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A Study on the Human Impulse Characteristics Of the Standing Shooting Posture

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Abstract. The rifle impact on human body is affected by the posture of human when shooting. The interaction human-rifle system has an influence on a firing accuracy. In this paper, the impact analysis of a human model for standing posture is carried out. MSC.ADAMS and BRG.LifeMOD are used in the impact analysis of rifle model and modeling of the human body. At the time when the rifle is discharged, the human model is affected by rifle impact during the first 0.001 second. The simulation is performed for 0.3 second. The interface between the human and the model is modeled using constraints. For the results, the displacement of the rifle and transfer path analysis of impact on human model is presented.

Introduction

At the shooting, a study of human motion requires a separate action for time and the space considerations. The shooting posture has another phase according to the time. On the view of the biomechanics, the human motion is the kinematic and dynamic structure. The kinematics of the shooter motion is decided by the variation that mass and effect of the space type. The time has no consideration. The character of kinematical motion of human-rifle system decides on the relation for the geometric shape and the location of human-rifle system. The study draws the optimal parameter of shooting posture for the shooter.

In this study, the impact analysis of the human body creates the human modeling of Koreans and obtains both the impact force and the applied load of the each joint through a simulation of occurred condition at the shooting. The transfer path of the impact is obtained by the analysis for variation of the load. In the standing posture, the coordinate of each impact path is shown in Fig.1.

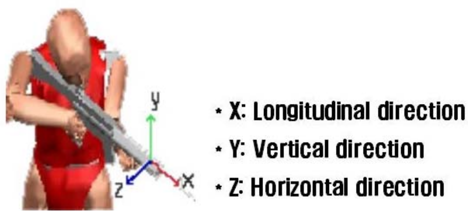

Fig. 1 Coordinate system of the human and rifle

Human modeling

In this study, the human modeling program, LifeMOD (Biomechanics Research Group, Inc.) is used in order to create the analysis model. The human body impulse is analyzed by the ADAMS (MSCsoftware).

In the study, the human body model was chosen as following physical condition: 170 cm of the height, 60 kg of weight, and a young man in his twenties, according to the report published at the Korean Agency for Technology and Standards. The chosen human was measured his height, weight, and joint length. And the simulation model is created by the measured size. Fig.2 shows the comparison of human and simulation model with the posture of shooting.

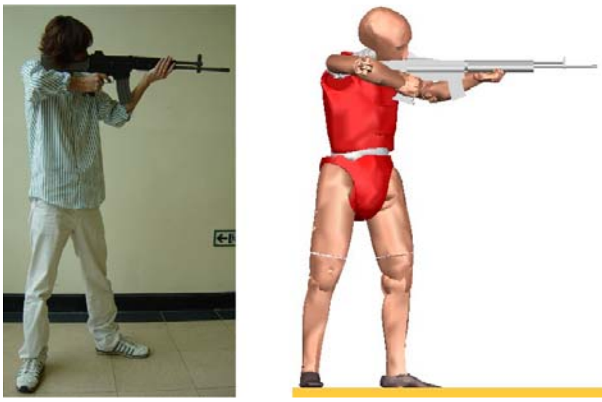

Fig. 2 Comparison of human and simulation model with the standing posture of shooting

Rifle modeling

In this study, the rifle used for the impulse analysis is K2. The modeling of K2 is conducted using the CATIA V5. Fig.3 shows the simulation model and photograph of K2. The information of rifle used for the analysis is presented in Table 1. Fig.4 shows the boundary condition of human-rifle system.

In the analysis, between rifle model and human model, the boundary condition of left hand and shoulder is the sphere condition. And the boundary condition of the right hand is the rotation condition. The applied load for the simulation inputs 3700 N to apply the Pro 25-MF-3B in ADD. The Fig.5 shows the experimental impulse and the modified impulse. And the Fig.5 shows the experimental distance and the modified distance.

Table 1 Basis information of rifle K2 [1]

Element	Value
Length	970 mm
Weight	3.26 kg

Fig. 3 K-2 Model (left) and photograph of K-2 rifle.

Fig. 4 Boundary conditions of the rifle and human body supports, left hand (left), right hand (center) and shoulder (right).

