Effects of offense, defense, and ball possession on mobility performance in wheelchair basketball

De Witte, Annemarie M.H.; Berger, Monique A.M.; Hoozemans, Marco J.M.; Veeger, Dirkjan H.E.J.; van der Woude, Lucas H.V.

published in
Adapted Physical Activity Quarterly (APAQ)
2017

DOI (link to publisher)
10.1123/apaq.2016-0125

document version
Publisher's PDF, also known as Version of record

document license
Article 25fa Dutch Copyright Act

Adapted Physical Activity Quarterly, 2017, 34, 382–400
https://doi.org/10.1123/apaq.2016-0125

Human Kinetics
ORIGINAL RESEARCH

Effects of Offense, Defense, and Ball Possession on Mobility Performance in Wheelchair Basketball

Annemarie M.H. de Witte
The Hague University of Applied Sciences and Vrije Universiteit Amsterdam

Monique A.M. Berger
The Hague University of Applied Sciences

Marco J.M. Hoozemans
Vrije Universiteit Amsterdam

Dirkjan H.E.J. Veeger
Vrije Universiteit Amsterdam and Delft University of Technology

Lucas H.V. van der Woude
University of Groningen

The aim of this study was to determine to what extent mobility performance is influenced by offensive or defensive situations and ball possession and to what extent these actions are different for the field positions. From video analysis, the relative duration of the various wheelchair movements during team offense/defense and individual ball possession was compared in 56 elite wheelchair basketball players. A two-way analysis of variance indicated that during offense, the guards and forwards performed longer driving forward than during defense. Overall, centers stood still longer during offense than during defense. Without ball, centers performed driving forward longer than with ball possession. It is

de Witte and Berger are with the Faculty Health, Nutrition and Sport, The Hague University of Applied Sciences, The Hague, The Netherlands. de Witte, Hoozemans, and Veeger are with the Dept. of Human Movement Sciences, MOVE Research Institute, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands. Veeger is also with the Dept. of Biomechanical Engineering, Delft University of Technology, Delft, The Netherlands. van der Woude is with Centre for Human Movement Sciences and Centre for Rehabilitation, University Medical Centre Groningen, University of Groningen, The Netherlands. Address author correspondence to Annemarie M.H. de Witte at a.m.h.dewitte@hhs.nl.

concluded that offense, defense, and ball possession influenced mobility performance for the different field positions. These differences can be used to design specific training protocols. Furthermore, field positions require potentially different specific wheelchair configurations to improve performance.

Keywords: offense/defense, video analysis, wheelchair–athlete interaction, wheelchair configurations

Wheelchair basketball is a Paralympic sport characterized by fast-paced defensive and offensive actions that include specific wheelchair maneuvers like starting, stopping, and turning (Wang, Chen, Limroongreungrat, & Change, 2005). Next to the functional abilities of the athlete, the movement dynamics of the wheelchair, specifically those actions related to handling the wheelchair and the ball, are crucial to both individual and team performance. Individual performance and therefore team performance, can be optimized by (a) the athlete, (b) the wheelchair design such as wheel camber and antitip castor positioning, and (c) the wheelchair–athlete interface configurations which essentially will determine the efficiency of power transfer from the athlete to the wheelchair (van der Woude, Veeger, Dallmeijer, Janssen, & Rozendaal, 2001). Performance in wheelchair basketball can be determined by three elements that continuously interact physical performance (athlete capabilities), mobility performance (wheelchair–athlete interaction), and game performance (athlete basketball tactics and skills; de Witte, Hoozemans, Berger, van der Woude, & Veeger, 2016). Game performance in wheelchair basketball can be defined as the true quality of a player's contribution to the game, such as the percentage of successful offensive rebounds, steals, and free throws (Byrnes & Hedrick, 1994; Vanlandewijck et al., 2003). The physical properties and capabilities of an athlete, often measured with indicators such as heart rate, oxygen uptake, and blood lactate, determine the physical performance (Bloxham, Bell, Bhambhani, & Steadward, 2001). Finally, what the athlete does (or can do) with a wheelchair can be referred to, as mobility performance (Mason, van der Woude, Lenton, & Goosey-Tolfrey, 2012).

Specific athlete training schedules mainly affect physical and game performance. In addition, changes in the wheelchair design and therefore wheelchair–athlete interface configuration have most impact on mobility performance. To optimally adjust wheelchair configurations to the benefit of individual wheelchair basketball players, not only lab and field-based experiments are required but also a thorough insight into mobility performance during wheelchair basketball games itself (Mason, van der Woude, Lenton, et al., 2012; Mason, van der Woude, Tolfrey, & Goosey-Tolfrey, 2012; van der Woude et al., 2001).

Regarding mobility performance during wheelchair basketball games, research is very limited (Bloxham et al., 2001; Coutts, 1992; de Witte et al., 2016). Based on a 6 min exhibition game, Coutts (1992) estimated that 64% of the time was spent in propulsive actions and 36% in braking activity. Propulsive actions were classified as positive accelerations and negative accelerations were considered indicative of braking activity. Bloxham et al. (2001) reported the time that elite wheelchair basketball players spent performing various wheelchair handling activities during a World Cup game. They stated that players moved across the field with light or no arm strokes for 24 ± 7% of the time. de Witte et al. (2016) showed significant differences in player activities during wheelchair basketball games between national and international standard players. National players drove relatively more forward whereas international players performed more rotational movements during the game. Recently, van der Slikke, Berger, Bregman, Lagerberg, and Veeger (2015) measured accelerations for wheelchair basketball players during games with inertial sensors. International standard players showed higher rotational and linear accelerations compared with national standard players.

The studies above showed differences in mobility performance between players in general, but important aspects such as functional classification, game-related aspects, and field position are not taken into account. All players are awarded from 1 (minimal functional potential) to 4.5 points (maximal functional potential) on an ordinal functional level scale. During international competition, the sum of points of the five players on court may not be greater than 14 points (International Wheelchair Basketball Federation, 2014). Earlier research has shown that functional classification and field position are closely related. The majority of classification 1 and 1.5 players play as guards, the majority of classifications 2 and 2.5 play as forwards, and classifications 4 and 4.5 mostly play the center position (de Witte et al., 2016; Vanlandewijck et al., 2003, 2004; Wootten & Wootten, 2012). When looking at the specific qualities that are required for the different field positions, this is a logical relationship (Boutmans & Rowe, 1997; Molik & Kosmol, 2001). Therefore, this study focused mainly on field position to found the specific qualities in wheelchair basketball. Centers play mainly in the lane under the basket and have high seat positions, and they need optimal trunk control though guards have high maneuverability and excellent ball skills. Nowadays, based on experience of coaches and players, the guards and forwards typically choose for wheelchair configurations favoring maneuverability and acceleration, whereas centers will prefer a higher sitting height to play in the bucket (Vanlandewijck, Daly, & Theisen, 1999). To improve the wheelchair configurations, players have to find the best compromise between the level of their impairment (classification level) and their field position.

