IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

# Effect Of Four-Weeks Of Strength Training On Change Of Direction

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***Abstract:*** Change of direction (COD) speed is a critical performance factor in field hockey, influencing an athlete's ability to react swiftly to opponents and game dynamics. This study examined the effects of a four-week strength training intervention on the COD ability of a junior-level male field hockey athlete. Pre-testing assessments included the T-test (COD), 1RM back squat (lower limb strength), vertical jump (lower limb power), and 40m sprint (straight-line speed). Initial results indicated that the athlete lacked lower limb strength relative to normative values. A structured four-week strength training program, incorporating unilateral and eccentric-focused exercises, was implemented alongside regular skill and conditioning sessions. Post-testing results showed improvements in COD speed (T-test time reduced by 0.12s), 1RM back squat (+5kg), and vertical jump height (+1cm), while 40m sprint performance slightly declined (+0.06s). These findings highlight the importance of lower limb strength development in enhancing COD speed. Future research should explore longer intervention periods and include additional components such as reactive strength and biomechanical analysis to further optimize COD performance.

***Index Terms*** – Field Hockey, Strength Training, Change of Direction (COD), Performance Enhancement, Lower Limb Strength, Vertical Jump, Eccentric Training.

## I. Introduction+Link to Performance

Field-hockey is considered as a fast-paced intermittent team game that requires several physical movements such as walking, sprinting, jogging, change of direction, passing and hitting during the course of a professional game and to successfully execute these physical qualities a field-hockey athlete must have an excellent aerobic and anaerobic fitness along with muscular strength and power (Lythe and Kildling, 2011).

The international field hockey federation (FIH) which is known as the governing body for field hockey have made several changes in the game reducing the time from 70 minutes to 60 minutes which consists of four quarters of 15 minutes with two additional rest periods which made the game more physically demanding (FIH 2017)

Time-motion analysis (TMA) and Global positioning system (GPS) were generally used to report the total distance, and it has been reported that the total distance covered by a hockey athlete during the first quarter of the game is typically higher in comparison with all the three quarters (Ihsan et al., 2018).

During a game a field hockey athlete must rely heavily on their change of direction (COD) capability in response to a ball or opponent and repeated sprint ability (RSA) to dodge an opposition defender or during marking of an opposition attacker (Spiteri T, Lawrence S, Spencer M, 2013).

A professional field hockey athlete must make an average of 60 turns (Withers et al., 1982). Additionally, a field hockey athlete must make a total of 723±22 turns during a 60-minute game (Bloomfield et al., 2007).

Moreover, it has also been stated that the ability to change direction with ball during sprinting is a key determinant factor in losing or winning a field hockey game (Sheppard and Young, 2006).
Change of direction (COD) refers to an athlete ability to accelerate, deaccelerate and reaccelerate again in a new direction (Spiteri T,2013). To successfully perform a change of direction, task an athlete should demonstrate three qualities namely, the braking phase which is also known as eccentric, the plant phase or the isometric and the propulsive phase which is also known as the concentric phase (Spiteri T, Newton RU, Binetti M, 2015). Moreover, an athlete's eccentric and isometric strength of the muscles of the lower limbs along with the neuromuscular control in the different phases of COD plays an important role in successfully completing a COD task during a game (Jones P, Naylor J, 2015).
Lower percentage of fat mass and relative strength have been shown to be useful while completing a COD task (Peterson MD, 2006). In a study of Chaouachi et al, a high corelation (r=0.8) of lower percentage of fat mass and performing COD task have been shown. Additionally, while performing a COD task, an athlete with lower percentage of fat mass takes lesser time to complete the task than an athlete with higher percentage of fat mass as the athlete requires to lower their centre of mass while deaccelerating and reaccelerating to a new direction to produce force on the ground (Chaouachi A, Manzi V, 2012).
Successfully completing a COD task during a game requires the athlete to produce greater amount of force on the ground in a short period of time while reaccelerating to a new direction to achieve maximum force output (Farrow, D, 2006). Reactive strength which is also considered as a subcomponent of COD which determines the athlete's ability to change from an eccentric action to a concentric action as quickly as possible fully utilizing the stretch-shortening cycle (SSC) also plays a huge role in determining an athlete's COD performance during a game of Field-hockey (Potach D, Chu D, 2009).
According to Newtons Law of Motion, to overcome inertia during deacceleration and effectively reaccelerating to a new direction during the time of a Field-Hockey game, lower limb strength is important (Bourgeois F, Gill N, Gamble P, 2017). Finally, a high corelation between lower limb strength and COD performance have been well established (r=0.89) (Jones P, Nimphius S, Spiteri T, 2014).
The aim of the study was to assess the COD capacity and its subcomponents of a junior level male field hockey athlete and to identify at which aspect the athlete is lacking and to work according to that.

