THE APPLICATION OF PRINCIPAL COMPONENTS ANALYSIS AS A MOVEMENT PATTERN RECOGNITION TECHNIQUE: A PROOF OF PRINCIPLE

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INTRODUCTION

Movement screening tests, such as the Functional Movement Screen™ (FMS), are used to screen for movement abnormalities that may be predictive of performance potential or injury risk in athletes and/or workers [1]. However, these screens are scored subjectively and scores can change based on the rater or the performer's knowledge of the grading criteria [2]. Quantitative methods can help us understand how underlying attributes (e.g. height, sex, ability, injury history) contribute to movement patterns. This information can then be used to identify ideal movement patterns for a specific class, faciliating customized movement screening. Using motion capture and principal components analysis (PCA) of whole-body motion may provide an objective data-driven method to identify unique and statistically important movement patterns. Therefore, the purposes of this study were to: 1) examine athletes' movement variability when performing standardized functional movements using PCA; and, 2) to determine if whole-body movement patterns coul be differentiated based on an athlete's skill level.

METHODS

This study is based on motion capture data collected from 542 athletes representing eight different sports (soccer, baseball, tennis, basketball, lacrosse, track and field, golf, and football) ranging in ability from recreational (e.g. do not play on competitive teams) to professional (e.g. NFL, MLB, FIFA). Each athlete performed 14 range of motion tasks and 7 stability tasks, where the tasks were designed to challenge athletes' balance, stability and power. Whole-body motion data were captured using an 8-camera Raptor-E motion capture system (Motion Analysis, CA, USA). A dual-principal component analysis (DPCA), as developed by Troje [3], was used to analyze the data. The first PCA is applied to time-series joint coordinate data within-subject, outputting the principal components and corresponding scores explaining the variability within the movement pattern itself. A second PCA is applied to participant's within-subject PCA data to compare how variability in the movement pattern varies between subjects. As a proof of principle, principal component (PC) z-scores from the bird-dog movement were compared as a function of experience (i.e. recreational vs. professional) using a repeated-measures ANOVA in SPSS (SPSS 23, IBM, NY, USA).

RESULTS

Professional athletes had significantly lower z-scores (-0.282±2.77) compared to recreational athletes (1.65±3.8) for PC1. Using single component reconstruction [4], this PC was interpreted as a magnitude operator corresponding to the range of motion used during the movement, where lower scores corresponded with a greater range of motion (Figure 1).

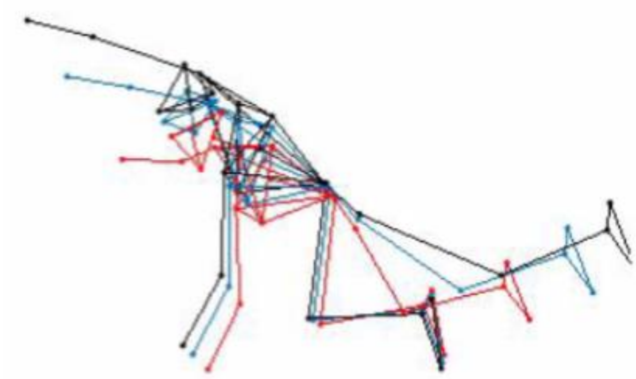

Figure 1: Reconstructed motion data using PC1 for the 5th (black), 50th (blue) and 95th (red) percentile z-scores. Professionals scored low while recreational athletes tended to score high.

DISCUSSION AND CONCLUSIONS

The application of a DPCA approach provided a data-driven objective method to identify significant differences in whole-body movement patterns between professional and recreational athletes performing a bird-dog task. We continue to explore the utility of this approach to identify meaningful differences in the other screening movements and by exploring other possible classifiers such as sports, or injury history. In future research we will examine the use of machine learning techniques to determine if athletes can be identified based on sport and/or level of play, where we plan to use tools like OpenSim to examine the biomechanical consequences of these unique movement patterns.

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