ROLE OF CORE STABILITY AND DYNAMIC BALANCE IN STANDING SHOOTING PERFORMANCE

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INTRODUCTION

- Performance during standing shooting is a major determinant of overall race outcome across multiple biathlon race formats [1,2].
- Several studies have reported critical mechanical factors for successful standing shooting showing that high performing athletes have less postural and rifle sway than lower performing athletes [3,4].
- To date, no studies have evaluated physical characteristics required for successful standing shooting.
- Stability of the core region may be critical to allow the athlete to stabilize the trunk against perturbations and thus minimize postural and rifle sway.
- How to measure core stability in a sport specific manner and doing so in environments without laboratory equipment are areas requiring further investigation.

Purposes

1) Examine associations between core stability and critical factors for standing shooting across a range of biathletes.

H1: Core stability would be associated with shooting measures and worse in youth and master's biathletes than senior level biathletes.

2) Determine whether a simple clinical movement screen can be used as a surrogate for core stability.

H2: Performance on the Y-Balance Test will predict performance on a biathlon specific core stability assessment.

METHODS

Participants

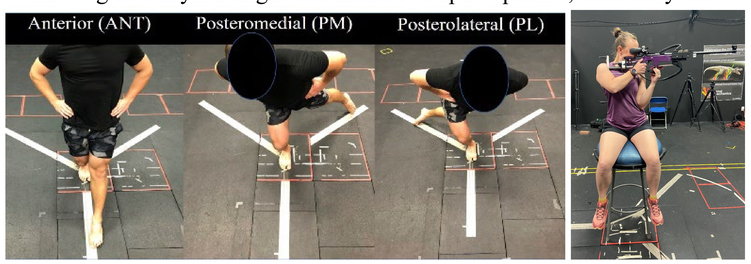
- Twenty-two biathletes participated in this study. Participants varied in age and biathlon experience as show below.

	Sex	Age (years)	Height (m)	Mass (kg)	Experience (years)
Youth	3 M / 5 F	14.2 ± 1.3	1.69 ± 0.08	60.9 ± 5.7	3.1 ± 2.1
Senior	2 M / 4 F	23.0 ± 4.9	1.72 ± 0.12	65.7 ± 10.6	5.7 ± 1.9
Master's	2 M / 6 F	51.5 ± 11.5	1.71 ± 0.07	61.7 ± 7.3	3.5 ± 2.1

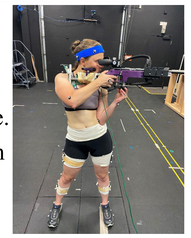
- Half participants were tested in the Neuromuscular Biomechanics Laboratory at Montana State University while the other half were tested at the 2022 USBA National Championships in Lake Placid, NY.

Experimental Protocol

- After a 10-minute warm up participants completed the Y-Balance Test and the biathlon specific core stability assessment.
  - YBT requires stabilizing on one limb while reaching as far as possible in three directions with the free limb.
  - Core stability required sitting as still as possible on an unstable surface. Holding on a dryfire target was added as a sport specific, secondary task.

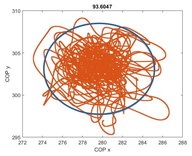


METHODS



- Participants then dryfired 4 5-shot magazines at 5m targets.
- IMU sensors placed on sacrum and bottom of the rifle sight to quantify movement of the body center of mass (COM) and rifle.
- A sub-cohort of participants repeated the shooting protocol with elevated heart rate (1000-meter threshold/L3 intervals).

Data Analysis



- YBT performance quantified by calculating a composite score (sum of each direction / 3 * leg length). Higher scores = better dynamic balance.
- Core stability was quantified by calculating a 95% confidence ellipse centered on the mean of the center of pressure position during the trial. higher values = worse core stability.
- Range of motion (ROM) and mean velocity of the rifle and COM in the last 0.5 seconds before each shot were quantified.
  - Motion quantified in-line and across line of shooting, and vertical direction.

