PROPULSION IN ELITE LOW-POINT CLASSIFICATION RUGBY WHEELCHAIR ATHLETES

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Wheelchair propulsion kinematics have been demonstrated to be dependent on chair configuration, although this knowledge is still limited in wheelchair rugby. This study monitored the propulsion kinematics during sprint performance in elite low-point wheelchair rugby athletes, with correlations between kinematics, athlete experience and configuration investigated. Increased experience was correlated with decreasing contact and push angles for the second push, as well as trends for the first and third pushes. Configuration parameters such as seat depth, seat angle, and seat depth-to-thigh length, were also shown to be correlated with kinematic variables. Findings provide important information for the configuration of wheelchairs to utilise efficient regions of their stroke and optimise sprint performance.

KEYWORDS: Kinematics; wheelchair configuration; sprinting

INTRODUCTION: Wheelchair propulsion kinematics for court sports such as rugby and basketball have received relatively limited attention (Crespo-Ruiz, Del Ama-Espinosa, & Gil-Agudo, 2011). Wheelchair configuration has been repeatedly shown to influence performance (Mason, van der Woude, & Goosey-Tolfrey, 2013; Usma-Alvarez, Fuss, & Subic, 2014; Vanlandewijck, Verellen, & Tweedy, 2011), however these studies have rarely investigated the associated kinematics such as hand contact and release angles or individual characteristics of the athlete. Wheelchair rugby (WCR) involves frequent stopping and changing direction, and hence acceleration from standstill has been identified as a critical performance factor (Mason, Porcellato, van der Woude, & Goosey-Tolfrey, 2010). Therefore, consideration of the propulsion kinematics of WCR athletes during a sprint from a stationary position is required to develop knowledge and improve performance.
WCR involves athletes with a wide range of impairments, with each athlete given a score ranging from 0.5-3.5 points based on their trunk and hand function, with a lower point score signifying reduced muscle function compared with higher point scores (Mason et al., 2013). Athletes are often grouped based on their point scores, such as a low-point group consisting of 0.5 and 1.0 point athletes. This study aims to investigate the importance of considering sub-groups due to large differences in impairment across WCR.

METHODS: Five low-point WCR athletes (one 1.0 point athlete and four 0.5 point athletes) participated in the study following written, informed consent. Each athlete's experience (number of years participating in the sport) was recorded, as well as measurements of their wheelchair, including: seat height, seat depth, seat angle, and camber angle (Mason et al., 2013; Usma-Alvarez et al., 2014). In addition, anthropometric measures were taken to assess the ratio of wheelchair-anthropometric measures (i.e., seat depth-to-thigh length, seat height-to-total arm length and elbow angle at top dead centre (TDC) of the wheel (Mason et al., 2013)). Athletes then performed five 5m sprints from a stationary position in their own time. Sprint times were recorded using a laser timing system (Kinematic Measurement System, Fitness Technology) and video footage (100Hz, Sony HDR-PJ 430) was recorded from side and rear views of the participant (Vanlandewijck et al., 2011). Propulsion kinematics including the hand contact angle (ContAng), release angle (RelAng), push angle (PushAng), push time (PushTime), recovery time (RecTime), and cycle time (CycTime) (West, Campbell, Goosey-Tolfrey, Mason, & Romer, 2014) were then calculated using Kinovea (Padulo et al., 2015) (Version 0.8.15, kinovea.org) for the first three strokes of the sprint. Timing of hand contact and release was identified using the first and final point of contact with the wheel, respectively (West et al., 2014). Hand contact and release angles were measured between the second metacarpo-phalangeal joint on the right hand (Tsai, Lin, Huang, Lin, & Su, 2012) and top dead centre (TDC) of the wheel, with PushAng the difference between the two. PushTime is the time in which the hand is in contact with the wheel, while RecTime is the time between the release of one stroke and contact of the next. The addition of push and recovery times gives the overall CycTime. Inter and intra-rater reliability of kinematic analysis was assessed using intraclass correlation coefficients (ICC). A random selection of 20 trials were chosen and re-analysed by the lead researcher two-weeks after initial analysis, as well as by an additional experienced researcher. Results show good to very good correlation for both intra- and inter-rater reliability consistent with typical error seen in previous research (0.88 and 0.92, respectively) (Ali, Foskett, & Gant, 2014; Atkinson & Nevill, 1998). Pearson correlations were performed in IBM SPSS Statistics (Version 21, 2012) investigating the influence of experience and wheelchair configuration on propulsion kinematics and performance.

RESULTS: Table 1 presents the correlation results between experience, configurations and propulsion kinematics. Athlete experience produced a positive correlation with the second push ContAng (ContAng2, 0.888, p=0.044). While ContAng1 and ContAng3 were not significant, they both showed a similar trend (p<0.1). PushAng2 showed a negative correlation with experience (-0.968, p=0.007), with PushAng1 and PushAng3 again demonstrating similar trends (p<0.06). No other propulsion variables had significant correlations with experience.
Seat depth demonstrated a negative correlation towards PushTime3 (-0.949, p=0.014), although neither PushTime1 nor PushTime2 had similarly strong correlations. Seat angle showed a positive correlation towards RelAng3 (0.893, p=0.041). All other variables were not significant.

Table 1: Correlations between propulsion kinematics, experience and wheelchair configuration.

