The Physical Characteristics Underpinning Performance of Wheelchair Fencing Athletes: A Delphi Study of Paralympic Coaches

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Abstract

Wheelchair Fencing (WF) is a Paralympic sport which is practiced by athletes with physical disabilities and is classified into three categories according to the degree of activity limitation the impairment causes in the sport. All Paralympic sports are requested to develop their own evidence-based classification system to enhance the confidence in the classification process however, this is yet to be achieved in WF. Research within WF is scarce therefore, the aim of this study was to reach expert consensus on the physical characteristics that underpin performance of athletes competing in the sport as this is known as one of the initial steps required to achieve an evidence-based classification system. Sixteen Paralympic WF coaches were invited to take part in a 3-round Delphi study, with experts drawing consensus on qualities of speed, strength, power, flexibility and motor control of the trunk and fencing arm being associated with increased athletic success. The required qualities of the non-fencing arm led to diverging opinions across the expert panel. This study provides clear guidance of the physical qualities to be developed to maximise athletic performance while also providing the initial framework to guide future WF classification research.

Key words: Wheelchair fencing, Classification, Physical, Attributes, Performance

1 Introduction

Wheelchair fencing (WF) is considered one of the oldest sport disciplines practiced by athletes with a disability [1]. The sport is a derivative of able-bodied fencing, using identical weapons (foil, epee and sabre), tactics, and rules [2, 3]. A major distinction is that athletes are competing seated in a sport-specific wheelchair fixed in place to provide stability while also maximizing upper body movement [4]. To participate in WF, athletes must display a permanent physical disability falling under one or more of the following impairment types; hypertonia, ataxia, athetosis, limb deficiency, impaired muscle power, and impaired range of movement [5].

An integral part of Paralympic sports is the process of classification [6]. The purpose of classification is to place athletes into different categories to promote fair competition and therefore enhance participation in sport [7]. As a result of classification, all athletes competing in a given category should display impairments causing approximately the same amount of disadvantage in the sport [6]. In WF, the current classification system is known as a functional system, where an emphasis is placed on the impact each impairment could have on sport performance [3]. During this process, athletes undergo a range of assessments (e.g. bench test) determining the functional status of athletes, where scores are aggregated leading to a class allocation into either A, B or C categories. The international governing body of the sport, the International Wheelchair & Amputee Sports Federation (IWAS) [5], defines of the three categories as follows: Category A athletes are the most functional and demonstrate good sitting balance and good fencing arm function (e.g. amputees or spinal cord injuries below T10). Category B athletes typically demonstrate fair sitting balance and good arm function (e.g. paraplegics with spinal lesions level T9 – 10). Finally, category C athletes are the most impaired with no sitting balance and affected function of the fencing arm (e.g. tetraplegics with spinal lesions level C5 – C8).

To date, numerous Paralympic sports including WF rely on subjectively aggregating results from a range of assessments to classify athletes [8]. Such systems have previously been described in the literature as lacking transparency and can also be contested, which in turn poses a significant threat to Paralympic sports and as a result need reconsidering [7, 9]. For this reason, in 2007 the International Paralympic Committee (IPC) released the IPC classification code requesting all Paralympic sports to develop their own evidence-based classification system [10]. This system was intended to be based on scientific evidence and therefore enhance confidence in the classification process [8]. Since the publication of the classification code, emerging research describing the required steps to achieve such a system have been published [6, 7, 9, 11]. One of the critical tasks required in developing an evidence-based classification system, is to identify the physical factors that determine overall performance [6]. To date, the research in WF is scarce and limited to exploring the physiological demand of the sport [12, 13], injury epidemiology [14] and kinematic and electromyography analysis of the lunge attack [2–4]. While these studies provide insightful and valuable information, they are not sufficient to understand which physical attributes underpin performance. To overcome the paucity of literature and to better understand performance, qualitative research involving expert coaches such as Delphi studies should be undertaken [6].

Therefore, the aim of this study is to use the Delphi method to reach expert consensus on the physical attributes underpinning the performance of category A athletes in WF. Category A athletes were the focus of this research due to their high functional abilities. It can be assumed that if an attribute is deemed as essential to enhance performance within a highly functional athlete, those that do not possess these attributes or experience reduced abilities due to the impairment type, will therefore be at a competitive disadvantage. The information provided by this study may provide further insight into the sport and therefore guide the research community in designing alternative measures of impairment which could help assess its relative contribution to sporting performance. Whilst the primary focus of this research is classification related, the information presented in this study can aid coaches and sports scientists better understand performance in WF.

