles

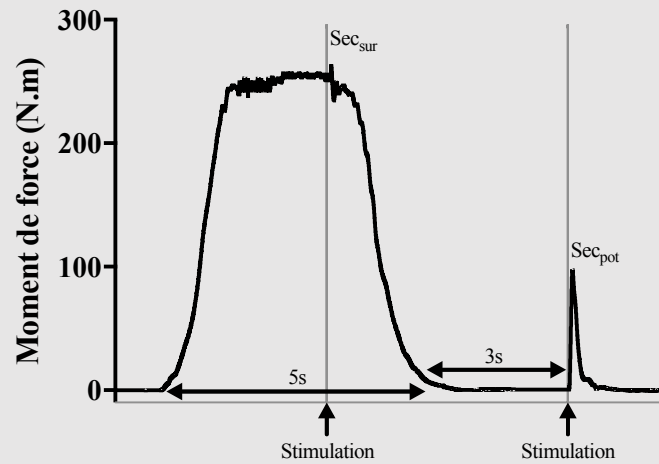
Plantar flexor muscles

Parameters

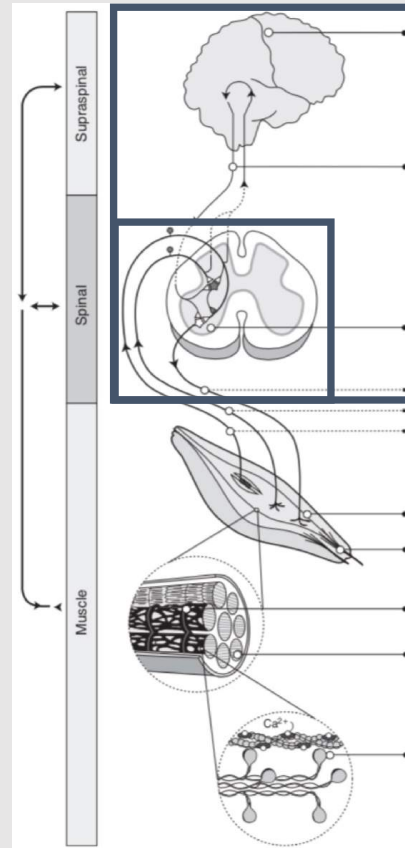
Fatigability \Rightarrow Total number of repetitions

Central fatigue :

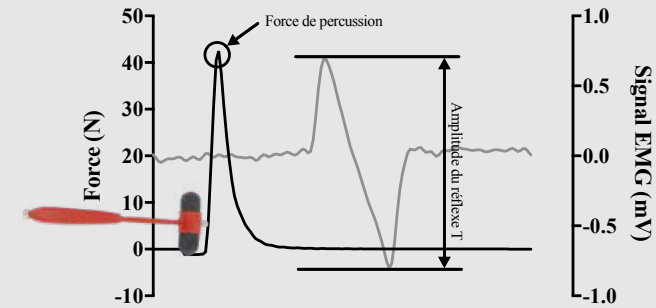
Twitch interpolated technique



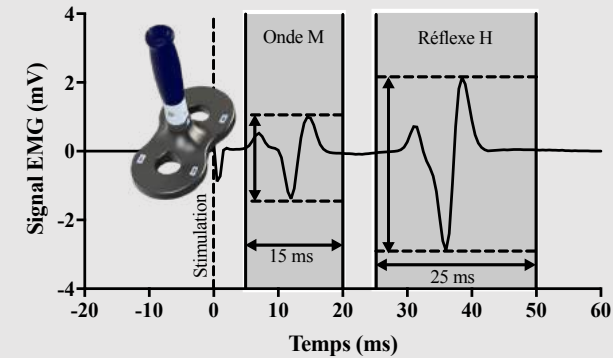
Voluntary activation level



Spinal fatigue

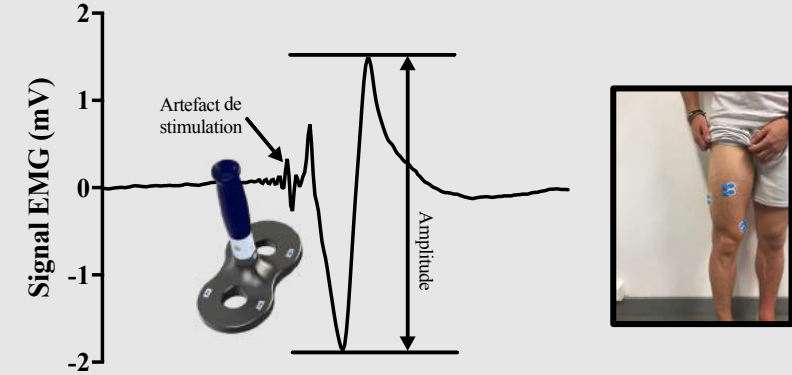
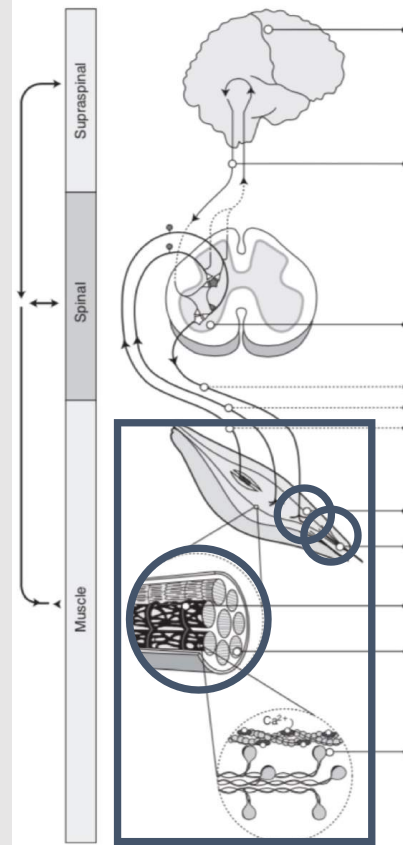
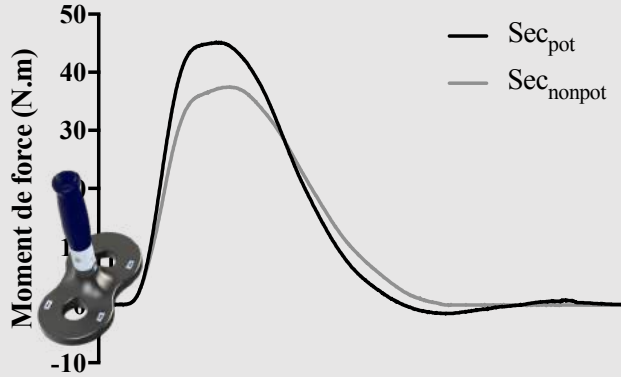


T-reflex



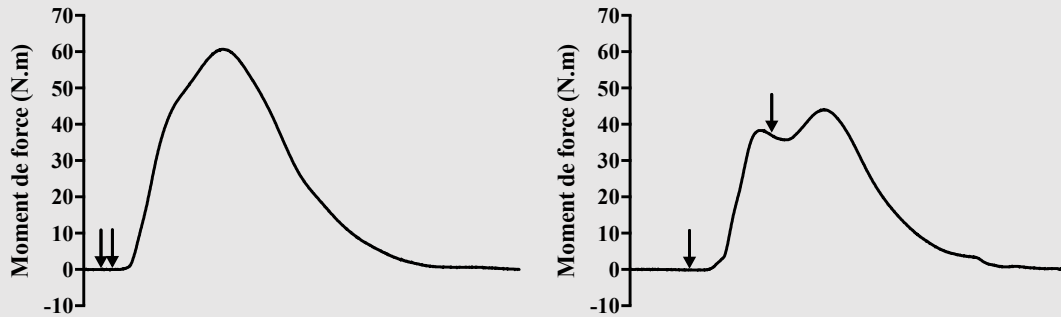
H-reflex

Peripheral fatigue

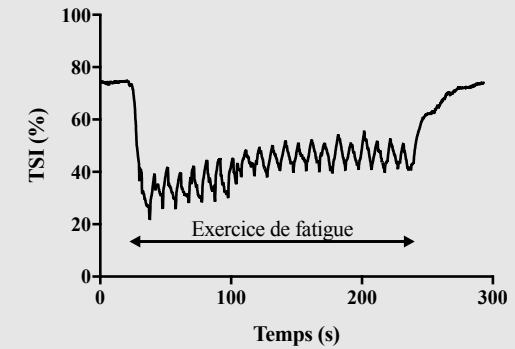


M-wave (Sarcolemmal excitability)

Potentiated single twitch



Low- to high-frequency doublet (Excitation-contraction coupling)



Near infrared spectroscopy

Muscle oxygenation



MUSCLE GROUP EFFECT



Child-adult differences in neuromuscular fatigue are muscle dependent

Enzo Piponnier,¹ Vincent Martin,¹ Bastien Bontemps,¹ Emeric Chalchat,¹ Valérie Julian,² Olivia Bocoock,² Martine Duclos,² and Sébastien Ratel¹

¹Clermont-Auvergne University, AME2P, Clermont-Ferrand, France; and ²Clermont University Hospital, Clermont-Ferrand, France

Submitted 16 March 2018; accepted in final form 6 August 2018

Aim and hypotheses

Aim: To compare difference in **development and etiology of the neuromuscular fatigue** between prepubertal boys and men during intermittent maximal fatigue protocol with KE and PF.

Hypotheses:



Greater difference in torque level between boys and men



Greater difference in neuromuscular fatigue between boys and men

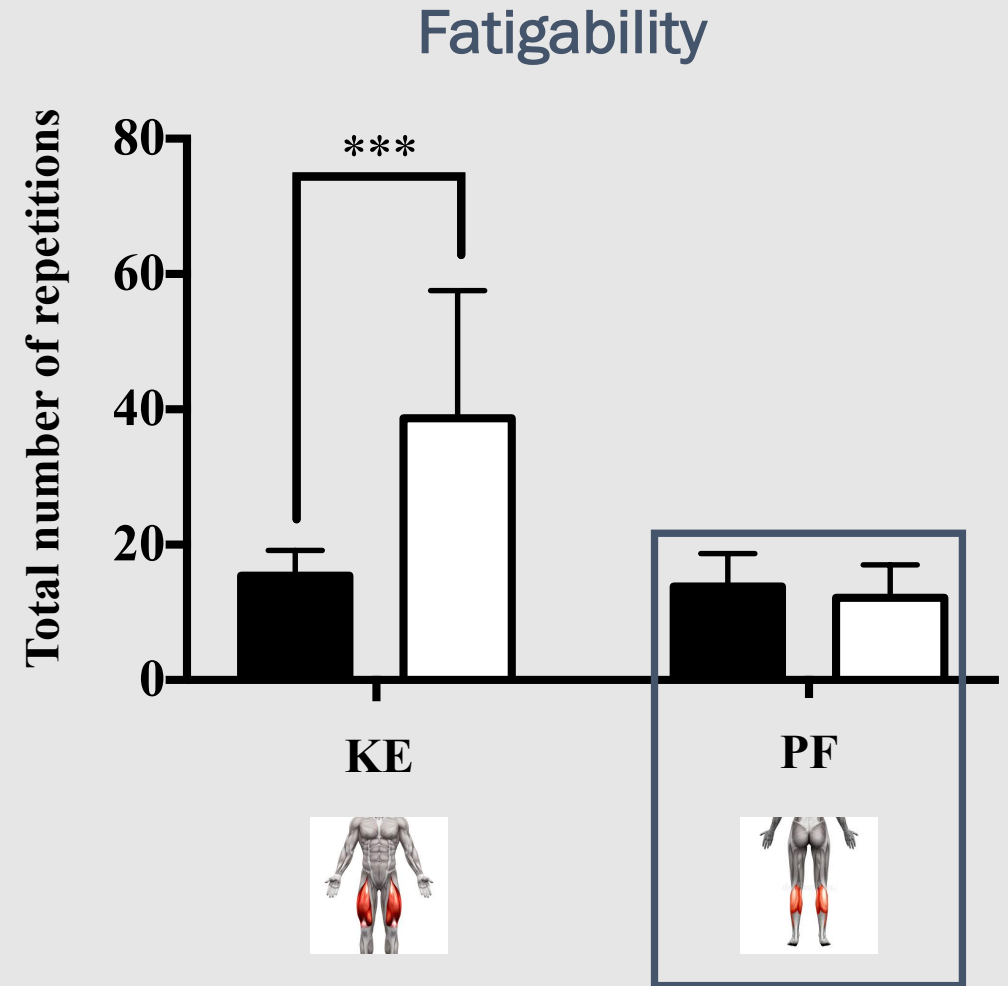
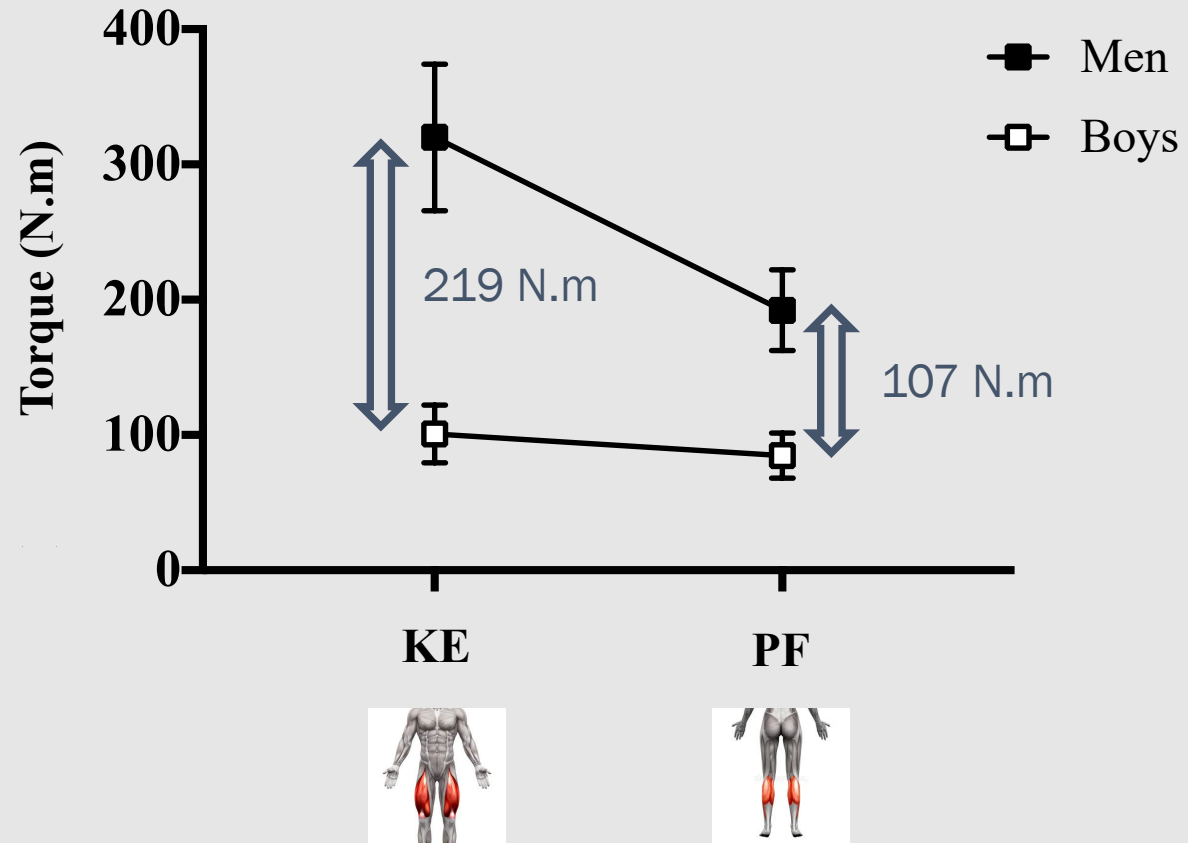


