

## ARCHERY PERFORMANCE: GUIDELINES FOR REPORTING IN SCIENTIFIC RESEARCH

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## Abstract

Archery performance analysis can be categorized into product analysis and process analysis, both crucial for understanding the sport's dynamics. Product Analysis focuses on the outcome of the shot, emphasizing accuracy, precision and hit distribution. Process Analysis explores the chain of events involved in the shooting process, encompassing four key interactions. Intra-subject, Archer-Bow, Bow-Arrow and Arrow-Environment interaction. Studies investigating the shooting process often correlate performance metrics with process elements, comparing athletes of different skill levels or championship placements. Regardless of the study's focus, it is essential to recognize that performance is multifactorial, with each analysed component representing only part of a broader set of interactions. This work aims to offer guidelines for the methodological presentation of scientific articles investigating archery elements related to performance, as well as a theoretical framework on the various interactions during the shooting process.

**Keywords:** Archery; Biomechanic; Performance

## Introduction

Measuring and analysing sports performance is one of the main objectives of all sports sciences in general, especially when seeking to compare results obtained in scientific studies of a specific sport. In archery, this task becomes somewhat challenging due to several factors, such as: different competition formats, different bow categories, favourable or unfavourable weather conditions, as well as the distance and model of the target. The Target format is the most popularly practiced and most present in the scientific literature on archery. It uses a fixed target at a certain distance and can be conducted in indoor or outdoor environments. The way archery is conducted in the Olympic Games is part of the Target modality.

A Target competition has two stages: the qualifying and the elimination stages, each with distinct characteristics. In the qualifying stage, all archers shoot a certain number of arrows (60 or 72) at their targets and record the sum of the value hit in each shot. This sum is used to create a ranking of the archers and a bracket system. In the elimination phase, each archer competes in a match against another archer, and the winner advances in the bracket until the medal matches. In each match, archers shoot a minimum of 9 arrows and a maximum of 16. Even shooting at the same target and distance, each of these phases has its own characteristics, making

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it difficult to compare performance in each, whether due to the volume of arrows shot, the pressure of one-on-one competition, among other factors.

Even before the arrow hits the target, the archer needs to manipulate the bow so that it launches the arrow forward. From the bodily movements made by the archer to the flight of the arrow, several interactions occur between the archer, the bow, the arrow, and the environment. These interactions form a complex chain of events that can be associated with performance, which is one of the main topics of investigation in archery studies. However, even studies with good methodological quality make mistakes when referring to performance or explaining how the investigated phenomenon is positioned within this chain of events, thus making it difficult to compare with other studies, which is detrimental to the development of this still underexplored field. This work aims to offer guidelines for the methodological presentation of scientific articles investigating archery elements related to performance, as well as a theoretical framework on the various interactions during the shooting process.

## Guidelines

## Performance

One of the main objectives of research in competitive sports is to understand the characteristics of the sport to enhance athletes' performance. In this section, we will present ways to evaluate and report performance in archery. These methods will be subdivided into two groups: product analysis and process analysis.

## Product Analysis

It refers to the main outcome of archery performance, whether in the qualifying or elimination phase. Total score, partial score, average points per arrow, and per round, among others, are the main measures for product analysis. However, the dispersion of arrows on the target is also an important parameter and can be useful for a more in-depth investigation (Ertan, 2016). Figure 1 presents three distinct dispersion patterns with the same score.

Accuracy and precision are concepts commonly found in the literature of sports sciences, health, education, and engineering. Depending on the context of the studies, they may have different definitions. Within the analysis of archery product performance, we define precision as the proximity of two or more arrows, popularly known as group size. It can be expressed by the mean distance – standard deviation between arrows, the minimum radius of a circle,

or the minimum perimeter of an ellipse sufficient to encompass all arrows on the target, among others. Accuracy is defined by the proximity of the arrows to the centre of the target or any other point defined as the objective to be hit. The score itself is a measure of accuracy, which can also be expressed by the mean distance-standard deviation of the arrows.

Although the procedures required to measure the dispersion of arrows on the target are more complex than simply verifying the score, analysis from digitized target images has already proven to be an effective and reproducible method (Callaway & Broomfield, 2012; Kolayis et al., 2014). Applications such as My Targets®, Mantis X8®, and Steady Aim®, among others, are already used by coaches and athletes for dispersion analysis. However, there are still no articles that validate and verify the reproducibility of these applications.

## Process Analysis

There is a complex chain of events that make up the entire shooting process. Within this chain, cumulative interactions occur that determine the final outcome, meaning that interactions occurring first tend to influence subsequent ones. Below, we exemplify some of the main interactions that we consider fundamental for process analysis in archery.

**I) Intra-subject:** This refers to the set of intrinsic characteristics and elements of the archer, which can be analysed and manipulated even before the archer touches their equipment. These include: general physical conditioning, body composition, body proportion, strength, endurance, flexibility, hydration level, psychological aspects, etc.

**II) Archer – Bow:** The bow can only shoot the arrow once opened and positioned correctly by the archer. The entire process of handling the bow until the shot is executed can be divided into several stages. The number of stages and their characteristics may vary between authors in the archery literature (Vendrame et al., 2022). Within these stages, various biological, psychological, neurological, and mechanical phenomena that make up the entire chain of events can be evaluated. For this reason, it may be the most studied interaction in the archery literature.

**III) Bow-Arrow:** As soon as the archer releases the string, the arrow is accelerated by the kinetic energy accumulated in the limbs, transmitted through the string, until it detaches from the string, starting its flight trajectory. This occurs in approximately 0.015 s (ZANEVSKYY, 2006). Even though this interaction is somewhat influenced by the archer's handling, it is predominantly

mechanical, where the components and accessories of the bow act on the arrow until it begins its flight.

