**QUANTITATIVE CLASSIFICATION OF BASEBALL PITCH STYLES**

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**INTRODUCTION**

In order to evaluate the baseball pitching motion, it is important to classify the pitch styles. The pitching motions are classified into four major pitch styles, as follows: over-arm, three-quarter, side-arm, and under-arm. However, this classification has been performed by baseball experienced person qualitatively up to now, and the classified results might be different by each expert. There is no standard method to classify the pitch styles. We have been developing the analysis system of the baseball pitching motion. To evaluate the motion quantitatively, the pitch styles must be classified clearly. The aim of this study was to classify the baseball pitch styles quantitatively.

**METHODS**

We measured pitching motions including four pitch styles, with regard to the whole body movement. The positions of 34 markers on subject’s skin were recorded at 500Hz, using a motion capture system (ProReflex MCU-500, Qualisys, Sweden). We determined the coordinate systems using the subset of the markers on each body segment. In order to reduce noise on the measured data, the data were filtered using the cubic spline function.

Fifty physiologically normal amateur pitchers served as the volunteers in this study. Their mean age was 19.6 ± 6.62 years old, and their average height and mass were 171.1 ± 11.23cm and 65.3 ± 13.29kg, respectively. Their pitch styles were classified into the following four reference groups as control by an expert: E1: over-arm (20/50), E2: three-quarter (23/50), E3: side-arm (4/50), E4: under-arm (3/50).

Next, in order to classify the pitch styles quantitatively, we selected following three kinematic parameters: upper arm elevation (θ_U), trunk tilt relative to the ground (θ_C), and angle of anatomical long axis of forearm relative to ground (θ_F), at the ball release. These parameters were indicated the difference between the four pitch styles. We employed MANOVA to investigate significant differences among the control group E1, E2, E3 and E4. Box’s M test was used to evaluate the equality of covariance matrix. Multivariate discriminant analysis was applied to classify four groups.

**RESULTS AND DISCUSSION**

Figure 1 shows relationship between the pitch styles and kinematic parameters. Table 1 described the average and standard deviation of the three kinematic parameters of the control group. The result of MANOVA showed significant differences among the control group (P < 0.01). The result of Box’s M test suggested us to apply a linear discriminant function for the discriminant analysis. Using the discriminant analysis, the pitching motions of fifty pitchers were classified into four predicted group. The correct answer rate was 82% (Table 2). The set of three kinematic parameters was verified to be capable of classifying the pitch styles. However, there were few subjects for side-arm and under-arm. Our next work is to increase the number of subjects.

**SUMMARY**

We suggested three kinematic parameters in order to classify the baseball pitch styles. The pitching motions of fifty baseball pitchers were classified into four pitch styles using multivariate discriminant analysis. The result showed that our method was able to classify the pitch styles reasonably.

**REFERENCES**

