

## Assessment of a Safe Work-Impulse for Farmers: A Case Study of Ilara-Mokin, Ondo State, Nigeria

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### Abstract

The study measured the heart rates of farmers in Ilara-mokin while they carried out a few regular farm tasks with a view to create a safe work-impulse chart for farmers in that locality. This is expected to provide the information required for the adequate use of muscular force and the prevention of fatigue or physical exertion, during farming. Farmers who were available and were willing to participate in the study were divided into five age groups, such as below 25, 25-34, 35-44, 45-54, and above 54 years, and their heart rates were monitored and recorded under three different categories of farm activities or load (light load, medium load, and heavy load) using a premium pressure monitor with comfit cuff. The load multiply by the gravity and time at which the farmers feel a sense of discomfort or tiredness were used to evaluate the safe work-impulse for each category of activities. The result shows that farmers below 45 years of age record a work-impulse of about 9.0M kNs and 7.2H kNs for medium and heavy loads respectively while older farmers manage to sustain medium and heavy loads at a work-impulse of 7.2M kNs, 5.4M kNs and 9.0M kNs, 5.4M kNs respectively. In conclusion, the study revealed that while farmers of any age can handle a light activity for a longer period of time than 18 minutes, they may not be able to sustain heavier loads for a longer period.

## 1. Introduction

Nigeria is primarily an agrarian country, and the agricultural industry has played a significant role in the country's socioeconomic development [1]-[4] considering that in Nigeria, cassava is the most extensively grown crop [3]-[6]. When it comes to both workplace injuries and occupational diseases, the agricultural industry is among the most dangerous areas of all economic activity [7]-[9]. Due to the harsh working environment, long working hours, physically demanding work, and the usage of basic farm tools, the working circumstances in Nigeria are exceedingly challenging. Musculoskeletal Disorders (MSDs), which have been identified as the most prevalent of all safety hazards in agriculture, might occur as a result of the exceeding strenuous working conditions [1],[10]-[12].

A survey of farm activities in Ilara-Mokin shows that farmers perform their work through various activities such as land clearing, weeding, cutting, applying fertilizers, mixing, spraying pesticides, harvesting, ridges formation, breaking, drying, packaging, manual lifting, and many more. In addition, their work postures comprise awkward body bending, stooping, repetitive movement, daily prolonged working, and awkward neck bending, heavy manual lifting [13]-[15]. A lot of people are also not aware of safe and healthy working circumstances, like the risk associated with repetitive activities [13]-[17]. All of these are regarded as greater risk factors than others for fatigue and musculoskeletal complaints among farmers [18].

Physical activity, which is prevalent among farmers, causes muscle exhaustion, which is a function of the imposed load on the muscles [18]-[19]. Its severity is influenced by the nature of activity, frequency, and duration of applying force or load to the muscle. Fatigue (physical exertion) can be measured in a number of ways which include heart rate measurement, biomechanical manifestation through intracellular pH change, blood samples, and electromyography or measuring oxygen consumption; and the limits for continuous work can be derived accordingly [19]-[22]. A different approach is to count the number of items moved, the overall weight lifted during the day, or the number of specific tasks completed in a given period of time [18],[22].

Work-impulse can be described as the maximum sustainable cardiovascular effort an individual can maintain before fatigue or risk of overexertion occurs. It is typically associated with the heartrate threshold beyond which aerobic capacity is exceeded and anaerobic process dominates [23]-[24]. This threshold, often measures as a percentage of maximum heartrate, indicates the upper boundary of efficient cardiovascular performance. Exceeding the work-impulse can lead to rapid fatigue, decreasing performance, and potential health risk [25]. Monitoring heartrate during exercise helps individual stay within safe limit and optimize training intensity for endurance and performance[26]-[29].

Among farmers, safe work-impulse refers to the maximum heart rate a farmer attains while working on the farm before fatigue or tiredness begins to set in. Meanwhile, farmers experience visible exhaustion from manual material handling while performing various farm tasks [30]. The number of times the heart beats per time, or heart rate, is a reliable indicator of the functional demands of a job on a worker and it is often influenced by age and is also thought to fluctuate with activity or exercise [21],[30]-[32]. Despite the fact that the heart rate steadily increases during exercises and repeated tasks; and eventually decreases after exercise, the maximum heart rate is the highest heart rate that a person attains without experiencing serious health consequences [31]-[34].

