Orchard ladders with shorter rung spacing for stone fruit harvest

Victor Duraj
University of California at Davis, UNITED STATES

Abstract:

Falls from ladders in orchard work represent huge costs to workers compensation companies in the states of California and Washington. The typical worker is South American and has an average height below that of the overall United States population. The literature includes efforts to study rung spacing, but the spacings utilized spacings could be considered to small and large for practical purposes. This paper reports on preliminary laboratory and field trials with manufacturer custom-built ladders with shorter rung spacing. The laboratory work suggests that 11-inch (27.9 cm) spacing minimizes relative sagittal oscillation, and the field work indicated strong adoptability of 11-inch (27.9 cm) and 10-inch (25.4 cm) spacings compared to the standard 12-inch (30.5 cm) spacing. Work in progress is developing a computerized biomechanical model in the AnyBody Modeling System to try to optimize a rung spacing based on worker anthropometry for worker muscle forces, stability, and fatigue.

Summary:

Ladder manufacturers have made some improvements over the years, including deeper rungs for greater foot surface area. Although manufacturers have built custom ladders with rung spacing greater than the United States standard of 12 inches (30.5 cm) for certain straight ladder applications, ladders with shorter rungs for orchard work have not been built. This paper reports on laboratory and field trials with alternative ladders with shorter rung spacing.

The laboratory experiment studied the kinematics of two differently sized university students ascending a standard 12-inch spaced ladder and custom-built ladders with 13-inch (33.0 cm), 11-inch (27.9 cm) and 10-inch (25.4) rung spacing. Data was obtained using a three dimensional video based motion analysis system along with a lumbar motional analysis system. The lumbar motion analysis system data indicated that the amount of relative sagittal oscillation of the low back was a minimum for the 11-inch spacing.

The field experiment was a worker adoptability study conducted during a five-week stonefruit harvest in peaches and nectarines in Califonria's Central Valley. The ladder options were an 11-inch and a 10-inch, of which 19 of each type were made available. Volunteers who were interested in participating in the study were allowed to climb up and down a 12-inch, an 11-inch, and a 10-inch in a non-production activity but in the soil near the orchard, and then choose to a non-12-inch ladder to participate. Of the 38 volunteers, no volunteer gave up their chosen alternative ladder during the five week harvest, and only one volunteer indicated at the end that they would prefer the 12-inch. Worker feedback included improved feelings of stability and reduced discomfort at the knees and back.

The long term objective of this work is to reduce falls from ladders by improving the stability of workers moving between rungs and by reducing fatigue. Reduced fatigue may mean improved worker ability to respond successfully to a perturbation of the ladder or of a shoe-rung slip. The preliminary field work suggests there is worker demand for an orchard ladder with shorter rungs when used in hourly work.

Current work is developing a biomechanical model in the AnyBody Modeling System to compare worker anthropometry to muscle forces. The model will be used in a laboratory study utilizing a 17-sensor virtural reality suit to track full-body kinematics of ascent and descent, followed by a more comprehensive field study.

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