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A Mobile based Decision Support System for Postural Evaluation of Agricultural Activities with Rapid Entire Body Assessment (REBA)

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SUMMARY

Agriculture is an unorganized sector and it is a very high drudgery prone profession due to the absence of awareness and entry of advanced agricultural technologies. Many farming activities and operations are carried out by farm workers in the agriculture sector, where they are subject to very poor working conditions which can lead to physical and mental stress. Workers in agriculture experience musculoskeletal disorders in various body parts throughout various agricultural operations. These problems are caused by heavy work loads, repetitive movements, uncomfortable postures, prolonged periods of time spent in neutral or unsupported positions and the use of conventional equipment and implements that are not ergonomically built. The ergonomic risk factors present in the workplace can be examined using various evaluation instruments to ascertain the workers abilities and drawbacks. The work-related risks are measured using the scientifically validated posture assessment instruments. Rapid entire body assessment (REBA) is a technique that assess a person's complete body including wrists, fore arms, elbows, shoulders, neck, trunk, back, legs and knees. It uses a systematic process to find the postural musculoskeletal disorders and risks associated with the job tasks. A mobile application is developed to assess the agricultural activities on the basis of physiological analysis and postural analysis using REBA ergonomics technique. The application evaluates the drudgery involved in the agricultural work by using physical assessment followed by postural ergonomics methods and provide recommendation of correct posture to avoid developing musculoskeletal disorders.

Keywords: Drudgery; Postural assessment; REBA; Mobile application.

1. INTRODUCTION

A significant portion of India's human resource base is employed in labour-intensive agriculture. Throughout various agricultural tasks, agricultural labourers suffer from musculoskeletal diseases in various body areas(Ojha *et al.,* 2017). Farmworkers perform a good deal of labour-intensive, continuous, manual labour in the fields. Agriculture is one of the most dangerous fields of work requiring labour-intensive operations and, in many countries, it shows high levels of musculoskeletal disorders (MSDs). The causes of MSDs in agriculture are the result of heavy pressure, constant motion, uncomfortable working postures, a long time working in sitting conditions, and the use of conventional tools and implements that are not ergonomically built (Joshi *et al.,* 2014). Different types of work-related MSDs are described among women. These include disorders of the back and neck, nerve entrapment syndromes, musculoskeletal disorders such as tenosynovitis, tendinitis, peri-tendinitis, epicondylitis, and nonspecific muscle and forearm tenderness (Devi *et al.,* 2019). The majority of the farm women reported musculoskeletal problems is non-specific and lacks a well-defined clinical diagnosis. The prevalence of specific disorders and syndromes are not precisely known since many of these disorders have been difficult to classify in epidemiologic studies

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(Halim *et al.,* 2014). Various evaluation devices used to measure the ergonomic threat elements intricate in the working environment for assessing the capacities and limitations of the worker. The evaluation tools like Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA; mentioned in Abhishek *et al.*, 2019) used to measure the work related risks. According to ergonomics research manual load carrying causes spinal loading that can lead to disc degeneration and musculoskeletal disorders (Kuiper *et al.,* 1999). Carrying load on the head has also been linked to accelerated cervical spondylitis (Joosab *et al.*, 1994; Jager *et al.,* 1997). According to Boocock *et al.,* (1994) it is rather frequent for occupational tasks that require a prolonged posture in the lumber region(overhead labor) to cause compressive stresses that pose biomechanical concerns.. Hignett and McAtamney (2000) developed a new tool that included human load interface(coupling), dynamic and static postural loading variables, and a novel idea of an upper limb position supported by gravity.

REBA is a postural assessment technique that provides a quick and simple way to assess the different working postures for the risk of WMSD's in a range of working positions. The REBA technique measures various agricultural work-related postures and musculoskeletal condition risk variables where the worker's full body is employed in the task. The body is divided into portions that are classified independently based on movement planes, and a scoring system for muscle activity across the complete body -whether it is idle, dynamic, rapidly changing, unsteady, or involving manual handling may occur these are referred to as a coupling score as it is significant in the loads handling but may not always be using the hands. The intensity of MSD experienced by operators working under specific settings is explained by the REBA score.

With the fast-technological improvement, the propagation of the internet, and globalization, the role of technology has changed from supporting corporations to transforming them. The Digital India agenda is a flagship schedule of the Government of India with a dream to change India into a digitally empowered society and knowledge economy. We will revitalize and revamp the extension programs in such a way that they can more effectively reach the farmers. The evolution of the "Decision Support System for Postural Assessment of Agricultural Activities with Rapid Entire Body Assessment (REBA) Technique" is an effort in this direction.

