DISCLOSURES

- Funded by an International Paralympic Committee Classification Research Grant (with World Para Snow Sport).
- Additional funding provided by University of Waterloo.
INTRODUCTION AND PURPOSE

- Classification in Paralympics
- Athlete Classification Code
- Evidence-based classification
  - Determining eligibility – Minimum impairment criteria
  - Allocation of athletes into sport classes
- Purpose
  - Investigate the minimum vision impairment criteria for Para Nordic Skiing using simulated vision impairments in skiers with normal vision in non-adapted Nordic skiing
Current Minimum Impairment Criteria

Static Visual Acuity (SVA)
1.0 logMAR

Visual Field (VF)
20° visual field radius
STUDY DESIGN

- With-in subject, repeated measures experimental design
- 2018 Para Nordic World Cup, Oberried, Germany
- Experienced adult ski racers
  - Guides, coaches, team members, members of the local ski club
- Two visits
METHODS

Visit 1:

- Questionnaire

- Vision function assessment (binocular)
  - Static visual acuity – ETDRS, BRVT charts (logMAR)
  - Contrast sensitivity – MARs chart (logCS)
  - Visual field - Arc perimeter (Esterman scoring in %)

- Conditions: Habitual & Simulated impairments
SIMULATED IMPAIRMENTS

Cambridge simulation glasses (8 levels)

- Visual Acuity
  - -0.02 to 1.36 logMAR

- Contrast Sensitivity
  - 1.77 to 0.34 logCS

Painted goggles (6 levels)

- Visual Field
  - 85% to 20% visual field extent
VISIT 2: SKIING TRIALS

- 400 to 500m course
- 18 skiing trials total
- First and last trials with clear goggles
- Middle 16 trials included:
  - 2 clear goggle trials
  - 8 visual acuity + contrast sensitivity impairments
  - 6 visual field impairments
  - Randomly assigned
- Time to complete each run compared to baseline
  - Average of 4 clear goggle trials
DATA ANALYSIS

- Normality: Shapiro-Wilk test, Q-Q plots
- Friedman’s Two-Way Analysis of Variance (p<0.05) with Dunn post-hoc test
  - Order & fatigue effects on race time
  - Simulation effects on race time
- ROC analysis
  - Youden’s J: optimum criteria - maximum sensitivity and specificity
    - Sensitivity: correctly include skiers with eligible vision impairments
    - Specificity: correctly exclude skiers without eligible vision impairments
POPULATION

- 22 sighted, experienced Nordic skiers (6 Females, 16 Males)
  - $28.09 \pm 9.67$ yrs; range: 16 to 50 yrs
  - Coaches (12), Guides (5), local ski club (4), Physio (1)
  - 11 Nations
- Years of experience: $21.59 \pm 10.86$ yrs; range: 5 to 44 yrs
- Total hours of skiing in a week: $8.90 \pm 4.68$ hrs; range: 1 to 20 hrs
ORDER & FATIGUE EFFECTS

- No difference in race time was found across the clear goggle trials
  - Skiers could maintain a consistent race pace
- No systematic order effect on performance in the data
  - Skiers did not get progressively faster as they became more familiar with the course
Simulated impairment trials compared to baseline time

- Race time increased gradually
  - Steeper increase from Level 5
    - $0.85 \pm 0.1$ logMAR
    - $0.95 \pm 0.11$ logCS
OPTIMUM CUT-OFF: VISUAL ACUITY

At 0.81 logMAR
Youden’s J = 0.59
• Sensitivity: 0.88
• Specificity: 0.71

At 1.01 logMAR (B3)
Youden’s J = 0.52
• Sensitivity: 0.68
• Specificity: 0.84
At $1.14 \log CS$  
Youden’s J = 0.60  
• Sensitivity: 0.91  
• Specificity: 0.69
SIMULATION EFFECT: VISUAL FIELD

- Skiing performance decreased gradually
- Significantly different at Level 5
  - 33.4% visual field extent
At 37.9%  
Youden’s J = 0.50  
Sensitivity: 0.71  
Specificity: 0.79

at 21.7% (B3)  
Youden’s J = 0.16  
Sensitivity: 0.21  
Specificity: 0.95
CONCLUSION

- Moderate reductions in visual acuity, contrast sensitivity, and visual field appear to affect skiing performance negatively

Visual Acuity At 0.81 logMAR

Contrast Sensitivity At 1.14 logCS

Visual Field At 38% (Esterman score)
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