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# Association between inhibitory control and tactical performance of under-15 soccer players

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**Abstract**

This study aimed to investigate the association between inhibitory control and tactical performance of under-15 soccer players. Data from 166 under-15 soccer players were analyzed. The tactical performance and the inhibitory control were assessed by the System of Tactical Assessment in Soccer (FUT-SAT) and by Conners Continuous Performance Test 2nd version (CPT-II), respectively. The scores of the tactical performance achieved by players in FUT-SAT were separated into three levels: low, intermediate and high. Values of Number of Commission Errors, Number of Omission Errors and Hit Reaction Time of CPT-II achieved by the players from low and high groups in tactical performance were compared by the non-parametric Mann-Whitney test. Results revealed that players with high scores in tactical performance presented lower values of Hit Reaction Time ($Z$ = - 2.569; $p$ = 0.010; $r$ = -0.35). These results suggest that players with better tactical performance presented a better ability to respond faster in an inhibitory control task.

**Keywords:** inhibitory control, tactical performance, soccer players

## Introduction

Inhibitory control is an important component of executive function related to successful performance of tasks in several domains (For more details, see Diamond, 2013). Inhibitory control involves the ability to control attention, behaviour, thoughts, and/or emotions to override a strong predisposition to performing an inappropriate action or behaviour, so that instead, one can perform a most appropriate or necessary action or behaviour within a context (Diamond, 2013). In addition, inhibitory control is linked to individual differences and developmental changes and, together with working memory and cognitive flexibility, is considered a core feature of executive functioning (Diamond, 2013). Intact inhibitory control enables individuals to think before acting, organize better, plan and solve problems (Barkley, 1997). The multiple brain circuits connected with regions of the prefrontal cortex and thalamic and subcortical structures are responsible for different types of inhibition (Aron et al., 2007).

In sports, inhibitory control has been revealed to distinguish the level of performance of athletes. A study conducted by Wang *et al*. (2013) presented differences in inhibitory control between athletes from open (e.g. tennis) and closed (e.g. swimming) skill sports. It was observed better responses in tennis players than in swimmers. According to the authors, such differences seem to be a consequence of the training characteristics of both sports. In general, open skill sports involve high cognitive demands and are likely to develop superior inhibitory control compared to closed skills sports in which the training is more cyclic and predictable (Wang et al., 2013). In another study, Lage *et al*. (2011) analyzed the relationship between impulsivity, which according to Logan, Schachar and Tannock (1997) is related to inhibitory control, and technical performance in female handball athletes. The authors found that the motor impulsivity of these athletes was negatively correlated with rebounds from the defensive ball possession.

In soccer, players are faced with variable and unpredictable situations resulting from the complex relationship of cooperation and opposition (Gréhaigne & Godbout, 1995). To address the complexity of the game, they must present well developed tactical knowledge, which has been referred to in the literature as declarative ("know what to do") and procedural ("know how to do") knowledge (Gréhaigne & Godbout, 1995; McPherson, 1994). Players with better tactical knowledge achieved a higher level of performance in soccer (Kannekens, Elferink-Gemser, & Visscher, 2009). Tactical knowledge about the game enables players to efficiently perform the right actions at the right moment and engage in appropriate tactical behavior (Gréhaigne & God-

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bout, 1995). Due to the constant changes in the game environment, players must be able to quickly identify and select relevant stimuli and make fast and appropriate decisions (Roca, Ford, McRobert, & Mark Williams, 2011; Ward & Williams, 2003). They are also forced to inhibit pre-planned responses, anticipate actions and coordinate corporal segments based on the complex and dynamic flow of sensorial information (Lage et al., 2011).

A study carried out by Vestberg *et al.*, (2012) revealed that inhibitory control and other executive functions could distinguish the level of performance of soccer players. They observed that players from the Premier Swedish league presented better inhibitory responses than those from the "lowest division". In the more recent study, Verburgh *et al.*, (2014) showed that highly talented young soccer players showed superior ability to inhibit an ongoing motor response than amateur young soccer players. These findings revealed a possible role played by the inhibitory control in the performance soccer of players.

