RECOIL DAMPING PADS IN RIFLE SHOOTING

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Recoil experienced in shooting may cause pain or injury to structures of the shoulder region. On way to minimise the effect of the impulse transmitted by the piston skirt is the use of damping pads inserted into the shooting jacket. In the present study the effectiveness of three commercially available pads was evaluated in a realistic setting. Analysis of co-variance controlling for three shooting positions, four weapons and four shooters revealed that all pads significantly decrease the peak impact force. There are also significant differences between the tested damping pads suggesting a superior performance of visco-elastic PU foams.

KEY WORDS: rifle shooting, recoil, damping.

INTRODUCTION: The acceleration of bullet causes a recoil of the weapon. This recoil may create discomfort or injury in prolonged shooting, depending on the mass and muzzle velocity of the projectile, the construction of the barrel, the mass of the rifle, the position of the shooter, the execution of the movement (technique), type of piston skirt, the shooting jacket worn and the properties of damping material inserted between the piston skirt and the shooter's shoulder region. The present study was undertaken to investigate the influence of different commercially available damping pads on the forces transmitted to the shoulder region of the shooter. It is commonplace procedure to perform material tests with an impacter on such damping pads. A mass is dropped from a set height, simulating the energy incurred in shooting. Force - time data and rebound heights are used to determine impulse and coefficient of restitution. This approach ensures reliability and objectivity of the data. However the validity of the results for the real situation remains highly questionable. The true stress on the biological system can only be determined in the real and complex setting.

METHODS: Four male subjects participated in the study. The sample was chosen to cover a wide range of expertise from beginner to experienced shooter. Table 1 summarises information about the weapons and projectiles used . Again, a wide spectrum is represented.

Table 1. Overview of weapons used.

Weapon	Mass of weapon (g)	Projectile	Mass of Projectile (g)	Theoretical recoil energy (J)	Piston skirt
Rifle	3000	12/70 pellet	28	23,28	Rubber
Springfield Gun	3500	30-06 Springfield	11,7	27,57	none
Weatherby Gun	4200	0.300 Weatherby Magnum	11,7	35,44	Rubber
Carbine	3800	8x57IS	11,7	21,46	Steel

The shooters assumed prone, standing and seated (supported) positions. In addition to the standard piston skirts (see Table 1), three different damping elements were inserted into the shooting jacket:

- PU8: Visco-elastic PU foam, 8mm (Dr. Gmünder)
- PU6: Visco-elastic PU foam, 6mm (Dr. Gmünder)
- Reactar™ Recoil System, 3/16 inch (Browning)

Additionally, measurements were performed without damping pads to facilitate comparison and evaluation of the effectiveness of the devices. The four subjects fired a total of 154 shots with the conditions: four weapons, three positions, four damping situations, in randomised

sequence. Pressure throughout the shot was measured with an FScan System (500 Hz). Data were recorded on a portable logger and transferred to a PC. Following static calibration the pressure distribution matrix for the instant when maximum pressure occurred was used to compute a value for the peak force for each shot. This value was then used in the statistical data analysis performed with SPSS 10.0.

RESULTS AND DISCUSSION: The present paper focuses on the influence of the four damping conditions (None, PU6, PU8 and Reactar™). On first sight, the means (see Table 2) show the expected decrease in peak force (Fmax) due to the damping pads: 8(none)=697,3; 8(PU6)=441,3; 8(PU8)=472,5; 8(Reactar™)=565,7. The Pearson correlation coefficient for damping vs. Fmax (r=.395; p=.000) and the partial correlation (controlling for weapon, shooter and position) of r=.544; p=.000 support the notion, that damping pads influence Fmax. Also, the peak force is not correlated with the shooters. This suggests that the results apply for a wide range of shooting competence and experience. Results from ANOVA for the entire group (n=154) further substantiate the assumed relation between damping pads and peak force (p=.000). This also hold true, when cases are extracted from the sample: shots for the conditions 'weapon=rifle' and 'position=standing' (n=63; p=.000). Finally, an analysis of co-variance was computed. With this statistical tool it is possible to analyse the influence of the independent variable 'damping pad' on the dependent variable 'Fmax' for all shots, while controlling for the intervening variables 'shooter', 'weapon' and 'position'. Furthermore the model computes estimated means, corrected for the effects of the intervening variables. Table 2 summarises the means and the corrected estimated means. The mean Fmax for PU8 is higher than for PU6. This would suggest that the 6mm foam has better damping properties than the 8mm foam (both made of identical visco-elastic material). However, this does not make sense and must be attributed to experimental design effects. The corrected estimated means are within 2% of the means for the conditions 'None' and 'Reactar' but reverse the ranking of 'PU6' and 'PU8'.

Table 2. Means (8) and corrected estimated means (analysis of co-variance).

Damping pad	Mean (8)	Corrected estimated mean
PU 8	472.5	439,6
PU 6	441,3	469,2
Reactar™	565,7	565,2
None	697,3	715,4

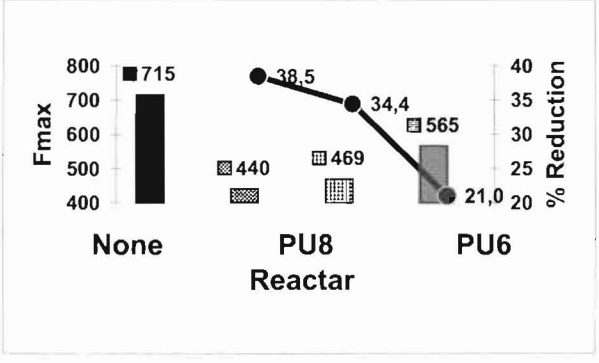

Figure 1. Peak recoil forces (Fmax) and % reduction for the condition without damping pad (None = 100%) and the three damping pads tested (PU6, PU8, Reactar).

The results of the statistical data analysis imply that all damping pads significantly reduce the impact as quantified by the peak force. Results are summarised in Figure 1. In comparison to the shots without damping mean reductions of 21% (Reactar), 34,4% (PU6) and 38,5% (PU8) are observed. Compared to the Reactar™ Recoil System the visco-elastic foams reduce Fmax by 17% (PU6) and 22,1% (PU8) respectively.

CONCLUSION: Damping pads inserted into the shooting jacket effectively reduce the recoil impact (peak impact force) and thereby help to decrease discomfort of the shooter especially in prolonged repetitive shooting. There are significant differences between the tested damping pads suggesting a superior performance of visco-elastic PU foams.

REFERENCES:

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