KINEMATIC PROFILE OF THE ELITE HANDCYCLIST

Thomas Abel[1], Dominik Bonin[1], Kirsten Albracht[2], Sebastian Zeller[1], Gert-Peter Brüggemann[2] Brendan Burkett[3] and Heiko K. Strüder[1]

Institute of Movement and Neurosciences, German Sport University, Cologne, Germany[1]
Institute of Biomechanics and Orthopaedics, German Sport University, Cologne, Germany[2]
Centre for Healthy Activities, Sport and Exercise, University of the Sunshine Coast, Australia[3]

KEYWORDS: spinal cord injury, wheelchair sport, paralympics.

INTRODUCTION: A handcycle is a relatively new sports equipment that is a combination of the traditional race wheelchair and a hand operated bicycle crank (Abel, Schneider, Platen, & Struder, 2006). The high mechanical efficiency of this geared fixed-frame racing cycle in comparison to a manual wheelchair can potentially increase the distance a person with a loss of lower limb function can travel. To guide the optimal setup for the handcyclist the influence of crank length (Goosey-Tolfrey, Alfano, & Fowler, 2008; Kramer, Hilker, & Bohm, 2009) and crank configuration (Faupin, Gorce, Meyer, & Thevenon, 2008a; Mossberg, Willman, Topor, Crook, & Patak, 1999) have been investigated. Actual neither research has been done on the upper body kinematics of elite athletes nor on relations between kinematics and performance. The aim of this study was to provide first sport specific information in this area with regards to athletes competing at an international level.

METHOD: Thirteen disabled international level handcyclists (height 176.6 ± 5.9 cm, body mass 69.0 ± 10.35 kg, age 39 ± 9.1 years), who participated in the Paralympics 2008 in Beijing, were recruited for the study. Tests were done on a self constructed, mechanical braked roller system that allowed sport specific testing in the one race handcyle with mounted food rest. Before starting the measurements, the participants completed a 5 min familiarization session to warm up and to get used to the required crank frequency of 90 rpm at approximately 90 Watts. A three-dimensional movement analysis was performed with four Basler Cameras (A602-f, Basler Vision Technologies, Ahrensburg, Germany) operating at 100 Hz and synchronized with a Vicon® MX Unit (Oxford Metrics; Oxford, United Kingdom). The recorded videos were analysed using Vicon® Motus and exported to Vicon® Nexus to determine 3D joint kinematics of the right upper body with the Vicon® upper limb model™. Therefore, thirteen spherical retro-reflective markers were attached to the skin at predetermined anatomic landmarks to define four rigid segments (thorax, upper arm, forearm, hand) with overall seven Degrees of Freedom (DoF). The shoulder joint exhibits three DoF (flexion/ extension, abduction/adduction, internal rotation/external rotation), the elbow joint two DoF (flexion/extension, internal rotation/external rotation) and the wrist joint two DoF (flexion/extension, abduction/adduction), either. The joint angles were calculated using the definition of the Bryant angles. To allow comparison across subjects, the calculated joint angles were normalized to one crank cycle. In the beginning of each session a static trial was acquired to define joint rotation centres. Performance capacity was measured during an additional sport specific stage test. Beijing competition results of each athlete were documented.

RESULTS AND DISCUSSION: The present findings may claim to represent the kinematic aspects of handcycling sport for international elite sports. Since the preparatory work for the determination of force maxima and force minima were collected with internationally active athletes, they can claim a high specificity. On one hand the objective was to adapt sports science research tools to the needs of the relatively new sport of handcycling. On the other hand, the data which were collected with the help of video analyses and their evaluation

were used to analyse relationships between biomechanical factors and performance. Currently there are no studies in the literature that have examined upper body kinematics of international level handcyclists.
The ranges of motion for the shoulder and elbow joints evaluated in this study are, compared to the published values (Faupin, Gorce, Meyer, & Thevenon, 2008b), somewhat lower. These differences may be explained by the examined subjects (elite athletes vs. able bodied persons without handcycling experience). It may be assumed that there was insufficient adapting to the sports equipment for this group within the meaning of an optimum seating position. This would explain that movements were performed, less economical in terms of optimal driving action and that this was followed by greater range of motion. The establishment of angular velocities and angles at certain especially relevant positions should complete range of motion in the scientific debate.
For all analyzed correlations no significant relationship was found between the examined parameters describing shoulder and elbow joint kinematics and the performance parameters (e.g. work load stage test, results Paralympics Beijing). The calculated correlation coefficients partially show a very weak or nonexistent relationship. However, some correlations can be understood at least as an indication of possible favourable configurations. On the one hand, a comparatively large angle of flexion of the shoulder seems to lead to a higher performance in the stage test. On the other hand, it can be seen that a relatively large angle of shoulder abduction was associated with a higher performance during the time trail in Beijing. Against the background of other factors influencing the performance and taking into account the number of participating subjects, these results should not be over-interpreted.

CONCLUSION: This study is a first approach to investigate the kinematic profile of the elite handcycling athlete. The methodology as an adaptation of well reviewed upper limb model provides valid information. No significant relationships were found between the upper limb kinematics and performance. For a clear justification the number of samples should be enlarged.

REFERENCES:

Abel, T., Schneider, S., Platen, P., & Struder, H. K. (2006). Performance diagnostics in handbiking during competition. *Spinal Cord, 44* (4), 211-216.
Faupin, A., Gorce, P., Meyer, C., & Thevenon, A. (2008a). Effects of backrest positioning and gear ratio on nondisabled subjects' handcycling sprinting performance and kinematics. *Journal of Rehabilitation Research and Development, 45* (1), 109-116.
Faupin, A., Gorce, P., Meyer, C., & Thevenon, A. (2008b). Effects of backrest positioning and gear ratio on nondisabled subjects' handcycling sprinting performance and kinematics. *J Journal of* Rehabilitation *Research and Development, 45* (1), 109-116.
Goosey-Tolfrey, V., Alfano, H., & Fowler, N. (2008). The influence of crank length and cadence on mechanical efficiency in hand cycling. *European Journal of Applied Physiology, 102* (2), 189-194.
Kramer, C., Hilker, L., & Bohm, H. (2009). Influence of crank length and crank width on maximal hand cycling power and cadence. *European Journal of Applied Physiology, 106* (5), 749-757.
Mossberg, K., Willman, C., Topor, M. A., Crook, H., & Patak, S. (1999). Comparison of asynchronous versus synchronous arm crank ergometry. *Spinal Cord, 37* (8), 569-574.

Acknowledgement

The study was supported by Federal Institute of Sport Science IIA1-0706091/08