Despite the importance of findings presented in previous studies about the important role played by the inhibitory control in the success of soccer players, it has not been reported which features (physical, technical or tactical) of performance in soccer are affected by players' response inhibition. It is believed that inhibitory control can be associated with tactical performance of players in soccer because in game situations they must suppress some planned motor responses and some distracting and competing stimuli before choosing and performing their tactical decisions (Lage et al., 2011; Roca et al., 2011). Thus, in the present study, we evaluated the tactical performance of selected sub-15 soccer players. Besides, we separated these athletes at different levels of tactical performance to verify the association between tactical performance and inhibitory control. Therefore, the current study aimed to investigate the association between inhibitory control and tactical performance of under-15 soccer players.

## Methods

### Participants

A sample of 166 under-15 soccer players (mean age = 14.80 + 0.59) from eight Brazilian soccer teams performed 10,498 tactical actions (5,038 offensives and 5,460 defensives). All players were participating in regular soccer training sessions at least three times a week. Moreover, they were participating in regional and/or national level championships in their age category.

Before data collection, directors of the teams signed documents authorizing the research. Additionally, participants and their parents signed a legal consent allowing the data collection and their use for research purposes. This study was authorized by the Ethics Committee in Research of the Federal University of Viçosa (Of. 132/2012/CEPH/01-12-11). It conforms to the requirements of the Brazilian National Health Council (CNS 466/2012) and the Declaration of Helsinki (1996) for research involving humans.

### Measures

The System of Tactical Assessment in Soccer (FUT-SAT) (Costa, Garganta, Greco, Mesquita, & Maia, 2011) was used to evaluate the tactical behavior and performance of the participants. This system evaluates the tactical actions performed by players according to the ten core tactical principles of the game. The field test of this system used in this study was Goalkeeper + 3 *vs.* Goalkeeper + 3 and they played it in a space of 36 meters long and by 27 meters wide for four minutes. The participants performed according to the official rules of soccer, except for the offside rule. All the tactical actions performed by the participants were analyzed and recorded. Tactical performance index provided by the output of FUT-SAT is based on a number, quality, place and resultsof tactical actions (For more details, please see Costa et al., 2011).

The Conners Continuous Performance Test 2nd version (CPT-II) (Conners & Staff, 2000) was used to measure the inhibitory control of the participants. The test was performed via computer. During the test, letters appear randomly and alternately in the center of a computer screen. Participants must press the space bar on the computer keyboard every time a stimulus (any letter except X) appears on the screen. When distractor stimuli (letter X) appear, the participant should inhibit the press response. The time duration of the test was 14 minutes. As in previous studies (Lage et al., 2011; Malloy-Diniz, Fuentes, Leite, Correa, & Bechara, 2007; Malloy-Diniz et al., 2011), the three main scores measured by the CPT-II test were used. The *Number of Omission Errors* indicates the number of times that stimuli (non-X letters) appeared on the screen and participants did not respond to it. The *Number of Commission Errors* indicates the number of times participants responded when the letter X appeared on the screen. The *Hit Reaction Time* indicates the time participants take to respond to a stimulus once it appears on the screen.

### Procedures

The first test performed by participants was the FUT-SAT. This test was performed according to the test protocol (Costa et al., 2011). At another time, participants completed the neuropsychological test CPT-II individually in a quiet room. For this test, they were invited to sit in a comfortable chair in front of a computer. Instructions about the test were read by the instructor, and the participants performed one-minute training period of the task. The test started after participants confirmed their understanding of the task.

Data from the field test of FUT-SAT were recorded with a digital camera (SONY HDR-XR100). The digital videos were then transferred to a laptop (COMPAQ 510 processor Intel Core 2 Duo) via a cable and converted into .avi files. The software Soccer Analyser® was used for data

processing. This software inserts spatial references onto the video and allows identifying positions and movements of the players on the field. Data collection of the CPT-II was carried out using two laptops (COMPAQ 510 processor Intel Core 2 Duo and HP Pavilion dv4 1430us). These data were filed in a computer where they were analyzed.