Consequently, this study was conceived to assess the heart rate of farmers in Ilara-mokin when performing some farm operations common among them with a view to developing a safe work-impulse chart for farmers in that locality. This is expected to provide the information required for adequate use of muscular force and prevention of fatigue or physical exertion among farmers.

## 2. Methods

### 2.1 Selection of Farmers for the Experiments

Farmers involved in food and cash crop production in Ilara-mokin, Ondo State, were carefully surveyed. Farmers who were available and were willing to participate in the study were divided into five age groups, including those below 25, 25-34, 35-44, 45-54, and above 54 years with sample size 11, 35, 39, 26 and 3 respectively as described by Abiola et al. [31]. Though, the distribution of farmers in Ero, Community, Reserve, Ijare, and Ipogun; all in ilara-mokin were male and female as well as the young and the old, only the male farmers were considered so as to avoid faith/sex violation.

The participants were explicitly informed of the inherent risk prior to the start of the experiment, and their consent to participate as test subjects was obtained. Additionally, the protocols for the experiments and the research methodologies were explained to the participants.

### 2.2 Farm Activities and Load Classifications

The different farm activities shown in Figure 1 and involved in this experiment are ridges making, stem insertion into ridges, and land clearing. These activities were selected from the several activities involved in cassava farming shown Table 1, which is a major crop farming in Ilara-mokin. These three activities were carefully selected with a view to classifying them into light, medium, and heavy activity or load with the assumption that it required more effort or energy to make ridges while it takes lesser effort to insert stems into already made ridges as elicited from farmers in that locality during the survey. Thus, the insertion of cassava stems into ridges (Fig. 1a) was classified as light activity/load, land clearing (Fig. 1b) as medium load, and ridge making (Fig. 1c) as a heavy load.



**Fig. 1** Selected farm activities in cassava farming (a) Light load: Insertion of cassava stem in ridges; (b) Medium load: Land clearing; (c) Heavy load: Ridge making

**Table 1** Major cassava farm activities and their corresponding load classification

Cassava farm activities	Classification
Land clearing	Medium load
Ridge making	Heavy load
Insertion of cassava stem in ridges	Light load
Wetting	Light load
Weeding	Medium load
Spraying of insecticides	Medium load

### 2.3 Measurement of Heart Rate of Farmers

The heart rates of farmers, selected for each age group classification were measured using a premium pressure monitor with Comfit Cuff (Double Model: G12 blood pressure monitor) shown in Fig. 2. Each farmer subject was made to carry out each of the activities (light load: insertion of cassava stem into ridges, medium load: weeding, and heavy load: making of ridges); maintaining a typical work posture (bending) found to be common and associated with farmers involved in these cassava farming activities in the study area. The heart rate of each subject was measured after every hour to ensure subjects were fit enough for the next experiment [23].



**Fig. 2** Premium pressure monitor with Comfit Cuff

The cuff was applied to the left upper arm of the subjects, as described by Abiola et al., [31]. Prior to the start of any activity, each subject's heart rate was obtained. This was recorded as the subject's control heart rate. The farmers' subsequent heart rates were then measured as they performed the recommended farm tasks. For the

following 18 minutes, the heart rates were tracked every 3 minutes [23],[31] and were replicated 3 times for each activity. The results were then analysed using the descriptive statistical analysis on Microft Excel 97-2003 Worksheet.

## 2.4 Estimation of Work-Impulse

The safe work-impulse for each activity was established for each group. In each farm activity or load classification, an increase in heart rate was plotted against work-impulse. The time at which the farmers feel discomfort or get tired was identified as the safe work limit and was used to determine safe work-impulse as shown in Equation 1 [31]. At this point the farmers have the maximum heart rate.

$$I = L \cdot g \cdot t \quad (1)$$

Where I is the work-impulse in Ns; L is the amount of load handled by the farmers in kg; t is the time of maximum heart rate occurrence in seconds, and g is the acceleration due to gravity taken as 10 m/s<sup>2</sup> [31].

