

GUILHERME FIGUEIREDO MACHADO

**DEVELOPMENT, VALIDATION AND APPLICATION OF A DECLARATIVE  
TACTICAL KNOWLEDGE TEST IN SOCCER**

Dissertação apresentada à  
Universidade Federal de Viçosa,  
como parte das exigências do  
Programa de Pós-Graduação em  
Educação Física, para obtenção do  
título de *Magister Scientiae*.

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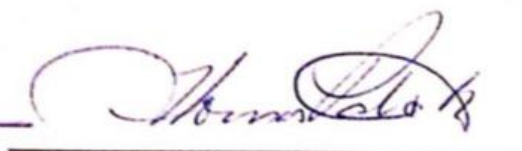
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APROVADA: 20 de julho de 2018.

  
Paulo Roberto dos Santos Amorim

  
Thomas Patrick

  
Thales Nicolau Primola Gomes  
(Presidente)

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“Whether you believe you can do a thing or not, you are right.”

(Henry Ford)

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## SUMMARY

LIST OF TABLES .....	ix
LIST OF FIGURES .....	x
ABSTRACT.....	xi
RESUMO .....	xii
DISSERTATION STRUCTURE.....	xiii
GENERAL INTRODUCTION .....	1
OBJECTIVES .....	5
STUDY 1 - Tactical knowledge in soccer: A systematic review.....	6
STUDY 2 - TacticUP video test: Development and validation of a declarative tactical knowledge test in soccer .....	53
STUDY 3 - Macro- and microstructure of soccer activities as a discriminant of different levels of tactical knowledge in soccer players .....	70
GENERAL DISCUSSION AND CONCLUSIONS .....	91
REFERENCES.....	94
APPENDIX 1 .....	107

## LIST OF TABLES

### STUDY 1

<b>Table 1.</b> Studies with the main topic age.....	14
<b>Table 2.</b> Studies with the main topic age (descriptive studies) .....	17
<b>Table 3.</b> Studies with the main topic expertise.....	20
<b>Table 4.</b> Studies with the main topic technical skills .....	22
<b>Table 5.</b> Studies with the main topic intervention.....	24
<b>Table 6.</b> Studies with the main topic playing position .....	26
<b>Table 7.</b> Studies with the main topic physical attributes .....	28
<b>Table 8.</b> Studies with the main topic of associations between declarative and procedural tactical knowledge.....	29
<b>Table 9.</b> Studies with other topics .....	30

### STUDY 2

<b>Table 1.</b> Players' acceptability values for the TacticUP video test .....	64
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## LIST OF FIGURES

### STUDY 1

<b>Figure 1.</b> Flow chart of the methodology used for the article search based on the preferred reporting items for systematic review (PRISMA).....	11
<b>Figure 2.</b> Flow chart of methodologies used for assessment of tactical knowledge. 12	
<b>Figure 3.</b> Flow chart of assessment of tactical knowledge based on tactical principles .....	12

### STUDY 2

<b>Figure 1.</b> Order of scenes presentation.....	59
<b>Figure 2.</b> Comparison of test score between groups with low accumulated training hours and high accumulated training hours in a) Offensive Declarative Tactical Knowledge; b) Defensive Declarative Tactical Knowledge; and c) General indexes of Declarative Tactical Knowledge. * $p < .05$ , ** $p < .01$ , *** $p < .001$ .....	63

### STUDY 3

<b>Figure 1.</b> Comparisons between the high and low knowledge groups, based on the offensive declarative tactical knowledge for: a) accumulated hours of different types of soccer activities; b) accumulated hours of different types of soccer activities in the microstructure of training; c) accumulated hours of different types of soccer activities based on decision making opportunities; and d) test score for the capacity of making decisions in soccer. * $p < .05$ , ** $p < .01$ , *** $p < .001$ .....	82
<b>Figure 2.</b> Comparisons between the high and low knowledge groups, based on the defensive declarative tactical knowledge for: a) accumulated hours of different types of soccer activities; b) accumulated hours of different types of soccer activities in the microstructure of training; c) accumulated hours of different types of soccer activities based on decision making opportunities; and d) test score for the capacity of making decisions in soccer. * $p < .05$ , ** $p < .01$ , *** $p < .001$ .....	83

## ABSTRACT

MACHADO, Guilherme Figueiredo, M.Sc., Universidade Federal de Viçosa, July, 2018. **Development, validation and application of a declarative tactical knowledge test in soccer.** Adviser: Israel Teoldo da Costa.

The aim of this dissertation was to expand and advance the process of tactical knowledge assessment of soccer players through the development, validation and application of a declarative tactical knowledge test. The document comprises three studies. The first study was a systematic review with the purpose to systematically review the state of the art of the literature about tactical knowledge in soccer and to know the potentialities and limitations of tactical knowledge assessment in soccer. This study identified the most researched topics about tactical knowledge and discussed the results regarding the methodologies and tactical principles used for tactical knowledge assessment. It was concluded that complementary instruments in declarative tactical knowledge assessment must be developed in line with available procedural tactical knowledge instruments and we provide future directions for the study of tactical knowledge. The second study aimed to expand the process of tactical knowledge assessment of soccer players, through the development and validation of a declarative tactical knowledge test based on core tactical principles. It was developed a new test (TacticUP video test) that demonstrated adequate content, construct and face validity and was also an reliable measure of declarative tactical knowledge. The third study analyzed the amount of hours accumulated in distinct soccer activities by soccer players with different levels of declarative tactical knowledge. It demonstrated that the main activities that differentiated high and low declarative tactical knowledge groups were: i) team practice; ii) collective tactics activities; and iii) “high decision making opportunities” activities. Therefore, this project has expanded and advanced the process of tactical knowledge assessment in soccer through: i) the organization of the current available literature about this topic; ii) the development of a valid and reliable declarative tactical knowledge test in soccer (TacticUP video test); and iii) the application of this test to analyze which types of soccer activities may favor the development of declarative tactical knowledge in soccer. We also provided practical applications and future directions for research in tactical knowledge in soccer in each study.

## RESUMO

MACHADO, Guilherme Figueiredo, M.Sc., Universidade Federal de Viçosa, julho de 2018. **Desenvolvimento, validação e aplicação de um teste de conhecimento tático declarativo no futebol.** Orientador: Israel Teoldo da Costa

O objetivo desta dissertação foi ampliar e avançar no processo de avaliação do conhecimento tático de jogadores de futebol através do desenvolvimento, validação e aplicação de um teste de conhecimento tático declarativo. O documento é composto por três estudos. O primeiro estudo foi uma revisão sistemática com o objetivo de revisar sistematicamente o estado da arte da literatura sobre conhecimento tático no futebol e conhecer as potencialidades e limitações da avaliação do conhecimento tático no futebol. Este estudo identificou os tópicos mais pesquisados sobre conhecimento tático e discutiu os resultados referentes às metodologias e princípios táticos utilizados para avaliação. Concluiu-se que é necessário o desenvolvimento de instrumentos complementares na avaliação do conhecimento tático declarativo em consonância com os instrumentos de conhecimento tático processual disponíveis, e foram fornecidas direções para estudos futuros. O segundo estudo objetivou ampliar o processo de avaliação do conhecimento tático de jogadores de futebol, através do desenvolvimento e validação de um teste de conhecimento tático declarativo baseado nos princípios táticos fundamentais. Foi desenvolvido um novo teste (TacticUP vídeo teste) que apresentou adequada validade de conteúdo, constructo e facial, além de ser uma medida confiável do conhecimento tático declarativo. O terceiro estudo analisou a quantidade de horas acumuladas em diferentes atividades de futebol por jogadores de futebol com diferentes níveis de conhecimento tático declarativo. Demonstrou-se que as principais atividades que diferenciaram os grupos de alto e baixo conhecimento tático declarativo foram: i) treino na equipe; ii) atividades de tática coletiva; e iii) atividades de “alta tomada de decisão”. Portanto, este projeto expandiu e avançou o processo de avaliação do conhecimento tático no futebol por meio da: i) organização da literatura disponível sobre o tema; ii) o desenvolvimento de um teste de conhecimento tático declarativo no futebol válido e confiável (TacticUP vídeo teste); e iii) a aplicação deste teste para analisar quais tipos de atividades de futebol podem favorecer o desenvolvimento do conhecimento tático declarativo. Também fornecemos aplicações práticas e direções futuras para pesquisa sobre o conhecimento tático no futebol em cada um dos estudos.

## DISSERTATION STRUCTURE

This dissertation is arranged according to the model proposed by the norms of presentation of dissertations and theses from the Universidade Federal de Viçosa, comprised by three studies that will be submitted for publication to indexed journals. This structure allows the presentation of the studies developed during the process.

The first part of this dissertation includes an introduction chapter, which is composed by a brief introduction of the theme and includes the rationale and relevance of this research. It is followed by the objectives section. In the following chapters, three studies are presented as follows:

The first study, entitled “Tactical knowledge in soccer: A systematic review” has the purpose to systematically review the state of the art of the literature about tactical knowledge in soccer and to know the potentialities and limitations of tactical knowledge assessment in soccer.

The second study, entitled “TacticUP video test: Development and validation of a declarative tactical knowledge test in soccer” aims to expand the process of tactical knowledge assessment of soccer players, through the development and validation of a declarative tactical knowledge test based on core tactical principles.

The third study, entitled “Macro- and microstructure of soccer activities as a discriminant of different levels of tactical knowledge in soccer players” has the aim to analyze the amount of hours accumulated in distinct soccer activities by soccer players with different levels of declarative tactical knowledge.

The presentation of these three studies is followed by a brief general discussion and final conclusions about the entire research.

## **GENERAL INTRODUCTION**

### **1. Importance of tactical knowledge**

The tactical dimension has been considered an important factor for soccer players achieve high performance level, since every action in the game has as its goal a tactical purpose (GARGANTA, 2009). In this regard, tactics can be defined as “...the management (positioning and displacement/movement) of the playing space by players and teams” (TEOLDO; GUILHERME; GARGANTA, 2015, p. 26). Supporting the importance of tactics, in the last decades there was an emergence of different teaching/learning methodologies, which focuses on the development on the understanding of the game, specially the knowledge of tactics (BUNKER; THORPE, 1982; GRÉHAIGNE; GODBOUT, 1995). In this sense, tactical knowledge has been divided into two distinct forms, declarative tactical knowledge (DTK) and procedural tactical knowledge (PTK) (ANDERSON, 1983; MCPHERSON, 1994). DTK is related to the knowledge about rules and goals of the game and refers to “knowing what to do”, while PTK is related to the response selection and execution in game situations and refers to “doing it” (MCPHERSON, 1994). These both types of knowledge can be understood as a continuum, which includes the possibilities that range from “knowing what do” to “doing it” (MCPHERSON, 1994).

Considering this continuum, empirical evidence showed that specially in high strategy sports, such as soccer, both types of tactical knowledge are more developed in experts compared to novices (SERRA-OLIVARES; GARCÍA-LÓPEZ, 2016) and has been shown to differentiate players’ future performance (AQUINO *et al.*, 2017) and professional achievement (KANNEKENS *et al.*, 2009). Furthermore, tactical knowledge is also related to players’ playing position (KANNEKENS *et al.*, 2009), technical skills (AQUINO *et al.*, 2016; RECHENCHOSKY *et al.*, 2017) and physical attributes (FORSMAN *et al.*, 2015). Therefore, the assessment of players’ tactical knowledge plays an important role during their process of sport development (TEOLDO; GUILHERME; GARGANTA, 2015).

### **2. Assessment of tactical knowledge**

Tactical knowledge assessment has contributed to different domains in soccer, such as the development and improvement of training methodologies (MESQUITA; FARIAS; HASTIE, 2012; SOUZA *et al.*, 2014), monitoring of players’ and teams’



performance (PRAÇA *et al.*, 2017) and also has been used for talent selection and development (HUIJGEN *et al.*, 2014). In regards to PTK, it has been assessed through questionnaires, video-based tests, interviews and specially based on small-sided and conditioned games, which are smaller versions of the formal game with adapted rules (CLEMENTE, 2016). This last type of assessment is the one with more representativeness of the game and is able to assess PTK in a game like situation (SERRA-OLIVARES; CLEMENTE; GONZÁLEZ-VÍLLORA, 2016). It keeps the most important aspects of the game, such as the ball, teammates and opposition. These components are fundamental to keep relationship between key sources of information and response execution of players, in a contextualized environment, which creates an optimum scenario to assess PTK.

In regards to DTK assessment, it has contributed to the knowledge that support the performance of actions in game situation (BLOMQVIST; VÄNTTINEN; LUHTANEN, 2005). The methodologies used for it assessment has been mainly based in questionnaires and video-based tests, despite interviews are used as well. Although the importance of its assessment, current available instruments have several limitations, such as: i) assessment based on subjective perceived measures (ELFERINK-GEMSER *et al.*, 2004); ii) assessment of only one phase of the game (MANGAS, 1999; SERRA-OLIVARES; GARCÍA-LÓPEZ, 2016); and iii) are based only in the assessment of the player in possession of the ball (MANGAS, 1999) (although 97% of the time players perform actions without the ball in the formal game). Therefore, there is a clear need to improve and develop new tools for DTK assessment.

In this regard, an important point that must be considered, is the methodology used for it assessment. In order to keep representativeness of the actual game, the assessment of players' knowledge should be done in more naturalistic settings, which can enhance its transferability and applicability for actual game. In this sense, the use of video-based tests are preferable to assess DTK, once it offer a more natural perception of the scene, compared to static figures, questionnaires or interview (MANN *et al.*, 2007).

Another important aspect of tactical knowledge assessment is its theoretical construct basis (GONZÁLEZ-VÍLLORA *et al.*, 2015). This assessment might be grounded in constructs that takes into account the logic of the game, which allows measure players' operationalization of such concepts. Additionally, consonance between training and tactical assessment in a regular basis is fundamental to qualify

the process of tactical knowledge development over the years of sport development of a player (GRÉHAIGNE; GODBOUT; BOUTHIER, 2001). Therefore, considering the tactical knowledge continuum of DTK/PTK (MCPHERSON, 1994), coherence of tactical knowledge assessment can be achieved by developing a DTK test based on the same theoretical construct of previous PTK instruments.

Furthermore, in order to assure effectiveness of assessment, the development of a new test must consider some characteristics, such as: i) acceptability of the test between the individuals assessed (face validity); ii) the extent to which a measure represents a construct (content validity); iii) the capacity to differentiate individuals of different skill levels (construct validity); and iv) the consistency and repeatability in measurements (reliability) (CRONBACH; MEEHL, 1955; LANDIS; KOCH, 1977; ANASTASI, 1988; CRONBACH, 1988; GRÉHAIGNE; GODBOUT; BOUTHIER, 1997; HOPKINS, 2000). With such characteristics, an instrument may be able to adequately measure DTK in different contexts, which can be used to understand in-depth the processes involved in tactical knowledge acquisition and development (ERICSSON, 2006).

### **3. Development of tactical knowledge**

Considering tactical knowledge development, some researchers suggested that high levels of knowledge can be achieved through engagement in practice of representative domain-relevant tasks (O'CONNOR; LARKIN, 2016). Such representative tasks can be practiced in different contexts, which raise the question of what types of soccer activities could contribute to tactical knowledge development. In this sense, the assessment of soccer players engagement in distinct soccer activities during their sport development phases could shed light into this topic.

However, in order to gather valid and useful information about this process, there is a need to have objective measures of players' tactical knowledge, instead of subjective perceptions of coaches about their players (FORD *et al.*, 2010). In this regard, the assessment of tactical knowledge might be grounded in constructs that takes into account the logic of the game, must be in consonance with training purposes, keep representativeness of the actual game and use valid and reliable tests. Following these assumptions, it will be able to identify those aspects that distinguish players with different levels of tactical knowledge (e.g. high and low tactical knowledge groups) and perhaps extend these implications for selection and training purposes (CÔTÉ; ERICSSON; LAW, 2005). This type of information must provide guidance on

theoretical and practical understanding into the role of different activities in athletes' tactical knowledge development in soccer.

#### **4. Rationale and relevance**

The study about tactical knowledge in soccer has gained great interest over the last decades, due: i) the importance that tactics assumed on training and performance (TEOLDO; GUILHERME; GARGANTA, 2015); ii) the development of teaching learning methodologies based on this domain (BUNKER; THORPE, 1982); and iii) based on empirical evidences that shows tactical knowledge association with other aspects of performance (BLOMQVIST; VÄNTTINEN; LUHTANEN, 2005). However, although the study of tactical knowledge in soccer has started in the 1990s (WILLIAMS; DAVIDS, 1995), up to date no efforts were done to systematically organize or revise the scientific research done about tactical knowledge in soccer, to our knowledge. Thus, there is a need verify the state of the art of the literature about this topic in order to identify in-depth the potentialities and limitations of tactical knowledge assessment.

Based on this process, will be possible to identify the gaps on tactical knowledge assessment, and propose the development of an instrument in line with cutting-edge theoretical and methodological assumptions. Moreover, the development and validation of such instrument will allow a step forward into the study about tactical knowledge in soccer, providing an alignment between the processes of training and tactical assessment. It will also enable to conduct research about the process of tactical knowledge acquisition and development.

## **OBJECTIVES**

### **General Objectives**

- Expand and advance the process of tactical knowledge assessment of soccer players through the development, validation and application of a declarative tactical knowledge test.

### **Specific Objectives**

- Systematically review the state of the art of the literature about tactical knowledge in soccer and to know the potentialities and limitations of tactical knowledge assessment in soccer.
- Develop and validate a declarative tactical knowledge test in soccer based on core tactical principles.
- Analyze the amount of hours accumulated in distinct soccer activities by soccer players with different levels of declarative tactical knowledge.

## STUDY 1

**Title:** Tactical knowledge in soccer: A systematic review

**Abstract:** In the last years, many studies demonstrated association between tactical knowledge and a variety of performance mediators in soccer. However, although the importance of this topic for players' development, no systematic reviews about tactical knowledge research in soccer has been carried out, to our knowledge. Thus, the purpose of this study was to systematically review the state of the art of the literature about tactical knowledge in soccer and to know the potentialities and limitations of tactical knowledge assessment in soccer. A systematic review of the available literature on tactical knowledge in soccer was conducted according to PRISMA (Preferred Reporting Items for Systematic reviews and Meta-analyses) guidelines. We searched in the Web of Knowledge, SCOPUS and EBSCOhost Online Research Databases for relevant publication prior to 17 April 2018. The title, abstract and key words were searched through the following descriptors: “(soccer OR football) AND (knowledge OR intelligence OR awareness) AND tact\*”. We considered original research written in English, Portuguese or Spanish language. Initially there was found 448 articles in the aforementioned databases. After screening against inclusion criteria, 40 articles were included in the final revision. We identified an increasing interest in tactical knowledge research in soccer, once 55.8% of the articles included in the review were published in the last five years (2014 to 2018). The most frequently topics studied were: age; expertise; technical skills; intervention; playing position; physical attributes; associations between declarative and procedural tactical knowledge; prediction of future performance; time span; gender; and motivation. We discuss the results regarding the methodologies and tactical principles used for tactical knowledge assessment. There was find great consonance between procedural tactical knowledge assessment and training process compared to declarative tactical knowledge assessment. It was concluded that complementary instruments in declarative tactical knowledge assessment must be developed in line with available procedural tactical knowledge instruments and we provide future directions for the study of tactical knowledge.

**Keywords:** tactical awareness; tactical skill; talent development; talent identification.

## ESTUDO 1

**Título:** Conhecimento tático no futebol: Uma revisão sistemática

**Resumo:** Nos últimos anos, diversos estudos demonstraram a associação entre o conhecimento tático e uma variedade de mediadores de desempenho no futebol. No entanto, apesar da importância deste tópico para o desenvolvimento dos jogadores, nenhuma revisão sistemática sobre conhecimento tático no futebol foi realizada, para o nosso conhecimento. O objetivo deste estudo foi revisar sistematicamente o estado da arte da literatura sobre o conhecimento tático no futebol e conhecer as potencialidades e limitações da avaliação do conhecimento tático. Uma revisão sistemática da literatura sobre conhecimento tático no futebol foi conduzida de acordo com as diretrizes do PRISMA (Itens Preferenciais para Relatar em Revisões Sistemáticas e Meta-análises). Foram utilizadas as bases de dados Web of Knowledge, SCOPUS e EBSCOhost para busca de publicações relevantes antes de 17 de abril de 2018. Título, resumo e palavras-chave foram pesquisados através dos seguintes descritores: “(soccer OU football) E (knowledge OU intelligence OU awareness) E tact\*”. Consideramos estudos originais escritos em inglês, português ou espanhol. Inicialmente, encontramos 448 artigos nas bases de dados. Após a triagem, considerando os critérios de inclusão, 40 artigos foram incluídos na revisão final. Identificamos um interesse crescente de pesquisas sobre conhecimento tático no futebol, uma vez que 55,8% dos artigos incluídos na revisão foram publicados nos últimos cinco anos (2014 a 2018). Os tópicos mais estudados foram: idade; perícia; habilidades técnicas; intervenção; posição; atributos físicos; associações entre conhecimento tático declarativo e processual; previsão de desempenho futuro; intervalo de tempo; gênero; e motivação. Discutimos os resultados referentes às metodologias e princípios táticos utilizados na avaliação do conhecimento tático. Verificou-se grande consonância entre a avaliação do conhecimento tático processual e o processo de treino em comparação com o conhecimento tático declarativo. Concluiu-se que devem ser desenvolvidos instrumentos complementares para avaliação do conhecimento tático declarativo em consonância com os instrumentos de conhecimento tático processual disponíveis e também fornecemos direções para estudos futuros.

**Palavras-chave:** consciência tática; capacidade tática; desenvolvimento de talento; identificação de talento.

## 1. Introduction

In soccer (Association Football), the tactical dimension has been considered an important factor for soccer players achieve high performance level, since every action in the game has as its goal a tactical purpose (GARGANTA, 2009). Teoldo, Guilherme and Garganta (2015, p. 26) define tactics as “...the management (positioning and displacement/movement) of the playing space by players and teams”. Apparently, the capacity of soccer players perform tactically well is linked to their previous knowledge acquired through experience in soccer activities (GUTIÉRREZ-DÍAZ *et al.*, 2011).

In this regard, the Oxford English Dictionary define knowledge as facts, information, and skills acquired through experience or education. In the theoretical field, knowledge has been divided into two forms, declarative and procedural (ANDERSON, 1982; 1983). There is a fundamental distinction between declarative knowledge, which refers to facts we know, and procedural knowledge, which refers to skills we know to perform (ANDERSON, 1983). When brought to sport context, these concepts are referred in the tactical domain as declarative tactical knowledge (DTK) and procedural tactical knowledge (PTK). Therefore, DTK is related to the knowledge about rules and goals of the game and refers to “knowing what to do”, while PTK is related to the response selection and execution in game situations and refers to “doing it” (MCPHERSON, 1994). These both types of knowledge can be understood as a continuum, which includes the possibilities that range from “knowing what do” to “doing it” (MCPHERSON, 1994).

This theoretical framework is linked to the first studies performed in sports with knowledge based approach (FRENCH; THOMAS, 1987; MCPHERSON; THOMAS, 1989). Since then, this type of research was brought to the study of soccer (WILLIAMS; DAVIDS, 1995) and has been continuously applied in this research field until the present days (KANNEKENS *et al.*, 2009; MENEGASSI *et al.*, 2018). More recently, a review study analyzed and described procedural tactical knowledge assessment tools in soccer, based on small-sided and conditioned games (SSCG) (GONZÁLEZ-VÍLLORA *et al.*, 2015). This study demonstrate the current interest of researchers in tactical knowledge assessment, but raised questions of the alignment between assessment tools and its transferability to training. The authors defend that tactical knowledge assessment

should be firmly in line to the teaching-learning process and thus advised that tactical game principles should be assessed in order to align this both processes (assessment and training).

Moreover, among the instruments described in the aforementioned review, one of them (e.g. GPET) was developed based on the instrument used by French and Thomas (1987), which suggested that paradigms in knowledge based research, should develop observational instruments able to differentiate players' response selection and response execution during actual games. Therefore, based in the knowledge continuum framework (MCPHERSON, 1994), and previous studies recommendation (FRENCH; THOMAS, 1987; MCPHERSON; THOMAS, 1989; ABERNETHY; THOMAS; THOMAS, 1993; MCPHERSON, 1994; GONZÁLEZ-VÍLLORA *et al.*, 2015), it is considered that the response selection (or decision adequacy) component assessed by this type of instrument during actual games, is used to assess the PTK of players.

