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LUMBAR SPINE REACTION FORCES IN SEATED PARA-SPORT: CROSS-COUNTRY SIT-SKIING

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INTRODUCTION

For wheel-chair users shoulder injuries [1] and lower back injuries [2] are common. Lower back kyphosis of the spine, increases the anterior shear force in the lower back [3] and increases the risk of shoulder injuries [4].

Cross-country sit-skiing (CCSS) is an endurance sport where the athlete is seated in a sledge mounted on a pair of skis and propel themselves by poling with a pair of sticks. This sport creates more equal loading on the muscles around the shoulder than wheel-chair rolling [5] which is positive in an injury perspective for the gleno-humeral joint [1].

Athletes in CCSS with reduced trunk muscle control often sits in a sledge with their knees higher than their hips (KH) and a backrest. This position is hypothesized to be associated with spinal kyphosis and hence an increased risk of injuries. Therefore we have created a new sitting position with knees lower than hips (KL) with the trunk restrained on a frontal support.

The aim of this study was to compute the L4/L5 joint reactions and compare the results between the positions KH and KL.

METHODS

Five female abled-bodied cross-country skiing athletes (62.6 ± 8.1 kg, 1.67 ± 0.05 m) performed one exercise test session in each sitting position; The sessions included a sub-maximal incremental test, including 4-6 exercise levels of 3 min (exercise intensity nr 4, 37W, reflected race-pace) and a maximal time-trial (MAX) of 3 min on a commercial skiing ergometer (ThoraxTrainer A/S, Denmark).

Full-body kinematics (Qualisys AB, Sweden) and pole forces (Biovision, Germany) were measured in 200 Hz. These data served as input to inverse dynamic simulations in The AnyBody Modelling system (AMS 6.0, Anybody Technology A/S, Denmark). For each participant and sitting position, simulations were made for exercise intensity 37W and MAX over four poling cycles using a 5th order polynomial muscle recruitment criteria. Compression forces and anterior shear forces between L4 and L5 were computed and normalized to each participant's standing joint reactions. Data were compared pair-wise between the two sitting positions.

Statistical significance ($p \leq 0.05$) were marked with asterisk (*). Tendency of difference ($0.05 \leq p < 0.10$) were marked (#).

RESULTS AND DISCUSSION

Performance was higher in position KH (KL: 0.77 ± 0.08 W/kg, KH: 1.00 ± 0.14 W/kg, $p < 0.01$). No difference were observed in cycle length or cycle time. Kinematics results showed that KL had less spine flexion and range of motion

in flexion. KH showed higher mean pole force in 37W and tendency of higher peak pole force in MAX.

In standing, L4/L5 compression and anterior shear forces were 354 ± 45 N and 32 ± 11 N respectively. The normalized L4/L5 reaction forces (fig. 1) were larger in KH, especially during MAX intensity due to higher power. For equal power output, 37W, the mean anterior shear force was larger in KH and the mean compression force showed tendency of larger in KH ($p=0.077$).

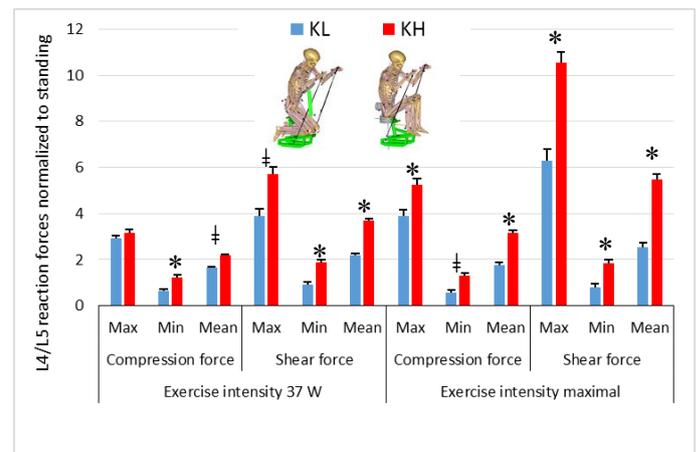


Figure 1: Normalized joint reaction forces, compression and anterior shear forces, between vertebrae L4/L5 for the two sitting positions KH and KL with trunk restraint. Min – minimal force, Maximal force and Mean – mean force over the four poling cycles.

CONCLUSIONS

Based on inverse-dynamics musculo-skeletal simulations of 5 abled-bodied athletes, the sitting position KL with frontal restraint reduced the compression and shear force between the L4/L5 vertebrae but impeded performance. This study shows the difficulty of comparing performance and safety in the same piece of equipment.

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