KNEE TORQUE KINETICS DURING HIGHLAND DANCING

Johnstone, R.J., T. Bauer, and J. McAuliffe
Lakehead University, Thunder Bay, Ontario, Canada

INTRODUCTION

The purpose of the study was to measure torque variations in the knees of malaligned Highland dancers during the early and late stages of a six step Highland Fling. A secondary objective was to measure variations in knee malalignment at impact, maximum flexion and extension.

The most frequently occurring injuries in dance involve the knee (Arnheim, 1980; Schafle, Requa, & Garrick, 1990; Solomon & Micheli, 1986) and develop largely from knee malalignment (Arnheim, 1980; Clarkson & Skrinar, 1988; Clippinger-Robertson, 1987; Ende & Wickstrom, 1982; Reid, 1988; Solomon & Micheli, 1986; Teitz, 1987; Watkins & Clarkson, 1990). Quantifying knee torque due to malalignment provides a measure to understand why injuries are so prevalent in dance and how potential injuries could be avoided.

METHODOLOGY

Seven subjects participated on a volunteer basis and were prescreened for knee malalignment from a previous study (Johnstone & Bauer, 1993).

Three dimensional measurement combined a frontal plane and an oblique plane taken 45 degrees from the frontal plane. The oblique angle of 45 degrees was selected based on the plane of motion of the supporting leg which is turned out approximately 45 degrees, with the hip, knee and ankle ideally aligned over the ball of the foot and in alignment in the oblique plane.

A sensor switch was attached to the bottom of the dance shoe, which caused a light to illuminate upon contact with the force platform. Thus, the force platform and two plane video recordings could be synchronized.

Each dancer performed a six step Highland Fling on the force platform while being video taped using two video cameras in both a frontal and a 45 degree oblique angle to the right of the dancer.

Ten hops were chosen toward the beginning of the dance and ten hops were chosen at the end of the dance to indicate changes in knee torque between early and late stages of a six step Highland Fling.

All joint centres were marked to aid in the digitization of the joint centres on the PEAK 2D System.

The maximum flexion frame of each hop was digitized on the PEAK 2D System from the frontal view to provide vector measures for the calculation of knee torque. Impact, maximum flexion and full extension frames for each hop were digitized from the oblique view to provide vector measures for the calculation of knee torque at maximum flexion and to measure variations in malalignment at impact, maximum flexion and full extension. Three-dimensional knee torque was calculated using trigonometry and the COS Rule ($Z^2 = X^2 + Y^2 - 2XYCOS0$, where Z = resultant, X = frontal view difference in horizontal coordinates of knee and centre of mass, Y = oblique view difference in horizontal coordinates of knee and centre of mass and $0 = 180^\circ - 45^\circ$) multiplied by the ground reaction force for the first and last steps.

When in correct alignment the x-coordinate, or horizontal coordinate, of the knee falls in alignment with the x-coordinate, or horizontal coordinate, of the centre of mass. When these horizontal coordinates are equal malalignment is minimal. However, when the difference in the x-coordinates of the centre of mass and the knee joint centre increases, the degree of malalignment increases.

Results were analyzed using a single subject baseline design.

RESULTS AND DISCUSSION

Results indicated mixed trends in knee torque, knee malalignment and knee flexion from early to late stages of the dance.

Knee torque values indicated a decrease from early to late stages of the dance. The combination of malalignment increases and knee flexion decreases provided the dominant trend in knee torque results. All seven subjects demonstrated increases in knee malalignment. The degree of knee flexion decreased in all seven subjects, and therefore, influenced the knee torque measures. Subject 6 did not follow the same trend in knee torque and indicated a large increase in knee malalignment, which resulted in an increase in torque at the knee. Decreases in knee flexion occurred, similar to all other subjects.

The results indicate a possible relationship between knee malalignment and knee flexion with one compensating for the other with decreases in knee flexion and increases in knee malalignment. This may be a fatigue controlling mechanism. Fatigue was not measured in this study. Less knee flexion may result in less shock absorption in the lower limb segments, and therefore, an increase in the malaligned position. The potential for knee injury increases with knee malalignment, as well as the potential for hindering performance. The dancer will not obtain the optimal height between jumps and since

jumping height is one of the criteria judged in competition for a Highland dancer, the quality of the performance is effected (Nichols, 1987). Although not measured in this study, there may be possible increases in ankle flexion to aid in absorption. Dropping the ankle also hinders a Highland dancer's performance (Nichols, 1987).

The majority of subjects (five) experienced increases in knee malalignment at maximum flexion. Two subjects produced maximum knee malalignment at extension early in the dance, suggesting potential postural malalignment while in a non-weight bearing position. Nonetheless, the subjects compensated at impact and maximum flexion with initial, correct technique. At the end of the dance, however, maximal malalignment developed at maximum flexion.

CONCLUSION

The study has quantified knee torque, knee malalignment, and knee flexion measurements in Highland dancing. Based on the available literature this is the first study to do so.

Increased knee malalignment measures, in the oblique plane, demonstrate a potential for injury unless the dancer's technique and lower extremity alignment is corrected. The research utilizes Highland dancers, however, the concentration is on dancing in a turned-out position. Since turnout is common to other dance forms, these results may be applicable to ballet, jazz, and modern dance.

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