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Development and validation of mobile based decision support system for Human Physical Drudgery Index (HPDI)

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ABSTRACT

The use of mobile applications and decision support system for agriculture is important in today's era. To enrich agriculture various mobile applications have been developed by different research institutes in NARES which are helping the farmers in their cultivation practices. In the present study, a mobile application named "*HPDI Ergon*" has been developed with intent to mapping of drudgery in physiological and psychological components and biomechanical evaluation of agricultural activities. In this respect the app named *"HPDI Ergon"* was developed during 2019–20 in computer application at ICAR-ISARI, New Delhi to assesses the drudgery involved in the work and give recommendation to mitigate it. In this app farmers are assessed based on different physiological and postural ergonomics parameters which includes heart rate, energy expenditure rate, total cardiac cost of work, physiological cost of work, human physical drudgery index variable etc. and conclusion is drawn on physiological and drudgery limitations. The app is developed using Android Studio and Java programming language. Individual registered farmers are selected to undergo different ergonomics and drudgery analysis. The data generated by different analysis is stored in the database which is implemented using SQLite database. Based on the results of all the ergonomic analysis and drudgery analysis using HPDI conclusion is drawn regarding whether there is any need of changing or improving the working condition or not. Accordingly, different suggestions and various improved tools are provided to the farmers for reducing their both physiological stress and drudgery in their working environment.

Keywords: Agriculture, Drudgery, Ergonomics, HPDI, Mobile Application

Indian agriculture is the backbone of our country. From the past few decades, the contribution of agriculture in the development of our country cannot be denied especially in the field of human civilization. The agricultural work performance is arduous, tiring, and stressful and it is because that there is less access to latest agricultural technologies which leads to physiological and psychological stress. The poor work environment along with low of facilities required for essential livelihood, which adhere the adoption of static repetitive, frequent, uncomfortable postures and without supportive positions, higher dependence on force implies on muscles and strength during carrying load or fuel make the work much laborious and energy demanding. As a result these people involved in agricultural activities suffer from Musculo-skeletal disorders (MSDs) in different body regimes (Devi *et al.* 2019), especially low and upper back pain, during different agricultural activities. Farm Biomechanical studies reports spinal loading during manual load carrying which results in degeneration of the disc and musculoskeletal disorder (Kuiper *et al.* 1999). Accelerated cervical spondylitis is also reported as a result of carrying load on head (Joosab *et al*. 1994, Jager *et al.* 1997). Boocock *et al.* (1994) reported that work activities which requires posture in which lumber region is extended (overhead work) are relatively common, may induce compressive loads, i.e. moderately high on the spinal lumbar region, and are occupational health hazard which lead to back issues.

Human Physical Drudgery index (HPDI) can be evaluated on the basis of statistically linear combination method with the scores recorded from Time spend on the particular activity, performance score of the task, difficulty score while carrying out activity, type of posture adopted, how many times posture is changing while carrying activity (frequency of postural change), load or force involved if any and postural discomfort pertaining to activity. The maximum drudgery prone activities of agriculture can be identified by using the procedure of Human Physical Drudgery Index. The development of the "Decision Support System for Biomechanical Evaluation of Agricultural Activities utilizing

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Fig 1 Calculation of ergonomics Parameters using mobile app *HPDI Ergon.*

Human Physical Drudgery Index (HPDI)" is an exertion toward this path.

The phrase DSS stands for "Decision Support System (DSS)" and it is given by Gorry and Mortan in 1971. More generally a Decision Support System (DSS) can be defined as "DSS are interactive computer-based systems that utilize data and models for aiding an organizational Decision-maker in semi structured problem" (Fabrice *et al.* 2018). Several DSS have been developed in different agricultural activities and on Ergonomics but there is no such system available for drudgery mapping technique of work related biomechanical problems in the different postures along with time factor, load/force coupled with discomfort. In this context, the development of DSS is being proposed for biomechanical issues of agricultural activities with Human Physical Drudgery Index (HPDI).

MATERIALS AND METHODS

The different types of software and tools that are used to develop the proposed DSS are JAVA programming language, XML, Android Platforms, DB Browser for SQLite, JAVA Libraries, Android Studio IDE, SQLite and Android Virtual Device (AVD) tool. In the project Android Studio version 3.6 with JDK version 1.8 is used for the development of the app.

The research work analysis of the farmers and their farm work has been conducted on the basis of physiological and psychological ergonomics parameters, viz. Body Mass Index, Physical Fitness Index, Energy Expenditure Rate (EER), Total Cardiac Cost of Work (TCCW), Physiological Cost of Work (PCW) and Human Physical Drudgery Index (HPDI). First of all the health condition of the farmers are evaluated using Body Mass Index (BMI) and Physical Fitness Index (PFI). If result of both the parameters come in suitable range then only we will proceed further towards EER, TCCW, PCW and HPDI analysis.

The Body Mass Index defines whether the weight of

the farmer is justified with his height or not. Following formula is used to calculate BMI

$$BMI = Weight (kg)/Height^2 (m).$$

The PFI denotes the health condition of the farmer. It is calculated by doing a work for 5 min and then recording the heart rates at three different times of recovery.

Circulatory stress was evaluated from the cardiac cost of work and cardiac cost of recovery. The cardiac cost of recovery is the total number of heart beats above the resting level occurring between the end of the work and return to the resting state.

Following formulae were used to calculate the total cardiac cost of work (TCCW) and physiological cost of work (PCW) (Borah 2015).

CCW = Δ HR .tA; CCR = (AhR recovery − AhR rest) .tR; TCCW = CCW +CCR; PCW = TCCW/tA

HPDI (Human Physical Drudgery Index) = (Ai+Bi… …+Gi) /7 *100.

RESULTS AND DISCUSSION

A DSS which is based on the android is developed. The main aim of the application is to evaluate the various agricultural activities based on the different ergonomic parameters. We become successful for developing the app named "HPDI Ergon" for biomechanical evaluation of agricultural activities using HPDI techniques. The HPDI Ergon is tested on sample data.

First of all the user have to do the registration in the app. After user registration there is the option for registering the details for each farmer on whom we can perform the drudgery analysis.

For BMI analysis the farmer's height and weight is entered and the farmer is evaluated by comparing the obtained value with the range wise category of BMI. The DSS will infer whether the farmer is suitable for further assessment. The calculated BMI, the entered height and weight are also stored in the database.

For PFI first of all the farmers whom we want to evaluate is to be selected and allowed to do an activity for 5 minutes or 300 seconds. After that the required inputs which are the three heart rates at 1st, 2nd and 3rd minute of recovery are entered and the PFI value is calculated by clicking on the "Submit" button. By comparing the obtained PFI value with the range of PFI values screen the selected farmer is evaluated. In the mobile application Energy Expenditure Rate, Cardiac Cost of Work, Cardiac Cost of Recovery and

other ergonomics parameters can be calculated. For HPDI After inputting all values of all the parameters, the HPDI value along with values of the coefficients of the parameters are given by the DSS.

The DSS is developed, tested and validated using the sample data. The system provides accurate results and it is helpful for finding the drudgery prone activities in agriculture and also helps to identify the part of activity which is causing the drudgery and therefore reducing it by adopting new tools or by changing the traditional method of cultural practices. The target beneficiaries for the uses of mobile application are researchers, agricultural engineers, developers and evaluators of farm tools and machineries on ergonomics protocol.

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