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ORIGINAL ARTICLE

ERGONOMIC INTERVENTION STUDY AMONG WOODBALL PLAYERS

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This paper proposed a feasibility study on the ergonomics intervention among the Woodball athletes. The objectives of this study are to identify the ergonomics risk factors that may cause harm to Woodball athlete by using the Initial Ergonomic Risk Assessment (ERA) and the Advanced ERA method. The ergonomic assessment of an athlete was focussed on the three different woodball exercises, namely the tee-off comprising of short tee-off, medium tee-off and long tee-off. The advanced ergonomic risk assessments were performed on the upper body part of an athlete such as the neck, shoulder, upper arm, hand or wrist and upper back by using the RULA employee assessment worksheet. Based on the findings and assessment done, the proper body posture is then proposed through the observation from the results of the initial and advanced ERA. A simulation using the Human Digital Modelling (HDM) was also performed to better analyse the ergonomic aspect of the selective body postures. The results of the simulation were then compared to the results of the RULA assessment. The improvised results from the RULA analysis were found to be able to reduce the ergonomics risk of the current and improvised posture. The improvised posture will be useful for future studies in order to obtain a more ideal body posture for the Woodball players.

Keywords: Woodball, musculoskeletal disorders, awkward posture, ergonomics

1.0 Introduction

In Malaysia, the Woodball sport has been introduced by Thomas Kok in 1995. Woodball is a sport played with a wooden mallet and wooden balls, which is somewhat similar to golf. The aim of this sport is simple which is to strike the wooden balls through the gates. The

Woodball course should be sited on a tract of the grassy field or clay ground, and its fairways were designed for games and competition [1].

Player will use a mallet to strike a 9.5 cm diameter wooden ball from a Tee Box towards the scoring gate which positioned on a Green. The path that the ball takes must not fall outside a boundary line. The player then completes the Gate by causing the ball to pass through a gate shaped object formed by two wooden bottles placed 16 cm apart. Each strike of the ball is counted as a stroke and the object of the game is to play the lowest number of strokes to complete a Gate [2]. Next, Out of Bounds (OB) is referred to areas outside the boundary lines of each Gates. Add one stroke to a player's score in the penalty for OB. The main equipment of this sport is the mallet, ball, and gates that typically made of wood. Also, there are different size and material used for woodball's mallet. The mallet itself has three different sizes which are 'S', 'M', and 'L' that depends on the athlete's height. The equipment used in play should be conform with the stipulated specifications by the inspection of the International Woodball Federation [3].

Woodball requires coordinating the body, space and objects around it. For example, the movement that occurs when the athlete swings the mallet to hit the ball towards the target or gate. Most of the time, player's body posture is not consistent and not in ergonomic form when swinging the mallet. Thus, it can cause stress on a certain part of the body and the outcomes of the inaccuracy of hitting the ball. Based on the studies conducted by Aditama [4], the results revealed that the arm muscle strength and the grip strength have a very important role in the implementation of upper body movement. The arm muscle strength, the grip strength and the flexibility are used when performing swing stages namely backswing, downswing, impact, and follow through. The grip strength is used to strengthen the grip when mallet contact with the ball. When pushing the ball, there will be an impact with the ball. The arm muscles must also be able to be maximally mobilized to turn the swing into an appropriate shot and the back muscles as a support for the upper body to withstand the weight of the stick to shape a good body position to remain stable so that the shots will be great.

Sports injuries are burdens on both individuals and societies concerning the duration and nature of the treatment, amount of sporting and working time lost, permanent damage and disability, reduced quality of life, and monetary costs [5]. Hence, this study includes identifying the proper and suitable body postures that can be obtained by doing an observation. Also, other processes that involve in this project are identifying the ergonomic risk factors, identifying the critical dimensions related to the ergonomic problems and listing of the hazard analysis such as the musculoskeletal disorder (MSD), work-related stress and others.

