

HOW DOES EXHAUSTIVE CYCLIC LOADING EXERCISE AFFECT MUSCLE ACTIVATION AND LOWER LIMB JOINT MOMENTS OF FORCE?

¹ Filipa João, ¹ António Veloso, ¹ Vera Moniz-Pereira and ¹ Ruth Agostinho

Neuromechanics of Human Movement Research Group

Faculty of Human Kinetics, Technical University of Lisbon, Portugal

e-mail: filipajoa@fmh.utl.pt

INTRODUCTION

The deep understanding of the neural and biomechanical mechanisms responsible for sports performance as well as the decrease of the risk of injury are the main concerns for the coach and for the athlete. This study is the first step of an investigation where the main goal is the analysis of the changes and adaptations of the musculoskeletal system when subjected to cyclic load exercise. The aim of this preliminary study is to assess and analyze changes in temporal, kinematic, kinetic and electromyographic data from one subject during an exhaustive jumping exercise. The next step will be the estimation of the muscular activations using the static optimization method with OpenSim biomechanical simulation software [1].

METHODS

One healthy adult (59.2kg and 1.65m height) performed a sequence of 10 unilateral hops with the dominant lower limb. After this sequence, she performed 25 drop jumps (DJ) from a step with a height of 25cm. She had to follow the instructions: 1) jump the highest she could and 2) jump the fastest she could (shortest ground contact time). These two sequences were repeated ten times (until task failure – the subject didn't perform the jumps maintaining the given instructions) [2]. Motion capture was collected with an optoelectronic system of 8 cameras Qualisys (Oqus-300) operating at 200Hz. 24 reflective markers and 4 marker clusters were used for the reconstruction of eight body segments (trunk, pelvis, thighs, shanks and feet). Ground reaction force (GRF) was collected with a Kistler force plate (type: 9865B) and joint moments were calculated by inverse multibody dynamics. Kinematic and kinetic data were calculated with Visual 3D software for biomechanics modeling. The electromyographic signal of the *tibialis anterior* (TA), *gastrocnemius medialis* (GM), *vastus lateralis* (VL) and *biceps femoris* (BF) was collected using surface electrodes (Ambu Blue Sensor N-00-S/25), according with the SENIAM Project recommendations. The EMG data were transmitted by telemetry (Glonner Biotel 88 system) and collected at 1kHz and A/D converted. All the data were processed with a lowpass 4th order Butterworth filter with a 6Hz frequency cut.

RESULTS AND DISCUSSION

A notorious change in the execution pattern of the task was observed, mainly reflected on the subject inability to avoid the impact of the heel with the ground. In the final sequences, an impact peak was noticeable on the GRF 50 to 80ms after ground contact. In the last hop sequence, the plantar flexion increased 20.3%, comparing with the first sequence; the knee flexion angle increased 19.2% and the hip angle also increases 44.4%. The peak flexion angles occurred between 64% and 67% of the PA-TO phase (PA:

pre-activation – 100ms immediately before the contact on the force plate; TO: toe-off).

The joint moments were normalized to the subject mass. The ankle moment increased 10% in the final sequence, comparing with the first hop. The knee moment increased 25.3% and the hip moment decreased 34.5%. The ankle and knee moments peaks occurred between 46% and 49% of the stance phase, while the hip moment peak occurs at about 90% of the stance phase in the last sequence.

The differences in the joint kinematic and kinetic parameters seem to reveal the effect of the cyclic loading exercise from the 7th hop sequence until the end of the task. The different joint moment results may be a good indicator that the muscle-tendon structures that cross this joint are affected by fatigue [3]. However, those changes occur mainly by alterations in the movement pattern, with an increased participation of the knee extensor muscles to produce the mechanical power required for the task.

The stance period doesn't seem to increase over time, although the propulsion phase increases until the 8th hop sequence. The power generated by the EMG signal in the pre-activation phase is the integration of the EMG signal from the PA to the TO. The EMG results are not conclusive because there isn't a visible trend. The VL starts its activity later than the other muscles in the pre-activation phase. With exception of the GM, there's a decrease in the EMG power between the first and the last hop sequence and the TA has its activation peak later in the last sequence.

CONCLUSIONS

It is clear the influence of exhaustion in the re-organization of the mechanical production by the musculoskeletal system of the lower limb. These effects are particularly noticed in the kinetic results, especially in the vertical GRF, when it starts to appear some impact force peaks, changing the energy transfer with the ground. The joint moments have also been changed, due to this re-organization [4]. The EMG data didn't reveal a clear evidence of fatigue. Nevertheless, the signal of the VL (the main knee extensor) increases in the final sequences, being this in accordance with the increase of the knee moment. Our results could suggest that the changes in the musculoskeletal system are related to the levels of fatigue, and these changes should be taken into account when modeling the musculoskeletal system.

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