



Physical and Psychological Correlates of VR Combat Performance

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Background

- Operational readiness requires coordinated cognitive, motor, physical, and psychological performance under dynamic, high-demand conditions.
- Traditional neuropsychological measures may not fully capture these integrated demands.
- Virtual reality (VR) provides a controlled environment for examining performance as task demands change.
- Marksmanship is influenced by physical, psychological, and task-specific factors, with the role of grip strength varying across performance conditions.
- This study examined grip strength and state anxiety in relation to shooting performance and adaptation during constrained VR combat gameplay.

Methods & Materials

PARTICIPANTS

- Participants N=25 (5 female, 20 male)
- Mean age = 25.2 ± 8.1 years



Figure 1. ZeroCaliber Reloaded-Dust task: First-person VR view during combat simulation following weapon mechanics training.

STUDY DESIGN

- Participants completed neurocognitive testing followed by VR gameplay conditions:
 - Objective 1: Standard Performance Condition:** Participants complete the scenario using their preferred shooting strategy, capturing less-constrained shooting performance across accuracy, kills, and headshots.
 - Objective 2: Constrained Precision Condition:** Participants repeat the scenario under a headshot-only requirement, restricting target elimination and increasing demands on precision and controlled target engagement.
- Grip strength and state anxiety (STAI) were assessed and standardized as Z-scores, with dominant- and non-dominant-hand grip combined into a composite measure.
- Participants completed *Zero Caliber: Reloaded* under two conditions: Round 1, standard target elimination, and Round 2, constrained headshot-only target elimination.
- VR outcomes included shooting accuracy, total kills, and headshots. Accuracy change was calculated as Round 2 – Round 1 and standardized as a Z-score.
- Separate multiple regression models examined grip strength as a predictor of Round 2 shooting accuracy, total kills, and headshots while accounting for state anxiety. Exploratory correlational analysis examined the association between state anxiety and change in shooting accuracy across conditions.

