L4/L5 COMPRESSIVE LOADING IN MALE PAIR FIGURE SKATERS DURING PRESSURE AND WAIST LOOP LIFTS

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Introduction

Pair skating is highlighted by spectacular overhead lifts, in which the lady is held 2 metres or more in the air above her male partner's head. Because younger and younger skaters are attempting overhead lifts, safety concerns arise related to the potential for back injury.

Very little research has been conducted investigating injury occurrence in pair skaters. Brock and Striowski (1986) and Brown and McKeag (1987) both noted a relatively high number of injuries (7 and 9 respectively) in small study groups of elite pair skaters (n=13 and n=14 respectively). Smith and Ludington (1989) determined that over a nine month period, 11 of 33 serious injuries (causing a skater to miss 7 or more consecutive days of practice) to pair skaters were caused by lifts. They noted that, "the low back strain of a junior pair male may have been prevented by his paying greater attention to proper lifting mechanics when holding his 165 cm partner overhead."

The purpose of this study was to estimate the L4/L5 compressive forces on young male pair figure skaters at the onset of two different sagittal plane overhead lifts (waist loop lift and pressure lift) using a 2-dimensional, quasi-static biomechanical model (WATBAK). Results were compared with industrial lifting guidelines of the National Institute for Occupational Safety and Health (NIOSH, 1981).

Methods

Three teams of competitive pair figure skaters were recruited, each representing a different competitive level of figure skating: one Junior and two Senior pairs. Subjects signed an Informed Consent letter approved by the Office of Human Research of the University of Waterloo prior to participation. Data was collected both in the laboratory and in the arena.

Laboratory:

One of the difficulties encountered in this study was estimating the load exerted on the hands of the male skater by his female partener. An estimate was made by having each pair execute each lift in a stationary manner on a force plate in the laboratory. Each laboratory lift was videotaped and synchronized with the a/d converter by a synch light for later analysis. From this videotape, the phases of the lift could be associated with the force plate profiles. The dynamic force on the hands was then estimated as the maximum force exerted by the female skater on the force plate during the take off of the lift. The static force on the hands was estimated as the partner's body weight.

Arena:

After making appropriate preparations for video analysis in which the male partner was fitted with reflective anatomical joint markers on the left side, each pair was videotaped in the sagittal plane performing five trials of two different overhead lifts.

The video data was digitized using the Peak Performance system. X,Y coordinates were downloaded to the WATBAK (University of Waterloo, Waterloo, Ontario) biomechanical analysis software by a conversion programme (Peak to Bak) developed at the University of Waterloo. The input loads used in the WATBAK analysis were the female partner's body mass (static) and the force on the hands determined from the simulated lifts on the force plate (dynamic) (Table 1). Mean L4/L5 compressive forces were then determined for the beginning (as the female partner just left the ice) and at the top position of the lady for each lift. Moment arm lengths from L4/L5 to the line of action of the erector spinae muscles were assumed to be 6 cm in all conditions.

Subject Data							
Skater	**Competitive Level**	**Age**	**Body Mass (kg)**	**Height (m)**	**Static Load (N)**	**Dynamic Load (N)**	
						Pressure	**Loop**
C.H.	Junior	17	72.83	1.82	329.2	434.1	171.9
S.M.	Senior	23	71.64	1.87	460.2	1574.5	921.2
S.R.	Senior	21	88.29	1.93	460.2	769.9	952.9

Table 1: Subject Information.

Results and Discussion

Statically modelled loads were generally lower than dynamically modelled loads for both types of lifts. Pressure lifts tended to result in greater compressive forces at L4/L5 than loop lifts for both static and dynamic loads. Compressive forces at the top of the lift, when the partner was stable, were lower than the

