# The Biomechanics of Bruising

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## Introduction

Haemoglobin concentration[1], photographic[2] and colour pattern identification[2,3] have been used for characterising contusions. However, few studies specifically focus on the mechanics of bruise formation[2,4]. Ultimately, we wish to determine if there is a link between the time progression of bruising and mechanics of impact, which necessitates controlled impact generation. Several studies have used a paintball marker[3, 5-7], yet to date their suitability has yet to be assessed. Therefore, this study aimed to determine if a BT-4 Combat marker is suitable for generating controlled blunt impacts.

## Methods

Figure 1. Experimental set-up of the marker and chronograph

A fully pressurised marker (~3000 psi), was secured via a table mount and reusable paintballs (mass of 2.6 g) were fired through a chronograph (Figure 1), until the cylinder depressurised. This procedure was repeated a further 5 times to determine the repeatability of firing velocity.

To determine accuracy, carbon paper targets were placed at distances of 4, 5, 6, 7 and 8 m and 40 shots were fired at each.

## Results and discussion

Above 800 psi the marker velocity is effectively constant, whilst below this value, velocity decreases with pressure (Figure 2). There was no significant difference between the 6 tests and above 1500 psi, the average velocity was 71.27 ± 0.529 $ms^{-1}$.

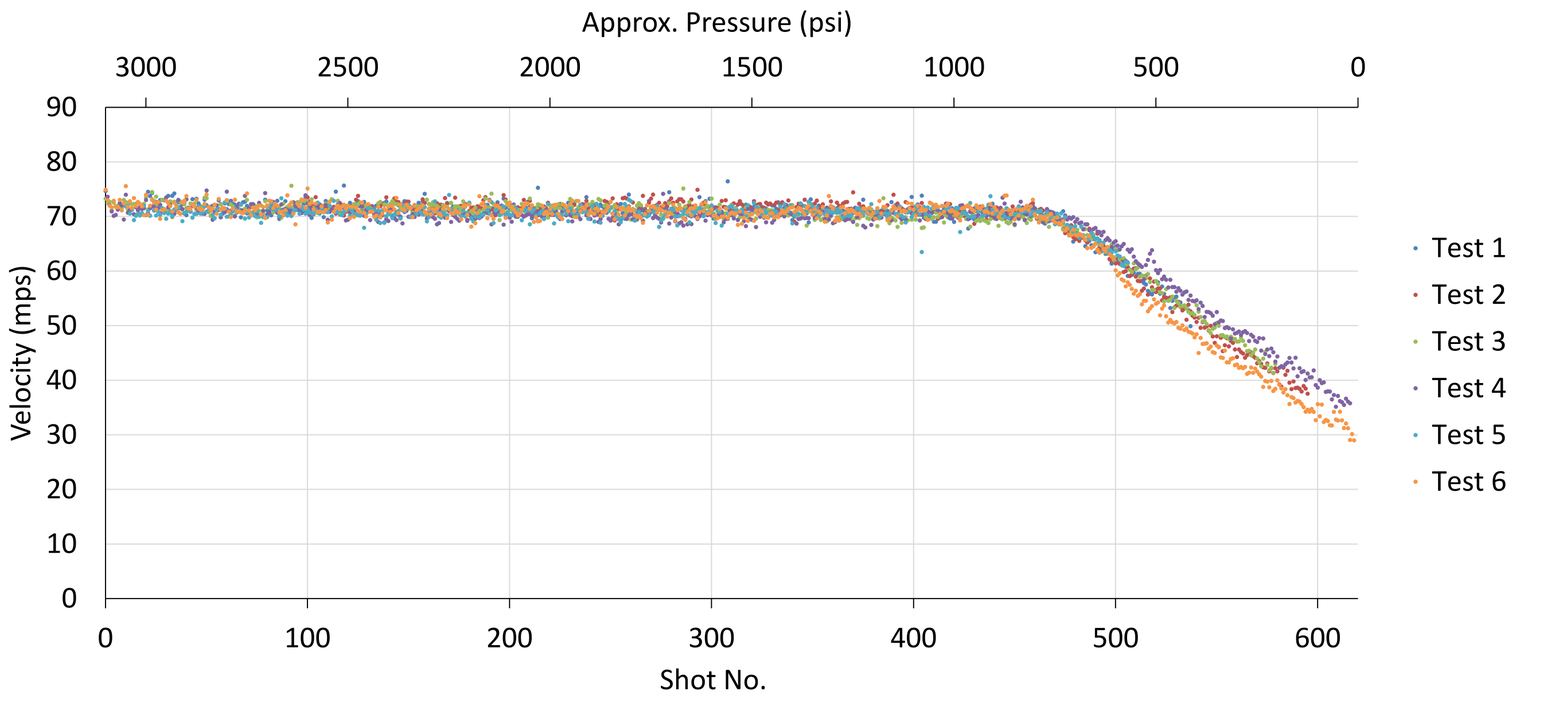


Figure 2. Firing velocities for all 6 tests

From 200 shots, the impact location of 177 were successfully recorded with impact overlap resulting in lost data (Figure 3). Marker trajectory and laser sight were divergent (Figure 4) resulting in predictable vertical (~2cm/m) and horizontal (~1 cm/m) error. The effect of gravity on marker impact location was not apparent. Impact dispersion increased with distance (Figure 3, Table 1).