Lower difference in torque level between boys and men

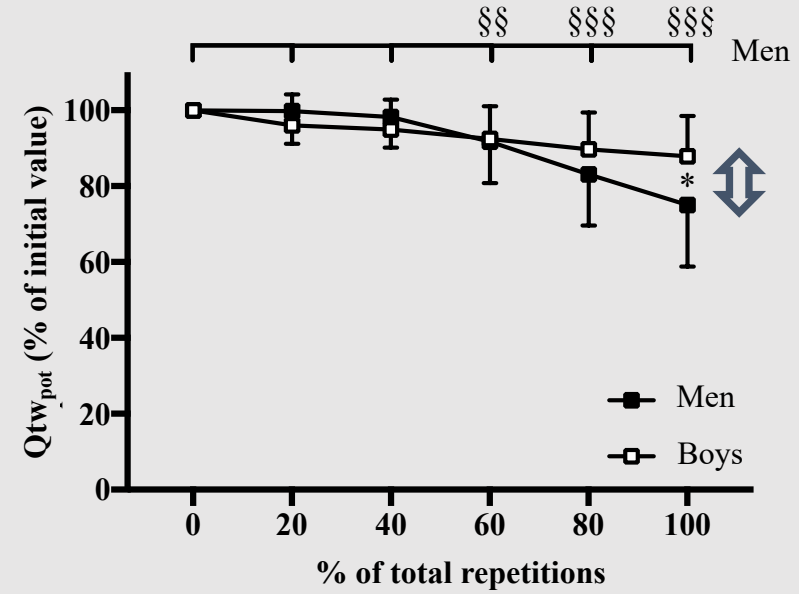
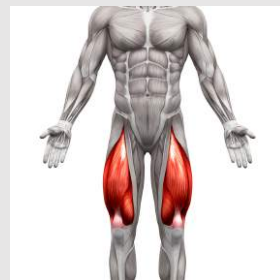
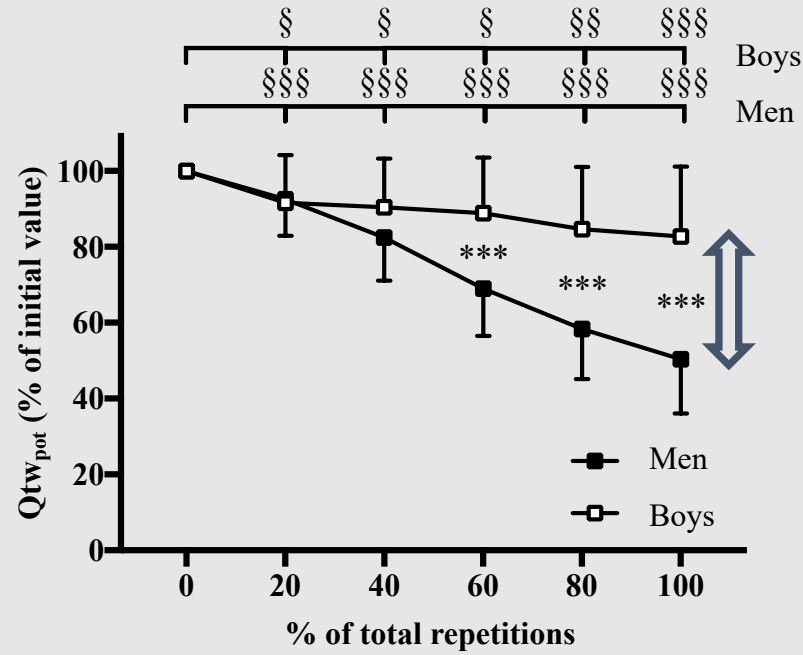


Lower difference in neuromuscular fatigue between boys and men

Results

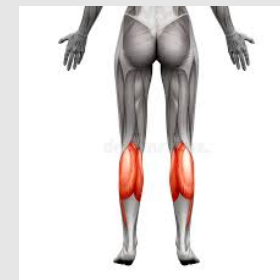
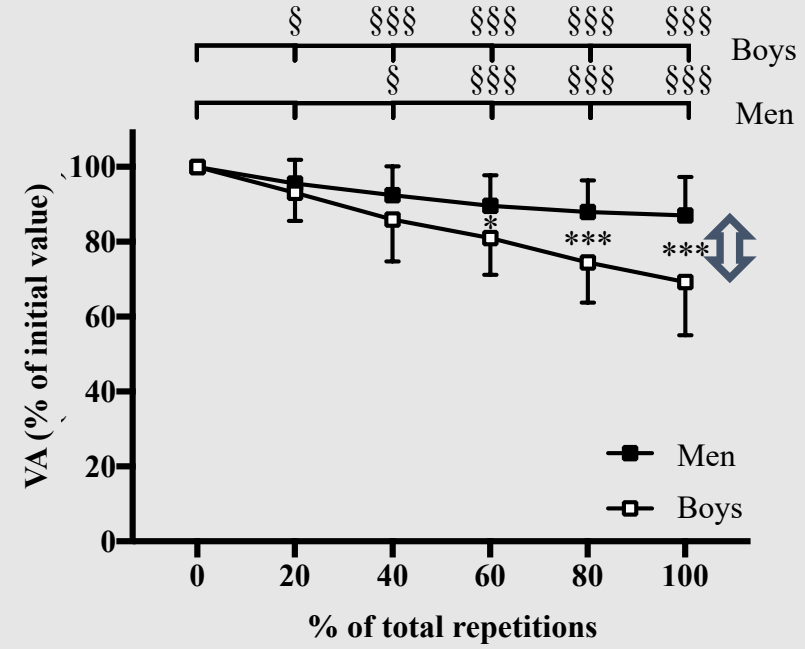
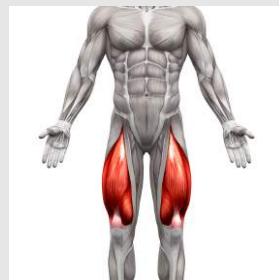
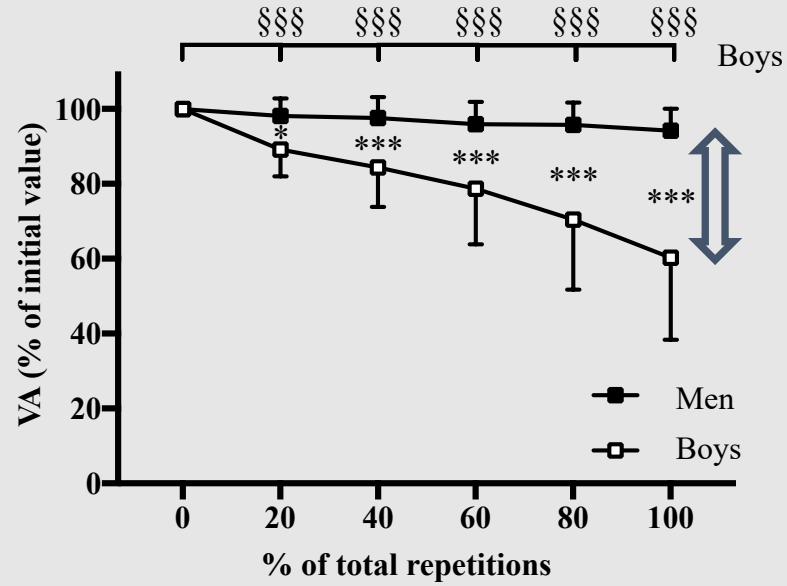


Peripheral fatigue



Qtw_{pot} : Potentiated single twitch

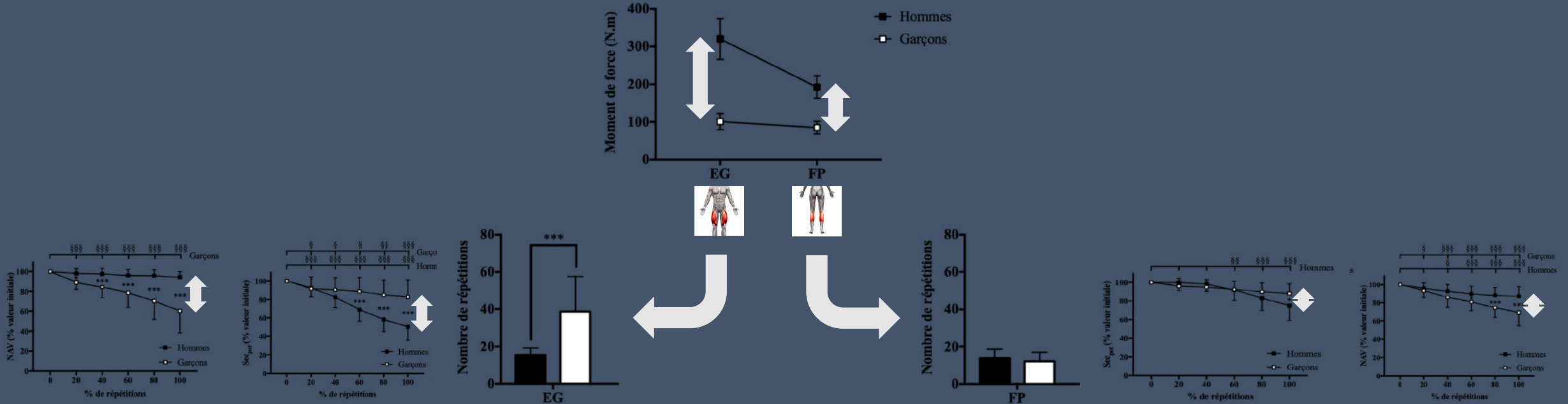
Central fatigue



VA : Voluntary activation level

Conclusion

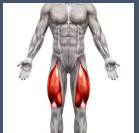
⇒ Muscle group impact difference in fatigability between children and adults but no difference in etiology of the neuromuscular fatigue



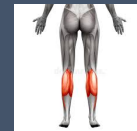
Limits :

Muscle group differences could also be accounted for by differences in muscle typology between children and adults

Type I fiber



>



=?



VL : 30% of type I fiber
Edgerton et al. 1975

Lexell et al. (1992)

SOL & GL : 70% and 50% type I fiber
Edgerton et al. 1975

Introduction

Methods

Muscle group effect

Muscle length effect

Metabolic profile effect

Conclusion



MUSCLE LENGTH EFFECT

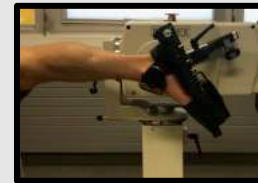


Aim and hypotheses

Aim: To compare difference in development and etiology of the neuromuscular fatigue between prepubertal boys and men during intermittent maximal fatigue protocol at different muscle length of KE and PF.