2 Methods

A Delphi study provides a structured method to systematically consult a panel of experts aiming to achieve consensus on a given subject [15, 16]. In this study, a three-round Delphi technique was employed with questionnaires administrated through Qualtrics (Qualtrics Research Suite, Qualtrics, Provo, Utah, USA). The scope of the current study focused on a specific subject matter. The methodological approach of this study was guided by the work of McCormack et al [17] and Zambaldi, Beasley & Rushton [18] who also applied a focused approach to a specific subject matter using the Delphi method. This study was approved by a Middlesex University Research Ethics Committee (UK).

2.1 Participants

A key challenge when conducting a Delphi study is the identification of appropriate experts [19]. In this study, expert WF coaches with international experience were utilised, however, all coaches had to also demonstrate sufficient English language proficiency in order to partake. In an attempt to sample the entire population of eligible Paralympic WF coaches and to remove any bias throughout the recruitment process, IWAS communicated with each of the member federations, inviting eligible coaches to voluntarily participate in the current study. All participants, were provided with information relating to the study aims, procedures and the link to the questionnaire and online consent form, via their respective federation. Coaches that provided consent were then taken to the first stage of this Delphi study. A total of 16 participants (panellists) consented to take part in this study (Table 1) including international coaches from 3 different continents; the majority of the panel was comprised of male coaches. Fifty percent of coaches had over 5 years of experience coaching WF at international level. A majority of the panellist coached more than one sword with a higher number (63%) coaching epee.

Table 1: Demographic information of panellists

	N (%)
Sex	
Male	14 (88)
Female	2 (13)
Continent	
Western Europe	11 (69)
North America	0 (0)
Australasia	0 (0)
South America	2 (13)
Eastern Europe	3 (19)
Africa	0 (0)
Asia	0 (0)
Years of experience as an international coach	
0-5	8 (50)
6-10	5 (31)
11-15	1 (6)
>15	2 (13)
Weapon coached *	
Foil	5 (31)
Epee	10 (63)
Sabre	8 (50)

* More than 1 answer was possible.

2.2 Procedure

A Delphi process was undertaken over the course of six months and consensus was mainly reached after 3 rounds. The questionnaire for the first round remained open for six weeks following the initial email sent to the federations. Four weeks were then provided to coaches upon reception of the questionnaire for round 2 and 3. An email reminder was sent to non-responders for round 2 and 3, one week prior to the closing date. Non-responders in round 2 were still invited to partake in the subsequent round. The Delphi method defines consensus on the basis of a chosen proportion of the panel agreeing on a given statement [20]. For the purpose of this study, a minimum agreement threshold of 80% was decided amongst the research team prior to the start of the study, which is considered as a high agreement level [20].

2.2.1 Round 1

Round one included a total of five questions. Four questions were closed requesting demographic and coaching related information. The fifth question was an open-ended question, which asked for up to 8 physical attributes desired to succeed as a category A wheelchair fencer at international level. The request was "*Please list a maximum of eight physical attributes that in your view are most important to athletic success for category A athletes in wheelchair fencing. Please write a sentence on why you think these are important to athletic success*".

2.2.2 Round 2

Round 2 started by introducing the panellists with a list of all physical attributes that were stated in the previous round. Panellists were then invited to share their view on the importance of each of the physical qualities identified using a 2-point modified Likert Scale (Agree or Disagree), following similar research by Dyer et al [21] who identified that respondents typically used the agree and disagree options. A neutral third choice was deliberately omitted to direct respondents to a clear opinionated decision [21]. The aim of this research was not to establish the relative contribution of each attribute based on the panel's view, but instead to identify the possible qualities associated with performance. Due to this, a 2-point Likert Scale was deemed appropriate by the research team. To prevent any potential misinterpretation and promote consistency across the panel, some key terms relating to physical qualities identified were defined by the research team (Table 2). Under each question, a comments section was also available for panellists to use it if they had any potential feedback or views.