*Data Analysis*

All the tactical actions performed by the participants in the field test of FUT-SAT were analyzed to measure the tactical performance. The tactical performance index provided by the output of FUT-SAT was used to quantify the game tactical performance. As in others previous studies (Gonzaga, Albuquerque, Malloy-Diniz, Greco, & Teoldo da Costa, 2014; Lage, Malloy-Diniz, Neves, de Moraes, & Corrêa, 2012; Lopes, Magalhães, Diniz, Moreira, & Albuquerque, 2016), the scores achieved by players in tactical performance were separated into low, intermediate and high groups. Values of the low and high group on tactical performance were compared and they showed to be different ($Z$ = -8.875; $p$ < 0.001; $r$ = -0.86) with large effect size. Values of intermediate groups were not analyzed.

### Statistical Analysis

Descriptive statistics were calculated to verify median, interquartile range (IQR) and tertile of Tactical Performance. Normality of data distribution was verified by the Kolmogorov-Smirnov test. The non-parametric Mann-Whitney test was used to compare the values of the high and low groups of tactical performance. To compare the scores achieved by each high and low groups on the Number of Omission Errors, Number of Commission Errors and Hit Reaction Time of CPT-II only the non-parametric Mann-Whitney test was used. The effect size analysis of the Mann-Whitney test was calculated with the following equation (Field, 2009):

$$r = \frac{Z}{\sqrt{N}}$$

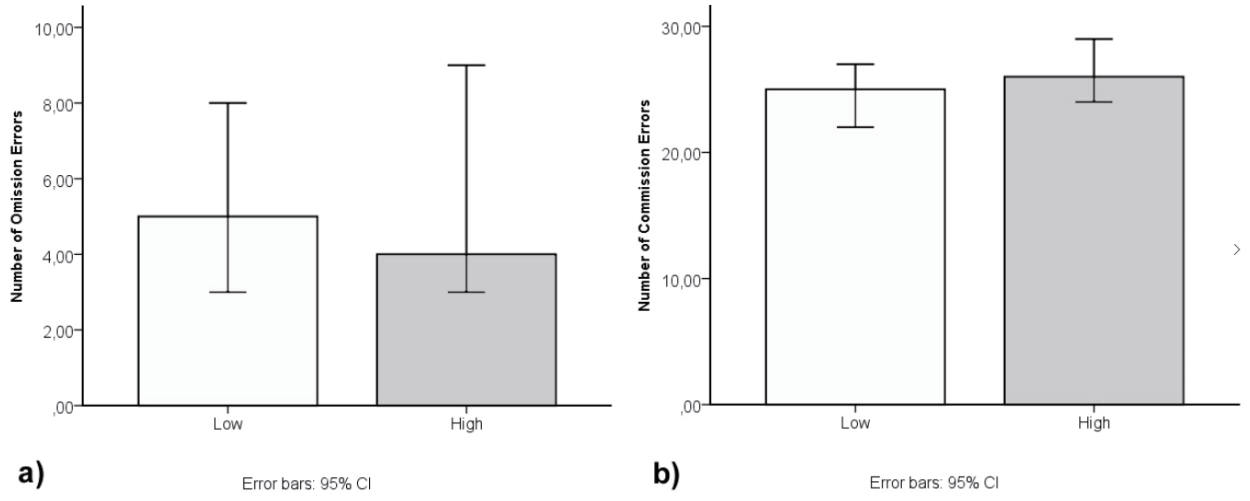
Where r is the effect size, Z is the z-score, and N is the overall number of cases.