Due to many tactical knowledge assessment tools developed in recent years (e.g. FUT-SAT, KORA, GPET), many studies in this topic were performed. In general, they have demonstrated association between tactical knowledge and a variety of performance mediators in soccer, such as technical and physical performance (RECHENCHOSKY *et al.*, 2017), age (TEOLDO *et al.*, 2010a), expertise level (SERRA-OLIVARES; GARCÍA-LÓPEZ; GUTIÉRREZ-DÍAZ, 2017) and etc. However, although the importance of tactical knowledge for soccer players' development, no systematic reviews about tactical knowledge research in soccer has been carried out, to our knowledge. Therefore, there is a need to systematically organize and review research published in journals in order to: i) inform the current state of the art of tactical knowledge in soccer; ii) characterize the potentialities and limitations of tactical assessment in soccer (declarative and procedural); and iii) verify the alignment between tactical knowledge assessment and teaching-learning (training) process. Thus, the purpose of this study is to systematically review the state of the art of the literature about tactical knowledge in soccer and to know the potentialities and limitations of tactical knowledge assessment in soccer.



## 2. Methods

### 2.1 Search strategy and inclusion criteria

A systematic review of the available literature on Tactical Knowledge in soccer was conducted according to PRISMA (Preferred Reporting Items for Systematic reviews and Meta-analyses) guidelines (MOHER *et al.*, 2009). In order to ensure article quality, the databases used were the Institute for Scientific Information (ISI) Web of Knowledge, SCOPUS and EBSCOhost Online Research Databases for relevant publication prior to 17 April 2018. These databases were selected due its relevant literature in the areas of sports science. The title, abstract and key words were searched through the following descriptors: “(soccer OR football) AND (knowledge OR intelligence OR awareness) AND tact\*”. Only empirical research was considered to further analysis.

The inclusion criteria for the articles were: 1) published in peer-reviewed international scientific journals; 2) the validity and reliability of the tools used in the studies should have been established and published in scientific journals; 3) the study was carried out with soccer players (adult and youth); 4) written in English, Portuguese or Spanish language. The exclusion criteria were applied if the article: 1) was related to any other sport; 2) was a review, opinion or a conference abstract; and 3) was carried out with robots. In case of disagreement it was solved by discussion between the two review authors.

Two independent reviewers (GM, FM) separately screened titles and abstracts to identify articles based on the inclusion criteria. For those articles, full-text were screened by those reviewers to stablish whether the inclusion criteria were met. Disagreements were solved by discussion between both reviewers.

We also performed a backward search through the screening of references for those selected articles in databases. These references that matched the inclusion criteria were included in the review.

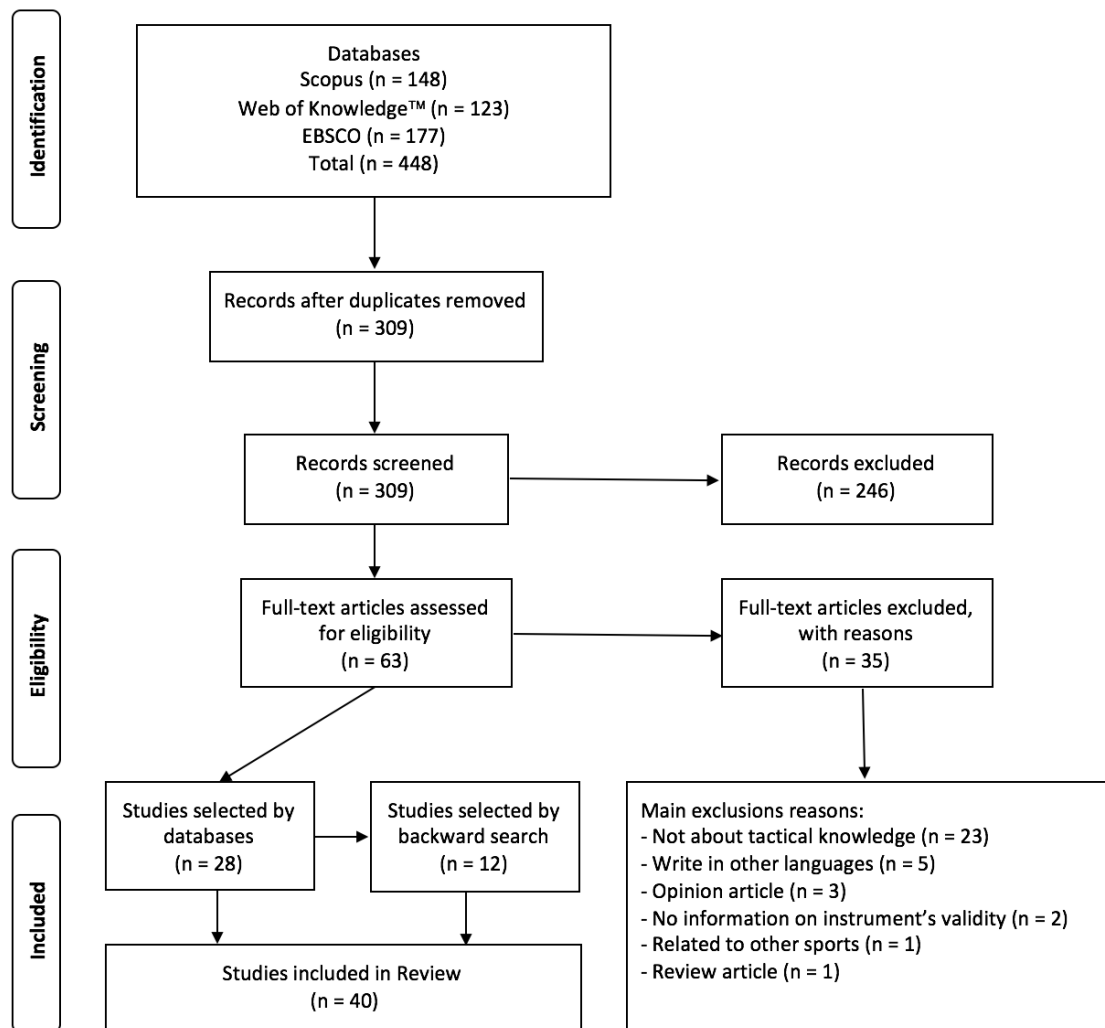
## 3. Results

### 3.1 Search, Selection and Inclusion of Publications

Initially there was found 448 articles in the aforementioned databases. All these articles were exported to the reference software manager (EndNote<sup>TM</sup> X8, Clarivate Analytics, Philadelphia, PA, USA). In the next step all duplicates (n = 139) were removed, both automatically or manually. Afterwards, the remaining

309 articles were screened for relevance based on their title and abstract, resulting in the exclusion of 246 articles. The remaining 63 articles were screened based on their full-text. There were 35 articles excluded based on the inclusion/exclusion criteria, which left 28 articles for in-depth reading and analysis. The main reasons for exclusions are described in the flow chart (Fig. 1). Subsequently, we performed a backward search based on the references from those 28 selected articles. There were included others 12 articles, which totaled 40 articles for the review process.

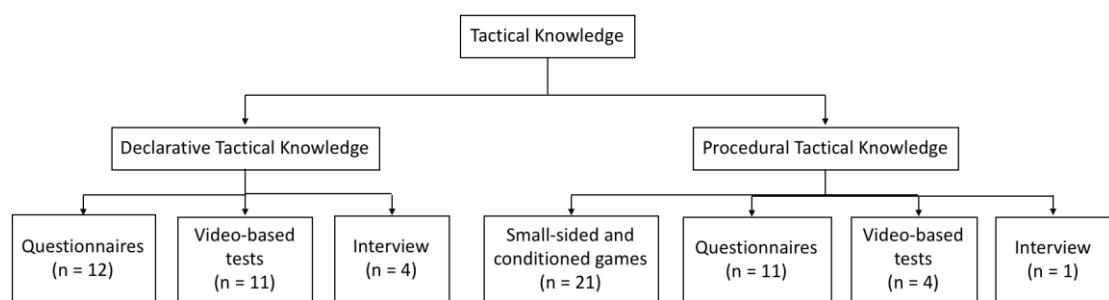
The chronological analysis of the articles included in this review showed that the selected articles were published between 2005 and 2018. Furthermore, more than a half of total articles included in this review (55.8%) were published in the last five years (2014 to 2018).



**Figure 1.** Flow chart of the methodology used for the article search based on the preferred reporting items for systematic review (PRISMA).

### 3.2 Methodologies used for Tactical Knowledge Assessment

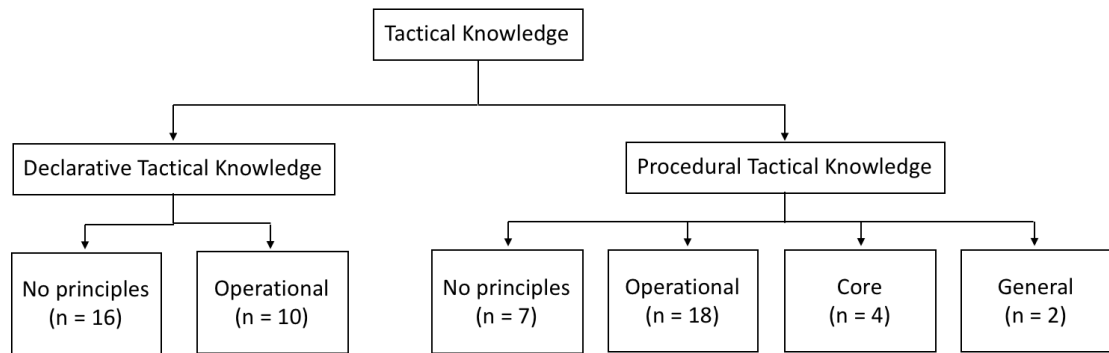
It was observed that both declarative and procedural tactical knowledge were assessed through a variety of methodologies, such as questionnaires, video-based tests, interview and small-sided and conditioned games (Fig. 2). In regard to declarative tactical knowledge, it was assessed through: i) questionnaires (n = 12); ii) video-based tests (n = 11); and iii) interview (n = 4). Additionally, procedural tactical knowledge was assessed through: i) small-sided and conditioned games (SSCG) (n = 21); ii) questionnaires (n = 11); iii) video-based tests (n = 4); and iv) interview (n = 1).



**Figure 2.** Flow chart of methodologies used for assessment of tactical knowledge.

### 3.3 Tactical Knowledge Assessment based on Tactical Principles

We evaluated the theoretical aspects based on tactical principles in which the instruments for assessment of tactical knowledge were developed (Fig. 3). It was observed that mostly articles that assessed declarative tactical knowledge did not take into account tactical principles. This assessment was divided by: i) no tactical principles (n = 16); and ii) operational tactical principles (n = 10). There were no records of assessment of both general and core tactical principles for declarative tactical knowledge. On the other hand, procedural tactical knowledge was mostly assessed based on tactical principles. It was divided by: i) no tactical principles (n = 7); ii) operational tactical principles (n = 18); iii) core tactical principles (n = 4); and iv) general tactical principles (n = 2).



**Figure 3.** Flow chart of assessment of tactical knowledge based on tactical principles.

### 3.4 Main Research Topics

This subsection identifies the most researched topics on tactical knowledge and discuss it in depth in the next section. The topics were divided into: i) age (n = 13) (Table 1 and 2); ii) expertise (n = 9) (Table 3); iii) technical skills (n = 7) (Table 4); iv) intervention (n = 6) (Table 5); v) playing position (n = 4) (Table 6); vi) physical attributes (n = 4) (Table 7); vii) associations between declarative and procedural tactical knowledge (n = 4) (Table 8); and viii) other topics (n = 10) (Table 9).

**Table 1.** Studies with the main topic age

Author	Sample	Tactical principles assessed	Methodology/ Instrument	Main results
<i>Studies of Declarative Tactical Knowledge</i>				
Giacomini et al 2011	221 male soccer players from U-14, U-15 and U-17, which participated in national competitions in Brazil	-	Video based test (Mangas, 1999)	Differences in DTK per category, were shown by the U-14, for the U-15 and U-17. U-14 had the lowest values. No differences were found between U-15 and U-17
Aburachid et al 2013	39 male soccer players from U-14, U-15, U-17, and U-20 categories from a Brazilian club	-	Video based test (Mangas, 1999)	There were differences in DTK level among U-14 and U-17 and U-14 and U-20. U-14 had the lowest values
Moreira et al 2014	26 male soccer players from U-15 and U-14 from a high level Brazilian club	-	Video based test (Mangas, 1999)	U-15 had bigger scores in DTK than U-14 players
Américo et al 2017	36 male soccer players from U-11 and U-15 teams of a Brazilian championship first division club	-	Video based test (Mangas, 1999)	Players from U-15 age groups had greater DTK compared to U-11 players
<i>Studies of Procedural Tactical Knowledge</i>				
Giacomini & Greco 2008	221 male soccer players from U-14, U-15 and U-17, which participated in national competitions in Brazil	General	SSCG - KORA (Memmert, 2010)	Results indicated differences between all the three age groups of the sample. PTK increased according to age

Teoldo et al 2010	300 male soccer players (U-11, U-13, U-15, U-17 and U-20) from Portugal	Core	SSCG - FUT-SAT (Teoldo et al, 2011)	The results showed 32 statistical differences regarding the efficiency of tactical behaviours (PTK) considering the 10 core tactical principles and all age groups. Overall PTK increased with age, except when comparing U-15 with U-17 soccer players
González-Víllora et al 2015	57 male soccer players (U-8, U-10, U-12 and U-14) from a Spanish first division youth team	Operational	SSCG - GPET (García-López et al, 2013)	There was found differences in PTK between the four age groups and overall it increases over time. These differences have been shown mainly in: i) attack - the progress toward goal tactical principle and shake off; and ii) defence - marking and cover (off-ball defenders). The application of operational tactical principles PTK increased specially from U-12 to U-14
Borges et al 2015	29 male soccer players from U-15 and U-17 age groups, belonging to an extension project in Brazil	-	SSCG - GPAI (Oslin et al, 1998)	No differences in PTK was found between U-15 and U-17 soccer players
Praça et al 2017	18 male soccer players from U-16 and U-17 from a national level Brazilian club	-	SSCG - TPTK:OE (Greco et al, 2015)	No differences in PTK was found between U-16 and U-17 soccer players

*Studies of both Declarative and Procedural Tactical Knowledge*

Kannekens et al 2009	191 elite youth soccer players (age range = 14 to 18) from the top 0.5% in their age group in Netherlands	-	Questionnaire - TACSIS (Elferink-Gemser et al 2004)	Offensive and defensive DTK, showed an increase over time only for attacker's scores, but not for defenders and midfielders. Offensive and defensive PTK followed the same pattern, and only attackers increased their scores
Serra-Olivares et al 2014	288 male and female primary school students between 8 and 13 years of age: boys (n=156) and girls (n=132)	Operational	Questionnaire - STKT (Serra-Olivares & Garcia-López, 2016)	Results showed that students from 10, 11 and 12 years of age had greater declarative and procedural tactical knowledge, compared to 8, 9 and 13 years of age students

Serra-Olivares et al 2015	109 youth soccer players (8-12 years) from a high level club in Spain	Operational	Questionnaire - STKT (Serra-Olivares & Garcia-López, 2016)	There was found no differences in comparisons between players of one year of differences (e.g 8-9 or 10-11 years of age). DTK had differences between players of 8-11; 8-12; 9-11; 9-12 years of age. PTK showed differences between players of 8-10; 8-11; 8-12; 9-11; 10-12 years of age. In all these differences older players scored higher
Serra-Olivares et al 2017	431 subjects between 7 and 13 years of age from high level clubs (n = 106); school context (n = 288); and recreational context (n = 37)	Operational	Questionnaire - STKT (Serra-Olivares & Garcia-López, 2016)	Results showed a positive low correlation between age and DTK ( $r = .299$ ) and PTK ( $r = .268$ )

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**Table 2.** Studies with the main topic age (descriptive studies)

Author	Sample	Tactical principles assessed	Methodology/ Instrument	Main results
<i>Studies of Procedural Tactical Knowledge</i>				
González-Víllora et al 2012	14 male soccer players from U-8 category of a high level Spanish club	Operational	SSCG - GPET (García-López et al, 2013)	Results of PTK showed that players only perform simple tactics, overusing dribbling and not passing the ball as a means of communication between players. Players obtain better results keeping the ball than advancing towards the opposite goal. PTK is better in attack than in defence. There was found a better PTK rate compared to skill execution rate. Overall these results suggest that teaching operational tactical principles might start focusing in situations of keeping the ball, followed by advancing toward the opposite goals and finally in situations of scoring



Studies of both Declarative and Procedural Tactical Knowledge

González-Víllora et al 2010	14 male soccer players from U-12 category of a high level Spanish club	Operational	DTK - Interview (González-Víllora, 2008) PTK - Video based test (González-Víllora, 2008) PTK - SSCG - GPET (García-López et al, 2013)	The DTK interview showed that players do not yet have a clear understanding of the game characteristics that a player who plays good soccer should possess. PTK video based test demonstrated that players understood the aspects involved in each game role. PTK SSCG results demonstrated that most of the game situations involved attacking (64.07%), followed by maintaining possession (33.09%) and finally by completing the move (2.84%). In the SSCG was found a better PTK rate compared to skill execution rate. Overall players' DTK and PTK are higher in individual technical-tactical aspects compared to the collective ones, and thus have a better command of offensive than defensive game situations
González-Víllora et al 2011	13 male soccer players from U-10 category of a high level Spanish club	Operational	DTK - Interview (González-Víllora, 2008) PTK - Video based test (González-Víllora, 2008) PTK - SSCG - GPET (García-López et al, 2013)	The DTK interview showed that players are not aware about the operational tactical principles of both attack and defence. Players know better the offensive phase than the defensive. PTK video based test demonstrated players' difficult recognising grupal tactical elements and a great focus on on-the-ball player instead of off-the-ball players. PTK SSCG results demonstrated that most of the game situations involved attacking (86.20%), followed by maintaining possession (7.60%) and finally by completing the move (6.20%). In the SSCG was found a better PTK rate compared to skill execution rate. Additionally, PTK measured through the SSCG were higher than that measured through video based test or DTK measured through interview

González-Víllora et al 2013	16 male soccer players from U-14 category of a high level Spanish club	Operational	DTK - Interview (González-Víllora, 2008) PTK - Video based test (González-Víllora, 2008) PTK - SSCG - GPET (García-López et al, 2013)	<p>The DTK interview demonstrated that players at this age have clear idea of the principles of scoring and winning possession, but have difficulties with other principles. PTK video based test showed a great understanding of tactical principles, but with difficulty to identify group and collective aspects. PTK SSCG results demonstrated that most of the game situations involved attacking (64.07%), followed by maintaining possession (33.09%) and finally by completing the move (2.84%). In the SSCG was found a better PTK rate compared to skill execution rate. PTK measured through the SSCG were higher than that measured through video based test or DTK measured through interview. Overall players' DTK and PTK are higher in individual technical-tactical aspects compared to the collective ones, and thus have a better command of offensive than defensive game situations</p>
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**Table 3.** Studies with the main topic expertise

Author	Sample	Tactical principles assessed	Methodology/ Instrument	Main results
<i>Studies of Declarative Tactical Knowledge</i>				
Costa et al 2016	45 subjects from U-17 category participated in this study, divided into two groups: players participating in systematic football training (n = 22); and physical education students (n = 23)	-	Video based test (Mangas, 1999)	Results showed no differences between both groups in DTK
<i>Studies of Procedural Tactical Knowledge</i>				
García-López et al 2010	140 participants aged 15 years from five different competitive soccer levels: international (n = 16); national (n = 28); regional (n = 23); provincial (n = 48); and no competitive experience (n = 25)	Operational	Video based test (García-López et al, 2010)	International and national soccer players presented similar results and both showed higher PTK compared to regional, provincial and no experience players. No more differences were found
Gutiérrez-Díaz et al 2011	129 participants from four age groups (7–8, 9–10, 11–12, and 13–14 years) and two performance levels: expert (n = 55) and novice (n = 74) soccer players. Experts players participated in a youth soccer program and novices were physical education students	Operational	SSCG - GPET (García-López et al, 2013)	Expert players demonstrated better offensive and defensive PTK compared to novice players in every age group. These differences increased with age
Mesquita et al 2012	26 fifth-grade students aged between 10 and 12 years, both boys (n = 9) and girls (n = 17). Participants were divided into three skill levels based on an objective measure	Operational	SSCG (Blomqvist et al, 2005)	There was found differences among high and medium skill level compared to lower skill level in Offensive on-the-ball PTK

Studies of both Declarative and Procedural Tactical Knowledge

Kannekens et al 2009	37 male soccer players from Dutch (n = 18, age 18-20 years) and Indonesian (n = 19, age 18-23 years) national youth soccer teams. Dutch team is ranked considerably higher than the Indonesian team	-	Questionnaire - TACSIS (Elferink-Gemser et al, 2004)	The Dutch players outscored the Indonesian players in offensive and defensive DTK and offensive PTK
Serra-Olivares 2014	288 male and female primary school students between 8 and 13 years of age: boys (n=156) and girls (n=132). Expertise was measured through the accumulated practice time	Operational	Questionnaire - STKT (Serra-Olivares & Garcia-López, 2016)	Results indicated a positive correlation between DTK and weekly training hours (r = .46) and years of competition (r = .54). PTK also showed positive correlation with weekly training hours (r = .37) and years of competition (r = .35)
Serra-Olivares et al 2015	109 youth soccer players (8-12 years) from a high level club in Spain. Their expertise level was measured and divided by coach's opinion	Operational	Questionnaire - STKT (Serra-Olivares & Garcia-López, 2016)	There was found a positive correlation between expertise level and DTK (r = .35) and PTK (r = .44). Results also showed a trend of years of experience influence positively in DTK and PTK, but not linearly as expertise level did
Serra-Olivares & García-López 2016	465 children aged 8-14 participated in the study, at three different sport contexts in Spain: specific sport context (n = 163); primary school students (n = 265); and recreational sport context (n = 37)	Operational	Questionnaire - STKT (Serra-Olivares & Garcia-López, 2016)	Players from specific and recreational sport context showed greater DTK and PTK compared to school students. No differences were found between recreational and specific sport context
Serra-Olivares et al 2017	431 subjects between 7 and 13 years of age from high level clubs (n = 106); school context (n = 288); and recreational context (n = 37)	Operational	Questionnaire - STKT (Serra-Olivares & Garcia-López, 2016)	Soccer players from both club and recreational context showed higher values in DTK and PTK compared to school context. There were no differences between club and recreational context. Positive correlation between DTK and PTK with weekly hours of practice were also found

**Table 4.** Studies with the main topic technical skills

Author	Sample	Tactical principles assessed	Methodology/ Instrument	Main results
<i>Studies of Declarative Tactical Knowledge</i>				
Rechenchosky et al 2017	68 regional male soccer players (12.83 ± 2.43 years)	-	Video based test (Mangas, 1999)	Results showed a positive correlations between DTK and shooting (r = .40) and a negative correlation between DTK and the time to complete a dribbling test (r = -.59)
Blomqvist et al 2005	12 male school students aged 14 - 15 years	Operational	Video based test (Blomqvist et, 2005)	Results showed a positive correlation between DTK and successful skill execution (r = .80) considering technical skills of receiveing, passing, dribbling, shooting, duel and interception. Offensive DTK correlated positevely with offensive skill execution (r = .69) and defensive DTK also correlated positevely with defensive skill execution (r = .56)
<i>Studies of Procedural Tactical Knowledge</i>				
Sánchez-Mora et al 2011	27 primary school students both boys (n = 19) and girls (n = 8) aged 9 and 10 years	Operational	SSCG - GPET (García-López et al, 2013)	There was found a positive correlation between the binomial of PTK and successful outcome in technical skills for passing (r = .98), dribbling (r = .75) and moving into space (r = .98)
González-Víllora et al 2015	57 male soccer players (U-8, U-10, U-12 and U-14) from a Spanish first division youth team	Operational	SSCG - GPET (García-López et al, 2013)	There was found a positive correlation, considering all age groups, between PTK and technical skill of carrying the ball (r = .735) in the tactical principle of keeping. There were other positive correlations considering passing, marking and losing one's defender for some age groups. Overall these correlations decreased with age
Borges et al 2015	29 male soccer players from U-15 and U-17 age groups,	-	SSCG - GPAI (Oslin et al, 1998)	The study showed a positive correlation between PTK and technical skills (r = .80) considering passing, shooting and controlling the ball