Table 2: Definitions of physical attributes

Attribute	Definition
Speed	How quickly the athlete or the weapon moves
Reaction Time	The period of time taken for an athlete to respond to a stimulus
Strength	The capacity of an athlete to generate a large amount of force
Power	The ability to exert a large amount of force quickly
Flexibility	The ability to use the full range of movement available at a joint
Stability and Motor Control	The ability to minimise unwanted body movements and execute fine motor skills (precise and accurate motor control)
Agility	The ability to rapidly change body position and or speed in response to a stimulus

2.2.3 Round 3

Round 3 started with a summary of the responses collected from the previous round and questions that had reached consensus were removed from this round. Any question not having reached consensus was resubmitted or rephrased based on the feedback received, and again graded using the same 2-point Likert Scale. The aim of this round was to invite panellists to consider their answer in relation to the group answer and decide whether they wanted to reconsider their response.

2.3 Data Analysis

Data from round 1 were downloaded from Qualtrics to MS Excel. Demographic and coaching related questions were analysed using descriptive statistics (frequency and percentages). The responses of the open-ended questions were thematically analysed by two trained members of the research team, using the six-step procedure of Braun and Clarke [22]. To reduce categorisation bias, the researchers independently analysed the data prior to collating their findings and agreeing on the final themes [18]. Data from rounds 2 and 3 were also downloaded from Qualtrics to MS Excel and analysed using descriptive statistics, displaying the percentage of agreement across panellists.

3 Results

3.1 Round 1

Thirty physical attributes were reported by the panel following round 1. Following the coding conducted by the two researchers, responses were ordered into eight themes including: speed, strength, flexibility, stability and motor control, agility, fitness, and anthropometry (Table 3). Overall speed (75%), ability to generate side to side movements (56%), overall flexibility (50%), and overall stability and control (50%), were amongst the qualities most frequently reported.

Table 3: Reported physical qualities (frequency of selection and expressed as a percentage) organised in themes.

Theme		Attribute	Frequency	Percentage
Speed	1	Overall	12	75%
	2	Arm Speed	3	19%
	3	Hand Speed	3	19%
	4	Reaction Time	3	19%
Strength	5	Overall Strength	3	19%
	6	Arm Strength	3	19%
	7	Arm Power	3	19%
	8	Overall Power	2	13%
	9	Non-fencing Hand Grip Strength	1	6%
	10	Both Hand Grip Strength	1	6%
	11	Fencing Arm Grip Strength	1	6%
	12	Hip Strength	1	6%
	13	Lower Limb Strength	1	6%
Flexibility	14	Overall Flexibility	8	50%
	15	Trunk Side to Side Flexibility	4	25%
	16	Arm Flexibility	2	13%
	17	Torso Rotational Flexibility	1	6%
	18	Hip Flexibility	1	6%
Stability and Motor Control	19	Overall Stability and Control	8	50%
	20	Trunk Stability	3	19%
	21	Arm Control (shoulder and elbow)	3	19%
	22	Wrist Control	1	6%
	23	Hand-Eye Coordination	2	13%
	24	Striking Precision	5	31%
Agility	25	Side to Side Movement	9	56%
	26	Overall Agility	2	13%
Fitness	27	Stamina	5	31%
Anthropometry	28	Reach	5	31%
	29	Size/Target Area	2	13%
	30	Seated Height	1	6%

3.2 Round 2

Fifteen participants (94%) participated in round 2. A total of 38 questions were devised for this round in line with the answers provided in round 1 (Table 4). In WF, function of body parts differ (e.g. fencing hand and non-fencing hand) and therefore questions targeting specific joints and or limbs were devised to better capture the coaches' views on their specific role and contribution to sport performance. As part of this round, one panellist only completed the first fifteen questions and the answers provided were included in the analysis. Twenty-four of the qualities reached consensus. On completion of this round, comments were made by coaches, with one highlighting that the ability to change rhythm may have been overlooked; it was thus added as part of the third round.

3.3 Round 3

Thirteen participants (81%) contributed to round 3. Following round 3, an additional four qualities reached consensus making a total of twenty-eight qualities reaching consensus and eleven attributes remaining having not reached consensus across the expert panel (Table 4).

