Effect of Load Placement on Lower Back Loading During Tripod Lifting in Childcare

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Summary

Childcare workers often lift and bend, putting strain on their lower backs. The tripod lifting technique, recommended by Occupational Health Clinics for Ontario Workers (OHCOW), helps reduce this strain by keeping the back straight. This study looked at how the position of a load on the thigh affects lower back stress at the L5/S1 joint. Eleven participants lifted an 11 kg sandbag, with placement of the sandbag modeled at different points along the thigh, from 10% to 70% of the thigh length proximally from the knee. External L5/S1 extension moments were calculated during both lifting and lowering phases. As the load moved farther from the knee, L5/S1 extension moments significantly increased ($P < 0.05$). At 70% of thigh length, the stress was 34% higher than at 10%.

Introduction

In occupational childcare, educators frequently engage in bending and lifting tasks while caring for children of varying ages and levels of independence [1,2]. The tripod lifting technique emphasizes maintaining a straight back and reduces perceived low back exertion [3]. However, there is limited research on how load placement along the thigh, relative to the knee joint, affects low back loading.

This study aimed to investigate how different load placements along the thigh affect the L5/S1 sagittal plane moment, hypothesizing that the external L5/S1 extension moment would decrease as the load moves closer to the hip and further from the knee joint.

Methods

Eleven healthy participants performed tripod lifts using an 11 kg sandbag to represent a 90th percentile infant. Tripod lifting an object involves positioning one foot next to the object, keeping the back straight, and lowering onto one knee beside the object. In this study, the object was grasped with both hands, set on the kneeled thigh while maintaining proper posture (head forward, back straight, buttocks out), then transferred to the opposite thigh, brought close to the chest, and lifted while exhaling [3]. The participant chose their preferred position for the sandbag on the thigh. Kinematic data were collected using an Optotrak Certus® system (NDI, Waterloo, Canada), and kinetic data were collected using four AMTI force platforms (AMTI, Massachusetts, USA). Using Visual3D (HAS-Motion, Kingston, Canada), the force exerted on the thigh by the sandbag was modeled at 7 possible positions along the thigh (10% - 70% of thigh length, in 10% increments, proximal to the knee joint). This force was assumed to be 100% of the weight of the sandbag. The measured ground reaction forces under the knee and feet were assumed to be the same as those directly measured with the sandbag in the preferred position across all simulated positions. External L5/S1 moments were calculated for each position during the lifting and lowering phases and normalized to %BW × Ht. A one-way ANOVA was used to assess the effect of load position on peak L5/S1 moments ($\alpha = 0.05$).

Results and Discussion

ANOVA results revealed a significant main effect of distance ($P < 0.05$). During both the ascending and descending phases, the mean peak L5/S1 extension moments significantly increased as the load's distance from the knee joint increased (Figure 1, note the negative y-axis scale). Specifically, the mean peak L5/S1 extension moments increased by 6%, 10%, 18%, 22%, 27%, and 34% when the load was positioned at 20%, 30%, 40%, 50%, 60%, and 70% of the thigh length from the knee, respectively, compared to the 10% position. Recall that the ground reaction forces from the preferred position were used for all simulations, making the hip moment the only load on the thigh that could change in response to the change in sandbag position, to maintain the sum of the thigh moments causing the thigh angular acceleration (or lack thereof) as measured in the preferred position. As the sandbag moved closer to the hip, it exerted a smaller extensor moment, which is counterbalanced by an increase in the extensor moment at the hip to maintain the same angular acceleration across all simulated positions. With no changes in external loads on the pelvis, the L5/S1 joint moment increased in response to the increased hip moment, as the load shifted toward the hip.

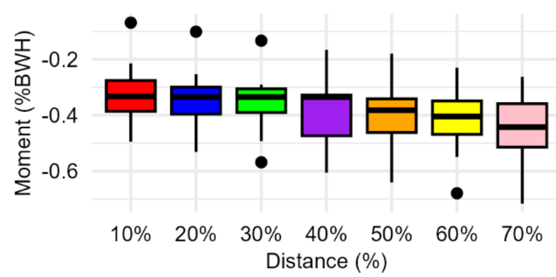

Figure 1: Box & whisker plot of peak L5/S1 moments at different load positions (% thigh length proximal to the knee) during the ascent phase. Extension moments are negative.

Conclusions

This study demonstrated that as the load moved farther from the knee, L5/S1 extension moments increased. The shift in load position led to compensatory changes in the hip moment, raising L5/S1 joint moments. Further work is required, allowing variation in the ground reaction forces to apply these findings to real-world scenarios.

References

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