EXAMINING HIP-KNEE JOINT ANGLE VARIABILITY IN THE POWER CLEAN USING BIVARIATE FUNCTIONAL PRINCIPAL COMPONENT ANALYSIS

T. Nagatani[1], S. Vial[1], K. Kendall[1], P. Comfort[1,2], G. G. Haff[1,2]
[1] Strength and Power Research Group, School of Medical and Health Sciences, Edith Cowan University
[2] Sport, Exercise, and Physiotherapy, University of Salford

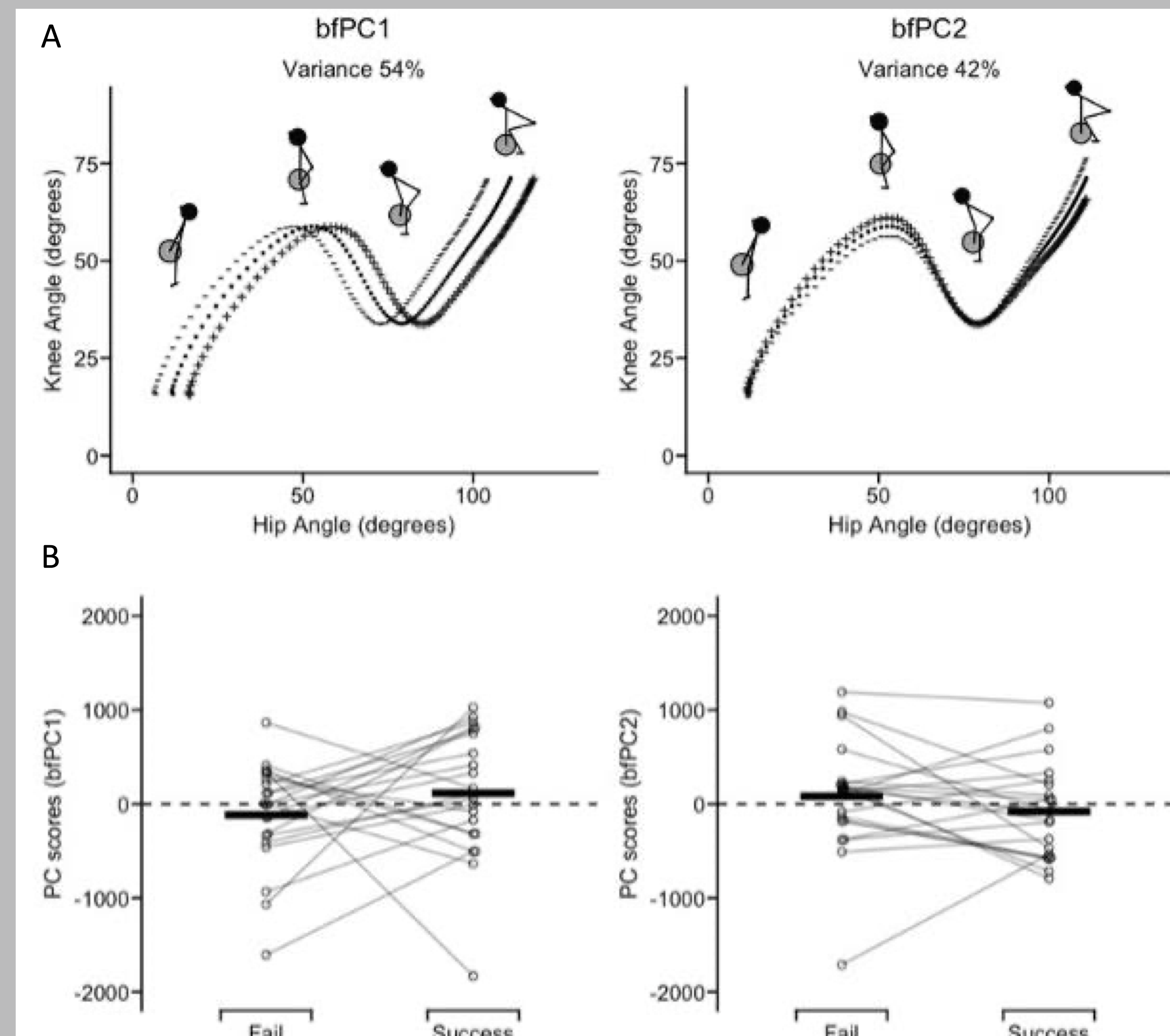
INTRODUCTION

Weightlifting movements begin with the pull phase. A key technique in this phase is the double knee bend, allowing for the lifter to reposition themselves to enhance muscular force production by better engaging the knee extensors. Proper execution of the pull is crucial for performance, relying on coordinated hip and knee joint movement. However, most researchers have analysed these joints separately, overlooking their interdependent coordination during the lift. **The purpose of this study was to determine the relationship between hip-knee joint patterns and successful and unsuccessful power clean performance.**

METHODOLOGY

Twenty-one strength-power athletes (18 males, 3 females; mean ± SD; height: 1.77±0.09 m, body mass: 88.1±16.5kg, age: 27.3±4.3 years), with the ability to power clean ≥1.0 times their body mass (relative one repetition maximum [1RM]: 1.20±0.16 kg·kg^{-1}) were recruited for this study. All subjects completed a standardized 1RM power clean test. Following a series of warm-up sets, subjects performed a maximum of five 1RM attempts, each separated by three-minutes of rest. Hip and knee joint angle data from the heaviest successful lift and the heaviest unsuccessful lift were tracked using a 3D motion capture system and then extracted for further analyses. Bivariate functional principal component (*bf*PC) analyses were performed to extract two *bf*PCs that accounted for most of the variances in barbell trajectory data (96%), with *bf*PC scores used for statistical analysis (1). Statistical analyses included dependent *t*-tests to examine differences in *bf*PC scores between successful and unsuccessful power clean lifts.

FIGURE 1



(A) Ensemble average hip-knee joint angle changes are represented by the dotted line. The + and – symbols respectively represent the effect of positive and negative bfPC scores on hip-knee joint angle changes, indicating the variation accounted for by a specific pattern.
(B) Differences in *bf*PC scores from each *bf*PC between successful and unsuccessful power clean lifts.

RESULTS

The first *bf*PC captured variations in the hip joint angle throughout the pulling phase of the power clean (Figure 1A). The second *bf*PC captured variations in the knee joint angle at the power position and during the first pull (Figure 1A). There were no significant differences in *bf*PC scores between successful and unsuccessful power clean lifts for either the first *bf*PC ($p = 0.272$) or the second *bf*PC ($p = 0.235$) (Figure 1B).

CONCLUSIONS

Kinematic patterns of the hip and knee joints, as examined through *bf*PC analysis, do not appear to differentiate successful from unsuccessful power clean attempts.

PRACTICAL APPLICATIONS

Although no significant differences in joint angle profiles were found between successful and unsuccessful lifts, *bf*PC analysis can be a useful tool for examining joint angle patterns and identifying areas of high movement variability during the power clean. This information may help coaches better understand the athlete's movement pattern during the power clean and identify potential areas for improvement.

REFERENCE

1. Warmenhoven J, Cobley S, Draper C, et al. Bivariate functional principal components analysis: considerations for use with multivariate movement signatures in sports biomechanics. *Sports Biomech* 18: 10-27, 2019.