Motor variability traits among individuals performing repetitive precision work

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7. Introduction

Motor variability (MV) refers to the intrinsic variability naturally present in the motor control system. Occurring even in the simplest movements, it is usually manifested as a difference in joint movements, joint coordination and/or muscle activities between successive repeats of a task which are intended to be identical in performance. Recent studies claim that MV is related to pain and fatigue, MV may have an important functional role in skill acquisition, and hypothetically, individuals with a larger MV would be better protected against overuse injuries, and recover faster after disorders affecting motor performance (reviewed in Srinivasan & Mathiassen 2012). A necessary requirement for this hypothesis to be valid is that motor patterns (and specifically MV) are consistent individual traits in tasks such as repetitive precision tasks that are associated with injury risk.

The purpose of this study was to let individuals perform a laboratory-based simulation of repetitive upper-extremity precision work and determine whether it is possible to systematically classify individuals based on their motor patterns; and if so, which motor characteristics would be the most important in differentiating between individuals.

8. Methods

Repetitive pipetting with a cycle time of 2.8s was performed in the laboratory by a group of 14 healthy female subjects, aged 20-45 years, right-handed and experienced in pipetting, on 3 different days under identical experimental conditions. Kinematic data were obtained using electromagnetic motion capture systems (FASTRAK). Kinematic data were summarized using mean values across 20 cycles of parameters describing shoulder elevation, elbow flexion and shoulder-elbow coordination, and cycle-to-cycle standard deviations of parameters such as joint range of motion, average and peak velocities, time to peak velocities, phase angle, time lag of peak velocities and inter-segmental phase angle.

The data were subjected to multivariate analysis using Principal component analysis (PCA), Hierarchal cluster analysis (HCA) and Partial least squares discrimination analysis (PLS-DA) in SIMCA+P 12.0, (Umetrics, Sweden) in order to analyze underlying relationships among variables and individual patterns in the data matrix.

9. Results

The PCA showed two distinct, visually detectable clusters of subjects in the first two principal component (PC) dimensions indicating two different classes of movement behavior. Discrimination analysis by PLS-DA of the two clusters extracted two significant PCs and revealed that the most important variables describing the separation were variability measures (group 1 displaying high variance). As shown in figure 1b, 13 of the 17 variables that significantly influenced the discrimination (i.e. they had Variable importance in the Projection (VIP) scores of greater than 1.0), including the six most influential variables all turned out to be standard deviations, i.e. measures of motor variability.

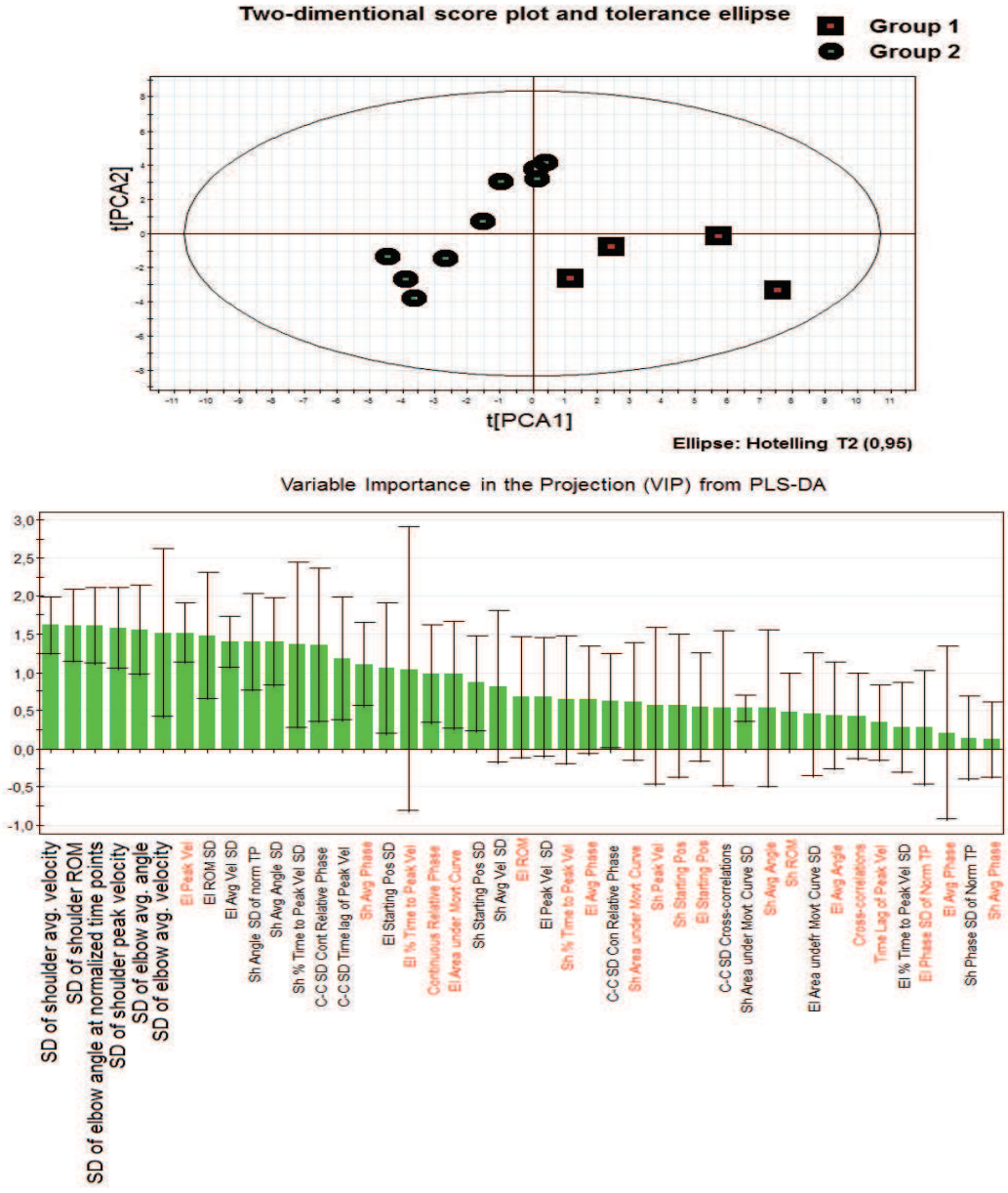

Fig 1(a): PCA scores showing two clusters of individuals based on motor patterns detected by HCA; Fig 1(b): Results of discrimination analysis, showing the most influential variables responsible for separation of the clusters in fig 1(a). The six very most influential

variables are marked by bold-face; these are cycle-to-cycle standard deviations of: (1) shoulder average velocity, (2) shoulder range of motion (ROM), (3) time-normalized elbow angle, (4) peak velocity of shoulder elevation, (5) Average angle of elbow flexion and (6) average velocity of elbow flexion

10. Conclusion

Our findings suggest that there may indeed be individual traits in motor patterns, and that motor variability may be an important part of what separates individuals into different clusters. As a next step, we will check whether these groups emerge even if only motor variability parameters are used in the multivariate analysis and whether the cluster structure stays consistent across several days of repeated measurements, and when working conditions such as the pace or precision of pipetting are slightly changed.