Neural Control of Movement

Does the change of direction deficit measure the time of change of direction?

Alexandre R. Alves[1], Fabíola B. Medeiros[2], Mauro H. Chagas[1], Gustavo H. Peixoto[1], Fernando V. Lima[1], Felipe P. Carpes[3], André G.P. Andrade[1]

[1]*Universidade Federal de Minas Gerais, Departamento de Esportes, Belo Horizonte, MG, Brazil;* [2]*Universidade Federal do Vale do São Francisco, Colegiado de Educação Física, Petrolina, PE, Brazil;* [3]*Universidade Federal do Pampa, Grupo de Pesquisa em Neuromecânica Aplicada, Uruguaiana, RS, Brazil.*

Associate Editor: Almir Dibai Filho, Universidade Federal do Maranhão, São Luis, MA, Brazil. E-mail: dibaifilho@gmail.com.

Abstract - Aim: To determine whether the change of direction (COD) deficit can represent the time of the change of direction in professional under 17 years old (U-17) soccer players. **Methods:** Sixteen young soccer athletes performed the adapted 505 agility test with the stationary stance (2 straight lines of 5 m) and the 10 m linear running test (LR). In both tests, the partial and total times were recorded every 2.5 m by time gates (0-2.5 m; 2.5-7.5 m; 7.5-10 m). The best performances were recorded and used to determine the COD deficit (difference between the time for the LR and 505 tests). The paired t-test compared the initial acceleration (0-2.5 m) time, the COD time (2.5-7.5 m), and the COD deficit among the tests. **Results:** Times in the LR test were significantly shorter in the initial acceleration phase (0-2.5 m), and the change of direction deficit was also lower than the change of direction time (2.5-7.5 m) for both sides ($p = 0.005$). **Conclusion:** When an athlete is aware of an upcoming change of direction, a lower initial acceleration results in biases for determining the change of direction deficit. Therefore, acceleration capacity might not be suitable to assess using the 505 agility test.

Keywords: soccer, athletic testing, acceleration.

Introduction

The ability to decelerate, reverse or change movement direction, and reaccelerate in a new direction, widely known as change of direction (COD)[1], is considered fundamental for performance in many sports[2,3]. Considering the speed and agility components involved in COD performance, Nimphius et al.[4] proposed the measure of COD deficit, defined by the difference between the time of a COD test and the time for a linear running test covering the same distance. This difference would represent the time needed to perform the change of direction. This assumption relies on the observation that only the time spent to complete a pre-determined trajectory, including at least one COD, would not adequately represent the COD ability. Nimphius et al.[5] showed that only 31 % of the time in the 505 test represents the time needed to change direction, while the remaining 69 % is spent running. In the past years, the COD deficit was adopted as a measure to express the ability to change direction[5,6]. While aspects related to validity and reliability of the COD test still are discussed in some papers[7,8], there are questions about the use of COD deficit as an indicator of speed performance, mainly because of the differences in the acceleration profiles for linear running tests and running with a change of direction[9,10].

For instance, if an athlete reaches a speed of 6.0 m/s covering the first 2.5 m in a 10 m linear running test, and the same athlete reaches a speed of 5.0 m/s when running the first 2.5 m of a 505 test with a stationary start, despite the same distance being covered, there will be a difference between the two recorded times, even before the athlete starts changing direction. It leads to confusion in applying the results from the COD deficit as performance in the change of direction because the COD deficit might not capture changes in the specific phase of acceleration (between 0-2.5 m). Considering the previous argument, verifying whether athletes adopt different strategies to cover the same linear distance in different tests (linear running test and running test with COD) can improve the understanding of this issue. Furthermore, it seems necessary to verify whether the deficit COD values (i.e., an indirect measure of the ability to change direction) differ from the COD values measured directly.

Therefore, we set out to determine whether the COD deficit represents the time of the change of direction in

professional U-17 soccer players. We hypothesize that a) the initial acceleration (0-2.5 m) is higher for a linear running test compared to a 505 running test, and b) that there is a significant difference between the time of the change of direction (2.5-7.5 m) and the COD deficit.

Methods

Experimental approach to the problem

This cross-sectional study evaluated whether the change of direction deficit represents precisely the time of the change of direction in a 505 test. Soccer athletes performed a 505 test with a stationary start and a 10 m linear running test. The partial times, corresponding to the initial acceleration (0-2.5 m) and final acceleration (7.5-10 m), were recorded and compared between the 505 test and 10-m linear running tests. The change of direction time (2.5-7.5 m) was also compared to the COD deficit.