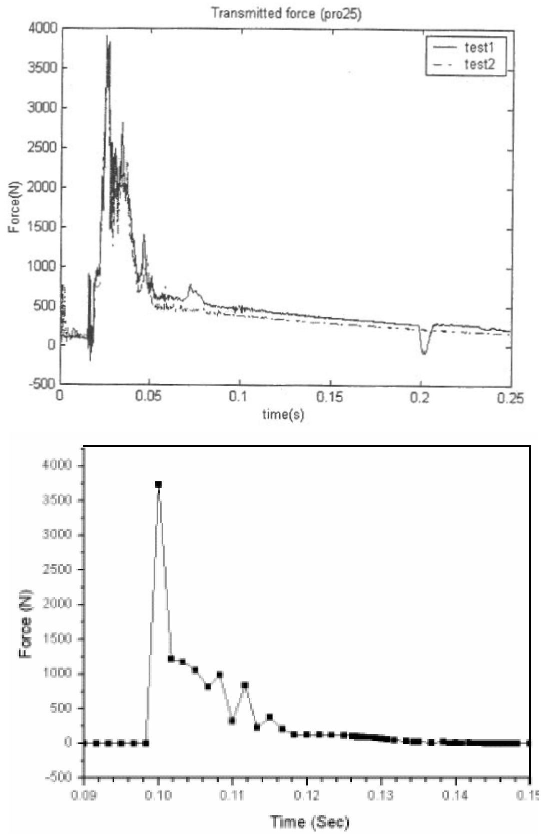

Fig. 5 Experimental (top) and modified impulse (bottom) history on the rifle at shooting

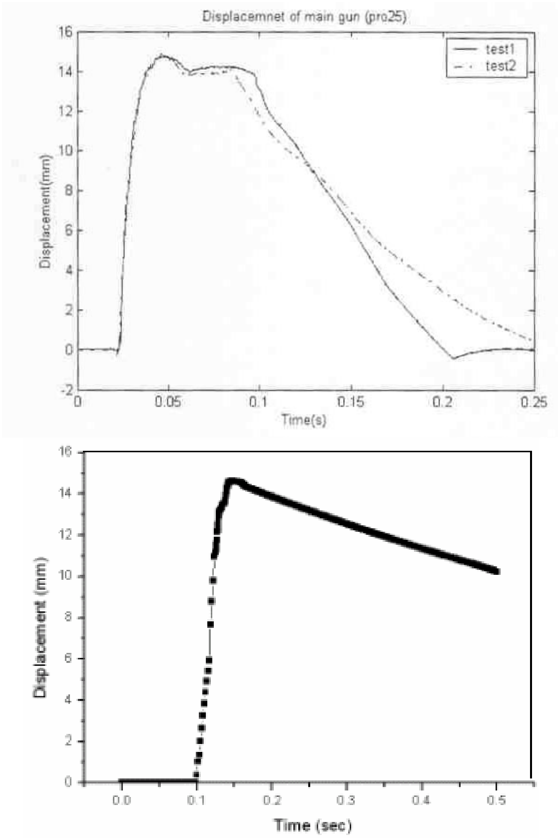

Fig. 6 Experimental (top) and modified impulse (bottom) history on the rifle at shooting

Impact characteristic of the standing posture

At the shooting, unstable standing posture occurs when the human body is pushed backward. To prevent the body from being pushed backward, the proportional reaction to the worked force occurs on the human body. The load of the horizontal direction is larger than that of the longitudinal direction because the point of occurred impact locates on the horizontal direction at the coordinate system. The large load acts on the longitudinal direction, the bullet direction to close the supportive part with the rifle.

While the load acts the 450N on the supportive right scapular the rifle, the left scapular is acted about the 80 N. This result is caused by the push backward of the human body at the shooting. The load of the vertical direction loads the other shoulder supported the rifle like scapular because of the rifle located between the shoulder and the scapular. The load of vertical direction is larger than that of horizontal direction in the left of the human body

The load on the hip occurs at early shooting. The load on the right hip is increased by transferred impact from the upper body because the right hip supports the upper body. Each knee and ankle transfers the occurred load to hip. The reason of this load transference is that the lower body supports the upper body at the joint with the rigid condition. At the 0.1 second, the impact of the shooting begins at the shoulder, scapular and the supported part with the rifle. And at 0.1005 second, the impact begins at the other part. As time passes, the impact force of the body increases on the body. The load of reaction occurred at the shooting seems like the phenomenon of increasing the load. The impact by the effect also increases until 0.102-seconds. Fig.7 shows the posture variation of human body model with the standing posture of shooting. After shooting, the front part of the rifle goes up and the upper body is pushed backward a little.

Fig.8 shows the contour plot of impulse transfer path of the body in the longitudinal direction at shooting. Fig.9, Fig.11 and Fig.13 show the vector plot of impulse transfer path of the human body in each direction from 0.1 second to 0.101 second at shooting. In the simulation result of the human model, the initial impact begins at the supported part with the rifle. And an occurred impact is transferred to both shoulder and scapular. The impact of the two wrists grasping rifle is transferred and concentrated to elbow. Therefore, the initial impact is transferred from upper to lower body and from right to left.

