

OVERHEAD POSITION ANALYSIS OF MEN'S SINGLE BADMINTON PLAYER BY KINEMATICS AND KINETICS ANALYSIS

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Introduction:

With approximately 200 million adherents, badminton has become a racket sport that is popular in the world [1, 2]. Fast movements with continuous change of direction and with lower intensity and short recovery periods are some of the characteristics observed in badminton [3]. Previous studies have observed and described overhead as movement that to risk injury [4]. In this research the movement in left clavicle (LCL), right clavicle (RCL), pelvis (PEL) dan thorax (TRX) was analyse using kinematics to see the instability during overhead movement. On the other hand, the previous studies also explained that weak lower limb that causes trunk muscle not stability increase risk of back pain injuries [5]. Therefore, in overhead movement, it is possible to create instability on the hip when landing on one leg (non-preferred leg). Thus, the aimed of this study was to examine the effect of overhead movement on ground reaction force (GRF), moment, and power in ankle, elbow, hip, knee during landing phase with two conditions (normal and fatigue conditions).

Methods:

Overall, 4 male badminton athletes aged 18-20 years, participated into the study, on the basis of the following criteria. Study design and procedures adopted based on previous biomechanical studies [6]. A week prior to this study, all participants required to complete a familiarization session for the procedure movement. A training team of 2 people (who have experienced as badminton coach minimum 10 years) conducting an investigation regarding quality each athlete's overhead movement in this project (the illustrated picture is displayed in Figure 1).

All participants undergo overhead movement in normal condition and overhead movement in fatigue condition, after exercise induced muscle damage (EIMD) protocol (Figure 2). The EIMD protocol consist of :

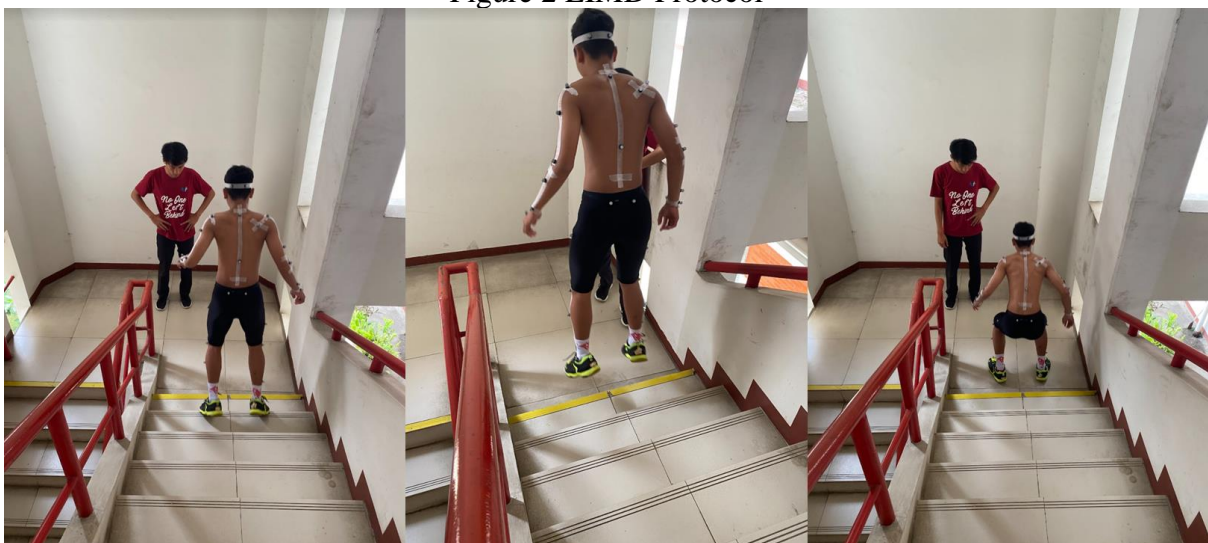
1. Prepare media with the height of 60 cm
2. Participant jumps from a height of 60 cm.

3. When landing, the position of the legs have to be parallel to the shoulders, bent 90 degrees and the trunk is upright.
4. Participants has to do 100 jumps without resting.

Figure 1. Illustrated picture for overhead movement

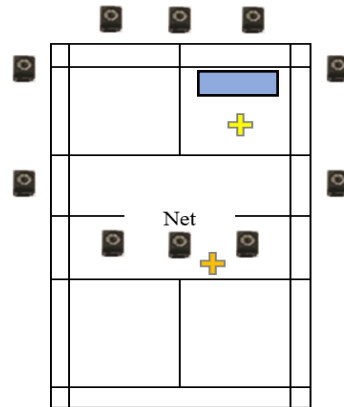


Figure 2 EIMD Protocol







In this research the GRF and kinematic data of the participants during each overhead trial collecting using a ten-camera Vicon® motion capture system (Vicon new, Nexus 2.5) that aligned in a circular fashion to allow capturing of all reflective markers of participants. Specifically, ten-camera synchronised force plate. Static and dynamic calibrations performing based on Vicon guide analysis. During overhead movements, a shuttlecock given by the coach to players, and we encouraged coaches to give difficult passing, so it can create an extreme overhead movement. The position of the cameras and the force plate shows in Figure 3.