In previous research, we observed no differences in mobility performance between field positions during both active and nonactive playtime together (de Witte et al., 2016). This was somewhat surprising because each field position has its own responsibilities on court, especially during the game situations offense and defense (Rose, 2004). For example, during offensive situations, the guards are floor leaders and are responsible for preserving ball possession. Moreover, during offensive situations, guards had the highest percentage of ball possession (between 23% and 44%) compared with other positions (Ortega, Cardenas, Sainz de Baranda, & Palao , 2006). During defensive situations, guards are primarily responsible for making opposing guards as ineffective as possible. Previously, de Witte et al. (2016) analyzed total playing time, even when the game clock was stopped. Because players remain active during this period, these movements may have caused differences between field positions to be minimal. It is, therefore, plausible that although overall field positions do not differ in mobility performance, differences may become apparent when game situations are compared.

Further analysis of the extensive dataset collected by de Witte et al. (2016) allowed us to get a more in depth view of mobility performance in wheelchair basketball in terms of game situation and ball possession.

Therefore, the purpose of this study was to examine differences in the mobility performance between wheelchair basketball players of different field positions and to determine whether mobility performance is influenced by game situation (offense and defense) and/or ball possession, and whether these actions are different for the field positions guard, forward, and center.

Methods

Participants

Several sports clubs of the Dutch first division competition and the participating teams in the Easter Tournament of Wheelchair Basketball in Blankenberge, Belgium (2014) were approached for participation in the present study. Of all teams and players that were informed—the number of which was not registered—56 trained male wheelchair basketball players volunteered to participate in the study during competitive games. Twenty-seven players competed at national standard in the Dutch first division, and 29 players played at international standard (Australia [$n = 6$], Great Britain [$n = 3$], The Netherlands [$n = 8$], Italy [$n = 5$], and Canada [$n = 7$]). In consultation with the coaches, three groups were defined based on field position: (a) guards ($n = 18$), including shooting guards and point guards, (b) forwards ($n = 24$), including power forwards and small forwards, and (c) centers ($n = 14$). The distribution of field position within categories is presented in Figure 1. Players in classifications 1 and 1.5 are categorized in Category 1, classifications 2–2.5 in Category 2, classifications of 3–3.5 in Category 3, and classifications 4–4.5 in Category 4. The local Ethical Committee of the

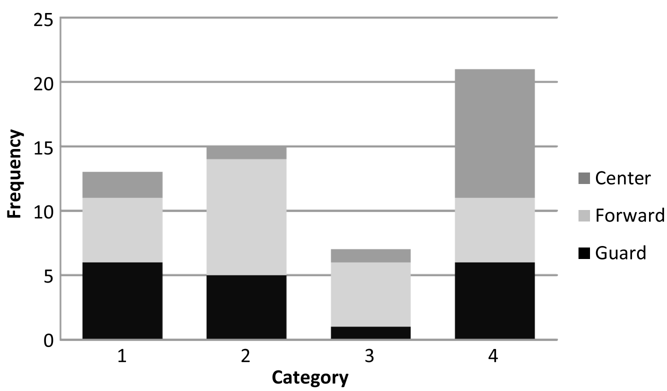

Figure 1 — Distribution ($n = 56$) of field position within classification categories. Players in classifications 1 and 1.5 are categorized in Category 1, classifications 2–2.5 in Category 2, classifications of 3–3.5 in Category 3, and classifications 4–4.5 in Category 4.

Department of Human Movement Sciences, Vrije Universiteit Amsterdam, approved the research project. Players participated on a voluntary basis and after signing an informed consent.

Time-and-Motion Analysis

Mobility performance was determined using video analysis. Players were filmed and observed during one entire match using an approach previously described by de Witte et al. (2016). In brief, video footage was collected during four entire games in the Dutch first division competition and five games at the Easter Tournament of Wheelchair Basketball in Blankenberge (Belgium, 2014) using two high-definition video cameras (Casio EX-FH100, 1280 × 720, 20–240 mm; Iruma, Japan) with fixed fields of vision. Measurement time was accurate to 0.03 s (29 Hz). Based on interviews with coaches, all possible wheelchair-handling activities and athlete control options, which determine mobility performance, were defined and are described in Table 1 (de Witte et al., 2016). These descriptors are the basis of the assessment of wheelchair and athlete activities by systematic observation, by four trained observers using Dartfish 7.0 TeamPro (Fribourg, Switzerland). A single observer observed the activities of one player during an entire game. Intraclass correlation coefficient (ICC) for intraobserver reliability was 0.96 (95% Cl, 0.73 to 0.99), and the ICC for interobserver reliability was 0.61 (95% Cl, 0.60 to 0.63), and the ICC between 0.40 and 0.75 for these types of analyses is considered as a moderate to good observer reliability (Shrout & Fleiss, 1979).

Data Analysis

Wheelchair-handling activities and athlete control options were only calculated during active playtime. Active playtime was defined as the time that a player was active on the court and with the game clock running. Due to unlimited substitutions in wheelchair basketball, the total absolute active playtime was different for each player. Data for all players who participated in the game were analyzed, regardless of active playing time. To validly compare game situations and the effect of ball possession, it is important to analyze the player's relative duration of wheelchair-handling activities to rule out the differences between players in action. Thus, for each player, the percentages of performing wheelchair–athlete activities and the athlete control options during active playtime were determined and defined as relative duration of activities.

During active playtime, the team can be in an offensive or defensive situation. An offensive situation is defined as the game situation in which someone from the team has ball possession, and the team had the objective to score, whereas a defensive situation is defined as the state when the opponent has ball possession. For each of those two game situations, the relative duration of activities was calculated as a proportion of the duration of the game situation within active playtime.