The test-retest method was used to verify the coefficient of reliability for the analysis of FUT-SAT. A minimum of three weeks was used for both analyses. Ten trained observers analyzed 1583 tactical actions (15.08% of the total), a value higher than recommended by the literature (Tabachnick & Fidell, 2007). Values of intra-observer reliability varied from 0.79 to 1.00 and values of inter-observer reliability varied from 0.71 to 0.85. The Kappa statistic was used to verify the coefficient of reliability in the test-retest analysis. The Statistical Package for Social Sciences (SPSS) 18.0 was used for statistical analysis. The level of significance used was $p$ < 0.05.

## Results

Figure 01 shows the results of the Number of Omission Errors and Number of Commission Errors obtained by players from low and high tactical performance groups. The non-parametric Mann-Whitney test did not indicated differences between players of high and low groups in Number of Omission Errors ($Z$ = - .044; $p$ = .965) and Number of Commissions Errors ($Z$ = -1.484; $p$ = .138).

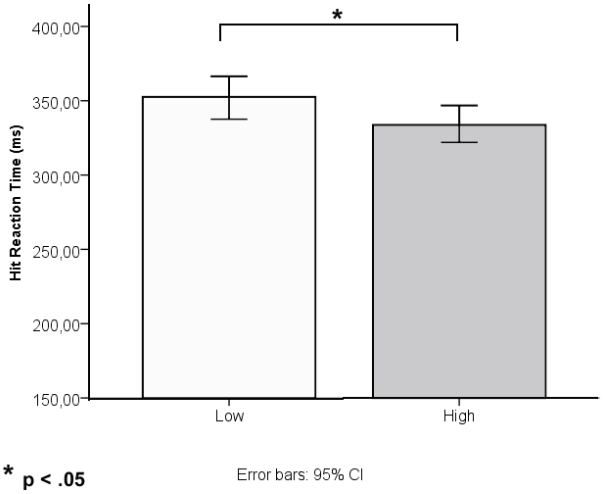
***Figure 1.*** Number of Omission Errors (a) and Number of Commission Errors (b) of the players from low and high groups in tactical performance




The non-parametric Mann-Whitney test revealed statistical differences with medium effect size between players of high and low groups in the Hit Reaction Time ($Z$ = -2.569; $p$ = 0.010; $r$ = -0.35). The low tactical performan-

ce group (Median = 352.60; IQR = 47.10) showed higher values than; high tactical performance group (Median = 333.70; IQR = 49.20). See Figure 02.

***Figure 2.*** Hit Reaction Time of the players from low and high groups in tactical performance




## Discussion

Previous researchers (Gonzaga et al., 2014; Verburgh et al., 2014; Vestberg et al., 2012) demonstrated that well-developed cognitive skills in soccer might be translated to the nonspecific (outside of the context of the soccer game) cognitive tasks to the fact that successful players showed better performance in nonspecific cognitive tasks than less successful players. Moreover, the ability to inhibit inappropriate tactical decisions and motor responses has been considered important for players' success in team sports (Lage et al., 2011; Wang et al., 2013). Thus, in the present study, we focused to investigate the association between inhibitory control and tactical performance in under-15 soccer players.. We did not find associations between commission and omission errors measures with tactical performance in under-15 soccer players. However, our main result revealed that players with higher scores of tactical performance had a shorter Hit Reaction Time than those with lower scores on the tactical performance. These results suggest that a better ability to respond faster to stimuli (shorter Hit Reaction Time) can be associated with better tactical performance when game situations were simulated.

A number of Commission Errors occurs when unexpected responses are made (Conners & Staff, 2000). These errors are related to the failure of the subject to suppress a prepotent response and have been established to measure the inhibitory control component of the executive function related to the impulsive behaviour (Bodnar, Prahme, Cutting, Denckla, & Mahone, 2007; Diamond, 2013). It was expected that the players with higher scores of tactical performance would also have better inhibitory control than those with lower scores. However, our results did not reveal any statistically significant differences in the number of Commission Errors. These results may have been influenced by the organization of teams in game situations, which can vary according to their goals as well as to the dynamics and scores of the game (Gréhaigne & Godbout, 1995; Greihaine, Godbout, & Zerai, 2011).

