Practical Guidelines for Wheelchair Selection in the Court Sports

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Introduction

Maintaining an active lifestyle is especially important for the health and wellbeing of wheelchair users. Regular exercise can play a key role in preventing the likelihood of cardiovascular disease and other associated health risks. Consequently, wheelchair sport can be an important vehicle for achieving an active lifestyle. The wheelchair court sports (wheelchair basketball, wheelchair rugby and wheelchair tennis) are an increasingly popular activity in the UK and contribute significantly towards an active lifestyle given that they are characterised as endurance based activities interspersed with frequent bouts of high intensity pushing.

Many participants progress through to competing at an elite level in these sports, whereby the performance of the following manoeuvres and characteristics become crucial to successful mobility performance:

Endurance
Acceleration
Manoeuvrability
Sprinting
Braking
Stability

Although the physical conditioning of the athlete is imperative to each of these aspects of mobility performance, the configuration of the wheelchair also plays a vital role. Until recently however, very little scientific research has been conducted to establish the exact influence of different wheelchair configurations on mobility performance specific to the wheelchair court sports.

The aim of this booklet is to document the effects that certain areas of wheelchair configuration can have on each aspect of mobility performance to assist users from a novice/rehabilitation setting to elite athletes about the consequences of certain wheelchair selections specific to both the task and individual. In addition to mobility, considerations are also offered wherever possible relating to the effects of configuration on ball handling skills and stroke production performance. A less than optimal wheelchair configuration not only impairs performance, it can also place the user at an increased risk of injury.

There are numerous areas to a court sports wheelchair that can be configured in a variety of different ways. This booklet addresses the following areas and documents considerations for users with regards to each:

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Basketball Wheelchair

Rugby Wheelchair

TennisWheelchair

Frames

Frames

The frame of the wheelchair is the focal point of all the other connecting parts of wheelchair configuration. Yet there are important considerations about the design of the frame that must be accounted for first:

Material:

The WEIGHT and STRENGTH of the frame is vital to performance which is largely dependent on the material used. Lighter chairs minimise the resistive forces experienced during propulsion and lower the physical demand for the user, both of which are desirable for maximising mobility performance. However, these materials must also be strong enough to withstand heavy impacts typically seen in wheelchair basketball and wheelchair rugby. Subsequently, aluminium, chrome moly and grade II titanium have emerged as popular materials for both their weight and strength properties.

Adjustability:

Court sport wheelchairs are available as either RIGID or ADJUSTABLE frames. Simply put, a rigid frame offers little or no flexibility in terms of configurations once it has been selected, whereas an adjustable frame does. There are advantages and disadvantages associated with both options that need to be considered:

	Advantages	Disadvantages
Rigid	Stronger Lighter	Limited flexibility if a change is required
Adjustable	Numerous configurations can be trialled Easier to repair a problem	Heavier Greater internal friction Less reliable

Top tip:

Based on the above, a rigid frame is only advisable for an experienced, intermediate/elite athlete who is aware of his/her optimal configurations and can benefit from the reduced weight and superior strength. Alternatively, a younger, less experienced individual who may still be growing physically and is unaware of his/her optimal settings would benefit from an adjustable frame to experiment with certain configurations before purchasing a rigid frame wheelchair.

Seating

Seating

There are 2 distinct components to the seat, the SEAT BASE and the BACKREST. Consideration must be given to the WIDTH, HEIGHT, TENSION and INCLINATION of each of these given the potential effects on performance discussed below:

Width:

A key requirement for a sports wheelchair is that it fits each individual athlete, ensuring they are at one with their wheelchair. This makes the wheelchair respond to the movements of the user with minimal energy loss between the user and the chair. One of the primary means for achieving this is the width of the seat base and the backrest. If these are too wide, the athlete can slide around in the chair making it less responsive. If the fit is nice and snug as it should be, the chair will move in sync with the player. To facilitate this, it is a good idea to have the seat taper in towards the knees and the backrest taper out towards the shoulders. This serves to improve the **STABILITY** of the performer's lower and upper body, thus preventing any unwanted movements which can negatively affect mobility performance.

Backrest Height:

The height of the backrest can influence the **STABILITY** of the performer. The higher the backrest is, the greater support provided to the upper body. However, if the backrest is too high this increased stability can come at the expense of mobility. It can prevent those individuals with sufficient trunk stability from leaning backwards in their chair. This can impair one's ability to handle the ball in wheelchair basketball and wheelchair rugby and can also restrict the rotation of the trunk, which is essential for stroke production in wheelchair tennis.