For more than 40 years in agriculture and related fields computers have been used. The fields of use of this system have grown from many current applications of agricultural research such as control, assessment and information processing, education and training programs, broadcasting, and support for decision making. Owing to the possibility of data collection and dissemination, the use of computers has improved the knowledge as well as the capacity of various departments (Sharda *et al.,* 1988). The recent advancements in computing and communication technologies have made use of software and hardware much simpler have been allowed the flow of information use quicker. Decision Support System (DSS) is a synergistic tool that provides computer-based modelling structure and expertise to support conclusion making processes, helps clarify the problem, explores various possible action paths, their impacts and promote sensitivity analysis. A mobile application is a kind of application software intended to run on a mobile phone. They are by and large small, individual software units with restricted capacity and can be downloaded easily on mobile phones for using them anytime, anywhere. They often serve to furnish clients with data, information and knowledge related to a specific area. A DSS for postural assessment of agricultural activities with REBA is a mobile application which will be helpful for physiological and postural assessment of persons involved continuously in physical work such as agricultural activities. It will provide recommendation of correct posture to avoid developing musculoskeletal disorders.

2. MATERIALS AND METHODS

To develop the proposed DSS various software and tools are used such as JAVA programming language, XML, Android Platforms, DB Browser to design, create and edit database files with the SQLite, JAVA Libraries, Android Studio IDE used to develop the Android app, SQLite is the open-source relational database used to store data on the device in the form of text files 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.

2.1 System Architecture

The Mobile based DSS for Evaluation of Postural Ergonomics using REBA (MDSS-REBA) is developed on Android platform. The MDSS is connected to the SQLite which provides database service for data storage and web related services.

The Android based DSS is composed of more than one component written in Java classes. Communications allying the application and SQLite is shown in Fig. 1 and the information flow of the system is shown in Fig. 2 as follows:

There are two parts in the Architecture of the App, in the first part there is a physiological analysis, and in the second part, there is a postural analysis.

In the preliminary stage of development of the DSS, the table data has been stored in the SQLite in the background.

After completion of database storage, useful data is retrieved from the SQLite.

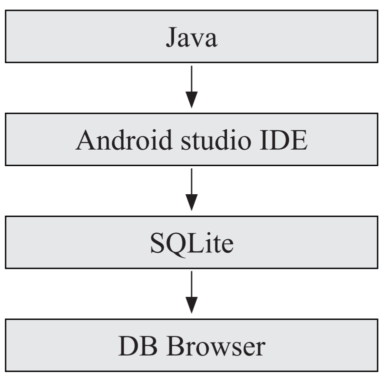

Fig. 1. Architecture of Mobile based DSS '*REBA*'

Research work analysis of the farmers and their farm work has been done based on physiological and psychological ergonomics parameters, such as Body Mass Index (BMI), Physical Fitness Index (PFI), Energy Expenditure Rate (EER), Total Cardiac Cost of Work (TCCW), Physiological Cost of Work (PCW) and Human Physical Drudgery Index (HPDI). First, the farmer's health is evaluated using the PFI and BMI. Only when the results of both parameters fall within a reasonable range then we will move on to the study of 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:

$$\text{BMI} = \text{Weight (kg)}/\text{Height}^2\ \text{(m)} \quad (1)$$

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

$$\text{PFI} = (\text{Duration of activity}/\ (\text{sum of I, II and III minutes of recovery of HR}))\ *\ 100 \quad (2)$$

$$\text{Energy Expenditure Rate (EER)} = 0.159 \times \text{heart Rate (b/min)} - 8.72 \quad (3)$$

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) (Singh *et al.* 2008).

$$\text{CCW} = \Delta\ \text{HR. tA} \quad (4)$$

where, CCW=Cardiac Cost of Work ΔHR=Mean Working heart Rate – Mean Resting heart Rate tA = Duration of Activity.

$$\text{CCR} = (\text{AhR recovery} - \text{AhR rest}).\ \text{tR} \quad (5)$$

where, CCR = Cardiac Cost of Work AhR recovery = Average Recovery heart Rate,

AhR rest = Average Resting heart Rate, tR = Duration of Recovery.

$$\text{TCCW} = \text{CCW} + \text{CCR} \quad (6)$$

Where, TCCW = Total Cardiac Cost of Work.

$$\text{PCW} = \text{TCCW}/\text{tA} \quad (7)$$

Where, PCW = Physiological Cost of Work.

