Changes in EMG and kinematic patterns during motor learning of ballistic movements

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Introduction

Recent investigation have shown the usefulness of pattern recognition based on Euclidean distances (ED) for the analysis of dynamic movements: SCHÖLLHORN (1999) e.g. identified individual running styles by an analysis of time continuous kinematic data. A similar classification approach for EMG data was applied by ZHANG et al. (1991) in order to assess injured and non-injured muscle activation in gait. In the present study we analyzed the changes in kinematic and EMG data during a learning process of a ballistic movement combining both methods.

Methods

Three subjects (MM, SB, TB) performed long jump during a learning experiment that consisted of pretest, 4 training sessions and posttest. Pre- and posttest took place under competing conditions, whereas in the training sessions Take-Off (TO)-conditions had been modified (Fig. 1).

Figure 1: modified TO-conditions for subjects MM, SB and TB

Kinematic data were taken with a LOCAM film camera at 150f/s. The subject's movement during TO was described by means of the time-courses of angles and angular velocities of the ankle, knee, hip, shoulder and elbow joint as well as the orientation of the trunk.

EMG data were measured in a bipolar arrangement using a portable computer (BIOVISION) with an acquisition rate of 1000 Hz. Each channel was bandpassed filtered with cut-off-frequencies of 10 and 700 Hz. The EMG of the following muscles were derived: m. tibialis ant., m. soleus, m. gastrocnemius, m. gluteus max., m. vastus med., m. biceps femoris and m. rectus fem. of the jumping leg; m. biceps fem. and m. rectus fem. of the swinging leg. The raw EMG were Fourier transformed (FFT).

Altogether, electromyographic and kinematic data of 35 long jump trials were available for analysis. ED were calculated between the phase and amplitude spectra of each muscle as between the time and amplitude normalized time courses of the main joint angles and angular velocities (Fig.2). Hierarchical cluster analysis was used to classify various sets of variables: kinematic and electromyographic variables were grouped separately and in different combinations.
**Results**

![Figure 2: Schema of data analysis](image)

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![Figure 3: Cluster analysis of kinematic data (angles and angular velocities) for subjects MM, SB, TB](image)

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Figure 4: cluster analysis of combined EMG (bicsw, rec, bic, glut) and kinematic (angles and angular velocities) data for subject MM

Clustering kinematic data of all subjects the dendrogram shows a separation of long jump trials by individuals (Fig. 3). The cluster analysis of kinematic and EMG data within the subject (Fig. 4) subdivides the long jump trials in two major clusters: One cluster contains all pretest trials. A second cluster obtains a further subdivision by posttest and training sessions TS1 and TS4.

Discussion

The analysis of kinematic data separates between individuals and shows therefore similar results to the study of SCHÖLLHORN. The separation of pre- and posttest trials which results from the combined analysis of kinematic and EMG variables can be interpreted as learning effects. While posttest trials and training trials are grouped in one major cluster, a greater similarity can be indicated between long jump performance of posttest and training sessions as between long jump performance of pretest and posttest. Thus, learning effects may result from long jump training under modified TO-conditions. Clusters of trials according to training session may be interpreted as different progress in learning.

Compared to ZHANG et al. the combined analysis allows to identify individual movement patterns and gives information about their changes following learning. Overall the pattern recognition approach seems to provide a sensitive tool for analyses of learning process in complex type of movements.

References