

Bridging the strength gap between able-bodied and disabled tennis players using the Bill Starr training program

FRANCESCO BOREA¹ , ANDREA CECILIANI², FRANCESCA D'ELIA¹

¹University of Salerno, Italy

²University of Bologna, Italy

ABSTRACT

The strength deficit is a very evident problem in the comparison between wheelchair tennis players and able-bodied tennis players, with important repercussions from a technical-tactical point of view. The aim of the study is to demonstrate that with strength-hypertrophy training using the Bill-Starr methodology, it is possible to fill, at least in part, the deficit in this motor capacity. Participants in the study are twenty tennis players (age: 28, weight: 70 kg; height: 184 cm) who compete regionally, comprising 10 wheelchair tennis players belonging to the experimental group and 10 able-bodied players belonging to the control group. The study includes three phases: a pre-test phase where players took a quantitative assessment test, an 8-week adapted Bill Starr strength-hypertrophy training period, and a post-test phase where the athletes they repeated the quantitative assessment test. Through the use of the t-test for dependent samples, a significant increase in the average speed impressed with the service by the experimental group was found. Specifically, the average increase was 19.7 km/h, with a gap with the able-bodied companions which went from an initial value of 77.6 km/h to 57.9 km/h. This therefore not only led to actual improvements for wheelchair tennis players, who will be able to rely more on the service to search for direct points and therefore reduce the time duration of exchanges and better manage energy, but also leads to the possibility of playing mixed matches in a more balanced way than before.

Keywords: Wheelchairs; Adapted physical activity; Adapted performance.

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Corresponding author. University of Salerno, Italy.

E-mail: f.borea1@studenti.unisa.it

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INTRODUCTION

Wheelchair tennis is a discipline with many similarities to classic tennis, as the rules are very similar, as are the technical-tactical components. The discovery of wheelchair tennis dates back to about 1970, a moment from which it began to enjoy increasing worldwide success over time, starting to organize real tournaments all over the world. The organizing body for wheelchair tennis is the International Wheelchair Tennis Federation ITF and the regulation is by the CIP, the Italian Paralympic Committee. This sport is having great success all over the world, and this highlights how sport is also important for these people (Cassese et al., 2017; D'Isanto & Di Tore, 2016). The rules of wheelchair tennis are very similar to normal tennis. You can play games in single and double, respecting the same measures of the field and the height of the net. Obviously, in double wheelchair tennis the side corridors will also be used, as in the classic one (D'Elia et al., 2021). The main difference is that in wheelchair tennis it is allowed to bounce the ball twice on your court before hitting it, as opposed to classic tennis, where you can only bounce the ball once on your court (Greenwood et al. 1990). In wheelchair tennis there are two different categories:

- Open Category: Neurological deficit near level S1 or higher, associated with loss of motor skills; Severe osteoarthritis or ankylosis and / or replacement with hip, knee or ankle prostheses, amputation of any part of the lower extremities, motor impairment in one or both lower extremities.
- Quad category: The player must correspond to the criteria of permanent physical disability of the open category, and also have a disability that corresponds to a substantial loss of motor skills in one or both upper extremities, such as: a neurological deficit near level c8 or superior, upper extremity amputation, phocomelia, muscular dystrophy or myopathy.

Table 1. Technical comparison of wheelchair tennis / conventional tennis.

Fundamental	Wheelchair tennis	Conventional tennis
Handle	Western forehand grip, for shots with a top spin effect, with an upward trajectory, given that the net is a particularly high obstacle.	Various types of grips based on the level of practicality: continental, eastern, semi-western and western.
Movement	The phase of the preparation movement is reduced, given the limited time available being seated. The acceleration increases from the impact with the ball until the end of the movement. Less energy production.	Free movement, possibility to perform anticipatory movement to hit the ball in the best possible way, as in the service.
Service	The wheelchair is a major obstacle to service, initially preventing the racquet from going down. The movement then develops laterally, and this will lead to a net loss of strength. Higher level of injury, especially abdominal and backbone, will reduce the effectiveness of the service.	Ability to perform complete movement for the service. Very high speeds can be achieved. Three types of service: dish, slice and kick.

Forehand	Forehand very similar to able-bodied, but with less acceleration impressed on the ball, given the preparation phase limited to movement.	Classic forehand, with the possibility of choosing various handles to find the right effect. Freedom of movement. Great accelerations can be applied to obtain a winner.
Backhand	The backhand is only with one hand, since the other will be used to move with the wheelchair. The blows will not have particular force, given the limited action of the trunk and shoulders during the preparatory phase of the movement.	It can be done with one hand or with two hands, with a twist of the torso. Choice of backhand in slice, backspin or topspin.