		Experience	Seat Height	Seat Depth	Seat Angle	Camber Angle
ContAng1	Correlation	**0.857**	−0.096	0.169	−0.348	−0.523
	Significance	**0.063**	0.878	0.786	0.565	0.365
PushAng1	Correlation	**−0.866**	0.153	−0.291	0.451	0.384
	Significance	**0.058**	0.806	0.635	0.446	0.524
PushTime1	Correlation	−0.597	0.490	−0.616	**0.833**	−0.230
	Significance	0.288	0.402	0.268	**0.080**	0.710
ContAng2	Correlation	**0.888**	0.314	−0.230	0.378	−0.706
	Significance	**0.044***	0.607	0.710	0.530	0.183
PushAng2	Correlation	**−0.968**	0.049	−0.163	0.132	0.303
	Significance	**0.007***	0.938	0.793	0.833	0.620
ContAng3	Correlation	**0.809**	0.522	0.057	0.323	−0.548
	Significance	**0.097**	0.367	0.927	0.596	0.339
RelAng3	Correlation	−0.490	0.621	−0.495	**0.893**	−0.161
	Significance	0.403	0.263	0.396	**0.041***	0.796
PushAng3	Correlation	**−0.873**	0.173	−0.423	0.506	0.205
	Significance	**0.053**	0.781	0.478	0.384	0.741
PushTime3	Correlation	−0.177	−0.221	**−0.949**	0.493	−0.516
	Significance	0.776	0.721	**0.014***	0.399	0.373

*Significant at p≤0.05

Table 2 presents the correlation results between anthropometric measures and propulsion kinematics. Seat depth-to-thigh length produced negative correlations for RelAng1 (-0.922, p=0.026) and RelAng2 (-0.946, p=0.015). However, RelAng3, as well as all other variables, displayed no significant correlations. Seat height-to-total arm length and elbow angle at TDC produced no significant correlations for any propulsion variables or sprint time.

Table 2: Correlations between propulsion kinematics and anthropometric measures.

		Seat depth-to-Thigh length	Seat height-to-Total arm length	Elbow angle at TDC (°)
RelAng1	Correlation	**-0.922**	0.471	0.329
	Significance	**0.026***	0.423	0.589
PushTime1	Correlation	**-0.856**	0.623	0.415
	Significance	**0.064**	0.261	0.487
RelAng2	Correlation	**-0.946**	0.647	0.219
	Significance	**0.015***	0.238	0.723
PushTime3	Correlation	**-0.826**	0.005	0.640
	Significance	**0.085**	0.993	0.245

*Significant at p≤0.05

DISCUSSION: This study investigated the influence of elite WCR athlete experience and wheelchair configuration on propulsion technique, using an elite sub-group of low-point classification athletes. Based on correlation results, major influences on propulsion technique were experience, seat depth and seat angle.

Experience displayed significant correlations for ContAng2 and PushAng2, as well as trends for ContAng1, ContAng3, PushAng1 and PushAng3. Positive correlations for the contact angles suggest that athletes with greater experience in WCR prefer a propulsion stroke that is closer to TDC of the wheel, possibly allowing greater force application over a shorter period. The negative correlation for push angles supports this, as increasing the contact angle reduces the overall push angle used by the athlete. Due to the increased time involved in the sport, experienced low-point WCR athletes may trend towards a shorter push approach due to perceived improved performance, reductions in effort in sprinting from standstill, or to reduce the amount of stress placed on the upper limb joints.

Increasing seat depth was associated with reduced PushTime3. An increase seat depth positions the athlete further behind the wheel axle, increasing the ability of the athlete to use a 'pull' approach in their propulsion stroke (Vanlandewijck, Theisen, & Daly, 2001). Low-point athletes generally have limited triceps function, and this allows the athlete to utilise an effective region of the stroke. This finding is partially supported by trends (p<0.1) evident for decreased PushTime1 and PushTime3 for increasing seat depth-to-thigh length ratio.

Increasing seat angle was associated with increasing RelAng3. This was a surprising result, as increasing seat angle has been shown to limit trunk motion (Vanlandewijck et al., 2011), reducing the ability of the athlete to reach forward during the final stages of the push. While this is likely true for athletes with high levels of trunk function, the trunk motion possible for low-point athletes is reduced due to their impairment. An increased RelAng3 may be evidence of the athletes increased confidence in their stability due a larger seat angle (Mason et al., 2010), or changes in push approach after motion has been initiated.

Whilst this study provides initial results on propulsion techniques used with varying wheelchair configurations, the sample size is limited. Although increasing sample size has obvious benefits in terms of statistical power, this is restricted by the number of truly 'elite' athletes available for testing. Elite athletes are desired as they are expected to use a technique that is close to optimal for performance. In future studies, altering the wheelchair configuration of individual athletes in a controlled approach similar to Usma-Alvarez et al. (2014), but continuing to test on-court, is likely to identify effects at an individual level.

CONCLUSION: This study identified propulsion tendencies for elite, low-point WCR athletes from standstill based on their experience and wheelchair configuration. Experience was the most apparent influence on propulsion technique, with shorter push angles correlated with increased experience. Variables such as seat depth, seat angle and seat depth-to-thigh length also produced correlations towards propulsion variables, although these were not as pronounced. Knowledge of the effect wheelchair configuration has on performance can allow athletes and coaches to select set-ups that allow the athletes to utilise efficient regions of their stroke and improve performance.

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