KNEE JOINT COMPRESSION AND SHEAR FORCES IN HEALTHY AND ACL DEFICIENT COPERS AND NON-COPERS DURING WALKING

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INTRODUCTION

Different walking and movement patterns have been observed between anterior cruciate ligemant (ACL) deficient subjects that compensate well for their injury (copers) and those who do not (non-copers). Basically, previous studies observed that the movement pattern of copers was very similar to that of healthy subjects while the movement pattern observed in non-copers was different. In a previous study we observed that the walking pattern of non-copers was characterized by a significant reduction of the knee extensor moment during the stance phase but knee joint kinematics were identical to controls. In contrast, the copers walked with the same knee extensor momtent as the controls but had a greater peak knee flexion [1]. The purpose of the present study was to investigate how the different walking patterns observed between copers, non-copers and controls affected the compression and shear forces on the knee joint.

METHODS

Nineteen healthy male subjects [mass: 76.7 (6.6) kg, height: 1.82 (0.04) m, age: 31.0 (4.5) years, mean (SD)] were selected as controls for the gait analysis. Nineteen male patients with complete unilateral chronic (i.e. post-injury time ≥6 months) ACL deficiency participated in the study. The patients were separated into copers and non-copers where the copers were able to return to their normal pre-injury activity level despite their injury while the non-copers were not. The copers consisted of nine subjects [mass: 76.7 (14.3) kg, height: 1.81 (0.06) m, age: 28.3 (6.1) years]. The non-copers comprised ten subjects [mass: 80.4 (6.7) kg, height: 1.79 (0.05) m, age: 31.7 (5.9) years]. All subjects gave their informed consent to participate in the experiments, which was approved by the local ethics committee.

The subjects walked across two force platforms (AMTI, OR6–5-1) at a speed of 4.5 km/h. Five video cameras (Panasonic WV-GL350) operating at 50 Hz recorded the movements. Three-dimensional inverse dynamics analyses were used to calculate joint kinematics and kinetics for ankle, knee and hip joints. To assess the knee joint compression and shear forces, a statically determinate knee model was applied [2]. The knee compression force was calculated as the vector sum of a) the knee joint reaction force resolved along the long axis of the tibia, b) the compression component of the active muscle group and c) the axial component of the cruciate ligament tension. In cases of ACL deficiency only the PCL was considered to be intact in the model. No antagonistic contractions were allowed in the model. The muscle forces were calculated by combining the net sagittal plane joint moments with the muscle moment arms derived from a third-order polynomium relating the knee joint angle to the muscle moment arms. The predicted joint compression values were normalized to body mass (N/kg). Statistical comparisons between the non-copers, copers and the control group were obtained by a one-way analysis of variance (ANOVA). In cases of significance the Scheffe´ multiple-comparison procedure was used to locate the differences. The statistical analyses were performed using SAS version 9.1.3 (SAS Institute). The level of significance was set at 5%. Results are presented as means with 95% confidence intervals (c.i.).

RESULTS AND DISCUSSION

There was a significant difference in the total knee compression force between groups (Table 1). The control subjects had a significant higher compression force at peak knee flexion than the non-copers, while copers walked with the same amount of knee compression as the controls. The comparison of the total shear force at peak knee flexion approached significance (Table 1). As earlier reported the peak knee flexion was significantly larger among the copers than among the controls, while the non-copers walked with same knee joint kinematics as the controls [1]. It is likely that the increased knee flexion among copers enabled them to load their knee joint as much as the controls. If they had walked with the same kinematics as the controls the shear force may have increased as a function of the angle between the patella ligament and the tibia and possibly placed their knee in a more unstable position.

CONCLUSIONS

The results reflected that the different walking patterns observed in copers and non-copers resulted in the same level (copers) or significantly lower (non-copers) knee joint compression and shear forces as in the healthy subjects.

REFERENCES

1. Alkjær T, et al. *Eur J Appl Physiol* **89**, 301-308, 2003
2. Schipplein OD et al. *J Orthop Res* **9**, 113-119, 1991.

Table 1: Knee joint loadings at the time of peak knee flexion. Means with 95% confidence intervals (c.i.).

	Total compression force (N/kg)	Total shear force (N/kg)
Controls (n=19)	24.5, c.i. 21.4 to 27.5	2.55, c.i. 1.88 to 3.23
Copers (n=9)	23.2, c.i. 18.8 to 27.6	1.77, c.i. 0.80 to 2.75
Non-copers (n=10)	17.4, c.i. 13.3 to 21.6	1.29, c.i. 0.36 to 2.22
p-value	0.028	0.082