Results

Grip Strength and Shooting Performance

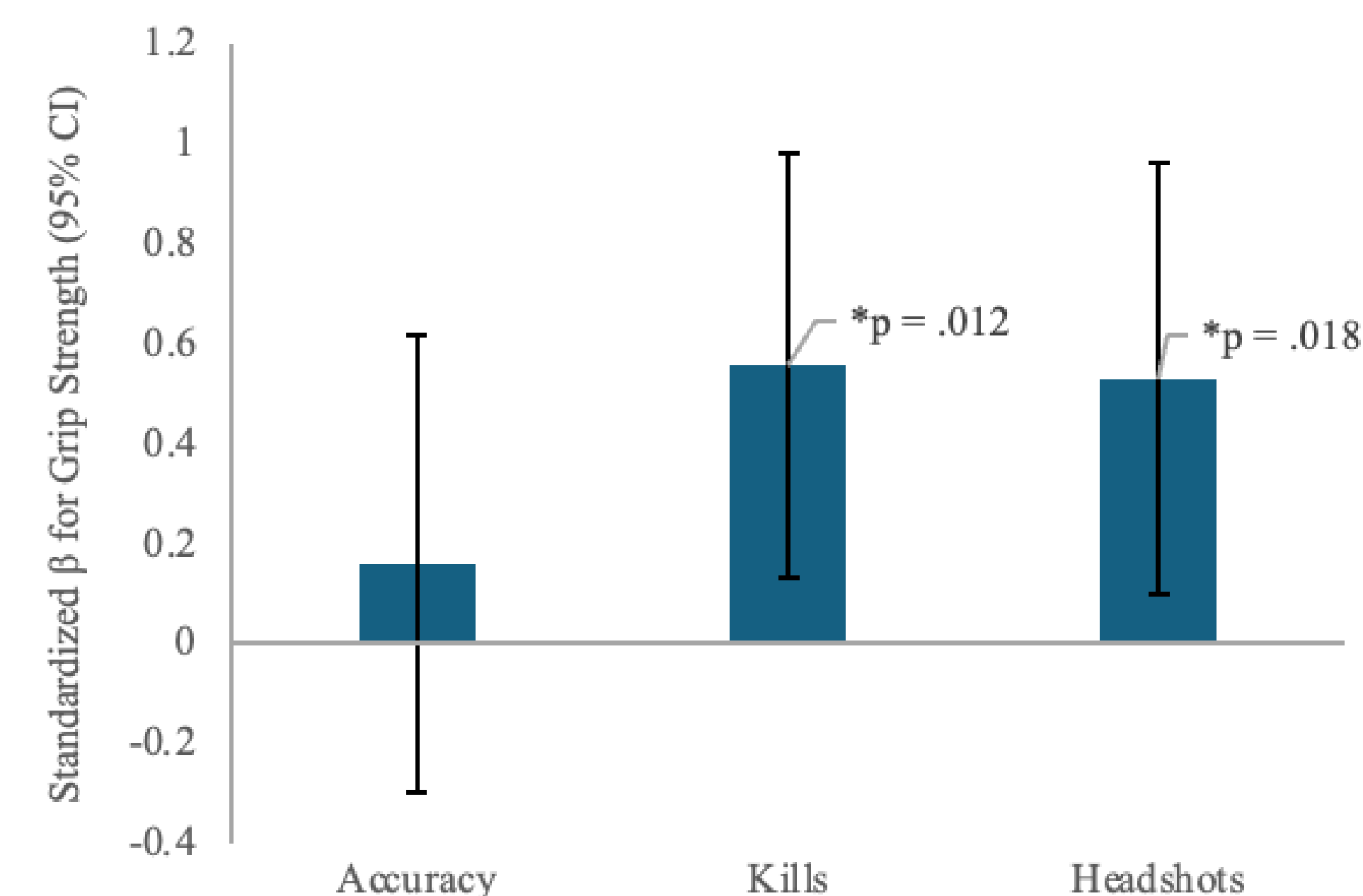


Figure 1. Standardized associations between grip strength and shooting performance during constrained gameplay, controlling for state anxiety. Grip strength significantly predicted total kills and headshots, but not shooting accuracy. Error bars represent 95% CIs. $*p < .05$.