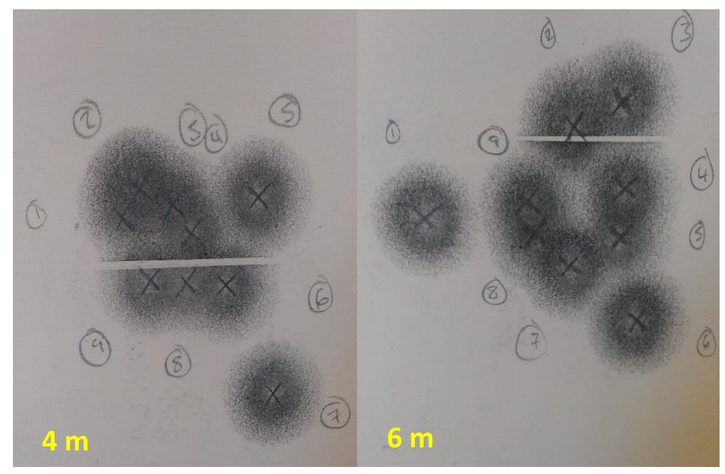


Figure 3. Examples of impact overlap and increasing dispersion at 4 and 6 m

| Distance (m) | x sd (cm) | y sd (cm) |
|---|---|---|
| 4 | 1.45 | 1.87 |
| 5 | 1.79 | 2.15 |
| 6 | 2.77 | 2.72 |
| 7 | 2.31 | 3.74 |
| 8 | 2.15 | 2.28 |
| Average | 2.09 | 2.55 |

Table 1. x and y standard deviations around the mean impact location

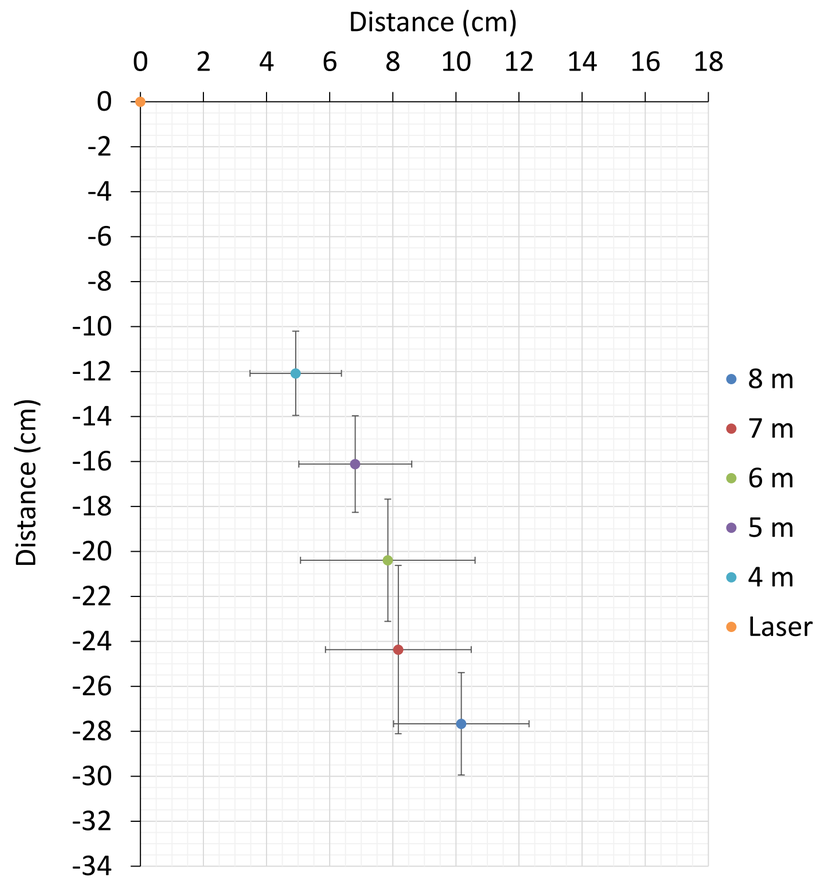


Figure 4. Average impact location ± *x* and *y* standard deviations for each target distance

## Conclusions

Impact velocity and location were highly predictable. Thus the paintball marker is appropriate for use as a controllable, repeatable and reliable method for blunt impact generation.
Combined with imaging techniques such as infrared and cross polarisation photography, this will allow for both the mechanics of impact and the aging of bruise injuries to be investigated.

## References

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