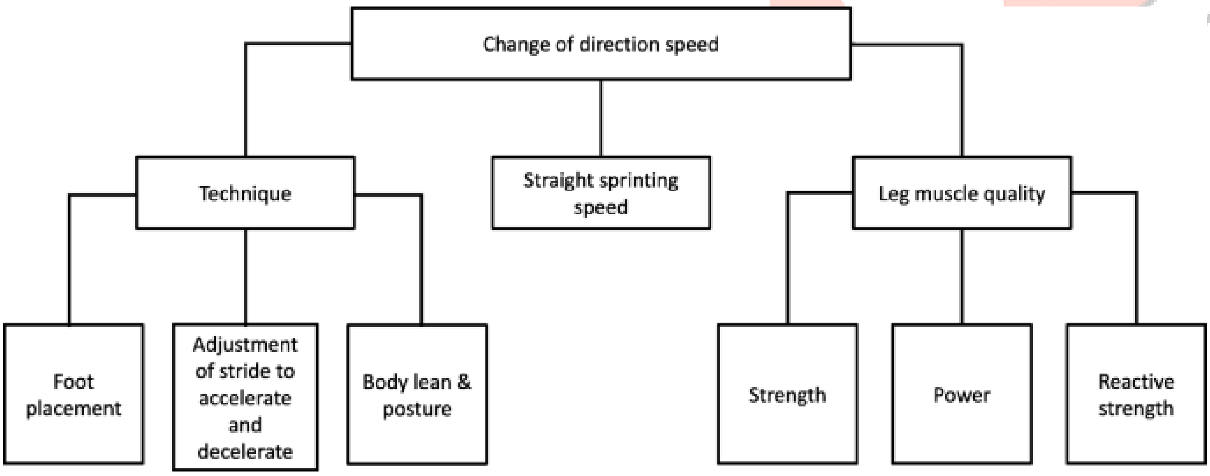


**Figure 1. Modified theoretical model of COD by Young et al.**
As shown in figure 1, successful competition of COD task during a game requires good body positioning, straight sprinting speed and strength, power and reactive strength of the lower limbs muscle (Young W, James R, 2006).
According to the theoretical model by Young et al, to assess the COD score of the athlete T-test was performed by the athlete, 1 RM back squat for lower limb strength, Vertical jump for lower limb power and 40mt speed for straight line sprinting speed was done.
The athletes T-test timing was 10.02 seconds which was 5.18% higher than the normative value of 9.5 seconds (Semenick, D, 1990). The vertical jump height of the athlete was 71 cm which was found to be 1.44% higher than the normative value of 70cm (Taylor et al, 2010). The athlete lifted 72 kg in his 1RM back squat which was 6.44% lower than the normative value of 80 kg (Bishop et al, 2015). The athlete 40MT sprint timing was 5.02 seconds which was found to be lower as opposed to the normative value of 5.10 seconds (Keogh et al, 2003).
After testing the athlete for speed, power and strength it was found that the athlete was lacking in his lower body strength portion and for that lower body strength have been taken as a subcomponent that needs to be work on to improve the COD performance of the athlete.