2.0 Methodology

The ergonomic assessment methods are imperative to determine the risk factors associated with the Woodball players and to further evaluate the risk level of ergonomics exist the Woodball sport. The respondents for this study are the *active Woodball players* in the University Malaysia Perlis (UniMAP), consisting of specifically four (4) male players who have appeared in multiple intervarsities, intra-state and national competitions. The age range of the players is from twenty-three (23) years old to forty (40) years old. The activities assessed for ERA were short tee-off, medium tee-off and long tee-off. The duration taken for every activity was about six (6) seconds. The data were collected through video recording about forty (40) minutes at UniMAP Woodball fairway during the players performing the tee-off. The recorded video was then observed and assessed using the musculoskeletal assessment. The non-occupational data, such as the previous injury and congenital abnormalities, relevant to that of the musculoskeletal discomforts were also determined.

The ergonomic risk factors that may cause harm to Woodball players were analysed using the Initial and Advanced Ergonomic Risk Assessment (ERA). The Initial ERA is useful for issues or problems identification that may affect the player's health and productivity, while the Advanced ERA is used to further identify specific ergonomics risk factors based on the posture, forceful and repetition assessments. Besides, it adds to propose a suitable and proper body posture based on the ergonomics assessment results. Also, the Rapid Upper Limb Assessment (RULA) method is used as the main postural analysis in this study to identify the awkward

posture of the athletes. RULA is a survey method developed for the use in ergonomics investigations of workplaces where task-related to upper limb disorders. This method is considered a biomechanical and postural load of task on the neck, trunk, and arm & wrists [6].

The initial ERA method was performed to identify the risk level of the players during the swinging of the mallet. The Initial ERA method was used among players by conducting the interview and observation based on the video that was recorded during the play. Then the ergonomics risk assessment such as the musculoskeletal assessment and ergonomics risk factors assessment were studied from the results obtained from the initial ERA. This study also utilized the Advanced ERA for the assessment method due to the higher risk of result obtained through the initial ERA. The Advanced ERA calculation was analysed through final posture intervention which interacts with the Human Modelling Simulation using CATIA V5 to validate that the improvised posture should reduce the ergonomics risk factor. The human Woodball activity analysis was specifically analysed in the context how a Woodball manikin player will interacts with the objects in the virtual environment. The simulation was carried out only for the improvised posture for all the tee-off postures, namely the short tee-off, medium tee-off and long tee-off. The improvised posture was determined based on the critical risk factors imposed by the players through the RULA analysis. The posture simulation will be further discussed in sub-section 3.3.

3.0 Results and Discussions

3.1 Result of Initial Ergonomics Risk Assessment (ERA)

The results of the initial ergonomics risk assessment (ERA) show that the risk factors faced by the athlete when playing Woodball are the awkward postures, static and sustained work postures and repetitive motions (see Table 2). It can be seen that the total score of two main risk factors, namely the awkward posture and static/ sustained work posture is about 7 and 2, respectively, which is beyond the minimum requirement needed for the advanced ERA assessment.

Table 2: Summary of Initial Ergonomic Risk Factor Assessment

Risk Factor	Total Score	Minimum Requirement for advanced assessment	Need Advanced ERA (Yes/No)
Awkward Posture	7	≥ 6	Yes
Static and Sustained Work Posture	2	≥1	Yes
Repetitive Motion	1	≥1	No
Lighting	0	1	No
Temperature	0	1	No
Ventilation	0	1	No
Noise	0	≥1	No

Figure 1 shows the summary of musculoskeletal disorder symptom indication among the four Woodball players when performing tee-off. The result shows that the neck discomforts have the highest respond which is 4 out of 4 athletes. The second highest pain/ discomfort is at wrists/hands part of body and lower back which 3 over 4 athletes. This is because the athlete requires to bend and having their part of body in discomfort posture during performing the tee-off. Besides, only 2 athletes faced musculoskeletal symptom on the upper back and calf/legs. Based on this result, the Advanced ERA method is conducted to assess the upper and lower limb of the body of the athlete since the athlete only faces discomfort at the upper section of the body such as the neck, lower back, wrist/hand and calf/legs.