Aquino et al 2016	belonging to an extension project in Brazil  15 male soccer players from U-11 category of a professional club in Brazil	Core	SSCG - FUT-SAT (Teoldo et al, 2011)	Results demonstrated a weak, positive correlation ( $r = .39$ ) between offensive PTK and specific soccer motor skills considering ball control, shooting, passing and dribbling
<i><u>Studies of both Declarative and Procedural Tactical Knowledge</u></i>				
Forsman et al 2015	288 male soccer players aged 12 to 14 years from 16 Finnish soccer clubs	-	Questionnaire - TACSIS (Elferink- Gemser et al, 2004)	Results demonstrated no correlation between DTK and PTK with technical skills of dribbling and passing

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**Table 5.** Studies with the main topic intervention

Author	Sample	Tactical principles assessed	Methodology/ Instrument	Main results
<i>Studies of Procedural Tactical Knowledge</i>				
Mesquita et al 2012	26 college students aged between 10 and 12 years, both boys (n = 9) and girls (n = 17). Participants were divided into three skill levels based on an objective measure	Operational	SSCG (Blomqvist et al, 2005)	Results demonstrated an improvement in PTK after 22-lesson soccer unit based on a hybrid Sport Education-Invasion Games Model for defensive and total off-the-ball situations
Souza et al 2014	18 male soccer players from U-14 youth category	Core	SSCG - FUT-SAT (Teoldo et al, 2011)	Players improved their PTK for the tactical principle of “width and length” after a 20 training sessions based on training of core tactical principles using the Teaching Games for Understanding methodology
Praxedes et al 2016	18 male football players aged 10-12 from an youth academy in Spain, divided equally into experimental (n = 9) and control (n = 9) groups	Operational	SSCG - GPET (García-López et al, 2013)	There was found an improvement in PTK for the experimental group in passing and dribbling situations after a 21 training sessions (one hour each) based on training of operational tactical principles using the Teaching Games for Understanding methodology. In post-test experimental group showed greater PTK in passing situations compared to control group, which was trained with a traditional methodology

Ashraf et al 2017	45 college students were randomly divided into experimental (n = 24, 20 ± 1.9 years) and control (n = 21, 20 ± 1.2 years) groups	Operational	SSCG - GPET (García-López et al, 2013)	The experimental group improved their PTK in offensive with- and without-ball actions and also defensive actions after a 24 lessons based on Teaching Games for Understanding methodology. Control group that were taught with traditional methodology during the same period showed no improvements
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Studies of both Declarative and Procedural Tactical Knowledge

Farias et al 2015	24 students from one fifth grade class (16 girls and 8 boys, mean age 10.3) from an elementary school in northern Portugal who participated in physical education lessons two times per week	Operational	PTK - SSCG (Blomqvist et al, 2005) DTK - Questionnaire - The Game Understanding Test (Farias et al, 2015)	There was an improvement in DTK and PTK measured by questionnaire and SSCG, respectively, in overall actions, actions with the ball, offensive off the ball actions and defensive actions after a 17 lessons lasting between 45 (n = 8) and 90 (n = 9) minutes based on an hybrid Sport Education-Invasion Games Model methodology
Viciano et al 2017	104 primary school students, boys (n = 49) and girls (n = 55) with an average age of 10.63 ± .64 years. They were divided into two groups: Traditional Teaching Units (TTU); and Alternated Teaching Units (ATU). The first group had five lessons in sequence of basketball and than five lessons in sequence of soccer. The second group had alternated lessons of basketball and soccer during the 10 lessons unit	Operational	PTK - SSCG - GPAI (Oslin et al, 1998) PTK/DTK - Questionnaire - TACSIS spanish version (Viciano et al, 2016) PTK/DTK - Questionnaire - Invasion Games Knowledge Test (Sánchez-Mora et al, 2011)	Results showed an improvement for the Alternated Teaching Units group in offensive (adjust) and defensive (adjust and marking) PTK measured through the SSCG. There was no improvements in PTK in the Traditional Teaching Units group. No improvements were found in DTK or PTK measured by the questionnaires of perceived tactical skills and conceptual tactical knowledge



**Table 6.** Studies with the main topic playing position

Author	Sample	Tactical principles assessed	Methodology/ Instrument	Main results
<i>Studies of Declarative Tactical Knowledge</i>				
Giacomini et al 2011	221 male soccer players from U-14, U-15 and U-17, which participated in national competitions in Brazil. They were divided into six positions: goalkeeper, fullbacks, centre backs, defensive midfielders, offensive midfielders and forwards	-	Video based test (Mangas, 1999)	No differences were found in DTK comparing the six positions
Aburachid et al 2013	39 male soccer players from U-14, U-15, U-17, and U-20 categories from a Brazilian club divided into five positions: fullbacks, centre backs, defensive midfielders, offensive midfielders and forwards	-	Video based test (Mangas, 1999)	No differences were found between DTK and positions

Studies of Procedural Tactical Knowledge

Giacomini & Greco 2008	221 male soccer players from U-14, U-15 and U-17, which participated in national competitions in Brazil. They were divided into six positions: goalkeeper, fullbacks, centre backs, defensive midfielders, offensive midfielders and forwards	General	SSCG - KORA (Memmert, 2010)	Results demonstrated that goalkeepers had the lowest values of convergent and divergent PTK compared to other positions. Additionally, offensive midfielders had greater values of divergent PTK compared to fullbacks, which is related to creative thinking
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Studies of both Declarative and Procedural Tactical Knowledge

Kannekens et al 2009	191 elite youth soccer players (age range = 14 to 18) from the top 0.5% in their age group in Netherlands divided into three positions: defenders, midfielders and attackers	-	Questionnaire - TACSIS (Elferink-Gemser et al 2004)	Attackers showed the lowest defensive DTK compared to midfielders and defenders at age 14. Offensive PTK had the greatest values of midfielders, followed by defenders and attackers at age 14. Defensive PTK was greater in defenders followed by midfielders and attackers at age 14
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**Table 7.** Studies with the main topic physical attributes

Author	Sample	Tactical principles assessed	Methodology/ Instrument	Main results
<i>Studies of Declarative Tactical Knowledge</i>				
Borges et al 2017	37 male soccer players aged 14.57 ( $\pm 1.26$ years), belonging to a regional soccer project in Brazil	-	Video based test (Mangas, 1999)	There was a negative correlation between peak height velocity and DTK, indicating that individuals who had not reached peak high velocity had greater DTK
Rechenchosky et al 2017	68 regional male soccer players (12.83 $\pm$ 2.43 years)	-	Video based test (Mangas, 1999)	Results showed relationships between DTK and aerobic power ( $r = .45$ ), speed ( $r = .42$ ) and agility ( $r = -.59$ )
<i>Studies of Procedural Tactical Knowledge</i>				
Borges et al 2015	29 male soccer players from U-15 and U-17 age groups, belonging to an extension project in Brazil	-	SSCG - GPAI (Oslin et al, 1998)	The results indicated a positive relationship between PTK and aerobic performance and a negative relationship with a time to complete a 50m running test. There was no relationship between PTK and muscle power of the lower limbs, endurance of abdominal limbs, agility and somatic maturity
<i>Studies of both Declarative and Procedural Tactical Knowledge</i>				
Forsman et al 2015	288 male soccer players aged 12 to 14 years from 16 Finnish soccer clubs	-	Questionnaire - TACSIS (Elferink-Gemser et al, 2004)	Results showed only one negative significant relationship (in nine) between speed and agility tests and PTK/DTK

**Table 8.** Studies with the main topic of associations between declarative and procedural tactical knowledge

Author	Sample	Tactical principles assessed	Methodology/ Instrument	Main results
<i>Studies of both Declarative and Procedural Tactical Knowledge</i>				
Blomqvist et al 2005	12 male school students aged 14 - 15 years	Operational	PTK - SSCG (Blomqvist et al, 2005) DTK - Video based test (Blomqvist et al, 2005)	Students presented a high positive correlation between total DTK and total PTK ( $r = .83$ ). Offensive DTK and offensive PTK showed the highest correlations values ( $r = .90$ )
Sánchez-Mora et al 2011	27 primary school students both boys ( $n = 19$ ) and girls ( $n = 8$ ) aged 9 and 10 years	Operational	PTK - SSCG - GPET (García-López et al, 2013) DTK - Questionnaire - The Knowledge Test (Contreras-Jordán et al, 2005)	No correlation was observed between the DTK and PTK the students possessed in relation to aspects of the game in both ball-keeping situations and in advancing on goal
Giacomini et al 2011	221 male soccer players from U-14, U-15 and U-17, which participated in national competitions in Brazil. They were divided into six positions: goalkeeper, fullbacks, centre backs, defensive midfielders, offensive midfielders and forwards	General	PTK - SSCG - KORA (Memmert, 2010) DTK - Video based test (Mangas, 1999)	There was a high positive correlation between the convergent PTK (game intelligence) and divergent PTK (game creativity) ( $r = .865$ ). Additionally it was observed an low positive correlation between DTK with convergent PTK ( $r = .148$ ) and divergent PTK ( $r = .153$ )

Farias et al 2015	24 students from one fifth grade class (16 girls and 8 boys, mean age 10.3) from an elementary school in northern Portugal who participated in physical education lessons two times per week	Operational	PTK - SSCG (Blomqvist et al, 2005) DTK - Questionnaire - The Game Understanding Test (Farias et al, 2015)	Results showed a moderate to high positive correlation between overall PTK with overall DTK ( $r = .61$ ), with-the-ball DTK ( $r = .50$ ) and off-the-ball DTK ( $r = .54$ ). There was also a moderate to high positive correlation between defensive PTK with overall DTK ( $r = .63$ ), with-the-ball DTK ( $r = .55$ ) and off-the-ball DTK ( $r = .57$ )
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**Table 9.** Studies with other topics

Tactical knowledge assessed	Variable assessed	Author	Sample	Tactical principles assessed	Methodology/ Instrument	Main results
DTK	Prediction	Aquino et al 2017	66 soccer players aged $16.18 \pm 0.63$ years from a high-level club in Brazil participated in this study. They were divided in groups chosen to continue in the club (selected, $n = 28$ ) and to leave the club (non-selected, $n = 38$ ). Players were assessed based on tactical skills, technical skills, biological maturation, anthropometry and motor performance	-	Video based test (Mangas, 1999)	Results showed that selected players exhibited higher values for DTK compared to deselected. Discriminant analysis showed that DTK, running speed – 30 m, maturity offset, dribbling, height, and peak power correctly classified 97% of the sample between these two groups. DTK proved to be the most important variable in the discriminant analysis
DTK and PTK	Prediction	Kannekens et al 2011	Data were collected in the period 2001–2008. Data from players who reached adulthood (21 years or older in 2009) were analyzed in this study, resulting	-	Questionnaire - TACSIS	The professional performance level was associated with the offensive PTK. For players scoring moderate (Fair–Good), the odds ratios

in a final data set of 105 players (age range: 16–18 years). These players were divided into two groups based on their adult performance level. Amateurs (n = 53) are players who play for an amateur club (second-division national league or lower). Professionals (n = 52) are players who are playing either with a Premier league club or on the first team of the first division of the national league

(Elferink-Gemser et al 2004)

indicated a 3.52 times greater chance of becoming a professional than players scoring low (Very Poor–Poor–Fair), whereas for players scoring high (Good–Very Good–Excellent), this chance is even 6.60 times greater. The correct classification of the adult performance level based on tactical skills was 69.2% for the defenders, 80.0% for the midfielders, while the attackers were classified correctly in 75.0%

DTK and  
PTK

Prediction

Huijgen et  
al 2014

113 talented adolescent soccer players attending one of two talent development programmes of professional soccer clubs in the Netherlands. They were enrolled in the development program at least two consecutive years. Players were divided in groups of selected (n = 76) and deselected (n = 37). At the moment of the selection process players were between 16-18 years. Players were evaluated based on tactical, physiological, technical and psychological skills

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Questionnaire -  
TACSIS  
(Elferink-Gemser et al 2004)

Selected players showed a greater offensive PTK compared to deselected players (high effect size;  $d = .63$ ). Furthermore, a discriminant analysis showed that peak dribbling, offensive PTK and peak sprint were responsible for correctly classify 69% of the sample in each group

PTK	Time span	Praça et al 2017	30 male soccer players from U-15 (n = 16) and U-14 (n = 14)	Core	SSCG - FUT-SAT (Teoldo et al, 2011)	There was found that throughout the season (9 measurements) U-15 athletes increased their PTK both offensive and defensive, and presented a higher PTK than U-14 players. No improvements were found for U-14 players
DTK and PTK	Time span	Forsman et al 2015	288 male soccer players aged 12 to 14 years from 16 Finnish soccer clubs measured during a period of one year	-	Questionnaire - TACSIS (Elferink-Gemser et al 2004)	Results indicated that DTK and PTK remained stable across the 1-year period, measured in three different moments
PTK	Gender	Mesquita et al 2012	26 fifth-grade students aged between 10 and 12 years, both boys (n = 9) and girls (n = 17). Participants were divided into three skill levels based on an objective measure	Operational	SSCG (Blomqvist et al, 2005)	Results showed that boys had a greater on-the-ball PTK compared to girls. Additionally, it was observed an improvement in girls' PTK in defensive off-the-ball, offensive off-the-ball and total off-the-ball situations after a 22-lesson soccer unit while no improvements were observed for PTK in boys
DTK and PTK	Gender	Serra-Olivares et al 2014	288 male and female primary school students between 8 and 13 years of age: boys (n=156) and girls (n=132)	Operational	Questionnaire - STKT (Serra-Olivares & García-López, 2016)	Boys presented a greater DTK and PTK compared to girls, regardless of age
DTK	Motivation	Menegassi et al 2018	103 male soccer players aged 10 to 17 years belonging to an extension project in Brazil	-	Video based test (Mangas, 1999)	Athletes with higher levels of autonomous motivation have twice more chances to be classified in high DTK group compared to players with low autonomous motivation

DTK and PTK	Motivation	Forsman et al 2015	288 male soccer players aged 12 to 14 years from 16 Finnish soccer clubs measured during a period of one year	-	Questionnaire - TACSIS (Elferink-Gemser et al 2004)	There was found a positive moderate to high correlation between motivation and PTK/DTK, varying between ( $r = .42$ ) to ( $r = .56$ )
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#### 4. Discussion

The aim of this study was to systematically review the state of the art of the literature about tactical knowledge in soccer and to know the potentialities and limitations of tactical knowledge assessment in soccer. The results showed a growing interest of research in this topic in the past few years (see section 3.1). In order to answer the research question of this review the results were organized based on the methodologies used for tactical knowledge assessment, the pedagogical theoretical basis used for assessment (tactical principles) and the similarities of research topics emerged from the review process.

##### *4.1 Methodologies used for Tactical Knowledge Assessment*

We found that DTK was mostly assessed by questionnaires ( $n = 12$ ) and video-based tests ( $n = 11$ ), while few studies used interview ( $n = 4$ ). The most common questionnaire found to be used in this review was the Tactical Skills Inventory for Sports (TACSIS) (ELFERINK-GEMSER *et al.*, 2004) ( $n = 6$ ), followed by the Soccer Tactical Knowledge Test (SKTK) (SERRA-OLIVARES; GARCÍA-LÓPEZ, 2016) ( $n = 4$ ). These both questionnaires assess the offensive and defensive phases. The great difference is that TACSIS is a self-assessed (perceived) tactical skills of youth soccer players whereas SKTK measure tactical knowledge based on the analysis of contextual situations in figures with multiple choice questions. There is some criticism about TACSIS regarding its subjective measure, as players are asked to compare themselves with “top players” of their age (ARAÚJO; TRAVASSOS; VILAR, 2010). It raises questions about scientific control of such measures, once it depends on players’ own reference of what top players are. Therefore, results from such subjective measures must be interpreted with caution.

On the other hand, video-based tests were mostly assessed by the instrument developed by Mangas (1999) ( $n = 10$ ). This methodology is based on the analysis of video sequences of official matches, where participants have to choose the best solution for each situation and are instructed to answer “What should the player in possession of the ball do?”. Although it has been widely used over time, this test assesses only the offensive phase and is based on the analysis of situations of the attacking player with the ball. Consequently, test results are limited to inform player’s DTK based on such situations, although during the actual game, players spend between

1% and 3% of the time in possession of the ball (GARGANTA, 1997). It means that around 97% of the time players are performing movements without the ball and it is not assessed by this test. Therefore, it shows a gap on current assessment of DTK based on video-based tests. This issue must be addressed in future research, with more coherence and representativeness of what is being assessed and what players actually perform on game situations.

A few studies in DTK also used interview to gather information about players' knowledge of general concepts of technical and tactical roles and rules of the game. This type of methodology enable assessment of more basic knowledge and might underestimate players' knowledge of game like situations, due the lack of representativeness of the game, especially for those with great accumulated practice (SERRA-OLIVARES; CLEMENTE; GONZÁLEZ-VÍLLORA, 2016). However, this type of methodology when used together with other methodologies, such as video-based test or game like situations, might be an important tool to analyze in-depth the development of procedures and the relation between DTK and PTK (MCIPHERSON, 1994; GONZÁLEZ-VÍLLORA *et al.*, 2013).

In regards to methodologies used for PTK assessment, we found that SSCG (n = 21) were the most common, followed by questionnaires (n = 11), and few research used video-based tests (n = 4) and interview (n = 1). The SSCG were assessed by the instruments GPET (GARCÍA-LÓPEZ *et al.*, 2013) (n = 9), FUT-SAT (TEOLDO *et al.*, 2011a) (n = 4), GPAI (OSLIN; MITCHELL; GRIFFIN, 1998) (n = 3), the instrument developed by Blomqvist *et al* (2005) (n = 3), KORA (MEMMERT, 2010) (n = 2) and TPTK:OE (GRECO *et al.*, 2015) (n = 1). These instruments have in common its representativeness of the game and are able to assess PTK in a game like situation (SERRA-OLIVARES; CLEMENTE; GONZÁLEZ-VÍLLORA, 2016). All of them keep the most important aspects of the game, such as the ball, teammates and opposition, whereas one of them was even more specific by keeping the goalposts and goalkeepers (e.g. FUT-SAT). These components are fundamental to keep relationship between key sources of information and response execution of players, in a contextualized environment, which creates an optimum scenario to assess PTK.

Questionnaires were the second most common methodology used to assess PTK. Again, TAC SIS (n = 6) and SKTK (n = 4) were the most common instruments used in this type of methodology. Moreover, video-based tests and interview were also used to assess PTK. These methodologies enable the assessment of players' response

execution components, but in a non like game situation, which might cause great disparity between the results and its transfer to actual game, differently of SSCG.

Taken together, we suggest that methodology used in future research be as representative as possible of actual game, in order to assess players' knowledge in more naturalistic settings and enhance its transferability and applicability for actual game. Therefore, the use of SSCG are preferable to other tools in order to assess PTK, due its representativeness of the game (SERRA-OLIVARES; CLEMENTE; GONZÁLEZ-VÍLLORA, 2016). On the other hand, the use of video-based tests are preferable to assess DTK, once it offer a more natural perception of the scene, compared to static figures, questionnaires or interview (MANN *et al.*, 2007). Although video-based tests are preferable to assess DTK compared to other methodologies, there is a need for improvement in current instruments, once it is limited to assess only the player in possession of the ball.

#### *4.2 Tactical Knowledge Assessment based on Tactical Principles*

An important aspect of tactical knowledge assessment is its theoretical construct basis (GONZÁLEZ-VÍLLORA *et al.*, 2015). This assessment might be grounded in constructs that take into account the logic of the game, which allows measure players' operationalization of such concepts. Additionally, consonance between training and tactical assessment in a regular basis is fundamental to qualify the process of talent development and identification over the years of sport development of a player (SARMENTO *et al.*, 2018). In this regard, the assessment based on tactical principles meet this both criteria, once it was constructed based on the logic of the game (TEOLDO *et al.*, 2010a) and it is a content used for tactical skill training (TEOLDO; GUILHERME; GARGANTA, 2015).

The results from this review showed that DTK was mostly assessed neglecting such principles (61.5%,  $n = 16$ ), and only the minority (38.5%,  $n = 10$ ) took into consideration tactical principles. Surprisingly, those studies that considered tactical principles, only operational principles have been assessed. These results are related to the lack of instruments available to assess both core and general tactical principles. It is a limitation that must be overcome, as these both types of principles are important in players' sports development. General tactical principles are the most basic type of principles and it is recommended its training between age 6–10 years, when children already can socialize with each other (PIAGET, 1993). On the other hand, core tactical

principles start to be taught around age of 11/12 years, when players have their cognitive maturation in final stage, and are able to use abstract thought to operationalize this type of tactical principle (TEOLDO; GUILHERME; GARGANTA, 2015). Therefore, research must give a step forward into the development of instruments able to assess DTK based on both core and general tactical principles.

In contrast to these results, PTK research was based largely on tactical principles (77,4%,  $n = 24$ ) and only less than a quarter (22,6%,  $n = 7$ ) did not considered such principles. These results are surprisingly stimulating, since it demonstrate great synergy between PTK assessment and the training process (GONZÁLEZ-VÍLLORA *et al.*, 2015). Mostly of these studies took into consideration operational tactical principles ( $n = 18$ ). It might be related to the availability of five different instruments used to assess this type of principle. On the other hand, research of PTK based on core ( $n = 4$ ) and general ( $n = 2$ ) tactical principles were less frequent. It demonstrate a need to carry out further research taking into account these both tactical principles, once they are related to important phases of players' development.

Overall, these results demonstrated that the field of PTK assessment is in a greater consonance to training process, compared to DTK assessment. In order to reduce this disparity, new tools for DTK assessment are needed, specially based on core and general tactical principles. We also suggest that future research investigate PTK and DTK interaction based in the same type of principle, in order to further our knowledge about tactical knowledge coherently with theoretical basis (ANDERSON, 1982; MCPHERSON, 1994).

### 4.3 Main Research Topics

#### 4.3.1 Age

Research on age and tactical knowledge was the most frequent found in this review (Table 1) and most of them were designed to compare samples from different age groups. The great majority of these studies showed a positive influence of age in both declarative (KANNEKENS *et al.*, 2009; GIACOMINI; SILVA; GRECO, 2011; ABURACHID; SILVA; GRECO, 2013; MOREIRA *et al.*, 2014; SERRA-OLIVARES *et al.*, 2015a; AMÉRICO *et al.*, 2017; SERRA-OLIVARES; GARCÍA-LÓPEZ; GUTIÉRREZ-DÍAZ, 2017) and procedural (GIACOMINI; GRECO, 2008; KANNEKENS *et al.*, 2009; TEOLDO *et al.*, 2010a; GONZÁLEZ-VÍLLORA;

GARCÍA-LÓPEZ; CONTRERAS-JORDÁN, 2015; SERRA-OLIVARES *et al.*, 2015a; SERRA-OLIVARES; GARCÍA-LÓPEZ; GUTIÉRREZ-DÍAZ, 2017) tactical knowledge. Such results support previous studies about the increase of performance over time due, to accumulation of hours of practice, play and competition (ERICSSON; KRAMPE; TESCH-ROMER, 1993; WARD *et al.*, 2007; FORD *et al.*, 2012). In contrast, Serra-Olivares (2014) found different results, where 13 years children showed lower DTK and PTK compared to younger colleagues (10, 11, and 12 years). However, this study was carried out with primary school students, which is not an specific sport development environment. Thus, accumulated hours of soccer activities (practice, play and competition) of such sample are more related to children personal interests in soccer instead of aging (MESQUITA; FARIAS; HASTIE, 2012).

We also found a consistent trend over players' development, which comparisons done among players with two years difference (e.g. U-11 with U-13) were more likely to show statistical differences in comparison to one year difference (e.g. U-8 with U-9) comparisons for both DTK and PTK. These results might be linked to current organization of competition and teams, that usually group players in a two year basis and therefore gives a more homogeneous training stimulus over development process (FORD; YATES; WILLIAMS, 2010).