Although the fundamentals are the same in the two sports, their execution varies a lot, given the different position, standing and sitting (D'Isanto, 2020; Raiola, 2015). A special wheelchair is used, usually made of carbon, but the search for new, more efficient means to encourage the performance of wheelchair athletes is constant (Boccia et al., 2019). The two rebounds rule allows you to manage the points differently during the match, with changes therefore from the technical tactical point of view, and it is the main difference from the point of view of the regulation (Martino et al., 2019).

Table 2. Tactical comparison of wheelchair tennis / conventional tennis.

Situation	Wheelchair tennis	Conventional tennis
Service	The service is not very effective, it will be difficult to get a winner. The slice is mainly used, to bring the opponent sideways and hit later with a winner.	The service is fundamental, for win directly and quickly the point. The maximum speed achieved in service was 253 km / h. All three variants are widely used.
Points in response	Very effective, given the low power of the service.	Overall, not very effective, especially if you are playing against a big server.
Points near net (smash, voleé...)	Scarcely used, given the difficulty in reaching the net and being exposed to lobs and passers-by.	Very used, especially after a slice serve as the opponent will leave a lot of fields open.
Drop shot	Quite used in prolonged exchanges when there is an energy reserve. It is often effective given the difficulty of reaching the net with the wheelchair.	Often used, especially with tall players who have difficulty lowering themselves and when opponents are very far from the net, for example after an effective serve.

As can be seen from the qualitative analysis reported above regarding the technical-tactical differences between tennis and wheelchair tennis also in order of biomechanics movements (Elia, et al, 2020, Raiola et al, 2020), it is evident that wheelchair tennis players express less force in their strokes, especially in the serve (Esposito et al., 2020). This is precisely due to the difficulties of movement, given the specific situation, which will not allow the preparation phase to be carried out completely and therefore to impart the necessary energy,

a frequent aspect also in other sports for the disabled (Forte et al., 2019). In addition, especially in the service is necessary to adapt the movement by carrying it out laterally, given the obstacle of the wheelchair, and this will also reduce the force of the blow. This lower general strength compared to able-bodied players will cause prolonged exchanges given the lower quality, few points won directly on the serve and few winning accelerations.

Aim of the study

The strength deficit is a very evident problem in the comparison between wheelchair and able-bodied tennis players, with repercussions from a technical-tactical point of view (Santopietro et al., 2020). The aim of the research design is to demonstrate that, with strength-hypertrophy training using the Bill Starr methodology, it is possible to partially fill this deficit of this motor capacity, thus also allowing to play matches, in single or in double, between disabled tennis players and able-bodied tennis players in the most balanced way possible. This will make it possible to further strengthen the terms of inclusion and sports integration.

MATERIALS AND METHODS

Participants

Twenty tennis players (age: 28; weight: 70 kg; height: 184 cm) competing at the regional level were divided into an experimental group (n = 10) consisting of 10 wheelchair tennis players, and a control group (n = 10) made up of 10 non-disabled tennis players. The experimental procedure, risks and benefits were explained to the parents prior to participation. An informational consent was signed by the subjects' parents and / or legal guardians. The study adhered to the code of ethics of the Declaration of Helsinki and the procedures were in line with ethical standards established in the sports sciences.

Design of the study

The participants in the study were initially subjected to a quantitative assessment test where the speed impressed on the ball during the serving was assessed. The measurement of the speed of a tennis ball was carried out using two radars pointing towards the centre line of each of the two halves. Before the tennis player served the serve, the radar closest to him was activated thus emitting waves at a known frequency. When the waves intercepted the moving ball, they were reflected. Their frequency at this point was different because it depended on the speed of the ball itself. The reflected wave was then intercepted by the same radar: from the difference between the emission frequency and the reflected one it was possible to mathematically go back to the calculation of the impressed speed, generally expressed in Km / h. Subsequently, both groups underwent a different training protocol. The champion of wheelchair tennis athletes was subjected to an adapted Bill Starr training, as it did not include the performance of the classic multi-joint exercises such as bench press, squat and deadlift, as they were not feasible. Specific exercises were then carried out for the upper limbs. The 8-week training schedule included the following exercises:

- 5x5 military press
- 5x5 curl with dumbbells
- 5x5 triceps extensions with dumbbell
- 5x5 reverse curl with dumbbells.