Hypotheses:

Short muscle length

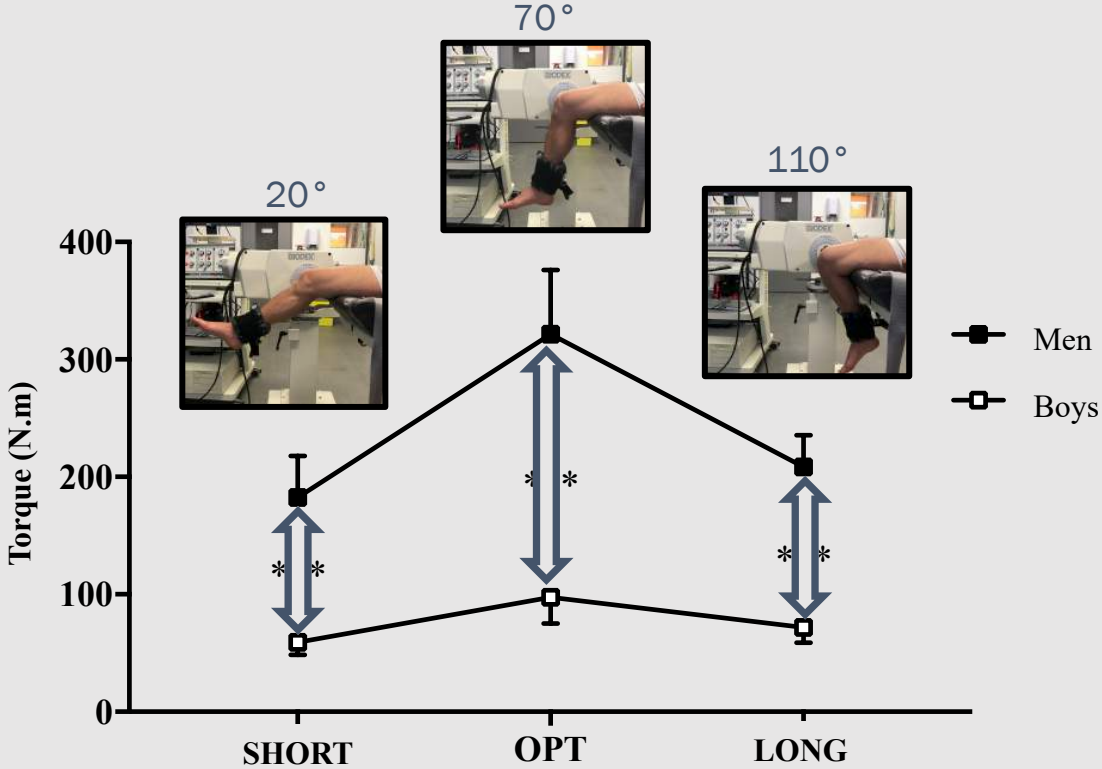


Reduced difference in torque level between children and adults

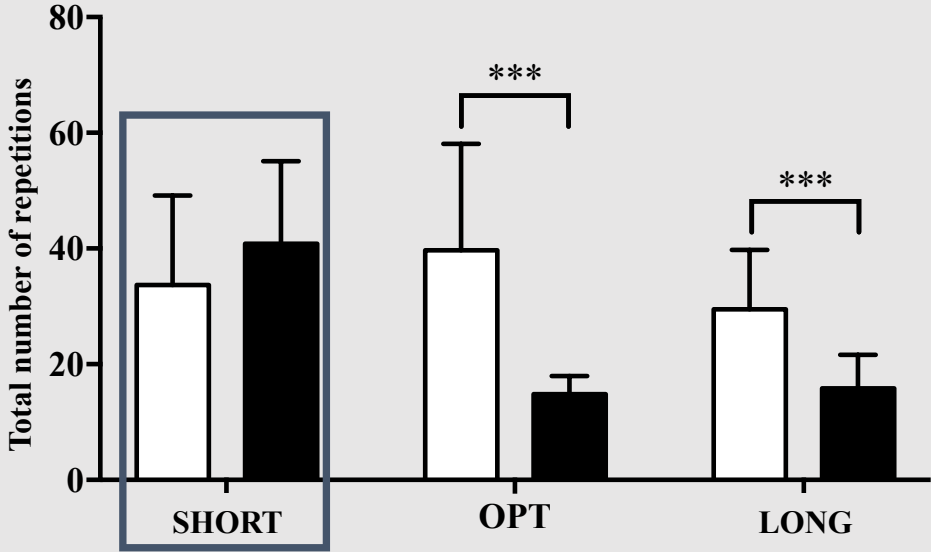


Reduced difference in neuromuscular fatigue between children and adults

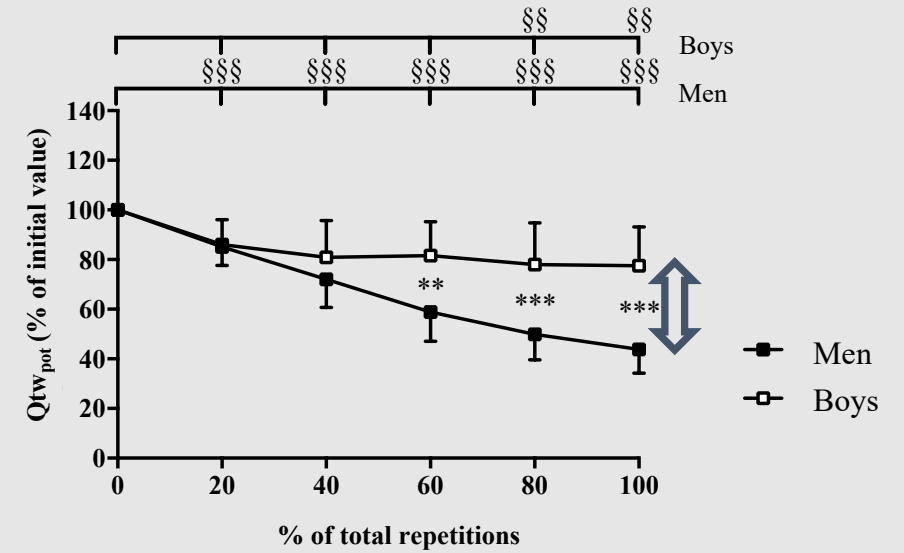
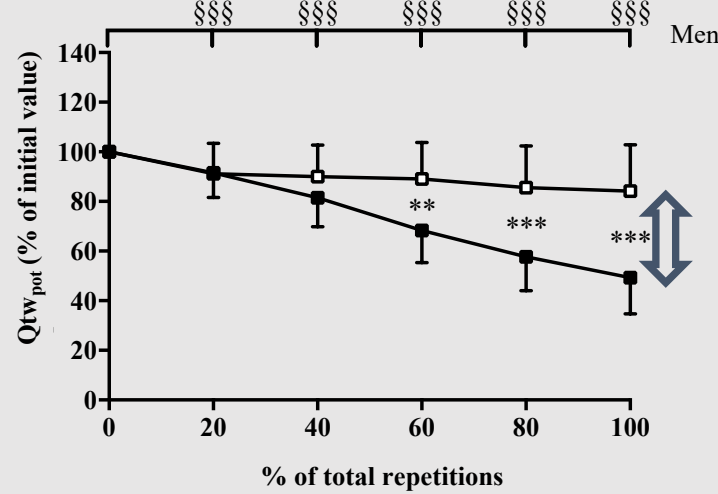
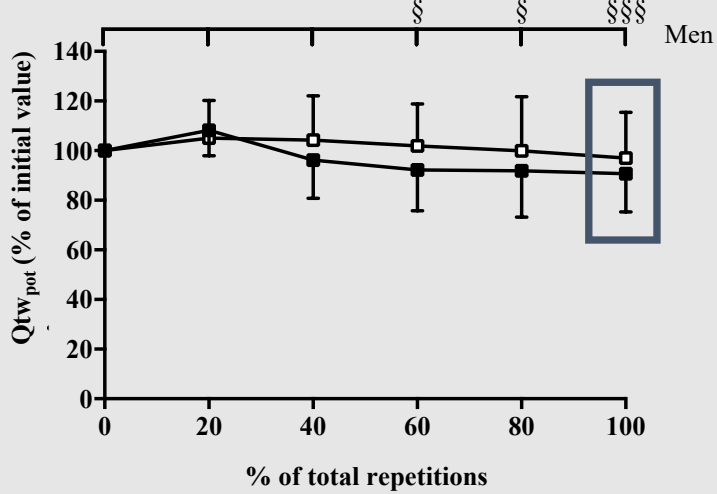
Results



Fatigability

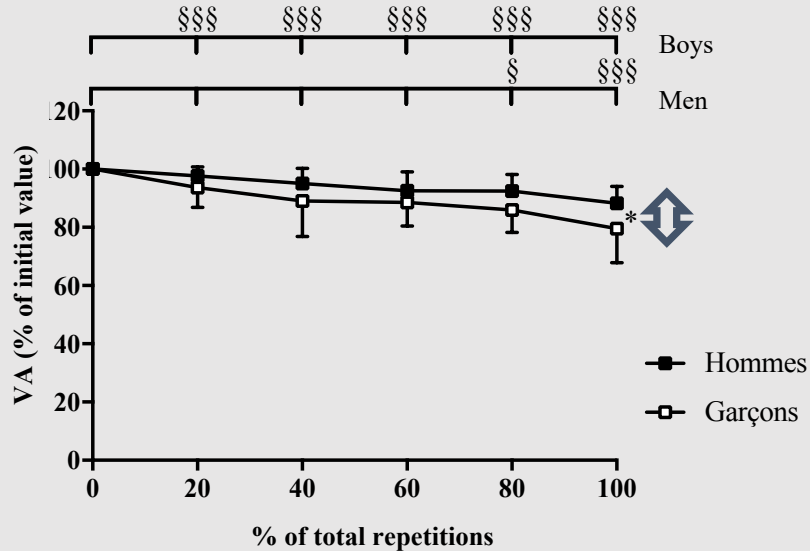
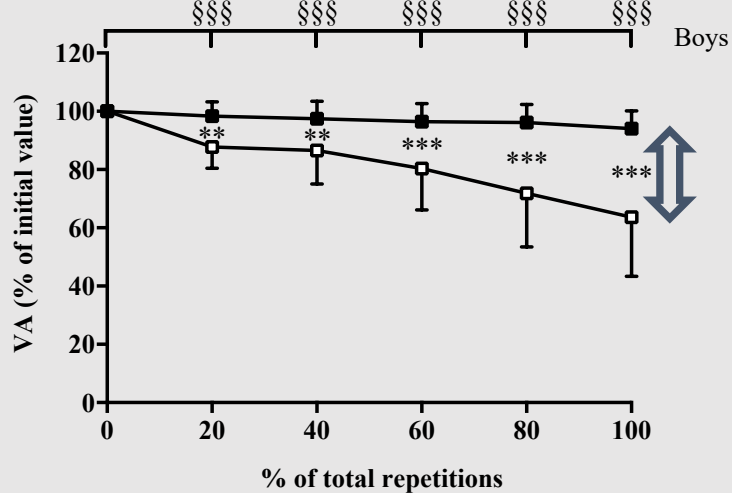
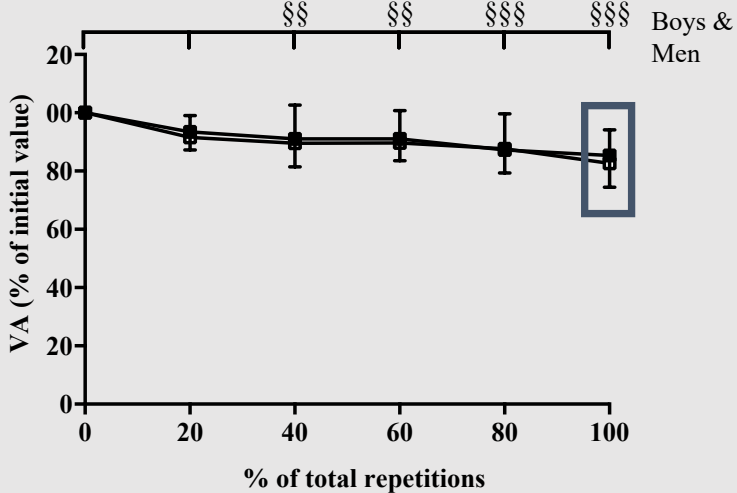
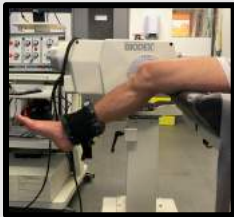