Table 4: Level of agreement (percentage) of panellists for each attribute across round 2 and 3, where a minimum agreement threshold of 80% was used to archive consensus.

Theme	**Importance of Attribute**	**Round 2**		**Round 3**	
		Agreement	**Disagreement**	**Agreement**	**Disagreement**
Speed	Overall Speed	100%	0%		
	Fast Arm Speed (fencing arm)	100%	0%		
	Fast Arm Speed (non-fencing arm)	80%	20%		
	Fast Hand Speed	100%	0%		
	Quick Reaction Time	80%	20%		
Strength	High Level of Trunk Strength	93%	7%		
	High Level of Arm Strength (fencing arm)	67%	33%	85%	15%
	High Level of Arm Strength (non-fencing arm)	67%	33%	69%	31%
	High Level of Grip Strength (fencing arm)	47%	53%	54%	46%
	High Level of Grip Strength (non-fencing arm)	67%	33%	62%	38%
	High Level of Hip Strength	80%	20%		
	High Level of Lower Limb Strength	60%	40%	69%	31%
	High Level of Arm Power (fencing arm)	80%	20%		
	High Level of Arm Power (non-fencing arm)	73%	27%	77%	23%
	High Level of Overall Power	73%	27%	85%	15%
Flexibility	Side to Side Flexibility	100%	0%		
	Trunk Rotational Flexibility	79%	21%	85%	15%
	Shoulder Flexibility (fencing arm)	100%	0%		
	Shoulder Flexibility (non-fencing arm)	93%	7%		
	Elbow Flexibility (fencing arm)	93%	7%		
	Elbow Flexibility (non-fencing arm)	86%	14%		
	Wrist Flexibility (fencing arm)	93%	7%		
	Wrist Flexibility (non-fencing arm)	79%	21%	54%	46%
	Hip Flexibility	86%	14%		
Stability and Motor Control	Trunk Stability	100%	0%		
	Arm Motor Control (fencing arm)	100%	0%		
	Arm Motor Control (non-fencing arm)	79%	21%	62%	38%
	Wrist Motor Control (fencing arm)	100%	0%		
	Wrist Motor Control (non-fencing arm)	64%	36%	54%	46%
	Hand Eye Coordination	100%	0%		
	Striking Precision	100%	0%		
Agility	Side to Side Agility	86%	14%		
	Overall Agility	86%	14%		
	Ability to change rhythm			100%	0%

Fitness	Repeated High Intensity Lunges	93%	7%		
	Sustain Effort for Entire Competition	100%	0%		
Anthropometry	Greater Reach	71%	29%	77%	23%
	Larger Body Mass	21%	79%	31%	69%
	Greater Seated Height	71%	29%	69%	31%

▢ Attributes not having reached consensus after round 3

4 Discussion

This Delphi study is the first to explore coaches' expert views on the physical qualities which underpin the performance of category A athletes in the sport of WF. The wide range of qualities shared by coaches demonstrate that athletes have to develop a high number of qualities to perform at the highest level in WF. Due to the limited primary research conducted within WF, additional evidence derived from empirically similar sports will be used whenever necessary to compare and contrast the views of the expert panel.

4.1 Overall Speed, Agility and Reaction Time

The ability to generate high overall movement speed was considered as an essential attribute by all participants. WF can be considered as an open skilled combat sport whereby greater attacking speed provides less time for an opponent to react and in turn increases the chance of success [23]. Consistent with the participant's view, previous research identified that speed of attacks and change of direction speed were consistently greater in elite fencers when compared to non-expert fencers [24, 25].

Reacting quickly to an opponent's movement was also an attribute reaching consensus across the panel with 80% agreement. Due to the open skilled nature of WF, athletes must rely on perceptual and psychomotor skills [2] to determine the opponent's next action [26]. The success of the athlete's defence will therefore rely on how quickly and accurately they respond to the opponent's attack [27]. Consistent with the coaches' view, Milic et al [28] identified that experienced able-bodied fencers were able to react quicker to a sport specific stimuli but also displayed superior ability to select an adequate physical response when compared to beginners.

