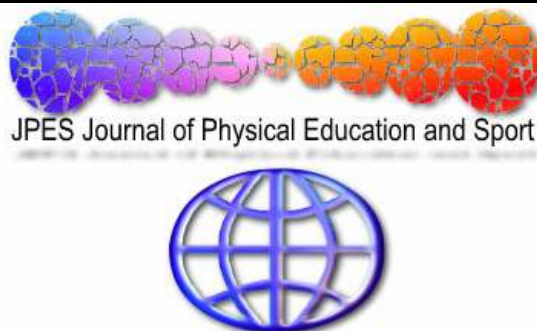




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ORIGINAL RESEARCH

THE EFFECT OF A STRETCH-SHORTENING CYCLE FATIGUE TEST ON THE DYNAMIC CHARACTERISTICS OF LOWER LIMBS IN ADULT MEN AND PRE-PUBESCENT BOYS.

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Abstract

Purpose: The present study focused on the acute effect differences between children and adults after a stretch shortening cycle fatigue test on drop jump performance.**Method:** Eleven pre-pubescent boys ($10,2 \pm 0,7$ y old) and eleven adult men ($24,3 \pm 3,3$ y old) performed a stretch shortening cycle fatigue test (SSFT, 10 sets /10 repetitions, with 30 sec interval between sets). Before and after fatigue test, maximal isometric torque, drop jump (DJ), contact time and ground reaction forces (GRF) were evaluated. Fatigue perceives and feel of pain were evaluated immediately after fatigue as well.**Results:** After fatigue MVC and DJ significantly decreased in both groups but this decrease was higher in adults. Contact time and GRF were increased in both groups but in a higher extend in adults. Fatigue perception and the feeling of pain were also higher in adults.**Conclusion:** In this research, the SSFT resulted in acute reduction of the performance of both age groups but more in adults. The higher performance reduction in adults could be attributed possibly both in neuromuscular, metabolic and inflammatory factors.**Keywords:** Pre-pubescent boys, adults, fatigue, stretch shortening cycle, pain,

Introduction

The physical muscular activity usually requires the involvement of the stretch-shortening cycle mechanism. The importance of this cycle is based on the store and release of the elastic energy which potentiates finally the concentric action of the selected task (Asmussen, 1956). Relevant studies also showed that after a SSCF protocol, both jumping and strength performance decreased dramatically (Horita et al., 2003; Marginson et al., 2005). This decrease has an acute and long term effect. The acute effect was attributed both in metabolic and inflammatory mechanisms (Nicol et al., 2003) while the long term effect (lasting 1-7days) was caused mainly by the inflammatory process and the muscle structure deformation. (Hough 1902, Armstrong et al., 1991, Byrne et al., 2004, Clarkson & Sayers 1999). During this long term fatigue phase, a pain appeared the so called "Delayed muscle soreness" (DOMS). However, the effect of SSCF has not been well studied in children.

It has been reported that children presented lower fatigability than adults during maximal efforts including strength (Halin et al., 2003, Armatas et al., 2010, (Zafeiridis et al., 2005, 2009, Paraschos et al., 2007) and maximal dynamic efforts (Hebestreit et al., 1993). This was attributed to the fact that after such fatigue test children presented a lower, accumulation of muscle metabolites (Ratel et al., 2006) and decrease in agonist activity (Halin et al., 2003, Paraschos et al., 2007). Moreover, recovery was faster in all cases in children (Armatas et al., 2010, Zafeiridis et al., 2005, 2009, Paraschos et al., 2007, Hatzikotoulas et al., 2009) because children present faster phosphocreatine (PCr) resynthesis (Ratel et al., 2008), higher oxidative capacity (Kaczor et al., 2005) and more effective acid-base regulation (Ratel et al., 2002).

Only two studies investigated the SSCF in children (Marginson et al., 2005, Streckis et al., 2005) giving conflicting results. Marginson et al., (2005) reported higher fatigability in adults, while Streckis et al., (2007) reported equal fatigability for both adults and children. From this point of view it would be interesting this issue to be re-examined.