Participants

The sample size required for a paired Student t-test (error = 0.05, and power = 0.80) was determined using G∗power 3.1 software (Heinrich Heine University, Düsseldorf, Germany) and data from previous studies[7,8] resulting in a sample size of 13 participants. To anticipate any sample loss, 16 participants were included. The 16 participants were male football players (age: 17.2 ± 0.6 years old; body mass: 66.5 ± 7 kg; height: 1.76 ± 0.07 m), playing soccer in a professional club, disputing the first division of the Brazilian Football Championship. All volunteers had completed at least four years of systematic training experience in this sport, had at least four training sessions and one official match per week, and not rehabilitating from any injury. The local Ethics Committee approved this study (CAAE: 57344016.0.0000.5149), and all volunteers and their respective legal guardians agreed with the participation and signed an informed consent to participate.

Procedures and instruments

All participants performed two running tests: the 505 agility test (stationary start)[9,10] and the 10 m linear running test (LR)[5]. The starting position was standardized, with the front foot aligned with the first photocell and the athlete determined the starting time for the tests to minimize the influence of reaction time. The times were measured with two or four photocells (Hidrofit, Belo Horizonte), and the data were processed using MultiSprint software, version 3.5.7 (Minas Gerais, Belo Horizonte). In the 505 tests, the time to run from 0 to 2.5 m (initial acceleration), 2.5-7.5 m (change of direction), and 7.5-10 m (final acceleration) were recorded. Six repetitions were performed alternately for each test, three with the left foot in front and with the change of direction performed with the same foot after the 5 m line, and three with the right foot in front at the starting line and with the change of direction performed with the same foot after the 5 m line. A 5 min rest was administrated between the tests, and the best performance obtained in the three repetitions was used for data analysis. The criteria for invalidating the tests were: 1) the athlete performed the COD before running 5 m; 2) the athlete performed the COD two feet after the 5 m line. In the linear running test (10 m), four photocells recorded the partial times (0-2.5 m; 2.5-7.5 m; 7.5-10 m) and the total time (0-10 m), with the starting position and athlete positioning being the same as for the 505 test. Three repetitions were performed with 5 min rest in between. The best performance was used for data analysis. Figure 1 illustrates the experimental design.

The time in LR was subtracted from the 505 test time to calculate the COD deficit[5].

Data analysis

The statistical analysis of this study was performed using the Statistical Package of the Social Sciences version 22.0 (SPSS Inc., Chicago, Illinois). A descriptive analysis of partial (0-2.5 m; 2.5-7.5 m; 7.5-10 m) and the total time of both tests were performed. The Shapiro-Wilk test verified data normality. The reliability of the measurements was assessed by the intraclass correlation coefficient and the standard error of measurement (SEM)[10]. The time for the initial acceleration of the tests (0-2.5 m), the difference in the COD time (2.5-7.5 m), and the COD deficit were compared using paired *t*-tests. Cohen´s d was used to determine the effect size.

Results

The time in 505 test for both sides and the 505 partial times for the right side showed good reliability (ICC = 0.62 and 0.71, respectively); 505 partial times for the left side showed excellent reliability (ICC = 0.87). The SEM values for all measures indicated a small random error (< 0.05 s), with only a small variation between repeated test measures being expected[9].

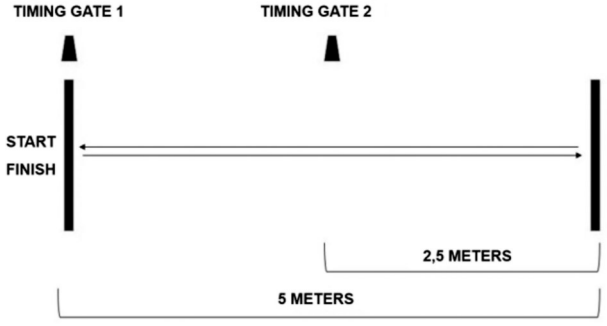

Figure 1 - 505 test adapted to 10 m.

Initial acceleration time in the 505 test was lower than in the linear running tests for right ($p = 0.001$; $d = 1.13$) and left sides ($p = 0.024$; $d = 0.85$). COD time (2.5-7.5 m) was higher than COD deficit for the right ($p = 0.001$; $d = 3.14$; Figure 2-A) and left sides ($p = 0.001$; $d = 2.96$).

The acceleration data from the COD test (2.5-7.5 m) for the right and left sides shows that athletes assumed a strategy to slow down in the 505 test. In the linear running test, the athletes continue to accelerate, while in the 505 test, they decelerate (Figure 2-B).

