MATURATION OF THE PASSIVE AND ACTIVE FRACTION OF THE PLANTAR FLEXORS SERIES ELASTIC COMPONENT IN PREBUBERTAL CHILDREN

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SUMMARY

The purpose of the present study is to evaluate the active and passive fraction of the series elastic component (SEC) in prepubertal children aged 7 to 10 years. Results indicate that the compliance of active fraction did not show any evolution with age, indicating that fiber type differentiation seems to be accomplished as these ages. In contrast, passive compliance showed a significant negative correlation, indicating that tendinous structures maturation is delayed. Finally, the opposite evolution of the musculotendinous (MT) stiffness index, when quantified with regard to torque or EMG confirms that MT quantification is influenced by immature activation capacities.

INTRODUCTION

The use of the quick-release technique to estimate MT stiffness has been extensively used over the last years, whether in animals or humans, in order to get insights of the adaptive process of the SEC. Recently, the mode of MT stiffness, i.e., SEC behavior [1], quantification has been revisited for subjects no able to fully activate their muscle, i.e., effects of long-term spaceflight [2] or non-mature muscles of prepubertal children [3].

METHODS

Prepubertal children with an age ranging from 7 to 10 years (± 4 months) were classified as prepubertal (n=41). Biomechanical testing was conducted, while the child was placed on an adjustable seat with the knee extended to 120˚ and the ankle was flexed to 90˚. Muscle strength was assessed in isometric condition and best torque was considered as maximal voluntary contraction (MVC). MT stiffness was obtained through quick-release experiments [4], by considering the ratio between variation in dynamic torque and displacement (i.e. stiffness), related to the isometric torque initially exerted by the subject (25%, 35%, 50% or 75% of MVC). The slope of this linear relationship was defined as $SI_{MT\text{-}Torque}$ [e.g. 5]. Furthermore, stiffness-EMG (electromyography) ($SI_{MT\text{-}EMG}$) relationships and passive stiffness from the intercept point with the ordinate (K_p) were determined [3, 6]. EMG was normalized with respect to the maximal M wave obtained from a supramaximal electrical stimulation. Eight of the tested children in the different age ranges were afraid to the stimulation so that they were excluded. Finally, the SEC active (α_0) and passive fractions ($C_{passive}$) were separated using the alpha method as described by Morgan [7]. Then, using alpha-torque ($\alpha_{0\text{-Torque}}$, $C_{passive\text{-Torque}}$) or alpha-EMG ($\alpha_{0\text{-EMG}}$, $C_{passive\text{-EMG}}$) relationships the SEC active and passive fractions can be separated, as described by the equations: $C = C_{active} + C_{passive}$ or $C \cdot T = \alpha = \alpha_0 + C_{passive} \cdot T$

Theoretical total compliance was calculated as the sum of active and passive compliance. Statistical analyses included Pearson Product Moment correlation analyses and linear regression analyses between the parameters and age. Significance was set to $p < 0.05$.

RESULTS AND DISCUSSION

Table 1 and 2 indicates the Pearson Product Moment correlation of the parameters either using stiffness-torque or stiffness-EMG relationships, respectively.

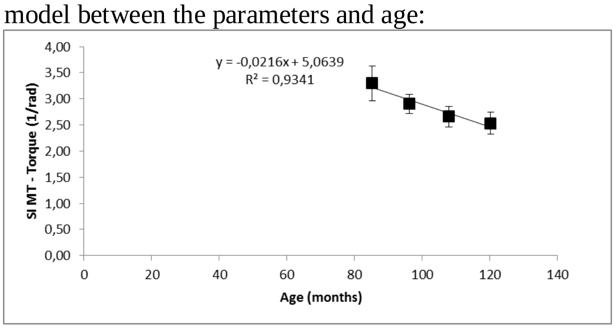
	$SI_{MT\text{-}Torque}$ (1/rad)	$\alpha_{0\text{-}Torque}$ (rad)	$C_{passive\text{-}Torque}$ (rad/Nm)	$K_{p\text{-}Torque}$ (Nm/rad)
Age: 7 to 10 years	R=-0.37 P<0.01 N=41	R=-0.2 P=0.21 N=41	R=-0.38 P=0.013 N=41	R=0.6 P<0.01 N=41

Table1.Pearson Product Moment Correlation: R correlation coefficient, p-value and N is number of subjects