Thus the purpose of this research was to examine the acute effect of SSC fatigue test in the performance of children and adults.

METHODS

Participants

Eleven pre-pubescent and eleven healthy male adults volunteered to participate in this study. Their anthropometric characteristics are written in Table 1. All participants were informed about the scientific procedure and they gave written informed consent including children's parents. Additionally, all the participants completed health questionnaires to screen for any potential health risk.

Those who had no neurological problems or injured lower limbs were finally selected for the experiment.

The biological level was 1 for children and 5 for adults according to Tanner's criteria (1962).

Table 1: Anthropometric characteristics of participants (mean $\pm$ SD).

Age Group	Age (yr)	Height (cm)	Body Mass (Kg)	Body Fat %	Biological level of maturation
Pre pubescent	10,2 $\pm$ 0,7	147 $\pm$ 8	40 $\pm$ 7	17 $\pm$ 5	1
Adults	24,3 $\pm$ 3,3	181 $\pm$ 5	81 $\pm$ 7	17 $\pm$ 4	5

Instruments

Bertec 4060 force plate (60 x 125cm) was used for the estimation of the jumping height, GRF and contact time. The isometric torque of knee extensor was evaluated in a dynamometer (Cybex Norm). For the anthropometric measurements an anthropometer, electronic scale and caliper were used.

Test and fatigue procedure

Body fat was estimated according to Slaughter et al., (1988). Subjects visit our lab and were informed verbally about the procedure. Afterwards, their anthropometric data were evaluated and they performed a warming up which included running on a treadmill in a self selected rate, warming up exercises and finally, submaximal and maximal jumps.

Drop jump height was evaluated before and after fatigue. For this purpose the subjects performed three maximal drop heights for familiarization from 30cm height. Finally, they also performed three maximal drop jumps and the highest jump was selected for further evaluation. The jumping height was calculated according to Komi & Bosco (1978) recommendations and was based on flight time. During drop height the instruction was to "jump as high as possible" with the hands kept on the waist. The contact time and GRF were evaluated as well.

For MVC evaluation the isolation of knee extensors was secured by the specific instructions of Cybex Norm Manual with knee joint fixed at 70° on knee flexion (0° knee joint in full extension). The MVC evaluation was performed according to Armatas et al., (2010) protocol. Briefly, the subjects performed initially submaximal isometric contractions and finally three maximal isometric ones. The best trial was selected for evaluation.

Fatigue protocol was consisted by ten sets of ten consecutively maximal vertical jumps. Between sets a 30 seconds rest period was applied. Participants stood with feet shoulder width apart and hands on hips. They were also asked to jump as high as possible and verbal encouragement was given. The fatigue perceive was estimated using a 20 degree Borg scale.

The feeling of pain was performed by palpation using a ten scale questionnaire according to Marginson et al., (2005). Jumping height and dynamic data were expressed as a percentage of baseline values for further analysis.

Statistical analysis

Mean values and standard deviations of the dependent variables were evaluated. A Two-Way Analysis of variance with repeated measures (2x2 ANOVA) was used for the statistical analysis of the data before and exactly after the fatigue protocol in both groups. Post hoc scheffe tests were used to follow up significant results. The level of significance was set at $p < 0.05$ (*) in all tests.

RESULTS

Borg scale showed that both age groups were affected from the fatigue protocol but the level of fatigue differed as it appears in figure 1. Adults estimated their attitudinal weariness about 18,2 ($\pm 2,07$) in mean values whereas the pre-pubescent boys reported only 13,7 ($\pm 1,55$) perceived exhaustion ($t_{21} = 5,77$ $P < 0,001$).

Regarding the feeling of pain it was higher in adults compared to children ($2,62 \pm 1.01$ vs $4,1 \pm 1.4$ for children and adults respectively $p < 0.01$).