The complete workflow of mobile based decision support system REBA is shown in Fig 2.

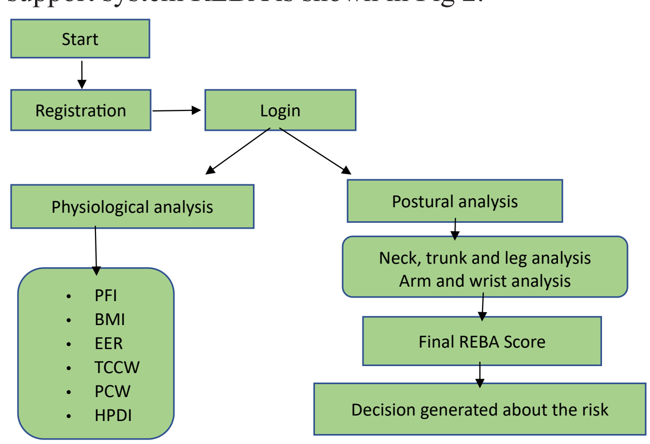

Fig. 2. Work flow of REBA Mobile application

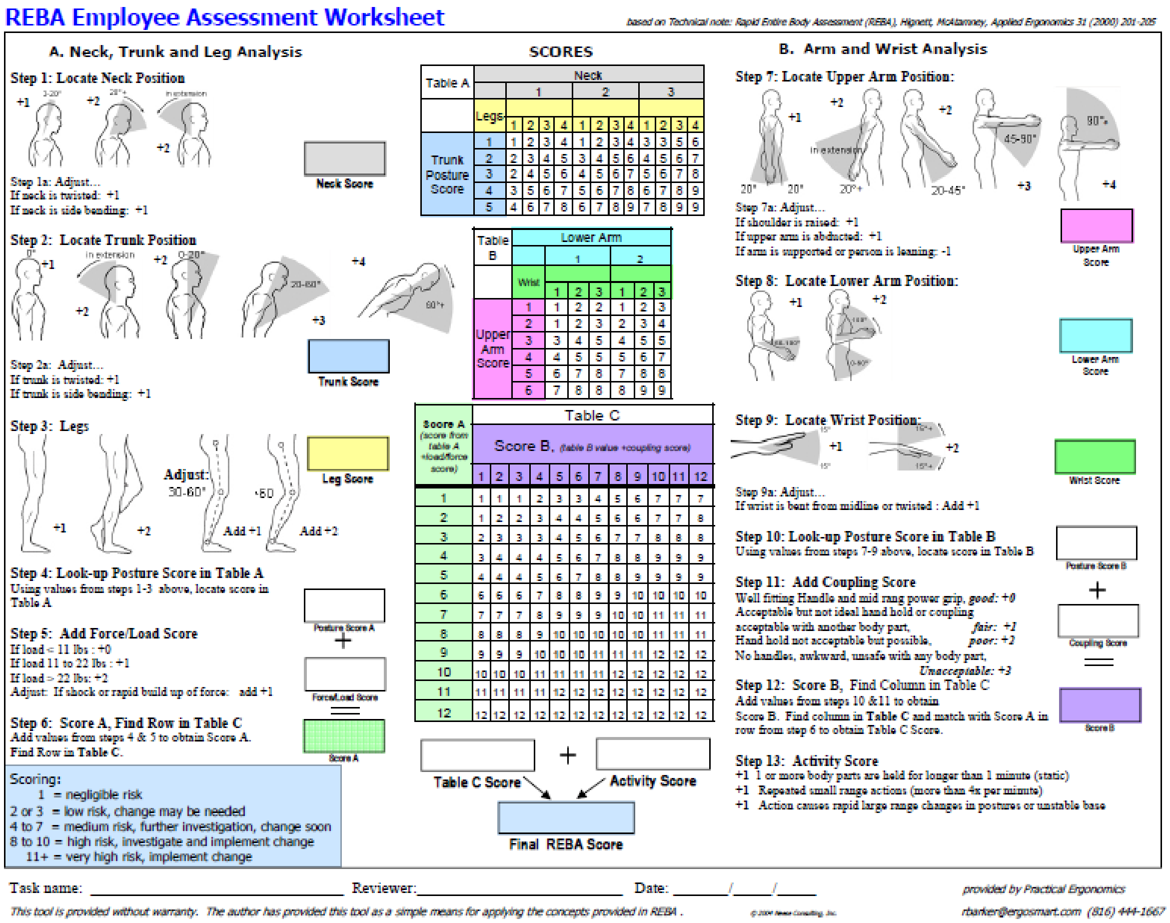

Fig. 3. REBA Employee Assessment worksheet

The postural analysis has been done with the aid of the REBA Employee assessment worksheet (Fig 3), which includes multiple postures for each body part. The sheet is segmented into different body segments named as A and B. The study of the neck, trunk, and legs is intended for the left side segment A. The analysis of the Arm and Wrist analysis is shown in right side segment B. The worksheet's segmentation attests to any difficulty or forced postures of the legs, trunk, or neck that may have an impact on the postures of the analysis includes the Arms and Wrist, Each region has a posture grading system and it was necessary to look into and account for extra modification in the score.

The work flow of postural analysis scoring is shown in Fig. 4.

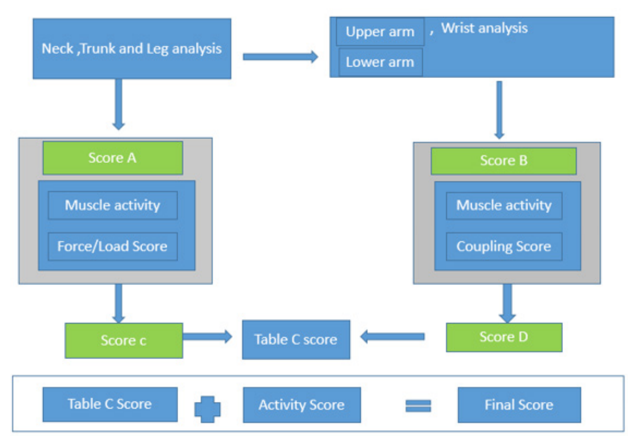

Fig. 4. Work flow of Postural analysis using DSS

The Score A for postures is first computed for (Neck, Trunk, and Legs) postures as per REBA assessment worksheet, then Score C for these postures is computed by adding Muscle Activity and Force/Load Scores to Score A. Score B for (Upper Arms, Lower Arms, and Wrists) postures is computed as per REBA assessment worksheet, Score D is then computed for these postures by adding Muscle Activity and Force/Load Score to Score B. Table C score is computed from Score C and

Score D and then the Final Postural score is computed by adding the Activity Score to Table C Score.

3. RESULTS AND DISCUSSION

An android based mobile app has been developed under the study which supports decision making regarding the extent of drudgery involved and desired course of action for the agricultural activity performed. The application's primary goal is to assess different agricultural tasks using various ergonomic metrices and recommend appropriate postures. The app "***REBA***" has been successfully developed for postural ergonomics for the activities where upper and lower body extremities are used simultaneously such as transplanting, load carrying etc. The mobile based decision support system is developed for analysing the drudgery that is involved in the various agricultural activities performed by the farmers as a part of crop production practices using the rapid entire body assessment technique to provide a decision regarding the extent of drudgery involved and desired course of action in the performed activity. The mobile application is tested on sample data across various mobile devices and operating systems and the results are shown in Fig. 5 and 6.

Fig. 5 represents the calculated values of physiological analysis and the category under which the agriculture worker falls. Based on calculated PFI values, the worker falls under the category of Good/ Very Good/ Excellent. Based on the calculated BMI values, the worker falls under the category of low weight/ normal/ overweight etc. Fig. 6 represents the calculated values of postural analysis. In postural analysis, score is given to each body posture then final REBA score is calculated. The final REBA score is compared with table then level of MSD risk is displayed.

