Human performance trials in spear thrusting and throwing

the mechanics and biomechanics of early weapon systems

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Introduction

Hand-delivered spear technologies, comprising both thrusting spears and hand-thrown spears, are thought to have been some of the earliest weapons systems used by Pleistocene hominins. The identification in the archaeological record of the use of these weapons, whether via damage signatures on potential lithic points, or via potential hunting lesions on zooarchaeological remains aids in better understanding Pleistocene subsistence strategies. Experimental replication is a key methodology in weapon research, generally aimed at either understanding the effectiveness of weapons, or replicating damage signatures to weapon armatures or bone. However, experiments replicating hand-delivered spears have methodological issues, in particular those caused by a lack of data on the human performance behind these weapons. Experimental designs for both thrusting and hand-thrown spears have necessarily relied upon estimates in the literature on impact velocities (thrusting and hand-thrown spears), impact forces (thrusting spears) and effective distances (hand-thrown spears) [e.g. 1, 2]. To address this, two human performance trials were conducted using trained participants using replicas of an untipped wooden spear in spear thrusting and throwing activities.

Spear Thrusting

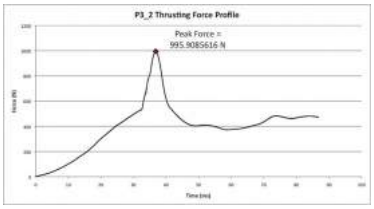
Materials and Methods:

11 male participants trained in bayonet use were recruited from the military to take part in the trial. Participants performed a minimum of three thrusts each using untipped wooden spear replicas designed to match published measurements of spear II from the Middle Pleistocene site of Schöningen, Germany.

The target consisted of a block of PermaGel™, a clear synthetic muscle simulant. A load cell inserted into the spear shafts captured force profiles (Newtons) and were translated into data by Imatek Impact Analysis software. Each spear thrust was filmed using Phantom V7 high speed video camera (1000 fps). Videos were analysed for impact velocity. Depth of penetration was also measured.

Results:

39 thrusts were recorded. Using trained participants resulted in velocities higher than those using untrained participants [3]. The mean spear thrusting velocity is lower than those from one-handed stabbing studies due to the heavier mass of the spear replica compared with those of knives. Force profiles had three variations. Force levels exceeded those from one-handed stabbing studies, in contrast with velocity results. The results support the view [e.g. 4] that mechanical devices firing a spear as a projectile fail to replicate the mechanics of a spear thrust and that trained humans provide the most accurate method of replicating thrusting activities. One spear broke around the midpoint during use.



Spear Throwing

Materials and Methods:

6 male javelin athletes took place in a spear throwing trial at Loughborough University throws centre. The trial was designed to better understand:

- effective distance of hand-delivered spears
- release and impact velocities at a series of distances
- flight mechanics of wooden spears

The trial was not intended to mimic a hunting scenario nor understand the effectiveness of hand-thrown wooden spears on an animal. Further experiments will address these questions. Two replicas were made to match spear II from Schöningen, crafted from spruce and finished with lithic tools. Participants each threw a series of aimed throws at a fixed target, at distances from 5 meters to 25 meters. Participants also threw a series of 'distance' throws. Impact velocities of successful 'hits' and their associated releases, and distance throw impact velocities were recorded using high speed video (1000 fps).

Results:

108 throws were recorded. Participants hit the hay bale target the majority of the time at 5 meters, with 'hits' decreasing at each distance. No throws at 25 meters resulted in a 'hit'. Impact velocities exceeded estimates in both directions, and contrary to expectation regularly exceeded release velocities. The maximum distance throw, (not aiming for the target) achieved a distance of over 30 meters. Highest velocities recorded were associated with distance throws. One spear broke upon impact with the ground.

Literature cited

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