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Acute effect of overload on the neuro-mechanical control in drop jumps and drop landings

Waldvogel, J.1, Freyler, K.1, Albracht, K.2,3, Stäudle, B.3, Monti, E.4, Helm, M.1, Gollhofer, A.1, Narici, M.4, Ritzmann, R.5

1 University of Freiburg, 2 German Sport University Cologne, 3 University of Applied Sciences Aachen, Germany, 4 University of Padua, Italy, 5 Rennbahnklinik, Muttenz, Switzerland

INTRODUCTION:
Jumps and landings are fundamental elements of locomotion and are functionally relevant not only in most sport disciplines but also in daily activities. Both movement modalities require precise neuronal control of the skeletal muscles and subsequently involve either an efficient transfer (Drop jumps, DJ) or dissipation of energy (Drop landings, DL) (1,2). This study aimed to examine biomechanical and neurophysiological modulations during DJ and DL to investigate load-dependency of human movement during parabolic flights.
METHODS:
DJ and DL were performed in normal load (1g, NL) and overload (1.7-1.9g, OL). In 17 subjects electromyographic (EMG) activity of shank and thigh muscles were assessed before (PRE) ground contact (GC) and during the eccentric phase (ECC). Knee joint kinematics (2D) and GRFs were recorded to calculate loading rate (LR) and leg stiffness (LS). To compare the load dependent neuro-mechanical control of both movement modalities and to identify interaction effects a two-factorial rmANOVA (2x2; DJ/DL and NL/OL) was used for statistical analysis.
RESULTS:
In NL, DJ showed a higher EMG activity in PRE and ECC in the shank and thigh muscles compared to DL indicating task-specific muscle activation ($p<0.05$). This is accompanied by enhanced LR, LS and reduced knee excursion during GC in DJ ($p<0.05$). In OL, significant interaction effects between gravity and movement modality for PRE indicate enhanced muscular stiffness before GC in both DJ and DL ($p<0.05$). Interaction for ECC indicate reduced EMG activity in DJ, whereas DL show increased ECC EMG in OL. LR, LS and knee excursions are significantly increased in both DJ and DL in OL ($p<0.05$).
CONCLUSION:
Both movement modalities show task-specific muscular activation in NL characterized by high PRE and ECC EMG for DJ, whereas DL require less muscular stiffness in PRE and ECC to dissipate energy (3). During OL, neuromuscular control is adjusted in a phase specific manner (4). The enhanced neuromuscular stiffness before GC, for both DJ and DL, confirms the anticipatory capacity of the central nervous system to predict the amount of impact at GC (4) regardless of the movement modality. This is essential for providing joints and the muscle-tendon complex (MTC) with adequate stiffness to withstand increased loading rates during OL. In contrast, reduced task-specific differentiation between neuromuscular and biomechanical parameters during ECC indicates a similar motor control strategy in both movement modalities in OL. In DL, increased leg stiffness during ECC is needed to resist the greater loading rates by adjusting leg stiffness. Downregulated EMG in ECC accompanied by increased knee excursions are evidence of a more compliant MTC during DJ. This may represent a preventive strategy for protecting the MTC from surpassing the muscle tendon safety factors (5).

1 Komi, JBiomech, 2000
2 Linstedt et al., News Physiol Sci, 2001
3 Leukel et al., Hum Mov Sci, 2012
4 Ritzmann et al., JAppl Physiol, 2016
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