This study quantified ball possession as the percentage of active playtime that an individual player held the ball. The relative duration of the wheelchair-handling activities and control options during ball possession was calculated as a proportion

Table 1 Descriptors of Wheelchair–Athlete Activities Used During Observation of Wheelchair Basketball Athletes

Wheelchair activity	Control option	Definition	Comment
Driving forward	One hand	Forward movement of the wheelchair performed with one hand on the rim	> Half propulsion stroke from initial position
	Two hands	Forward movement of the wheelchair performed with two hands on the rim	
	Otherwise	Wheelchair moves forward without athlete action	
Driving backward	One hand	Backward movement of the wheelchair performed with one hand on the rim	> Half propulsion stroke from initial position
	Two hands	Backward movement of the wheelchair performed with two hands on the rim	
	Otherwise	Wheelchair moves backward without athlete action	
Rotate	Clockwise	Rotational movements of the wheelchair, performed clockwise (turn right)	Turn must be >45°
	Counter clockwise	Rotational movements of the wheelchair, performed counter clockwise (turn left)	
Standing still	One hand	No/small movements of the wheelchair performed with one hand on the rim	< Half propulsion stroke from initial position
	Two hands	No/small movements of the wheelchair performed with two hands on the rim	
	Otherwise	No/small movements of the wheelchair performed with no hands on the rim	
Brake	Two hands	Slowing down the wheelchair with two hands	–
	Otherwise	Slowing down the wheelchair with a handling other than hand-rim contact	–

Note. Adapted from "Do Field Position and Playing Standard Influence Athlete Performance in Wheelchair Basketball?" by A.M.H. de Witte, M.J.M. Hoozemans, M.A.M. Berger, L.H.V. van der Woude, and D.H. Veeger, 2016, *Journal of Sports Sciences*, *34*(9), pp. 811–820.

of the active playtime that a player performed activities during ball possession or without the ball.

Statistical Analysis

The relative duration of all variables was calculated for each athlete and presented as the mean (standard deviation) and complemented with the 95% CI for the mean differences. Data were analyzed using a two-way mixed design analysis of variance with "field position" as between-subject factor (guard, forward, center). The within-subject factor was in the first analysis "game situation" (offense and defense) and in the second analysis "ball possession" (with ball and without ball), respectively. The assumptions of normality and homogeneity of variance within the data were, respectively, checked with the Shapiro–Wilk's test and the Levene's test. The main effects for ball possession and game situation were tested, as well as the interaction between these factors and field position. When a significant interaction ($p < .05$) was observed, t tests with the Bonferroni correction were used to examine the interaction effect with a main focus on the differences in mobility performance within field positions. In addition, Cohen's d effect size (ES) and their 95% CI were calculated for all pairwise comparisons within field positions (guard vs. guard; forward vs. forward; center vs. center; Cohen, 1992). The (absolute) magnitude of the ES was interpreted as follows: <0.2 (trivial), 0.2 to <0.6 (small), 0.6 to <1.2 (moderate), 1.2 to <2.0 (large), and ≥2.0 (very large; Hopkins, Marshall, Batterham, & Hanin, 2009). IBM SPSS statistics version 22 was used for all statistical analyses (IBM Corporation, Armonk, NY).

Results

The mean active playing time for guards was 21 ± 7 min, forwards played 23 ± 9 min, and centers played 26 ± 7 min of 40 min game time. Offense and defense were equally divided over playing time for all field positions (50 ± 2%). During the game, guards had the highest percentage ball possession (21 ± 15%) when compared with forwards (16 ± 12%) and centers (18 ± 8%). Figures 2 and 3 summarize the differences between game situation and ball possession for the main activities.

Game Situation

Means and standard deviations for all wheelchair–athlete activities and control options during game situations are shown in Table 2. Two-way mixed design analysis of variance revealed a significant main effect for game situation for rotational movements ($p < .01$), both clockwise and counterclockwise. During defense, all field positions performed on average 4 percentage points (pp) more rotational movements than during offense. Moreover, during defense, all field positions stood still 4 pp longer with two hands on the rim ($p < .01$), and during offense, all field positions stood still longer without hands on the rim than during defense ($p < .01$). The magnitude of the effect sizes of these three pairwise comparisons was large (ES ≥ 1.34).

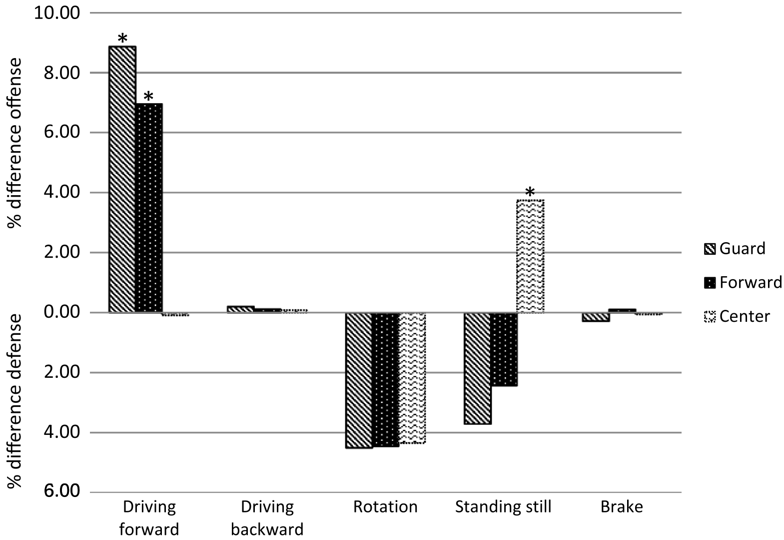

Figure 2 — Differences in mean relative duration (%) of wheelchair–athlete activities between offense and defense situation. Deviation from the axis means that the activity is performed longer during offense/defense than the other game situation. *Significant difference between offense and defense ($p < .05$).

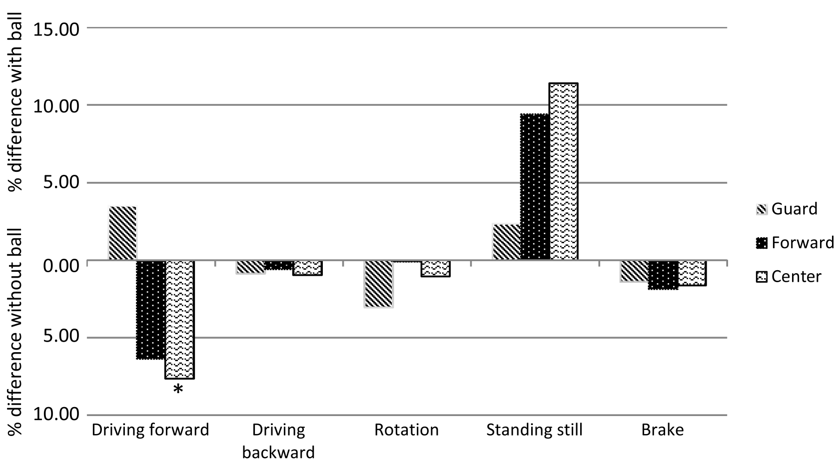

Figure 3 — Differences in mean relative duration (%) of wheelchair–athlete activities between ball possession and no ball possession. Deviation from the axis means that the activity is performed longer during ball possession than no ball possession. *Significant difference between ball possession ($p < .05$).