Figure 3. The research concept during overhead movement



Abbreviations:

-  Coaches who passing a shuttlecock to players
-  Badminton players
-  Force plat
-  Vicon camera

The overhead movement used in this research were divided into 7 stage; Stage 1 is when the player in initial position, stage 2 is when players move 1 step to the back, stage 3 is right before the player bend the back, stage 4 is when the player bend his back to the maximum position to receive the shuttlecock, stage 5 is when the player bend the back towards, stage 6 is when the back foot ankle touch the ground and stage 7 is when the player back to initial posture.

Figure 4. Overhead stage



The markers used in this research were sets for plug-in gait full body model sets by Vicon® plug-in Gait Reference. The following figures 5,6 show front and back views where the location of the markers was.

Figure 5. Markers location in front view

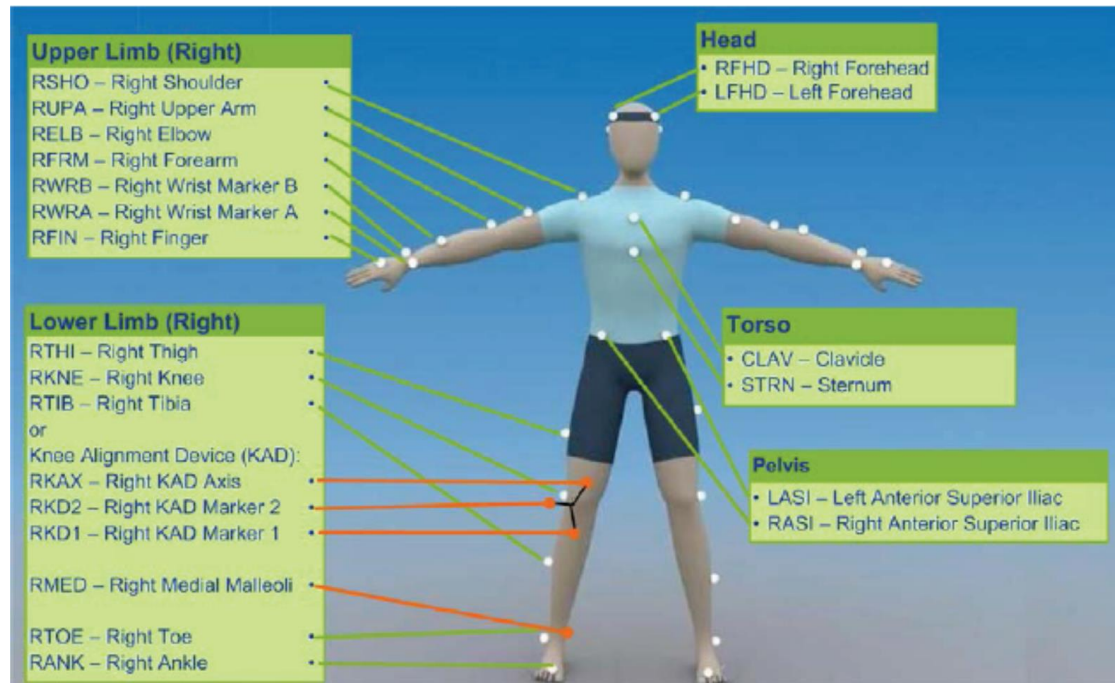
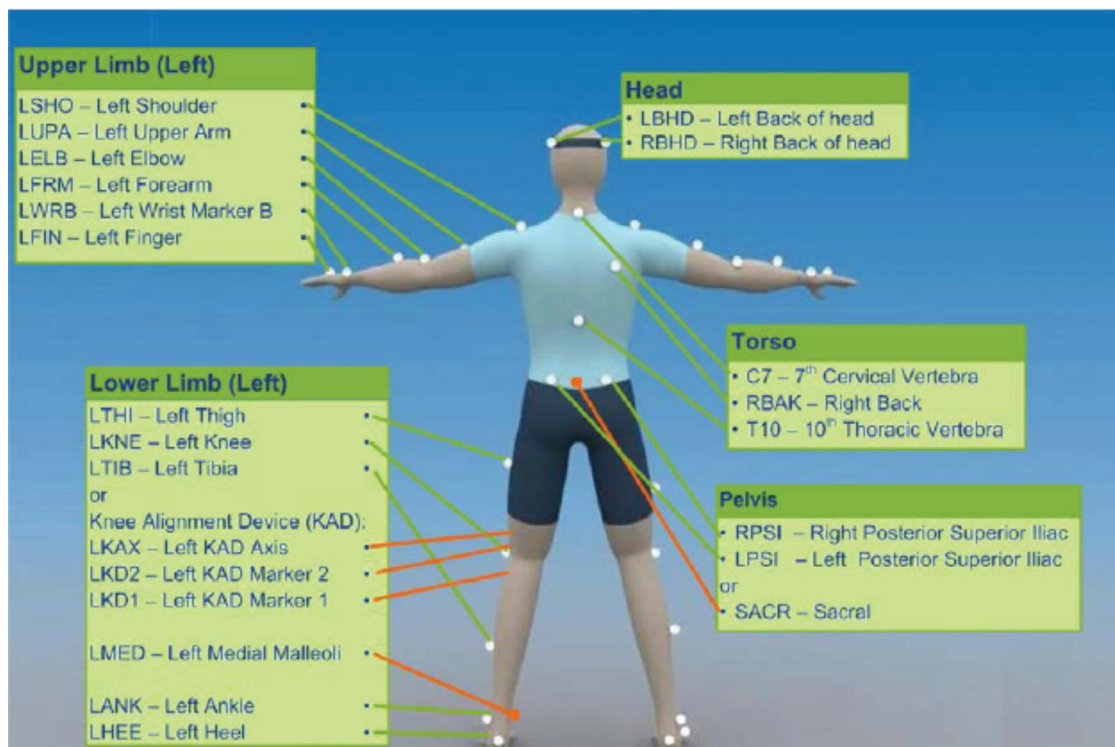


Figure 6. Markers location in back view



All participants had 5 attempts opportunities to perform extreme overhead trials in each condition (non-fatigue and fatigue) which were considered as one of the most critical manoeuvres with the greatest impact intensity among other overhead direction. To ensure that athletes highly motivated and illustrates the realistic shoe-ground interfaces of a standard badminton court, professional badminton mat glued to the top of the force plat.