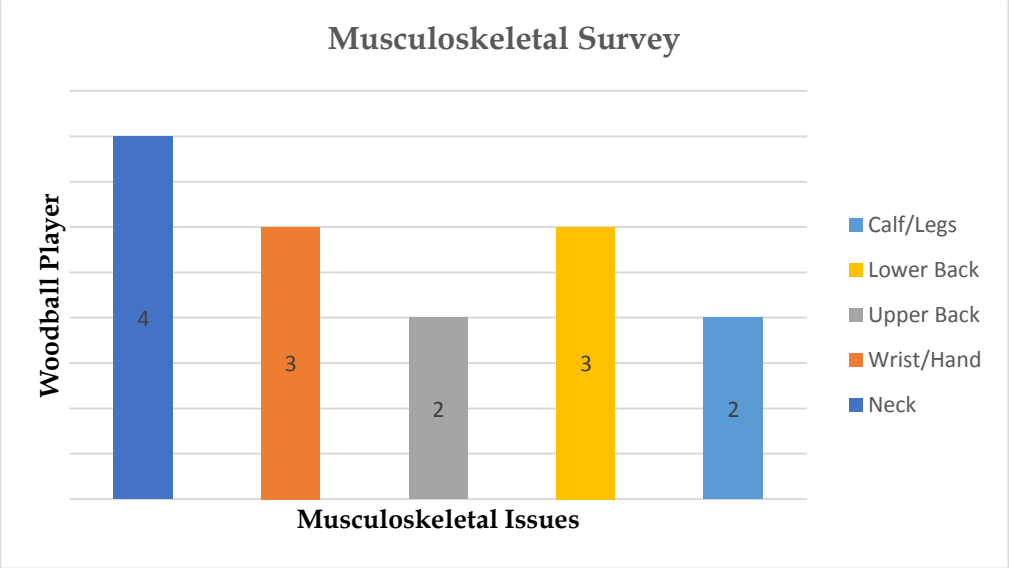

Figure 1: Summary of musculoskeletal disorder symptom among Woodball athlete.

The Nordic checklist was used in this musculoskeletal survey to collect the information regarding body discomfort symptoms. Table 3 shows the result of musculoskeletal symptom which has been performed using the Cornell Musculoskeletal Discomfort Questionnaire. The result shows that majority of the athletes had pain at neck, both hands/wrists, lower back and both calf/legs. The tee-off activity causes physical discomforts at upper and lower limb of the body.

Table 3: The Result of Musculoskeletal/ Symptom Survey by using Cornell Musculoskeletal Discomfort Questionnaire

Woodball Athlete	**Musculoskeletal Issues**									
	Neck	**Both Shoulders**	**Elbows**	**Both wrists/ hands**	**Upper back**	**Lower back**	**Both tights**	**Both knees**	**Both calf/ lower legs**	**Both ankles/ feet**
1	x			X		x			x	
2	x			X		x				
3	x				x	x				
4	x			X	x				x	
Total	4	0	0	3	2	3	0	0	2	0

Table 4 shows the result of the awkward posture faced by the athletes, comprising on the highest score compared to the other risk factors. This is because the tee-off activity requires the athlete to bend and having their part of the body in discomfort posture which exceeds the recommended maximum exposure duration. Hence, it is imperative to conduct the Advanced ERA to obtain a proper survey on the musculoskeletal disorders among athletes.

Table 4: Awkward Posture

Body Part	**Physical Risk Factor**	**Max. Exposure Duration**	**Please tick (/)**	
			Yes	**No**
Shoulders	Work with hand above the head OR the elbow above the shoulder	More than 2 hours per day	/	
	Work with shoulder raised	More than 2 hours per day		/
	Work repetitively by raising the hand above the head OR the elbow above the shoulder more than once per minute	More than 2 hours per day		/
Head	Work with head bent downwards more than 45 degrees	More than 2 hours per day	/	
	Work with head bent backwards	More than 2 hours per day		/
	Work with head bent sideways	More than 2 hours per day	/	
Back	Work with back bent forward more than 30 degrees OR bent sideways	More than 2 hours per day	/	
	Work with body twisted	More than 2 hours per day	/	
Hand/Elbow /Wrist	Work with wrist flexion OR extension OR radial deviation more than 15 degrees	More than 2 hours per day	/	
	Work with arm abduction sideways	More than 4 hours per day	/	
	Work with arm forward more than 45 degrees OR arm backward more than 20 degrees	More than 2 hours per day		/
Leg/Knees	Work in a squat position.	More than 2 hours total per day		/

Body Part	Physical Risk Factor	Max. Exposure Duration	Please tick (/)	
			Yes	No
	Work in a kneeling position	More than 2 hours per day		/
Sub Total (Number of tick(s))			**7**	6

Based on the summary of the risk factor in Initial ERA from Table 5, it can be found that the athletes had discomforts due to the static and sustained posture. Athlete needs to be in static posture while aiming the ball in order to obtain a good swing.