Table 2 Mean (*SD*) Relative Duration (%) of Wheelchair–Athlete Activities With 95% Confidence Intervals (CIs) of Mean Differences During a Game for Position (Guard, Forward, and Center) and During Game Situations (Offense and Defense) Complemented With Cohen's *d* Effect Sizes With 95% CI

		Guard					Forward					Center				
		M (*SD*)					*M* (*SD*)					*M* (*SD*)				
Action	Control	Offense	Defense	95% CI mean difference	Effect size	95% CI effect size	Offense	Defense	95% CI mean difference	Effect size	95% CI effect size	Offense	Defense	95% CI mean difference	Effect size	95% CI effect size
Driving forward	Overall*	51 (8)	43 (6)	3.84 to 13.90	1.19***	0.46 to 1.87	48 (10)	41 (6)	2.27 to 11.65	0.86***	0.26 to 1.44	44 (6)	44 (4)	–4.28 to 4.12	–0.01	–0.76 to 0.73
	One hand**	1 (1)	0 (1)	–0.18 to 0.97	0.47	–0.20 to 1.12	1 (1)	0 (0)	–0.05 to 0.99	0.53	–0.06 to 1.09	1 (2)	0 (1)	–0.89 to 1.56	0.21	–0.53 to 0.95
	Two hands*	48 (9)	40 (7)	2.16 to 13.15	0.94	0.24 to 1.61	44 (9)	38 (6)	1.90 to 11.11	0.82	0.22 to 1.40	40 (7)	40 (5)	–4.12 to 4.94	0.07	–0.67 to 0.81
	Otherwise*	3 (2)	2 (2)	–0.26 to 2.45	0.55***	–0.13 to 1.20	3 (3)	3 (3)	–1.68 to 1.75	0.01	–0.55 to 0.58	3 (8)	4 (3)	–5.25 to 4.04	–0.10	–0.84 to 0.64
Driving backward	Overall	2 (1)	1 (1)	–0.59 to 0.99	0.17	–0.48 to 0.82	2 (1)	2 (2)	–0.74 to 0.98	0.08	–0.49 to 0.65	2 (1)	1 (1)	–0.61 to 0.76	0.09	–0.66 to 0.83
	One hand	0 (0)	0 (0)	–0.04 to 0.01	–0.48	–1.13 to 0.19	0 (0)	0 (0)	–0.04 to 0.05	0.08	–0.48 to 0.65	0 (0)	0 (0)	–0.08 to 0.10	0.07	–0.68 to 0.80
	Two hands	2 (1)	1 (1)	–0.59 to 0.94	0.16	–0.50 to 0.81	2 (1)	2 (2)	–0.77 to 0.91	0.05	–0.52 to 0.61	1 (1)	1 (1)	–0.59 to 0.66	0.04	–0.70 to 0.78
	Otherwise	0 (0)	0 (0)	–0.03 to 0.11	0.42	–0.25 to 1.07	0 (0)	0 (0)	–0.03 to 0.11	0.37	–0.21 to 0.93	1 (1)	0 (0)	0.77 to 2.02	1.73	0.82 to 2.54

(continued)

Table 2 (continued)

		Guard					Forward					Center				
		M (*SD*)					*M* (*SD*)					*M* (*SD*)				
Action	Control	Offense	Defense	95% CI mean difference	Effect size	95% CI effect size	Offense	Defense	95% CI mean difference	Effect size	95% CI effect size	Offense	Defense	95% CI mean difference	Effect size	95% CI effect size
Rotate	Overall**	27 (9)	32 (10)	−10.88 to 1.87	−0.48	−1.13 to 0.19	28 (8)	33 (8)	−9.21 to 0.30	−0.54	−1.11 to 0.04	26 (7)	30 (6)	−9.66 to 0.96	−0.64	−1.38 to 0.14
	Clockwise**	12 (5)	15 (7)	−6.90 to 1.07	−0.50	−1.15 to 0.18	13 (6)	16 (5)	−5.37 to 0.57	−0.47	−1.03 to 0.11	12 (4)	15 (3)	−5.53 to 0.32	−0.87	−1.62 to 0.07
	Counter clockwise**	15 (6)	17 (5)	−5.30 to 2.13	−0.29	−0.94 to 0.37	15 (5)	17 (5)	−4.93 to 0.88	−0.41	−0.97 to 0.17	14 (4)	15 (4)	−4.63 to 1.81	−0.34	−1.08 to 0.42
Standing still	Overall*	15 (6)	19 (8)	−8.19 to 0.76	−0.56	−1.21 to 0.12	17 (7)	20 (7)	−6.48 to 1.63	−0.35	−0.91 to 0.23	23 (7)	20 (6)	−1.30 to 8.79	0.58***	−0.20 to 1.32
	One hand	1 (2)	1 (1)	−0.95 to 1.29	0.10	−0.55 to 0.75	1 (1)	1 (1)	−0.84 to 0.58	−0.11	−0.67 to 0.46	2 (3)	2 (1)	−1.35 to 1.70	0.09	−0.66 to 0.83
	Two hands**	11 (4)	18 (7)	−10.33 to −2.04	−1.01	−1.68 to −0.30	13 (7)	18 (7)	−8.61 to −0.46	−0.65	−1.22 to −0.06	16 (6)	17 (6)	−5.82 to 3.65	−0.18	−0.91 to 0.57
	Otherwise**	3 (2)	0 (1)	1.11 to 3.38	1.34***	0.59 to 2.03	3 (2)	1 (1)	1.45 to 2.97	1.69***	1.01 to 2.32	5 (2)	1 (1)	3.45 to 5.85	3.01***	1.86 to 3.99
Brake	Overall	3 (2)	3(2)	−1.68 to 1.13	−0.13	−0.78 to 0.52	3 (2)	3 (2)	−0.94 to 1.16	0.06	−0.51 to 0.62	3 (2)	3 (1)	−1.29 to 1.16	−0.04	−0.78 to 0.70
	Two hands	3 (2)	3 (2)	−1.75 to 1.01	−0.18	−0.83 to 0.47	3 (2)	3 (2)	−0.95 to 0.88	−0.02	−0.59 to 0.54	3 (2)	3 (1)	−1.22 to 1.12	−0.03	−0.77 to 0.71
	Otherwise	0 (0)	0 (0)	−0.01 to 0.20	0.60	−0.08 to 1.26	0 (1)	0 (0)	−0.15 to 0.45	0.29	−0.29 to 0.85	0 (0)	0 (0)	−0.05 to 0.08	0.23	−0.52 to 0.97

Note. For each activity, the overall percentage is presented, as well as the distribution of the control options. The relative duration is calculated as a proportion of the duration of a game situation. Summative differences are caused by rounding off.

*Significant interaction between game situation and field position ($p < .05$).