Tension:

Most seats will offer some flexibility regarding the amount of tension in both the seat base and the backrest. By simply tightening or loosening the Velcro straps you can increase or reduce the tension respectively. A tighter backrest may be of particular value to wheelchair tennis players since it pushes the performer forward and encourages players to hit the ball out in front of them, which is desirable. Alternatively, wheelchair basketball and wheelchair rugby players may prefer a bit more give in the backrest from a ball handling perspective as it enables them to be less restricted when passing or shooting. This also enables individuals to sit further back into the backrest, which can also offer greater lateral **STABILITY** which may be of value to those with a high lesion level spinal cord injury. Due to the constant strain the backrest is under, combined with the moisture it collects from perspiration, the material becomes progressively looser. Therefore, regular maintenance checks are required to make sure that the desired tension is maintained by frequently tightening up the Velcro straps.

Seating

Inclination:

The inclination angle of the seat base and backrest combined, commonly referred to as the 'seat bucket' is another way for affecting the STABILITY of the performer. Increasing the bucket essentially brings the performers knees closer to their chest, improving their balance. This is particularly advisable for spinal cord injured individuals with a high lesion level who do not possess a great deal of trunk function, hence why a bucket is so common in wheelchair rugby. These individuals may benefit from an 'ergonomic seat' which is a recent addition. The 'ergonomic seat' has a flat section of seat base before a bucket is created. This serves to keep the pelvis in a more favourable position to promote trunk flexion in those individuals who may naturally struggle with this, in addition to improving stability and pressure distribution.

A bucket or an 'ergonomic seat' also enables a stable base for these players to carry the ball whilst pushing, which would not be possible on a flat seat base, as the ball would keep rolling off the lap. However, as with the height of the backrest, too much bucket can make the performer so stable that subsequent movements are inhibited. Therefore, performers who possess a sufficient amount of trunk stability often require little or no bucket since the trunks range of motion and the subsequent thrust they can apply during propulsion can be restricted. Too much bucket can also be problematic for wheelchair tennis since the raised position of the knees can sometimes be an obstacle during groundstrokes.

Strapping:

Strapping has become a vital accessory to wheelchair configuration, as it can play an important role in making the athlete feel at one with his/her chair. It has enabled low point players to perform manoeuvres they may previously have been unexpected to perform. There are a variety of straps that can be used to support the trunk, thighs, knees and feet. It is recommended to keep the lower limbs as fixed as possible during competition, since any unwanted movement can oppose the desired direction of the wheelchair. Strapping around the trunk is important for improving trunk STABILITY, however a fine line again exists between using enough strapping to provide stability without using too much, too high up whereby movements are restricted and mobility performance is impaired.

Top tip:

The minimal amount of bucket and backrest height required to provide stability is advisable from a performance perspective to prevent any negative effects associated with being over stable. Additional stability can always be sought from strapping if required.

Top tip:

For athletes with no or limited upper body impairment no upper body strapping should be required as this can only impair movements. However, those individuals who require strapping should use enough to feel stable and confident in their chair, without becoming so stable that they restrict their movements.

Seating

Two of the most important areas of wheelchair configuration are deciding on the vertical and horizontal positioning of the seat, referred to as SEAT HEIGHT and FORE-AFT position respectively.

Seat Height:

It is desirable to sit as high as possible in each of the wheelchair court sports. For wheelchair basketball, sitting high brings you closer to the basket making skills such as shooting easier. Similarly in wheelchair rugby, sitting high allows you to receive passes above other opponents. Finally for wheelchair tennis, a high seat height offers a better view of the court and increases the margin of error for shots, especially the serve.

Although it is desirable to sit high, there are a number of factors that need to be considered first as seat height can affect both the STABILITY of the performer and MANOEUVRABILITY performance:

- By sitting high, the centre of gravity of the wheelchair-user combination is elevated and if you do not possess sufficient trunk function your STABILITY may be compromised.
- A higher seat position effectively increases the distance between yourself and the main wheels, requiring you to lean further forwards during propulsion. This may not be possible for individuals with limited trunk function and subsequently mobility performance can be impaired. It may also require a larger wheel size to counteract this, however this can be accompanied by other advantages and disadvantages (see page 11).
- The higher centre of gravity associated with a higher seat position can also restrict MANOEUVRABILITY performance, making it harder to spin on the spot and manoeuvre between obstacles on court. Therefore, you need to consider which aspect of performance is most important to your specific role and sport. For example, a forward in wheelchair basketball may be happy to sacrifice his manoeuvrability in favour of sitting high to make shooting easier, which is one of their main responsibilities. However, for a ball handler this is not such a high priority and subsequently this individual would benefit from sitting lower to make him/her more agile.