**Table 1. Pre-test score of the athlete**

| | |
|---|---|
| T- test | 10.02 seconds |
| Vertical jump | 71 cm |
| 40MT sprint timing | 5.02 seconds |
| 1 RM back squat | 72 kg |

**Table 2. Normative values of T-test, 1RM back squat, 40MT sprint test and 1RM back squat**

| | |
|---|---|
| T-test | 9.5 seconds (Semenick D) |
| Vertical jump | 70cm (Taylor et al) |
| 40MT sprint timing | 5.10 seconds (Keogh et al) |
| 1 RM back squat | 80 kg (Bishop et al) |


**Figure 2. Pre-test scoring of the athlete in relation to Normative values**

In figure 2, the athlete was scored from 1-10 scale in T-test, vertical jump test, 1RM back squat test and 40MT speed test in relation with the normative values as shown in Table 2.

## II. METHODS AND REPORTING

One junior level male field hockey athlete was recruited for the study. The athlete was 17.2 years old with body weight of 64.1 kg, height= 176 cm and a body mass index of 20.69 kg-m$^2$. The athlete's bodyweight, height and body mass index were calculated through SECA -213 BMI calculator.

The athlete had a training experience of 5 years and was currently playing at junior level national tournament for his state. The athlete was training 5 days a week and was familiar with all the testing techniques. The study was conducted where the athlete was training throughout the year and have given an informed consent form for the purpose of the study.

At the time of testing, the team doctor prescribed that the athlete was free from any kind of muscular injuries or health disorders. Moreover, the athlete was also asked not to do any kind of high intensity workouts, not to

consume any alcoholic or caffeinated drinks before 48 hours prior to testing. Finally, an ethical approval was also taken from the Director of the center where the study was conducted.
The athlete was tested for T-test to assess the COD speed, vertical jump for lower body power, 40mt speed to assess straight line sprinting speed and 1RM back squat for the lower limb maximal strength.
All the testing were done after a general and specific warm up followed by an adequate rest period of 3-5 minutes.