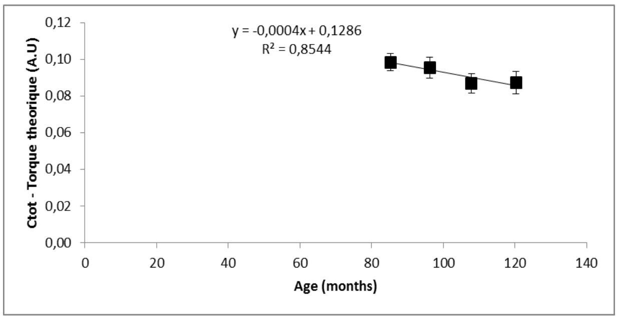
	$SI_{MT\text{-}EMG}$ (Nm/rad %)	$\alpha_{0\text{-}EMG}$ (rad)	$C_{passive\text{-}EMG}$ (rad/%)	$K_{p\text{-}EMG}$ (Nm/rad)
Age: 7 to 10 years	R=0.52 P<0.01 N=33	R=-0,09 P=0.62 N=33	R=-0.37 P=0.036 N=33	R=0.58 P<0.01 N=33

Table2.Pearson Product Moment Correlation: R correlation coefficient, p-value and N is number of subjects

Finally, figures 1 to 2 indicate the linear regression model between the parameters and age:

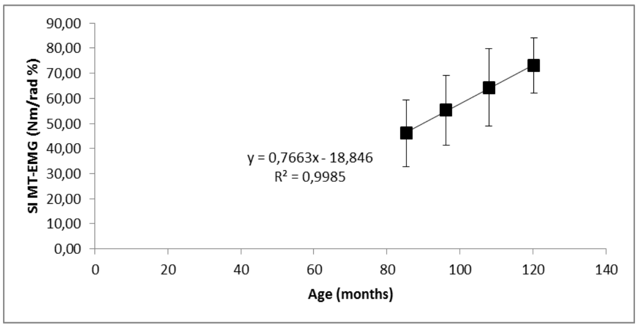


A



B

Figure1. Comparison between $SI_{MT\text{-}torque}$ - (1A) and $C_{tot\text{-}torque}$ – age (1B) relationships, respectively. Data are mean ± SE.



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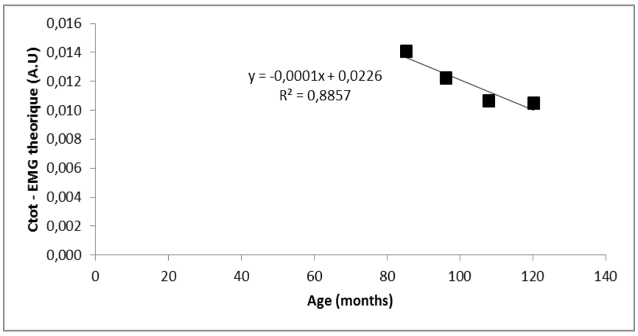

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Figure2. Comparison between $SI_{MT\text{-}EMG}$ - (2A) and $C_{tot\text{-}EMG}$ – age (2B) relationships, respectively. Data are mean ± SE.

The results of the present study confirm the evolution of the maturation process of MT stiffness index in prepubertal children, indicating that the opposite evolution of the MT stiffness index (when qua notified with regard to torque or EMG) is influenced by the activation capacities [3] (see figure 1A and 2A). This is also supported by the similar evolution of the total compliance and $SI_{MT\text{-}torque}$ (see figure1). Interestingly, these parameters showed the opposite evolution when expressed with regard to the activation capacities (increase in $SI_{MT\text{-}EMG}$ and decrease in $C_{tot\text{-}EMG}$ theoretical, see figure 2). This seems to be mainly attributable to the increase of the passive stiffness, like tendinous structures [3]. As a matter of fact, K_p showed a highly positive correlation, while $C_{passive}$ showed a negative correlation (see table 1 and 2). The influence of maturation of passive structures on MT stiffness index is also supported by the non-correlation of the SEC active fraction ($\alpha_{0\text{-}Torque}$ and $\alpha_{0\text{-}EMG}$), which can be mainly attributed to the muscle stiffness, i.e., cross bridges. In other words, fiber type differentiation seems to be accomplished in children aged 7 to 10 years, knowing that slow-type and fast-type fibers can exhibit different stiffness values [8].

CONCLUSION

The results of the present confirm the evolution of the maturation process of MT stiffness in prepubertal children, indicating that MT stiffness quantification is influenced by the activation capacities. Changes in MT stiffness index can be then attributed to evolution of the stiffness of passive strcutures.

ACKNOWLEDGEMENTS

This study was supported by grants from CNPq. Dr Daniel Lambertz is a DCR-CNPq/FACEPE fellow.

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