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APPLICATION OF PRINCIPAL COMPONENT ANALYSIS IN KINETICS STUDY FOR ISO-SQUAT

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INTRODUCTION: Force production of the muscular system undergoing isometric muscle contractions provides the ability to measure maximal voluntary strength (MVS), which could show the strength level of athletes for sport performance assessment (Stone, Stone, & Sands, 2007; Zatsiorsky, 1995). The derivative of the force-time curve generated by muscle contraction(s) is known as the rate of force development (RFD), the area under this curve is known as impulse (IMP), and the maximum force generated is known as peak force (PF). RFD and IMP affect an athlete's ability to accelerate or decelerate, whereas PF determines the range over which RFD and IMP can be produced. The higher RFD could accelerate object more rapidly which indicates better capacities in acceleration. Acceleration changed speed of an object. Large acceleration was produced by high force output. A certain level of force generated over a long time period would keep increasing velocity of an object. Therefore, large IMP will bring about high speed of an object (Massachusetts Institute of Technology, 1957).

A kinetic evaluation of the isometric squat is complex because RFD and impulse are variable at different time points. Therefore, the dimensions of the database can become large with different variance between variables which are complex and can provide challenges for analysis. Jolliffe (Jolliffe, 2002) summarized the method of principal component analysis (PCA) which reduces the dimension of variables. The variables left after the PCA is applied are uncorrelated and have the same variance as variables before the reduction. Therefore, the variables from different parameters could be discriminated and clustered to form principal components (PCs). The original values that are clustered provide smaller groups on which analysis can be performed. Therefore, the purpose of this study was to use PCA to determine the principal components of the isometric squat (IS).

METHODS: Eighteen college males (ages: 20.7±0.4 yrs) were enrolled in the study. The study was approved by East Tennessee State University's Institutional Review Board and informed consent forms were signed by subjects before the initiation of testing. The IS test was performed statically with a 90 degree knee angle measured with a goniometer. Kinetic parameters of PF, RFD at 200ms and 250ms and impulse at 50ms, 90ms, 200ms and 250ms were recorded during IS. PCA was applied to a correlation matrix set up by the kinetics parameters in order to determine the PCs. The PCA was completed using MATLAB for data interpretation. Eigenvalue cut-off line was set at 0.7 due to the number of variables under consideration (Jolliffe, 1972).

RESULTS: The correlation matrix indicated variables within RFD are highly related ($r>0.9$). Variables of impulse at different time points are strongly correlated to each other. ($r>0.8$) Large variation in the variable standard deviations was due to the different scaling measures (Table 1). The Scree graph shows that the 'elbow' point was at the second principal component. After the second principal component, the curve was linear without any considerable 'steep' point (Figure

1).

The first PC could explain 90.33% total variance in the data set (Table 2). The main source of variation came between subjects with large 50ms and 90ms impulse which were negatively related to 250ms RFD. Explanation of total variance of the second PC dropped to 6.88%. Primary variation of the second PC is due to PF conferring a negative relation to 200ms RFD. The third PC could be explained IPF due to 2.78% of the total variation for first three PCs. The eigenvalue was close to the cutoff point of 0.7 at the third PC.

Table 1: Correlation matrix of variables in iso-squat

Correlation Matrix (n=18)							
	IPF	200ms RFD	250ms RFD	50ms impulse	90ms impulse	200ms impulse	250ms impulse
IPF	1						
200ms RFD	0.48	1					
250ms RFD	0.65	0.92	1				
50ms impulse	0.38	0.06	-0.07	1			
90ms impulse	0.35	0.23	0.04	0.97	1		
200ms impulse	0.44	0.47	0.28	0.89	0.96	1	
250ms impulse	0.51	0.52	0.35	0.88	0.94	1.00	1
Standard deviation	299.04	875.13	710.81	9.43	18.21	44.40	55.20

Figure 1: Scree graph for principal component decision

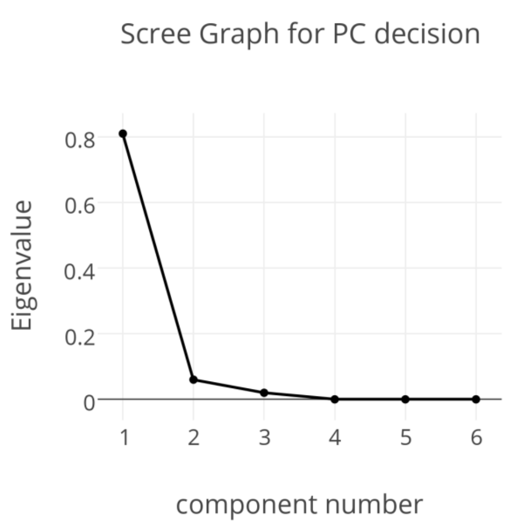

Table 2: PCA results

variable	component number		
	1	2	3
IPF		-0.55 (-)	0.76 (+)
200ms RFD		0.62 (+)	
250ms RFD	-0.45 (-)		
50ms impulse	0.51 (+)		
90ms impulse	0.46 (+)		
200ms impulse			
250ms impulse			
Eigenvalue, l_k	4.38	2.02	0.57
$t_m = 100\sum_{k=1}^{m} l_k / p$	62.57	28.86	8.14
$l_{k-1} - l_k$		2.36	1.45
Cumulative percentage of total variation	90.33	97.21	99.99

('+, -' in the bracket was used to indicate variable with value over 70% of the largest value in the relative PC. Variable value less than 0.1 was omitted and left with blank.)

DISCUSSION: The PCA in this study has provided evidence that variation in IS between subjects is primarily due to the large variation in impulse at 50ms and 90ms. Large standard deviation difference implied the necessity of correlation matrix application. PCA shows that IMP rather than RFD and PF was the main source of variation. However, due to the small sample size, total number of variables, and variable's loadings, findings should be interpreted with caution. Variables loadings in the study were around 0.5 which was at a low saturation level implied by Guadagnoli and Velicer (Guadagnoli & Velicer, 1988). The probability of committing a type II error was over 11% higher than 11% due to the small sample size. Conversely, type I error was less likely to be committed due to the loadings set at 0.4. The higher Type II error rate may explain why RFD was not included as one of the variables in the first PC. On the other side, the future study should include more variables at different time point by using PCA, such as RFD at 50ms and 90ms. More variables would show a comprehensive shape of the IS force curve. Based on the study findings, sport science researchers should focus more on impulse-related characteristics during IS.

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