*T-test*

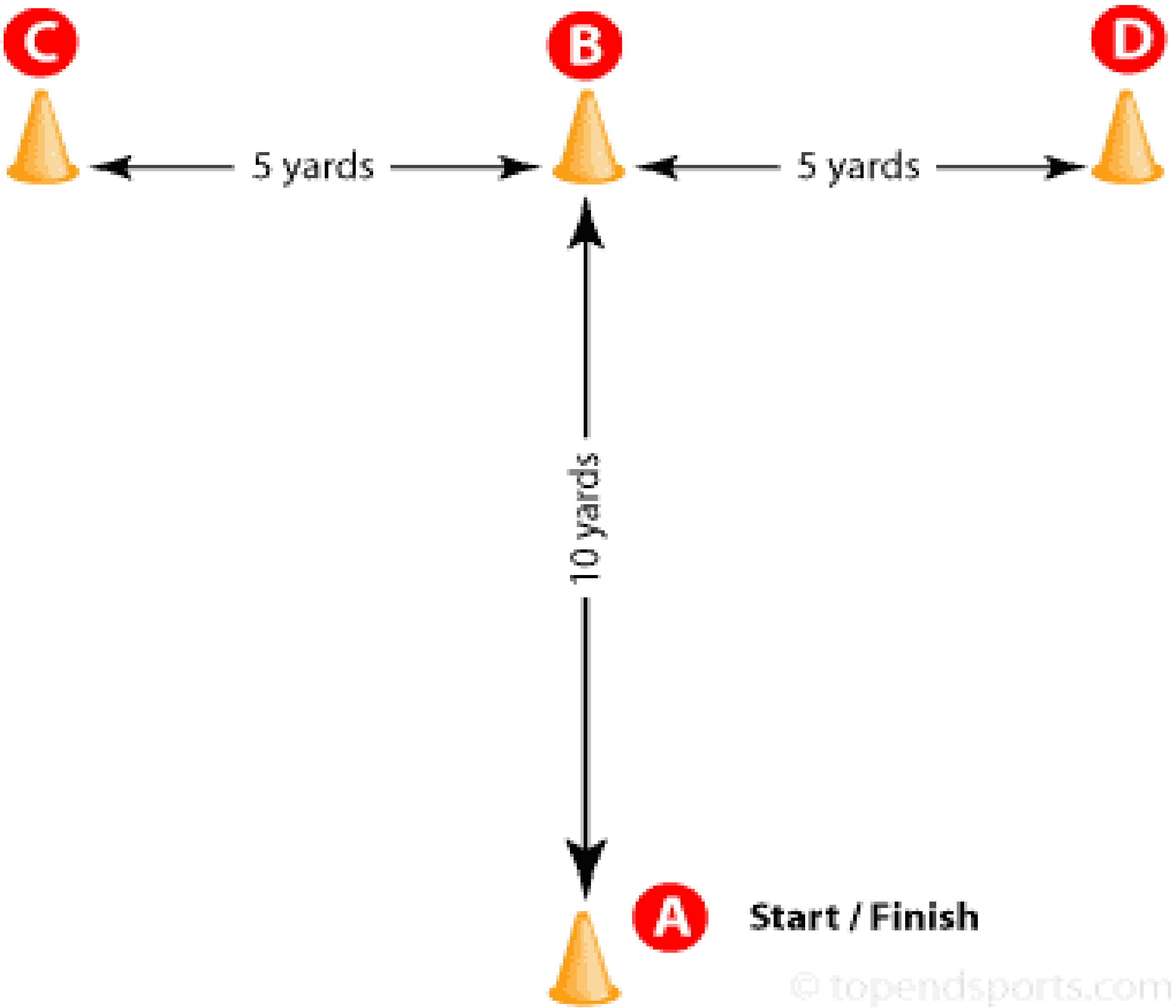


**Figure 3. procedure for T-test**
Many team sports in the world uses T-test to assess the change of direction capability of an individual athlete (Pauole Kainoa, 2000). As shown in figure 3, to start the test the athlete will stand at point A and on the command "3 2 1go" the athlete will make a forward sprint to point B and will touch the base of the cone at point B and then will laterally shuffle to point C and after touching the base of the cone at point C the athlete will again laterally shuffle to point D and will touch the base of the cone, will again laterally shuffle to point B and after touching the base of the cone at point B the athlete will make a backward sprint and finish the test at point A (Madole, Kent, 2000).
After finishing one attempt the athlete was given a rest of 5 minutes and was asked to give another 2 trials and best timing close to 0.1 seconds of the three attempts was taken (Semenick D, 1990). The timings were recorded using a stopwatch.
Before the start of the test the athlete was also informed that if he failed to touch the base of the markers at each point or if he fails to face forward during the whole test or if his one foot crosses the other the test will be immediately discontinued (Lacourse, Michael, 2000).