In regards to DTK, differences were mainly found in comparisons between U-15 with younger age groups (e.g. U-14 and U-11) (GIACOMINI; SILVA; GRECO, 2011; AMÉRICO *et al.*, 2017). However, all the studies that found such differences assessed DTK through the video-based test developed by Mangas (1999), which assess only the attacking player with the ball in the offensive phase. Such methodological limitation might cause a bias in comparisons performed between U-15 and older age groups, as from these age players are in the investment years of sports development (CÔTE; BAKER; ABERNETHY, 2007), and the training focuses on group and collective tactics, instead of individual actions (TEOLDO; GUILHERME; GARGANTA, 2015). Accordingly, as training and assessment must be in line, future research might focus DTK assessment on group and collective tactical aspect of both offensive and defensive phases for players in investment years (e.g. U-15 and older) instead of only individual aspects.

Results from PTK research showed an improvement of players earlier as eight years of age up to 20 years in a two years comparison basis (e.g. U-8 and U-10) (GIACOMINI; GRECO, 2008; TEOLDO *et al.*, 2010a; GONZÁLEZ-VÍLLORA;

GARCÍA-LÓPEZ; CONTRERAS-JORDÁN, 2015; SERRA-OLIVARES *et al.*, 2015a). On the other hand, no differences were found between players of U-17 compared to U-16 years (PRAÇA; MOREIRA; GRECO, 2017) and U-17 compared U-15 years (BORGES; AVELAR; RINALDI, 2015). An interesting aspect of these results, is that all studies that showed differences between ages, the assessment instruments were based on tactical principles (general, operational or core principles), in contrast to those that showed no differences. Probably it is related to sensitivity of the instruments used, which enabled the measurement of tactical knowledge acquisition based on tactical principles that were trained and developed over the years of players' sport development (TEOLDO *et al.*, 2009). By contrast, instruments that measure other aspects of tactical knowledge, different of tactical principles, might be in less consonance with the training process and therefore have less sensitivity to capture players' tactical knowledge development (GONZÁLEZ-VÍLLORA *et al.*, 2015).

Taken together, studies with a descriptive approach (Table 2) (GARCÍA-LÓPEZ *et al.*, 2010; GONZÁLEZ-VÍLLORA *et al.*, 2011; GONZÁLEZ-VÍLLORA *et al.*, 2012; GONZÁLEZ-VÍLLORA *et al.*, 2013) showed that players between eight and 14 years of age have: i) better DTK and PTK in attack compared to defense; ii) greater DTK and PTK in individual actions compared to group and collective actions; iii) better PTK rate compared to skill execution rate; and iv) PTK measured through SSCG showed higher values compared to measurement of PTK on video-based tests. These results were based on operational tactical principles and showed a consistency along these years of sport development. Furthermore, players were better able to perform attacking situations, followed by possession maintenance and then scoring situations. Based on these results we suggest: i) that technical and tactical skills should be taught together in game like situations, such as SSCG, in order to develop tactical knowledge and skill execution in consonance (DAVIDS *et al.*, 2013); ii) teaching-learning should start focusing in individual situations, as it is easier for players to understand, and progressively increase complexity to group and collective situations (GONZÁLEZ-VÍLLORA; GARCÍA-LÓPEZ; CONTRERAS-JORDÁN, 2015); and iii) balance the focus on training between attack and defense, in order to develop both types of tactical knowledge in consonance.

Overall, the great majority of studies assessed in this section evaluated the influence of age on the development of DTK and PTK with no control of practice,

playing and competition time. It makes hard to draw firm conclusions about the role of age, or instead, the experience time accumulated over the years in different soccer activities (CÔTE; BAKER; ABERNETHY, 2007). Therefore, we suggest for future research a better control of such variables, in order to identify the real influence of age and type of soccer activities on players' tactical knowledge development. Furthermore, there is a lack of longitudinal designs in this topic research (only one of 17 studies) that must be included in future research to further our knowledge of intra-individual tactical knowledge development.

#### 4.3.2 Expertise

Expertise has been widely studied in different areas of sport, in order to identify important aspects of its development (WILLIAMS *et al.*, 2011). In this review, almost every study about expertise (Table 3) showed that increases of expertise level reflects in higher declarative (KANNEKENS; ELFERINK-GEMSER; VISSCHER, 2009; SERRA-OLIVARES, 2014; SERRA-OLIVARES *et al.*, 2015a; SERRA-OLIVARES; GARCÍA-LÓPEZ, 2016; SERRA-OLIVARES; GARCÍA-LÓPEZ; GUTIÉRREZ-DÍAZ, 2017) and procedural (KANNEKENS; ELFERINK-GEMSER; VISSCHER, 2009; GARCÍA-LÓPEZ *et al.*, 2010; GUTIÉRREZ-DÍAZ *et al.*, 2011; MESQUITA; FARIAS; HASTIE, 2012; SERRA-OLIVARES, 2014; SERRA-OLIVARES *et al.*, 2015a; SERRA-OLIVARES; GARCÍA-LÓPEZ, 2016; SERRA-OLIVARES; GARCÍA-LÓPEZ; GUTIÉRREZ-DÍAZ, 2017) tactical knowledge. These results are in line with previous studies about the development of expertise, which consistently showed an increase of performance and specific knowledge over time due to accumulation of hours of practice, play and competition (ERICSSON; KRAMPE; TESCH-ROMER, 1993; WARD *et al.*, 2007; FORD *et al.*, 2012). An exception was found in a study of Costa (2016) that found no differences in DTK compared between U-17 players from an soccer club context and a school context. However, this study was carried out with an Brazilian sample, which has soccer as it main sport practiced by males, and there was no control on players' previous experience in soccer, which might have influenced this result. Additionally, the instrument used in this study (MANGAS, 1999) is not based in tactical principles and it might be less sensitive to find differences in tactical knowledge due its lack of consonance with the training process (GONZÁLEZ-VÍLLORA *et al.*, 2015).

We also found a trend that players from soccer clubs and recreational context



showed no differences among them but outperformed school students in DTK and PTK (SERRA-OLIVARES; GARCÍA-LÓPEZ, 2016; SERRA-OLIVARES; GARCÍA-LÓPEZ; GUTIÉRREZ-DÍAZ, 2017). These results are somehow surprising, due no differences in recreational and club contexts, once specific soccer training has been systematically shown to be an important variable to achieve high levels of performance (WARD *et al.*, 2007; FORD *et al.*, 2009). Alternatively, it might be explained by the methodology used in these studies, based on a questionnaire (SERRA-OLIVARES; GARCÍA-LÓPEZ, 2016), which are less representative of the game, compared to SSCG and video-based tests (MANN *et al.*, 2007; SERRA-OLIVARES; CLEMENTE; GONZÁLEZ-VÍLLORA, 2016). Therefore, in order to test this hypothesis future studies should use more representative methodologies to compare tactical knowledge between recreational and soccer club players.

In regards to PTK it was found that international and national players outperformed regional, provincial and no experienced players (GARCÍA-LÓPEZ *et al.*, 2010). Additionally, differences among different expertise levels increases with age (GUTIÉRREZ-DÍAZ *et al.*, 2011). These results might be due to the systematic increase of differences in accumulated hours of practice and competition between these groups according to aging and expertise level (WARD *et al.*, 2007) as these two types of activities are positively correlated to PTK (SERRA-OLIVARES, 2014).

Taken together, the aforementioned studies showed differences in tactical knowledge of different expertise levels earlier as seven years of age (GUTIÉRREZ-DÍAZ *et al.*, 2011) up to 23 years (KANNEKENS; ELFERINK-GEMSER; VISSCHER, 2009). Furthermore, all of the studies that used instruments based on tactical principles were sensitive to find differences among expertise levels. However, all these studies focused on operational tactical principles and for future research we suggest comparisons between different expertise levels based on other types of principles, such as core tactical principles for samples from 11 years of age up to professional and general tactical principles for samples from six years of age.

#### 4.3.3 Technical skills

In the past few decades, players' technical skills are probably the dimension considered by coaches and staff one of the most important for high achievements in soccer, and consequently the one of the most trained (FORD; YATES; WILLIAMS, 2010). We found that a considerable research attention has been driven to understand



associations between this topic and tactical knowledge (Table 4). The most part of studies showed a positive association between technical skills, such as shooting, dribbling, passing, receiving, dueling and intercepting with DTK (BLOMQVIST; VÄNTTINEN; LUHTANEN, 2005; RECHENCHOSKY *et al.*, 2017), and skills of shooting, dribbling, passing and receiving with PTK (SÁNCHEZ-MORA *et al.*, 2011; BORGES; AVELAR; RINALDI, 2015; GONZÁLEZ-VÍLLORA; GARCÍA-LÓPEZ; CONTRERAS-JORDÁN, 2015; AQUINO *et al.*, 2016).

Although these positive associations were found, there was a great variability between weak to high correlations. The highest correlations were found in studies that assessed technical skills and PTK in the same SSCG (SÁNCHEZ-MORA *et al.*, 2011; BORGES; AVELAR; RINALDI, 2015). On the other hand, medium and weak correlations were found in assessment of technical skills without a game context with DTK (RECHENCHOSKY *et al.*, 2017) and PTK (AQUINO *et al.*, 2016). In contrast to these findings, there was an unique study that found no differences between technical skills and tactical knowledge (DTK and PTK) (FORSMAN *et al.*, 2015). Not surprisingly, this study was the only one that assessed tactical knowledge based on a questionnaire, and which did not used tactical principles (ELFERINK-GEMSER *et al.*, 2004), correlated to technical tests without a game context. Taking these results altogether, they reinforce the narrow link between technical and tactical skills in a game context and the importance of assessment based on representative tasks of soccer in order to maintain the variability and unpredictability of the game, instead of decontextualized use of technical skills (GONZÁLEZ-VÍLLORA *et al.*, 2015; SERRA-OLIVARES; CLEMENTE; GONZÁLEZ-VÍLLORA, 2016).

#### 4.3.4 Intervention

An important topic of sports sciences are based on development and testing of interventions, in order to measure effectiveness of diverse instructional approaches (ARAÚJO; MESQUITA; HASTIE, 2014). In this regard, some relatively recent approaches emerged from cognitive and constructivist concepts, such as Teaching Games for Understanding (TGfU), which focus on the development of tactical skills in different sports. We found that interventions based on TGfU (SOUZA *et al.*, 2014; PRÁXEDES *et al.*, 2016; ASHRAF, 2017), hybrid Sport Education – Invasion Games Model (MESQUITA; FARIAS; HASTIE, 2012; FARIAS; MESQUITA; HASTIE, 2015) and Alternated Teaching Units (VICIANA *et al.*, 2017) improved players' PTK

(Table 5). These interventions were mostly taken with the minimum of 20 lessons albeit two of them took less than 20 lessons (FARIAS; MESQUITA; HASTIE, 2015; VICIANA *et al.*, 2017). Furthermore, when compared to traditional methodology, focused on technical approach different from real games situation, TGfU showed more effectiveness on the development of PTK (ASHRAF, 2017).

These results are in line with recent literature findings supporting game-based approaches effectiveness, compared do technique-centered approach, in the development of both tactical and technical skills (ARAÚJO; MESQUITA; HASTIE, 2014; SERRA-OLIVARES *et al.*, 2015b). Game-based approaches have been gradually introduced in physical education and sport clubs curriculum, because enable the development of both perceptual and motor skills coupled in representative tasks of the game and based on the logic of the game (e.g. tactical principles) and pedagogical principles. Therefore, experimental designs must use assessments tools developed based in such game-based approaches in order to perform a coherent analysis of intervention effectiveness (GONZÁLEZ-VÍLLORA *et al.*, 2015). Interestingly, the unique study that showed no improvements in DTK after an intervention (VICIANA *et al.*, 2017) used a questionnaire based in perceived tactical skills and used no tactical or pedagogical principles (ELFERINK-GEMSER *et al.*, 2004). This lack of improvement arise the question if this result is linked to the intervention used or the sensitivity of assessment tool used to measure DTK.

The other study found in this review that measured DTK assessed school students and showed improvement in both offensive and defensive actions after a hybrid Sport Education – Invasion Games Model (FARIAS; MESQUITA; HASTIE, 2015). Unfortunately, due to scarce studies (only two in this review) assessing the impact of interventions in DTK is hard to draw firm conclusions about this topic. Therefore, future studies should investigate DTK with different interventions and assessment based on tactical principles and more representative methodologies, differently of perceived tactical knowledge based on questionnaires. Additionally, interventions in soccer club contexts were assessed in only two studies (SOUZA *et al.*, 2014; PRÁXEDES *et al.*, 2016), and future research should focus in this type of context, specially testing intervention based on different types of tactical principles in both DTK and PTK.

#### 4.3.5 *Playing position*

Due to the high demanding environment of soccer matches, different tactical functions are necessary to perform individual well, as a team (GRÉHAIGNE; BOUTHIER; DAVID, 1997). These diverse functions are determined by the playing position of each player on the match. Therefore, some research aimed to answer if there differences in DTK and PTK comparing different playing positions (Table 6). In regards to DTK, no differences were found in comparisons between fullbacks, center backs, defensive midfielders, offensive midfielders and forwards (GIACOMINI; SILVA; GRECO, 2011; ABURACHID; SILVA; GRECO, 2013). Additionally, in comparisons among attackers, midfielders and defenders (14 to 18 years of age), differences were found only in U-14 soccer players with attackers showing lower DTK compared to the other positions (KANNEKENS *et al.*, 2009).

These results are somehow surprising, due to differences in players roles according to different positions, in which more defensive positions (e.g. fullbacks and center backs) are expected to have better defensive tactical knowledge, while more offensive positions (e.g. offensive midfielders and forwards) are expected to possess better offensive tactical knowledge. Therefore it might be linked to exposure of uniform training settings during sport development process (FORD; YATES; WILLIAMS, 2010) regardless of playing position, which can lead to a uniform tactical knowledge basis. An alternative explanation also can be driven based on the assessment tools in such studies, as they have not assessed DTK based on tactical principles, and might be hidden differences between these playing positions due the lack of consonance among training and assessment contents (TEOLDO *et al.*, 2009).

On the other hand, research on PTK found that goalkeepers had lower knowledge, convergent (linked to game intelligence) and divergent (linked to creative thinking), compared to fullbacks, center backs, defensive midfielders, offensive midfielders and forwards (GIACOMINI; GRECO, 2008). Additionally, midfielders had higher divergent PTK compared to fullbacks. Similar findings, showed higher offensive PTK of midfielder players compared to defenders and attackers of U-14 category, while defenders had greater defensive PTK compared to midfielders and attackers (KANNEKENS *et al.*, 2009). These results probably are linked to the lack of training and active participation of goalkeepers in attacking situations compared do other positions and specific roles in the game performed by midfielders, such as creating more creative solutions in situations of great pressure, and defenders that are

main responsible for regain the ball possession (TAYLOR; MELLALIEU; JAMES, 2004).

Overall, these findings suggest that playing position influences PTK but have few impact on DTK. However, due the few studies in this topic and methodological limitations, further research should assess players' tactical knowledge in line with training process and therefore use instruments based on tactical principles, especially for DTK, in order to confirm (or not) the results found in this review.

#### 4.3.6 *Physical attributes*

A characteristic of soccer is the multivariate nature of performance that allow players of a variety of profiles and physical attributes to achieve professional standard, differently of other team sports, based mostly in physical characteristics, such as basketball and volleyball. This characteristic of soccer arise questions of how physical attributes and tactical knowledge are linked to players' development. Some studies addressed this question (Table 7) and found that DTK is positively associated to aerobic power, speed, and player's agility (FORSMAN *et al.*, 2015; RECHENCHOSKY *et al.*, 2017), while PTK is positively associated to aerobic performance and speed (BORGES; AVELAR; RINALDI, 2015; FORSMAN *et al.*, 2015). It is well known that players' physical performance increases according to age (FIGUEIREDO; COELHO E SILVA; MALINA, 2011) as well PTK and DTK also increases (TEOLDO *et al.*, 2010a; SERRA-OLIVARES; GARCÍA-LÓPEZ; GUTIÉRREZ-DÍAZ, 2017). Therefore the aforementioned results are probably an outcome of players getting bigger and stronger, which positively affect physical performance (PHILIPPAERTS *et al.*, 2006), and accumulation of more hours in soccer specific activities according to aging, which is positively associated to tactical knowledge (SERRA-OLIVARES, 2014).

On the other hand, Borges et al (2017) found a negative correlation between DTK and peak height velocity (PHV). It means that players that had not reached PHV had greater DTK and advance in maturation did not meant superior DTK. Although players from this study differed in PHV, groups were homogeny in terms of experience time in soccer. This result might indicate that players with similar practice time that underlies less in physical attributes (early matures), can compensate this physical disadvantage outperforming their peers in tactical knowledge and performance as found in previous studies, especially for the offensive phase (TEOLDO *et al.*, 2010b;

MACHADO; SCAGLIA; TEOLDO, 2015; MACHADO; TEOLDO, 2016).

In order to understand the real association between physical attributes and tactical knowledge, future studies should control maturation status as Borges et al (2017) did and compare players within-groups of maturity status, or alternatively use homogeneity samples that already past the peak high velocity. Furthermore these studies also should assess tactical knowledge based on game principles, differently of the studies found in this review.

#### 4.3.7 *Associations between declarative and procedural tactical knowledge*

Theoretical assumptions and research in other domains, have found that knowledge acquisition usually proceeds from declarative to procedural (ANDERSON, 1983). In sports, some evidences also supported this view in open-skill sports (MCPHERSON; KERNODLE, 2003). In regards to soccer, although 40 studies were selected in this review, only 10% (n =4) aimed to study associations between DTK and PTK (Table 8). The results showed great variability, with high correlations (BLOMQVIST; VÄNTTINEN; LUHTANEN, 2005), medium correlations (FARIAS; MESQUITA; HASTIE, 2015), low correlations (GIACOMINI *et al.*, 2011) and no correlations (SÁNCHEZ-MORA *et al.*, 2011) been found.

Two of these studies coherently assessed PTK and DTK based in the same category of tactical principles (operational) and one showed the greatest correlation (high) (BLOMQVIST; VÄNTTINEN; LUHTANEN, 2005) and the other found no correlation (SÁNCHEZ-MORA *et al.*, 2011). Although surprisingly, these findings actually seems to be in line with knowledge based theory, as one explanation for such results could be the age of the samples, where the greatest correlations were found in 14-15 years group, whereas no correlation was found in 9-10 years group. Theory assumes that knowledge development has different stages, and in the first stage, known as declarative stage (or cognitive stage), individuals have available declarative knowledge but not procedural knowledge and therefore correlations between these two types of knowledge are not expected (FITTS; POSNER, 1967; ANDERSON, 1982). On the other hand, the second stage of knowledge development, known as knowledge compilation (or associative stage), is really a transition between the declarative to procedural knowledge, where correlations of these knowledges are expected to be higher. Interestingly, these age groups and the aforementioned findings are in line with the two first stages of the Developmental Model of Sport Participation (DMSP),

namely sampling years (6-12 years) and specializing years (12-15 years) (CÔTE; BAKER; ABERNETHY, 2007). It might indicated somehow an association between the different stages of knowledge development with the sport development phases.

The other two studies assessed DTK and PTK based in different theoretical constructs, which make hard to draw firm conclusions about such results. In order to further understand the development of tactical knowledge in soccer we suggest that future studies explore the association of both DTK and PTK based on the same theoretical constructs. Furthermore, other categories of tactical principles (general and core) must be assessed and different DMSP phases can be taken into account in line with the stages of knowledge development theories.

#### 4.3.8 *Other topics*

We organized the previous sections based in similar topics emerged from the review process. In order to comprise topics found less frequently in this review ( $n < 4$ ), we included this category called “Other topics” to discuss such themes (Table 9). These studies were carried out with topics such as prediction of selection in training programs (HUIJGEN *et al.*, 2014; AQUINO *et al.*, 2017) and prediction in future performance (KANNEKENS; ELFERINK-GEMSER; VISSCHER, 2011); timespan comparisons (FORSMAN *et al.*, 2015; PRAÇA *et al.*, 2017); gender (MESQUITA; FARIAS; HASTIE, 2012; SERRA-OLIVARES, 2014); and motivation (FORSMAN *et al.*, 2015; MENEGASSI *et al.*, 2018).

Studies that assessed prediction to be selected from a soccer club based on a multivariate battery of soccer tests, showed that both DTK (AQUINO *et al.*, 2017) and PTK (HUIJGEN *et al.*, 2014) were important to discriminate between selected and non-selected players. Aquino and colleagues (2017) found that DTK, measured through video based test (MANGAS, 1999), was the most important variable in discriminant analysis to classify 97% of players correctly in selected and non-selected groups among technical, physical, maturational and anthropometrical variables. Additionally, Huijgen *et al.* (2014) showed that offensive PTK, measured through questionnaire (ELFERINK-GEMSER *et al.*, 2004), was the second most important variable to correctly classify 69% between selected and non-selected groups among technical and physiological variables. In these both studies aforementioned, selected players showed great values in tactical knowledge compared to non-selected players. Furthermore, the prediction of adult performance (professional or amateur) of players assessed between



16 to 18 years of age was positively influenced by offensive PTK, measured through questionnaire (ELFERINK-GEMSER *et al.*, 2004), and correctly classified players 69,2% for defenders, 75% for attackers and 80,0% for midfielders (KANNEKENS; ELFERINK-GEMSER; VISSCHER, 2011). These results showed the importance of tactical knowledge assessment used solely or together with other tests, in order to predict players' permanence in development programs or future performance. It indicates the value of such assessment to be included in development and selection processes, specially using multidimensional approaches, in order to enhance knowledge driven decisions and improve such processes (WILLIAMS; REILLY, 2000; SARMENTO *et al.*, 2018).

In regards to studies carried out in a time span of approximately one year (one sport season), results showed an improvement in offensive and defensive PTK (PRAÇA *et al.*, 2017), but no improvements in perceived DTK and PTK (FORSMAN *et al.*, 2015). Probably PTK enhancement, which was assessed based in SSCG and tactical principles (TEOLDO *et al.*, 2011a), is related to accumulation of soccer activities during this period of one year, specially team practice specifically designed to improve players' performance during the sport season, which has been systematically proved to positively influence perceptual-cognitive skills and is related to great expertise in soccer (WARD *et al.*, 2007; ROCA; WILLIAMS; FORD, 2012). Interestingly, Praça and colleagues (2017) found that although PTK improved throughout a season, it was non-linear, which indicates a need to constantly assess such development in order to adequate the training process (GONZÁLEZ-VÍLLORA *et al.*, 2015). On the other hand, Forsman et al (2015) found no improvements in perceived DTK and PTK, measured through a questionnaire (ELFERINK-GEMSER *et al.*, 2004), which indicates that players' perception about their tactical knowledge has not improved over a season, but not necessarily indicate that their tactical knowledge has not changed over this time span. Previous research that compared PTK measured through this same questionnaire (TACSIS) with a SSCG, has found no correlation between them (NORTJE *et al.*, 2014), which indicates that perceived tactical knowledge is not necessarily linked to tactical knowledge measured in more objective tests (e.g. SSCG). Therefore, in longitudinal designs, such as used in these both studies aforementioned, we suggest the use of more objective measures instead of self-perceived measures of tactical knowledge.

Gender was other topic of research found in this review and studies showed that

boys had greater DTK (SERRA-OLIVARES, 2014) and PTK (MESQUITA; FARIAS; HASTIE, 2012; SERRA-OLIVARES, 2014) compared to girls, regardless of age. These results are probably linked to differences in interest and engagement with soccer activities, among gender. Boys rated soccer as their favorite sport more frequently (78%) compared to girls (25%) (MESQUITA; FARIAS; HASTIE, 2012) and also had more accumulated hours of weekly training and accumulated more competition years compared to girls (SERRA-OLIVARES, 2014). Both interest and accumulated hours in specific domains have been proved to facilitate learning and lead to great performance (ERICSSON; KRAMPE; TESCH-ROMER, 1993; CÔTÉ, 1999). Therefore, this difference in tactical knowledge among gender is probably an outcome of cultural characteristics, which usually incentivize soccer activities more frequently among boys in contrast to girls. These both studies were carried out in countries (Portugal and Spain) that soccer is more popular among boys and would be interest in future studies assess different cultures, where soccer is more popular among female population (e.g. USA).