Results:

The basis of mechanics related to Newton's Law is used in the analysis of the movements to be performed. The kinematics aspects to be investigated are velocity and acceleration. Velocity is defined as the change in movement with time. Acceleration is obtained from data changes in velocity with time. Scalar velocity and acceleration values are obtained from the square root of velocity and acceleration in the x, y, and z coordinates. Information on these three kinematic variables is used to understand movement characteristics and compare movements of two different subjects.

There are four points that analysed. They are LCL (Left Clavide), RCL (Right Clavide), PEL (Pelvis), and TRX (Thorax). The LCL position was obtained from analyzing the positions of the other 3 markers, namely CLAV (Clavideo), C7 (7th Vertical Vertebra) and LSHO (Left Shoulder) when position of RCL obtained by CLAV, C7 and RSHO (Right Shoulder) position. We were using position of LSPI (Left Posterior Superior Iliac), RSPI (Right Posterior Superior Iliac), LASI (Left Anterior Superior Iliac) and RASI (Right Anterior Superior Iliac) to define PEL. Position of TRX determined by position of T10 (10th Thoracic Vertebra), RBAK (Right Back) and CLAV.

Based on the graph shown in Figure 7-14 there are no significant difference in maximum velocity and acceleration before and after EIMD protocol. Table 1 shows the maximum value of velocity and acceleration in non-fatigue and fatigue condition. In general, the maximum velocity and acceleration was decrease in fatigue condition.

Table 1. Maximum velocity and acceleration in non-fatigue and fatigue condition

		Maximum Velocity (m/s)				Maximum Acceleration (m/s ²)			
		LCL	RCL	TRQ	PEL	LCL	RCL	TRQ	PEL
Participant 1	Non-Fatigue	3.201	2.160	2.338	2.349	22.197	31.677	29.809	35.054
	Fatigue	2.985	2.174	2.606	2.471	20.972	29.522	25.796	27.238
Participant 2	Non-Fatigue	2.925	2.616	2.337	2.516	28.037	34.692	20.058	22.773
	Fatigue	2.672	2.292	2.407	2.361	23.576	31.890	17.502	19.026
Participant 3	Non-Fatigue	3.642	3.433	3.099	2.831	34.494	23.576	27.867	28.887
	Fatigue	3.422	3.328	3.029	2.988	34.196	35.143	23.337	27.241
Participant 4	Non-Fatigue	3.312	2.664	2.766	2.863	26.041	34.689	26.562	28.225
	Fatigue	2.878	2.510	2.671	2.795	21.528	33.160	29.269	24.258