*Vertical jump test*

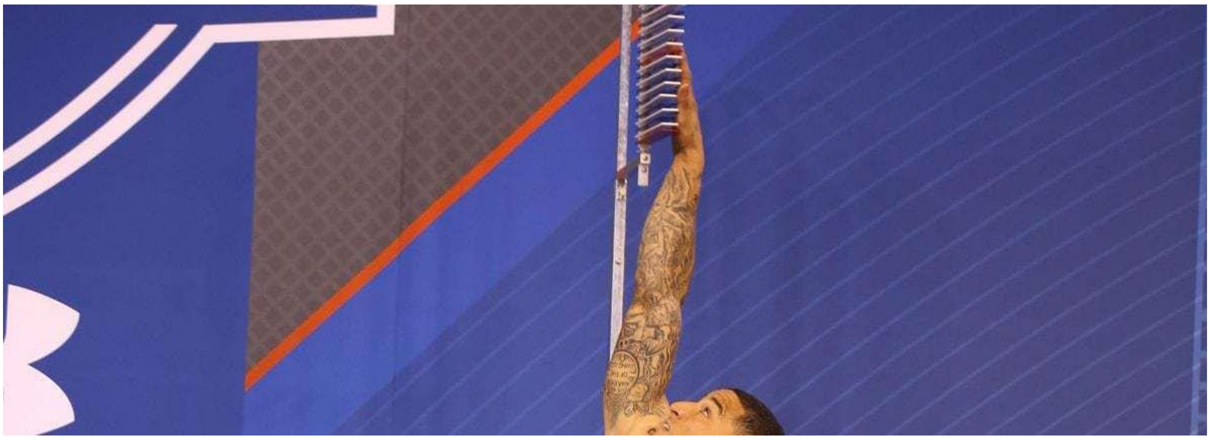

**Figure 4. procedure of vertical jump test**

Vertical jump is used to assess the lower limb power using a vertec device where the athlete either using a single or double arm with full effort will try to jump as high as possible to reach a maximum point at the vertec device (Muehlbauer T, Pabst j, 2017).

To start the test the athlete will stand below the vertec device with a slight bend at the knees, ankles and the hips and with the command "jump" the athlete will use his full effort to reach as high as possible and hit the vanes of the device (Moris J, Folland J, 2012).

Jump height of the athlete was determined by the difference between the athletes standing reach height and the highest vanes displaced at the device, and after one trial the athlete was given a rest for 3 minutes and was asked to perform another 2 trials in which the best jump height was taken (cm) (Leard J, Miller T, 2007).

Before the start of the test the athlete was informed to jump vertically as high as possible as any lateral or backward movement will affect the score (Bui H.T, Farinas M, 2016).

*40MT sprint*

To assess the straight-line sprinting speed many teams uses the 40MT sprinting to determine the athletes speed capability (Brown T.D, Nagahara R, 2012).

The 40mt speed test was conducted in Hockey turf where the athlete trained throughout the year.

Before the test two markers were set up at 40mt from point A to point B and the athlete was asked to stand just 10cm with a 3-point start behind from point A and with the command "3 2 1 GO" sprint to point B with maximal effort (Gabbett T. J, 2012).

Timings were recorded using a stopwatch with one administrator standing at point A and other administrator at point B. As soon as the athlete crosses the point B marker the administrator standing at point B will stop the timing at point B.

Three trials were given by the athlete and after one trial adequate rest of 5 minutes were given and the best time close to 0.1 seconds was taken (Docherty D, Wenger HA, 2012).

1RM Back Squat

1 RM back squat which is known as the maximum weight one can lift at a time was used by athletes across the world in many sports to assess the lower limb strength (Braith R.W, 1993).

The 1RM back squat of the athlete was conducted at an indoor gym where the athlete was doing strength training throughout the year.

To initiate the test the athlete was asked to lift a weight that allowed him to complete 8 repetitions and after giving a rest of 1 minute the athlete was asked to increase the weight by 20% of the previous weight and was asked to perform 3 repetitions and after giving a rest period of 5 minutes the athlete began his 1RM trial and was asked to increase the load by 30-40% of the previous attempt with a rest of 5 minutes between each trial (English K.L, Loehr J.A, 2008).