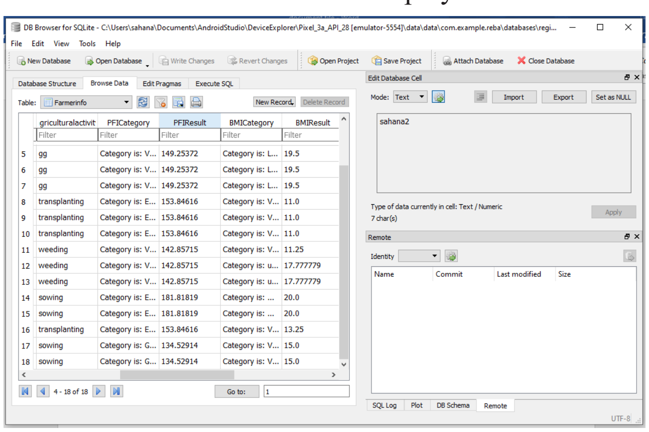

Fig. 5. Physiological Analysis Results from REBA Database

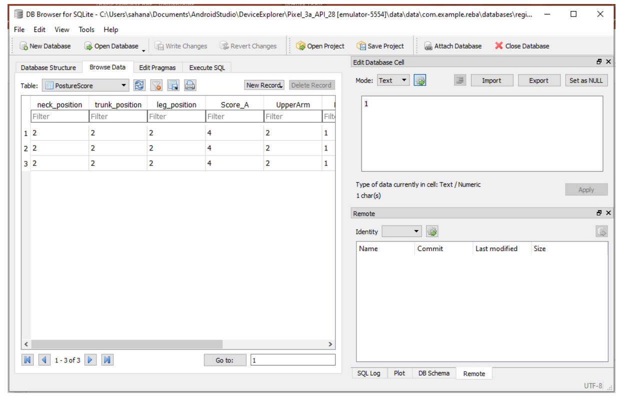

Fig. 6. Postural Analysis Results from REBA Database

Users can use the REBA application only after the successful registration. Registration requires some information, by providing those requirements users can register to the app as shown in Fig. 7. Following user registration there is a feature to register each farmer's details so that we can analyze the drudgery. There are two options available to the user. One is if the user is new then he or she don't have any farmer registered under him or her. So he or she must have to register the details of the farmer on whom he or she wants to perform biomechanical analysis. In that case the user has to click on the button "Register New farmer". Then the user has to enter the name, age, village, district and state of the farmer. There will be a list of farmer will be shown on the screen who are registered under that particular user. We can proceed further by selecting the desired farmer. If the user who is an old user wants to show the farmer list which was made by him or her and also wants to perform the Biomechanical and drudgery analysis on those previously registered farmers. For executing this requirement, the button "Show Existing Farmer" is used and similarly we can proceed by selecting one farmer from the list.

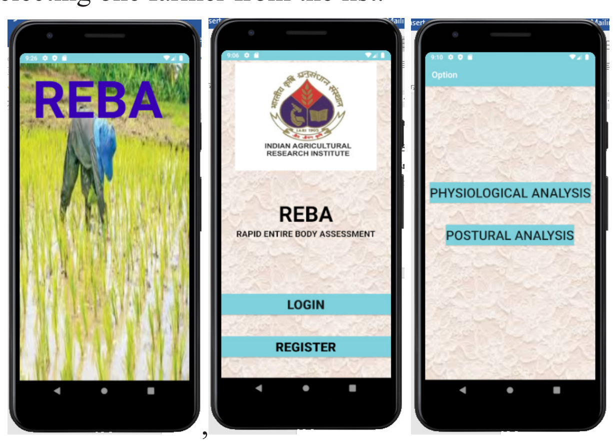

Fig. 7. Estimation of drudgery using REBA

3.1 Physiological Analysis

The farmer is evaluated by comparing the BMI analysis's resultant value with the range wise category of BMI, as seen in Fig. 8, which displays the evaluated data for physiological analysis. The farmer's height and weight are entered for the analysis. The farmer's eligibility for will be decided by the DSS. The entered weight and height, as well as the computed BMI, are also kept 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.

The Energy Expenditure Rate (EER) is calculated based upon the value of heart rate in working condition. Besides the EER the circulatory stress experienced by the agricultural workers during working can also be calculated using Cardiac Cost of Work (CCW) and Cardiac Cost of Recovery (CCR). The TCCW and PCW is calculated using the DSS where TCCW is dependent upon CCW and CCR and PCW is evaluated using TCCW and Duration of Work.

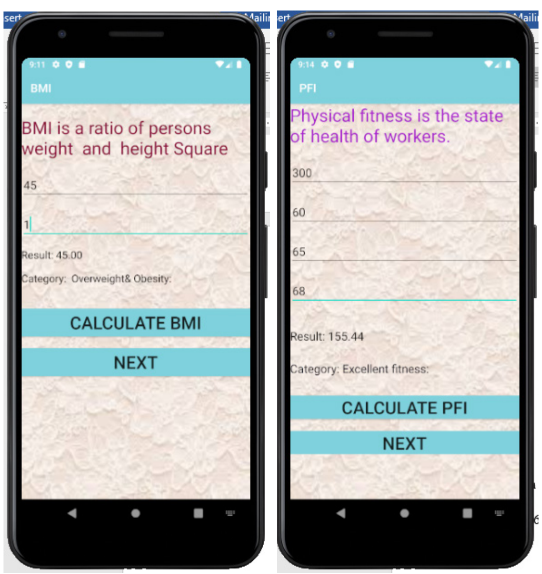

Fig. 8. Physiological analysis

3.2 Postural Analysis

Postural analysis has been done with the aid of the REBA Employee assessment worksheet, which includes multiple postures for each body part.

