28th ECSS Anniversary Congress, Paris/France, 4-7 July 2023

Optimal arrow grouping based on arrow mechanical properties and vanes positionning

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INTRODUCTION:
The material used by an archer affect the score, alongside the shooting technique and conditions [1]. Since different arrows are shots during an event, selecting a set of similar arrows based on their properties is crucial [2]. To obtain optimal grouping on the target, which leads to better score, matching characteristics have been identified: diameter [2], straightness [3], mass [4] or stiffness [4]. In addition, stiffness around the arrow shaft is variable [5] but never considered in those studies, nor the vanes positions with respect to the stiffness pattern. This work aims to investigate if these two aspects influence arrow grouping.
METHODS:
Sixty arrow shafts were analyzed using a test bench to obtain their diameter, straightness, and stiffness. Every shaft started on a standardized position (S) according to their labels, then rotated four times around its longitudinal axis, with eight measures per rotation. A sine wave was used to characterize the stiffness. The mean, amplitude, frequency, and phase were found by a Fourier transform and nonlinear fitting. Each shaft was associated with an arrow point and fletched so that out of three vanes, one was placed on S. The angular position of the maximum and minimum of the stiffness, relative to S and therefore one of the vanes was computed. The mass of the shaft, point and assembled arrow were also considered. Five sessions were made with a shooting machine, using the same bow, at the Olympic distance of 70 meters, indoor. The average coordinates of a given arrow across the five shots were collected with graph paper.
The normalized Cartesian distance between every existing pair of arrows (n = 1770) on the target was computed. Likewise, the normalized mechanical distance for the pairs were evaluated for every existing combination of the eleven parameters (n = 2047). Finally, to assess which parameters to consider for arrow grouping, the RMSE between the two distances were computed.
RESULTS:
For each arrow, the standard deviation of the positions was 2.2 ± 1.1 cm on the horizontal axis and 2.0 ± 1.0 cm on the vertical axis. The minimum for the RMSE between target and mechanical distances was found for a combination of three parameters: mean stiffness, frequency and assembled arrow mass.
CONCLUSION:
This work provides three parameters to consider for arrow selection, from the eleven parameters that were considered initially. As expected, arrows that had similar stiffness and total mass were closer to each other on the target. The third parameter was the sinusoidal frequency of the stiffness, which suggest that the stiffness pattern variation around the shaft has also to be considered for optimal arrow grouping. Shaft diameter, straightness and vanes positions with respect to stiffness extrema were found to be less relevant in arrow grouping.
REFERENCES:
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Topic: Sport Technology

Presentation Oral