Figure 7. Velocity of LCL in Non-Fatigue and Fatigue Condition

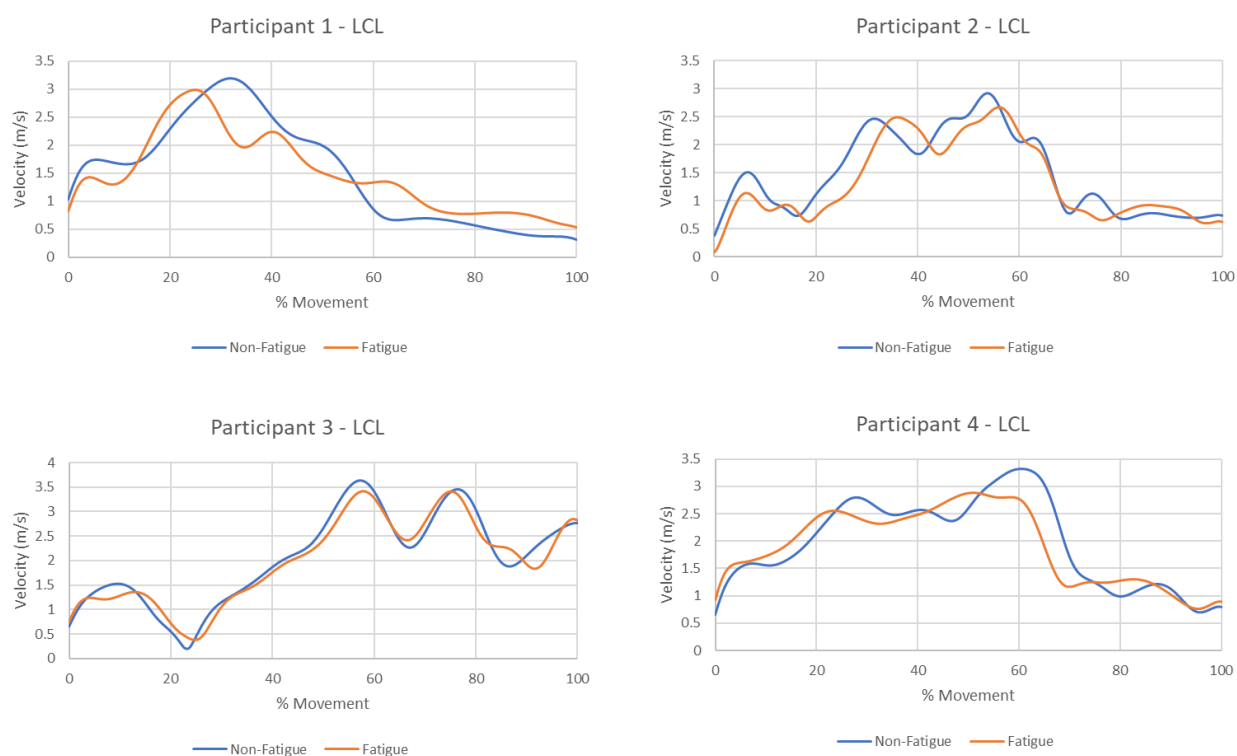


Figure 8. Acceleration of LCL in Non-Fatigue and Fatigue Condition

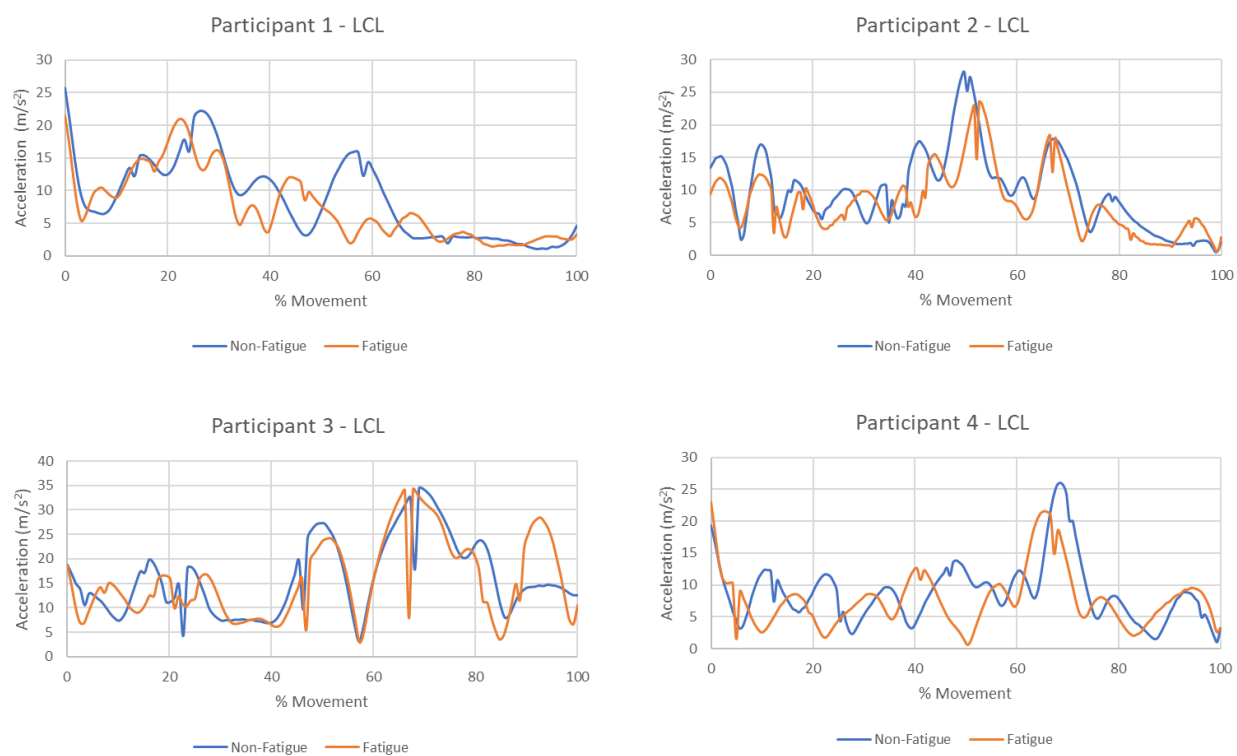