Top tip:

Sitting high can be advantageous for the wheelchair court sports but if you do not have the trunk stability or your specific role requires greater manoeuvrability around the court, greater gains can be achieved by sitting slightly lower.

Seating

Fore-aft Position:

The horizontal positioning of the seat is another key area of consideration when configuring a new sports wheelchair. A more posterior seat position can be achieved by placing the camber bar further forward and alternatively a more anterior seat position can be achieved by moving the camber bar further back. This area of wheelchair configuration can affect both MANOEUVRABILITY performance and propulsion TECHNIQUE:

Having the camber bar positioned further forwards (posterior seat position) can facilitate MANOEUVRABILITY performance, since the majority of the weight is now positioned towards the rear of the wheelchair, making it easier to spin. A limitation with this position can be that if the seat is too far back it can cause you to rock back on to your anti-tip castor wheels in between pushes and can effectively waste energy.

Ideally, it would be favourable to sit directly above the camber bar so that you can push the wheels down and forward from a 12 o'clock to 3 o'clock position. However, this is based on the premise that individuals have both the trunk stability to sit above the wheels and also sufficient triceps function in order to push down and forwards forcefully. For low point players, particularly those from wheelchair rugby, triceps function is often limited, therefore it would be more advisable to sit slightly lower and further back to allow for a push starting from approximately 9 or 10 o'clock. This allows the biceps to be more active during a 'pulling' motion and may result in greater force being applied to the wheels.

Footrest Position:

Another important consideration when determining the optimal positioning of the seat is where the feet are positioned in relation to this. If the footrest is positioned too high off the ground it can force your knees higher up and almost create a bucket as has previously been mentioned (see page 7). However, the best way to create a bucket is through the angle of the seat, not the positioning of the feet. The fore-aft positioning of the footrest can have a bearing on MANOEUVRABILITY performance and STABILITY. By pushing the feet back underneath the body, quicker turning is enabled since more body weight has been moved towards the centre of the chair. By placing the feet further out in front of you, you may become more stable, although your manoeuvrability may be compromised. Subsequently, both your level of trunk function and specific role on court should be considered before the footrest position is determined.

Wheels

Wheels

The main wheels are responsible for driving the wheelchair-user combination. How effectively they can perform this task is dependent on the selection of a variety of areas of configuration associated with the wheels:

Wheel Size:

The size of the main wheels can have a significant bearing on the ECONOMY of propulsion, as well as ACCELERATION and SPRINTING performance. Wheel sizes for the court sports typically range from 24" to 27". In sports where sitting high is particularly important i.e. forward in wheelchair basketball, selecting a bigger wheel size is one method employed to enable the athlete to access their wheels easier – sitting at maximum height with a small wheel size means the performer has to lean forward quite a long way to be able to even reach the wheels, let alone be able to apply enough force effectively. However, there a number of consequences on performance from selecting different wheel sizes and considerations specific to the individual that needs to be accounted for first based on some research conducted at Loughborough University:

- At a given speed, smaller wheels experience a greater rolling resistance – the consequence of this was that smaller wheels (24") increased the physiological demand of propulsion, as a greater force needed to be applied by the user in order to maintain the given speed compared to larger wheels (26"). This is an important consideration for athletes as wheelchair court sport competitions are relatively long in duration. Therefore, any increase in physiological demand demonstrated by a certain configuration may increase the onset of fatigue, which can have negative consequences on all aspects of performance.
- Larger wheels enabled higher top speeds to be reached during a 20 m sprint compared to smaller wheels, whereas no differences were observed for initial acceleration or manoeuvrability performance.

The results from this research are not specific to all individuals and other factors such as the ROLE of the performer and the STRENGTH and POWER of the performer must be considered. No differences in initial ACCELERATION performance were revealed between wheel sizes potentially due to the high level of strength/power possessed by the elite athletes studied.