Another theme found in this review was research among motivation and tactical knowledge. Results showed positive associations between DTK (FORSMAN *et al.*, 2015; MENEGASSI *et al.*, 2018) and PTK (FORSMAN *et al.*, 2015) with motivation. Menegassi and colleagues (2018) found that autonomous motivation had positive influence in players' DTK, whereas amotivation were negatively related to DTK. Furthermore, moderate to high correlations were found between motivation with DTK and PTK, measured with a perceived tactical knowledge questionnaire (ELFERINK-GEMSER *et al.*, 2004). These results indicate the need to create stimulating training environments (FORD; YATES; WILLIAMS, 2010), which may increase players' motivation, and consequently have a positive influence in tactical knowledge. Furthermore, for future studies we recommend PTK assessment based on more objective measures (e.g. SSCG) compared to perceived measures, as used in the Forsman et al study (2015) in order to confirm such results using more representative tests (GONZÁLEZ-VÍLLORA *et al.*, 2015).

## 5. Limitations

A possible limitation of this review was the languages of the studies included, as five studies were excluded based on this criteria. Another possible limitation was the search process, which was limited to Web of Knowledge, SCOPUS and



EBSCOhost databases, and might have omitted relevant studies.

## 6. Conclusions

To our knowledge, this study was the first to perform a systematic review about this research topic. We identified an increasing interest in tactical knowledge research in soccer, especially in the last five years (see section 3.1), and the most frequently topics studied were: age; expertise; technical skills; intervention; playing position; physical attributes; associations between declarative and procedural tactical knowledge; prediction of future performance; time span; gender; and motivation.

The contribution of this study was to show, based on theoretical (see sections 4.1 and 4.2) and empirical (see section 4.3) data, the importance of congruence between tactical knowledge assessment with players' training process and sport development phases (see section 4.2). Moreover we also showed the importance of assessment based on representative tasks of soccer in order to maintain the variability and unpredictability of the game (see section 4.1). Fortunately, in the last decade, assessment instruments more congruent to training process were developed (e.g. FUT-SAT, GPET and KORA). They took into account the understanding of the game and the tactical knowledge based on tactical principles (general, operational and core), which refer to game concepts, and allow an objective assessment and its transferability to training.

We found that especially the field of procedural tactical knowledge (PTK) assessment is in a great consonance to training process, compared to declarative tactical knowledge (DTK), in both theoretical and methodological issues. Although these both types of tactical knowledge (declarative and procedural) are complementary, mostly of current available instruments are based on different assumptions, which reduce effectiveness of such assessment. Exceptions are tools based on operational tactical principles, which have available instruments for DTK and PTK assessment.

However, both core and general tactical principles have no available instruments for DTK assessment. It is a limitation that must be overcome, as these both types of tactical principles are important in players' sports development. Therefore, complementary instruments in DTK assessment must be developed in line with available PTK instruments (e.g. FUT-SAT and KORA). Thus, we suggest the development of DTK assessment instruments based in core and general tactical

principles, using video-based tests, as they have superior stimulus linked to the game compared to other types of methodologies, such as questionnaires (MANN *et al.*, 2007).

In regards to available instruments, we suggest the use of those based in more representative stimulus of the game, such as SSCG for PTK assessment, and video-based tests for DTK assessment, and also based on tactical principles, which are aligned with cutting-edge theoretical and pedagogical assumptions (TEOLDO; GUILHERME; GARGANTA, 2015). Furthermore, the age of the sample also must be taken into account in order to use assessment tools in line with sports development phases (see section 4.2). Evidences from this review showed that players from different expertise levels can be differentiated by their tactical knowledge as earlier as seven years of age (GUTIÉRREZ-DÍAZ *et al.*, 2011) up to 23 years of age (KANNEKENS; ELFERINK-GEMSER; VISSCHER, 2009). It demonstrated the need to start the training and assessment of tactics early in sports development, and monitor its development until players reach professional level. Moreover, no studies were found in professional categories, which raise questions whether tactical knowledge can be a moderating factor of player's performance in such high level context.

Another important point to highlight is that although theory assumes that knowledge acquisition usually proceeds from declarative to procedural (ANDERSON, 1983), only four studies in this review investigate the association between DTK and PTK. Therefore we suggest the design of more theory driven studies based in such assumptions and future research should explore the association of both types of knowledge based on the same theoretical constructs. Additionally, we need to further our understand by which one acquires tactical knowledge and we believe we can benefit from frameworks such as the "Expert Performance Approach" (WILLIAMS; FAWVER; HODGES, 2017) in order to answer this question. It would also be interesting to explore associations of tactical knowledge between different categories of tactical principles (e.g. PTK based on operational and core tactical principles) in order to understand its interactions. We found only few studies with predictive and longitudinal designs, and future works could benefit from these both types of research. We believe that these type of research aforementioned could help in the field of talent identification and development, besides the development of soccer syllabus based on empirical data. Finally, an interesting option to facilitate future research and the

systematic use by soccer clubs and sport development programs, would be the development of more automatized platforms and software of tactical knowledge assessment in order to speed up this process.

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## STUDY 2

**Title:** TacticUP video test: Development and validation of a declarative tactical knowledge test in soccer

**Abstract:** Although the important role of tactical knowledge on players' development and performance, there are several limitations on current assessment instruments, especially for declarative tactical knowledge. Therefore, the purpose of this study is to expand the process of tactical knowledge assessment of soccer players, through the development and validation of a declarative tactical knowledge test based on core tactical principles. The TacticUP video test is composed by offensives and defensives video sequences of 11 versus 11 soccer situations. Participants should choose the most appropriate solution for each video sequence. Content validity was established based on a panel of nine experts, from four different countries. As inclusion criteria, each video sequence should have an agreement above 70% between experts in the best solution. Construct validity was assessed comparing players with distinct expertise levels. Comparisons between groups final scores showed statistical differences ( $p < 0.05$ ) in ten of the 15 variables assessed, where the expert group showed higher values compared to the non-expert group in all these ten variables. Differences were found for the tactical principles of penetration, width and length without the ball, offensive unity, defensive coverage, defensive balance, concentration and defensive unity in addition to the general indexes of offensive phase, defensive phase and game. Face validity examined acceptability and suitability of the test by players and it was measured through participants' answer of the following questions at the end of the test: Q1) Did you enjoy taking the test? (94% answered yes); Q2) If asked, would you like to take the test again? (83,9% answered yes). Reliability was determined through the test-retest method for each video sequence and Cohen's Kappa values ranged from .622 to 1.0. Therefore, the TacticUP video test showed adequate content, construct and face validity and was a reliable measure of declarative tactical knowledge. We also overcame limitations from previous video-based tests that assessed declarative tactical knowledge in soccer by introducing assessment of players without the ball, in both offensive and defensive phases.

**Keywords:** tactical skill; tactical awareness; talent development; talent identification; video-based test.

## ESTUDO 2

**Título:** TacticUP vídeo teste: Desenvolvimento e validação de um teste de conhecimento tático declarativo no futebol

**Resumo:** Apesar do importante papel do conhecimento tático sobre o desenvolvimento e o desempenho dos jogadores, há várias limitações nos atuais instrumentos de avaliação, especialmente para o conhecimento tático declarativo. Portanto, o objetivo deste estudo é ampliar o processo de avaliação do conhecimento tático de jogadores de futebol, através do desenvolvimento e validação de um teste de conhecimento tático declarativo baseado nos princípios táticos fundamentais. O TacticUP vídeo teste é composto por sequências de vídeo ofensivas e defensivas de 11 contra 11 em situações de futebol. Os participantes devem escolher a solução mais adequada para cada sequência de vídeo. A validade de conteúdo foi estabelecida com base em um painel de nove peritos, de quatro países diferentes. Como critério de inclusão cada sequência de vídeo deveria ter um concordância acima de 70% entre os peritos sobre a melhor solução. A validade de constructo foi avaliada comparando jogadores com diferentes níveis de perícia. A comparação das pontuações finais entre grupos de diferentes níveis de perícia apresentaram diferenças significativas ( $p < 0,05$ ) em dez das 15 variáveis avaliadas, onde o grupo de peritos obteve maior pontuação em todas essas dez variáveis comparado com o grupo de menor perícia. Diferenças foram encontradas para os princípios de penetração, espaço sem bola, unidade ofensiva, cobertura defensiva, equilíbrio defensivo, concentração e unidade defensiva, além dos índices gerais da fase ofensiva, fase defensiva e de jogo. A validade facial examinou a aceitabilidade e adequação do teste pelos jogadores e foi avaliada através de perguntas respondidas pelos participantes ao final do teste: Q1) Você gostou de realizar o teste? (94% responderam sim); Q2) Se solicitado, você aceitaria realizar o teste novamente? (83,9% responderam sim). A confiabilidade foi determinada através do método de teste-reteste e os valores de Kappa de Cohen foram avaliados para cada vídeo e os valores variaram de 0,622 a 1,0. O teste mostrou adequada validade de conteúdo, constructo e facial, e também foi uma medida confiável do conhecimento tático declarativo. Também foram superadas limitações de testes anteriores baseados em vídeo, que avaliaram o conhecimento tático declarativo no futebol.

**Palavras-chave:** capacidade tática; consciência tática; desenvolvimento de talento; identificação de talentos; teste de vídeo.

## 1. Introduction

In soccer, the tactical knowledge is considered an important factor for soccer players achieve high performance level, since every action in the game has as its goal a tactical purpose (GARGANTA, 2009). Teoldo, Guilherme and Garganta (2015, p. 26) define tactics as “... the management (positioning and displacement/movement) of the playing space by players and teams”. In regards to tactical knowledge, it has been divided into two distinct forms, declarative tactical knowledge (DTK) and procedural tactical knowledge (PTK) (ANDERSON, 1983; MCPHERSON, 1994). DTK is related to the knowledge about rules and goals of the game and refers to “knowing what to do”, while PTK is related to the response selection and execution in game situations and refers to “doing it” (MCPHERSON, 1994). These both types of knowledge can be understood as a continuum, which includes the possibilities that range from “knowing what do” to “doing it” (MCPHERSON, 1994).

Considering this continuum, there are evidence that both DTK and PTK in soccer are related to players’ development over time (TEOLDO *et al.*, 2010a; AMÉRICO *et al.*, 2017), distinction between different expertise levels (SERRA-OLIVARES; GARCÍA-LÓPEZ, 2016), predictive achievement of higher performance in the future (HUIJGEN *et al.*, 2014; AQUINO *et al.*, 2017), relationship with playing position (KANNEKENS *et al.*, 2009) technical skills (AQUINO *et al.*, 2016; RECHENCHOSKY *et al.*, 2017b) and physical attributes (FORSMAN *et al.*, 2015). Although these indications of the important role that tactical knowledge plays on players’ development, there are several limitations on current instruments for assessment of players’ tactical knowledge, specially the DTK (TEOLDO; GUILHERME; GARGANTA, 2015).

In this regard, some limitations of available instruments for DTK assessment are related to their methodology. One of these instruments is based on self-assessed (perceived) tactical skills questionnaire, developed by Elferink-Gemser *et al.* (2004), which raise questions about scientific control of such measures, once it relies on subjective measures of players’ own perception (NORTJE *et al.*, 2014). Another DTK assessment instrument is a video-based test developed by Mangas (1999). However, this test only assesses the offensive phase and is based on the analysis of the situations of the attacking player with the ball. Consequently, test results are limited to inform player’s DTK based

on such situations, although during the actual game, players spend between 1% and 3% of the time in possession of the ball (GARGANTA, 1997). It means that around 97% of the time players are performing movements without the ball and it is not assessed by this test, which represent a severe limitation. Therefore, these limitations aforementioned represent a gap on current DTK assessment that must be overcome with more coherence and representativeness of what is being assessed and what players actually perform on game situations.

In order to achieve this coherence, an important aspect of tactical knowledge assessment is its theoretical construct basis (GONZÁLEZ-VÍLLORA *et al.*, 2015). This assessment might be grounded in constructs that take into account the logic of the game, which allows measure players' operationalization of such concepts. Additionally, consonance between training and tactical assessment in a regular basis is fundamental to qualify the process of talent development and identification over the years of sport development of a player (GRÉHAIGNE; GODBOUT; BOUTHIER, 2001; SARMENTO *et al.*, 2018). In this regard, the assessment based on tactical principles meet this both criteria, once it was constructed based on the logic of the game (TEOLDO *et al.*, 2010a) and is a content used for tactical skill training (TEOLDO; GUILHERME; GARGANTA, 2015). Fortunately, there are currently available instruments that were developed based on such assumptions, but used for PTK assessment, as the System of Tactical Assessment in Soccer (FUT-SAT) (TEOLDO *et al.*, 2011a). Therefore, considering the tactical knowledge continuum of DTK/PTK (MCPHERSON, 1994), coherence of tactical knowledge assessment can be achieved by developing a DTK test based on the same theoretical construct of FUT-SAT, which are the core tactical principles.

These principles represent “a set of ground rules that guide players' and team's actions in both phases of play (defense and attack), in order to create unbalances in the opponent's organization, stabilize the organization of the team and provide players with an adjusted intervention within the center of play” (TEOLDO *et al.*, 2009, p. 2). The development of an DTK assessment instrument based on such principles, will allow a more effective tactical knowledge assessment based on complementarity of both types of knowledges (DTK and PTK). Additionally, it will support research based on theory-driven assumptions (ANDERSON, 1983; MCPHERSON, 1994). Another important point that

must be considered, is the methodology used for the instrument development. In order to keep representativeness of the actual game, the assessment of players' knowledge should be done in more naturalistic settings, which can enhance its transferability and applicability for actual game. In this regard, the use of video-based tests are preferable to assess DTK, once it offer a more natural perception of the scene, compared to static figures, questionnaires or interview (MANN *et al.*, 2007). Therefore, the purpose of this study is to expand the process of tactical knowledge assessment of soccer players, through the development and validation of a declarative tactical knowledge video-based test based on core tactical principles.

## **2. Development and validation of the TacticUP video test**

The development and validation of the TacticUP video test followed the perspectives suggested by Cronbach (1988) and considered important characteristics indicated by literature, such as: i) acceptability of the test between the individuals assessed (face validity) ; ii) the extent to which a measure represents a construct (content validity); iii) the capacity to differentiate individuals of different skill levels (construct validity); and iv) the consistency and repeatability in measurements (reliability) (CRONBACH; MEEHL, 1955; LANDIS; KOCH, 1977; ANASTASI, 1988; CRONBACH, 1988; GRÉHAIGNE; GODBOUT; BOUTHIER, 1997; HOPKINS, 2000). With such characteristics, the instrument may be able to adequately measure DTK in different contexts.

### *2.1 Structure of the test*

The declarative tactical knowledge test in soccer (TacticUP video test) was based on the core tactical principles of soccer (WORTHINGTON, 1974; TEOLDO *et al.*, 2009; TEOLDO; GUILHERME; GARGANTA, 2015). These principles allows players to find effective solutions for movements of the game through management of game space (TEOLDO; GUILHERME; GARGANTA, 2015). The principles are divided into five for offensive phase: i) penetration; ii) offensive coverage; iii) depth mobility; iv) width and length; v) offensive unity; and five for the defensive phase: vi) delay; vii) defensive coverage; viii) balance; ix) concentration; and x) defensive unity. These principles were

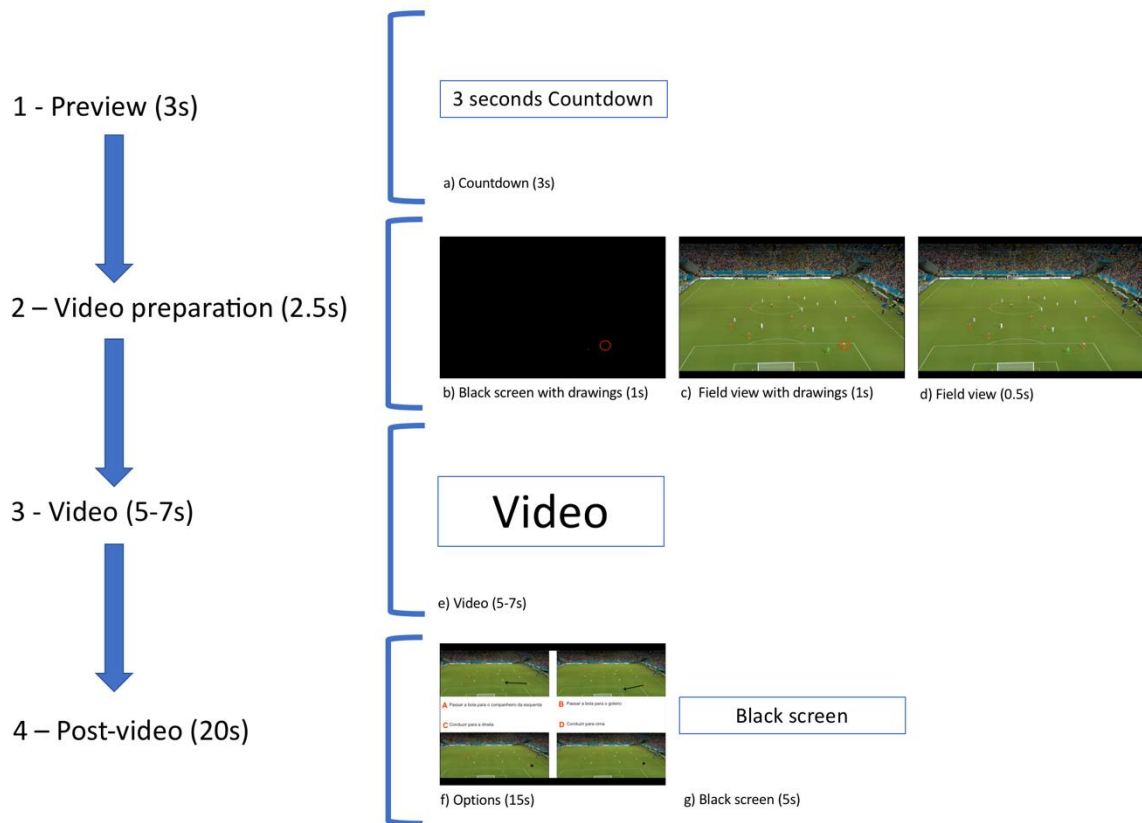


chosen because they display central aspects of the educational process of tactical capacities. Furthermore, these principles have objective measures of players' movements related to management of game space performed (TEOLDO; GUILHERME; GARGANTA, 2015)..

The TacticUP video test is composed by offensives and defensives video sequences (scenes) of 11 versus 11 soccer situations. Each scene lasted between 5s to 7s. The videos were recorded on bird's-eye view, which is an elevated view of an object from above. This view was chosen, because it allow players to visualize the tactical principles, both close or far from the ball. The test is composed by scenes of each tactical principle, from both offensive and defensive phases. In relation to the offensive principle of width and length, were created scenes for "width and length with the ball" and for "width and length without the ball". Similarly occurred with the defensive principle of balance, which were created scenes for "recovery balance" and for "defensive balance". It was done due the update of these tactical principles by Teoldo, Guilherme and Garganta (2015), which represent differences on the management of game space for each one of these tactical principles. For each scene was proposed four possibilities of solutions for the video sequence. Participants should choose the most appropriate solution for each scene. Prior to starting the test, were given instructions to participants regarding the test structure and three testing scenes were shown in order to make them familiarized to the task. These three scenes included: two offensive sequences (one scene with the observed player with the ball; and the other scene the observed player without the ball); and one defensive sequence (the observed player was in defensive phase). These three conditions were chosen to allow participants be aware of the type of video sequences they were going to watch. These scenes were edited with the software Video Observer® and Imovie®.

The scenes are presented in the following order (Figure 1): a) three seconds countdown appear (3s); b) a black screen appear, with a red dot representing the place where the ball will be shown, and a red circle with the place where the observed player will appear (1s); c) a static image of the field appear with the red dot and circle markings in order to identify the ball and the observed player (1s); d) the red dot and circle markings disappear and only the static image of the field is shown (.5s); e) the scene of the video starts (5-7s); f) answer options appear (A, B, C and D) and participants must choose the

must adequate option for that situation (15s); g) finally a black screen appear and participants have to mark the answer sheet. The video scenes are occluded with the black screen before the evolving game-play is concluded (player in possession of the ball making a pass, dribbling forward or shooting at goal). At this point participants has to answer to que question “what the observed player should do?” by marking the answer sheet. This sequence was identical for each scene within the test. We adopted the 1.5s time to shown the static image of the field, because in the game, players are aware of the position of the ball and in some degree the position of teammates and opponents (ROCA *et al.*, 2011). We choose the time of 15s to allow participants to see the answer options and 5s to mark the answer sheet, based on a pilot study carried out with soccer players between 11 and 17 years of age (same age of participants in this study), which showed that this time was enough for them to choose between the answer options and mark the sheet. The test was presented to participants via projection screen on a 3.0 x 2.2m size and the whole test application took approximately 30 minutes.



**Figure 1.** Order of scenes presentation.

The score for each scene were calculated based on the correspondence between participants answer with those chosen by a panel of experts ( $n = 9$ ). The final scores given by the TacticUP video test were separate in 15, one for each core tactical principle, plus the offensive phase, defensive phase and the game (offensive and defensive phases altogether).

## 2.2 Content validity

The selection and setting of scenes was based on conceptual description and objective parameters for core tactical principles representation (WORTHINGTON, 1974; TEOLDO *et al.*, 2009; TEOLDO; GUILHERME; GARGANTA, 2015). In this regard, the selection of the scenes was carried out considering: i) spatial references for the performance of core tactical principles (TEOLDO; GUILHERME; GARGANTA, 2015); ii) occurrence in the game of performance indicator(s) of each core tactical principle (TEOLDO; GUILHERME; GARGANTA, 2015).

For measurement of content validity of the scenes, nine experts participated in this study, from four different countries: Brazil ( $n = 4$ ), Portugal ( $n = 2$ ), Spain ( $n = 2$ ) and England ( $n = 1$ ). An expert was considered as a professional with 10 year of experience or more (ERICSSON; KRAMPE; TESCH-ROMER, 1993) in the soccer area (as coach or professor), which is in agreement with the concept established by Ericsson et al (2006) that consider an expert as an very skillful individual and recognized in a specific domain that reached good level of expertise through deliberate practice. Experts ranked the answer options for each scene between 1st, 2nd, 3rd, and 4th most adequate for that situation. Additionally, they were encouraged to provide feedback regarding the appropriateness of the content and context of the videos and the answer options in each scene, as suggested by previous research (LARKIN *et al.*, 2014). As inclusion criteria, the scenes should have an agreement above 70% between experts in the best option for each scene.