3.2.1 Neck Analysis

The degree of neck flexion or extension and any necessary corrections for neck twisting or side bending (lateral flexion) are used to evaluate neck posture, as shown in Fig. 9.

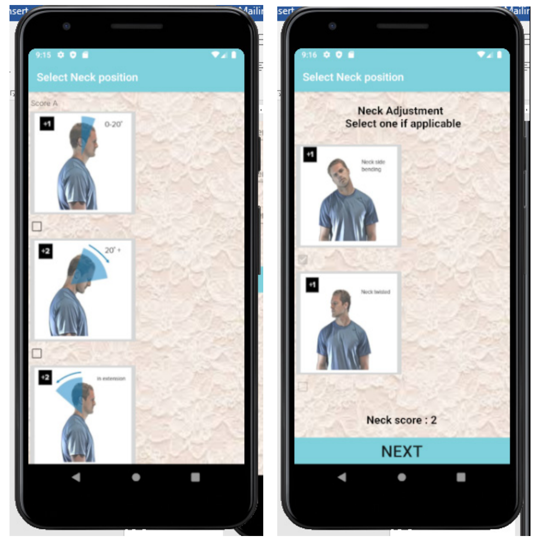

Fig. 9. Neck analysis

3.2.2 Trunk Analysis

As seen in Fig. 10, the degree of trunk flexion or extension as well as any necessary adjustments for trunk twisting or side bending (lateral flexion) are used to evaluate the trunk.

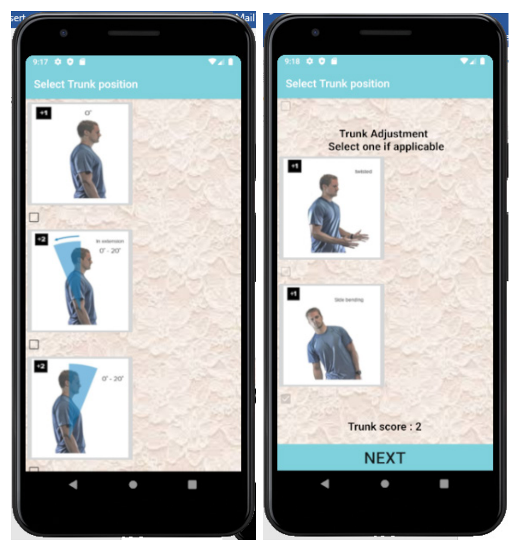

Fig. 10. Trunk Analysis

3.2.3 Leg Analysis

Bilateral or unilateral weight bearing on the legs, along with any knee adjustment, are the basis for evaluating the leg. Knee flexion is defined as the bending angle at the knee joint between the limb's femur and tibia bones. Score A (Neck , Trunk, Leg analysis) is also computed as seen in Fig. 11.

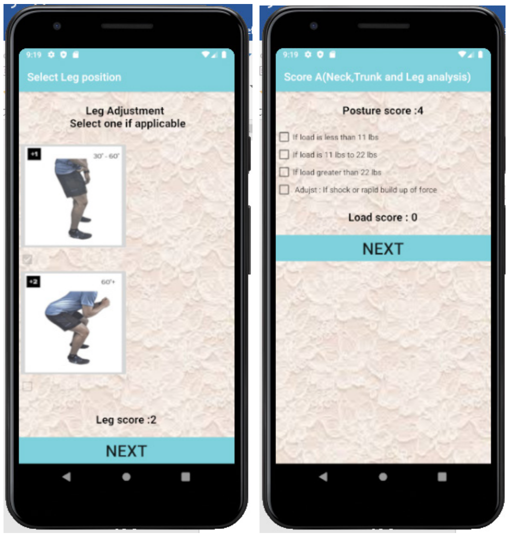

Fig. 11. Leg Analysis

3.2.4 Arm analysis

The degree of shoulder flexion or extension and a correction for the elevated shoulder as seen in Fig. 12, are the basis for evaluating the arm.