Peripheral fatigue



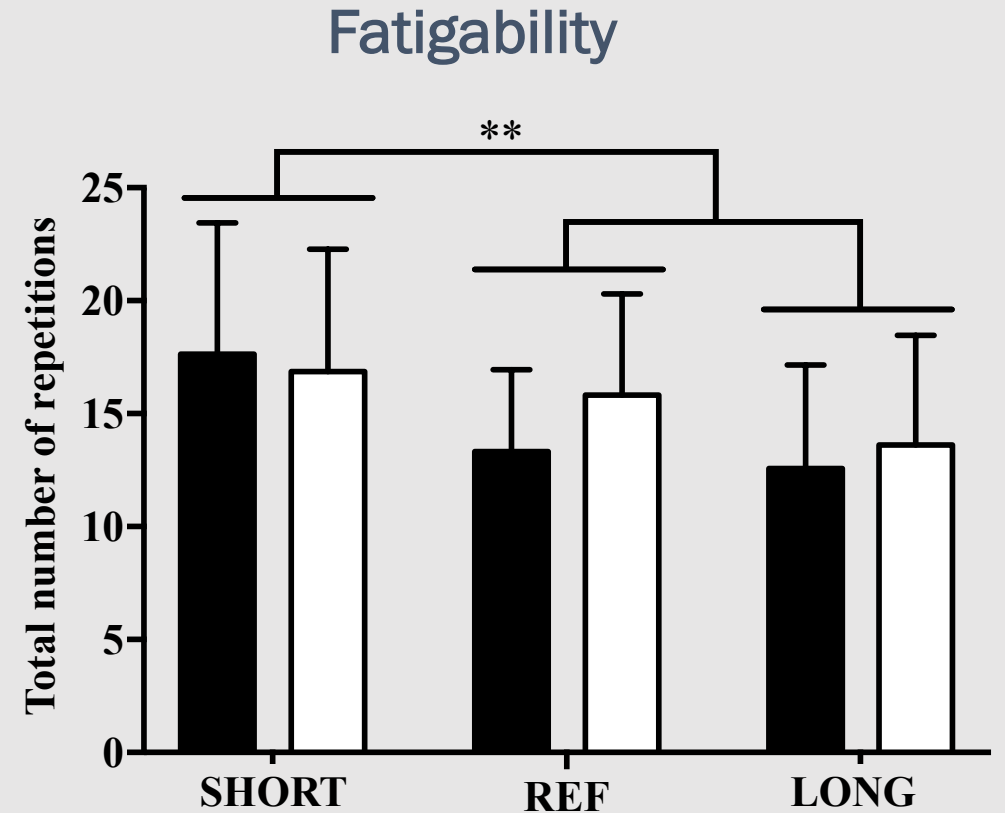
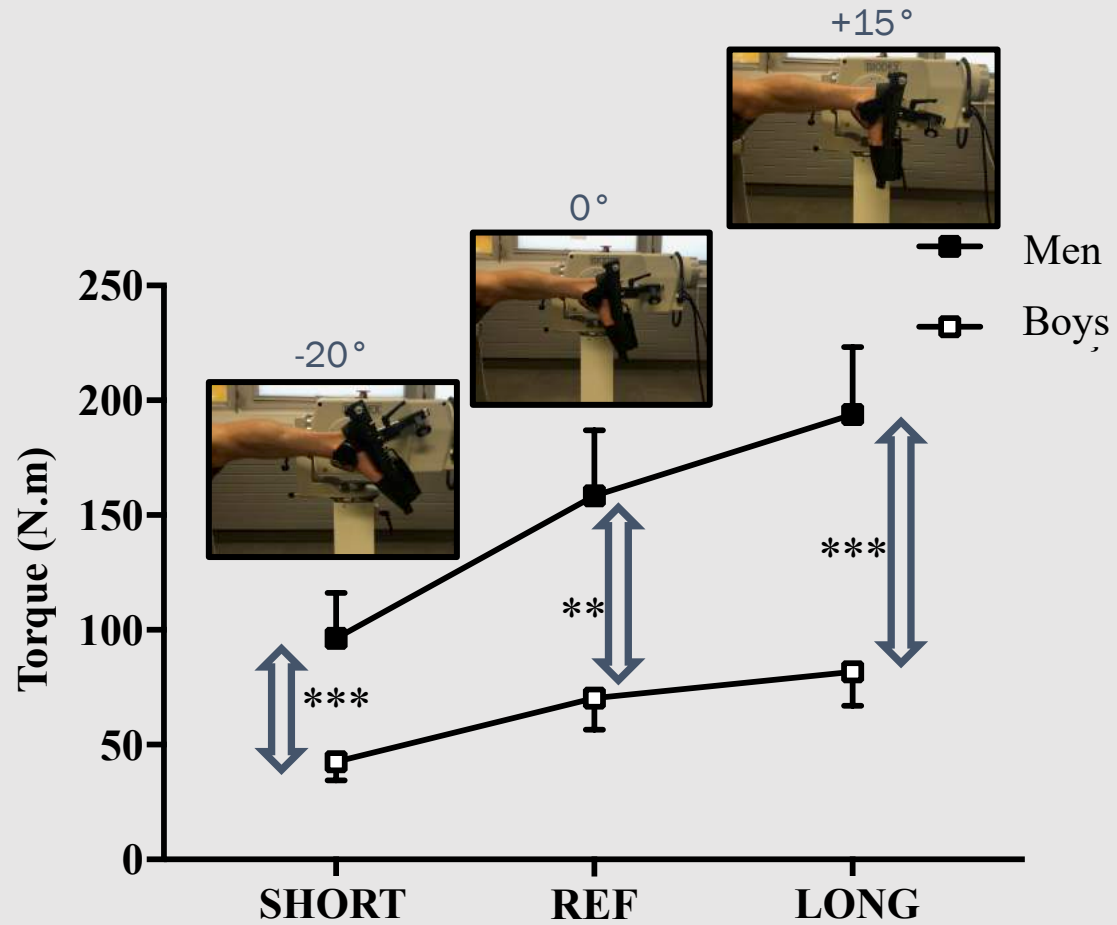
Qtw_{pot} : Potentiated single twitch

Central fatigue



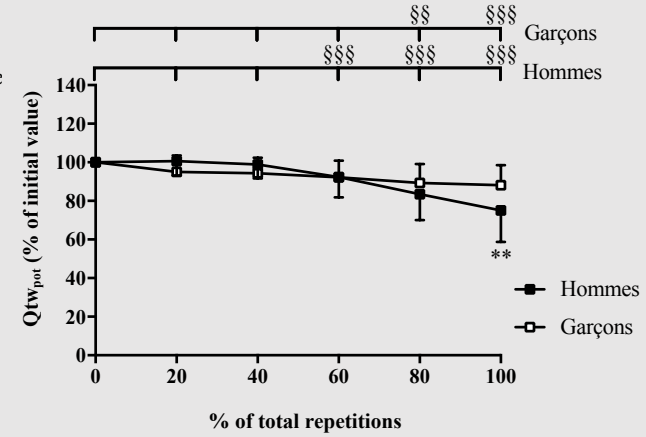
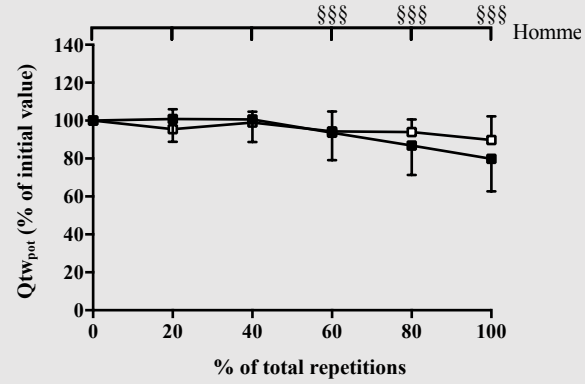
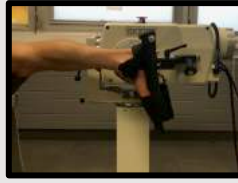
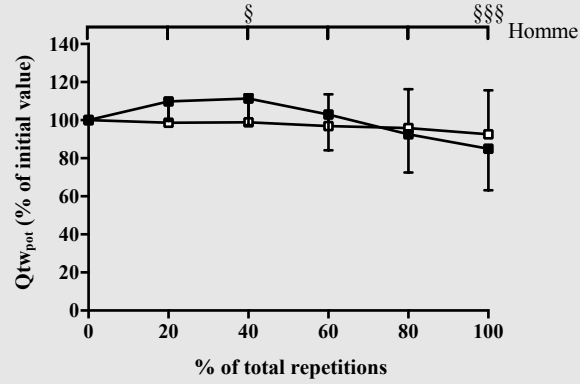
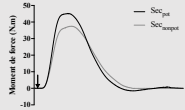
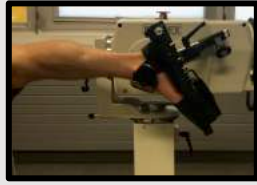
NAV : Niveau d'activation volontaire

Results

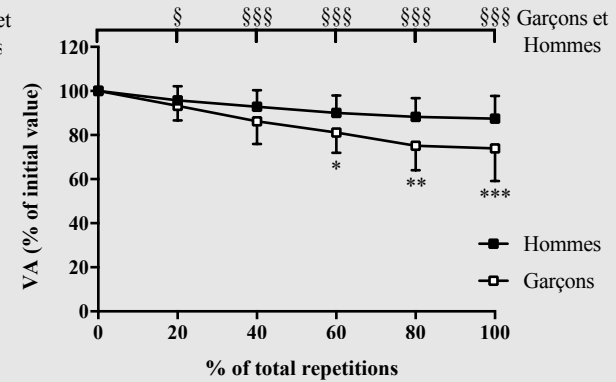
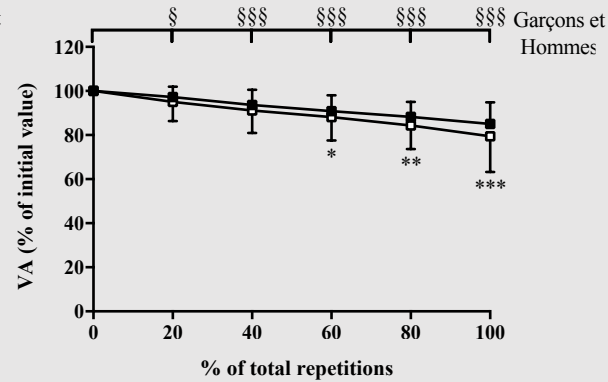
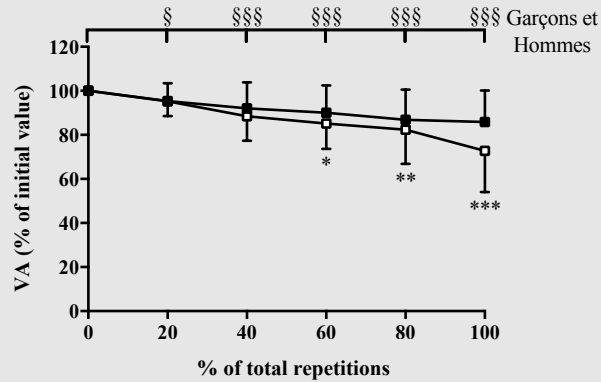
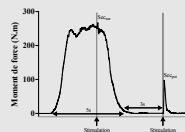


Results

Peripheral fatigue



Central fatigue



Conclusion

⇒ KE muscles length impact difference in development and etiology of the neuromuscular fatigue between children and adults but not PF muscles length.

Knee extensor muscles



Muscle length effect



Difference in neuromuscular fatigue

↔
Difference in torque level



Difference in neuromuscular fatigue

↔
Similar difference in torque level



Difference in neuromuscular fatigue

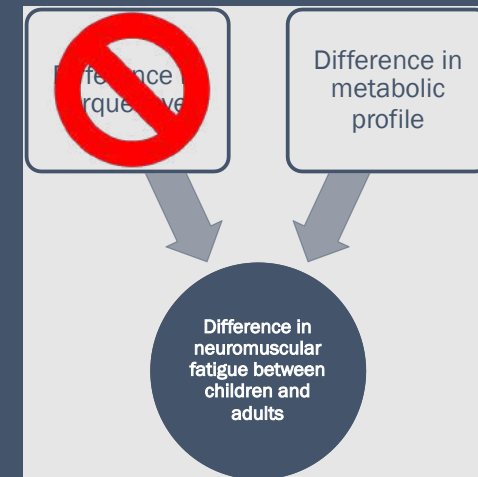
Plantar flexor muscles



No effect of muscle length



Difference in neuromuscular fatigue





METABOLIC PROFILE EFFECT



Aim and hypotheses

Aim : To compare difference in development and etiology of the neuromuscular fatigue between prepubertal boys and endurance athletes during intermittent maximal fatigue protocol

Hypotheses :



Difference in neuromuscular fatigue

Reduced difference in neuromuscular fatigue

ORIGINAL RESEARCH ARTICLE Provisionally accepted The full-text will be published soon. Not!  **frontiers**
in Physiology

Front. Physiol. | doi: 10.3389/fphys.2019.00119

Children exhibit a more comparable neuromuscular fatigue profile to endurance athletes than untrained adults

 Bastien BONTEMPS¹,  Enzo PIPONNIER¹,  Emeric CHALCHAT¹,  Anthony J. BLAZEVICH²,
 Valérie JULIAN³,  Olivia BOCOCCO³,  Martine DUCLOS³,  Vincent MARTIN³ and  Sébastien RATEL^{1*}

¹Université Clermont Auvergne, France
²Edith Cowan University, Australia
³Centre Hospitalier Universitaire de Clermont-Ferrand, France

 **frontiers**
in Physiology

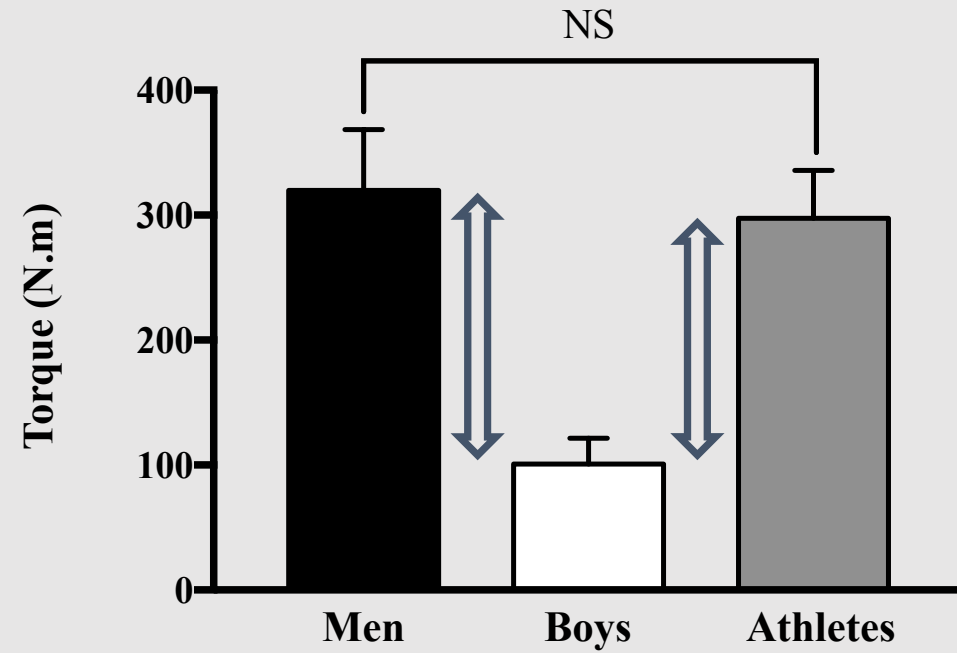
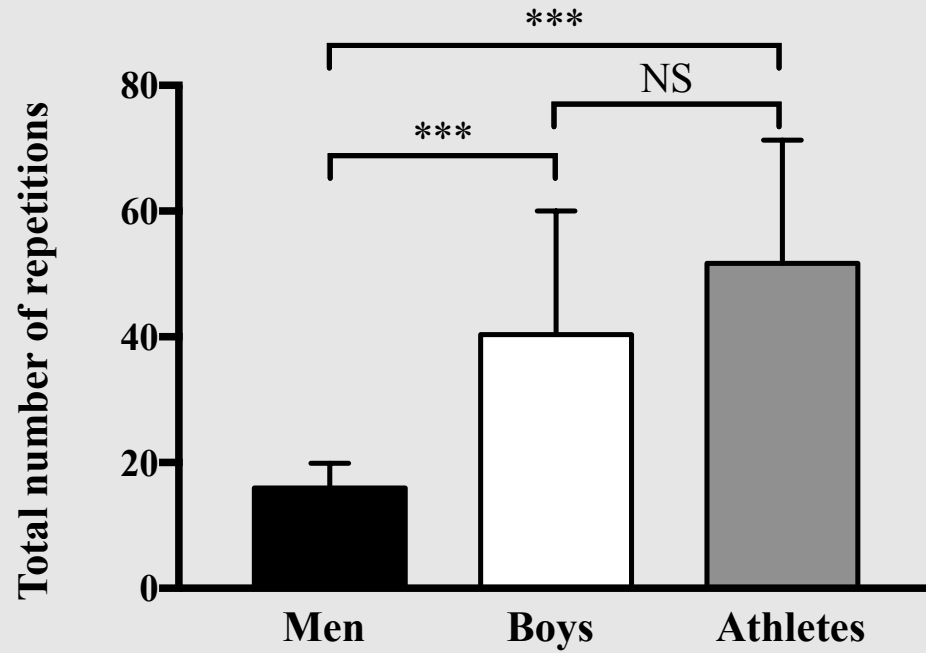
ORIGINAL RESEARCH
published: 24 April 2019
doi: 10.3389/fphys.2019.00087