Side to side movements as well as overall agility were attributes that were also considered as important by the panel, by reaching an 86% agreement. To date, no time motion characteristics have been undertaken in the sport of WF, however, it can be suggested that athletes engage in successive attacking and defensive sequences requiring high levels of agility as observed in their counterpart able-bodied fencers [29]. In fact, in able-bodied fencing, agility has also been identified as a fundamental skill required by athletes [29]. Agility would allow athletes to cope with the opponent's attacks by quickly moving away and changing body positioning to accommodate for a potential counterattack. The need to quickly change body positioning when reacting to an opponent's movement is further evidenced by all coaches agreeing that changing rhythm was an important attribute contributing to performance in WF.

4.2 Fencing Arm and Wrist Speed

All participants unanimously agreed on the prevalence of a fast fencing arm (shoulder and elbow) and hand (wrist) speed. To score in WF, athletes must touch their opponent with the weapon on predefined body parts (weapon specific target zones). The hand-arm unit holding the weapon will therefore play an important role in achieving the task. Its role is even more important given that during bouts, athletes are seated thus limiting spatial displacement and disrupting the normal sequence of the kinetic chain [3]. Therefore, the ability of the fencing hand-arm unit to produce accurate and high movement speed appears crucial. In line with this, previous research demonstrated that able-bodied fencers displayed 1.5 times faster peak weapon velocity than wheelchair fencers. Wheelchair fencers however, displayed considerably greater shoulder flexion peak angular velocity (1065.7°/s), when compared to their counterpart able-bodied fencers (430.3-655.1°/s), potentially compensating for the reduced spatial displacement possible [3]. This may also serve to support the coaches' view of the need to generate high speed from the fencing hand-arm unit.

4.3 Fencing Arm and Wrist Strength

Panellists reached consensus regarding the importance of strength (85%) and power (80%) qualities of the fencing arm (shoulder and elbow). Considering the need for high movement speed, the mechanisms facilitating speed would therefore play an essential role in improving performance of wheelchair fencers. To date, no kinetic analysis linking force to performance in WF has been undertaken. However, the importance of strength on movement velocity can be explained by the impulse momentum relationship (Newton's second law of motion) [30]. If an increasing force is exerted on a constant mass (weapon and athlete), a proportional increase in change of momentum will occur, which will result in higher movement velocity and thus quicker movement time [30].

Interestingly, diverging opinions across the panel were observed relating to grip strength of the fencing arm, where panellists were unable to reach consensus across round 2 and 3. Previous studies observed weak muscular activity of the wrist flexors and extensors when wheelchair fencers completed a lunge [3]. These findings would support the low contribution of the wrist to movement speed. Comments provided by coaches across rounds may have led to believe that diverging opinions may possibly be explained by different coaching styles and techniques used by coaches. While certain techniques such as the lunge may require little strength from the wrist muscles, other techniques such as the '*flick*' may require a higher contribution of the wrist muscles in order to accelerate the wrist and thus the sword.

4.4 Fencing Arm and Wrist Flexibility and Motor Control

Flexibility and motor control of the fencing arm and wrist reached consensus with a high level of agreement across the expert panel ranging from 93% to 100% agreement. Three of the six impairment types eligible to WF, including hypertonia, ataxia and athetosis, present athletes with reduced flexibility and/or impaired motor coordination [31]. Therefore, their ability to execute skilled movement fluidly, rapidly, and accurately, is reduced [31]. During a kinematic analysis of the lunge in category A wheelchair fencers, Chung [3] observed large angular displacements of the fencing arm and joint angles proportionally increased as lunge distances increased. In addition to this, moderate to high cross correlation coefficients between joints of the fencing arm were observed demonstrating the importance the muscles facilitating these movements to act in a coordinated manner [3]. Consistent with the coaches' view, flexibility and coordination of the fencing arm and wrist appears essential to fencing performance. The optimal interaction of flexibility and motor control would also allow fencers to achieve striking precision, which was another important attribute agreed by all participants.