## 2.3 Construct validity

Construct validity is related to the capacity of some test to differentiate individuals with distinct performance/ characteristics (THOMAS; NELSON; SILVERSMAN, 2011). In this regard, we assessed 149 soccer players between 11.0 and 17.9 years of age ( $14.9 \pm$

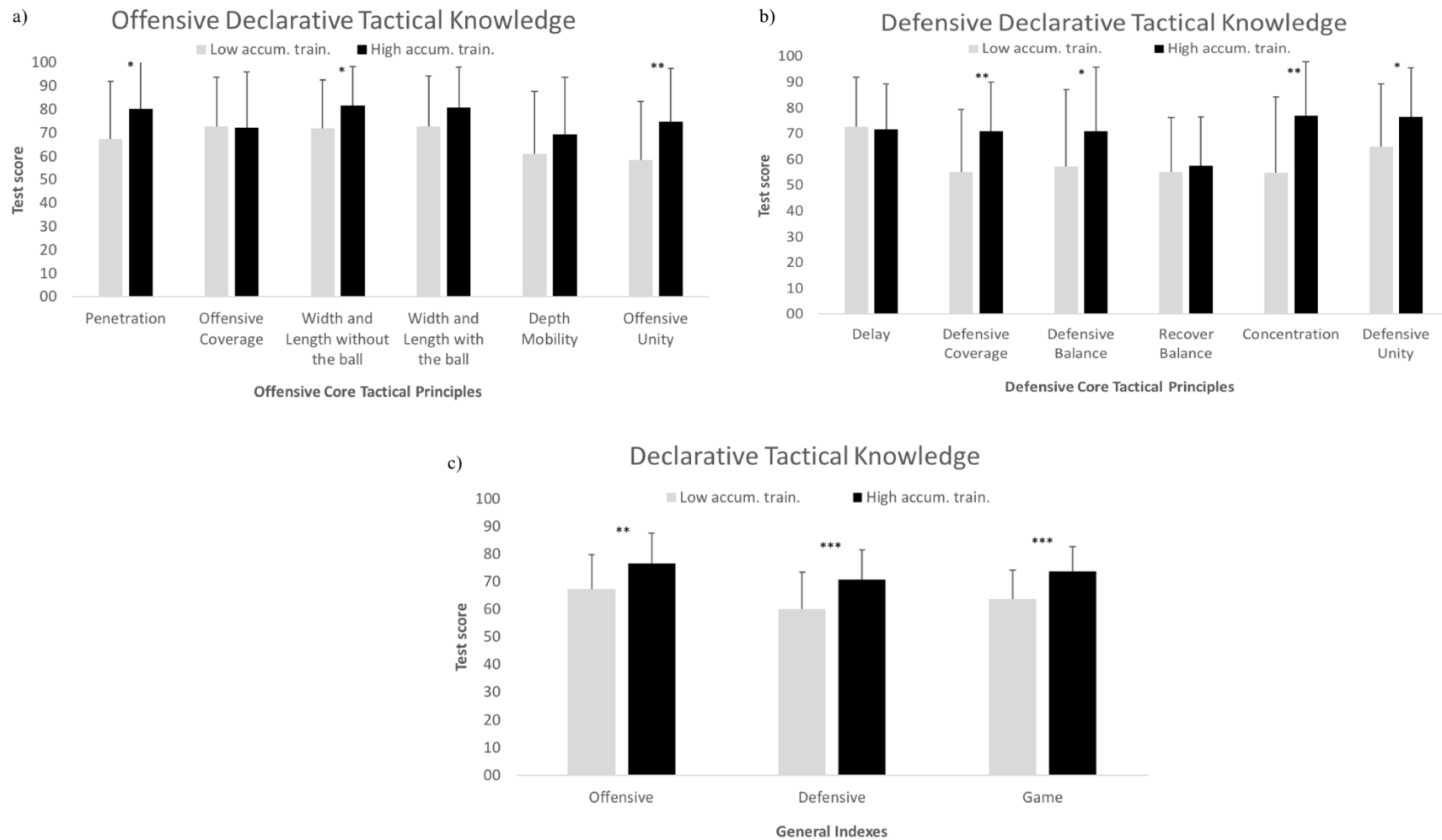
1.6 years) from three soccer teams. All the participants were training at least three times a week and were participating in national level championship for their age level, affiliated to their respective state soccer federations. Moreover, This study was approved by the Research Ethics Committee CAAE: 75581617.0.0000.5153 of Universidade Federal de Viçosa, Brazil and all procedures were in accordance with the standards of the Declaration of Helsinki (2008) and of the Brazilian National Health Board (466/2012). Moreover, the participants and their parents signed a legal consent authorizing the data collection and their use for research purposes.

For construct validity assessment, it was compared two groups of different expertise levels considering the quantity of accumulated training hours, assessed based on a validated retrospective questionnaire (WARD *et al.*, 2007). This division was done taking into account theoretical assumptions (ERICSSON; SMITH, 1991) and empirical data that shows the quantity of accumulated training hours is a discriminating factor between different expertise levels (WARD *et al.*, 2007; WEISSENSTEINER *et al.*, 2008; FORD *et al.*, 2009; FORD *et al.*, 2010; ROCA; WILLIAMS; FORD, 2012). Players were ranked according to accumulated training hours and we considered for analysis the 25% of the top, the high training hours (HTH) group ( $n = 38$ ,  $M = 2019.0$ ,  $SD = 789.4$  hours of training), and the 25% of the bottom, the low training hours (LTH) group ( $n = 38$ ,  $M = 95.8$ ,  $SD = 95.6$  hours of training) of this ranking. The rest of the sample was excluded from analysis. This procedure was used to ensure that the division criteria of participants in different expertise levels subgroups (based on accumulated training hours) were based in objective criteria that statistically differentiated both groups analyzed ( $P < .001$ ), as used in previous research (FORD *et al.*, 2010; ROCA; WILLIAMS; FORD, 2012; WILLIAMS *et al.*, 2012). Afterwards we verified the between-group differences in all the final scores using an independent  $t$  test, for normal distribution data, and a Mann-Whitney U-test, for non-normal distribution data. Distributions were checked for normality with a Kolmogorov-Smirnov test. Software SPSS 22.0 was used for analyses.

Comparisons between groups final scores showed statistical differences in ten of the 15 variables assessed, where the HTH showed higher values compared to the LTH in all these variables (Figure 1). In regards to the core tactical principles, the differences were found for the principles of: i) penetration, where the HTH ( $M = 80.3$ ,  $SD = 20.2$ ) scored

higher than the LTH ( $M = 67.4$ ,  $SD = 24.7$ ),  $U = 506.00$ ,  $z = -2.26$ ,  $p = .023$ ; ii) width and length without the ball, where the HTH ( $M = 81.8$ ,  $SD = 16.5$ ) outscored the LTH ( $M = 72.0$ ,  $SD = 20.7$ ),  $U = 518.00$ ,  $z = -2.13$ ,  $p = .033$ ; iii) offensive unity, in which the HTH ( $M = 74.9$ ,  $SD = 22.5$ ) outscored the LTH ( $M = 58.5$ ,  $SD = 24.8$ ),  $U = 449.00$ ,  $z = -2.85$ ,  $p = .004$ ; iv) defensive coverage, where the HTH ( $M = 70.9$ ,  $SD = 19.1$ ) scored higher than the LTH ( $M = 55.2$ ,  $SD = 24.2$ ),  $U = 427.00$ ,  $z = -3.07$ ,  $p = .002$ ; v) defensive balance, in which the HTH ( $M = 70.9$ ,  $SD = 24.9$ ) scored higher than the LTH ( $M = 57.3$ ,  $SD = 29.8$ ),  $U = 529.00$ ,  $z = -2.03$ ,  $p = .042$ ; vi) concentration, in which the HTH ( $M = 77.0$ ,  $SD = 21.0$ ) outscored the LTH ( $M = 54.9$ ,  $SD = 29.2$ ),  $U = 392.00$ ,  $z = -3.46$ ,  $p = .001$ ; and vii) defensive unity, where the HTH ( $M = 76.6$ ,  $SD = 18.8$ ) outscored the LTH ( $M = 64.9$ ,  $SD = 24.3$ ),  $U = 518.50$ ,  $z = -2.13$ ,  $p = .033$ .

Considering the general indexes (Figure 2), in the offensive phase, the HTH ( $M = 76.7$ ,  $SD = 10.8$ ) scored higher than the LTH ( $M = 67.3$ ,  $SD = 12.5$ ),  $t(74) = -3.33$ ,  $p = .001$ ; in the defensive phase, the HTH ( $M = 70.8$ ,  $SD = 10.7$ ) outscored the LTH ( $M = 60.0$ ,  $SD = 13.5$ ),  $t(74) = -3.86$ ,  $p < .001$ ; and in the game the HTH ( $M = 73.7$ ,  $SD = 9.1$ ) scored higher than the LTH ( $M = 63.7$ ,  $SD = 10.4$ ),  $t(74) = -4.37$ ,  $p < .001$ .



**Figure 2.** Comparison of test score between groups with low accumulated training hours and high accumulated training hours in a) Offensive Declarative Tactical Knowledge; b) Defensive Declarative Tactical Knowledge; and c) General indexes of Declarative Tactical Knowledge. \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

### 2.4 Face Validity

Face validity was verified through participants' answer of two questions at the end of the test in order to examine acceptability and suitability of the test, according to participants' motivation to perform the task (ANASTASI, 1988). The questions were: Q1) "Did you enjoy taking the test?"; and Q2) "If asked, would you like to take the test again?".

**Table 1.** Players' acceptability values for the TacticUP video test

Q1) Did you enjoy taking the test?		Q2) If asked, would you like to take the test again?	
Yes	No	Yes	No
140 (94,0%)	9 (6,0%)	125 (83,9%)	24 (16,1%)

### 2.5 Reliability

Reliability was verified through the method test-retest (BAUMGARTNER; JACKSON, 1991), respecting the interval of 21 days, to avoid familiarity with the task (ROBINSON; O'DONOGHUE, 2007). There were reassessed 15 players, representing 10,1% of the sample, according to recommended value (10%) by literature (TABACHNICK; FIDELL, 2013). Cohen's Kappa was used to determine reliability of each scene, between the first and second test application. We adopted Kappa values categorization according to reliability scale established by Landis and Koch (1977): poor agreement (<.00); slight agreement (.00 - .20); fair agreement (.21 - .40); moderate agreement (.41 - .60); substantial agreement (.61 - .80); almost perfect agreement (.81 - 1.00). Kappa values of the scenes ranged from .622 to 1.0, which means that they were classified as "substantial agreement" and "almost perfect agreement".

## 3. Discussion

The purpose of this study was to expand the process of tactical knowledge assessment of soccer players through the development of a declarative tactical knowledge test based on core tactical principles. We developed the TacticUP video test, which showed adequate content, construct and face validity and was also an reliable measure of

declarative tactical knowledge. In regards to validation, we used a panel of experts to assure content validity of the TacticUP video test, as done on previous video-based validation studies (ROCA *et al.*, 2011; LARKIN *et al.*, 2014). Obtaining the opinion and feedback from expert practitioners is an important step to ensure that the instrument measures what it claims to measure and represents the context and content of the domain being measured (SIRECI, 1998). Furthermore, following recommendations from Larkin *et al.* (2014), a novelty in our study compared to others declarative tactical knowledge tests, is that we used experts from 4 different countries, which brings a cross-cultural view of the game and is less susceptible to have some bias regarding a “point of view” about soccer tactics from one country or culture.

The construct validity of tactical knowledge tests has been usually assessed based on its capacity to differentiate players with different performance contexts or distinct accumulated amounts of training (MANGAS, 1999; GARCÍA-LÓPEZ *et al.*, 2013; SERRA-OLIVARES; GARCÍA-LÓPEZ, 2016). In this regard, previous studies that compared individuals with different expertise levels, demonstrated differences in their declarative tactical knowledge (MANGAS, 1999; SERRA-OLIVARES; GARCÍA-LÓPEZ, 2016), which suggest the construct validity of these tests. In our study we found that players were differentiated based on their expertise levels in seven core tactical principles, the offensive phase, defensive phase and in the game. All these differences showed that players with higher accumulated hours of training had greater tactical knowledge compared to those with less training hours, which provide great evidence of the construct validity of the TacticUP video test. Additionally, our findings give support to theories that indicate improvement of knowledge according to specific and accumulated practice in training (deliberate practice) (ANDERSON, 1983; ERICSSON; KRAMPE; TESCH-ROMER, 1993). Another strength of our test is that we separate groups with different expertise levels based on objective measures (accumulated training hours) instead of subjective ones (e.g. coaches’ assessment of players abilities), as suggested by literature (BLOMQVIST *et al.*, 2000; ERICSSON *et al.*, 2006)

Another important process of a test development is the face validity, which is related to the assessment of individuals’ acceptance that are taking the test, in order to assure that results are an outcome of their engagement and effort with the task (ANASTASI, 1988).



However, other declarative tactical knowledge tests have neglected this aspect of validation (MANGAS, 1999; ELFERINK-GEMSER *et al.*, 2004; SERRA-OLIVARES; GARCÍA-LÓPEZ, 2016). In this study, face validity was measured based on the acceptance of the test by players, as suggested by Anastasi (1988). It was shown a great acceptance, as 94% of them enjoyed taking the test (Chart 1). Moreover, players also showed a great propensity to retake the test (83.9%) in the future, which is a very important property of the test because allow coaches and researchers to assess players' declarative tactical knowledge acquisition along the sport development process.

Assessment of reliability is also a fundamental point in the development of an instrument, in order to inform whether a change in participants' performance is a result of a training program/intervention or due to an unreliable test. In our study we showed appropriate values of reliability based on Landis and Koch (1977) references and compared to previous video-based instrument validation (LARKIN *et al.*, 2014). Therefore, the TacticUP video test may have an important application in terms of reliably monitor declarative tactical knowledge development on soccer training programs or school context. It also can be used to measure or compare effectiveness of intervention programs that seek to develop individuals declarative tactical knowledge.

We would like to acknowledge that the TacticUP video test was based in another instrument, the System of Tactical Assessment in Soccer (FUT-SAT) (TEOLDO *et al.*, 2011a), which is a field test, for procedural tactical knowledge assessment, with approximately ten years of usage and scientific knowledge production. Among the studies carried out with FUT-SAT there are empirical data that support the important role and relationship of tactical knowledge with: i) the development according to age (TEOLDO *et al.*, 2010a; AMÉRICO *et al.*, 2016; BORGES *et al.*, 2017b)}; ii) the relative age effects, which are (des)advantages between players born in different quartiles within an sport season (TEOLDO *et al.*, 2010b; MACHADO; TEOLDO, 2016); iii) players' playing position (MACHADO *et al.*, 2016; RECHENCHOSKY *et al.*, 2017a); iv) training intervention programs (SOUZA *et al.*, 2014; AQUINO *et al.*, 2015); v) affective decision making, (GONZAGA *et al.*, 2014; ANDRADE; MACHADO; TEOLDO, 2016); vi) training settings (e.g. numerical superiority) (BREDT *et al.*, 2016; PADILHA *et al.*, 2017); vii) motor and technical skills (PRAÇA *et al.*, 2015; AQUINO *et al.*, 2016); viii)

peripheral perception (GONÇALVES *et al.*, 2017); ix) maturation (BORGES *et al.*, 2017a; GONÇALVES *et al.*, 2017); and x) mental fatigue (KUNRATH *et al.*, 2018). Therefore, both FUT-SAT and the TacticUP video test measure complementary constructs of tactical knowledge (declarative and procedural forms), based on the same theoretical and pedagogical basis, the core tactical principles. This connection represent an important step in order to align research with theory, once theory assumes that knowledge acquisition usually proceeds from declarative to procedural (ANDERSON, 1983; MCPHERSON, 1994). Therefore, the use of such complementary instruments allow the design of more theory driven studies and should be used together in the future, in order to test this assumption based on empirical data.

We overcame limitations from previous video-based tests that assessed declarative tactical knowledge, by introducing: i) assessment of players without the ball, in both offensive and defensive phases; and ii) introduction of core tactical principles on its conceptual design, which has great transferability to the training process. This represent a step forward in the pursue of consonance between training and tactical assessment (GRÉHAIGNE; GODBOUT, 1998). Furthermore, our test enable tactical assessment in a regular basis, which is fundamental to qualify the process of talent development and identification over the years of sport development of a player (SARMENTO *et al.*, 2018).

Moreover, a characteristic of the test is the distinction between scores obtained in different core tactical principles assessed, which has more applicability and transference to training, in contrast to only general assessment by offensive and defensive phases (GONZÁLEZ-VÍLLORA *et al.*, 2015). This outcome organization based on each tactical principle scores, enable researchers and coaches to gather more specific information about players' knowledge of distinct situations on the management of game space. This organization of information shows a more detailed picture of players' strengths and weaknesses, which allows more specific and individualized intervention on training, based on these results (TEOLDO *et al.*, 2011b).

Another possibility of the test is the use together with verbal reports, which enable players to verbalize their thoughts (e.g. "why" an individual choose each answer) in order to understand in-depth the cognitive processes involved in tactical knowledge acquisition and development (ERICSSON, 2006). Additionally, it also can be used with tools that

objectively measure players' eye movement recording, which can inform about how individuals perceive the environment and which one are the most important sources of information (e.g. player in possession of the ball, teammates, opponents) that enable players to choose the most adequate answers (WILLIAMS; FAWVER; HODGES, 2017)

Another important aspect, is the age of the individuals, which must be taken into account in order to use assessment tools in line with sports development phases (GONZÁLEZ-VÍLLORA *et al.*, 2015). We advise to start the use of the TacticUP video test with groups around the age of 11/12 years, as core tactical principles start to be taught at this age, when players have their cognitive maturation in final stage, and are able to use abstract thought to operationalize this type of tactical principles (PIAGET, 1964; TEOLDO; GUILHERME; GARGANTA, 2015). In addition, would also be interesting to investigate what type of soccer activities (e.g. deliberate practice, deliberate play or competition) favor tactical knowledge development in different age groups, in order to seek for empirical data that support the construction of a longitudinal soccer syllabus.

A possible limitation of this study was not to have tested the TacticUP video test in inexperienced soccer players, as done on previous validation studies (BLOMQVIST *et al.*, 2000; GARCÍA-LÓPEZ *et al.*, 2013). The use of such group (inexperienced) could have enable comparisons between groups (experienced) with greater contrast. We have not tested an inexperienced group because comparisons with low and high experienced groups was able to differentiate them in our test. However we advise that for future studies it is worth to make comparisons between experienced soccer players with groups with no previous experience in soccer.

#### **4. Conclusions**

It was concluded that the TacticUP video test followed the main steps for validation suggested by literature and presented adequate results for content, construct and face validity and was also a reliable measure. Therefore, it indicates that this instrument enable to objectively measure players' strengths and weaknesses based on their declarative tactical knowledge considering the core tactical principles. Moreover, the aim of this study was achieved and we expanded the process of tactical knowledge assessment with an instrument that is complementary to another available instrument (FUT-SAT). This type

of approach has a great potential to improve future practical applications by soccer practitioners and also improve research investigation quality, because it aligned theoretical assumptions and create instruments connected to one another, which enable a more in-depth analysis of tactical knowledge development and acquisition.

## **5. Practical Applications**

- This instrument can be used to measure effectiveness of intervention and training programs in soccer players or school students.
- Development soccer programs can benefit from this instrument, as it allows a reliable monitoring of players' tactical knowledge development.
- The instrument can be used in talent identification programs as it proved to differentiate players from different expertise levels and enable to create a player tactical profile based on their strengths and weaknesses in different core tactical principles.

## **6. Acknowledgements**

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### STUDY 3

**Title:** Macro- and microstructure of soccer activities as a discriminant of different levels of tactical knowledge in soccer players

**Abstract:** Tactical knowledge in soccer has been considered an important factor for soccer players achieve high performance level. Although the development of tactical knowledge can be achieved through engagement in practice of representative domain-relevant tasks, it is not clear which types of activities favor this process. The aim of this study was to analyze the amount of hours accumulated in distinct soccer activities by soccer players with different levels of declarative tactical knowledge. The sample comprised of 149 youth soccer players ( $M = 14.9$ ,  $SD = 1.6$  years of age) from three soccer teams. We used a retrospective questionnaire to examined the type and amount of soccer activities that contributed to distinguish players with different levels of both offensive and defensive declarative tactical knowledge. Players' tactical knowledge were assessed based on an objective declarative tactical knowledge test (TacticUP video test). Scores in the test were used to create groups with high and low declarative tactical knowledge in both the offensive and defensive phases. The main activities that differentiated high and low declarative tactical knowledge groups were: i) team practice; ii) collective tactics activities; and iii) "high decision making opportunities" activities. The high knowledge group accumulated more hours in these types of activities compared to the low knowledge group. Deliberate practice was also a discriminant factor of groups with different levels of declarative tactical knowledge.

**Keywords:** tactical development; tactical skill; tactical awareness; talent development; talent identification.

### ESTUDO 3

**Título:** Macro e microestrutura de atividades de futebol como discriminantes de diferentes níveis de conhecimento tático em futebolistas

**Resumo:** O conhecimento tático no futebol tem sido considerado um fator importante para que jogadores de futebol alcancem um alto nível de desempenho. Embora o desenvolvimento do conhecimento tático possa ser alcançado por meio do envolvimento na prática de tarefas representativas relevantes deste domínio, não está claro quais tipos de atividades favorecem esse processo. O objetivo deste estudo foi analisar a quantidade de horas acumuladas em diferentes atividades de futebol por jogadores de futebol com diferentes níveis de conhecimento tático declarativo. A amostra foi composta por 149 jovens jogadores de futebol ( $M = 14,9$ ;  $DP = 1,6$  anos de idade). Foi usado um questionário retrospectivo para examinar o tipo e a quantidade de atividades de futebol que contribuíram para distinguir os jogadores com diferentes níveis de conhecimento tático declarativo, ofensivo e defensivo. O conhecimento tático dos jogadores foi avaliado com base em um teste objetivo sobre o conhecimento tático declarativo (TacticUP vídeo teste). As pontuações no teste foram usadas para criar grupos com alto e baixo conhecimento tático declarativo nas fases ofensiva e defensiva. As principais atividades que diferenciaram os grupos de conhecimento tático declarativo alto e baixo foram: i) treino na equipe; ii) atividades de tática coletiva; e iii) atividades de “alta tomada de decisão”. O grupo de alto conhecimento acumulou mais horas nesses tipos de atividades em comparação ao grupo de baixo conhecimento. A prática deliberada também foi um fator discriminante de grupos com diferentes níveis de conhecimento tático declarativo.

**Palavras-chave:** desenvolvimento tático; capacidade tática; consciência tática; desenvolvimento de talento; identificação de talento.

## 1. Introduction

Tactical knowledge in soccer has been considered an important factor for soccer players achieve high performance level, since every action in the game has as its goal a tactical purpose (GARGANTA, 2009). In this regard, tactics can be defined as “... the management (positioning and displacement/movement) of the playing space by players and teams” (TEOLDO; GUILHERME; GARGANTA, 2015, p.26). Considering tactical knowledge, it has been divided into two distinct forms, procedural tactical knowledge (PTK) and declarative tactical knowledge (DTK) (ANDERSON, 1983; MCPHERSON, 1994). On the one hand, PTK is related to the response selection and execution in game situations and refers to “doing it”. On the other hand, DTK is related to the knowledge about rules and goals of the game and refers to “knowing what to do” (MCPHERSON, 1994).

In regards to DTK, studies in several sports indicated that knowledge bases are necessary for the development of skillful performance (THOMAS; FRENCH; HUMPHRIES, 1986; WILLIAMS; DAVIDS, 1995; MCPHERSON; KERNODLE, 2003). More specific to soccer, there is evidence that DTK is related to players' development over time (AMÉRICO *et al.*, 2017), may distinguish different expertise levels (SERRA-OLIVARES; GARCÍA-LÓPEZ, 2016), is related to predictive achievement of higher performance in the future (AQUINO *et al.*, 2017), have relationship with playing position (KANNEKENS *et al.*, 2009), technical skills (RECHENCHOSKY *et al.*, 2017) and physical attributes (FORSMAN *et al.*, 2015). Therefore, these studies indicate the important role that DTK plays on players' performance.

Considering tactical knowledge development, some researchers suggested that high levels of knowledge can be achieved through engagement in practice of representative domain-relevant tasks (O'CONNOR; LARKIN, 2016). Although we share the same view, few efforts were dedicated in this research area, to investigate based on empirical data, which type of soccer activities could contribute to tactical knowledge development. On the other hand, many researches in soccer have been using retrospective history questionnaires with the goal to investigate the contribution of different types of soccer activities for the development of expertise (WARD *et al.*, 2007), acquisition of perceptual cognitive skills (ROCA; WILLIAMS; FORD, 2012) and development of creativity (MEMMERT; BAKER; BERTSCH, 2010).

The use of such questionnaires enable assessment of the macro- and microstructure of soccer activities. The macrostructure is related to domain-specific activities, such as, competition, team practice, individual practice and play, while the microstructure is related to specific practice activities (e.g. drills and pairs activities) (HELSEN; STARKES; HODGES, 1998; WARD *et al.*, 2007). In this regard, Ericsson (1993) labeled this type of practice (microstructure) as deliberate practice, which is defined as a domain-specific, structured activity with the primary goal of improving an important aspect of current performance. On the other hand, Côté and colleagues (2007) have equate the term play as deliberate play, which is defined as an activity enjoyable with rules adapted from adult norms that are monitored by the children themselves. Research that investigated these types of activities have led to important insights into direction to the development of different skills and attainment of superior performance in soccer (HAUGAASEN; JORDET, 2012). Therefore, we believe that research regarding tactical knowledge development also may benefit from this type of approach. In this sense, to our knowledge no previous studies have examined interaction of DTK with macro- and microstructure of soccer activities.