Table 5: Static and Sustained Work Posture

Body Part	Physical Risk Factor	Max. Exposure Duration	Please tick (/)	
			Yes	No
Trunk/ Head/ Neck/ Arm/ Wrist	Work in a static awkward position as in Table 1	More than 1 minute continuously	/	
Leg/Knees	Work in a standing position with minimal leg movement	More than 2 hours continuously	/	
	Work in static seated position with minimal movement	More than 30 minutes continuously		/
Sub Total (Number of tick(s))			**2**	1

Table 6 shows the result of Repetitive Motion which has lowest score compared to the other risk factors. This is because athlete continuously moving their fingers while griping the mallet before they swing the mallet.

Table 6: Repetitive Motion

Body Part	Physical Risk Factor	Max. Exposure Duration	Please tick (/)	
			Yes	No
Neck, shoulders, elbows, wrists, hands, knee	Work involving repetitive sequence of movement more than twice per minute	More than 3 hours on a "normal" workday OR More than 1 hour continuously without a break		/
	Work involving intensive use of the fingers, hands or wrist		/	
	Work involving repetitive shoulder/arm movement with some pauses OR continuous shoulder/arm movement			/
	Work using the heel/base of palm as a "hammer" more than once per minute	More than 2 hours per day		/
	Work using the knee as a "hammer" more than once per minute.	More than 2 hours per day		/
Sub Total (Number of tick(s))			**1**	4

3.2 Rapid Upper Limb Assessment (RULA) for Current Posture based on Observation

The RULA Assessment Tool was developed to evaluate the exposure of individual workers to ergonomic risk factors associated with the upper extremity Musculoskeletal Disorder (MSD). The RULA ergonomic assessment tool considers the biomechanical and postural load requirements of job tasks/demands on the neck, trunk and upper extremities. The current postures comprising of the short, medium and long tee-off postures are shown in Figure 2.

(a) (b) (c)

Figure 2: Current Postures (a) The Short Tee-off Posture, (b) The Medium Tee-off Posture, (c) The Long Tee-off Posture

The results obtained from the RULA assessment tool for all the ergonomic parameters on the three current postures (i.e. short tee-off, medium tee-off and long tee-off) are tabulated in Table 7. Based on the result shown in Table 7, the final score obtained for the current short tee-off posture using the RULA form is 4, which requires to do further investigation or changes that may be needed in order to reduce the critical musculoskeletal disorders while for the current medium tee-off the final score is 6, where further investigation is need in order to prevent the related injury. For the current long tee-off posture, the final score is about 7 which requires to do further investigation and changes for a new posture in order to reduce the critical musculoskeletal disorders. The comparison between the current RULA results with the improvised results based on the simulation analysis will be discussed in sub-section 3.3.

Table 7: RULA for Current Posture based on Observation

RULA Analysis Detail	**Activity Description**		
	Short Tee-off	**Medium Tee-off**	**Long Tee-off**
Upper Arm	2	3	4
Forearm	3	3	3
Wrist	4	3	3
Wrist Twist	1	1	1
Posture A	5	4	5
Muscle	0	0	0
Force/Load	0	0	0
Wrist and Arm	5	4	5
Neck	1	2	2
Trunk	3	5	5
Leg	1	1	1
Posture B	3	6	6
Neck, Trunk, Leg	3	6	6
Final Score	**4**	**6**	**7**

3.3 Rapid Upper Limb Assessment (RULA) for Improvised Posture based on Simulation

Based on the RULA results observed for the current postures in Figure 2, the improvised postures were indicated and simulated in the context of ergonomics analysis using the Human Digital Modelling (HDM) in CATIA V5. The anthropometry data, such as the stature dimension was fixed to 168 cm of average height of the male Woodball athlete. Then, the angle was set

according to the position of the body posture for each tee-off. In the simulation, the manikin helps to generate the Rapid Upper Limb Assessment (RULA) analysis. The simulation results will then be interpreted and compared between the current posture (see Table 7) and the improvised posture. Figures 3 to 5 show the result of RULA for each tee-off generated from the Manikin simulation. The results obtained from the generated RULA assessment from the simulation for all the three current postures (i.e. short tee-off, medium tee-off and long tee-off) are tabulated in Table 8. As observed before, the current posture caused critical risk factors for the medium and long tee-off while imposed low risk factors for the short tee-off. The improvised posture reduced the disorders to minimum score which is 3 for each tee-off posture. The neck, wrist twist and leg were found in very safe body posture when performing the tee-off.