The training schedule included an exercise for each specific muscle group, namely shoulders, biceps, triceps and forearms, with a recovery of 2 minutes between each series. Alternating exercises have been specifically avoided to avoid causing imbalance and the risk of muscle injuries. The purpose of the Bill Starr sheet was to increase the strength of the muscles involved, progressively increasing the loads, but at the same time also seeking hypertrophy, thus increasing the cross section of the muscle (Di Palma et al., 2016). At the end

of the workout, stretching and joint mobility exercises are also proposed. The goal was to propose functional training for sport, which allowed to obtain real advantages on the pitch (Latorella et al., 2020). The expression of force required optimal intramuscular coordination and agonist and antagonist muscles and above all a high recruitment of motor units (Ferrara et al., 2019). Alongside training with weights, tactical training was carried out on rest days with a central focus on the fundamental of the serve, in the search for the best technique that would allow them to express their strength to the maximum. After the eight weeks of strength-hypertrophy training using the Bill Starr method, a new evaluation of the speed of the service was made, using the same type of evaluation test. A new comparison was then made between the speed impressed on the ball in the serve between wheelchair players after strength training-hypertrophy Bill Starr and the sample of able-bodied tennis players analysed at the beginning.

Statistical analysis

A dependent sample t-test was used to assume a non-significant change in pre-intervention values. An additional dependent sample t-test was used to record post-intervention differences. The significance level was set with $p < .05$. The data showed a normal distribution ($p > .05$) with the Shapiro-Wilk test. The data was analysed using Excel 2017 software.

RESULTS

Table 3. Results of the ball speed test with the service (inbound).

Participants	Wheelchair tennis player (Km/h)	Able-bodied tennis player (Km/h)
Athlete 1	60	130
Athlete 2	76	145
Athlete 3	82	155
Athlete 4	91	166
Athlete 5	103	175
Athlete 6	110	183
Athlete 7	118	200
Athlete 8	127	210
Athlete 9	135	222
Athlete 10	142	234
Average	104.4	182

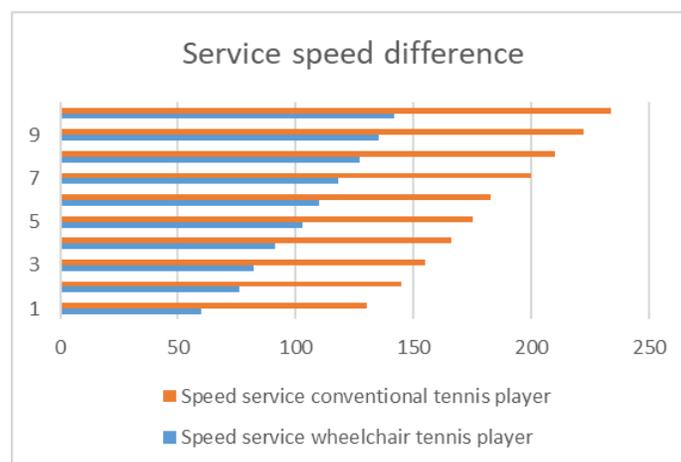


Figure 1. Ball speed difference on service.

Table 4. T-test for pre and post intervention samples.

	Speed pre-Bill Starr	Speed post-Bill Starr
Average	104.4	124.1
Variance	726.4888889	1025.877778
Observations	10	10
Overall variance	876.1833333	
Difference assumed for the averages	0	
gdl	18	
Stat t	-1.488174075	
p(T<=t) one-tailed	.077007651	
t critic one-tailed	1.734063607	
p(T<=t) two-tailed	.154015302	
t critic two-tailed	2.10092204	

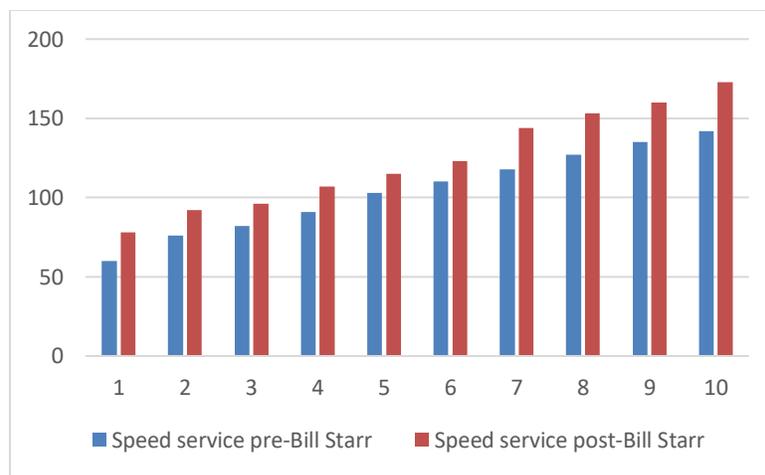


Figure 2. Difference in the speed of the pre- and post-intervention service.

Table 5. Results of the ball speed test with the service (outbound).