Discussion

This study determines whether the COD deficit corresponds to the COD time in a 505 agility test (stationary start). To confirm that the COD deficit represents the time needed to perform the COD, no difference in the time referring to the initial acceleration of the tests (0-2.5 m) nor a difference between the start time where the COD occurs within the test trajectory (2.5-7.5 m) and the COD deficit would be expected. The lack of difference would support the use of these two parameters theoretically measuring the same phenomenon. However, we found a significant difference between the measures. The COD deficit does not consider the distance to change of direction. Still, it assumes that any time difference between running a straight line and running with a change of direction would result from the change of direction. Therefore, the COD deficit does not capture possible changes in strategy from other parts of the test, such as the acceleration phase (between 0-2.5 m) or the direction change phase itself.

A time difference between the tests indicates particular acceleration strategies assumed for each test. It seems that when the athlete is aware of an upcoming sudden change of direction (180 °) after running linearly for 5 m, starting acceleration is lower. It is unclear how the athlete makes this decision, but increasing the speed before the change of direction will require greater braking impulses and stability to accelerate in a new direction[11]. Before, during, and after the turn move, the overall speed regulation is the most important factor determining COD performance[12]. In contrast, in a linear running test, the athletes do not have to consider decelerating as they can accelerate as much as possible during the test until the end of the distance.

A change of direction is a multi-step action, where deceleration is necessary to reduce time, especially when the change of direction involves larger angles[11,13]. In this study, the partial time corresponding to 2.5-7.5 m distance in a 505 agility test (stationary start) was assumed as the COD time. With this metric, the athlete had 2.5 m to decelerate and adequately position himself. Subsequently, another 2.5 m are available to accelerate towards the new direction. Theoretically, this time might represent the time the COD deficit should measure. Therefore this significant difference indicates that the COD deficit might not represent an accurate measure if the initial speed of the COD and linear tests are not similar. In this sense, the COD deficit cannot precisely obtain the essential strategies

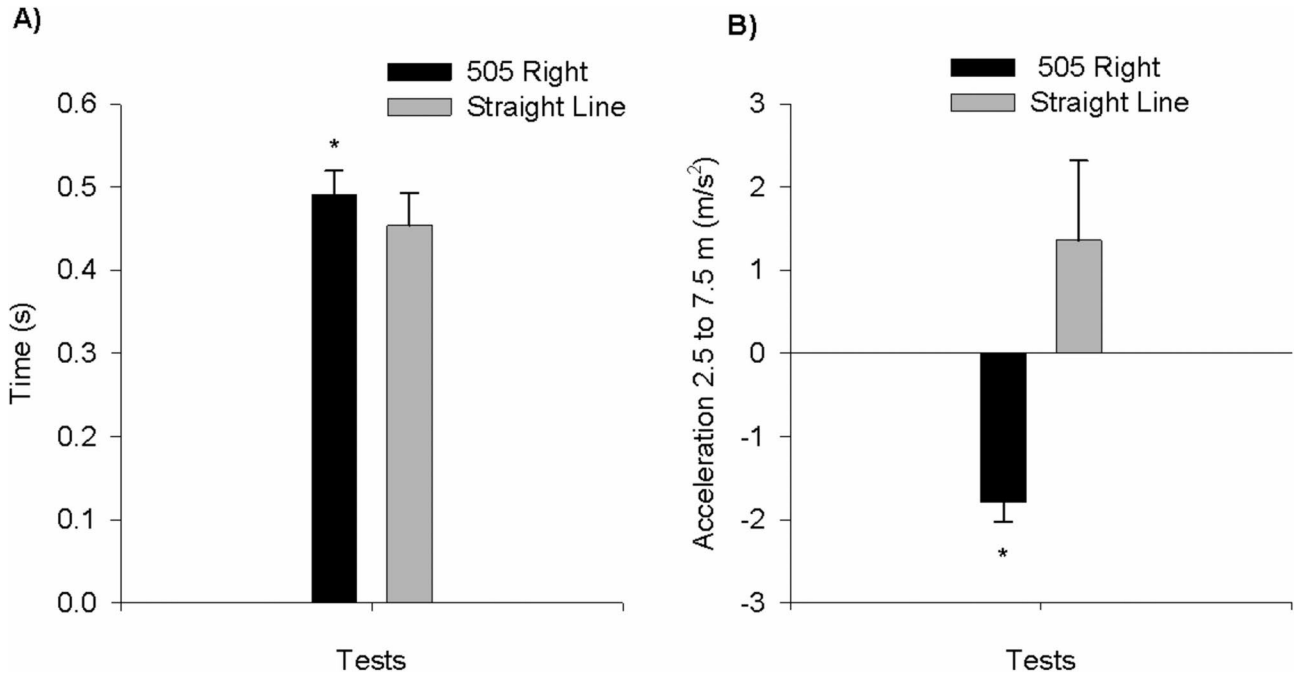

Figure 2 - A) Time (s) obtained by the COD time in the 505 right test (0-2.5 m) and the linear running test. * p-value < 0.05; B) Acceleration between 2.5 and 7.5 m in the 505 right test and linear running test. * p-value < 0.05.