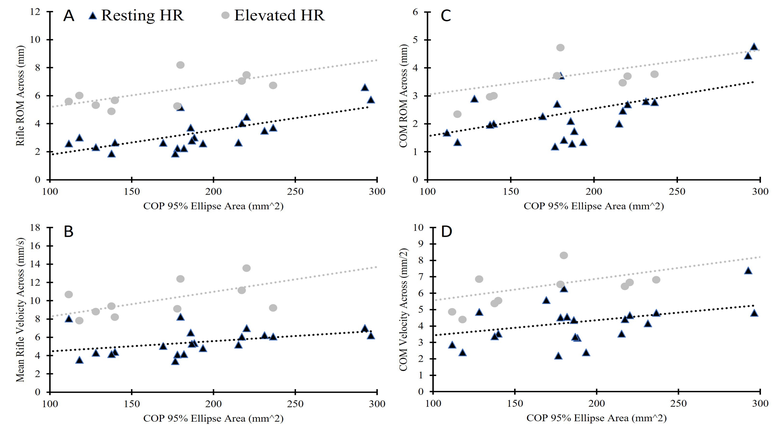
RESULTS

- Years of biathlon experience was different across groups ($F_{2,19} = 3.55$, p = 0.043) with both youth (p = .022) and master's groups (p = .048) have less experience than the senior group.
  - Groups represent experienced athletes verse those new to the sport at either young or older ages.
- Core stability ($F_{2,19} = 9.386$, p = .001) and dynamic balance control ($F_{2,19} = 4.616$, p = .023) were worse in the youth and master's groups than the senior group.
- For most shooting parameters the master's group performed worse than either youth (superscript a) or senior groups (superscript b).

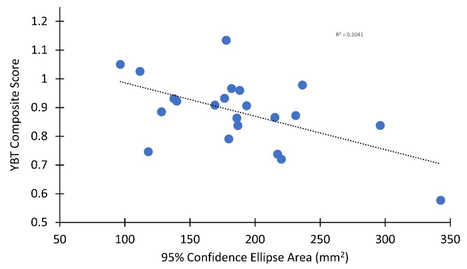
Variable	Youth (n=8)	Senior (n = 6)	Masters (n = 8)
Core stability (mm²)	187.22 (± 13.58)[b]	130.32 (± 28.43)	231.53 (± 65.7)[a,b]
YBT composite score	0.904 (± 0.046)[b]	0.984 (± 0.022)	0.799 (± 0.122)[a,b]
Rifle ROM inline (mm)	1.77 (± 0.24)	1.80 (± 0.28)	2.08 (± 0.31)
Rifle ROM across (mm)	3.15 (± 0.86)[b]	2.50 (± 0.39)[a]	4.19 (± 1.27)[a,b]
Rifle ROM vertical (mm)	1.91 (± 0.17)	2.33 (± 0.75)	2.87 (± 0.89)[a]
Rifle velocity inline (mm/s)	3.77 (± 0.47)	3.83 (± 0.58)	5.01 (± 0.81)[a,b]
Rifle velocity vertical (mm/s)	6.97 (± 0.91)	5.87 (± 1.07)	8.12 (± 2.47)[a,b]
Rifle velocity across (mm/s)	4.71 (± 0.49)	3.71 (± 1.65)	5.72 (± 1.76)[a,b]
COM ROM across (mm)	2.16 (± 0.71)	1.85 (± 0.73)	3.06 (± 0.66)[a,b]
COM ROM inline (mm)	0.63 (± 0.28)	0.48 (± 0.11)	0.93 (± 0.37)[a,b]
COM ROM vertical (mm)	0.54 (± 0.35)	0.35 (± 0.16)	0.36 (± 0.11)
COM velocity across (mm/s)	3.65 (± 1.13)	3.71 (± 1.16)	5.17 (± 1.09)[a,b]
COM velocity inline (mm/s)	3.26 (± 1.86)	2.44 (± 0.28)	3.73 (± 1.66)
COM velocity vertical (mm/s)	2.84 (± 2.42)	1.39 (± 0.68)	1.44 (± 0.54)

RESULTS (cont.)

- Core stability was positively associated with 6 shooting variables (4 shown below) in both resting and elevated heart rate conditions.



- Performance on the YBT was able to predict performance on the biathlon specific core stability assessment (R^2 = .304, p = .007). Higher composite scores had better core stability.



CONCLUSIONS AND RECOMMENDATIONS

- Developing sufficient core stability may be a prerequisite for successful standing shooting. This may be particularly important for athletes new to the sport.
- Correlation coefficients generally increased from resting to elevated heart rate conditions suggesting core stability may play an important role in shooting with fatigue.
- Simple movement screens such as the YBT can be used as surrogate measures of core stability if laboratory environment is not available.
- There is likely an opportunity for developing simple IMU based systems for real-time monitoring of shooting and skiing performance.

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