The absolute values were presented in table 1.

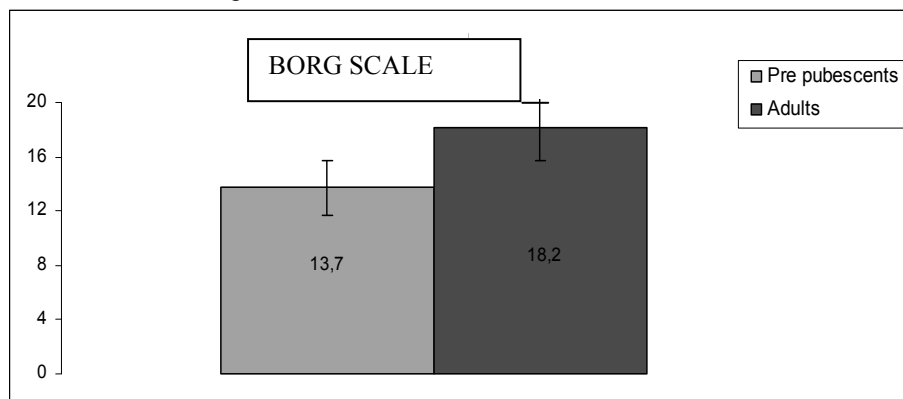


Figure 1: Record of perceived exhaustion for the pre-pubescent boys and adults. 20grade scale (Borg scale).

Isometric torque performance: There were group x time interaction for knee extensors torque (Cybex) $F_{(1,20)} = 56,541$, $p < 0,001$. Post hoc analysis revealed that adults were fatigued more immediately after the fatigue protocol in comparison to initial values ($F_{(1,10)} = 899,385$ $p < 0,001$). Additionally, knee extensors torque was also decreased in pre-pubescent boys, but in a lower level ($F_{(1,10)} = 683,397$ $p < 0,001$).

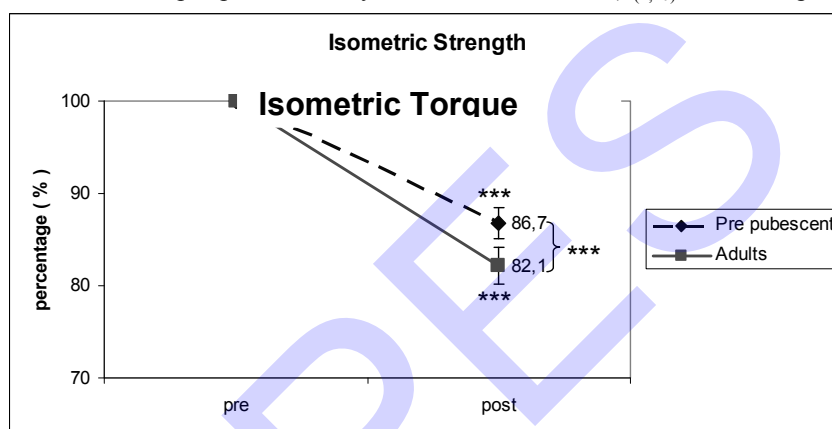


Figure 2: Record of knee extensors isometric torque performance pre and post fatigue exercise in pre-pubescent boys and adults.

Jumping height performance: There were group x time interaction for relative drop jump height $F_{(1,20)} = 43,217$ $p < 0,001$ (fig 2). Post hoc analysis showed that the reduction in height performance was greater in adults ($F_{(1,10)} = 255,922$ $p < 0,001$) than in pre-pubescent boys ($F_{(1,10)} = 95,879$ $p < 0,001$) immediately after the fatigue protocol.

