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Design of combine harvester seat based on anthropometric data of Iranian operators

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ABSTRACT

Harvesting operation with agricultural combines imposes excessive physical loads on the operators and the poorly designed seats may be an important contributory factor in this regard. This aims of this field study were to evaluate the possible mismatch between seat dimensions of existing harvesting combines and anthropometric characteristics of 200 Iranian operators and to propose seat dimensions based on anthropometric principles. The anthropometric dimensions of each individual operator were compared to the relative seat dimensions using the equations proposed in the literature. The results showed a considerable mismatch for different seat dimensions including upper backrest width (100%), seat height (97%), armrest height (83.7%), seat width (52.8%), lower backrest width (40.6%) and seat depth (39.5%). This meant that the existing combine seats were too high, too narrow and too shallow and had armrests and backrests which did not match with body dimensions of the majority of the operators. It was shown that compared to the existing designs, the new proposed dimensions (including seat height = 400 mm, seat width = 450 mm, seat depth = 410 mm, armrest height = 290 mm, backrest height = 420 mm, upper backrest width = 360 mm and lower backrest width = 400 mm) better matched to the operator's anthropometry, with the match percentages ranging from 77% to 100%.

Relevance to industry: The design and manufacturing of agricultural machinery should be made based on the anthropometric characteristics of actual users to avoid unnecessary demands on them. This study provide additional data on the operator's anthropometry that can be used as a starting point for designing more appropriate agricultural machinery or used by other researchers in the field.

1. Introduction

Although technological advances may lead to reduction of work difficulty as well as improvement in productivity, there may be adverse health and safety consequences associated with using technology in human–machine interaction. This is the case for agricultural machinery which imposes excessive physical loads on the operators (Mehta et al., 2008). There are a set of too complex and different controls in agricultural machinery, including harvesting combines, to allow the operator to do all the harvesting operations in a seated working posture. Harvesting operation is a highly repetitive task which requires force to operate pedals and controls and involves frequent trunk twisting and bending movements for a long period of time (Donati et al., 1984; Mehta and Tewari, 2000). Such a working condition, together with environmental constraints, may results in unacceptable postural loading on the structures of the body and thereby imposing surface pressure and pain in the back, buttocks, thighs and legs (Bovenzi and Betta, 1994; Hostens et al., 2001).

The sitting system characteristics may have major impacts on the operating conditions of the agricultural machinery workers (Hostens et al., 2001). Seat, which provides an interface between the human operator and vehicle's mechanical system, may greatly affects the imposed loads on the operator's body and influences the operator's discomfort (Mehta and Tewari, 2000; Hostens et al., 2001). The vehicle's seat should provide the operator with a comfortable and controlling posture, appropriate vision, and safe access to different pedals and controls. Correct sitting posture has been acknowledged as an important factor for the prevention of musculoskeletal problems (Cranz, 2000). Anthropometric measurements are one of the important considerations in designing

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ergonomically appropriate seats for agricultural machinery (Victor et al., 2002). Thus, the anthropometric dimensions including sitting popliteal height, hip breadth, buttock–popliteal length and sitting shoulder height of agricultural workers may be needed to design seat height, seat pan width, seat pan depth and seat backrest height, respectively, of an agricultural vehicle (Mehta et al., 2008).

Agricultural development continues to play an important role in the Iranian economy (Javadi and Rostami, 2007). However, such a development may not be feasible without the extensive use of mechanised agricultural practices with different types of machinery. This, therefore, increases the demand for ergonomically well-designed interaction between the human and machine. Increased attention to the improvement of working conditions and health and safety issues of this sector will have a significant impact on national productivity and farmers' quality of life.

The currently available harvesting combines in Iran may not be appropriate for Iranian users, partly because most of this machinery is being imported from foreign countries without consideration of the user's anthropometric dimensions. This may be the case in other developing countries, where the technology is transferred without paying much attention to the actual needs of the user population (Victor et al., 2002). In addition, the availability of anthropometric data in Iran is too limited to allow the design of appropriate products, particularly agricultural machinery. To the author's knowledge, there has been no study so far on the match between seat dimensions of self-propelled agricultural machinery and the anthropometric dimensions of Iranian operators. The present study was, therefore, conducted to evaluate the possible mismatch between the seat dimensions of typically available harvesting combines and the operators' anthropometric characteristics. It was also intended to provide additional data on the operator's anthropometry that can be used as a starting point for designing more appropriate agricultural machinery or used by other researchers in the field.