Figure 9. Velocity of RCL in Non-Fatigue and Fatigue Condition

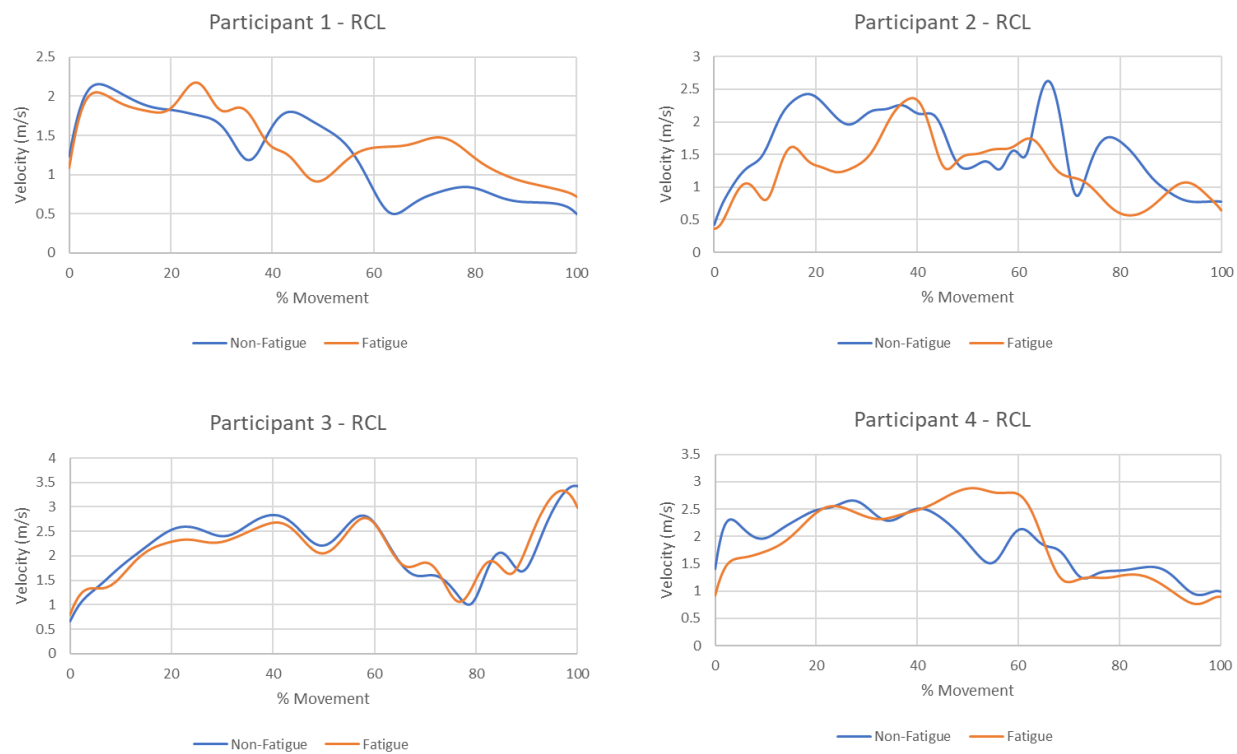


Figure 10. Acceleration of RCL in Non-Fatigue and Fatigue Condition