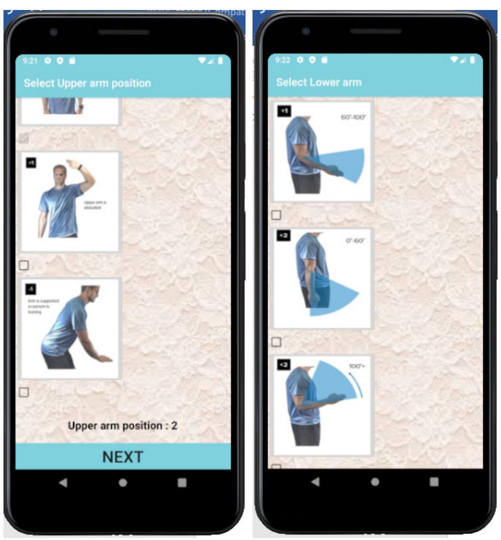

Fig. 12. Arm assessment

3.2.5 Wrist analysis

Evaluation of the Wrist is based on the degree of wrist flexion or extension, as well as any correction for wrist deviation or twisting and score B (Arm and wrist analysis) is calculated as shown in Fig. 13 and 14 represents the posture data score of tested data.

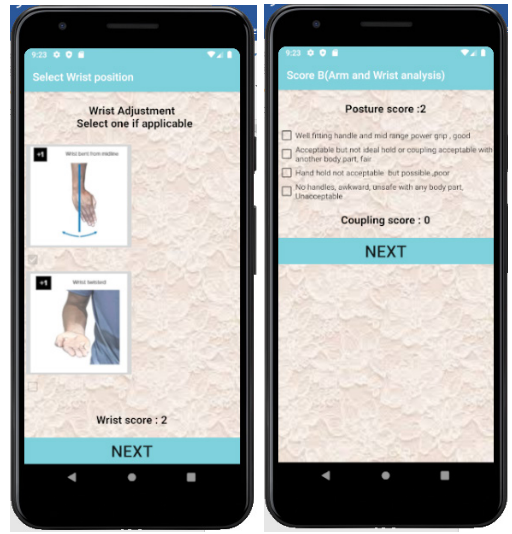

Fig. 13. Wrist Analysis

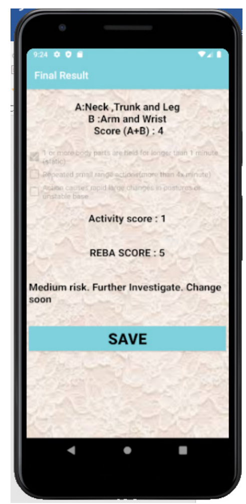

Fig. 14. Final REBA score

The REBA Score for the activities is provided in Fig15, along with a recommendation for the next course of action and the level of Musculoskeletal risk. The characterization of score refers to score 1 (negligible risk, no action required), score 2-3 (low risk, change may be needed), score 4-7 (medium risk, further investigation, change soon), score 8-10 (high risk, investigating and implement change) and score 11 or more (very high risk and implement change).

Score	Level of MSD risk
1	Negligible risk, no action required
2-3	Low risk, change may be needed
4-7	Medium risk, further investigation, change soon
8-10	High risk, investigating and implement change
11+	Very high risk, implement change

Fig. 15. Level of MSD risk

4. CONCLUSION

The Mobile based decision support system for assessing working posture and physiological analysis during agricultural activities is developed to avoid the musculoskeletal disorders of rural workers and improve health. DSS performs various calculations, access data from the database stored in tables, and provides results, reports and recommendations. The developed MDSS-REBA has been tested with compatibility, usability and exploratory testing methods and vindicate using the sample data for physiological and postural assessment of MSDs. The system provided accurate results with REBA score 5 as medium risk, further investigation is required and change the body posture soon which were verified by the evaluators. It is useful for identifying the agricultural tasks that are labor intensive. It also helps in determining the portion of a task that is producing drudgery so that it can be reduced by implementing new techniques or altering customary cultural behaviors. The application will interact with the database internally in order to access as well as store data from the database. The results discuss the output of the research and also explains the flow of DSS. It displays the decision support system interface that connects with the end user straight away. Researchers, agricultural engineers, developers and evaluators of farm tools and machineries on ergonomics protocol are the intended beneficiaries of the mobile application.