State Anxiety and Accuracy Change

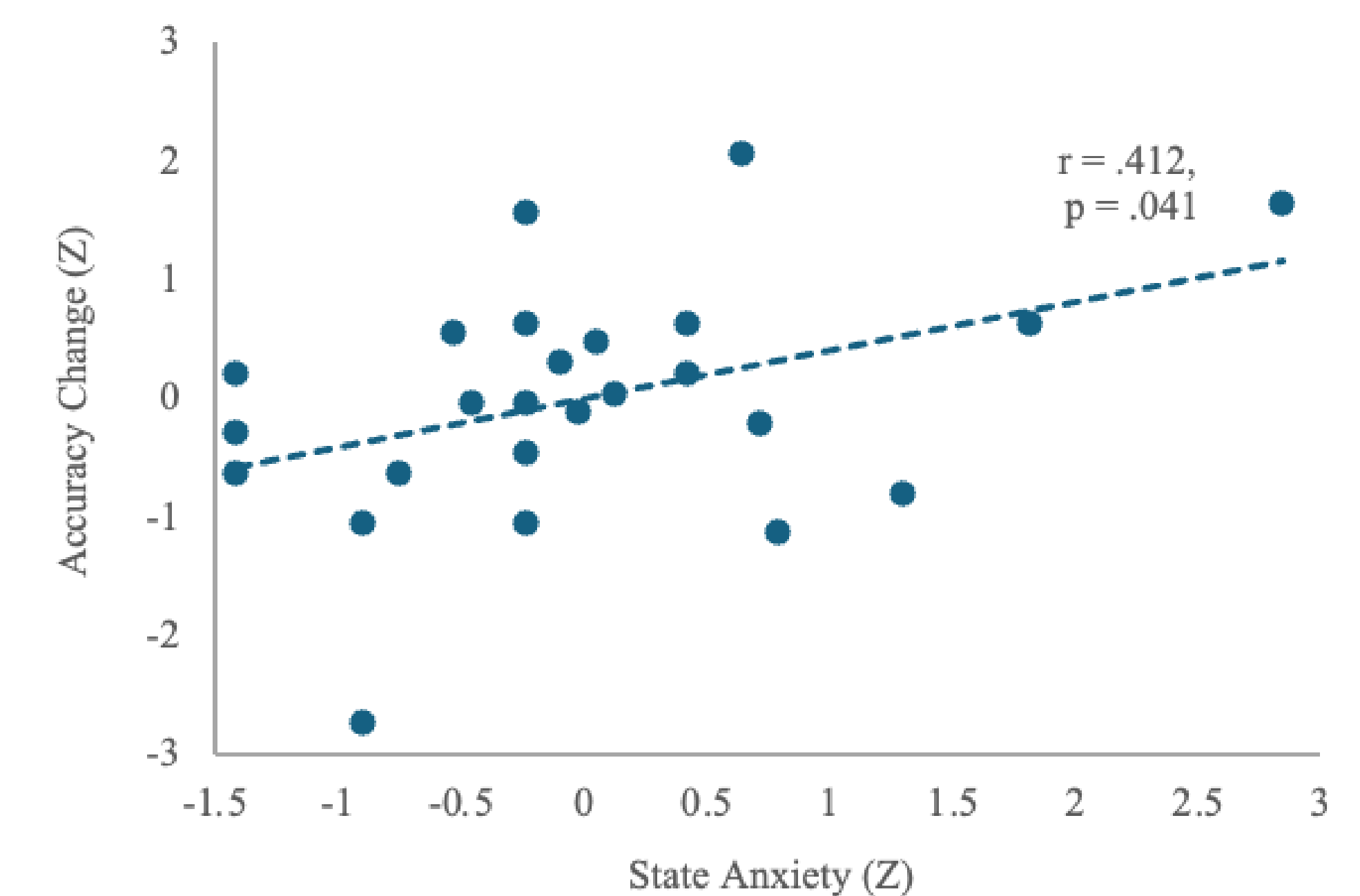


Figure 2. Higher state anxiety was associated with greater improvement in shooting accuracy across gameplay conditions ($r = .412$, $p = .041$). Accuracy change reflects Round 2 – Round 1; positive values indicate improved accuracy under the constrained condition.

- Grip strength was associated with constrained shooting performance after accounting for state anxiety. Greater grip strength was associated with more total kills ($\beta = .558$, $p = .012$) and headshots ($\beta = .529$, $p = .018$), but not greater shooting accuracy ($\beta = .160$, $p = .477$). The overall model for kills was significant, explaining 25.3% of the variance ($R^2 = .253$, $p = .040$), whereas models for headshots ($R^2 = .228$, $p = .058$) and accuracy ($R^2 = .128$, $p = .223$) were not significant overall.
- Exploratory analysis showed that higher state anxiety was associated with greater improvement in shooting accuracy across conditions ($r = .412$, $p = .041$), explaining 16.9% of the variance in accuracy change.

Conclusions

- Grip strength was significantly associated with kills and headshots**, but not shooting accuracy, during constrained VR gameplay, suggesting that greater physical capacity may contribute more to successful target elimination than shooting precision alone.
- These relationships remained significant after accounting for state anxiety**, with grip strength showing distinct associations across multiple dimensions of shooting performance. This highlights the importance of examining performance beyond accuracy as a single outcome.
- Physical capacity and psychological state may relate to different aspects of performance. **Higher state anxiety was associated with greater improvement in accuracy across conditions**, suggesting psychological state may influence how performance adapts as task demands change.
- Overall, **these findings highlight operational performance as multifactorial, shaped by physical capacity, psychological state, and task constraints**. Larger samples are needed to clarify how these factors independently and jointly contribute to performance under changing operational demands.

References

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