adopted by athletes, such as decelerations (Figure 2-B). Therefore, despite the COD deficit providing an important advance in the literature, caution is necessary to interpret COD deficit results from developing athletes or physically active individuals.

We recommend recording partial times during COD and linear running tests to compare the performance since COD information obtained by the COD deficit can be insufficient to guide coaches and physical trainers in identifying COD deficiencies. The use of COD deficit outcomes to guide training prescriptions requires caution, as it might not be a precise measure if the starting acceleration is different between the two tests. Among the limitations of our study is that it is still unclear if individual capacities, such as training level, affect this difference regarding COD deficit assessment. Further study is needed to verify if training level could differentiate the acceleration strategies adopted at the beginning of the two tests.

Conclusions

Comparing the adapted 505 agility test and the 10 m linear running test, we conclude that when an athlete is aware of an upcoming change of direction, a lower initial acceleration results in biases for the change of direction deficit determination.

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References

1. Jones P, Bampouras TM, Marrin K. An investigation into the physical determinants of change of direction speed. J Sports Med Phys Fitness. 2009;49(1):97-104. PMID
2. Spiteri T, Nimphius S, Hart NH, Specos C, Sheppard JM, Newton RU. Contribution of strength characteristics to change of direction and agility performance in female basketball athletes. J Strength Cond Res. 2014;28(9):2415-23. doi
3. Zahidi NNM, Ismail SI. Notational analysis of evasive agility skills executed by attacking ball carriers among elite rugby players of the 2015 Rugby World Cup. Movement Health & Exercise. 2018;7(1):99-113. doi
4. Nimphius S, Geib G, Spiteri T, Carlisle D. "Change of direction deficit" measurement in Division I American football players. J Australian Strength Cond. 2018;21(S2):115-7.
5. Nimphius S, Callaghan SJ, Sptieri T, Lockie RG. Change of direction deficit: a more isolated measure of change of direction performance than a total of 505 times. J Strength Cond Res. 2016;30(11):3024-32. doi
6. Loturco I, Jeffreys I, Abad CCC, Kobal R, Zanetti V, Pereira LA, et al. Change-of-direction, speed and jump performance in soccer players: a comparison across different age-categories. J Sports Sci. 2020;38(11-12):1279-85. doi
7. Taylor JM, Cunningham L, Hood P, Thorne B, Irvin G, Weston M. The reliability of a modified 505 test and change-of-direction deficit time in elite youth football players. Sci Med Football. 2019;3(2):157-62. doi
8. Dugdale H, Sanders D, Hunter AM. Reliability of change of direction and agility assessments in youth soccer players. Sports. 2020;8(4):51-62. doi
9. Castilho-Rodriguez A, Fernandez-Garcia JC, Chinchilla-Minguet JL, Carnero EA. Relationship between muscular strength and sprints with changes of direction. J Strength Cond Res. 2012;26(3):725-32. doi
10. Gabbett TJ, Kelly JN, Sheppard JM. Speed, change of direction speed, and reactive agility of rugby league players. J Strength Cond Res. 2008;22(1):174-81. doi
11. Weir JP. Quantifying test-retest reliability using the intraclass correlation coefficient and SEM. J Strength Cond Res. 2005;19(1):231-40. doi
12. Dos'Santos T, Thomas C, Comfort P, Jones P. The effect of angle and velocity on change of direction biomechanics: an angle-velocity trade-off. Sports Med. 2018;48(10):2235-53. doi
13. Hader K, Palazzi D, Buchheit M. Change of direction speed in soccer: how much braking is enough? Kinesiology. 2015;47(1):67-74.
14. Dos'Santos T, Thomas C, Comfort P, Jones P. The role of the penultimate foot contact during change of direction: implications on performance and risk of injury. Strength Cond J. 2019;41(1):87-104. doi

Corresponding author

André G.P. de Andrade. Universidade Federal de Minas Gerais, Departamento de Esportes, Belo Horizonte, MG, Brazil.
E-mail: andreguto@yahoo.com.br.

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