Influence of a 4-Month Barefoot Training upon Muscle Activation of Overload Controllers

Ana Paula da Silva Azevedo, Raísa Valvassori, Bruno Mezêncio, João G. O. Claudino, Juliana Pennone, Murilo Alves de Souza, Fernanda O. M. dos Anjos, Alberto Carlos Amadio and Julio Cerca Serrão

Laboratory of Biomechanics, School of Physical Education and Sport, University of São Paulo, 65 Professor Mello Moraes Avenue, São Paulo, Brazil

1 OBJECTIVES

Running has been a very important expression of movement. The expansion of your practice has been followed by a seeking for new strategies to improve mechanical load control and performance. Thus, the belief that barefoot running could be an effective strategy to attend these objectives has been reinforcing (Divert et al., 2005, Lieberman et al. 2010, Squadrone and Gallozzi, 2009).

In short-term, external load seems to be increased during barefoot locomotion in subjects who are inexperienced in this mechanical condition (Cavanagh *et al.*, 1981, De Wit *et al.*, 2000). Considering that the lower limb muscles, mainly placed in thigh, are involved in the mechanical load control (Novacheck, 1988), they could have their activity increased either. However, there are evidences that the human body could adapt to barefoot situation, altering the control of mechanical load and the muscle activation pattern in running (Divert et al., 2005, Lieberman et al. 2010). Nevertheless, few studies analyzed the long-term effect of barefoot running upon the intensity of muscular activation, and little is known about the consequences of this strategy in subjects who are inexperienced in this mechanical condition. Thus, the investigation of lower limb muscles responsible for the overload control during running, as biceps femoris, vastus lateralis and rectus femoris, (Novacheck, 1988) becomes crucial for the understanding of barefoot adaptation's process in long-term.

Therefore, the purpose of this study was to analyze the influence of 4 months of barefoot training upon the muscle activation intensity of biceps femoris, vastus lateralis and rectus femoris, comparing the electromyiographic signal obtained during barefoot and shod running, before and after intervention.

2 METHODS

Twenty runners (13 men e 7 women; 33.2 ± 6.4 years; 72.6±14.2kg; 1.72±0.11m) without experience in barefoot running were recruited for the study. Participants were excluded if they had suffered any structural injury in the last 12 months and/or had any experience in barefoot running or with minimalist shoes. All participants read and signed an informed consent term. The experimental design was approved by the local ethics committee.

During the 4 months of intervention, participants ran progressively at the barefoot condition, starting the training with 5% and ending with 20% of their weekly training volume being performed without shoes. The barefoot running training was performed three times per week. The participants kept their normal running training routine, using shoes, while they were involved in this research.

Runners were evaluated at two different moments: pre and post intervention. They ran during 10 minutes at 9 $km.h^{-1}$ on a treadmill, in two conditions: shod and barefoot. The electromyo-graphic signal (EMG) of the long head of biceps femoris (BF), rectus femoris (RF) and vastus lateralis (VL) of the right leg of each volunteer were monitored. Nine acquisitions (10 seconds each) of EMG for each experimental condition were performed, with sampling frequency of 2600 Hz.

The acquisition of EMG signal occurred through the Lynx-EMG System 1000 (Lynx Electronic Technology LTDA.), composed by data acquisition EMG1000-VxRy module, an Analog/Digital (A/D) converter and the Lynx-AqDados program. Bipolar surface electrodes "Double" (Hal Industry and Trade LTDA), AgCl, were placed on muscle bellies and connected to active preamplifiers AX1010 (Lynx Electronic Technology LTDA.). The electrodes placement in each muscle occurred according to the criteria established by SENIAM (Surface

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Electromyography for the Non-Invasive Assessment of Muscles). The muscle activation was assessed through the calculation of the RMS (Root Mean Square) of the EMG signal from each muscle analyzed, only in the stance phase, during shod and barefoot running. The signals were filtered by a digital Butterworth band pass filter of 4th order (cutoff frequency from 20 to 450Hz) and notch filters of 60Hz, 120Hz and 180Hz. Data was normalized by the maximum voluntary isometric contraction (MVIC), obtained at the beginning of the test session, prior to the running test. The statistical analysis of data was performed in SigmaStat 3.5 (Systat, Germany) software. Data normality was verified using the Kolmogorov-Smirnov test, while homoscedasticity was checked by Levene's test. For means comparison, an analysis of variance (one-way ANOVA) for repeated measures was performed. The level of significance adopted was $p < 0.05$.

3 RESULTS

The Table 1 shows average values and standard deviations for the RMS of the three selected overload controllers muscles (BF, VL e RF) in both shod and barefoot. No significant difference was found for BF and RF. On the other hand, the VL was significant different between experimental conditions. Before intervention, the VL had an activation intensity about 131% higher in barefoot running (p=0.002) when compared to shod. However, after 4 months of barefoot training, the RMS of VL was significant smaller for barefoot running than before the intervention, decreasing its activation in about 65% (p=0,017) after intervention and showing a activation pattern similar to shod running.

Table 1: RMS values (%MVIC) during stance phase of running with shoes and barefoot in pre and post-intervention.

	Pre		Post	
Variables	Shod	Barefoot	Shod	Barefoot
BF	23,60 ± 7,69	50,90 ± 10,50	20,4 ± 10,50	52,60 ± 10,50
VL (*) (#)	17,80 ± 3,32	41,20 ± 4,45	14,70 ± 3,32	14,40 ± 3,32
RF	29,60 ± 4,99	39,80 ± 7,06	31,10 ± 4,99	21,80 ± 4,99

Legend: Long head of biceps femoris (BF), vastus lateralis (VL) and rectus femoris (RF). (*) significant difference between the conditions (shod and barefoot) in pre moment; (#) significant difference between the moments (pre and post) in barefoot condition.

4 DISCUSSION

According to the results, individuals who are not adapted to barefoot locomotion seemed to have a higher intensity of muscle activation of overload controllers muscles compared to shod condition before intervention, mainly for VL. Studies showed an increase of the external forces in barefoot running to not adapted subjects (Cavanagh et al., 1981; De Wit et al., 2000). Therefore, the greater muscle activation without shoes is probably a response to this possible increase in mechanical load, especially VL which is directly involved in impact absorption (Novacheck, 1988). Thus, despite representing an intrinsic protection strategy, the greater muscle activation at pre-moment may influence internal load and energy expenditure in running.

However, 4 months of progressive barefoot running training seemed to be efficient to promote some adaptations in muscle activity intensity. Barefoot training significantly reduced the muscle activity of the VL, making it similar to running shod. Thus, it’s possible to conclude that a 4-monthy barefoot running training has potential to decrease the intensity of muscle activation of the lower limbs, mainly the VL, in subjects who are not adapted to locomotion under this mechanical condition.

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