Besides the use of such retrospective questionnaires, groups of distinct declarative tactical knowledge levels might be created based in objective measures, as suggested by previous studies (ERICSSON *et al.*, 2006; FORD *et al.*, 2010). This procedure elicit to perform comparisons on soccer activities engaged by soccer players with high and low declarative tactical knowledge. In this regard, the assessment of tactical knowledge might be grounded in constructs that takes into account the logic of the game, which allows measure players' operationalization of such concepts. Additionally, consonance between training and tactical assessment in a regular basis is fundamental to qualify the process of tactical knowledge development over the years of sport development of a player (GRÉHAIGNE; GODBOUT; BOUTHIER, 2001). Indeed, the assessment based on tactical principles meet this both criteria, once it was constructed based on the logic of the game (TEOLDO *et al.*, 2010a) and is a content used for tactical skill training (TEOLDO; GUILHERME; GARGANTA, 2015).

Moreover, this type of assessment of players' tactical knowledge should also be done in more naturalistic settings, which can enhance its transferability and applicability for actual game. The use of video-based tests are preferable to assess DTK, once it offer a more natural perception of the scene, compared to static figures, questionnaires or interview (MANN *et al.*, 2007). This approach to assess both



declarative tactical knowledge, and involvement in previous soccer activities, will elicit to gather information about the development of tactical knowledge. Furthermore, we may be able to identify those aspects that distinguish players with different levels of tactical knowledge (e.g. high and low tactical knowledge groups) and perhaps extend these implications for selection and training purposes (CÔTÉ; ERICSSON; LAW, 2005). This type of information must provide guidance on theoretical and practical understanding into the role of different activities in athletes' tactical knowledge development in soccer.

The purpose of this study is to analyze the amount of hours accumulated in distinct soccer activities by soccer players with different levels of declarative tactical knowledge. Therefore we examine the type and amount of soccer activities that contributed to distinguish players with different levels of both offensive and defensive declarative tactical knowledge. Players' tactical knowledge were assessed based on an objective declarative tactical knowledge test (TacticUP video test) (MACHADO; TEOLDO, 2018). Scores in the test were used to create groups with high and low declarative tactical knowledge in both the offensive and defensive phases. We choose to separate groups based on their offensive and defensive tactical knowledge (instead of an overall tactical knowledge score), due evidences of distinct rates of development between these two types of knowledge (GONZÁLEZ-VÍLLORA *et al.*, 2010; GONZÁLEZ-VÍLLORA *et al.*, 2011; GONZÁLEZ-VÍLLORA *et al.*, 2013). We used a retrospective questionnaire (FORD *et al.*, 2010) to collect information about previous participation in different soccer activities.

It was hypothesized that both high declarative tactical knowledge groups (offensive and defensive) would have accumulated more hours compared to the low groups in different types of soccer activities, specifically in: i) team practice, as it is a component of deliberate practice supervised by coaches, and may favor players' understand of the game (ERICSSON; KRAMPE; TESCH-ROMER, 1993) and also is related to higher performances in soccer (WARD *et al.*, 2007; ROCA; WILLIAMS; FORD, 2012); ii) group tactics; and iii) collective tactics activities in training, because both types of activities are related to the operationalization of the core tactical principles in game context (TEOLDO; GUILHERME; GARGANTA, 2015) and these types of activities were shown to differentiate soccer players with distinct expertise levels (WARD *et al.*, 2007); iv) activities based on high decision making opportunities in the training, such as small-sided and conditioned game (DAVIDS *et al.*, 2013), as

this type of activity is related to declarative tactical knowledge acquisition (FARIAS; MESQUITA; HASTIE, 2015) and differences in levels of expertise (WARD *et al.*, 2007); and v) players' perceived capacity of making decisions in soccer would be higher, as they rated such type of activities as the most relevant to performance (HELSEN; STARKES; HODGES, 1998). Moreover, we expect for the offensive phase, that high declarative tactical knowledge group would have accumulated more hours in competition, as shown in previous studies (SERRA-OLIVARES *et al.*, 2015a; SERRA-OLIVARES; GARCÍA-LÓPEZ, 2016; SERRA-OLIVARES; GARCÍA-LÓPEZ; GUTIÉRREZ-DÍAZ, 2017).

## 2. Methods

### 2.1 Participants

The sample comprised of 149 youth soccer players ( $M = 14.9$ ,  $SD = 1.6$  years of age) from three soccer teams. All the participants were training at least three times a week and were participating in national level championship for their age level, affiliated to their respective state soccer federations. This study was approved by the Research Ethics Committee CAAE: 75581617.0.0000.5153 of Universidade Federal de Viçosa, Brazil and all procedures were in accordance with the standards of the Declaration of Helsinki (2008) and of the Brazilian National Health Board (466/2012). Moreover, the participants and their parents signed a legal consent authorizing the data collection and their use for research purposes.

### 2.2 Measures

#### 2.2.1 Declarative Tactical Knowledge Test (*TacticUP video test*)

It was presented to participants a video-based test that assess players' declarative tactical knowledge (*TacticUP video test*) (MACHADO; TEOLDO, 2018). This test is composed by 36 scenes (18 offensives and 18 defensives) from video sequences of 11 versus 11 soccer situations and was developed based on the core tactical principles of soccer (WORTHINGTON, 1974; TEOLDO *et al.*, 2009; TEOLDO; GUILHERME; GARGANTA, 2015). The videos were recorded on bird's-eye view, which is an elevated view of an object from above. This view was chosen, because it allow players to visualize the tactical principles, both close or far from the ball. Each scene lasted between 5s to 7s. This test provided the offensive and defensive declarative tactical knowledge score for each participant.

The score for each scene is calculated based on the correspondence between participants answer with those chosen by a panel of experts ( $n = 9$ ). Each one of the scenes were rated by the experts according to the adequacy of the answer options (A, B, C and D). They had to determine which one of the options were the 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> most adequate for the viewed scene. For those were awarded: 1<sup>st</sup> option: score 10; 2<sup>nd</sup> option: score 6; 3<sup>rd</sup> option: score 3; and 4<sup>th</sup> option: score 0. Afterwards, it was summed the scores awarded by the experts for each one of the options (A, B, C and D) in each scene. After this process, the options were transformed in a scale that ranged between 100 to 0 points based on the score awarded by experts. The option with the highest score was given 100 points, where the option with the lowest score was given 0 points. The two options in the middle were given points calculated proportionally to the score they received by experts and not linearly as used in previous studies, such as the following example (e.g. 1<sup>st</sup> option: 100 pts; 2<sup>nd</sup> option: 75 pts; 3<sup>rd</sup> option 50 pts; 4<sup>th</sup> option: 25 pts) (GIACOMINI; SILVA; GRECO, 2011; GIACOMINI *et al.*, 2011). This choice was done based on experts suggestion, which argued that on their opinion every scene had one correct (100 points) and one wrong (0 points) option, but the adequacy of those in the middle varied in some degree from scene to scene, and therefore they should not worth the same amount of points in every scene. The offensive and defensive declarative tactical knowledge scores were calculated based on the average of the scores received for the 18 scenes of each phase.

### 2.2.2 Questionnaire

The Participant History Questionnaire (PHQ), used in several studies (FORD *et al.*, 2010; FORD *et al.*, 2012; ROCA; WILLIAMS; FORD, 2012), was used to measure the soccer activities undertaken by players. The test-retest reliability and the concurrent validity of the PHQ were shown in Ford et al (2010). This questionnaire allowed to gather information on engagement in soccer-related activities. Four types of soccer activities, also included in previous studies (HELSEN; STARKES; HODGES, 1998; FORD *et al.*, 2012), were assessed: i) competition; ii) team practice; iii) individual practice; and iv) play. Competition was related to activities playing organized competitive soccer matches against another team (e.g. league games). Team practice was related to soccer activities under the supervision of coaches or adults in which the goal is to enhance performance (e.g. training with the team). Individual practice referred to soccer activities undertaken alone to improve skills (e.g. practicing

dribbling skills alone). Play activities are related to play-type games with specific rules created and supervised by participants themselves in which the major goal is enjoyment (e.g. playing soccer game with friends in the park).

Participants should provide the number of hours per week and the number of months per year they spent in those soccer activities since they start participation in soccer. They also provided information about the number of weeks from each year they were injured and unable to participate in soccer activities. This information were given retrospectively, from the present season, going backwards in one year interval up to the age they started participation in soccer activities. The calculation of the accumulated hours in soccer activities was performed by multiplying hours reported per week by weeks per year, minus weeks per year players reported injuries that prevented them to participate in soccer activities. For the number of weeks per year, we considered a 40 week season for practice and competition, as used in previous studies (ROCA; WILLIAMS; FORD, 2012).

Moreover, the questionnaire also elicited information about the microstructure of practice for the present and past seasons (2 years), by calculating the accumulated hours in different types of activities using the same procedure as described above. The activities were divided into: i) individual (e.g. dribbling the ball alone); ii) pairs (e.g. passing or 1x1); iii) drills (e.g. situations that re-enacting isolated simulated game incidents, such as going to an designated area to another); iv) group tactics (e.g. small-sided and conditioned games of 2x2 up to 4x4); and v) collective tactics (e.g. small-sided and conditioned games of 5x5 or higher configurations). Considering these activities, it was created two subgroups of activities, namely, “low decision making opportunities”, composed by individual, pairs and drills activities, and “high decision making opportunities”, composed by group and collective tactics activities. This subdivision was performed considering the degree of complexity of each one of those activities and it similarity with the demands and components of the actual game (WARD *et al.*, 2007; FORD; YATES; WILLIAMS, 2010).

Finally, it was assessed players’ perceived capacity of making decisions in soccer, calculated based on the sum of three questions answered in the questionnaire. The questions are: Q1) During team practice over the previous two years, did your coach gave you guidance/ instruction about the types of decisions you should make during the exercises?; Q2) During team practice, how often have you been given the opportunity to make decisions?; and Q3) Evaluate your own capacity to make correct

decisions. These questions were answered through a seven-point Likert scale, varying between “never” to “always” for Q1 and Q2, while varied between “very poor” to “excellent” for Q3.

### *2.3 Test Procedures*

Prior to starting the tasks, procedures were explained to participants and the researcher was available to answer any question that have arisen. The TacticUP video test was presented to groups of about ten participants per time via projection on a 3.0 x 2.2m size screen. Before starting the test, were given instructions to participants regarding the test structure and three testing scenes were shown in order to make them get used to the task. At the end of each scene participants were required to answer to the question “what the observed player should do?” by choosing the most adequate option on their opinion, among the four possibilities (A, B, C and D) options that appeared in the video. Their answer should be marked in the answer sheet. The whole test application took approximately 30 minutes.

Following the video presentation, participants were divided into groups of up to four people, in order to complete the PHQ, with one researcher available to supervise each group. The supervisor researcher provided verbal instructions in how to fill the questionnaire and was available during the whole process to answer queries related to the completion of the questionnaire. This part took approximately 60 minutes to be completed.

### *2.4 Data Analyses*

Soccer players were divided according to their declarative tactical knowledge into two rankings, being one for the offensive phase and other for the defensive phase. Players were separated into three groups of knowledge (low, medium and high) for each one of the rankings. For analysis were considered only the low knowledge group (LK) and high knowledge group (HK) in their respective rankings. This procedure was used to ensure that the division criteria of participants in different knowledge levels subgroups (based on the score of a declarative tactical knowledge test) were based in objective criteria that statistically differentiated both groups analyzed, as used in previous research (FORD *et al.*, 2010; ROCA; WILLIAMS; FORD, 2012; WILLIAMS *et al.*, 2012). Comparisons between groups to verify differences in test scores were carried out using an independent *t* test. In the offensive ranking, the HK

( $n = 50$ ,  $M = 15.2$ ,  $SD = 1.4$  years of age) showed statistically higher values in offensive declarative tactical knowledge ( $M = 84.0$ ,  $SD = 4.3$  test score) compared to the LK ( $n = 50$ ,  $M = 14.5$ ,  $SD = 1.8$  years of age) test score ( $M = 58.6$ ,  $SD = 9.0$  test score),  $t(98) = -18.02$ ,  $p < .001$ . In regards to the defensive ranking, the HK ( $n = 50$ ,  $M = 14.9$ ,  $SD = 1.5$  years of age) showed statistically higher values in defensive declarative tactical knowledge ( $M = 79.4$ ,  $SD = 5.5$  test score) compared to the LK ( $n = 50$ ,  $M = 14.5$ ,  $SD = 1.7$  years of age) test score ( $M = 50.1$ ,  $SD = 6.9$  test score),  $t(98) = -23.57$ ,  $p < .001$ .

Afterwards we verified the between-group differences in all the variables measured by the PHQ using a Mann-Whitney U-test. Distributions were checked with a Kolmogorov-Smirnov test. Effect size for the Mann-Whitney tests was calculated through the formula described by (FRITZ; MORRIS; RICHLER, 2012) as ( $r = Z/\sqrt{n}$ ). The interpretation of  $r$  value was made as follows Cohen (1988): small effect .1 - .29; medium effect .3 - .49; and large effect  $> .5$ . For statistical procedures were utilized the software SPSS (Statistical Package for Social Sciences) 22.0.

Reliability for the TacticUP video test was verified through the method test-retest (BAUMGARTNER; JACKSON, 1991), respecting the interval of 21 days, to avoid familiarity with the task (ROBINSON; O'DONOGHUE, 2007). There were reassessed 15 players, representing 10,1% of the sample, according to recommended value (10%) by literature (TABACHNICK; FIDELL, 2013). Cohen's Kappa was used to determine reliability of each scene, between the first and second test application. We adopted Kappa values categorization according to reliability scale established by Landis and Koch (1977): poor agreement ( $<.00$ ); slight agreement (.00 - .20); fair agreement (.21 - .40); moderate agreement (.41 - .60); substantial agreement (.61 - .80); almost perfect agreement (.81 - 1.00). Kappa values of the scenes ranged from .622 to 1.0 and 30 of them were classified as "substantial agreement" and six classified as "almost perfect agreement".

### 3. Results

#### 3.1 Offensive Declarative Tactical Knowledge

The results showed that the types of soccer activities were different for competition and team practice between the HK and LK (Figure 1a). In competition, the HK accumulate more hours ( $M = 214.9$ ,  $SD = 209.8$  hours) compared to the LK ( $M = 108.2$ ,  $SD = 140.7$  hours),  $U = 742.00$ ,  $z = -3.50$ ,  $p < .001$ ,  $r = -.351$ , *medium effect*. Similarly, in team practice, the HK accumulate more hours ( $M = 1145.5$ ,  $SD =$

861.3 hours) in comparison to the LK ( $M = 589.0$ ,  $SD = 674.4$  hours),  $U = 660.50$ ,  $z = -4.06$ ,  $p < .001$ ,  $r = -.407$ , *medium effect*.

Considering the microstructure of the training, we found that the HK accumulated more hours of training than the LK in all the five types activities assessed (Figure 1b). For individual soccer activities, the HK accumulate greater amounts of time ( $M = 71.6$ ,  $SD = 84.5$  hours) compared to the LK ( $M = 29.9$ ,  $SD = 42.2$  hours),  $U = 893.00$ ,  $z = -2.48$ ,  $p = .013$ ,  $r = -.248$ , *small effect*. In pairs activities, the HK had more accumulated hours ( $M = 84.5$ ,  $SD = 77.3$  hours) in comparison to the LK ( $M = 42.2$ ,  $SD = 54.5$  hours),  $U = 880.50$ ,  $z = -2.55$ ,  $p = .011$ ,  $r = -.255$ , *small effect*. Drills activities showed more accumulated hours for the HK ( $M = 123.1$ ,  $SD = 183.9$  hours) compared to the LK ( $M = 60.3$ ,  $SD = 80.9$  hours),  $U = 956.00$ ,  $z = -2.02$ ,  $p = .043$ ,  $r = -.203$ , *small effect*. In group tactics activities we found that the HK accumulate greater amounts of time ( $M = 144.4$ ,  $SD = 169.0$  hours) compared to the LK ( $M = 60.7$ ,  $SD = 85.4$  hours),  $U = 803.50$ ,  $z = -3.08$ ,  $p = .002$ ,  $r = -.309$ , *medium effect*. For collective tactics the HK accumulate more hours ( $M = 175.2$ ,  $SD = 165.5$  hours) in comparison to the LK ( $M = 78.9$ ,  $SD = 101.4$  hours),  $U = 660.50$ ,  $z = -4.07$ ,  $p < .001$ ,  $r = -.407$ , *medium effect*.

In regards to the subgroups of activities in training, based on the degree of decision making, the HK also showed more accumulated hours compared to LK (Figure 1c). In activities of “low decision making opportunities”, the HK had more hours accumulated ( $M = 270.9$ ,  $SD = 253.2$  hours) compared to the LK ( $M = 134.6$ ,  $SD = 142.4$  hours),  $U = 810.00$ ,  $z = -3.03$ ,  $p = .002$ ,  $r = -.303$ , *medium effect*. Considering the activities of “high decision making opportunities”, the HK accumulated more hours ( $M = 319.5$ ,  $SD = 311.1$  hours) in comparison to the LK ( $M = 139.5$ ,  $SD = 175.2$  hours),  $U = 654.50$ ,  $z = -4.10$ ,  $p < .001$ ,  $r = -.411$ , *medium effect*. Finally, considering the players’ capacity of making decisions in soccer (Figure 1d) the HK had greater values ( $M = 15.6$ ,  $SD = 2.2$  test score) compared to the LK ( $M = 14.1$ ,  $SD = 2.7$  test score),  $U = 757.50$ ,  $z = -2.78$ ,  $p = .005$ ,  $r = -.286$ , *small effect*.

### 3.2 Defensive Declarative Tactical Knowledge

There was found differences in the types of soccer activities for the team practice and individual practice in comparisons between the HK and LK (Figure 1a). The HK accumulated more hours in team practice activities ( $M = 990.9$ ,  $SD = 875.3$  hours) compared to the LK ( $M = 481.4$ ,  $SD = 535.4$  hours),  $U = 740.50$ ,  $z = -3.51$ ,  $p < .001$ ,  $r$

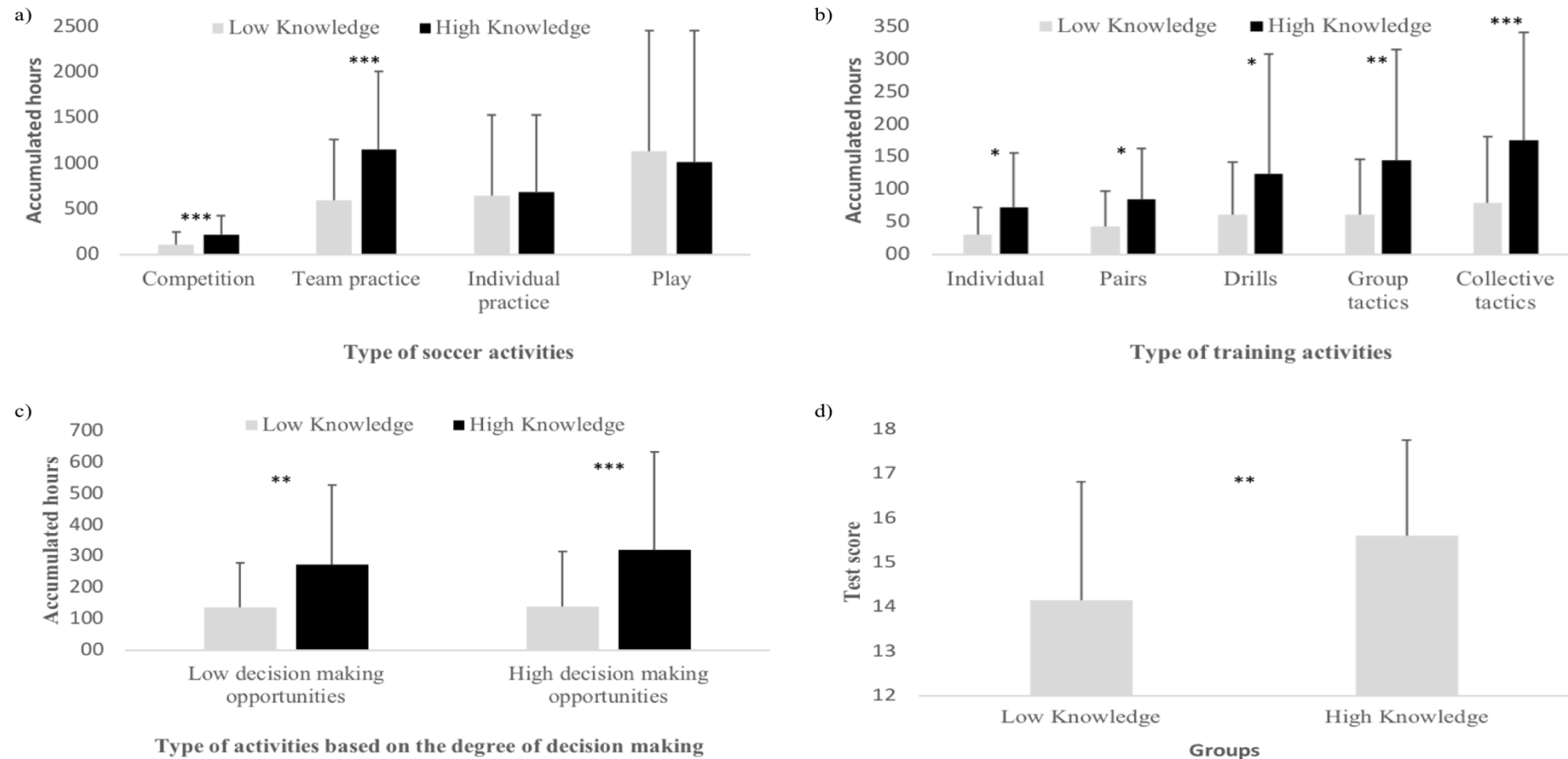
= -.351, *medium effect*. For individual practice activities the HK accumulate more hours ( $M = 724.3$ ,  $SD = 850.7$  hours) in comparison to the LK ( $M = 473.2$ ,  $SD = 678.2$  hours),  $U = 963.50$ ,  $z = -1.99$ ,  $p = .047$ ,  $r = -.198$ , *small effect*.

Taking into account the microstructure of the training, results showed that the HK accumulated more hours of training than the LK in individual, drills and collective tactics activities (Figure 2b). For individual soccer activities, the HK accumulate greater amounts of time ( $M = 65.4$ ,  $SD = 84.0$  hours) compared to the LK ( $M = 28.7$ ,  $SD = 39.0$  hours),  $U = 935.50$ ,  $z = -2.18$ ,  $p = .029$ ,  $r = -.218$ , *small effect*. In drill activities we found that the HK accumulate greater amounts of time ( $M = 107.8$ ,  $SD = 177.5$  hours) compared to the LK ( $M = 54.3$ ,  $SD = 90.9$  hours),  $U = 899.00$ ,  $z = -2.42$ ,  $p = .015$ ,  $r = -.242$ , *small effect*. For collective tactics the HK accumulate more hours ( $M = 150.4$ ,  $SD = 153.7$  hours) in comparison to the LK ( $M = 69.6$ ,  $SD = 106.6$  hours),  $U = 718.00$ ,  $z = -3.67$ ,  $p < .001$ ,  $r = -.367$ , *medium effect*.

Considering the subgroups of activities in training, based on the degree of decision making, the HK and LK showed differences in both variables assessed (Figure 1c). In activities of “low decision making opportunities”, the HK had more hours accumulated ( $M = 236.4$ ,  $SD = 251.6$  hours) compared to the LK ( $M = 127.6$ ,  $SD = 150.1$  hours),  $U = 908.00$ ,  $z = -2.35$ ,  $p = .018$ ,  $r = -.235$ , *small effect*. For activities of “high decision making opportunities”, the HK accumulated great amounts of hours ( $M = 249.6$ ,  $SD = 274.9$  hours) in comparison to the LK ( $M = 144.0$ ,  $SD = 211.8$  hours),  $U = 807.50$ ,  $z = -3.05$ ,  $p = .002$ ,  $r = -.305$ , *medium effect*. Lastly, in regards to players’ capacity of making decisions in soccer (Figure 1d) the HK scored higher ( $M = 15.5$ ,  $SD = 2.2$  test score) compared to the LK ( $M = 14.5$ ,  $SD = 2.5$  test score),  $U = 808.50$ ,  $z = -1.95$ ,  $p = .049$ ,  $r = -.203$ , *small effect*.