Metabolic and Fatigue Profiles Are Comparable Between Prepubertal Children and Well-Trained Adult Endurance Athletes

Anthony Birat¹, Pierre Bourdier¹, Enzo Piponnier¹, Anthony J. Blazevich², Hugo Maciejewski³, Pascale Duché³ and Sébastien Rattel^{1*}

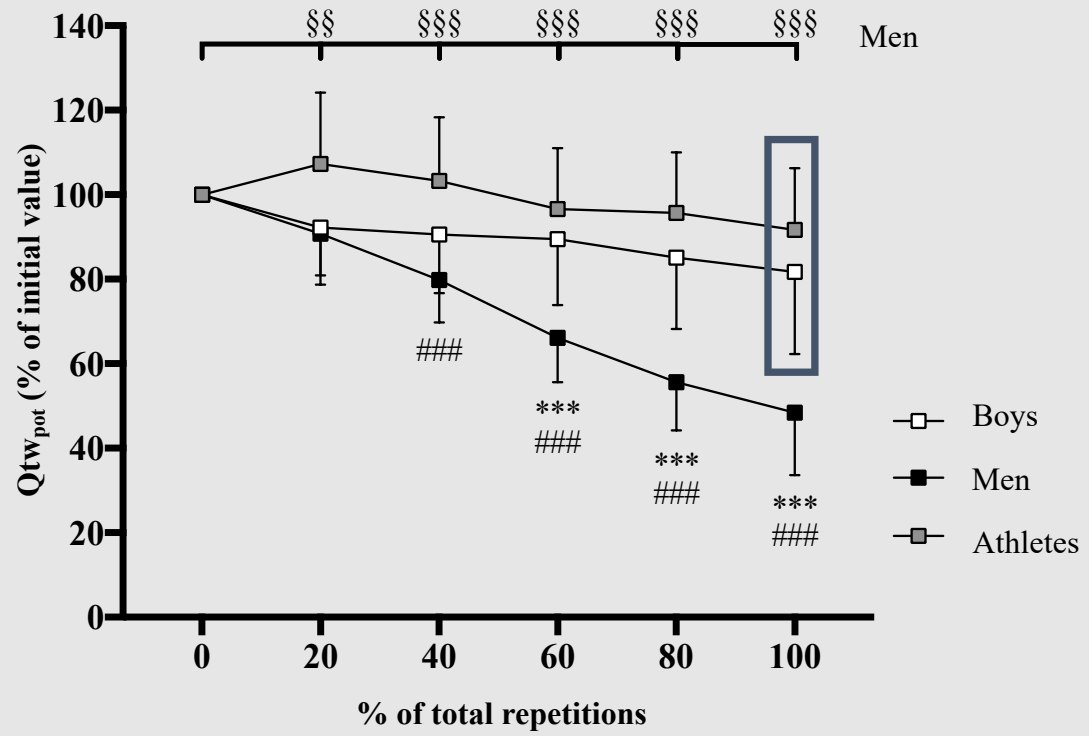
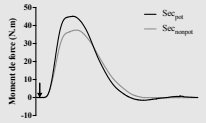
¹UMR207 UFR STAPS, Clermont-Auvergne University, Clermont-Ferrand, France, ²Centre for Exercise and Sports Science Research, School of Exercise and Health Sciences, Edith Cowan University, Joondbarup, WA, Australia, ³French Rowing Federation, Nogent-sur-Maine, France

Fatigability

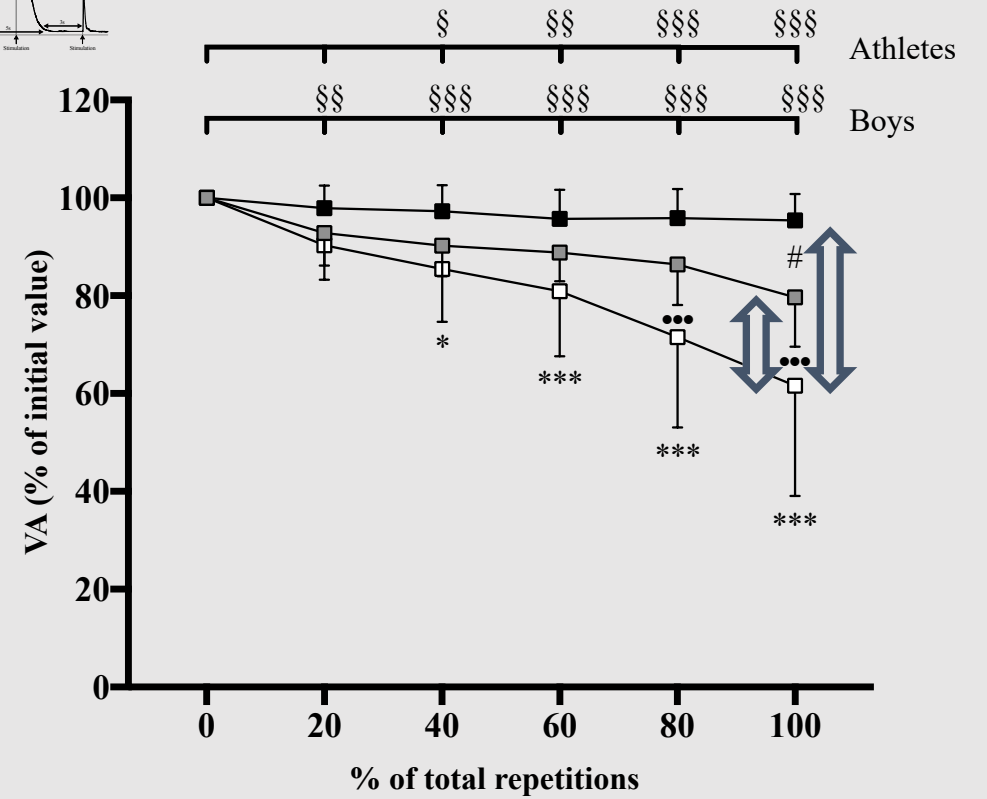
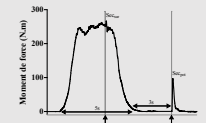


Results

Peripheral fatigue



Central fatigue

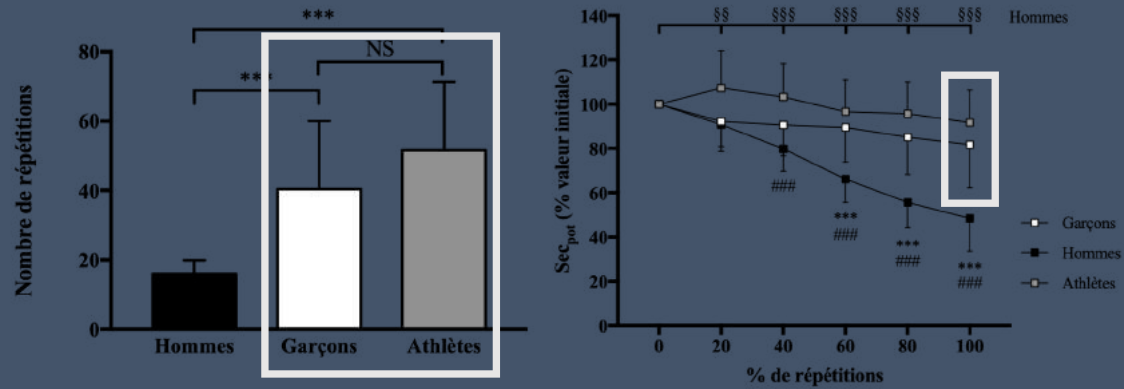


Qtw_{pot} : Potentiated single twitch; VA: Voluntary activation level

Conclusion

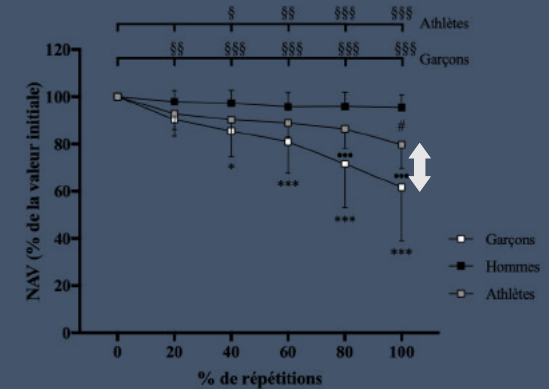
⇒ Boys and athletes have a more comparable neuromuscular fatigue profile than boys and untrained men