Top tip:

If your role in your sport requires you to sit high and you have/can improve your physical power, a larger wheel size (26"/27") is a sensible choice. However, if you do not need to/are incapable of sitting high, lack physical power and are a little bit sluggish over the initial few pushes, a smaller wheel size (24"/25") would be advisable.

Wheels

Camber:

The angle of the main wheels in relation to the vertical is commonly referred to as camber, which is a common feature of all court sport wheelchairs. These chairs tend to range from as little as 15° to as much as 24° and can be dependent on a combination of the sport, the role of the performer and their physical characteristics. Like wheel size, camber can also affect the ECONOMY of propulsion, as well as ACCELERATION and SPRINTING performance. In addition though, camber can also impact upon MANOEUVRABILITY performance.

Two of the main reasons for selecting increased degrees of camber are to improve STABILITY and MANOEUVRABILITY performance:

- The wider wheelbase created by larger camber settings provides a more stable base, which can be of particular use to players with a high sitting position. This reduces the likelihood of them tipping in their chair and losing balance, both of which can have negative effects on mobility performance. However, in wheelchair basketball and wheelchair rugby where being able to negotiate small gaps and avoid other opponents is important, excessive camber can hinder the ability to do so.
- It has often been assumed that greater camber leads to improved MANOEUVRABILITY performance, which may be the case for the ability to spin on the spot. However, research from Loughborough University assessed manoeuvrability performance through a slalom course to simulate manoeuvring up court and avoiding obstacles/opponents. This research showed that although manoeuvrability performance improved from 15° to 18°, no further improvements in manoeuvrability performance were observed from selecting camber in excess of 18° all the way up to 24°.

Top tip:

If you are looking to improve your MANOEUVRABILITY you need to consider which area of manoeuvrability performance is most important to your role. For example if you are a ball handler and wish to negotiate small gaps between opponents whilst progressing up court, selecting camber in excess of 18° may not be necessary. However if your role requires you to be able to spin quickly on the spot (i.e. forward in basketball) greater camber may be required (although not as excessive as 24°) to facilitate this skill as well as improving the STABILITY of these individuals who predominantly sit high.

Wheels

Camber can also have an impact on aspects of linear performance, with increases in camber shown to increase the rolling resistance experienced. Research from Loughborough University showed that these increases in camber resulted in increased physiological demand in greater camber, especially 24°. On court, no significant influence of camber was evident for top speeds reached or initial acceleration. However, there were tendencies for greater camber to impair ACCELERATION over the initial two and three pushes. It is anticipated that athletes who do not possess a high level of STRENGTH and POWER, would experience more negative effects on repeated bouts of initial acceleration in order to overcome the added resistance in these settings.

Top tip:

As with all areas of configuration, one setting will not be optimal for all individuals, however based on previous research, inexperienced athletes who are new to wheelchair court sports may be advised to select 18° as a starting point given its strong performance for linear and non-linear aspects of mobility performance.

However, if you either:

- Become more powerful
- Need to be more stable due to a high sitting position
- Play tennis or as a forward in basketball where a greater emphasis is placed on turning quickly...

...you may wish to consider slightly more camber, although 24° is again too excessive and not advisable.

Wheels

In addition to the size and camber of the main wheels, which are often seen as the key areas of consideration when configuring a new sports wheelchair, other areas which may have been considered minor can still have a critical bearing on performance:

Tyres:

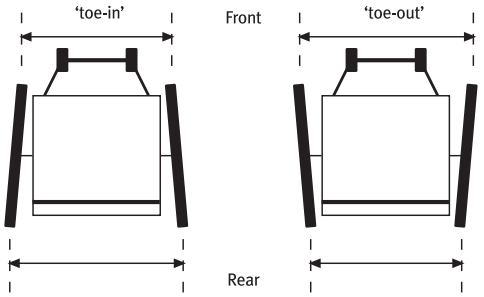
Tyre pressure tends to range from about 80 psi in athletes who use 27" wheels up to as much as 200 psi in certain wheelchair rugby wheels that have pneumatic tyres without the need for any inner tubes. Most tyres will have a recommended inflation limit of around 110-120 psi. It is very important to regularly monitor tyre pressure as it can drop quickly. When this occurs, tyre deformation increases as does the rolling resistance experienced, which as we now know is not desirable. Alternatively, an over-inflated tyre may reduce the contact area and effectively the grip between the tyre and the surface, increasing the likelihood of slipping and sliding.