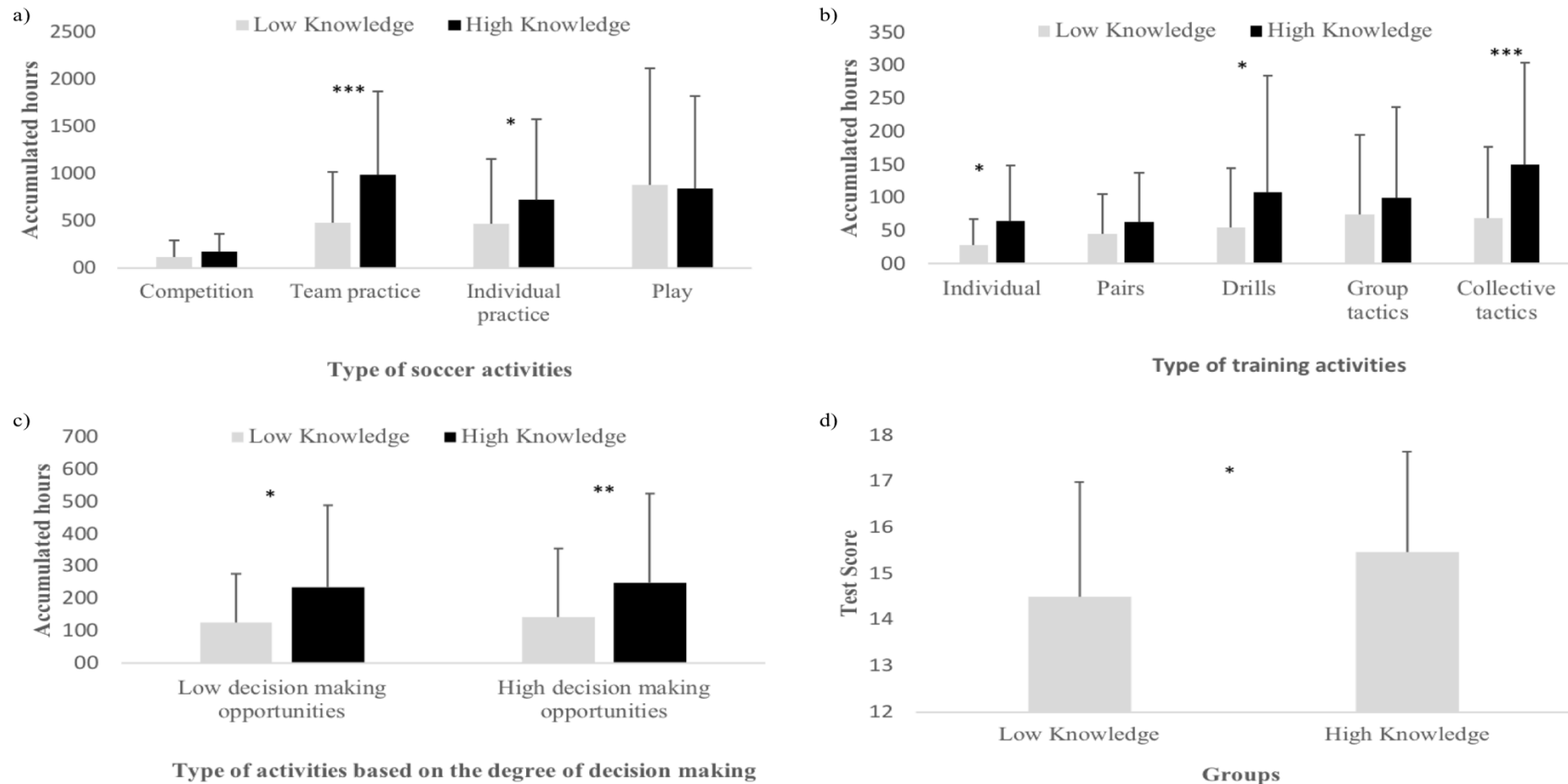


## Offensive Declarative Tactical Knowledge



**Figure 1.** Comparisons between the high and low knowledge groups, based on the offensive declarative tactical knowledge for: a) accumulated hours of different types of soccer activities; b) accumulated hours of different types of soccer activities in the microstructure of training; c) accumulated hours of different types of soccer activities based on decision making opportunities; and d) test score for the capacity of making decisions in soccer. \*p < .05, \*\*p < .01, \*\*\*p < .001

## Defensive Declarative Tactical Knowledge



**Figure 2.** Comparisons between the high and low knowledge groups, based on the defensive declarative tactical knowledge for: a) accumulated hours of different types of soccer activities; b) accumulated hours of different types of soccer activities in the microstructure of training; c) accumulated hours of different types of soccer activities based on decision making opportunities; and d) test score for the capacity of making decisions in soccer. \*p < .05, \*\*p < .01, \*\*\*p < .001

#### 4. Discussion

The purpose of this study was to analyze the amount of hours accumulated in distinct soccer activities by soccer players with different levels of declarative tactical knowledge. We hypothesized that both high declarative tactical knowledge groups (offensive and defensive) would have accumulated more hours compared to the low groups in different types of soccer activities, specifically in: i) team practice, as it is related to higher performances in soccer (WARD *et al.*, 2007; ROCA; WILLIAMS; FORD, 2012); and ii) collective tactics activities in training, because this type of activity was shown to differentiate soccer players with distinct expertise levels (WARD *et al.*, 2007); iii) activities based on high decision making opportunities in the training, because this type of activity is related to declarative tactical knowledge acquisition (FARIAS; MESQUITA; HASTIE, 2015); and iv) players' perceived capacity of making decisions in soccer would be higher, as they rated such type of activities as the most relevant to performance (HELSEN; STARKES; HODGES, 1998). Moreover, we expected for the offensive phase, that high declarative tactical knowledge group would have accumulated more hours in competition, as shown in previous studies (SERRA-OLIVARES *et al.*, 2015a; SERRA-OLIVARES; GARCÍA-LÓPEZ, 2016; SERRA-OLIVARES; GARCÍA-LÓPEZ; GUTIÉRREZ-DÍAZ, 2017).

As predicted, the both high declarative tactical knowledge groups (offensive and defensive), showed greater amounts of accumulated hours in soccer team practice with a medium effect size. It was expected, as this type of activity usually is coach-determined with the purpose to improve performance and this type of practice was shown to be the most useful variable to discriminate different level of attainment in team-oriented sports at an adult level (HELSEN; STARKES; HODGES, 1998). More specific to soccer context, Ward and colleagues (2007) found that team practice consistently discriminate soccer players throughout expertise development in soccer as early as 9 years of age, up to 18 years of age, which is a similar age as used in our study. In regards to other cognitive variables, such as creativity, anticipation and decision-making in team-oriented sports, team practice has shown to play an important role on its acquisition (MEMMERT; BAKER; BERTSCH, 2010; ROCA; WILLIAMS; FORD, 2012). Additionally, previous evidence are in line with our results, and showed a positive correlation between

declarative tactical knowledge with weekly team practice hours in soccer (SERRA-OLIVARES; GARCÍA-LÓPEZ; GUTIÉRREZ-DÍAZ, 2017). Therefore, these results have systematically supported the importance of team practice as a mediator of superior performance and declarative tactical knowledge in soccer.

Another type of soccer activity that differentiate high and low groups of declarative tactical knowledge, was competition for the offensive phase, with a medium effect. This results were also expected, as they are supported by previous studies that showed a positive association between offensive declarative tactical knowledge and the number of years in competition (SERRA-OLIVARES *et al.*, 2015a; SERRA-OLIVARES; GARCÍA-LÓPEZ, 2016; SERRA-OLIVARES; GARCÍA-LÓPEZ; GUTIÉRREZ-DÍAZ, 2017). This type of activity provide players with the opportunity to be in the most representative scenario of the game and allow an extent variety of feedback about their tactical knowledge application in the game, based on score outcome, coach, colleagues, and internal feedback. Moreover, competition has a strong emotional involvement by players, which has been associated with long term learning in other domains (HASCHER, 2010), and this component may favor the attainment of high levels of declarative tactical knowledge. Such findings highlight the importance to include competition as part of the sport calendar and soccer syllabus in the development process of soccer players. Furthermore, based in our results we suggest as an adequate strategy to favor development of offensive declarative tactical knowledge, that players of the same squad, have opportunities to participate in similar amounts of time in competition, mainly in early phases of soccer development (CÔTÉ; VIERIMAA, 2014).

In regards to individual practice, it differentiate high and low groups of declarative tactical knowledge, for the defensive phase, with a small effect. This result was somehow surprising and unexpected, especially because occurred in the defensive phase, which is constituted by opposition situations, and require at least another player to represent such opposition (GARGANTA; PINTO, 1994). In this regard, previous study found that individual practice was related to high performance achievements in team-oriented sports, when coupled with great amount of time dedicated to team practice, similarly to the results we have found (HELSEN; STARKES; HODGES, 1998). However, individual practice in the aforementioned study was related to physical and technical skills instead of tactics,

which makes unclear how this type of activity could be related to greater amounts of defensive declarative tactical knowledge. A possible explanation for this result is that players that accumulated more team practice, as found in our study, also were inclined to engage more hours in individual practice.

Considering that our results showed that team practice was the unique soccer activity that mediate differences in both offensive and defensive tactical knowledge, with a medium effect, we deepen our analysis by investigating the microstructure of training activities. Results showed that individual, drills and collective tactics activities had more accumulated hours by the high knowledge groups in both offensive and defensive phases. Therefore, our prediction that collective tactics would differentiate groups of distinct tactical knowledge levels was confirmed. This type of activity was the one that showed biggest effect of groups distinction (medium) compared to the other types of activities assessed in training (small effects). Similar result was found by Ward et al (2007) , that showed that elite players spent considerably more time in tactical and strategic skills activities in training, compared to sub-elite players. In this regard, collective tactics activities are those that allow players to use perceptual, cognitive and motor skills simultaneously in game like situations, which is also required for successful match performance (FORD; YATES; WILLIAMS, 2010). Engagement in this type of activity is likely to develop the knowledge structures and cognitive processes underlying a variety of cognitive skills, such as anticipation, decision making, and tactical knowledge (WILLIAMS *et al.*, 2011; O'CONNOR; LARKIN, 2016). Therefore, considerable time of training must be allocated to such type of activity in order to provide more opportunities to develop tactical knowledge in game like environments.

In regards to individual and drills activities, although they were not expected to differentiate players' level of tactical knowledge, they showed statically differences between groups, but with a small effect. These both types of activities are technical oriented by nature, which is linked with motor skill development, in contrast to tactical development (GRÉHAIGNE; GODBOUT; BOUTHIER, 2001). However, despite empirical data have suggested to shift this type of activities for those more representative of the game (e.g. small-sided and conditioned games), analysis of training sessions have shown that great amounts of time are dedicated to technical oriented activities (WARD *et*

*al.*, 2007; FORD; YATES; WILLIAMS, 2010; HORNING; AUST; GÜLLICH, 2014). These studies showed that this type of activities represent between 31% to 69% of total training time. Therefore, it suggest that the results found in our study probably represent the outcome of been involved in more hours of tactical oriented team activities (that favor superior tactical knowledge) also implies to be involved in more hours of technical-oriented activities, such as individual and drills activities.

The other two types of training activities, pairs and group tactics, showed to be a moderating factor to differentiate players with distinct level of offensive tactical knowledge. This both types of activities allow players to experience situations of 1x1 up to 4x4 in training. These situations are related to the execution of offensive core tactical principles, such as progressing with the ball or enhancing width and length of the team, that have been positively associated with offensive tactical performance (MACHADO; SCAGLIA; TEOLDO, 2015). Therefore, accumulating more hours in such activities may favor the development of offensive tactical knowledge, specially related to situations closer to ball. These types of training configurations are indicated to be used more often specially in early phases of sport development (e.g. 6 years up to around 13 years of age) (CÔTE; BAKER; ABERNETHY, 2007; TEOLDO; GUILHERME; GARGANTA, 2015; AMÉRICO *et al.*, 2016) due it less complexity that favor skill acquisition at this time.

We confirmed our predictions that activities in training based on “high decision making opportunities” and players’ perceived capacity of making decisions in soccer would differentiate high and low groups of declarative tactical knowledge, for both offensive and defensive phases (medium effects). Activities that allow players interact in an environment with high variability and unpredictability, enable players to experience similar problems as those they will face in competition. Such environment are highly relevant to performance because they recreate demands from perceptual, cognitive and motor skills as those faced in actual game (FORD; YATES; WILLIAMS, 2010). These skills are likely to change over the sport development process (WILLIAMS *et al.*, 2011; MACHADO; CARDOSO; TEOLDO, 2017) and evolve with practice on representative domain-relevant tasks (O’CONNOR; LARKIN, 2016). In this sense, a study carried out by Farias and colleagues (2015) showed that intervention based in this type of activities improved declarative tactical knowledge in youths. Moreover, tactical activities in team

practice, which allow great opportunities of decision making, were rated by team-oriented players, as the most relevant for performance (HELSEN; STARKES; HODGES, 1998). In line with such findings, a recent work from O'Connor and Larkin (2016) recommended a soccer national curriculum in Australia, based on high amounts of playing form activities, such as group and collective tactic activities, in order to develop players decision making and tactical knowledge. Thus, we encourage coaches and physical education teachers to design activities with high decision making opportunities (e.g. small-sided and conditioned games) and grounded in constructs that takes into account the logic of the game, such as the core tactical principles (TEOLDO; GUILHERME; GARGANTA, 2015).

There was also found that activities based on “low decision making opportunities” differentiated distinct levels of declarative tactical knowledge in both phases, although the effects size were small. This type of activity usually isolate some component of performance, such as passing skills, and seek its development separately to other components of performance. Such approach has been shown to have low transference to actual game (DAVIDS *et al.*, 2013) because it neglect the role of interaction between perceptual, cognitive and motor skills in performance attainment. In this regard, previous study showed that such “traditional” teaching model did not improved tactical knowledge after an intervention period (ASHRAF, 2017). Thus, we hypothesize that such differences are an outcome of players classified as high knowledge, been involved in great amounts of team practice (especially in “high decision making” activities), which also implies to be involved in more hours of technical-oriented activities due training design (FORD; YATES; WILLIAMS, 2010; HORNING; AUST; GÜLLICH, 2014).

In general, we verified that similar activities were responsible for differentiate player from high and low groups of both offensive and defensive declarative tactical knowledge. The variables that showed larger effects in both phases were, respectively: i) team practice; ii) collective tactics in team practice activities; and iii) “high decision making opportunities” in team practice activities. These findings support the idea that declarative tactical knowledge development may be favored by coach-led training designed with activities that allow players to use perceptual, cognitive and motor skills simultaneously in game like situations. Although the activities that differentiate high and

low knowledge groups in offensive and defensive phases were quite similar, some differences were found. In regards to soccer activities, competition was a discriminant in the offensive phase, while individual practice discriminate groups in the defensive phase. Interestingly, these two activities plus team practice, are labeled as structured activities (ERICSSON; KRAMPE; TESCH-ROMER, 1993; FORD *et al.*, 2010). Therefore, our results showed that the amount of accumulated hours in deliberate practice (structured activities) are discriminant factors of groups with different levels (high and low) of declarative tactical knowledge (offensive and defensive) based on an objective measure.

We acknowledge that a limitation in our study was the assessment of team practice activities (microstructure) of players, conducted only with the previous two years, and this procedure can hidden the effect of previous training microstructure in our results. For future research we suggest further investigation within the topic of tactical knowledge development and acquisition, considering investigation with different sample characteristics, such as distinct competitive levels, age, history profile and country. Moreover, future research should employ a longitudinal design and adopt intervention based on activities that favor the opportunity to make decision in game like situations, through the use of small-sided and conditioned games (FORD; YATES; WILLIAMS, 2010), especially with designs of 5x5 or larger (supported by our findings). We also suggest investigation about soccer activities that contribute to acquisition of procedural tactical knowledge. Finally, the use of objective measures of soccer tactical knowledge, especially those that assess tactical principles and both phases of the game (as the one used in our study), should be included in future research.

## **5. Conclusions**

It is concluded that the amount of hours accumulated in distinct soccer activities distinguished soccer players with different levels of declarative tactical knowledge. The main activities that differentiated high and low declarative tactical knowledge groups were: i) team practice; ii) collective tactics in team practice activities; and iii) “high decision making opportunities” in team practice activities. The high knowledge group accumulated more hours in these types of activities compared to the low knowledge group. Moreover, we gave support to deliberate practice theory (ERICSSON; KRAMPE;



TESCH-ROMER, 1993; HELSEN; STARKES; HODGES, 1998) as a discriminant factors of groups with different levels (high and low) of declarative tactical knowledge (offensive and defensive) based on an objective measure.

## **6. Practical Applications**

- Team practice designed based on playing forms (e.g. small-sided and conditioned games), especially large structures (5x5 or larger), may favor the development of both offensive and defensive declarative tactical knowledge.
- Directions for the development of a soccer syllabus based on tactical knowledge development may be supported by our findings.
- Information about previous amount of deliberate practice engaged by players may be used as an indicative of their declarative tactical knowledge in absence of available objective measures.

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## GENERAL DISCUSSION AND CONCLUSIONS

The aim of this work was expand and advance the process of tactical knowledge assessment of soccer players through the development, validation and application of a declarative tactical knowledge test. Although the study of tactical knowledge in soccer has started in 1990s (WILLIAMS; DAVIDS, 1995), no attempts had been done to organize the literature about this topic until nowadays. Thus, we firstly systematically reviewed the state of the art of the literature about tactical knowledge in soccer in order to identify the potentialities and limitations of tactical knowledge assessment. We found an increasing interest of researchers studying tactical knowledge in soccer, mainly in the last five year. The literature pointed out the importance of congruence between tactical knowledge assessment with players' training process and sport development phases (GONZÁLEZ-VÍLLORA *et al.*, 2015; TEOLDO; GULHERME; GARGANTA, 2015)

The field of procedural tactical knowledge (PTK) assessment showed to be in a great consonance with the training process, compared to declarative tactical knowledge (DTK), in both theoretical and methodological issues. Moreover, although these both types of tactical knowledge (declarative and procedural) are complementary (ANDERSON, 1983; MCPHERSON, 1994), mostly of current available instruments are based on different assumptions, which reduce effectiveness of such assessment. Therefore, we proposed the development of an instrument for DTK assessment based on another available PTK assessment instrument (FUT-SAT) (TEOLDO *et al.*, 2011a), which is based on cutting-edge theoretical and pedagogical assumptions (core tactical principles of soccer). This strategy increases congruence of tactical knowledge assessment and will allow future research about this domain be more aligned to theory-driven assumptions.

Therefore, the second study aimed to expand the process of tactical knowledge assessment of soccer players, through the development of a DTK test, based on core tactical principles (WORTHINGTON, 1974; TEOLDO *et al.*, 2009; TEOLDO; GUILHERME; GARGANTA, 2015). We conducted the development of the TacticUP video test based on these principles, because they display central aspects of the educational process of tactical capacities (GARGANTA; PINTO, 1994) and have

objective measures of players' movements related to management of game space performed (TEOLDO; GUILHERME; GARGANTA, 2015). Subsequently, it was followed the validation processes suggested by literature (CRONBACH; MEEHL, 1955; LANDIS; KOCH, 1977; ANASTASI, 1988; CRONBACH, 1988; HOPKINS, 2000), and we verified that the test demonstrated adequate content, construct and face validity and was also an reliable measure of declarative tactical knowledge based on core tactical principles.

The validation was carried out with a sample of soccer players between 11.0 and 17.9 years of age that participated in national competitions for their age. This age was chosen in respect to sports development phases of soccer players (CÔTE; BAKER; ABERNETHY, 2007; GONZÁLEZ-VÍLLORA *et al.*, 2015). Therefore, we suggest to start the use of the TacticUP video test with groups around the age of 11/12 years, as core tactical principles start to be taught at this age, when players have their cognitive maturation in final stage, and are able to use abstract thought to operationalize this type of tactical principles (PIAGET, 1964; TEOLDO; GUILHERME; GARGANTA, 2015). Moreover, as the TacticUP video test enables to gather objective measures of players' DTK, it can be used to investigate what type of soccer activities (e.g. deliberate practice, deliberate play or competition) could favor tactical knowledge development.

In this regard, in the final study (study 3) we analyzed the amount of hours accumulated in distinct soccer activities by soccer players with different levels of DTK. Our results showed that the amount of accumulated hours in structured activities, such as team and individual practice (deliberate practice) and competition, are discriminant factors of groups with different levels (high and low) of DTK (offensive and defensive). Furthermore, considering the macro- and microstructure of practice, we found that the variables that showed larger effects to distinguish players based on their DTK (in both phases) were, respectively: i) team practice; ii) collective tactics in team practice activities; and iii) "high decision making opportunities" in team practice activities. It suggest that DTK development may be favored by activities in training that require players to use perceptual, cognitive and motor skills simultaneously in game like situations (e.g. small-sided and conditioned games), which allow them to experience similar problems as those they will face in competition. These findings strongly support

the idea that declarative tactical knowledge development is favored by coach-led training. Additionally, it also provide guidance on theoretical and practical understanding into the role of different activities in athletes' tactical knowledge development in soccer.

Concluding, this project has expanded and advanced the process of tactical knowledge assessment in soccer through: i) the organization of the current available literature about this topic; ii) the development of a valid and reliable declarative tactical knowledge test in soccer (TacticUP video test), in line with theoretical and methodological assumptions for the assessment of tactics; and iii) the application of this test to analyze which types of soccer activities may favor the development of declarative tactical knowledge in soccer. We also provided practical applications and future directions for the study of tactical knowledge in soccer based in the organization of the current literature, the advance of assessment instruments and grounded in empirical evidences for tactical knowledge development.

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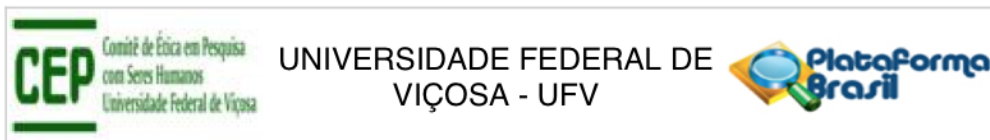
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## APPENDIX 1

### Ethics Committee Approval



#### PARECER CONSUBSTANCIADO DO CEP

##### DADOS DO PROJETO DE PESQUISA

**Título da Pesquisa:** DESENVOLVIMENTO E VALIDAÇÃO DE UM TESTE DE CONHECIMENTO TÁTICO DECLARATIVO NO FUTEBOL

**Pesquisador:** ISRAEL TEOLDO DA COSTA

**Área Temática:**

**Versão:** 1

**CAAE:** 75581617.0.0000.5153

**Instituição Proponente:** Departamento de Educação Física

**Patrocinador Principal:** Capes Coordenação Aperf Pessoal Nível Superior

##### DADOS DO PARECER

**Número do Parecer:** 2.312.402

##### Apresentação do Projeto:

O presente protocolo foi enquadrado como pertencente à Área Temática: Ciências da Saúde

Conforme resumo apresentado no formulário online da Plataforma: **INTRODUÇÃO:** No futebol, uma distinção comumente feita para a análise da componente tática é o tipo de conhecimento que se está avaliando, sendo considerado o conhecimento declarativo e processual (ANDERSON, 1982). Segundo Anderson (1983) o conhecimento declarativo está relacionado ao conhecimento das regras e objetivos do jogo e refere-se ao “saber o que fazer”. Para a avaliação do conhecimento tático declarativo atualmente há limitações metodológicas, pois os testes desenvolvidos não levaram em consideração os princípios táticos, que são regras de ação que permitem alcançar soluções táticas para o jogo, e avaliam apenas uma das fases de jogo (MANGAS, 1999; ROCA et al., 2011). Dessa forma, há a necessidade de desenvolvimento de um teste baseado nos princípios táticos fundamentais do futebol e que abranjam as duas fases de jogo (ofensiva e defensiva), que permita avaliar o conhecimento tático declarativo de jogadores de futebol. Portanto, o objetivo deste projeto é desenvolver e validar um teste de conhecimento tático declarativo no futebol, a partir dos princípios táticos fundamentais do futebol.

**MÉTODOS:** A amostra será composta por 120

**Endereço:** Universidade Federal de Viçosa, Avenida PH Rolfs s/n, Edifício Arthur Bernardes  
**Bairro:** Campus Universitário **CEP:** 36.570-900  
**UF:** MG **Município:** VICOSA  
**Telefone:** (31)3899-2492 **E-mail:** cep@ufv.br