Exercise Responses between Outdoor and Virtual Reality Indoor Arms+FES-leg Cycling in Individuals with Spinal Cord Injury

Nasrin Hashim, Che Fomase, Ruby Hafiz, Glen M. Davie, FACSM, ‘University of Sydney & University of Malaya, Sydney, Australia. University of Sydney, Sydney, Australia. University of Malaya, University of Malaya, Malaysia.

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Functional electrical stimulation (FES) leg cycling has the potential to improve cardiopulmonary fitness after spinal cord injury (SCI). Combined arm and leg (‘hybrid’) exercise develops a higher oxygen uptake and greater cardiovascular demand compared to FES-leg cycling alone. Recent technologies have enabled outdoor hybrid cycling as well as virtual reality (VR) indoor hybrid exercise. VR-enhanced exercise enables the individual to interact within a virtual environment mimicking outdoor exercise, and provides a sense of participation and exercise motivation.

PURPOSE: This study compared submaximal exercise responses during outdoor hybrid cycling versus VR-enhanced indoor hybrid cycling.

METHODS: Eight individuals with chronic thoracic-lesion SCI were recruited. They performed voluntary arm and FES-assisted leg cycling on a commercially available hybrid recumbent trike. The experiments were conducted outdoors and indoors incorporating VR technology whereby the same outdoor environment was simulated on a large flat screen monitor. Four separate trials (2 outdoor, 2 VR) were conducted at least two days apart. Electrical stimulation was applied bilaterally to the quadriceps, hamstrings and glutei muscle groups and individuals modulated stimulation intensity according to preference and comfort. They were instructed to cycle to their best ability and safely. Oxygen consumption, heart rate and energy expenditures were measured over a 36-min outdoor and VR-simulated indoor test course.

RESULTS: During outdoor cycling, mean VO2 was 15.95 ± 1.20 ml·kg⁻¹·min⁻¹ compared to 16.60 ± 0.87 ml·kg⁻¹·min⁻¹ for indoor VR exercise. Energy expenditures were 25.7 ± 1.4 kcal·min⁻¹ for outdoor cycling versus 26.8 ± 1.0 kcal·min⁻¹ indoors. The outdoor cycling heart rate was 128 ± 3 bmm·min⁻¹ compared to 125 ± 3 bmm·min⁻¹ during VR exercise. T-tests revealed that there was no significance difference (p>0.05) between indoor and outdoor test responses. There was also no significance differences in the highest VO2 or heart rates observed over the 36 min test course.

CONCLUSION: This study concluded that VR-enhanced hybrid cycling produces no different physiological responses than outdoor arms-leg cycling. Virtual reality technology may provide new opportunities for exercise rehabilitation in the SCI population.

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