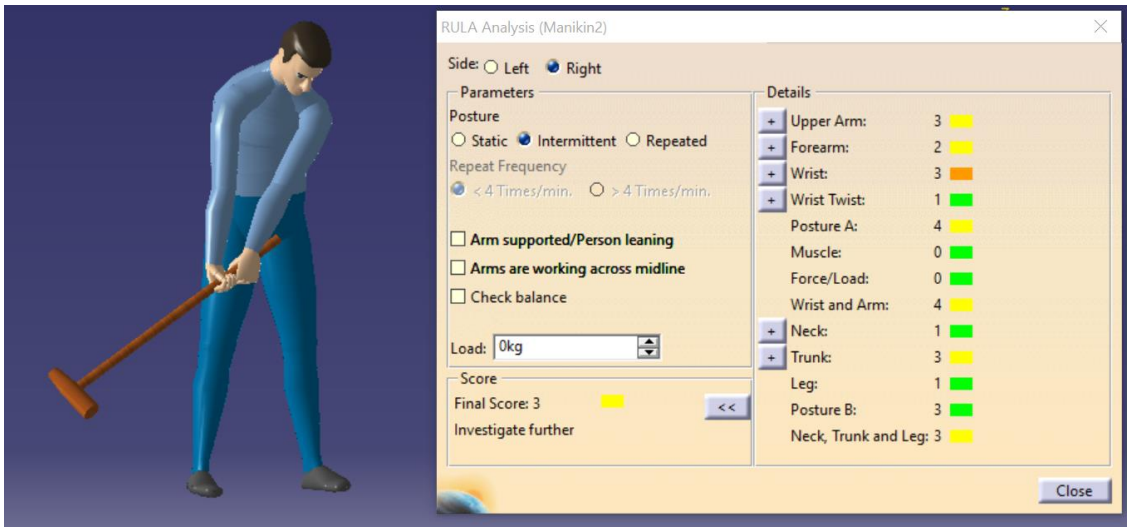

Figure 3: The results of RULA for Improvised Short Tee-off Posture

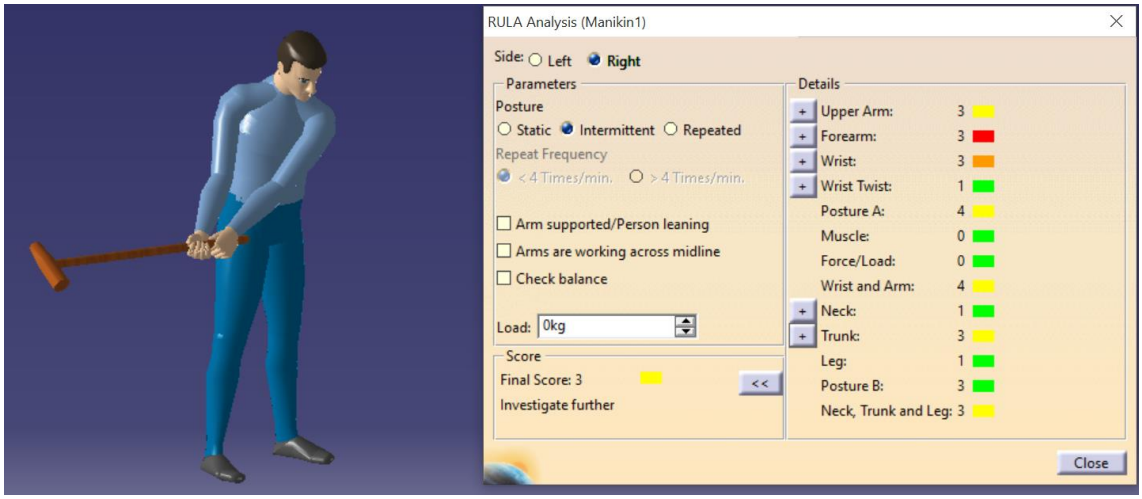

Figure 4: The results of RULA for Improvised Medium Tee-off Posture

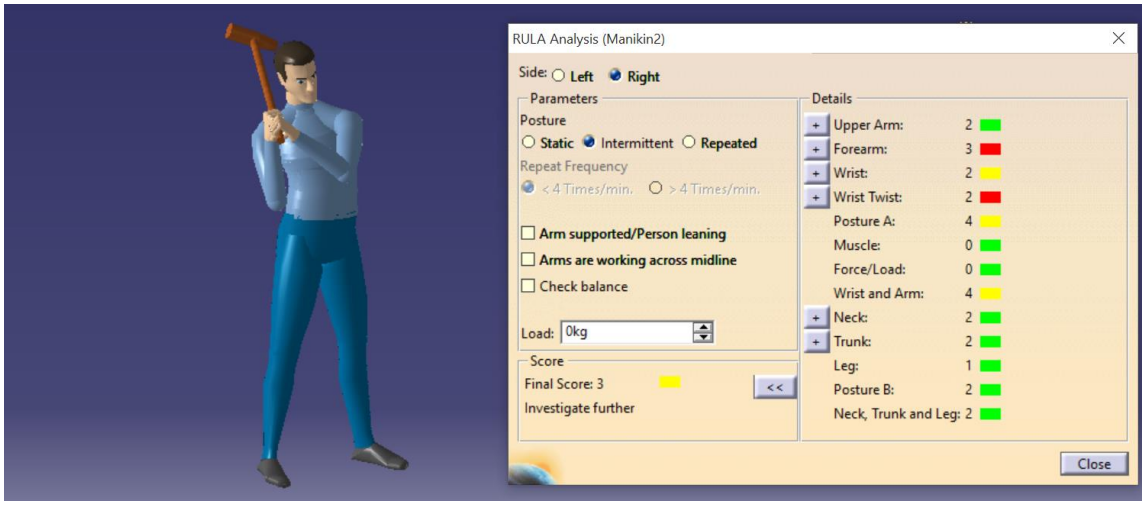

Figure 5: The results of RULA for Improvised Long Tee-off Posture

Table 8: RULA for Improvised Posture based on Simulation

RULA Analysis Detail	**Activity Description**		
	Short Tee-off	**Medium Tee-off**	**Long Tee-off**
Upper Arm	3	3	2
Forearm	2	3	3
Wrist	3	3	2
Wrist Twist	1	1	2
Posture A	4	4	4
Muscle	0	0	0
Force/Load	0	0	0
Wrist and Arm	4	4	4
Neck	1	1	2
Trunk	3	3	2
Leg	1	1	1
Posture B	3	3	2
Neck, Trunk, Leg	3	3	2
Final Score	**3**	**3**	**3**

Table 9 shows the summary of the RULA final score comparison between the current and improvised posture, which has been analysed through observation and HDM simulation, respectively. The results clearly show that the improvised posture demonstrate a more sensible risk score compared to that of the current posture for all the postures. It can be concluded that

the improvement of the player's posture using RULA analysis decreases player's risk level and subjective disorders for all the Woodball practice, namely the short, medium and long tee-off postures.

Table 9: Comparison of RULA Final Score between the Current and Improvised posture

Activity Description	**Final Score**	
	Current Posture	**Improvised Posture**
Short Tee-off	4	3
Medium Tee-off	6	3
Long Tee-off	7	3

4.0 Conclusions

The results of the initial and advanced ERA were obtained in order to evaluate the ergonomic intervention among the Woodball players. The main identified problems are ergonomic risk factors due to the awkward posture, static and sustained posture, and repetitive motion when athlete performing the tee-off. The results of the initial ERA show that it is vital that the following risk factors, comprising the awkward posture, static and sustained posture, and repetitive motion need to be minimized. Next, the obtained result of the advanced ERA uses the RULA assessments to identify the level of risk factor. From the result of RULA Employee Assessment Worksheet, it can be summarized that the critical risk factors were on the upper body part, consisting of the neck, shoulder, hand/wrist and upper back of the Woodball athlete. Since the current tee-off posture caused the high ergonomics risk factors, further analysis and recommendation for proper tee-off posture of RULA was performed using the CATIA Human Digital Modelling. The improvised results from the RULA analysis were found to be able to reduce the ergonomics risk of the current and improvised posture in this study.

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