4.5 Trunk Strength and Stability and Hip Strength and Flexibility

All coaches agreed that trunk strength and stability was an essential quality to assist WF performance. In addition to this, hip strength also reached consensus across the panellists with 80% agreement. Trunk and hip muscles are considered responsible for postural stability [32]. These muscles are at the core of the current classification system and can dictate which category athletes are allocated to. Indeed, Category A athletes typically display good sitting balance, while athletes from category B have fair sitting balance due to reduced trunk and hip function (e.g. spinal cord injury T1-T9) [5]. When attempting to score in WF, athletes have to extend the arm as well as lean towards the opponents if necessary. A pool of research has provided evidence that trunk control is an important component to controlling arm movement during reaching tasks when in a seated position, in an able-bodied population [33-35]. In line with this, Borysiuk et al [2] identified an anticipatory activity of the external abdominal oblique muscles prior to the initiation of the reaching task during the lunge in wheelchair fencers. Further evidence supporting the coaches' view is provided by Chung [3] who identified a reduction of performance when lunging distances increased in a population of wheelchair athletes with impaired trunk function when compared to athletes with good trunk function. While hip strength was highlighted as an important attribute, hip flexibility was also agreed as an important attribute. It can be speculated that optimal hip mobility will facilitate side to side movement observed during fencing; its role may be increasingly important at further lunging distances.

4.6 Lower Limb Strength

Lower limb strength did not reach consensus across the panel across round 2 and 3 with 60% and 69% agreement respectively. The role of the lower limb in WF remains unexplored with no research to date investigated its contribution to performance. Comments provided by coaches across rounds revealed that some coaches believe that lower limb muscles when in contact with the chair may contribute to movement speed as force can be exerted against the metal frame of the wheelchair providing foot support. Other coaches thought that lower limb contribution may be negated due to the fact athletes are competing seated. Further research is needed to fully understand the role of the lower limbs in WF.

4.7 Role of the Non-Fencing Arm and wrist

Consistently throughout this Delphi study, the role and required qualities of the non-fencing arm and wrist lead to diverging opinions across the expert panel. Qualities of strength, power, flexibility and motor control failed to reach consensus. The sport specific wheelchair used by fencers are equipped with supporting bars on the side of the non-fencing arm. Athletes may wish to use the bar to help maintain sitting balance if necessary or assist with the speed of attacks and defensive retreats [4]. To date, only one study provides a comprehensive understanding of the non-fencing arm in WF. Fung et al [4] analysed the trunk kinematics of fencers from category A (with good trunk function) and B (with reduced trunk function) with and without the use of the non-fencing arm during the lunge and fast return tasks. For both, the lunge and fast return tasks, performance of maximum trunk velocity was significantly increased by athletes from category A (+ 0.47 ms^{-1} and + 0.36 ms^{-1}) and B (+ 0.99 ms^{-1} and + 0.80 ms^{-1}) when using the supporting bars. It is worth noting that the extent of performance enhancement was considerably more important for athletes within category B, probably due to the reduced trunk function. These results highlight that athletes from category A may not rely as much on the supporting bar and this may explain the diverging opinions across the panel. In line with this, results from seated throwing studies indicated that able-bodied participants displayed no significant difference in performance when they were using an assistive pole which fulfils a similar function to the supporting bar in WF when compared to not using the pole [36-37]. However, it is worth noting that Fung et al [4] identified that performance of category A and B athletes was significantly improved when the non-fencing arm was used indicating its potential role in sporting performance. In this instance, strength, flexibility and motor control of the non-fencing arm may be desired qualities and thus should be considered for classification purposes. Further research exploring the contribution of the non-fencing arm could be of value and assist the decision-making process towards WF classification.

4.8 Fitness

Components of fitness will not contribute to the decision-making process regarding classification as impaired cardiovascular function is not an eligible impairment but this information can be of interest to sport scientists aiming to enhance the performance of athletes. The two fitness components including the ability to repeat high intensity lunges and to sustain a high level of energy throughout the competition were attributes that reached consensus. The ability to repeat high intensity lunges is in line with existing research, whereby Bernardi et al, [12] simulated a direct elimination bout (sword not mentioned) and observed blood lactate values raising up to 4.70 ± 1.38 mmoI/L. While these values are not excessively high, they are above the onset of blood lactate accumulation (OBLA) [38], indicating the potential contribution of the anaerobic system. Low mean VO_2 values (24.7±5.6 ml/kg/min) have previous been recorded in a simulated epee direct elimination bout in WF, indicating the low contribution of the aerobic system [13]. However, it is worth noting that during competitions, athletes will engage in a number of pool and direct elimination bouts and therefore the ability to recover from bout to bout may be important as highlighted by the expert panel. Previous research in able-bodied fencing which has a similar competition structure to WF identified that athletes would rely increasingly on the aerobic system as the competition progresses during a simulated competition of epee [39]. Furthermore, aerobic fitness has previously shown to enhance recovery from high intensity intermittent exercise through increased aerobic response, improved lactate removal, and enhanced PCr regeneration [40, 41].

