INTRODUCTION

The bilateral measurement of isokinetic thigh musculature strength in unilateral Anterior Cruciate Ligament (ACL) deficient patients may assist in determining pre surgical intervention progress, as well as be of value for establishment of baseline data for post surgical comparisons. Current analysis methods of strength curves in this patient population are exclusively based on use of discrete-time point variables, such as the peak or average moment of each muscle group. This a-priori decision on the choice of outcome variables may result in a loss of potentially useful information, as well as may lead to redundancy in the sense that the extracted variables may be highly correlated [1]. Principal Component Analysis (PCA) has been suggested as a suitable statistical procedure to eliminate such deficiencies [2]. In specifics, PCA allows the objective extraction of uncorrelated curve features that account for the majority of variation between conditions. This feature of PCA also has the added benefit of reducing the amount of data to be further explored. The purpose of this investigation was to utilize PCA to objectively identify isokinetic curve features that may enhance the bilateral thigh musculature strength assessment of ACL deficient patients.

METHODS

Procedures were approved by the institutional review board and written informed consent was obtained from all participants prior to testing. The concentric knee strength of 37 unilateral deficient patients (20 women) was measured using a Biodex System 4 isokinetic dynamometer, (Biodex Medical Systems Inc., Shirley, NY, USA). The protocol entailed performance of 6 reciprocal knee extension and flexion repetitions at a preset angular velocity of 60°/sec performed through a 90° range of motion (ROM). The uninjured knee was always tested first, and concurrent verbal encouragement and visual feedback on performance were given in order to facilitate maximal effort production.

Data were divided into extension and flexion repetitions, and each repetition was normalized to the product of each participant’s bodyweight (kg.) and height (m). From all participants, strength curves from repetitions 2 through 5 were subjected to PCA using procedures previously described [2]. For data reduction purposes, the number of PCs retained was determined using a 95% trace criteria. Differences in PC scores obtained for the strength curves of the injured and non injured knee were assessed using paired two t-tests (α = 0.05), and complimented with effect size (ES) estimates. For interpretation of the results, loading vector plots, as well as plots obtained using the single PC reconstruction method were visually examined.

RESULTS

The 1st PC accounted for 81.4% of the variance between sides, and a significant difference in PC1 scores of the healthy and injured knee was noted (p<0.001, ES = 0.25). Inspection of the accompanying loading vector and single PC reconstruction plots suggest that comparatively, the healthy knee exhibited a higher level of strength through the entire ROM. The 2nd PC obtained for knee extension efforts accounted for 14.4% of the variance between sides. This PC, which was statistically insignificant (p = 0.29, ES = 0.19) represented a phase shift where strength curves obtained from the healthy knee were characterized by a sharp increase in strength up to peak in the initial 20º of range of motion, followed by a gradual decline in strength output for the remainder of the ROM. On the other hand, strength curves from the injured knee were characterized by a more gradual increase in strength during the initial part of the range of motion; reaching peak value at approximately 50º.

DISCUSSION AND CONCLUSIONS

Current results suggest that the magnitude of strength production throughout the entire ROM does account for the majority of variation between the healthy and injured knee. As such, use of conventional and arguably more clinically interpretable output measures utilizing data from the entire curve (e.g. work or average moment) may be considered best to represent this phenomenon. Although not reaching statistical significance, the time shift in strength production in the injured knee may be of relevance for comparisons of pre operative scores to those obtained following surgery. Consideration should perhaps be given to quantifying this phenomenon using a more clinically interpretable measure, such as perhaps the angle of peak moment occurrence.

In summary, utilization of PCA for the bilateral assessment of isokinetic concentric knee extension strength curves of ACL deficient patients allowed the objective identification of curve features that may of relevance for clinical decision making regarding patient progression though targeted interventions before and following surgery, as well as for determination of readiness to return to regular activities following rehabilitation.

REFERENCES