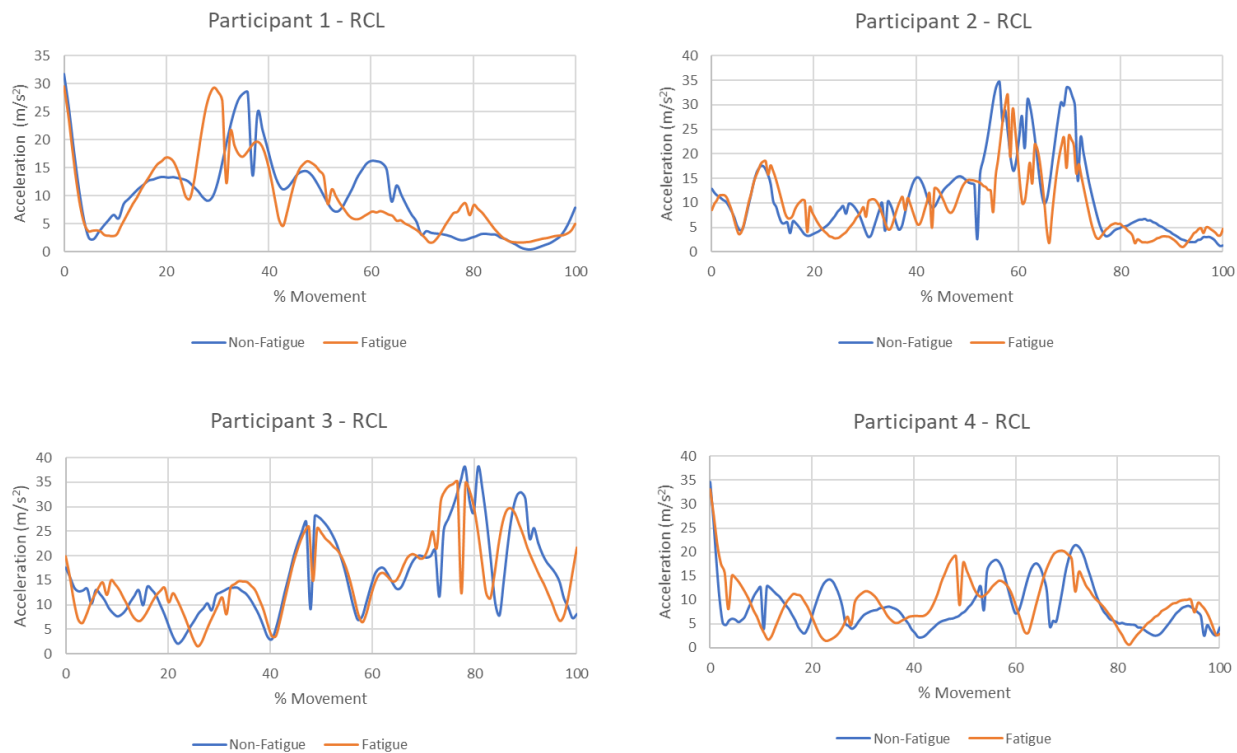


Figure 11. Velocity of TRQ in Non-Fatigue and Fatigue Condition

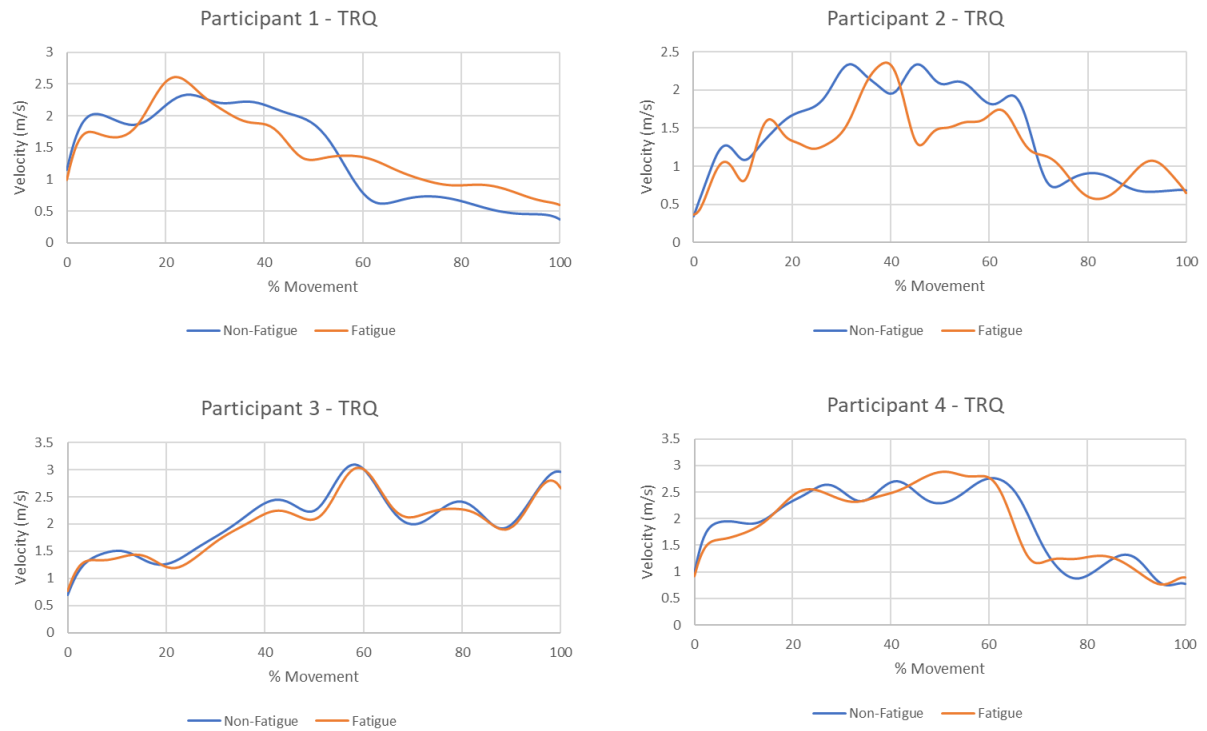


Figure 12. Acceleration of TRQ in Non-Fatigue and Fatigue Condition