The load is indicated by the farm activity which is repetitively handled by the farmers. While work-impulse was considered as the force applied by farmers over time, safe work-impulse is taken as the work limit at the exhaustion of each farmer. It is referred to as the work-impulse at which the heart rate of farmers reached its maximum, due to fatigue or tiredness. Consequently, the safe work-impulse for farmers repetitively handling the different categories of load or activity (light load, insertion of cassava stems into ridges; medium, weeding; and heavy, ridge making) was established.

## 3. Result and Discussion

### 3.1 Heartrate of Farmers

The result of farmers' heart rate shown in Table 2 indicates that the heart rate progressively decreases as age increases. While the minimum heart rate recorded in Table 2 reflects the normal heart rate of the farmers when they have not handled any load or done any work. The maximum heart rate is the peak heart rate recorded for farmers handling each category of work. The average heart rate recorded by farmers below the age of 25 years handling light load (insertion of stems into ridges) is 98.7 bpm, medium load (land clearing) is 106.7 bpm, and heavy load (ridges formation) is 107.4 bpm. Farmers between 25-34 years handling light, medium, and heavy load record an average heart rate of 92.7 bpm, 100.8 bpm, and 102.2 bpm respectively. Those between 35-44 years, 45-54 years, and above 54 years record a heart rate of 89.7 bpm, 99.9 bpm, and 100.8 bpm; 84.0 bpm, 91.5 bpm, and 93.1 bpm; and 71.6 bpm, 76.0 bpm, and 73.6 bpm for light, medium and heavy load respectively. The result reveals that the amount of energy required to carry out an activity is dependent on how tedious the work is, as well as the time taken on the work which usually places a load on the cardiac. Thereby progressively increasing the heart rate. This was explained by Kweka [30] and Lunde et al. [35] as a cardiac cost of work which is a functional demand of work on the workers [36]-[37]. He reported that the amount of heart rate is a function of the level of work done by an individual. The average heart rates recorded in this study are similar to the heart rate (78.4±12.6 bpm to 113.0±18.4 bpm) reported by Mieda et al. [38] during trekking, unlike the higher values (66.75±6.18 bpm to 135.0±17.83bpm) reported by Kweka [30] during timber sawing activity. It is then easy to assume that timber sawing is a much heavier activity compared to farming while trekking is comparable to light activity in farming.

**Table 2** Heartrate of farmers handling different categories of load or activities in the farm

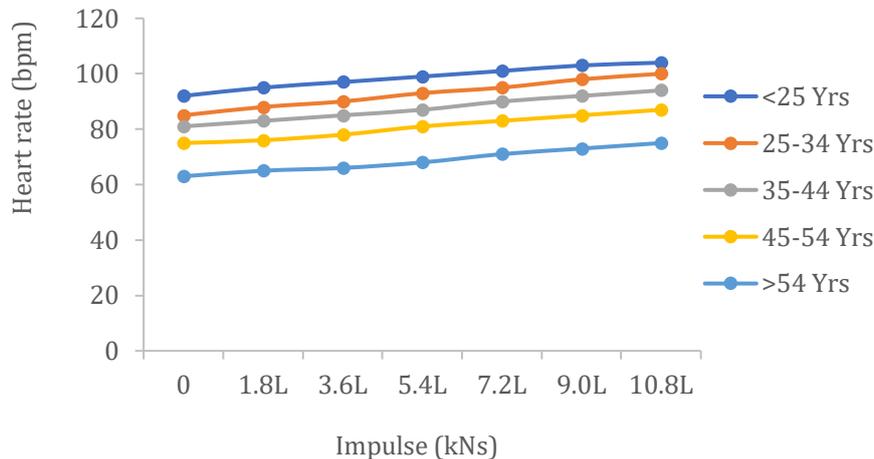
Age Group (Years)	Load (kg)	Heart rate (bpm)			
		Minimum	Maximum	Average	Standard Deviation
<25	LL	86	115	98.7	6.0
	ML	86	125	106.7	9.0
	HL	86	125	107.4	9.7
25-34	LL	77	105	92.7	6.4
	ML	77	124	100.8	11.1
	HL	77	123	102.2	11.1
35-44	LL	61	107	89.7	9.1
	ML	61	122	99.9	12.5
	HL	61	125	100.8	13.0