## III. VALIDITY AND RELIABILITY

As strength is an important subcomponent to determine the change of direction speed of an athlete, 1RM back squat is considered to be a reliable and valid tool to measure the strength of an individual and it's also known as a "Gold Standard" measurement to assess individuals strength capacity (Ribeiro, A.S, Nasimento, M.A., English, K.L., Bezerra, E.S, 2013).
Straight line sprinting speed is an important subcomponent that determines COD performance and 40mt sprint test is considered as an reliable and valid test for team sport athletes to determine sprinting capability of an athlete (Moir, G.C, Button,M, 2011). Though timing gates were considered as the gold standard to take 40mt sprint time but in absence of timing gates stop watch can also be used to take 40mt sprint time and it is also considered to be valid and reliable (Moir, G.C, Button, M, 2011).
To assess the lower body power, vertical jump test is used by many team sport and strength and conditioning coaches. Vertical jump test using a vertec device is considered as a valid and reliable test to measure the lower limb power of an individual (Rodriguez-Rosell, Mora-Custodio, R, 2016).
Finally, T-test which is used by many individuals to determine the change of direction speed is considered to be a valid and reliable tool to determine the leg power, leg speed and agility of an individual, though T-test is a pre-planned change of direction test and not a reactive agility test but still it is considered as a valid and reliable test for agility (Pauole, Kainoa, Madole, 2000). Moreover, apart from hockey many field sports in the world uses T-Test to measure an athlete change of direction capability and be agile (Ellis and Smith, 2000).

## IV. INTERVENTION

As shown in figure 2, among all the subcomponent (figure 1) that the athlete was tested to determine the change of direction speed, it was found the athlete was lacking in his lower body strength section that was figured out from the 1RM back squat test and studies have found that unilateral eccentric strength while deacceleration and unilateral concentric strength while reaccelerating to a new direction was very important (Bourgeois F, Gill N, Peterson MD, Alvar BA, 2017). Moreover, a high corelation (r=0.89) between strength and change of direction performance was also found (Jones P, Newton RU, Spiteri T, 2009).
The 4-week strength training intervention that the athlete used in this study was a revised version of 8-week strength training protocol that was used Nunez FJ and Santalla A, 2018. Training sessions were conducted twice a week with an adequate recovery of 72 hours (Santalla A, 2018). During the time of training the athlete was asked to exhale at the sticking point and was also asked to slowly perform all the exercise during the eccentric phase (Gill N, 2018). The athlete performed the strength session along with his regular skill practice and conditioning session. Finally, all the strength training sessions was done under guidance and was performed with good techniques.

**Table 3. 4-week strength training protocol (Nunez F, Santalla A).**

| Sl no | Exercise | Week 1 | Week 2 | Week 3 | Week 4 |
|---|---|---|---|---|---|
| 1 | Bulgarian split squat | 3* 6 R | 3*8 R | 3*6 R | 3*4R |
| 2 | Plate walking lunges | 3*5R | 3*6R | 3*8R | 3*6R |
| 3 | Eccentric Nordic hamstrings curls | 3*5R*BW | 3*6R*BW | 3*8R*BW | 3*6R*BW |
| 4 | Single leg RDL | 3*6R | 3*8R | 3*6R | 3*4R |
| 5 | Barbell calf raises | 3*10R | 3*10R | 3*10R | 2*10R |
| R= repetitions, BW=bodyweight. Intra set rest=3 minutes | | | | | |

As the 1RM values of the Bulgarian split squat, walking lunges, single leg RDL and barbell calf raises was not tested the athlete was asked to do the exercises with autoregulation which was also found to be beneficial to improve strength qualities (Larsen, 2021).

## V. RESULTS

After the 4-week of strength training protocol the athletes, T-Test, vertical jump test, 40MT speed test and 1RM back squat was again tested. All the testing procedures were same that it was before the 4-week strength training protocol and the athletes was scored in relation with the normative values (Table 2).

**Table 4. Post-test score of the athlete**

| | |
|---|---|
| T- test | 9.90 seconds |
| Vertical jump | 72 cm |
| 40MT sprint timing | 5.08 seconds |
| 1 RM back squat | 77 kg |