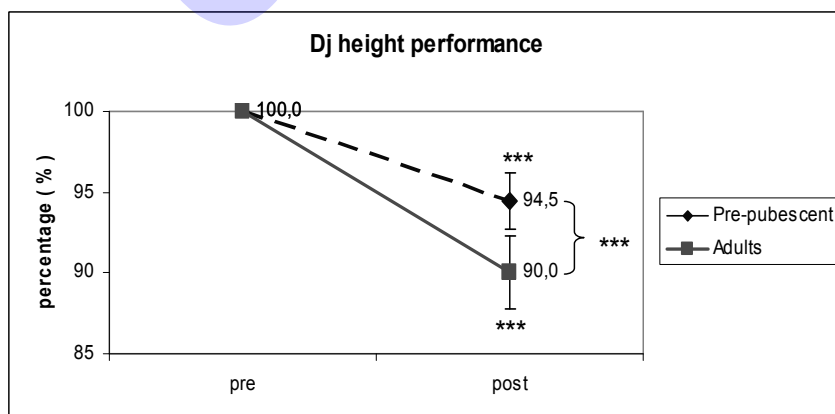


Figure 3: Record of height performance pre and post fatigue exercise in pre-pubescent boys and adults.

Ground reaction force: There were group x time interaction for GRF $F_{(1,20)} = 12,648$ $p < 0,01$. Post hoc analysis revealed that adults exerted greater vertical force during landing phase immediately after the fatigue protocol in comparison to initial values $F_{(1,10)} = 31,517$ $p < 0,001$. It was also showed that pre-pubescent, increased their GRF but this increase was lower than adults ($F_{(1,10)} = 14,409$ $p < 0,01$).

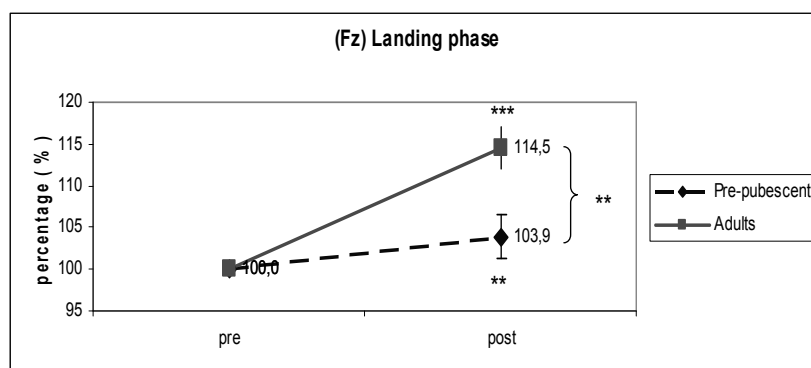


Figure 4: Record of ground reaction forces during landing phase pre and post fatigue exercise in pre-pubescent boys and adults.

Contact time: There were group x time interaction for contact time $F_{(1,20)} = 32,215$ $p < 0,001$. Post hoc analysis showed that contact time increased 5,7% in adults after the fatigue protocol $F_{(1,10)} = 162,511$ $p < 0,001$. In pre-pubescent an increase also observed but it was lower compared to adults (3,2% $F_{(1,10)} = 61,111$ $p < 0,01$).

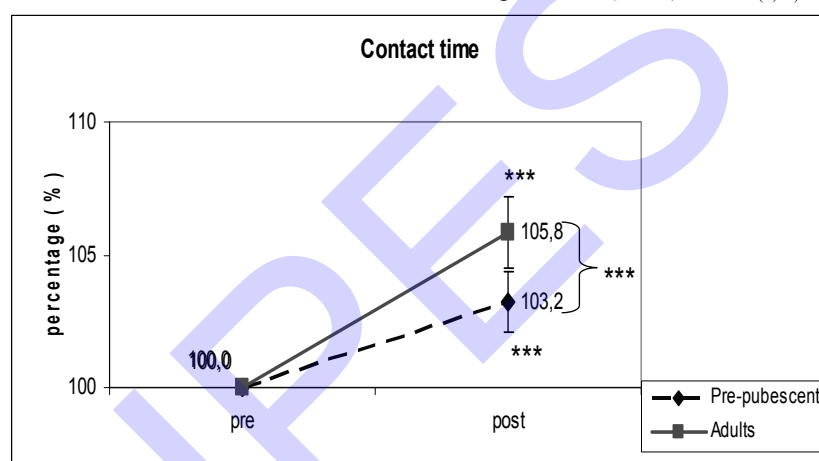


Figure 5 : Record of contact time pre and post fatigue exercise in pre-pubescent boys and adults

TABLE 1: Changes in drop jump performance, ground reaction force (landing and push off phase), ground contact time and perceived weariness immediately after the fatigue SSC protocol in pre-pubescent boys and adults.