The number of Omission Errors refers to the number of times the individual did not respond to the stimulus when it appeared during the test (Conners & Staff, 2000). These measures assess the attentional component of the impulsive behavior in the CPT-II (Malloy-Diniz et al., 2007). Inhibitory control of attention enables individuals to focusing on select relevant information and to suppressing attention to other stimuli (Diamond, 2013). In the present study, no differences were found in the Number of Omission Errors achieved by players with higher and lower scores. In addition, the results of the attentional abilities are in accordance with previous studies that have demonstrated no differences between players in some nonspecific cognitive tasks based on their level of performance (Furley & Memmert, 2010; Helsen & Starkes, 1999; Memmert, Simons, & Grimme, 2009). For example, in Memmert *et al.* (2009) study, differences in attention in nonspecific tasks did not appear to predict the level of expertise of athletes, and expert advantages in team sports might be limited to their domain of expertise. In other words, it seems that the specificity of the task may be a factor that reduces or eliminates the sensitivity of the tasks in finding differences between different levels of performance.

Our main results revealed that players with higher scores of tactical performance had a shorter Hit Reaction Time than those players with lower scores on the tactical performance. The fast reaction time may help players to make decisions efficiently and hence present great tactical performance. The ability to respond quickly to a stimulus and present great performance in open skill sports has been associated with some perceptual-cognitive skills that enable players to catch up, identify, and select relevant information from game environment, make fast and appropriate tactical decisions and execute efficient motor responses (Helsen & Starkes, 1999; Mann, Williams, Ward, & Janelle, 2007). In CPT-II, Hit Reaction Time is a measure of cognitive efficiency (Riccio, Reynolds, Lowe, & Moore, 2002) that is related to impulsivity and inattentive behaviour, in which fast reaction time may be associated with impulsivity, and slow reaction time indicate inattentiveness (Conners & Staff, 2000; Riccio et al., 2002). Thus, it is possible that our results may represent functional impulsivity (Dickman, 1990) of the athletes with better tactical performance. Dickman (1990) suggests that functional impulsivity is the tendency to rapid responses and acts with little forethought when it is beneficial, for example, when rapid responses are advantageous. In addition, functional impulsivity is related to acting rapidly and with relatively little forethought in a context where time is very restricted to one's decision

or motor response (Dickman & Meyer, 1988; Lage et al., 2012). Therefore, in open skills sports, like soccer, in which the time available for decision-making and for performing a technical action is restricted, the athlete need to answer not only correctly, but also quickly (Gomes et al., 2017) . So, our results showed that athletes with better tactical performance respond faster than athletes with worse tactical performances, but this did not reflect a worse performance. Thus, our results indicate that soccer athletes of the sub-15 category with better tactical performance present behaviour that is associated with functional impulsivity.

Some studies have shown that athletes react faster and make fewer errors than non-athletes in inhibitory control tasks (For example, Chan, Wong, Liu, Yu, & Yan, 2011; Kida, Oda, & Matsumura, 2005; Wang et al., 2013). These results suggest that the inhibitory control may be related to amount (systematic training) and type of practice (open versus close skills sports). Therefore, it is important to emphasize that extended periods of practices in sports contexts can contribute to the improvement of the executive functions (Diamond & Lee, 2011; Diamond & Ling, 2016), in particular, inhibitory control. Then, regular practice in which competitiveness and selections processes are high and an environment that requires inhibiting pre-planned responses, anticipate actions and coordinate corporal segments based on the complex and dynamic flow of sensory information (Lage et al., 2011), as in Brazilian soccer clubs, can contribute to the improvement of the inhibitory control ability of this young soccer players.

Despite being broadly used to assess the inhibitory control of patients and healthy individuals, the test used in this study had not been applied in sports. Thus, the results of this study can contribute to a new perspective on assessing the abilities of soccer players. Such results suggest that it is important for trainers and coaches to know the performance of the inhibitory control of the players, which can help them to recognize their limitations and potential and create strategies to better develop the players' tactical performance and to encourage their development more efficiently.