Fig.10 shows the contour plot of impulse transfer path of body in the vertical direction at the shooting. The impulse transfer path of vertical direction is similar to longitudinal one. The impact to the vertical direction concentrates on right shoulder and lumber. In the impact result of vertical direction, the result difference of longitudinal direction is that the impact is acted on both knees. The reaction is occurred from the surface. The impact is transferred from the upper body. The reaction and impact meet on the knee. Fig.12 shows the contour plot of impulse transfer path of the body in the horizontal direction at the shooting. The impact of the horizontal direction in the lower body is transferred to the left foot. And the impact in the upper body is concentrated to the left hand.

In the result of the standing posture, the supported part of the rifle is appeared to the high load. And both wrists grasping rifle are occurred to the load. The load on the hip supported of the upper body occurs at early shooting. And the load on the thoracic and lumber occurs at the after shooting.

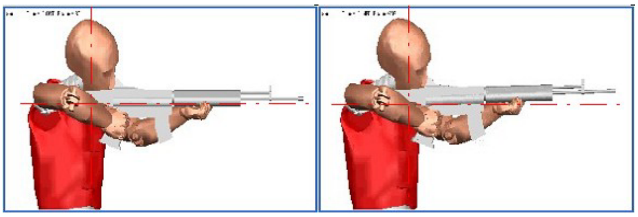

Fig. 7 Posture variation of the human body model with standing posture before (left) and after (right) shot.

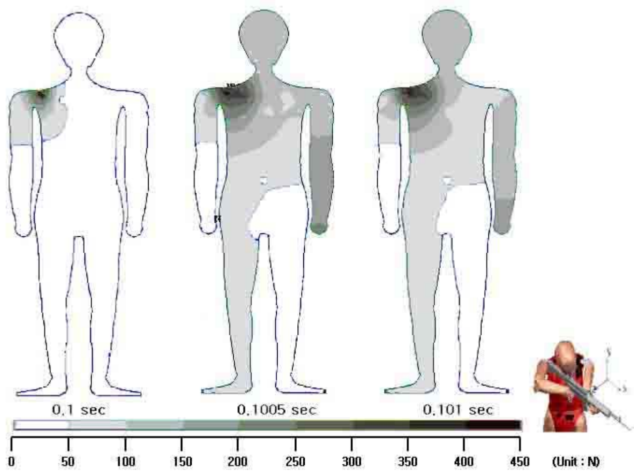

Fig. 8 Contour plot of impulse transfer path of the human body part in the longitudinal direction (X) with the standing posture.

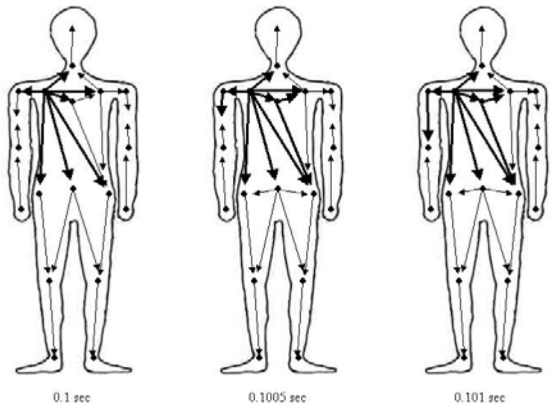

Fig. 9 Vector plot of impulse transfer path of the human body part in the longitudinal direction (X) with the standing posture

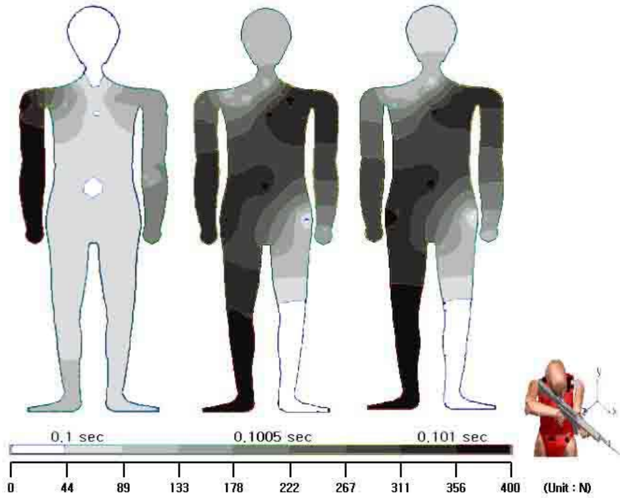

Fig. 10 Contour plot of impulse transfer path of the human body part in the vertical direction (Y) with the standing posture