**Significant main effect of game situation ($p < .05$).

***Significant difference between offense and defense ($p < .05$).

Furthermore, there was a significant interaction between game situation and field position for driving forward in general ($p = .001$) and driving forward with the athlete control options "otherwise" ($p = .044$) and "two hands" ($p = .006$). During offensive situations, guards and forwards performed driving forward activities more than during defensive situations (guards 51 ± 8% vs. 43 ± 6%; ES = 1.19; forwards 48 ± 10% vs. 41 ± 6%; ES = 0.86) whereas centers showed no differences between offense and defense, and the effect sizes were trivial (44 ± 6% vs. 44 ± 4%; ES = –0.01). Furthermore, only guards performed driving forward without hand rim propulsion (control option "otherwise") less during defensive situations than during offensive situations (3 ± 2% vs. 2 ± 2%; ES = 0.55).

There was also an interaction between game situation and field position for the activity standing still overall ($p = .018$). During offense, centers stood still 4 pp longer than in a defensive situation (23 ± 7% vs. 20 ± 6%; ES = 0.58) whereas the guard and forward showed no differences (guards 15 ± 6% vs. 19 ± 8%; ES = –0.56; forwards 17 ± 7% vs. 20 ± 7%; ES = –0.35). The magnitudes of the effect sizes of these three comparisons were small (<0.6).

Ball Possession

Ball possession had a major impact on wheelchair–athlete mobility performance: in 12 of the 18 activities, a main effect for ball possession was seen. Players with ball possession stood still longer, and they showed fewer moving activities than without ball possession. There was a remarkable difference for turning clockwise. During ball possession, players performed on average 2 pp fewer rotations clockwise than without ball possession with a small effect (12 ± 7% vs. 14 ± 4%; ES = –0.36).

An interaction effect between ball possession and field position was only observed for the activity driving forward ($p = .017$; Table 3). Follow-up analyses showed that centers with ball possession drove less forward than without ball possession (38 ± 12% vs. 45 ± 5%; ES = 0.84), whereas guards and forwards showed no differences between possession and driving forward (guards 50 ± 10% vs. 46 ± 7%; ES = 0.42; forwards 38 ± 16% vs. 45 ± 7%; ES = –0.52). The magnitudes of the effect sizes ranged from small (>0.2) to moderate (<1.2).

Discussion

The purpose of this research was to determine whether mobility performance is influenced by offensive and defensive game situations and/or ball possession and whether the effects of these actions differed between field positions. Game situation and ball possession influenced mobility performance for the three field positions in a different way. During offense, guards performed 9 pp more driving forward activities, and forwards performed 7 pp more driving forward activities than during defense. Moreover, centers stood still 4 pp longer during offense than during defense and without ball possession, centers performed 7 pp more driving forward activities than with ball possession. All field positions performed on average more rotational movements and stood still longer with two hands on the rim during defensive states. In the case of ball possession, almost all dynamic wheelchair activities are influenced.

Table 3 Mean (*SD*) Relative Duration (%) of Wheelchair–Athlete Activities With 95% Confidence Intervals (CIs) of Mean Differences During a Game for Position (Guard, Forward, and Center) and During Ball and No Ball Possession Complemented With Cohen's *d* Effect Sizes With 95% CI

		Guard					Forward					Center				
		M (*SD*)					*M* (*SD*)					*M* (*SD*)				
Action	Control	With ball %	Without ball%	95% CI mean difference	Effect size	95% CI effect size	With ball %	Without ball%	95% CI mean difference	Effect size	95% CI effect size	With ball %	Without ball%	95% CI mean difference	Effect size	95% CI effect size
Driving forward	Overall*	50 (10)	46 (7)	−2.22 to 9.25	0.42	−0.25 to 1.07	38 (16)	45 (7)	−13.42 to 0.72	−0.52	−1.09 to 0.06	38 (12)	45 (5)	−14.68 to −0.61	−0.84***	−1.59 to −0.05
	One hand**	3 (6)	0 (0)	−0.31 to 5.17	0.60	−0.08 to 1.25	2 (5)	0 (0)	−0.05 to 3.85	0.57	−0.02 to 1.13	2 (3)	1 (1)	−0.88 to 3.13	0.44	−0.33 to 1.17
	Two hands**	43 (13)	44 (8)	−8.41 to 6.04	−0.11	−0.76 to 0.55	32 (14)	41 (7)	−16.02 to −3.11	−0.86	−1.44 to −0.26	32 (15)	42 (5)	−18.15 to −1.09	−0.88	−1.62 to −0.08
	Otherwise**	4 (6)	2 (2)	−0.60 to 5.16	0.54	−0.14 to 1.19	4 (6)	3 (3)	−1.17 to 3.83	0.31	−0.27 to 0.87	3 (3)	3 (3)	−1.97 to 2.62	0.11	−0.63 to 0.85
Driving backward	Overall**	1 (1)	2 (1)	−1.68 to −0.04	−0.71	−1.37 to −0.03	1 (2)	2 (1)	−1.52 to 0.38	−0.35	−0.91 to 0.23	1 (1)	2 (1)	−1.65 to −0.29	−1.10	−1.86 to −0.28
	One hand	0 (0)	0 (0)	−0.02 to 0.00	−0.47	−1.12 to 0.20	0 (0)	0 (0)	−0.05 to 0.09	0.16	−0.41 to 0.72	0 (1)	0 (0)	−0.13 to 0.46	0.43	−0.33 to 1.17
	Two hands**	0 (1)	2 (1)	−1.73 to −0.60	−1.41	−2.10 to −0.65	1 (2)	2 (1)	−1.62 to 0.30	−0.40	−0.96 to 0.18	0 (1)	2 (1)	−1.68 to −0.65	−1.75	−2.57 to −0.84
	Otherwise	0 (1)	0 (0)	−0.16 to 0.78	0.45	−0.22 to 1.10	0 (0)	0 (0)	−0.05 to 0.19	0.33	−0.25 to 0.89	0 (0)	0 (0)	0.00 to 0.00	NaN	NaN

(continued)

Table 3 (continued)

