

Investigating the Effects of Various Handle Grip Designs on the Distal Arm during Short-Term Hand Tractor Field Operation

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Abstract

Laboratory studies on handle vibration and hand-arm biomechanics for hand tractor usage were previously studied and results showed that having a handle grip minimizes negative upper limb responses. This study investigates whether the same responses can be observed during field operations, where posture and grip exertion are not controlled. Essentially, the study aims to investigate the effects of different handle shapes on the (1) activities of three forearm muscles namely: flexor carpi ulnaris (FCU), flexor carpi radialis (FCR), and extensor carpi radialis (ECR), (2) subjective discomfort rating of the hand area, and (3) grip suitability rating during field operation where grip exertion and posture may vary over time of use. Objective and subjective ergonomic assessments were performed since both are determined to be necessary for evaluating reliable design. Fourteen farm operators with mean age, height, and weight of 37.3 ± 10.4 years old, 169.1 ± 7.3 cm, and 70.8 ± 9.0 kg respectively, were recruited. Three handle shapes, namely: circular (C), double frustum (DF), and grooved (GV) were investigated, including the no-handle grip (NG) condition. The participants were asked to operate a hand tractor around a grass field while engine vibration and forearm muscle activations were recorded. Pre- and post-task subjective assessments were also taken. It was found that frequency-weighted engine vibrations across the various conditions did not vary significantly. The vibration level on NG, C, DF, and GV conditions ranged from $24.43 - 36.32$ m/s², $21.15 - 37.89$ m/s², $24.24 - 39.35$ m/s², and $24.21 - 45.96$ m/s² respectively. Meanwhile, in the four conditions, ECR and FCR activated at mild level or about 15% to 20% maximum voluntary contraction (MVC) while FCU activity was at moderate level or about 45% MVC. Moderate FCU activity was observed to be due to the handlebar width, which required the wrist to deviate constantly towards the ulnar side. Regarding shape effects, GV design moderately exhibited higher forearm muscle activities because it created a better grip leading to higher muscle coordination. Discomfort and suitability ratings also revealed that the GV design is preferred because of the adequate contact between the palm and handle. Lastly, DF was the least preferred as it generated a significantly higher perceived discomfort specifically along the palm area.

Keywords

Handle Shape, Actual Operation, Forearm Muscle Workload, Hand Discomfort, Grip Comfort.

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