VIRTUAL JACK MANIKIN USED TO ASSESS POSTURAL VARIABLES AND VISIBILITY MEASURES FROM THE CAB OF LOAD-HAUL-DUMP MACHINES

[1] Alison Godwin, [2]Tammy Eger and [2]Sylvain Grenier
[1]Queen's Ergonomic Research Group, Queen's University
[2]Biomechanics Ergonomics and Kinesiology Lab, Laurentian University; email:4aag@qlink.queensu.ca

INTRODUCTION

Load-haul-dump (LHD) machines were previously shown to have significant visibility deficits within a computer-aided design environment known as Classic JACK [1]. The virtual human simulation program was then used to assess the postural deviations of the head and trunk that may be associated with obtaining a line-of-sight from the cabin of these machines. Since minor retro-fit modifications were insufficient to create a large increase in visibility measures [2], a concept change was tested in the virtual environment for feasibility.

A rotating operator seat has been successfully used to reduce postural deviations for tractor operators and other, sideways-seated machine operators [3,4]. A rotating seat and console was incorporated into the virtual environment to allow testing of a 20º and 45º seat rotation intervention. Postural load variables and visibility measures were evaluated as dependent variables.

METHODS

Virtual human operators representing a range of anthropometric sizes (1st to 99th percentile) were placed in the cab of a 7yd3 LHD machine. A series of movement strategies (n=15) representing typical neck and trunk movements used by actual operators to view specific hazards around their vehicles were developed. These movement strategies were constrained by known biomechanical tendencies (twist developed by thoracic vertebrae and flexion developed by lumbar vertebrae). The virtual hands and feet were constrained to hand controls and foot pedals. A variety of biomechanical variables were collected while the virtual human used their unique movement strategy to view the left-most target point. Selected dependent variables included muscular activity of five trunk muscles (N), compression (N), shear (N), L4/L5 moment (Nm), trunk rotation (º), neck rotation (º), trunk flexion(º) and trunk lateral bend (º). Data was assessed using t-tests to determine if differences existed between the current cab condition and a seat rotation of 20º and 45º. Using the Bonferroni correction, a $p<0.0167$ was required for significance.

RESULTS AND DISCUSSION

There was a lack of statistical significance to demonstrate that a seat rotation will unequivocally reduce the risk factors that may lead to injury for LHD operators. Compression, shear, L4/L5 moment and muscular activity all showed decreasing trends. It was possible to demonstrate that a virtual environment can show decreases in postural load variables when a proposed beneficial solution is tested. All postural angle values decreased as seat rotation increased with a concomitant increase in visible area available to the operator (Figure 1).

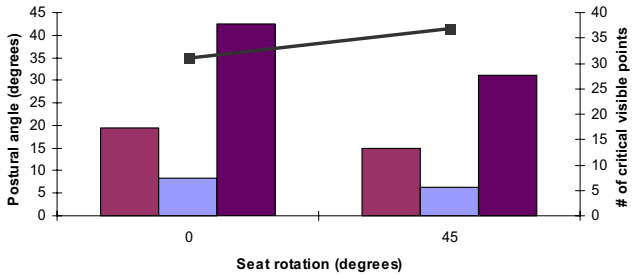

Figure 1: Trunk rotation, trunk lateral bend and neck rotation decreased as seat rotation increased from 0 to 45. An advantageous increase in the number of visible critical points was also achieved.

Even without statistical significance, these results can be used by manufacturers to evaluate and refine potential designs and concepts. Limitations to consider before implementation of these types of modifications include the ability to obtain accurate machine representations and validated operator movements.

CONCLUSIONS

Despite some reservations, this research shows promise for the ability to analyze a virtual human in industrial machinery. Most industrial manufacturers use 3-D programs to design future equipment. It is advantageous to the eventual human user if ergonomic principles and biomechanical considerations can be assessed and refined prior to building prototypes.

REFERENCES

1. Jeffkins AA, et al. *Ergonomics in* Design,**12(2)**,12-17, 2004.
2. Godwin AA, et al. *International Journal of Industrial Ergonommics*, submitted, 2004.
3. Eklund J, et al. *Ergonomics*, **37(4)**, 623-639, 1994.
4. Bottoms DJ and Barber TS. *Applied Ergonomics*, **9**,77-84, 1980.

ACKNOWLEDGEMENTS

The authors would like to thank the Workplace Safety and Insurance Board (WSIB) of Ontario for their continued support of visibility studies.