		Guard					Forward					Center				
		M (SD)					*M (SD)*					*M (SD)*				
Action	Control	With ball %	Without ball%	95% CI mean difference	Effect size	95% CI effect size	With ball %	Without ball%	95% CI mean difference	Effect size	95% CI effect size	With ball %	Without ball%	95% CI mean difference	Effect size	95% CI effect size
Rotate	Overall	27 (15)	30 (9)	−5.05 to 9.75	−0.25	−0.44 to 0.87	30 (12)	30 (7)	1.17 to 17.63	−0.01	0.07 to 1.23	27 (9)	28 (6)	2.96 to 19.85	−0.13	0.23 to 1.81
	Clockwise**	11 (8)	14 (5)	−0.14 to 6.79	−0.50	−0.03 to 1.31	14 (8)	15 (5)	0.35 to 4.02	−0.13	0.10 to 1.26	11 (6)	13 (3)	−0.12 to 5.70	−0.48	−0.04 to 1.49
	Counter-clockwise	16 (9)	16 (5)	−12.76 to −4.61	0.04	−2.14 to −0.68	17 (9)	16 (4)	−11.61 to −2.42	0.12	−1.46 to −0.28	15 (6)	14 (4)	−9.77 to 2.86	0.23	−1.16 to 0.34
Standing still	Overall**	20 (15)	18 (5)	3.06 to 12.43	0.22	0.39 to 1.80	28 (19)	18 (6)	6.17 to 22.15	0.66	0.41 to 1.61	32 (14)	20 (6)	7.42 to 16.72	1.05	1.06 to 2.86
	One hand**	4 (7)	1 (1)	−11.34 to 5.26	0.65	−0.90 to 0.41	3 (4)	1 (1)	−5.69 to 5.51	0.69	−0.58 to 0.56	4 (5)	1 (1)	−7.29 to 5.18	0.74	−0.87 to 0.61
	Two hands**	7 (7)	16 (5)	−7.72 to 1.19	−1.44	−1.15 to 0.18	9 (9)	16 (6)	−4.69 to 2.99	−0.89	−0.69 to 0.44	14 (10)	17 (5)	−5.88 to 1.41	−0.43	−1.21 to 0.29
	Otherwise**	9 (10)	1 (1)	−4.75 to 5.33	1.12	−0.62 to 0.69	15 (19)	1 (1)	−3.15 to 4.72	1.03	−0.45 to 0.68	14 (8)	2 (1)	−2.69 to 5.03	2.02	−0.52 to 0.97
Brake	Overall**	1 (2)	3 (2)	−2.85 to 0.06	−0.65	−1.30 to 0.04	1 (2)	3 (2)	−3.07 to −0.66	−0.90	−1.48 to −0.29	2 (2)	3 (2)	−2.88 to −0.36	−1.00	−1.75 to −0.19
	Two hands**	1(1)	3 (2)	−3.30 to −1.12	−1.37	−2.06 to −0.62	1 (2)	3 (2)	−3.10 to −1.28	−1.39	−2.00 to −0.74	2 (2)	3 (1)	−2.87 to −0.47	−1.08	−1.84 to −0.26
	Otherwise	0 (0)	0 (0)	0.00 to 0.00	NaN	NaN	0 (0)	0 (0)	0.00 to 0.00	NaN	NaN	0 (0)	0 (0)	0.00 to 0.00	NaN	NaN

Note. For each activity, the overall percentage is presented, as well as the distribution of the control options. The relative duration is calculated as a proportion of the duration of ball and no ball possession. Summative differences are caused by rounding off. NaN = not a number.

*Significant interaction between ball possession and field position ($p < .05$).

**Significant main effect of ball possession ($p < .05$).

***Significant difference between ball possession and no ball possession ($p < .05$).

Game-Related Aspects

During offensive situations, a team has ball possession and tries to score. The individual ball possession differed between the field positions; guards had the highest percentage ball possession, followed by centers and forwards. This is similar with running basketball where guards also have more ball possession compared with the other players (Ortega et al., 2006). In running basketball as well as in wheelchair basketball, this position requires the ability to facilitate the team during a play, and therefore, the guards have the most ball possession (Rose, 2004).

During defense, guards stood still longer than during offense whereas centers stood still longer during offense. This can be explained by defensive basketball strategies. Most defensive schemes in wheelchair basketball are designed to block an opponent's chair from getting into the restricted area. This means that a guard during defense must focus more on stopping an opponent driving to the basket, rather than on locating the ball (Titmuss, 2005). Centers play mainly in the lane under the basket, both in offensive and defensive situations, to shoot from inside the lane and grasp rebounds (Vanlandewijck et al., 2004). As a result, the relative percentage standing still is higher in both situations for centers compared with guards and forwards.

Moreover, guards in an offensive situation drove more forward with two hands on the rim than during a defensive situation. Guards are the floor leaders and are responsible for carrying the ball and generally cover greater distances in offensive situations (Rose, 2004). Greater distances and a higher relative duration are not directly related with each other, and kinematic data are necessary to confirm this assumption. The centers primary role in offense is to score from a position close to the basket (Titmuss, 2005). Guards and forwards led the offense and mostly play the ball to the centers who stood still near by the basket. By doing so, centers with ball possession performed 8 pp less driving forward activities than without ball possession.

Rotational movements are a very important factor of mobility performance. During the game, almost 30% of the wheelchair-handling activities consisted of turning (de Witte et al., 2016). During offense and individual ball possession, there is a striking difference in rotation direction clockwise or counterclockwise. During offensive situations, all field positions performed on average 2 pp more rotations counterclockwise than clockwise. During individual ball possession, the difference in the direction of rotation is even higher (on average 4 pp). This could be explained by the use of the dominant hand. Of all people, about 90% is right handed and 10% left handed (van Strien, 2001). During situations with more pressure, it is likely that the dominant hand is used or prepared for ball possession. Most of the players use their dominant hand (right) to handle the ball and use their other hand (left) to rotate the wheelchair, which lead to a counterclockwise rotation. For all players during ball possession, it is important to have the opportunity to turn both, clockwise or counterclockwise because opponents might anticipate on the preferred direction that can lead to turnovers. Therefore, it is advisable to incorporate drills with rotational movements in both directions during ball possession in training schedules.

Important to note, players are able to change their positions throughout the game. In addition, the interaction between classification level and field position-dependent tasks may have obscured some interclass differences between performance variables. Earlier research showed differences in performance between classification level 1 and the other classifications levels (Cavedon, Zancanaro, & Milanese, 2015; Vanlandewijck, Spaepen, & Lysens, 1995). Main difference between classification 1 players and the others is reflected in the inability to have active stability and rotation of the trunk. These functional disadvantages result in lower maneuverability and more limited range of action for the classification 1 player. The functional abilities are often necessary in player-to-player offensive and defensive actions during the game (Vanlandewijck et al., 1995). In this study, there are significant differences described between game situations and ball possession. These differences are related to the specific tasks associated with field position. It is important for the trainer and coach to know what the specific requirements for (mobility) performance are related to the field positions. The coach is responsible for allocating players over the specific tasks and does not violate the classification rules to achieve maximal performance. However, one has to be aware that field position versus mobility performance is highly influenced by classification level and vice versa.