**IV) Arrow-Environment:** After leaving the bow, the arrow starts a parabolic flight trajectory, decelerating until it reaches the target. At this moment, it is subject to its aerodynamic characteristics and climatic conditions such as wind and rain, without any further interference from the archer or the bow.

When the objective of a study is to analyse process elements, it is common to correlate or associate them with performance, either through a direct comparison with performance measures or indirectly, comparing athletes of different levels or who achieved different positions in a given championship. Additionally, some aspects of the shooting process can be investigated even if they are not directly associated with performance metrics. For example, performing the shooting cycle more quickly can provide the archer with extra seconds, allowing them to rest, adjust the equipment, or wait for more favourable wind conditions. In all cases, it should be emphasized that performance is multifactorial and that the research proposes to analyse only a part of this set of elements.

### Recommendations for Reporting

- Use "performance" or "performance measures" as terminology for variables referring to scores and dispersion measures. Likewise, use accuracy and precision appropriately, as mentioned earlier.
- Describe in detail the procedures for verifying dispersion: on-site procedures, digitization, mathematical calculations, etc.
- Whenever possible, certify the validity, reproducibility, and error measures of the instruments and procedures adopted.
- When reporting that one or more variables of the shooting process are related to performance, indicate the nature of this relationship as well as the chains of interactions and possible mechanisms involved.
- Use the terms "process," "shooting process," "shooting cycle," or equivalents to refer to the set of events that make up the shot.
- Describe in detail which stages of the shooting process were analysed.

### Participants

In the characterization of participants, different approaches can be observed to identify the level of archers, such as: participation in the national team of their respective countries (Açıkada et al., 2019); winning medals in regional, national, international, or Olympic championships (Spratford & Campbell, 2017); scores obtained in the qualifying phase of these championships (Lim, 2018); score in specific protocols applied in each study (Shinohara & Urabe, 2018); personal records (Ertan, 2016), or even a combination of these and other forms of classification of the archers' level. All these approaches are valid and provide some degree of understanding of the athletes' level, but they present limitations.

Reporting that archers participate in national teams' disregards differences between countries that historically have a higher level in archery, such as South Korea, and other countries with less tradition in the sport. Furthermore, the criteria for selecting athletes for national teams can vary significantly. Winning medals or obtaining certain scores in competitions depends primarily on the archer's performance in the qualifying and elimination phases, which have distinct characteristics, as mentioned earlier. Additionally, this approach does not take into account environmental conditions such as wind and rain, which can influence the competition.

On the other hand, reporting performance in the qualifying or elimination phase may be relevant when the research objective is to analyse these stages. The score obtained in research protocols reflects the archer's current state well, especially when the protocols are similar or identical to the standard of official competitions, either indoor or outdoor. However, this approach does not consider all the stress factors of a real competition environment. Moreover, it is important to assess whether the reported parameters are recent or outdated.

### Recommendations for reporting

- Training experience focused on competitions.
- Results achieved (qualifying and elimination) in indoor or outdoor competitions in the last year, according to the relevance to the research theme.
- Position in the world ranking at the time of data collection, informing the corresponding date.
- Other metrics relevant to the study's objective.

### Collection Environment and Target

The environment where the archer performs the shots can influence their performance both positively and negatively. Exposure to sun, wind, and rain makes each practice location unique. On the other hand, indoor competitions eliminate the influence of these external factors.

In most research on archery, protocols requiring the archer to shoot are adopted. These shots can be performed in a laboratory environment, which benefits researchers by allowing greater control of experimental conditions. However, the laboratory infrastructure may not allow the target to be positioned at 18 meters or more (minimum official distance for indoor events), as observed in the studies of (SARRO; VIANA; DE BARROS, 2020) and (KIM et al., 2023).

Shots performed in an outdoor environment, even respecting official distances, are subject to climatic variations, which can not only interfere with data collection but also hinder comparisons with other studies. This is because it is practically impossible to accurately report environmental conditions during data collection or reproduce exactly the conditions reported in another research.

Since archery returned to the Olympic Games in 1972, modifications have occurred in the competition format, target dimensions, and distances used. These changes are part of the natural development of archery, as occurs in other sports. Comparing athletes from different eras, using different equipment and in various competition formats, makes direct performance comparison extremely difficult, if not unfeasible. Therefore, a detailed description of the experimental conditions is recommended to allow more accurate comparisons between studies.

### Recommendations for reporting

- Whenever possible, use official guidelines for standardized indoor and outdoor events.
- Describe the type and dimensions of the target used, along with the year of data collection. Example: "Indoor target, single face, 40 cm in diameter, positioned at 1.30 m in height, score 1-10, 2025".

### Conclusions

Our main objective was to provide a reference methodological guide for archery studies that in some way analysed performance. Since performance is multifactorial and some of its elements are difficult or impossible to measure, it is challenging to gain a deep understanding of the entire chain of events and how variations in each element affect performance. For this, it is necessary to analyse and compare various studies, which need to use appropriate technical terminology and elements common to the practice of archery. This study also offers, for the first time in the archery literature, a detailed explanation of the entire chain of interactions involved in the shooting process. We believe it is beneficial for researchers to understand more globally where their study objects are positioned in the chain of interactions and how they can be more easily compared to other studies.

### Author contributions

All authors participated in the theoretical-methodological elaboration of the guidelines suggested in this study, as well as in the writing and textual review of the manuscript.

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### Disclosure statement

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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