Fatigability and peripheral fatigue



⇒ Comparable profile

Central fatigue

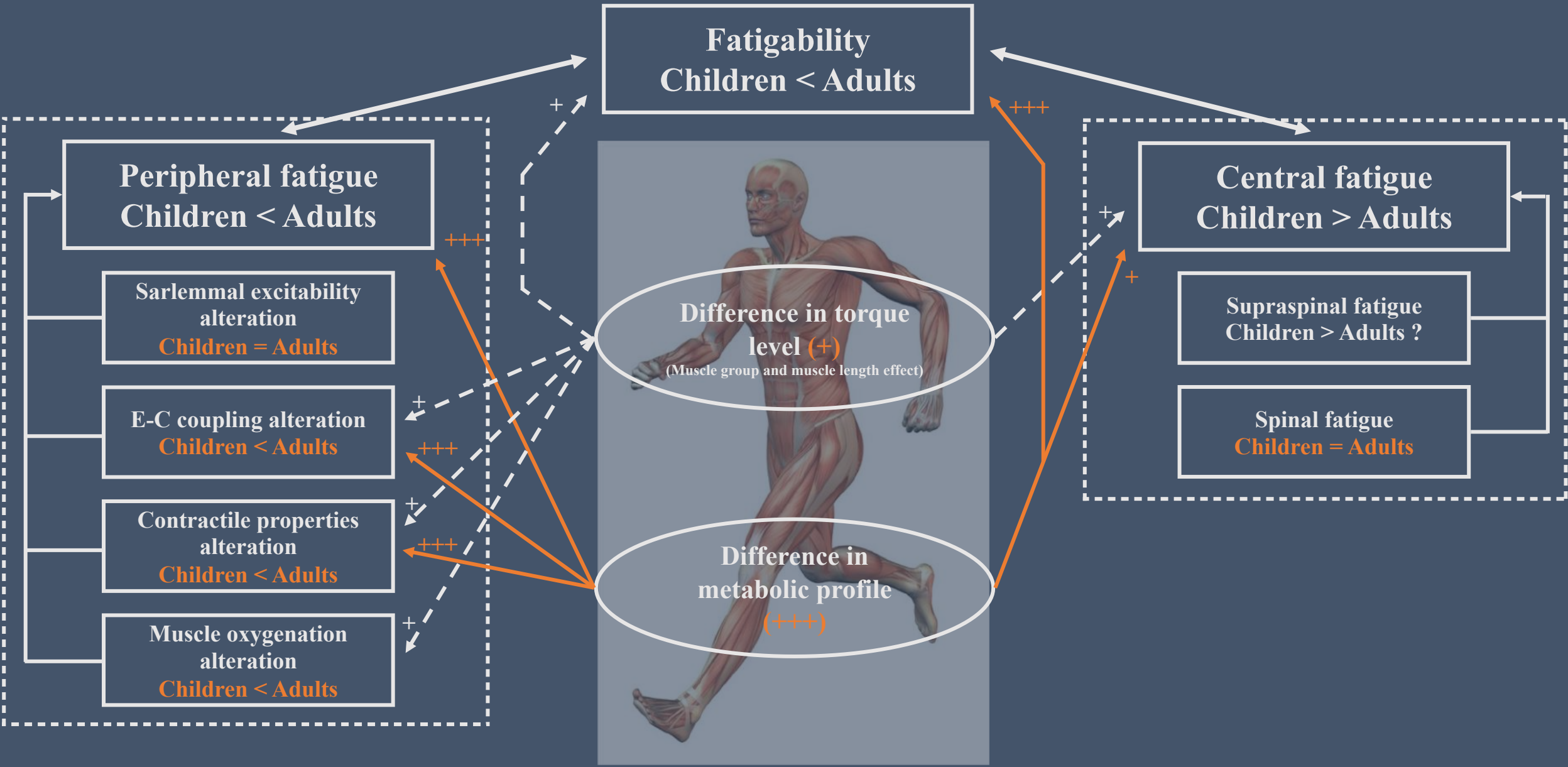


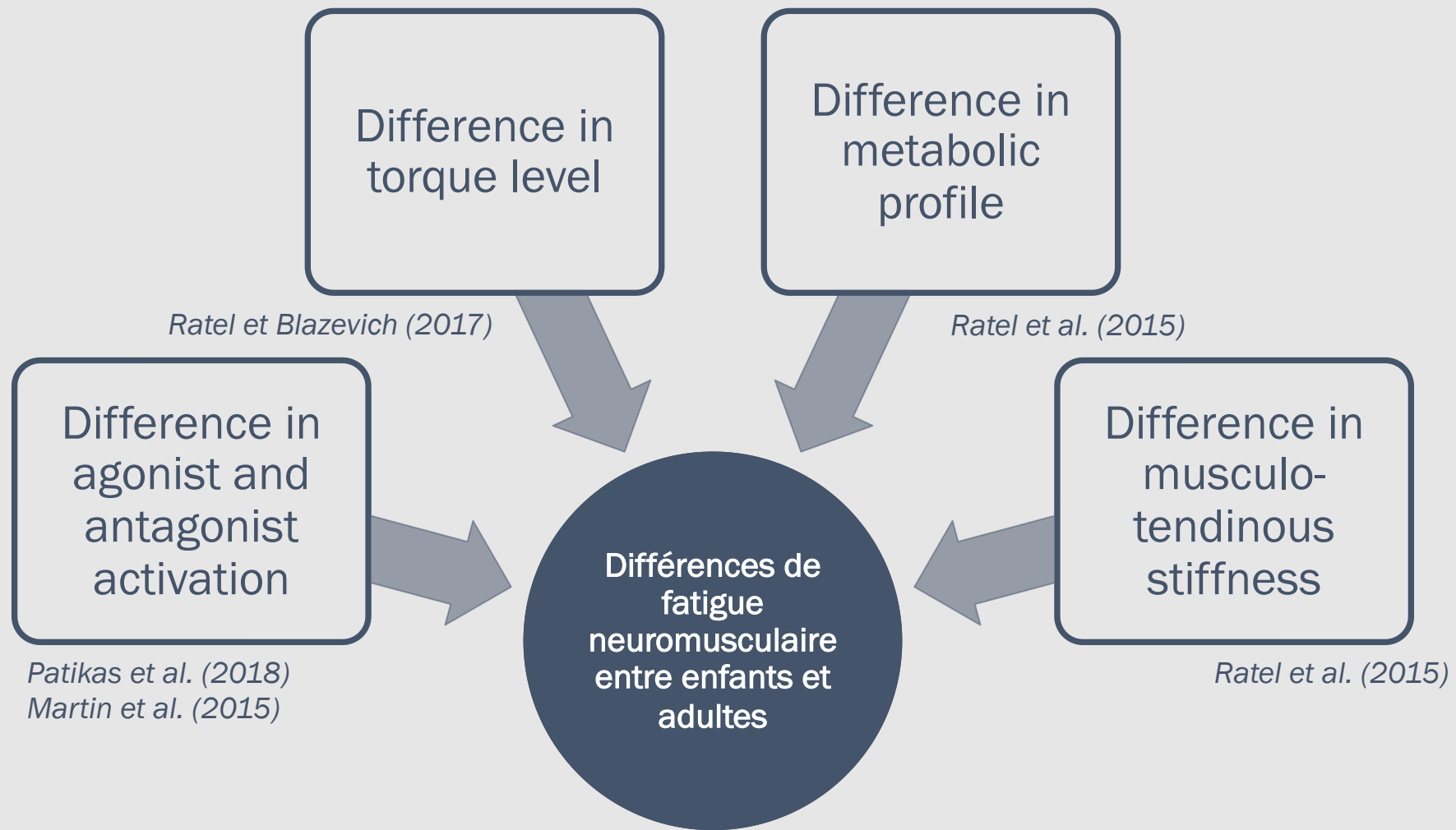
⇒ Different profile

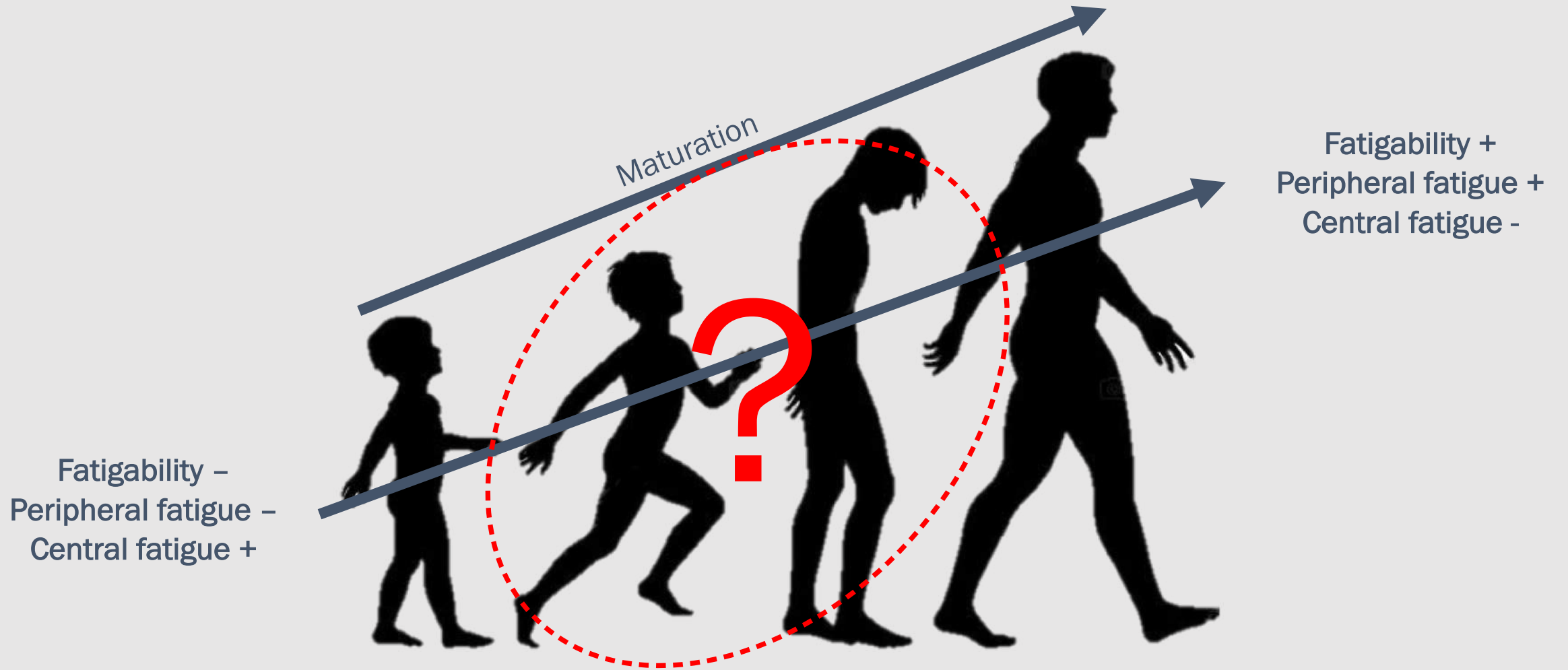


CONCLUSION











Children exhibit comparable fatigue to well trained endurance athletes



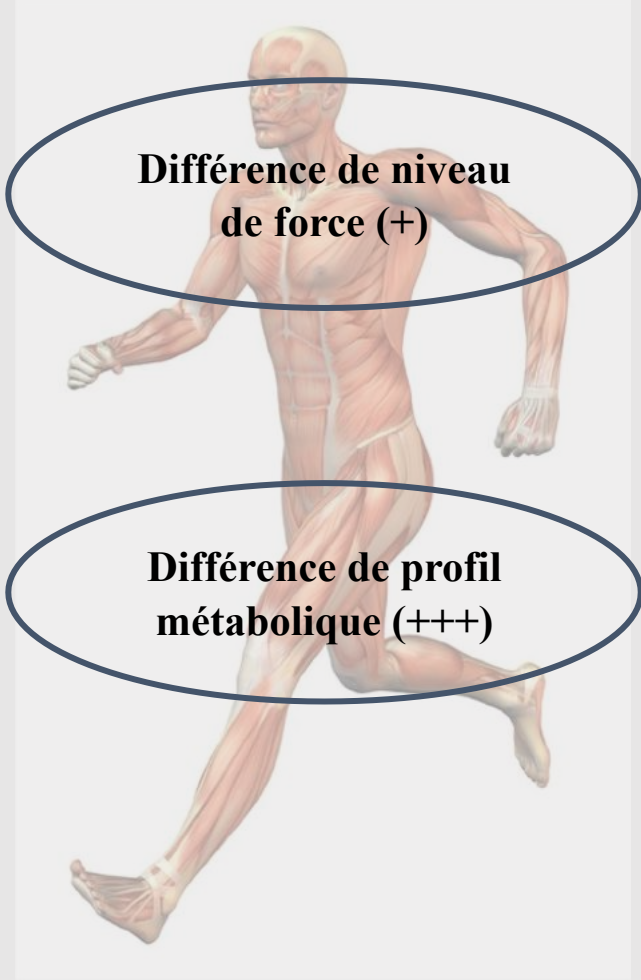
THANK YOU FOR YOUR
ATTENTION



Fatigabilité
Enfants < Adultes

Fatigue périphérique
Enfants < Adultes

Fatigue centrale
Enfants > Adultes



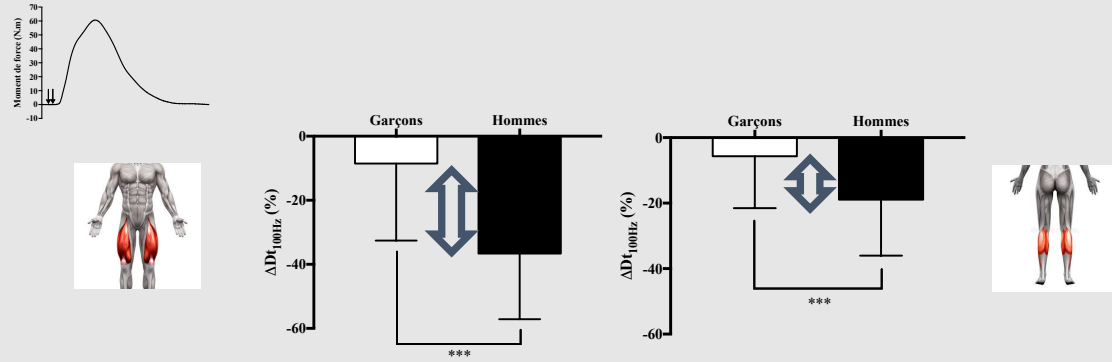
Fatigue supra-spinale
Enfants > Adultes ?