Practical Implications for Wheelchair Configurations and Recommendations

The observed differences in mobility performance with or without the ball, for the different field positions and game situations, can be used to design specific training schedules. Moreover, this information may also be used to improve individual wheelchair configurations and subsequent field performance. Based on this study, guards and forwards could benefit more from improved acceleration characteristics of the wheelchair (driving forward) in offensive situations, whereas centers could benefit more from improved stability (standing still). Rotational movements (maneuverability) are not influenced by game situation or ball possession but take almost 30% of the relative duration during all game phases. Rear wheel camber plays an essential role here (Van der Woude et al., 2001). Clearly, maneuverability should not be negatively affected by any adjustments of the wheelchair mechanics of interfacing. The effects of manipulating wheelchair configurations, on aspects of mobility performance during wheelchair court sports, have received limited attention in scientific research. In the past, some studies investigated seat height parameters within the propulsion cycle in a laboratory setting (Masse, Lamontagne, & O'Riain, 1992; Samuelsson, Tropp, Nylander, & Gerdle, 2004; van der Woude et al., 2009; van der Woude, Veeger, & Rozendal, 1989). Lower seat heights have been associated with reductions in push frequency, and increasing seat height was reflected in decreased push duration. Therefore, seat height could be a key interface characteristic that may improve the acceleration characteristics of the wheelchair for guards and forwards (as well as reach). Under sport-specific conditions, Walsh, Marchiori, and Steadward (1986) assessed maximal effort mobility performance during a combination of different vertical and horizontal seat positions. Fore-aft position of the wheelchair–athlete combination influences, as with seat height, the center of gravity and therefore will affect stability (Masse et al., 1992). Fore-aft position may improve stability characteristics of the wheelchair which could be beneficial for centers. Because the basketball wheelchairs have changed in recent years (i.e., use of antitip castors at the backs), one has to wonder whether scientific knowledge is helpful or valid for today's court sports. Recently, only Mason, van der Woude, Lenton, et al. (2012) and Mason, van der Woude, Tolfrey, and Goosey-Tolfrey (2012) studied effects of sports wheelchair configurations on mobility performance in the context of court sports. Wheels with 18° camber reduced 20 m sprint times and enabled greater initial acceleration over the first two and three pushes in comparison with 24° camber (Mason, van der Woude, Tolfrey, & Goosey-Tolfrey, 2012). Furthermore, larger 26-in. wheels improved the maximal sprinting performance in wheelchair basketball players compared with 24-in. wheels (Mason, van der Woude, Lenton, et al., 2012). Hand-rim and wheel size are related; the diameter of the hand rim of court sport wheelchairs are typically 1 in. (0.025 m) smaller than the diameter of the main wheel (Mason, Van Der Woude, Tolfrey, Lenton, & Goosey-Tolfrey, 2012). Knowledge about the effects of wheel size, hand rim, and wheel camber on acceleration performance could be beneficial for the different field positions. Therefore, the study of the effects of wheelchair configuration on mobility performance during wheelchair basketball matches is warranted.

To increase mobility performance, players have to find the best compromise between wheelchair configurations, in terms of field position and their disability (classification level). When it is considered how many compromises are possible to potentially optimize wheelchair–athlete configurations and consequent performance in wheelchair basketball, it is clear that further research is required. Because the specific qualities for the field positions are known, future research should test the effects of wheelchair configurations on mobility performance in wheelchair basketball. Apart from the wheelchair basketball playing characteristics for different field positions and game situations, the basketball rulings and wheelchair regulations/legalizations should be taken into account when future research is designed. It is important to identify which areas of wheelchair configuration need priority for scientific research. In addition, it must be acknowledged that this study only focused on mobility performance. Wheelchair basketball also includes game performance and physical performance. Future investigations should also explore whether the differences in mobility performances also apply for game and physical performance. The influence of game situation, classification, ball possession, and possibly optimization of wheelchair configurations on game and physical performance should also be examined in future studies.

Video analysis lacked quantitative data of distances and acceleration, which is necessary to get a thorough understanding of mobility performance during games. Results of mobility performance during games complemented with kinematic data of wheelchair basketball games (van der Slikke et al., 2015) could be used to develop a field-based test circuit with the most common wheelchair-handling activities. This field-based test can be used to test the impact of wheelchair configurations on mobility performance with players competing in wheelchair basketball under the most ecologically valid conditions.

Conclusions

It can be concluded that game situation and ball possession influenced mobility performance for the different field positions. The specific tasks associated with field position are reflected in mobility performance. Because guards and forwards lead the offense, they perform more driving forward activities during offense than during defense. Centers stand still longer during offense than during defense because they try to score from the area under the basket. During defense, all field positions perform more rotational movements than during offense. In parallel, ball possession has a high impact on almost all wheelchair–athlete activities. This information can be used to design specific training protocols to improve performance (e.g., increase mobility performance during ball possession), and it can help the coach to allocate specific roles to players, taking into account specific individual qualities. Future research is imperative to identify optimal (individual) wheelchair and interface configurations in terms of their disability and their field position.

Perspectives

Wheelchair basketball is one of the most popular Paralympic sports. Players have become elite in their sport, and due to the increased professionalism, there is a need for scientific input. To make adjustments to, for example, training protocols and wheelchair–athlete configurations, it is important to have a comprehensive and thorough understanding of the influence of game related aspects and wheelchair–athlete activities during the game. This study is an important basis for the design of further research that contributes to performance in wheelchair basketball games. In addition, wheelchair experts can take into account the main wheelchair–athlete activities related to the field position to make a firm choice between possible configurations.

Acknowledgments

This work was supported by Taskforce for Applied Research (part of Netherlands Organization for Scientific Research). The authors declare that there are no conflicts of interest. This manuscript is based on the same data collection as published by de Witte et al. (2016).

References

Bloxham, L.A., Bell, G.J., Bhambhani, Y., & Steadward, R.D. (2001). Time motion analysis and physiological profile of Canadian World Cup wheelchair basketball players. *Sports Medicine, Training and Rehabilitation, 10*, 183–198. doi:10.1080/10578310210398

Boutmans, J., & Rowe, P. (1997). *Basketbal: theorie en praktijk* [Basketball: Theory and practice]. Leuven, Belgium: ACCO.

Byrnes, D., & Hedrick, B. (1994). Comprehensive basketball grading system. In B.Hedrick, D.Byrnes, & L.Shaver (Eds.), *Wheelchair basketball* (p. 79). Washington, DC: Paralyzed Veterans of America.