Age Group (Years)	Load (kg)	Heart rate (bpm)			
		Minimum	Maximum	Average	Standard Deviation
45-54	LL	62	100	84.0	8.5
	ML	62	120	91.5	12.2
	HL	62	120	93.1	12.4
>54	LL	54	86	71.6	8.3
	ML	54	98	76.0	12.1
	HL	54	97	73.6	12.4

LL, Light load; ML, Medium load; HL, Heavy load

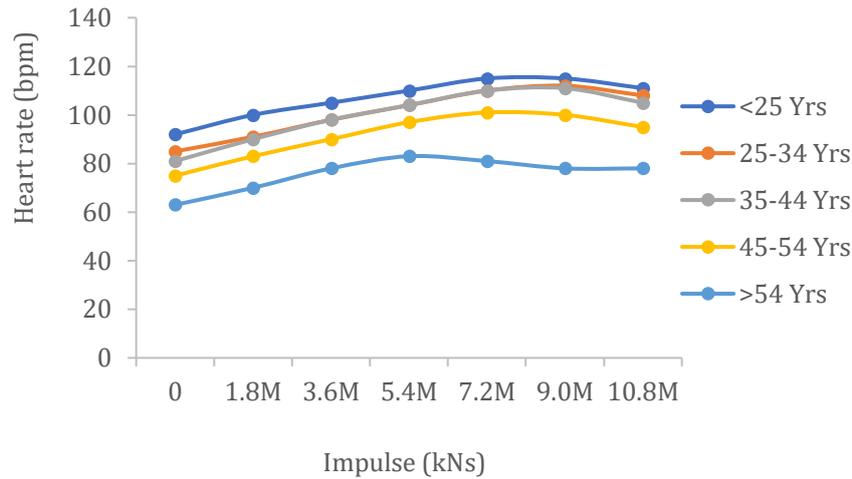
### 3.2 Safe Work-impulse

The maximum heart rate recorded by farmers with the maximum work-impulse of 10.8L kNs after 18 minutes is 75, 87, 94, 100, and 104 bpm for farmers below 25, 25-34, 35-44, 45-54, and above 54 years of age as shown in Fig. 3. The result shows that the force applied by a farmer of any age handling load progressively increases with heart rate without any sign of decline. This reveals that farmers involved in repetitive light activities like the insertion of stems into ridges may possibly be able to handle the activity for a period longer than 18 minutes used in this study.



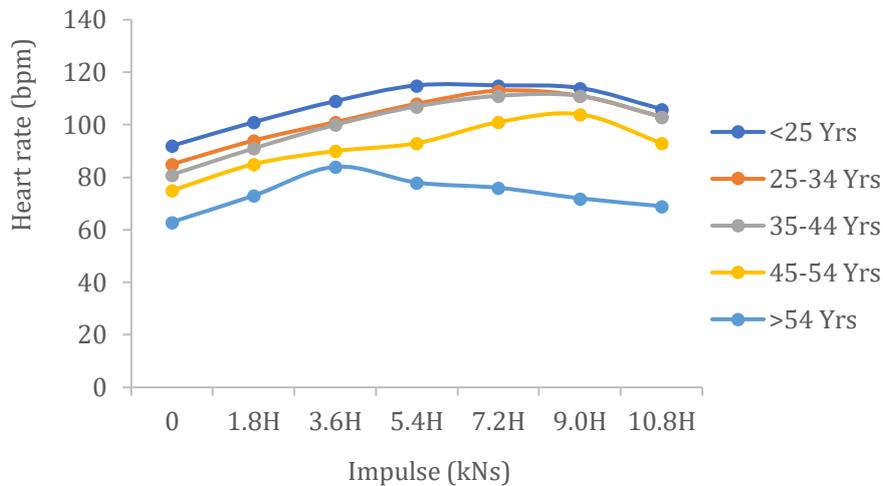
**Fig. 3** Safe work-impulse for farmers handling light load (where L: light)