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REFERENCES

Abhishek, M.P., Kumar, M., Joshi, P., Dahiya, S., Arora, A. and Pal, S. (2019). Development and validation of mobile based decision support system for postural assessment of agricultural activities using rapid upper limb assessment (RULA) technique. Progressive

Research. 14: 335-337.

Boocock, M.G., Jackson, J.A., Burton, A.K. and Tillotson, K.M. (1994). Continuous measurement of lumber spinal posture using flexible electrogonionmeters. *Ergonomics,* 37: 175-85.

Devi, G.N., Mallikarjun, M., Reddy, P.N. and Kumar, M.R. (2019). Ergonomic Study on Drudgery Reduction Using Easy Planter for Transplanting Tomato Seedlings. *Int. J. Curr. Microbiol. App. Sci*, 8(7): 2499-2506.

Halim, I., Arep, H., Kamat, S. R., Abdullah, R., Omar, A.R. and Ismail, A.R. (2014). Development of a decision support system for analysis and solutions of prolonged standing in the workplace. *Safety and Health at Work*, 5(2): 97-105.

Hignett, S. and McAtamney, L. (2000). Rapid entire body assessment (REBA). *Applied Ergonomics*, *31*(2): 201-205.

Jager, M. and Luttmann, A. (1999). The load on the lumbar spine during asymmetrical bi-manual materials handling. *Ergonomics*, 35: 783-805.

Joosab, M., Torode, M. and Rao, P.V. (1994). Preliminary findings on the effect of load carrying to the structural integrity of the cervical spine. *Surgical and Radiologic Anatomy,* 16(4): 393-398.

Joshi, P., Jethi, R., Chandra, N., Roy, M L., Kharbikar, H.L. and Atheequlla, G.A. (2016). Ergonomics Assessment of Post Harvest Finger Millet Threshing for reducing Women Drudgery. *Indian Research Journal of Extension Education*, 15(1): 25-30.

Khayer, S. M., Patel, T. and Ningthoujam, B. (2019). Ergonomic Postural and Biomechanical Analysis of Manual Weeding Operation in Agriculture Using Digital Human Models. Springer, Singapore in *Research into Design for a Connected World* 41**:**451-62.

Kuiper, J.I., Burdorf, A., Verbeek, J.H. *et al.* (1999). Epidemiologic evidence on manual materials handling as a risk factor for back disorders: a systematic review. *International Journal of Industrial Ergonomics*, 24: 389–404.

Ojha P, Poonam S. and Abha S. 2017. Assessment of drudgery level of female farm workers involved in sugarcane cultivation. *Asian Journal of Home Science*. 12(1): 205-7.

Sharda R, Barr S.H. and McDonnell J. C. 1988. Decision support system effectiveness: a review and an empirical test. *Management science*. 34(2): 139-59.

Singh S.P., Gite L.P., Majumder J. and Agarwal N. 2008. Aerobic capacity of farmwomen using sub-maximal exercise technique on tread mill. *Agricultural Engineering International: the CIGRE Journal.* Manuscript MES 08 (10): 1-10.

Mallick, P. (2016). Mobile Application for Plant Quarantine Regulations to Import in India. M.Sc. Thesis Dissertation, IASRI, New Delhi.

Priyadarshini, S. (2016). Mobile App for Chlorophyll Content Estimation in Rice. M.Sc. Thesis Dissertation, IASRI, New Delhi.

Pal, A., De, S., Sengupta, P., Maity, P., and Dhara, P.C. (2015). Evaluation of work related musculoskeletal disorder and postural stress among female potato cultivators in West Bengal, India. *Ergonomics SA: Journal of the Ergonomics Society of South Africa*, *27*(1), 46-64.

Sung, K., and Freivalds, A. (2014)). Evaluating both Physiological and Biomechanical Strains in Women Using Different Hoe Handle Designs. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 58, No. 1, pp. 1795-1799). Sage CA: Los Angeles, CA: SAGE Publications.

Sonkusle, L. (2018). Mobile App for Ergonomics assessment of Drudgery prone activities in agriculture (master's thesis). Indian Agricultural Statistics Research Institute, IARI, New Delhi.

Tutorial, XML (2006). W3Schools. Available at: http://www.w3schools. Com/xml /default.asp.

Vasudevan, S. and Misra, K.D. (2016). Sourcebook on Drudgery Reduction Technologies for Women in Rural Areas. Vigyan Prasar, 25-95.