Cavedon, V., Zancanaro, C., & Milanese, C. (2015). Physique and performance of young wheelchair basketball players in relation with classification. *PLoS ONE, 10*(11), e0143621. PubMed doi:10.1371/journal.pone.0143621

Cohen, J. (1992). Statistical power analysis. *Current Directions in Psychological Science, 1*(3), 98–101. doi:10.1111/1467-8721.ep10768783

Coutts, K.D. (1992). Dynamics of wheelchair basketball. *Medicine & Science in Sports & Exercise, 24*(2), 231–234. PubMed doi:10.1249/00005768-199202000-00012

de Witte, A.M.H., Hoozemans, M.J.M., Berger, M.A.M., van der Woude, L.H.V., & Veeger, D.H. (2016). Do field position and playing standard influence athlete performance in wheelchair basketball? *Journal of Sports Sciences, 34*(9), 811–820. PubMed doi:10.1080/02640414.2015.1072641

Hopkins, W., Marshall, S., Batterham, A., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine & Science in Sports & Exercise, 41*(1), 3–13. PubMed doi:10.1249/MSS.0b013e31818cb278

International Wheelchair Basketball Federation. (2014). *Official wheelchair basketball rules 2014*. Incheon, Korea: International Wheelchair Basketball Federation.

Mason, B., van der Woude, L., Lenton, J.P., & Goosey-Tolfrey, V. (2012). The effect of wheel size on mobility performance in wheelchair athletes. *International Journal of Sports Medicine, 33*(10), 807–812. PubMed doi:10.1055/s-0032-1311591

Mason, B., van der Woude, L., Tolfrey, K., & Goosey-Tolfrey, V. (2012). The effects of rear-wheel camber on maximal effort mobility performance in wheelchair athletes. *International Journal of Sports Medicine, 33*(3), 199–204. PubMed doi:10.1055/s-0031-1295443

Mason, B.S., Van Der Woude, L.H., Tolfrey, K., Lenton, J.P., & Goosey-Tolfrey, V.L. (2012). Effects of wheel and hand-rim size on submaximal propulsion in wheelchair athletes. *Medicine & Science in Sports & Exercise, 44*(1), 126–134. PubMed doi:10.1249/MSS.0b013e31822a2df0

Masse, L.C., Lamontagne, M., & O'Riain, M.D. (1992). Biomechanical analysis of wheelchair propulsion for various seating positions. *Journal of Rehabilitation Research & Development, 29*(3), 12–18. PubMed doi:10.1682/JRRD.1992.07.0012

Molik, B., & Kosmol, A. (2001). In search of objective criteria in wheelchair basketball player classification. In G.Doll-Tepper, M.Kröner, & W.Sonnenschein (Eds.), *Vista'99—New horizons in sport for athletes with a disability: Proceedings of the international Vista'99 conference* (pp. 355–368). Köln, Germany: Meyer & Meyer Sport.

Ortega, E., Cardenas, D., Sainz de Baranda, M.P., & Palao, J.M. (2006). Differences in competitive participation according to player's position in formative basketball. *Journal of Human Movement Sciences, 50*(2), 103–122.

Rose, L.H. (2004). *The basketball handbook*. Champaign, IL: Human Kinetics.

Samuelsson, K.A., Tropp, H., Nylander, E., & Gerdle, B. (2004). The effect of rear-wheel position on seating ergonomics and mobility efficiency in wheelchair users with spinal cord injuries: A pilot study. *Journal of Rehabilitation Research & Development, 41*(1), 65–74. PubMed doi:10.1682/JRRD.2004.01.0065

Shrout, P.E., & Fleiss, J.L. (1979). Intraclass correlations: Uses in assessing rater reliability. *Psychological Bulletin, 86*(2), 420–428. PubMed doi:10.1037/0033-2909.86.2.420

Titmuss, D. (2005). Wheelchair basketball: Transition from defense to offense. *FIBA Assist Magazine,* (13), 15–17.

van der Slikke, R.M., Berger, M.A., Bregman, D.J., Lagerberg, A.H., & Veeger, H.E. (2015). Opportunities for measuring wheelchair kinematics in match settings; reliability of a three inertial sensor configuration. *J Biomech. 48*(12), 3398–405. PubMed doi:10.1016/j.jbiomech.2015.06.001

van der Woude, L.H., Bouw, A., van Wegen, J., van As, H., Veeger, D., & de Groot, S. (2009). Seat height: Effects on submaximal hand rim wheelchair performance during spinal cord injury rehabilitation. *Journal of Rehabilitation Medicine, 41*(3), 143–149. PubMed doi:10.2340/16501977-0296

van der Woude, L.H., Veeger, H.E.J., Dallmeijer, A.J., Janssen, T.W.J., & Rozendaal, L.A. (2001). Biomechanics and physiology in active manual wheelchair propulsion.

Medical Engineering & Physics, 23(10), 713–733. PubMed doi:10.1016/S1350-4533(01)00083-2

van der Woude, L.H.V., Veeger, D.E.J., & Rozendal, R.H. (1989). Ergonomics of wheelchair design: A prerequisite for optimum wheeling conditions. *Adapted Physical Activity Quarterly, 6*(2), 109–132. doi:10.1123/apaq.6.2.109

Vanlandewijck, Y.C., Daly, D.J., & Theisen, D.M. (1999). Field test evaluation of aerobic, anaerobic, and wheelchair basketball skill performances. *International Journal of Sports Medicine, 20*(8), 548–554. PubMed doi:10.1055/s-1999-9465

Vanlandewijck, Y.C., Evaggelinou, C., Daly, D.D., van Houtte, S., Verellen, J., Aspeslagh, V., … Zwakhoven, B. (2003). Proportionality in wheelchair basketball classification. *Adapted Physical Activity Quarterly, 20*(4), 369–380. doi:10.1123/apaq.20.4.369

Vanlandewijck, Y.C., Evaggelinou, C., Daly, D.J., Verellen, J., Van Houtte, S., Aspeslagh, V., … Zwakhoven, B. (2004). The relationship between functional potential and field performance in elite female wheelchair basketball players. *Journal of Sports Sciences, 22*(7), 668–675. PubMed doi:10.1080/02640410310001655750

Vanlandewijck, Y.C., Spaepen, A.J., & Lysens, R.J. (1995). Relationship between the level of physical impairment and sports performance in elite wheelchair. *Adapted Physical Activity Quarterly, 12*(2), 139–150. doi:10.1123/apaq.12.2.139

van Strien, J. (2001). Handvoorkeur en taaldominantie [Hand dominance and language dominance]. *Neuropraxis, 5*(2), 30–35. doi:10.1007/BF03070979

Walsh, C.M., Marchiori, G.E., & Steadward, R.D. (1986). Effect of seat position on maximal linear velocity in wheelchair sprinting. *Canadian Journal of Applied Sport, 11*(4), 186–190. PubMed

Wang, Y.T., Chen, S., Limroongreungrat, W., & Change, L. (2005). Contributions of selected fundamental factors to wheelchair basketball performance. *Medicine & Science in Sports & Exercise, 37*(1), 130–137. PubMed doi:10.1249/01.MSS.0000150076.36706.B2

Wootten, M., & Wootten, J. (2012). *Coaching basketball successfully* (3rd Rev. ed.). Champaign, IL: Human Kinetics.