4.9 Anthropometry

In this study, the anthropometric qualities cited by coaches are not identified as eligible impairment types and will therefore be of interest from a performance perspective but will provide no insight for classification purposes. All three anthropometric qualities identified did not successfully reach consensus although consistently reaching a relatively high level of agreement of > 69%. Greater reach and seated height surprisingly did not reach consensus. The diverging opinion across the panel could potentially be explained by the proximity of the two fencers in WF, which tends to increase the pace of the bouts [3]. A proportion of the panel may consider that these qualities may be negated as a result of the close proximity. Therefore, qualities of strength and power, which affect speed generation, may be regarded as more important. Although not reaching consensus, a majority of the panel thought that a large body mass would be a disadvantage to performance. An increase in body mass can be the result of increased cross-sectional area or increased fat mass. Previous literature in able-bodied fencing identified that lunge time was significantly correlated ($p \leq 0.05$) to dominant and non-dominant thigh cross-sectional area (r= 0.29 and 0.28) while body fat was detrimental to lunge performance with a significant correlation ($r=0.36$, $p \leq 0.05$) [25]. Follow up conversations with coaches lead to believe that due to the close proximity of athletes in WF and the limited spatial displacement possible, an out-of-range strategy as per able-bodied fencers cannot be employed [42]. As a result of this, athletes with a larger body mass would display a larger target area to the opponent resulting in a competitive disadvantage.

4.10 Limitations

There are some limitations to the current study, in particular, recruiting and retaining participants in Delphi studies is known to be challenging. To ensure expert opinions were gathered, the governing body IWAS, targeted active Paralympic coaches from 41 potential federations identified as an active nation during the 2018 and 2019 competitive calendar. Therefore, while 16 participants may be considered a low number, when considering the diverse countries represented in the sport, and the need to demonstrate sufficient English language proficiency to partake, the current sample size can be considered as relatively large and captures approximately 20% of the overall population. This also remains within the recommended guidelines of Iqbal & Pipon-Young [16], who suggested that a panel between 10 and 50 is sufficient. Considering this research focused on a single Paralympic sport, such number of participants was also deemed appropriate. In addition, a low sample size has previously been acknowledged as appropriate if the expert panel has consistent training and knowledge in the sport [18]. Another limitation is the retention rate from round 1 to 3. One participant did not complete round 2 and 3 participants did not return the questionnaire after round 3. Sumsion [43] suggested that a 70 per cent response rate should be maintained across all rounds. This study had a 94% response rate in round 2 and 81% in round 3, which would therefore be considered as an acceptable participation rate.

4.11 Application of Current Findings and Future Directions

To develop an evidence-based classification system in Paralympic sports, a systematic and structured approach is required as described in a number of publications [6, 7, 9, 11]. One of the initial steps is to develop a theoretical model of the determinants of sports performance by identifying the key activities observed in the sport as well as the physical qualities leading to sporting success. The current research is the first study attempting to explore all physical qualities underpinning success in the sport of WF. This information can be used as the premise to guide the development of valid measures of impairments, which is the subsequent step required in the process of developing an evidence-based classification system. To drive classification research further in WF, future research should focus on identifying the key activities observed in the sport by exploring the time motion characteristics as well as quantifying movement occurrence across swords. Such research would assist with the development of standardised, sport-specific determinants of performance, which in turn would enable the relationships between measures of impairment performance to be established, laying the foundation of an evidence-based classification system.

5 Conclusion

In WF, qualities of strength, power, flexibility and motor control of the trunk and fencing arm prevail. The role of the non-fencing arm remains to be determined for category A athletes even if a majority of coaches and some research suggests it has a positive contribution to performance. Any athletes displaying physical impairments reducing these functions may be at a competitive disadvantage and therefore the assessment of such qualities should be considered as part of an evidence-based classification system.

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