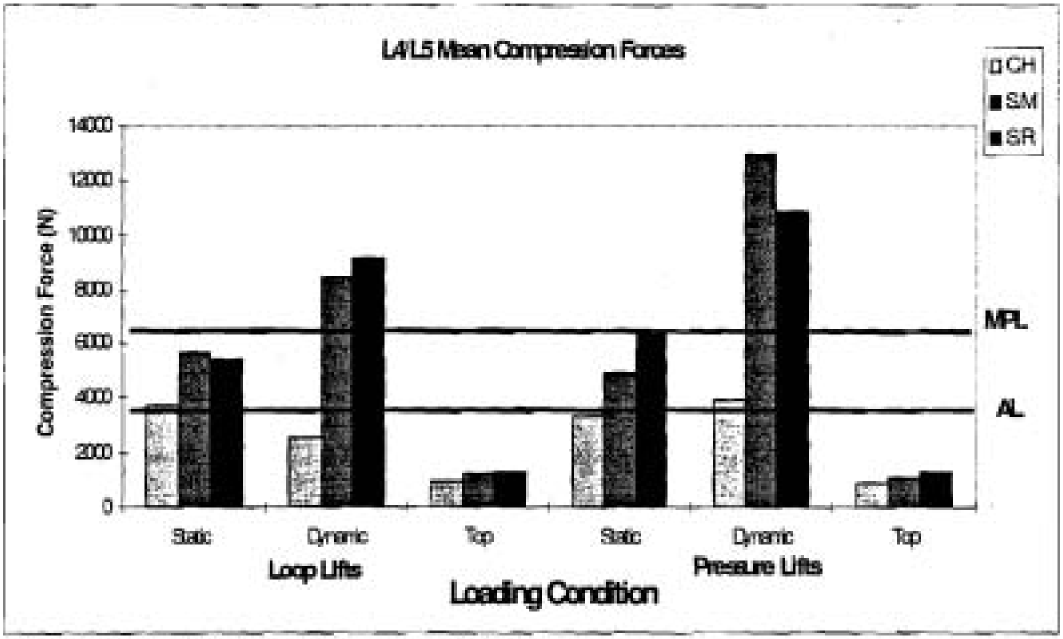

Figure 1: L4/L5 Mean Compression Forces

compressive forces at the beginning of the lift regardless of the type of load (static or dynamic).

The 1981 NIOSH Work Practices Guide gives two limits, the Action Limit (AL) and the Maximum Permissible Limit (MPL) by which to evaluate a task. These limits are based on epidemiological, physiological, psychophysical and biomechanical studies. The NIOSH equation considers four factors in the evaluation of a lifting task: the horizontal location of the load from the centre of mass of the individual, the vertical displacement of the load, the distance through which the load is moved, and the frequency of lifting. This information is entered into a mathematical equation to determine a relative evaluation of the task. From these evaluations, lifting tasks may be classified into three hazard categories. Loads below the AL are believed to impose nominal risk of injury to workers. Loads between the AL and MPL require careful consideration for employee selection, placement, and training or job redesign. Loads exceeding the MPL pose excessive risk to the worker and the task should be redesigned (Chaffin et al., 1991). The AL is 3433 N, while the MPL is 6376 N.

All of the static lifts were below the NIOSH Maximum Permissible Limit (MPL), while the MPL was exceeded by two subjects in both of the dynamically modelled situations. One subject's compressive loads were lower than the other two, possibly because his partner's mass was only 46% of his own mass, while the other partners were 66% and 53% of the males' masses. While the dynamic lifts exceeded the NIOSH MPL, these forces were only sustained for very short periods of time.

It is important to note that the NIOSH AL and MPL were designed for use in **industrial situations** and that the guidelines were intended for workers involved in repetitive manual handling tasks working 8-12 how shifts. The NIOSH guidelines were chosen for this study because they are well-known levels of comparison in industrial biomechanics.

In pair figure skating competitions, (long program- 4 1/2 minutes), skaters may perform a maximum of 5 different lifts (Canadian Figure Skating Association, 1994). It is not likely that skaters would perform such lifts continuously for hours at a time in practice.

However, based on the results of this study, it is recommended that practice sessions do not involve several successive lifts, but that they are interspersed with other non-lifting activities.

This study demonstrates that the well-established practice of teaching young male pair skaters waist loop lifts before pressure lifts is a sound one.

References

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