The result shown in Fig. 4 indicates a decline in the heart rate of farmers at some stage. The heart rate of farmers continues to increase with the increase in time and as the farmers reach a certain impulse, the decline sets in. Farmers with ages below 25, 25-34, and 35-44 years begin to experience a decline in heart rate at an impulse of 9.0M kNs whereas those between 45-54 years experience a decline at an impulse of 7.2M kNs and those above 54 years at a lower impulse of 5.4M kNs. The stage at which the farmer's impulse begins to decline is the stage when the farmers begin to feel uncomfortable continuing with the load handling. At this stage, it is assumed that the farmers have reached the safe work-impulse level and are therefore exhausted, tired, and discomfort and can no longer continue with the activity [24]. It is then easy to assume that the age of a farmer has a direct implication on the force that a farmer can apply when handling any repetitive activity as evident in the study of Voss et al [39] and Rinsky-Halivni et al [40] which establishes that lower muscular strength in older people is responsible for the gradual deterioration in their physical strength. This may be due to increasing illness and impairment rates which reduce workers' capability and productivity [38], [41]-[43].



**Fig. 4** Safe work-impulse for farmers handling medium load (where M: Medium)

Fig. 5 shows more rapid exhaustion in farmers as they tend to assume discomfort at a lower work-impulse when handling heavier loads or activity compared to medium loads. Farmers below 25, 25-34 and 35-44 years old handling heavy activity appear to get exhausted at a work-impulse of 7.2H kNs, while those between 45-54 and above 54 years get exhausted at a work-impulse of 9.0H kNs and 5.4H kNs respectively. The lower heart rate recorded by older farmers handling medium and heavy loads may be due to a decline in strength capability in older people as suggested by Roman-Liu et al. [32]. Kweka [30] suggested a gradual decrease in heart rate after exhaustion but the sharp decline in the heart rate of farmers >54 years of age in Figure 5 may be due to insufficient sample size for that particular age group as higher sample size guarantee a more accurate result [41]-[44].



**Fig. 5** Safe work-impulse for farmers handling heavy load (where H: Heavy)

#### 4. Conclusion

This study assessed the heart rate responses of farmers in Ilara-Mokin, Nigeria, during typical cassava farming activities categorized by different workload intensity to determine age-specific safe work-impulses. Farming in this area involves in a lot of repetitive activities and manual material handling which has the capacity to increase occupational health hazards and musculoskeletal disorders among farmers.

Heart rate increases with workload intensity and decreases with age, indicating younger farmers can tolerate more physical exertion. Meanwhile, safe work-impulse thresholds vary significantly by age and task intensity, with younger farmers (<45 years) able to handle higher impulses and endure longer work durations without exhaustion.

Farmers below 45 years can safely work up to 9.0M kNs for medium load activities while those between 45-54 years up to 7.2M kNs, and those over 54 years, up to 5.4M kNs. For heavy loads, the safe limit for those under 45 is 7.2H kNs, for ages 45-54 is 6.0H kNs, and for those over 54 is 5.4H kNs. This implies that rest periods should be incorporated: every 15 minutes for medium loads and every 12 minutes for heavy loads, especially for older farmers.

The research emphasizes the importance of recognizing and respecting personal physical limits to minimize musculoskeletal disorders and occupational health risks. It advocates for work-rest cycles tailored by age and task type to enhance farmer safety and productivity.

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## Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

## Author Contribution

The authors confirm contribution to the paper as follows: **study conception and design:** Abiola O. A., Ogedengbe T. S.; **data collection:** Abiola O. A., Joseph O. I., Omonayin O. B.; **analysis and interpretation of results:** Abiola O. A., Ogedengbe T. S.; **draft manuscript preparation:** Abiola O. A. All authors reviewed the results and approved the final version of the manuscript.

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