Moreover, it is important to consider that the sample in this study consisted of under-15 players. Although the ability to inhibit prepotent responses is thought to be well developed in early adolescence, there is evidence of development continuing even in adulthood (Williams, Ponesse, Schachar, Logan, & Tannock, 1999). According to Durston et al. (2002) the frontostriatal circuit related to inhibitory control reaches its maturity in early adulthood. Thus, this executive function can be improved during the developmental years. In addition, Additional studies with players of different age categories and levels of competitiveness are recommended to expand these findings to others groups.

This study presents some limitations, being that the most important being the fact that we did not control for the presence of psychiatric disorders level of schooling and amount of practices in our sample. Therefore, we are aware that control of the presence of psychiatric disorders, level of schooling and amount of practices is recommended in future studies.

In the end, the present study revealed that players with higher scores of tactical performance scores had faster Hit Reaction Times. Based on these results, it is possible to conclude that better tactical performance in the under-15 soccer players is associated with an inhibitory control task, especially behaviour of functional impulsivity, considering that athletes with better tactical performance respond faster than athletes with worse tactical performances, but this did not reflect a worse performance.

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**Asociación entre el control inhibitorio y el rendimiento táctico de los jugadores de fútbol sub-15**

**Resumen**

Este estudio tiene como objetivo investigar la influencia la asociación entre el control inhibitorio y el rendimiento táctico de jugadores de fútbol menores de 15 años; por tanto se analizaron los datos de 166 jugadores. .. Para evaluar el desempeño táctico y el control inhibitorio se utilizó el Sistema de evaluación táctica en futbol (FUT-SAT) y el *Conners Continuous Performance Test* (CPT-II), respectivamente. El desempeño de los jugadores en FUT-SAT eran dividieron en tres niveles: bajo, intermedio y alto. Valores del número de errores de la comisión, número de errores de la omisión y tiempo de reacción de los jugadores de los grupos con bajos y altos desempeño táctico fue comparado por la prueba no-paramétrica de Mann-Whitney. Los resultados revelaron que los jugadores com altos niveles de desempeño táctico presentaron valores más bajos de Tiempo de Reacción ($Z = - 2.569$; $p = 0.010$; $r = -0.35$). Estos resultados sugieren que los jugadores con un mejor rendimiento táctico presentan una mejor capacidad para responder más rápido en una tarea de control inhibitorio.

**Palabras clave**: control inhibitorio, desempeño táctico, jugadores de fútbol

**Associação entre controle inibitório e desempenho tático de jogadores de futebol com menos de 15 anos**

**Resumo**

Este estudo teve como objetivo investigar a associação entre o controle inibitório e o desempenho táctico de jogadores de futebol com menos de 15 anos. Dados de 166 jogadores de futebol com menos de 15 anos foram analisados. O desempenho tático e o controle inibitório foram avaliados pelo Sistema de Avaliação Tática no Futebol (FUT-SAT) e pelo Teste de Desempenho Contínuo 2ª versão (CPT-II), respectivamente. Os escores do desempenho tático obtidos pelos jogadores no FUT-SAT foram separados em três níveis: baixo, intermediário e alto. Os valores do Número de Erros de Comissão, Número de Erros de Omissão e Tempo de Reação de Acerto do CPT-II alcançados pelos jogadores dos grupos baixo e alto no desempenho tático foram comparados pelo teste não-paramétrico de Mann-Whitney. Os resultados revelaram que os jogadores com altas pontuações no desempenho tático apresentaram menores valores de Tempo de Reação da Batida (Z = - 2,569; p = 0,010; r = -0,35). Estes resultados sugerem que os jogadores com melhor desempenho tático apresentaram uma melhor capacidade de responder mais rapidamente em uma tarefa de controle inibitório.

**Palavras-Chaves:** Controle Inibitório, Desempenho Tático, Jogadores de Futebol.

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