Spokes:

It is important that the wheels remain 'true' for them to run as effectively as possible. To ensure this, the wheels must maintain their stiffness, which is achieved by ensuring that all individual spokes remain as tight as possible. A loss of tension can result in increased energy loss, which is unfavourable. One method for protecting wheel spokes is through the use of spoke guards which are common in wheelchair rugby whereby contact with other wheelchairs is extremely likely. The challenge here is to select a spoke guard with a material that is strong enough to withstand impacts whilst not excessively adding to the overall weight of the chair. Polyethylene plastic and alloy metals are often selected, with the former demonstrating reduced weight and the latter exhibiting greater strength.

Toe-in Toe-out:

In addition to ensuring that the wheels are 'true', another key maintenance issue that can negatively affect performance if not corrected for is the horizontal alignment of the main wheels, commonly referred to as toe-in toe-out. Toe-in is when the distance between the wheels is shorter at the front than the rear of the chair and toe-out is the reverse (see below), both of which can increase the rolling resistance of the wheelchair. Usually minor adjustments to the sleeve in the camber bar can correct this, which can be checked by holding the chair in a fixed position and measuring the distance between the wheels at a fixed height.



Top tip:

Check your tyre pressure regularly and if you play on different surfaces i.e. wheelchair tennis it may be worthwhile to adjust tyre pressure accordingly. Some experienced athletes advocate a slightly lower pressure being more suitable to grip on softer surfaces like clay, whereas higher pressures are more suited to harder surfaces.

Wheels

The HAND-RIMS are responsible for helping to drive the main wheels, therefore their importance is clear. However, there remains a variety of options in the way in which these can be configured including DIAMETER, MATERIAL, THICKNESS and PROXIMITY to the tyre:

Hand-rim Diameter:

The diameter of the hand-rims in court sports wheelchairs are traditionally 1" smaller than the diameter of the main wheel. Recently there have been a few exceptions, whereby a small number of foreign wheelchair tennis players have configured their chair with hand-rims the same diameter as the wheel. Due to the camber of the wheels the hand-rims do not contact the floor, however the only benefit from this is likely to be the athlete's comfort of pushing having the wheel and hand-rim configured in this manner.

Wheelchair racers have a significantly reduced diameter hand-rim in relation to their main wheel. This facilitates the ability to reach high top speeds since a smaller diameter hand-rim on a given wheel size rotates at a slower rate, making the rim easier to couple and increase speed. This has not been seen in the wheelchair court sports due to a combination of the reduced emphasis on high top speeds and the desire to sit high meaning that a smaller diameter hand-rim would be even harder to access.

Material:

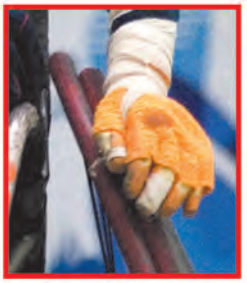
The material of the hand-rim can also differ dependent on the SPORT and the ROLE of the performer. In wheelchair rugby, two distinct hand-rims exist. Low point players who occupy the defensive roles use a rubber coated hand rim that is set slightly further away from the wheels (see page 16). The rubber allows greater grip to be achieved, which is important to these individuals who often lack sufficient hand function. These rims also have another advantage, as they facilitate 'picking' out opponents' wheelchairs, which is a key responsibility of low pointers, since the rubber material grips to other chairs easier. Alternatively, high point players in wheelchair rugby tend to have a standard metal hand-rim that does not protrude very far from the wheel. The idea behind this is to make their chair harder to pick.

Wheelchair tennis players are also frequently seen to select a rubber or plastic coated hand-rim to facilitate coupling between the user and the hand-rim as these athletes have the additional constraint of a racket to hold whilst pushing. These materials are thought to allow better grip to be achieved than with a standard chromium hand-rim (see page 16) especially when the whole of the hand cannot encompass the rim.

Wheels

Gloves:

Another way to maximise the grip between the user and the hand-rim is through the use of gloves. Not only may gloves improve the friction during mobility performance but they can also minimise abrasions and other injuries to the hands.



- Gloves are generally not worn by wheelchair basketball players since a certain amount of feel with the ball is desired in order to facilitate the accuracy of ball handling skills.
- A number of players from wheelchair tennis have started to use a thinner glove similar to a golf glove.
- Gloves are worn by the vast majority of wheelchair rugby players due to their limited hand function. However, no sport specific gloves exist and subsequently athletes utilise a variety of gloves including American football gloves, building gloves, gardening gloves and even multipurpose gloves and then modify them in a way in which they feel best suits them as individuals. Research from Loughborough University suggested that modifying an individual glove with additional materials and substances to suit the individuals needs resulted in the most favourable mobility performance.