Participants	Wheelchair tennis player (Km/h)	Able-bodied tennis player (Km/h)
Athlete 1	78	130
Athlete 2	92	145
Athlete 3	96	155
Athlete 4	107	166
Athlete 5	115	175
Athlete 6	123	183
Athlete 7	144	200
Athlete 8	153	210
Athlete 9	160	222
Athlete 10	173	234
Average	124.1	182

Table 6. Points won with the service pre- and post-Bill Starr training.

Participants	Points won with the service pre-Bill Starr	Points won with the service post Bill star
Athlete 1	36	52
Athlete 2	45	58
Athlete 3	49	67
Athlete 4	53	78
Athlete 5	57	82
Athlete 6	63	86
Athlete 7	68	88
Athlete 8	74	91
Athlete 9	79	95
Athlete 10	84	102
Average	60.8	79.9

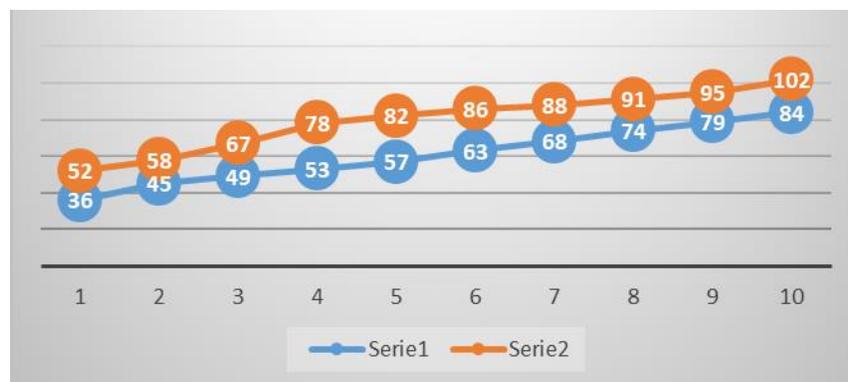


Figure 3. Difference points won with the service between pre- and post- Bill Starr.

DISCUSSION

As can be seen from the data in the table shown, there is a clear difference between the average service speed of the sample of disabled athletes and non-disabled athletes of 77.6 km / h. It's clear that playing a mixed game can be unbalanced in this respect. Through the statistical tool of the T Test, an effective increase in force impressed on the ball was highlighted, with a significantly higher speed expressed in km/h, passing from an initial average of the wheelchair tennis sample of 104.4 km/h to one of 124, 1 km/h, a difference of 19.7 km/h. The difference has significantly decreased from 77.6 km h to 57.9 km/h. In detail, the sum of the points won with the service in three mixed matches was calculated for each disabled athlete, played both before carrying out the Bill Starr work methodology and subsequently. The results from the match analysis (Raiola et al., 2016) showed a significant increase in points won directly with the serve for all ten disabled athletes playing mixed games, with an average increase of 19.1 points. We know very well the importance of being able to win a direct point with the serve, speeding up your turn and spending less energy during the match (Raiola et al., 2016). The results obtained satisfy the hypotheses previously formulated, namely how an (adapted) training methodology focused on strength-hypertrophy, in this case the Bill Starr program, can improve the service of able-bodied tennis players and fill, at least in part, the gap with able-bodied athletes. The results are also confirmed by other scientific studies, such as a longitudinal study carried out, where in that case a similar training program led to an improvement in the force expressed, measured as the

propulsion force of the wheelchair (D'Elia et al., 2019; D'Elia et al., 2020). However, it is necessary to underline some limitations that must be taken into consideration in research, also caused by the Covid-19 pandemic (Raiola et al., 2020), such as a not excessively large sample and a single type of playground (in the study it has been the concrete), which did not allow to evaluate any variations on clay or grass (Sanseviero et al., 2019). The research launches interesting future perspectives from the point of view of programming and planning the training of disabled tennis players, to try to make the disparity with able-bodied companions as small as possible. The trainer must obviously have the appropriate knowledge and specific training in the field of disability (Cascone et al., 2020).

CONCLUSIONS

The results that emerged from the research design show that Bill Starr strength-hypertrophy training allows us to clearly bridge the gap between the strength of wheelchair players and that of able-bodied players. This allows you to play mixed matches more evenly, but at the same time to improve the quality of the exchanges, reducing their duration, and to win more points directly with the service, which is the fundamental where the motor capacity of strength has greater implication. Therefore, to conclude, an increase in the force impressed on the ball was found and, as a consequence of this, also a greater amount of points won directly with the service in mixed matches, at least partially filling the large deficit that occurred in this fundamental among tennis athletes and wheelchair tennis athletes.

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