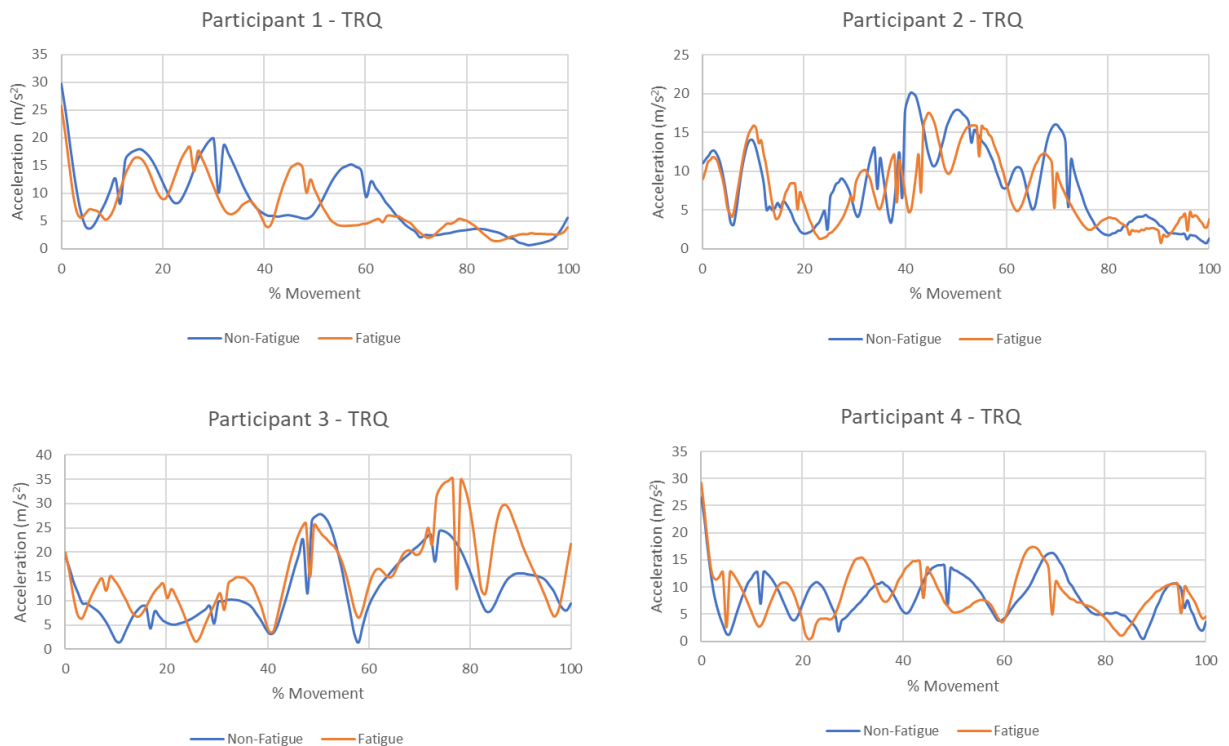


Figure 13. Velocity of PEL in Non-Fatigue and Fatigue Condition

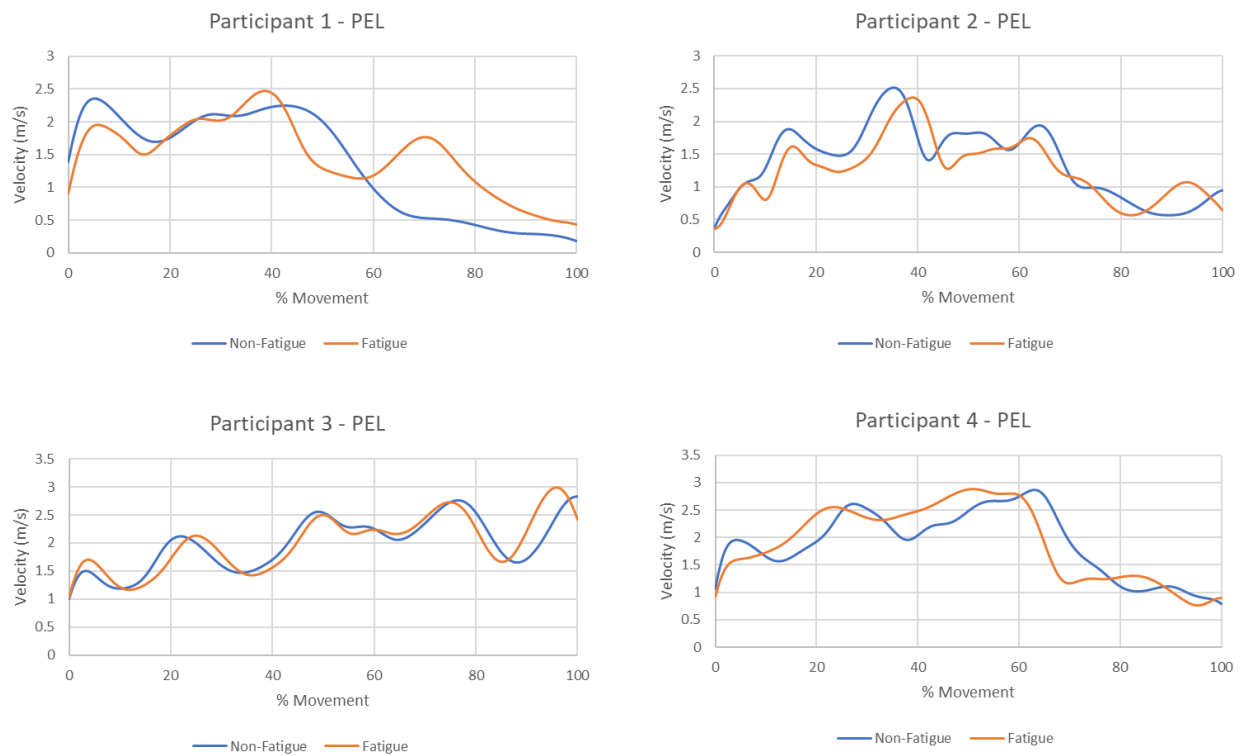
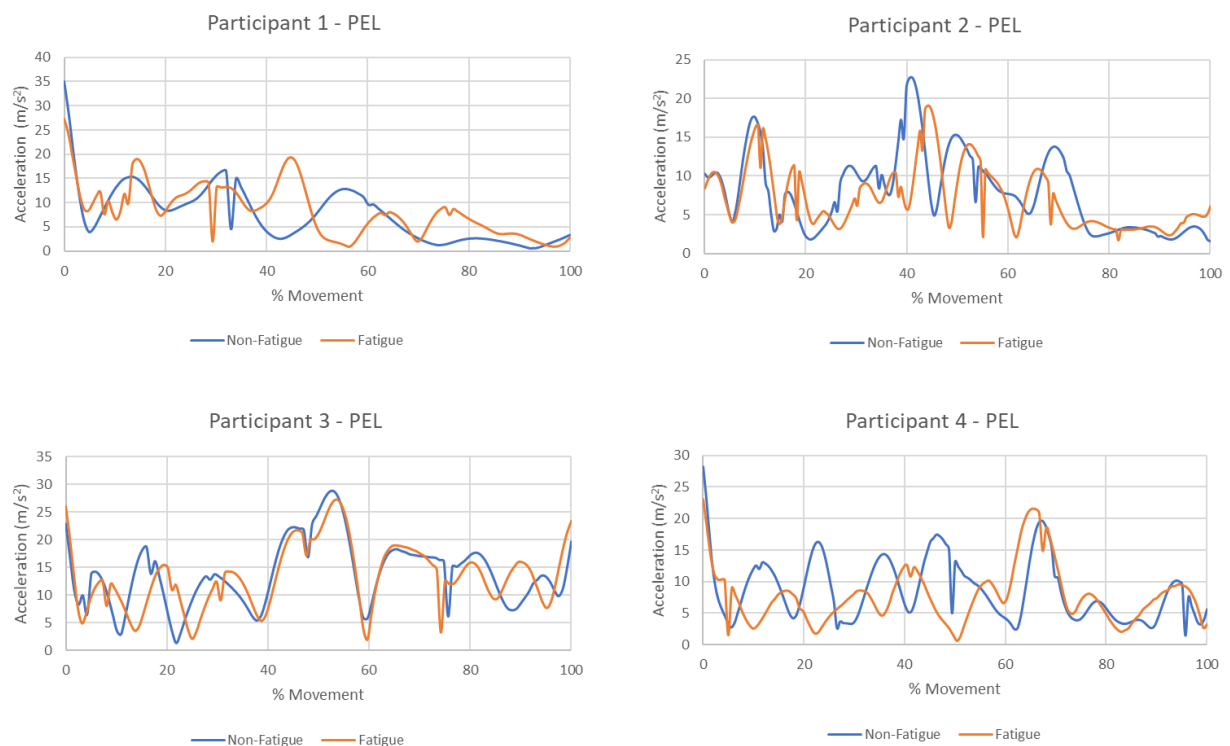