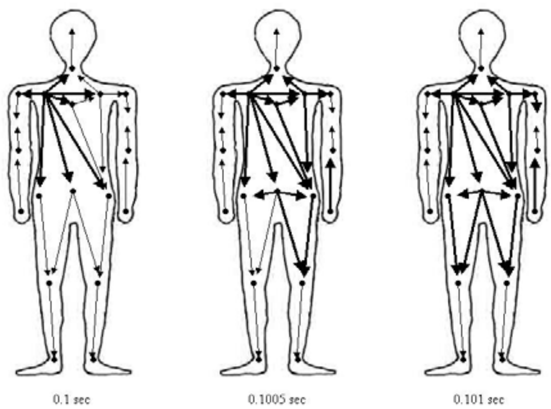

Fig. 11 Vector plot of impulse transfer path of the human body part in the vertical direction (Y) with the standing posture

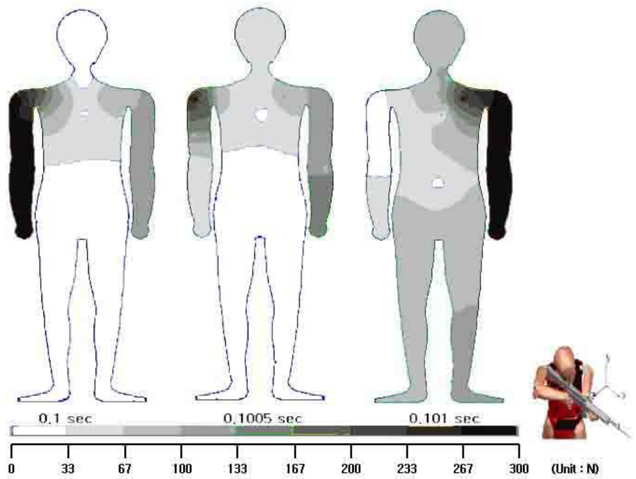

Fig. 12 Contour plot of impulse transfer path of the human body part in the horizontal direction (Z) with the standing posture

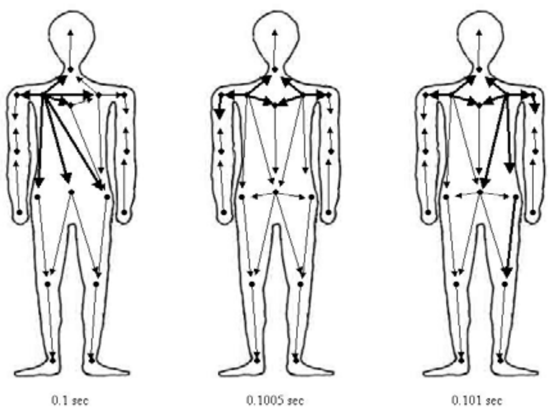

Fig. 13 Vector plot of impulse transfer path of the human body part in the horizontal direction (Z) with the standing posture

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Conclusions

The major conclusions from this study are as follows

1. Impact force at shooting takes place in human body contacting the rifle.
2. Maximum impact force occurs to the opposite direction of the bullet direction
3. The impact force is transferred to the lower body from the upper body and is transferred to the left from the right.
4. The impact force occurs to the other part of the body for maintaining of the shooting posture.

References

[1] Kim, H.J., Park, Y.P., Yang, H.S., Choe, E.J., Lee, S.B. and Hong, K.J.: Investigation of Dynamic Absorbing System in the Gas-operated Gun with High Transmitted Shock Force: Journal of the Korean Society for Noise and Vibration Engineering Vol. 12, No. 5 (2002), pp. 389-396

[2] Park, Y.P.: Design of Dynamic Absorbing System Considering Human Model Characteristics: Agency for Defense Development Report No. UD980022CD(1999)

[3] Lee, Y.S, Choi, K.J., Cho, K.H. and Lim, H.K.: Development of Design Techniques of Plastic Ankle Foot Orthosis for the Hemiplasics I: An Approach through Stress Analysis: Transactions of the Korean Society of Mechanical Engineers Vol.26, No.1(2002), pp. 7-14

[4] Lee, Y.S., Lee, S.K., Kim, C.J. and Park, S.J.: A Study of Measurement on Range of Arm Joint Motion of Korean Male in Twenties: Journal of the Ergonomics Society of Korea, Vol.15, No.1(1996), pp. 39-52

[5] Zakharenkov,V.F., Arseniev,S.E., Belov,A.V., Agoshkov,O.C., Lee,Y.S., Kim,I.W. and Chae, J.W.: Modeling and Numerical Investigation of the Stochastic Biomechanical Interaction Human-Rifle System: Proceedings of the 20th International Symposium on Ballistics(2002)

[6] Chae, J.W.: Human Anthropological and Bio-mechanical Model of Human-Rifle System: Agency for Defense Development Report No. GSDC-619-011092(2001)

[7] Yuan, C.K.: Effects of Rifle Weight and Handling Length on Shooting Performance: Applied Ergonomics Vol. 28, No. 2(1997), pp. 121-127