Effet de l'entraînement en force

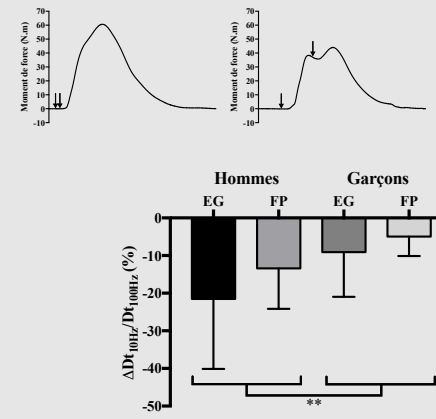
Effet de l'entraînement en endurance

Results

Peripheral fatigue

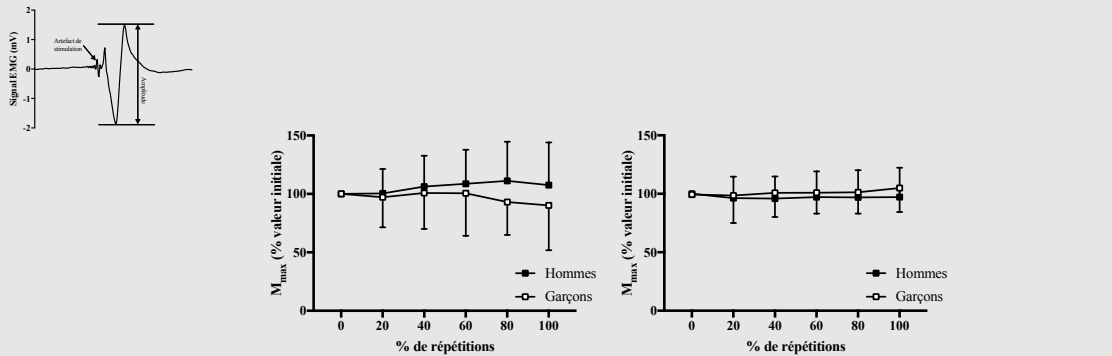


⇒ Lower alteration of contractile properties



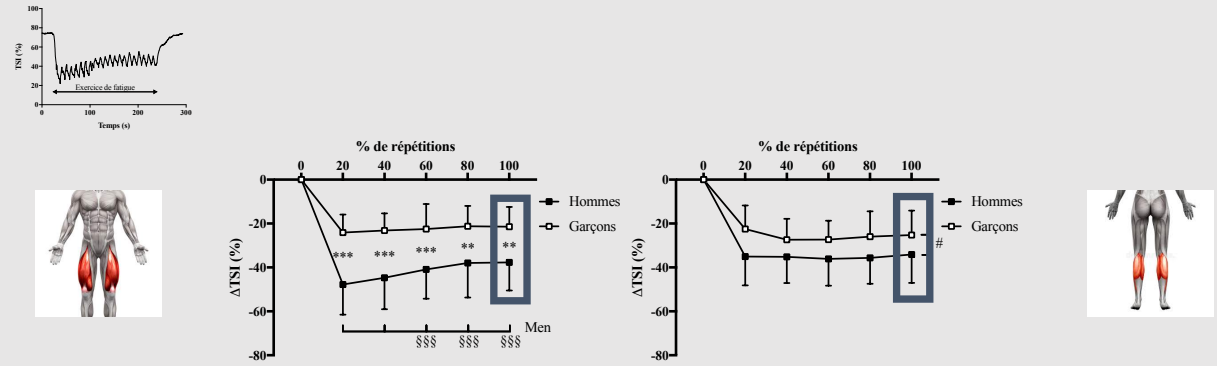
⇒ Lower alteration of E-C coupling

Dt_{10Hz}/Dt_{100Hz} : Ratio des doublets à basse et haute fréquences



⇒ No alteration of sarcolemmal excitability

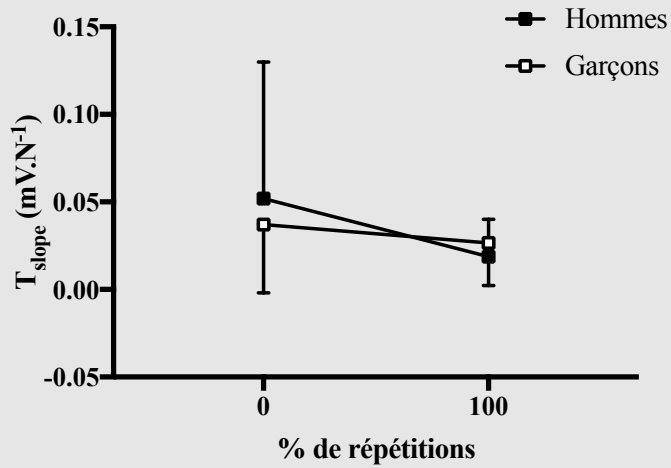
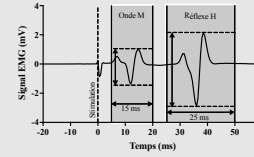
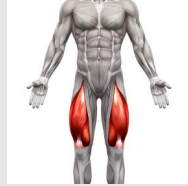
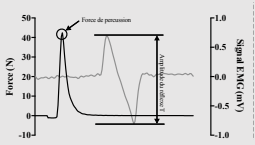
M_{max} : Onde M maximale



⇒ Lower alteration of muscle oxygenation

TSI : Index de saturation en O_2 tissulaire

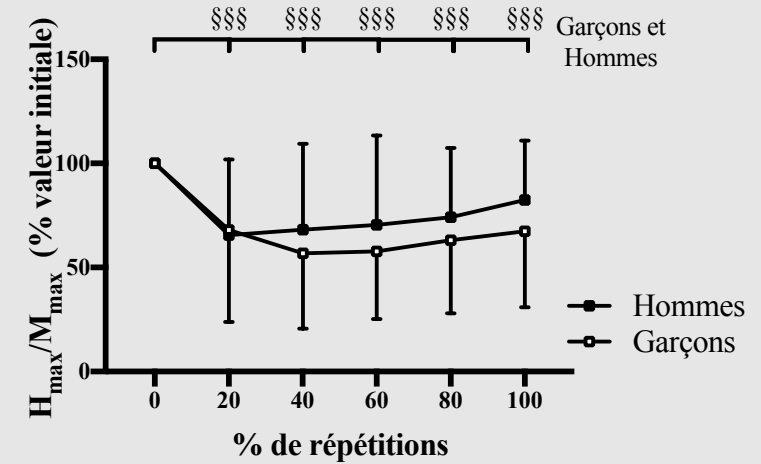
Central fatigue



⇒ No spinal fatigue

T_{slope} : T reflex gain

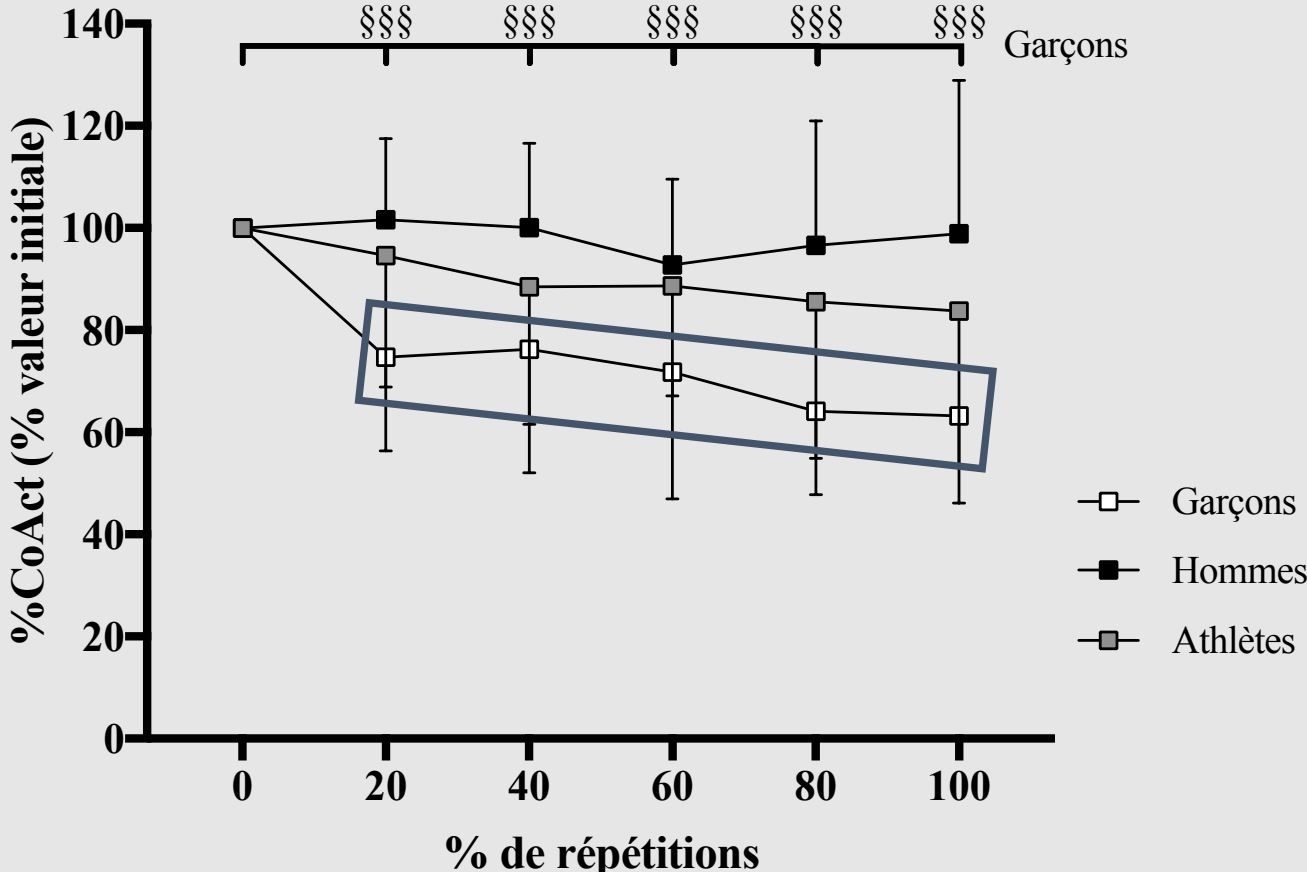
⇒ Supraspinal fatigue boys > men ?



⇒ No difference in spinal fatigue

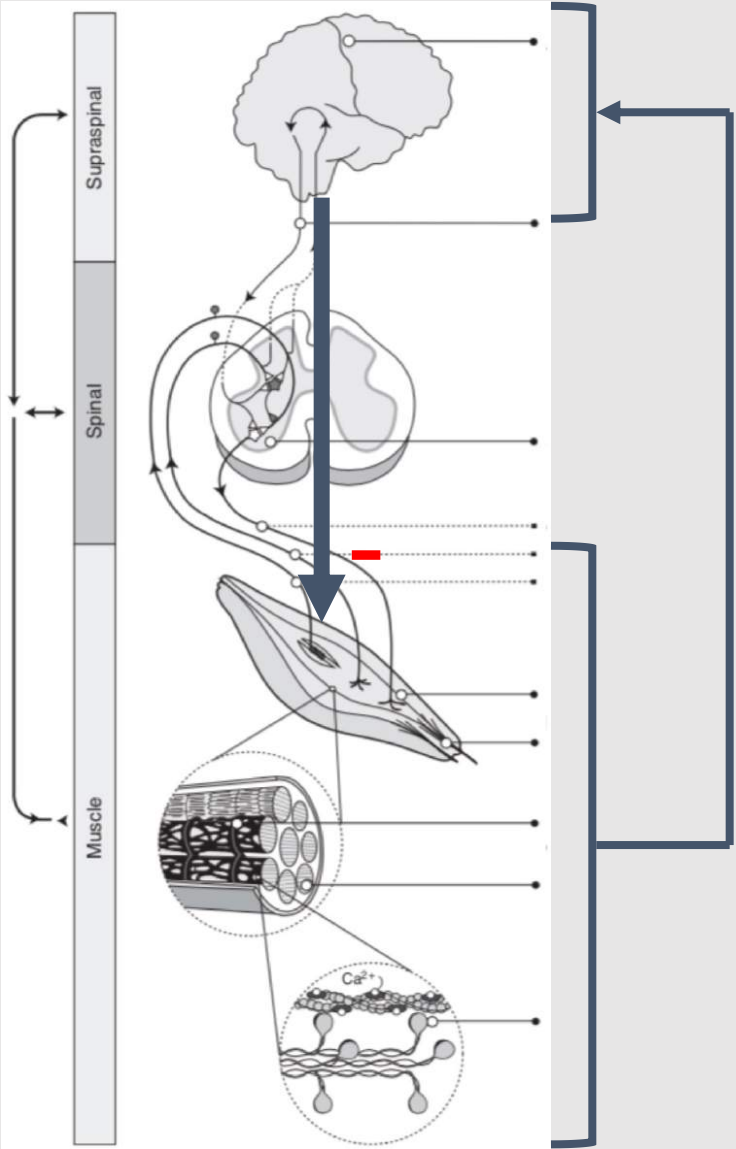
H_{max}/M_{max} : H reflex to Mmax ratio

Co-activation

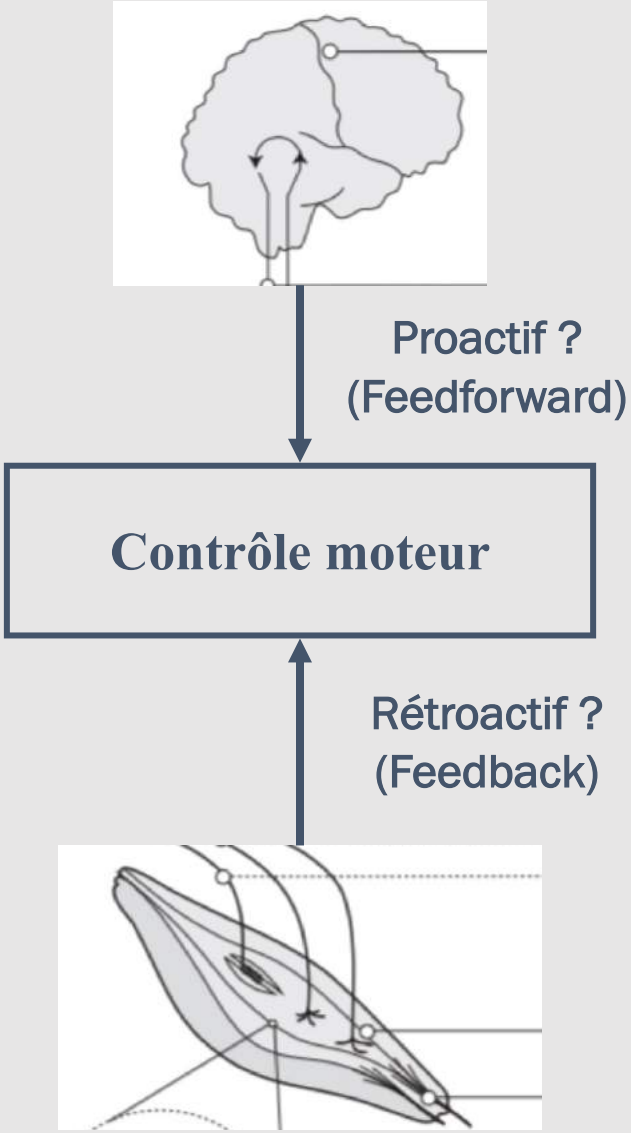


⇒ Specific neural regulation in boys?