Figure 14. Acceleration of PEL in Non-Fatigue and Fatigue Condition



In contrast with the kinematics of 4 location before, Table 2, Table 3, and Table 4 displays mean and SD values of force, moment, and power, respectively.

Force

T-test showed significant value between non fatigue and fatigue on GRF ($p=0.041$), ankle ($p=0.037$), elbow ($p=0.044$), and hip ($p=0.049$) on left foot segment. Furthermore, significant value observed in right foot segment on GRF ($p=0.042$).

Table 2 Different effects of force on GRF, ankle, elbow, and hip during overhead movement.

Variable	Segment	Left Foot		p-value	Right Foot		p-value
		Non-Fatigue	Fatigue		Non-fatigue	Fatigue	
Force	Ground reaction force (N)	6,70	2,06	0.041*	14,08	17,52	0.042*
	Ankle (N/kg)	0,84	0,54	0.037*	3,34	3,02	0.072
	Elbow (N/kg)	0,57	0,60	0.044*	2,03	1,77	0.064
	Hip (N/kg)	4,12	3,85	0.049*	3,30	3,15	0.078
	Knee (N/kg)	2,02	2,08	0.425	1,68	1,50	0.061

Abbreviation:

GRF- Ground reaction force; * Statistically significant differences between fatigue and non-fatigue ($p < 0.05$)

Moment

There was a significant change in the independent t-test in ankle ($p=0.001$), hip ($p=0.042$), and knee ($p=0.001$) on segment left foot. On the other hand, segment right foot had significant in ankle ($p=0.001$), and knee ($p=0.001$).

Table 3 Different effects of moment on GRF, ankle, elbow, and hip during overhead movement

Variable	Segment	Left Foot		p-value	Right Foot		p-value
		Non-Fatigue	Fatigue		Non-fatigue	Fatigue	
Moment	ground reaction moment (N.mm)	219,64	218,09	0.892	218,97	220,46	0.784
	Ankle (N.mm/kg)	123,02	79,25	0.001**	402,31	550,53	0.001**
	Elbow (N.mm/kg)	13,50	14,57	0.782	21,99	20,78	0.693
	Hip (N.mm/kg)	187,03	249,88	0.042*	281,56	299,14	0.587
	Knee (N.mm/kg)	130,42	76,94	0.001**	200,56	224,26	0.001**

Abbreviation:

GRF- Ground reaction force; * Statistically significant differences between fatigue and non-fatigue ($p < 0.05$); ** Statistically significant differences between fatigue and non-fatigue ($p < 0.001$)

Power

Regarding the power results, there was a significant change between non-fatigue and fatigue in hip ($p=0.042$) on the left foot segment. Moreover, on the right foot segment there were a significant in elbow ($p=0.001$) and knee ($p=0.039$).

Table 4 Different effects of power on GRF, ankle, elbow, and hip during overhead movement

Variable	Segment	Left Foot		p-value	Right Foot		p-value
		Non-Fatigue	Fatigue		Non-fatigue	Fatigue	
Power	Ankle (W/kg)	1,04	0,54	0.682	8,57	9,41	0.6892
	Elbow (W/kg)	0,24	0,29	0.878	0,98	2,84	0.001**
	Hip (W/kg)	3,11	4,46	0.042*	3,81	3,40	0.793
	Knee (W/kg)	2,60	2,30	0.742	5,25	5,72	0.039*

Abbreviation:

GRF- Ground reaction force; * Statistically significant differences between fatigue and non-fatigue ($p < 0.05$); ** Statistically significant differences between fatigue and non-fatigue ($p < 0.001$)

Conclusion

This study showed that fatigue condition induced instability of non-preferred leg, during landing movement. Specifically, our results indicated that the risk of back pain injuries is higher on fatigue condition because reduce of force, moment, and power in the knee during the landing phase in overhead movement. However, based on the kinematics analysis, the trend of velocity and acceleration in % movement did not show any significant different in non-fatigue and fatigue condition. This was because the fatigue protocol only focus on lower body not the upper body and the overhead movement was conditioned in extreme position based on each player technique. This conclude that we need a better fatigue protocol that can be representative of the fatigue in real match so that we could see the difference in fatigue and non-fatigue condition specially in upper body.

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