The importance of combined field and laboratory research for effective ergonomics interventions – an example from the citrus industry in South Africa

Miriam Mattison\textsuperscript{a}, Elizabeth Bassey-Duke\textsuperscript{a}

\textsuperscript{a}Department of Human Kinetics and Ergonomics, Rhodes University, Grahamstown, Eastern Cape Province, SOUTH AFRICA

1. Introduction

Ergonomics is an applied science and, as such, the research findings which are often obtained from laboratory-based studies should be applied to the actual working situation they were designed for (Bao & Shahnavaz, 1989). Laboratory studies on ergonomics interventions have distinct strengths, but also limitations. Conditions in laboratory experiments can be rigorously controlled and variables of interest studied in much greater detail than would be feasible in situ. However, as already pointed out by Chapanis in 1967, in reality, physical, perceptual and productivity responses are influenced by a myriad of factors, and responses may thus differ considerably from those obtained in a laboratory-based study. The current study was an ergonomics intervention project based in the citrus industry of the Eastern Cape of South Africa. It demonstrates the complexity of intervention transfer from the laboratory and into field, and emphasizes the need for verifying laboratory-based findings in a ‘real world’ context.

As in other industrially developing countries, the harvesting of citrus fruit is performed manually and hence exposes labourers to various biomechanical risk factors, increasing the likelihood of premature fatigue and development of musculoskeletal disorders. As an intervention, the standard harvesting satchel, which is predominantly used in the citrus industry and which is carried unilaterally across one shoulder, was redesigned to reduce the pressure exerted by a full bag on the shoulder, as well to reduce the asymmetry caused by the unilateral load carriage. For one redesign, a hip-belt had been added to the standard harvesting bag, and the second design was a backpack-type bag with an added hip-belt. The objective of this study was to compare the two new designs to the standard design by using a combination of laboratory and field testing.

2. Method

The project consisted of a three-phase approach. The first phase served to conduct a detailed task analysis in the field, based on which the standard harvesting bag was redesigned and the laboratory simulation was developed. During the second phase, the redesigned harvesting bags were tested and compared to the standard harvesting bag in a laboratory protocol on 36 student volunteers. Bilateral EMG measurements of the upper trapezius, anterior deltoid and erector spinae, and local Ratings of Perceived Exertion of the shoulders and the back were measured while the participants simulated the harvesting process in the laboratory. These activities included carrying ladders, climbing ladders, picking fruit, carrying satchels filled with fruit and emptying the contents of a full harvesting bag into a collection bin. During the third phase of the project the harvesting bags were introduced into a field setting, where 17 Xhosa-speaking citrus harvesters went about performing their jobs of harvesting oranges, using the three bag designs. During this field phase, ratings of perceived exertion of the shoulders and back were recorded, productivity was assessed by counting the number of bags harvested, and a Perceived Usefulness & Ease of Use (PUEU) questionnaire was utilized to obtain feedback on workers’ impressions of the three bag designs.

3. Results

The EMG results from the laboratory study consistently showed that the ‘backpack’ design elicited the lowest muscle activity for all three muscles tested and for both sides of the body. Contrary to expectations, the new ‘hip-belt design’ generally showed the greatest EMG activity, although not always significantly. RPE responses from the laboratory study however indicated that participants perceived the ‘standard bag’ to require the greatest amount of effort from the back and the shoulders, whereas the ‘hip-belt’ and the
‘backpack’ designs did not differ significantly in local RPE. In the field study, on the other hand, the workers rated the ‘backpack’ design as the worst, whereas the ‘hip-belt’ design received the lowest ratings of perceived exertion. Similarly, productivity was greatest for the ‘hip-belt’ design, but lowest for the ‘backpack’ bag. Finally, when asked about the ease of use and usefulness of the different harvesting bags, the ‘hip-belt’ design also received the most favourable ratings, whereas the ‘backpack’ design was not accepted by the workers.

4. Discussion

The results from both phases of the project are contradictory and were attributed to a variety of social, educational, cultural and economic factors. This highlights that, particularly in the context of an industrially developing country, extreme caution should be practiced in the transfer of an intervention from the laboratory to the field due to the numerous interactions in real life that cannot be simulated in the laboratory.

References