Hand-rim Thickness & Proximity:

The thickness of the hand-rim tube and the distance from which it is set away from the wheel are also key considerations which seem to be strongly based on personal preference. We have already highlighted the game related benefits of having your rims set closer in or further out in wheelchair rugby. These decisions are also influenced by factors such as TECHNIQUE and HAND SIZE. Those individuals who prefer to push by the hand-rim alone may favour a hand-rim that is set out slightly wider to facilitate coupling, whereas those who prefer to push a combination of the tyre and the rim may favour a narrower rim position in order to encompass both during a push. In addition, athletes with a smaller hand size may struggle to push with the latter technique, especially if a large hand-rim tube is desired.

Wheels

The smaller castor wheels at the front and rear of a sports wheelchair have varied in SIZE, NUMBER and the types of BEARINGS used over the years. Although castor wheels are predominantly intended to improve the **STABILITY** of the wheelchair, each of these specific design characteristics can also influence other aspects of mobility performance:

Castor Wheel Size:

As referred to previously (see page 11), smaller wheels increase the rolling resistance, therefore the size of the castor wheels is an important consideration for users. The smallest castor wheels tend to be approximately 45 mm in diameter and it may be partly owing to their effects on rolling resistance that a size of approximately 62mm seems to be the most commonly selected size.

Number of Castor Wheels:

The number of castor wheels has varied between one and two wheeled designs at both the front and rear of the chair. The benefit of having one wheel at the front was to minimise the rolling resistance during pushing since this reduces the number of parts of the wheelchair in contact with the surface. However, it is more common for two wheeled designs nowadays at the front of the chair, as these provide a greater degree of **STABILITY** to the user during high speed manoeuvres.

Anti-tip:

Anti-tip wheels are also a common sight in court sport wheelchairs, although the number still varies, which is predominantly dictated by the sport. The majority of tennis players opt for one anti-tip wheel in order to reduce the rolling resistance of the wheelchair. However, it is more common for wheelchair basketball and wheelchair rugby players to select two anti-tip castor wheels, with the main purpose of this to facilitate the 'picking' of opponents's chairs in these team sports.

The height at which the anti-tip wheels are set off the ground is often adjustable in sports wheelchairs. If these wheels are too low and are subsequently in contact with the ground all the time, then the resistance experienced during propulsion increases. It also increases the likelihood that the more important main wheels may be slightly raised from the surface, leading to a loss of grip. Therefore, players tend to leave a small gap between the anti-tip wheel and the surface, which allows them to rock back slightly and facilitate ball handling and striking skills. However, if the gap is too big the player can rock between front and rear castor wheels too severely during propulsion, which results in a loss of energy during the recovery phase of the push.

Castor Wheel Bearings:

The bearings used are a vital component of castor wheels, as regardless of the size and number of wheels selected, the performance of the wheel is dependent on the bearing within. Tests conducted at Loughborough University revealed that ceramic bearings reduced the resistance experienced compared to standard bearings that accompany a new sports wheelchair, hence why many elite athletes now modify their castor wheels with ceramic bearings. These tests also revealed that both these sets of bearings demonstrated a lower rolling resistance than rusted bearings.

Top tip:

As with all areas of wheelchair configuration maintenance is a key issue and is strongly applicable to castor wheels, as it is an area which is rarely checked. These wheels can pick up all sorts of residue and dust from sports halls or outdoor surfaces. Maintenance should include scraping any residue off the outside of the wheels and also removing the wheels and bearings from the castor fork to wipe away any unwanted materials to ensure that these wheels rotate smoothly.

Summary

This booklet has covered some of the key factors that need to be considered when configuring a new wheelchair for participation in the court sports, however it is by no means an exhaustive list. Therefore it is recommended that whenever you are about to purchase a new sports wheelchair that you discuss what is required from you as an individual with your coach so that you are clear on what you are looking to achieve from your new chair and then to discuss your options in detail with the wheelchair manufacturer so that the best possible solution is reached. Once you have received your new wheelchair regular maintenance checks highlighted throughout this document (i.e. seat tension, spoke tension, tyre pressure etc.) are necessary in order for your chair to continue performing to the best of its potential.

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