	Pre-pubescent boys		Adults	
	Pre test	After test	Pre test	After test
Borg scale		13,7		18,2
Jumping performance (m)	0,231	0,218***	0,362	0,326***
F(z) landing phase ^a	2,27	2,36**	1,99	2,28***
Contact time (msec)	544	562***	499	529***
Isometric strength ^b	0,28	0,24***	0,36	0,29***

* * * * Significantly different from before fatigue at $p < 0,05$ (*), $p < 0,01$ (**), $p < 0,001$ (***)

^aExpressed as ground reaction force/body weight

^bExpressed as Nm/body weight

Discussion

The main finding of the current study was that the applied stretch shortening fatigue test caused a significant decrease in performance both for children and adults. The MVC and DJ were decreased more in adults. The increase in contact time and GRF were higher in adults. The fatigues perceive and the feelings of the pain were higher in adults.

The obtained results concerning MVC and DJ are supported by Marginson's et al., (2005) findings and are contrasting to Streckis et al., (2005) who did not find differences between age groups. These differences between the obtained results and Streckis' et al., (2005) findings could be attributed to the different protocols used. In Streckis' et al., (2005) protocol, 100 jumps were performed with 20sec interval between them a fact which was not probably sufficient to cause substantial fatigue. The fact that children were less fatigued could be based also on Borg scale findings where the perceived fatigue was higher in adults. Higher fatigue perceive was also observed in adults compared to children in previous studies supporting the obtained results as well (Armatas et al., 2010) but for first time is presented after a SSCF protocol in children. The possible mechanisms which could explain the obtained results could be the higher metabolites accumulation and the effect of inflammatory process in adults since they possess higher distribution of fast muscle fibers and have stiffer tendon (Marginson et al., 2005). The obtained results regarding the feeling of pain can support this assumption.

The present study showed that there was an increase in ground reaction force in both groups but this increase was higher in adults. These data are in contrast to previous studies (Streckis et al., 2005) which did not find any differences between children and adults. No other available data from previous studies exist on this issue. Generally speaking ground reaction force increase after fatigue has been previously reported in adults in SSCF (Komi, 2000; Kuitunen et al., 2002) and in generally indicates a loss in neuromuscular coordination (Nicol et al., 2003;1996). The obtained results indicate that this neuromuscular control decrease was higher in adults.

An increase in contact time was observed after the fatigue test which is a typical characteristic for previously used SSCF protocols (Gollhofer et al., 1987; Horita et al., 1996; Komi 2000, Proske & Morgan 2001). It indicates a total reduction in muscle function and especially in eccentric phase (Regueme et al., 2005; Avela et al., 1998; Horita et al., 2003). The stretch shortening cycle fatigue protocol probably caused a reduction of knee stiffness, which is also verified in research of Kuitunen et al., (2002). The reduction of joint stiffness makes muscle tendon complex more compliant leading to a higher flexion of lower limb which consequently caused an elongation of the contact time. The obtained results also indicate that possibly the reduction in muscle tendon stiffness was higher in adults (Arampatzis et al., 2001; Kuitunen et al., 2005).

Conclusion

The basic conclusion indicate that the application of the certain SSC fatigue test causes significant decrease of performance both in children and adults but the fatigue occurrence is higher in adults. This higher decrease in adults could be attributed simultaneously in neuromuscular, metabolic and inflammatory factors.

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