Co-activation

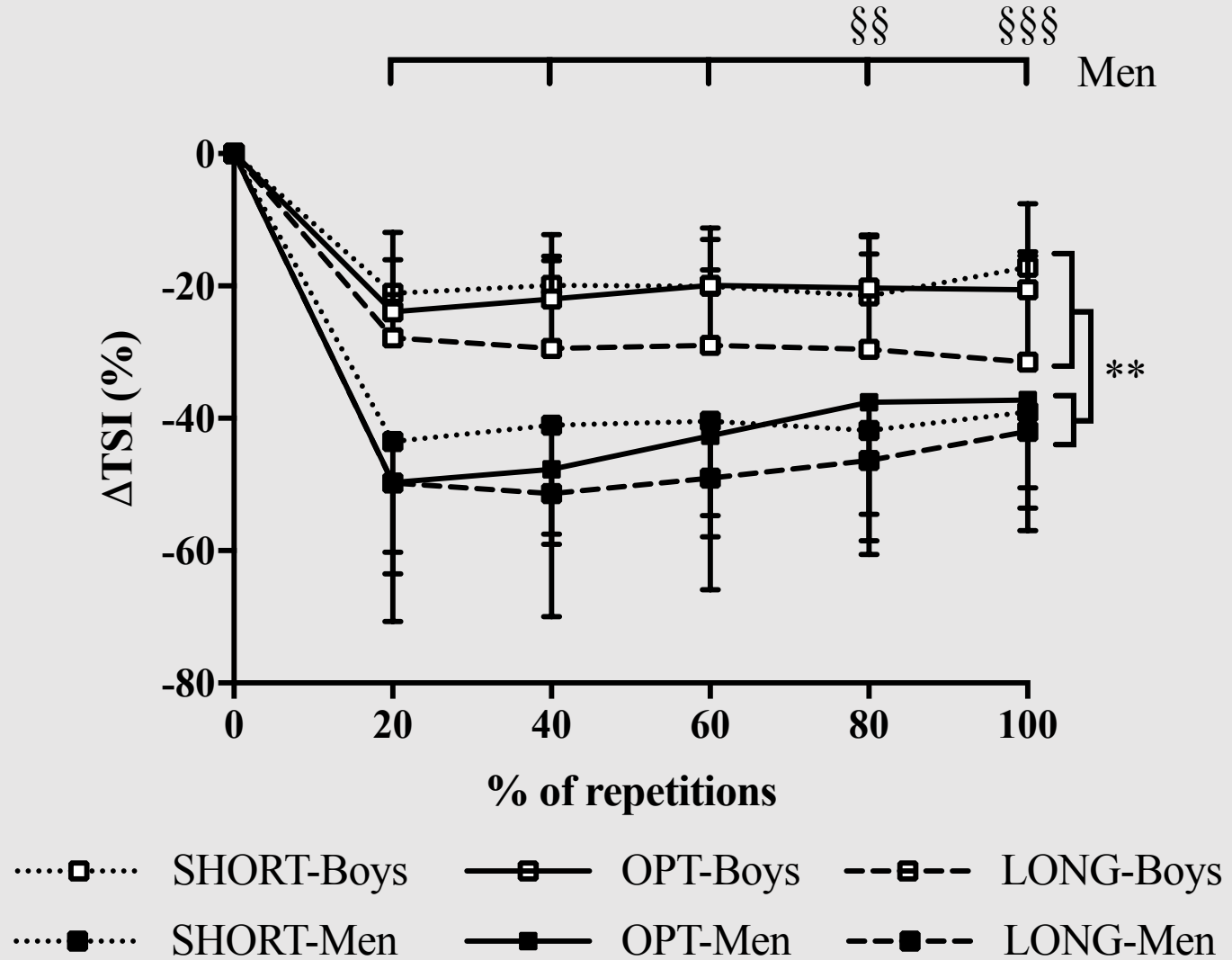


Sagesse musculaire ?

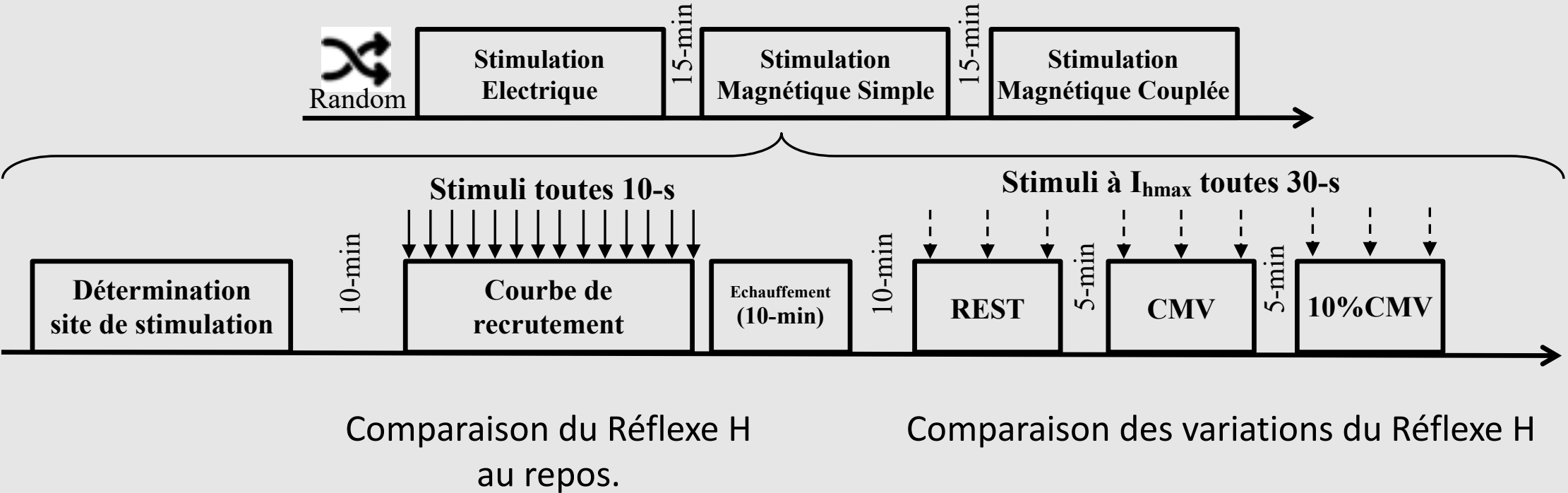


Différence enfant/adulte en condition de fatigue ?

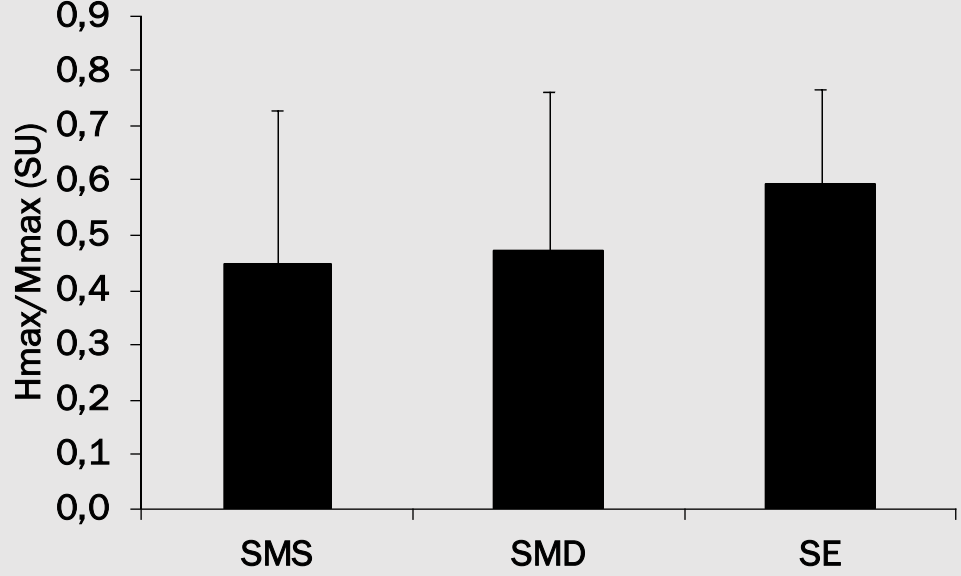
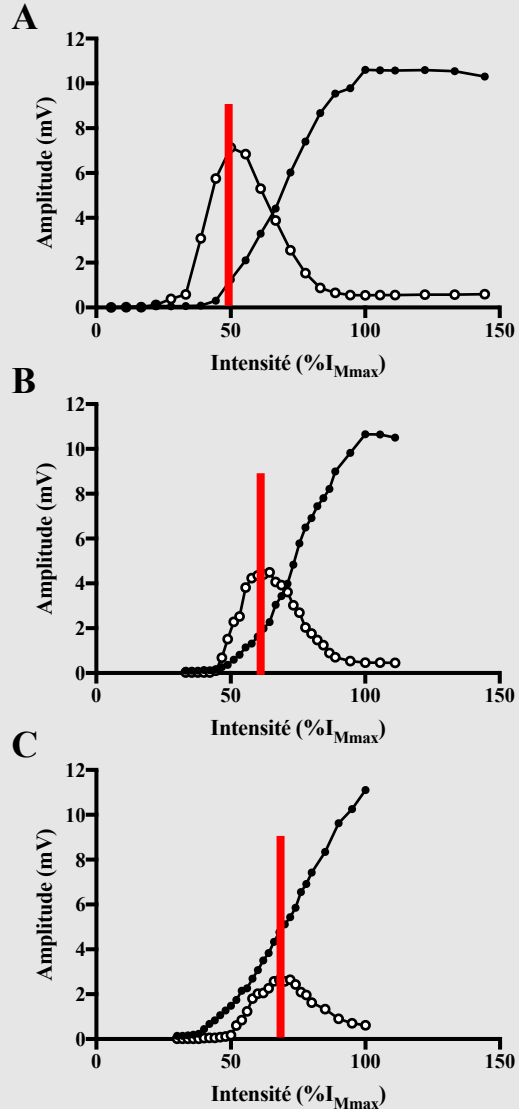
Muscle oxygenation



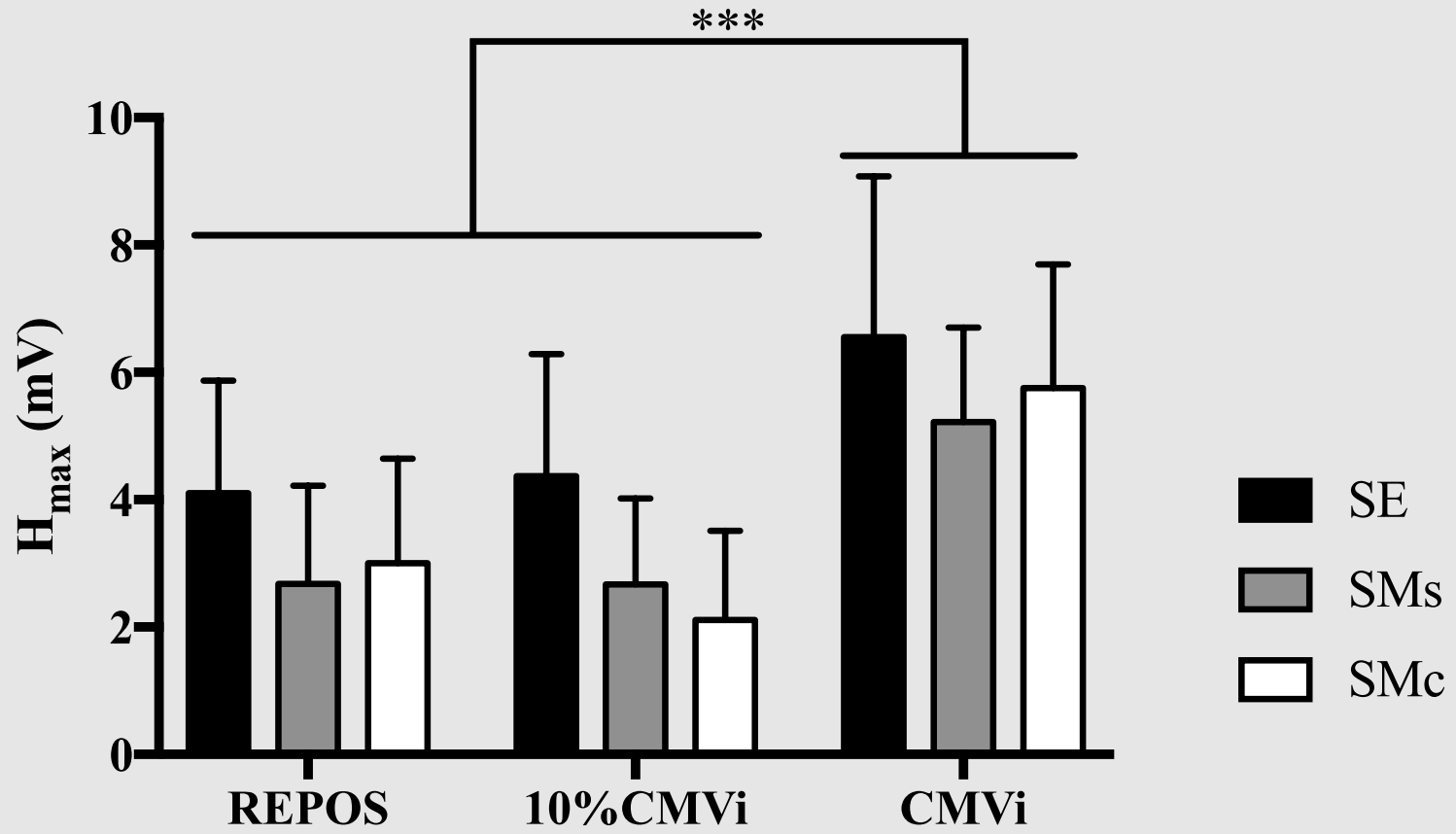
Validation de la stimulation magnétique pour l'évaluation du réflexe H



Validation de la stimulation magnétique pour l'évaluation du réflexe H



Validation de la stimulation magnétique pour l'évaluation du réflexe H



Activation volontaire enfants/adultes pour des contractions à différentes intensités