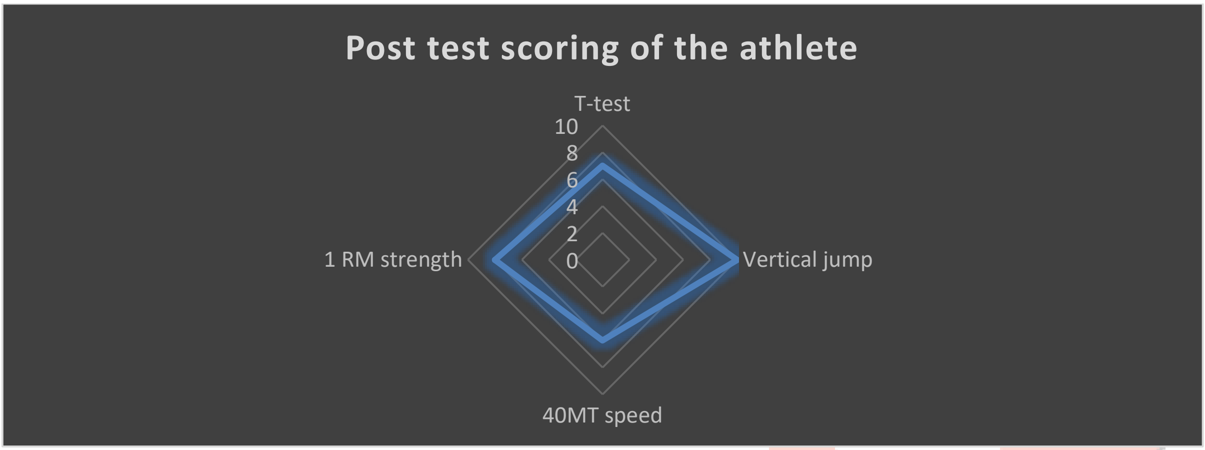


**Figure 5. post-test scoring of the athlete in relation to normative values**

As seen in figure 5. The athlete T-Test scored was improved by 0.12 seconds (table 4). The athletes also improved in his 1RM back squat strength from 72kg to 77kg, vertical jump height from 71cm to 72cm but the athletes 40MT sprint time was increased from 5.02 seconds to 5.08 second (table 4).



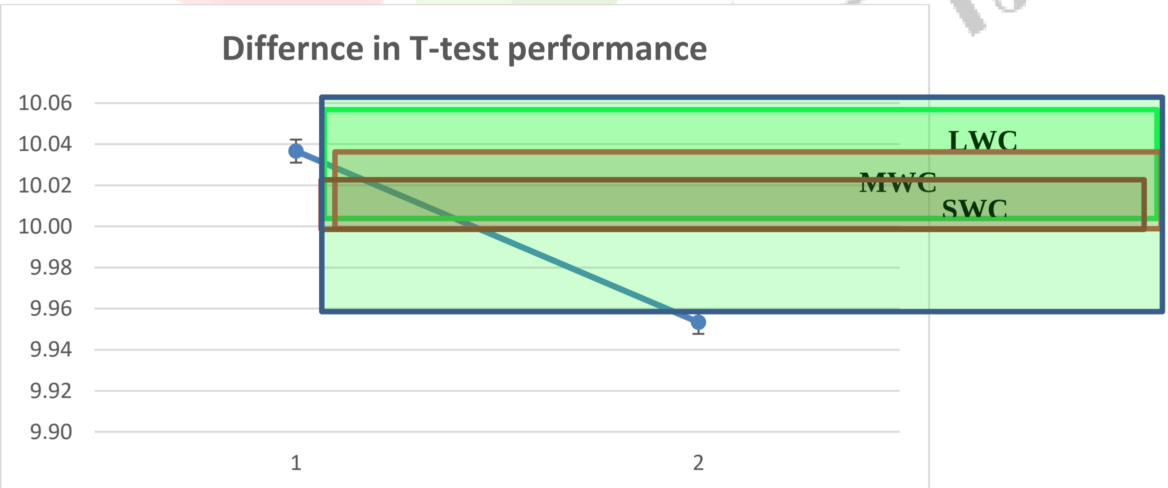


**Figure 6. Pre VS Post T-test change**

The error bars in figure 6, indicates the typical error of measurement from reliability trial. Additionally, the athlete also showed a smallest worthwhile change with a mean improvement of 0.08 seconds in T-Test performance.