2. Methodology

2.1. Study design and procedure

This cross-sectional field study was conducted over a four-month period between August and November, 2012. The study setting was in Bukan, a city located in northwest Iran. Data on the number of farmers working with harvesting combines as well as the different types of combines existing in the study area were obtained from the Agriculture Office of Bukan. This information has already been presented in Table 1. There were a total of 476 combine operators who worked on 5 different types of combines. A sample of 200 harvesting combine operators was randomly selected (based on proportion to size sampling procedure) for the purpose of the study (as shown in Table 1). All the participants were males and their ages ranged from 19 to 70 years. Arrangements were made and then investigators visited the selected farms for data collection. All farmers were familiarised with the study procedure and any questions were answered by the investigator before participation in the study. They were told that participation was strictly on a voluntary basis and the farmers were under no obligation to complete the study. Each participant then signed a written informed consent form and was not paid for his participation. Ethical approval for the research was obtained from the ethical review committee of Shahr-e Kord University.

Table 1
Different types and number of combines, operators and study participants.

	Harvesting combines					
	JD 955	JD 1055	SK5	Class 68	Class 76	Total
Combines (n)	250	10	30	20	12	325
Operators (n)	330	36	40	40	30	476
Participants (n)	138	15	17	17	13	200

2.2. Measurements

2.2.1. Anthropometric measures

The anthropometric dimensions were measured using an adjustable seat height chair with a horizontal surface, portable stadiometer, measuring tape, and caliper. All anthropometric measurements (except for stature) were made while the operator was sitting in an erect position on an adjustable seat height chair, with his knees bent at 90°. The measurements were made to the nearest millimetre. The measurements followed the standard procedures given by Pheasant (2003) (Table 2 and Fig. 1). All anthropometric measurements were made by one trained investigator and during a single session. The operator was without shoes and wearing light clothing during the measurements. The following anthropometric dimensions were measured for each operator: popliteal height, buttock–popliteal length, elbow height (sitting), shoulder (acromial) height (sitting), sitting height, hip breadth, shoulder breadth (biacromial), shoulder breadth (bideltoid) and stature.

2.2.2. Seat dimensions

Different types of harvesting combines that were in common use were evaluated in the study (Fig. 2). One of the models, namely SK5, had two different types of seat (SK5 (1) and SK5 (2)). Moreover, JD 955 model had also two types of seat which one of them was structurally very similar to that of JD 1055, and therefore one of them was evaluated in this study. As a result, 5 types of seats were evaluated in the study. The International Standard ISO 5353 (1984) was used to determine the Seat Index Point (SIP) as a reference point for all the measurements. For this, a SIP device together with an extra weight of 65 ± 1 kg (i.e. the average weight of an adult person) was used to define the SIP (as shown in Fig. 3). The following seat dimensions were measured in the study: seat height,

Table 2
Definitions of anthropometric dimensions measured in the study.

Anthropometric dimensions	Descriptions
Popliteal height	Measured as the vertical distance from the footrest surface to the popliteal space (posterior surface of the knee).
Buttock–popliteal length	Measured as the horizontal distance from the posterior surface of the buttocks to the posterior surface of the knee.
Elbow height, sitting	With the elbow flexed at 90°, measured as the vertical distance from the bottom of the tip of the elbow (olecranon) to the participant's seated surface.
Shoulder (acromial) height, sitting	Measured as the vertical distance from a sitting surface to the top of the shoulder at the acromion.
Sitting height	Measured as the vertical distance from a sitting surface to the highest point of the head (vertex).
Hip breadth	Measured as the maximum horizontal distance across the hips in the sitting position.
Shoulder breadth (biacromial)	Measured as the horizontal distance across the shoulders between the acromia.
Shoulder breadth (bideltoid)	Measured as the maximum horizontal breadth across the shoulders, (measured to the protrusions of the deltoid muscles).
Stature	Measured as the vertical distance from the floor to top of the head (vertex).