Finally, Microsoft Excel 2019 was used to complete all the statistical analysis.

## VI. Discussion

The aim of the present study was to assess the change of direction performance of a junior level national field hockey athlete after testing for strength, power and straight-line sprinting speed. The athlete was found to lack in his lower body strength section (table 1) and a strength training protocol was performed by the athlete for 4-weeks. The athlete showed an improvement of 0.12 seconds after performing the 4-week strength training. The verdicts of the study were that improving the lower body strength can lead to a improvement of change of direction speed which was also found by Nunez FJ and Santalla A, 2018 in his study.

Additionally, the importance of strength in determining change of direction speed during a game of field-hockey as the athlete required to continuously change their direction with velocity in response to an opponent or a ball is well established (Baker D.G, 2008). Several investigations have also reported that to determine the change of direction capability of an athlete during a professional game 1RM strength of an individual athlete plays an important role (Newton, R.U, 2015).

Moreover, to be successful in field sports like hockey an athlete should have a good change of direction capacity in respect to a ball or an opponent, and to enhance those capacities training for speed, power, reactive strength, straight line speed and specific COD training is very important (Burghelli et al., 2008). The findings of the current study stated that a small change in strength capacity can lead to a change in change of direction ability of an athlete. Therefore, coaches working in field hockey should evaluate an athlete strength, power, straight line sprinting speed, reactive strength and technique before implementing any training intervention to develop the change of direction ability as any poor intervention can lead to a decrease in performance of the athlete.

The most important finding of this study was that developing unilateral strength, which the athlete has done in his 4-week training program was an important factor in reducing the timing of the T-Test as previous studies have also stated that developing unilateral strength of the lower limb can develop the change of direction ability of field-sport athlete (Jones p, Bampouras T.M, Marrin k, 2009). Ecentric Nordic hamstring curl was also included in the training program of the athlete as studies have shown that Ecentric Nordic hamstring exercise increases change of direction performance by 2.46% as eccentric muscle strength of the hamstring plays a huge role while deaccelerating and reaccelerating to a new direction (Manzi V, Chaalali A, Wong DP, 2012). Therefore, coaches working with field-sport athlete should aim to develop unilateral strength of the lower limbs and eccentric strength of the hamstring muscles which in result will develop the change of direction performance of the athlete.

In this present study there were certain limitations. Firstly, the athletes anthropometric could not be tested which includes the athlete's percentage of body fat, imbalance of muscle mass between both legs and arms. The imbalance of muscle mass between right and left and a higher percentage of body fat can lead to a decrease in change of direction performance as the athlete requires to lower his Centre of mass to produce appropriate force on the ground and a higher percentage of fat mass will also lead to a decrease in the acceleration speed (Gamble p, 2017). secondly, the athlete's technique could not be tested which includes the foot placement during deacceleration, positioning of the hips, ankles and the shoulder during the reacceleration phase of COD and that can be improved only with specific COD training, as all these factors plays an important role in change of direction during a professional game (Young W, Farrow D, 2006). Thirdly, as COD requires the athlete to produce force on the ground in a short period of time, reactive strength plays a huge role in COD performance (Deweese B,), but due to the unavailability of equipment the reactive strength of the athlete could not be tested.

Additionally, the strength training that the athlete used in this study was a revised 8-week strength training protocol that was used by Nunez FJ and Santalla A, 2018 in his study and showed an improvement of 0.42 ±0.18 seconds in T-Test performance. Moreover, in the study of Nunez FJ and Santalla A, 2018 athlete performed the strength training with twice a week sprint training but in this present study the athlete performed the strength training protocol with regular skill and conditioning session and that can be a reason that the athlete didn't show as much improvement as it was expected.

Future intervention studies can use the full 8-week training protocol that was used by Nunez FJ and Santalla A, 2018 in his study and assess the difference in change of direction speed.

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