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Faculty of Physical Activity and Sport Sciences

- INEF -

**Influencia de la discapacidad intelectual sobre el
rendimiento en baloncesto /**

**Influence of intellectual impairment on basketball
performance**

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Bachelor in Physical Activity and Sport Sciences

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*“I don’t care about someone being intelligent; any situation between people,
when they are really human with each other,
produces intelligence”*

Susan Sontag

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Dicen que el doctorado es un camino largo, sin embargo, para emprender el camino es necesario tener una línea de salida. Una línea que pasa por unos estudios, una formación persona y profesional que debo gracias al apoyo de mi familia: mis padres (Isabel y Fernando) y mis hermanos (Eduardo y Carlos). ¿Cuántas personas en este mundo no han tenido esta oportunidad? En este sentido, sólo puedo sentirme un privilegiado y tener palabras de agradecimiento por esta oportunidad vivida.

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TABLE OF ABBREVIATIONS

- **AAIDD:** Association on Intellectual and Developmental Disabilities
- **AB:** Able-bodied
- **ACB:** Spanish Basketball Club's Association
- **C:** Center
- **CHC:** Cattell-Horn-Carroll
- **D-48:** Domino test.
- **E.g.:** For example
- **ES:** Effect Size
- **Etc:** Et cetera
- **F:** Forward
- **FFH:** Fast and Frugal Heuristic
- **FIBA:** International Basketball Federation
- **G:** Guard
- **ID:** Intellectual Disability
- **IF:** International Sport Federations
- **II:** Intellectual Impairment
- **INAS:** International Federation for Para-athletes with Intellectual Disabilities
- **INEF:** Faculty of Physical Activity and Sport Sciences. Madrid
- **IOSDs:** International Organizations of Sport for the Disabled
- **IQ:** Intellectual Quotient
- **IPC:** International Paralympic Committee

- **ICF:** International Classification of Functioning, Disability and Health
- **LEB:** Spanish Basketball League
- **MABC:** Movement Assessment Battery for Children
- **Mp:** Avoidance motivation values
- **Mr:** Approach motivation values
- **NPC:** National Paralympic Committees
- **Ku-Leuven:** Catholic University of Leuven
- **R&D:** Research and development
- **SVPN:** Perceptive differential logical conclusion.
- **U-16:** Under 16 years old
- **U-18:** Under 18 years old
- **UPM:** Technical University of Madrid
- **V:** Value of the actions
- **VO₂:** Maximal oxygen consumption.
- **WHO:** World Health Organization

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SUMMARY

Throughout the present work, four studies aimed to answer from different perspectives the general research question: **how intellectual impairment (II) influences basketball performance?** The **first study revealed that II-players played basketball in a different way than AB-players.** II-teams played more ball possessions per game and the variables which best discriminated II and AB-teams were: 2-point unsuccessful shots, 3-point successful, 3-point unsuccessful, free-throws successful and fouls. In all playing positions, II-players presented more 2-point unsuccessful and lower shooting percentage in all kind of shots. The **second study confirmed that II-players present significant limitations to recognize and order correctly a basketball game sequence.** The time II and AB-players employed to carry out these process was the variable that best discriminated them. The **third study indicated that II-players presented significant limitations to make decisions in basketball.** In line with the previous study, also the variable “time” was the variable that best discriminated between II and AB-players. In **the last study it was observed that II-players presented significant limitations to solve different basketball game situations in the field** through a standardized test in which athletes were asked to solve situations from 1 on 1 to 2 on 2o. These studies confirmed that II influences negatively on basketball performance. These results can potentially contribute to develop II-basketball eligibility systems based on the limitations presented by the players to carry out the abilities assessed in the different studies.

RESUMEN

A través del presente trabajo, cuatro estudios trataron de responder desde diferentes perspectivas la pregunta general de investigación: **¿Cómo influye la discapacidad intelectual (DI) en el rendimiento en baloncesto?** El **primer estudio reveló que los jugadores-DI jugaban al baloncesto de manera diferente que los jugadores sin DI.** Los equipos-DI jugaron más posesiones de balón por partido y las variables que más discriminaron los equipos con y sin DI fueron: lanzamientos de 2-puntos fallados, 3-puntos encestados, 3-puntos fallados, tiros libres encestados y faltas. En todas las posiciones de juego, los jugadores-DI fallaron más canastas de 2-puntos y presentaron peores porcentajes de tiro en todo tipo de lanzamiento. **El segundo estudio confirmó que los jugadores-DI presentan limitaciones significativas para reconocer y ordenar correctamente una secuencia de juego.** El tiempo que los jugadores con y sin DI emplearon para llevar a cabo este proceso fue la que más les discriminó. **El tercer estudio indicó que los jugadores-DI presentan limitaciones significativas para tomar decisiones en baloncesto.** En línea con el estudio anterior, la variable tiempo fue la que más discriminó a jugadores con y sin DI. **En el último estudio se observó que los jugadores-DI presentaron limitaciones significativas para resolver una situación de juego en el campo** a través de un test estandarizado en el que los deportistas tenían que resolver situaciones desde 1 contra 1 hasta 2 contra 2. Estos estudios confirmaron que la DI influye negativamente sobre el rendimiento en baloncesto. Estos resultados pueden contribuir potencialmente al desarrollo de sistemas de elegibilidad para baloncesto-DI basándose en las limitaciones presentadas por los jugadores para llevar a cabo las habilidades evaluadas en los diferentes estudios.

1. General Introduction

The present study aims to analyze the influence of intellectual impairment (II) on basketball performance with the final purpose to contribute to the development of basketball-specific eligibility systems which ensure that only athletes with significant limitations to perform basketball participate in II-basketball competitions. The development of these systems in II-sports became an important need after the Sydney 2000 Paralympic Games, in which some able-bodied (AB) athletes participated in II-basketball competitions, being the established eligibility systems at that moment inefficient to detect this situation. This fact made the IPC remove all competitions for II-athletes from the Paralympic program until scientific and reliable evidence-based eligibility systems were developed.

This study is framed into the research project: “Sport intelligence assessment tools development for applications: applications to the international eligibility system for players with intellectual disability” (Spanish Ministry of Economy and Competitiveness, DEP2012-33649), carried out by the research group from the Faculty of Physical Activity and Sport Sciences (INEF) from the Technical University of Madrid (UPM). This group was set as satellite group of the “Classification Research & Development (R&D) Centre for Classification of Athletes with ID” (KU-Leuven) that was recognized by INAS and IPC since 2014 to coordinate a largest research project to develop eligibility systems in those sports for II-athletes with potential to be re-included in the Paralympic program (Van Biesen, 2014). As result of this large research, eligibility systems were developed for table-tennis, swimming and athletics; being these sports included in London 2012 Paralympics (Burns, 2015). However, this research is still needed in II-basketball, probably one of the most popular team sports for this population worldwide, aiming the present study to address this need.

This first chapter aims to introduce the conceptual framework from which this research has been carried out and to review the most recent studies analyzing the influence of II on sport performance.

1.1 Terminology and definitions

1.1.1 ICF Terminology

The World Health Organization's (WHO) International Classification of Functioning, Disability and Health (ICF) is the framework for measuring health and disability at both individual and population levels (WHO, 2001). The model presented by the WHO formulates human functioning in a multiple dimensions under a biopsychosocial view and established a common language globally agreed (Kostanjsek, 2011). The ICF is based on the impact on the functioning of the individual, using a common metric which allows us to compare functioning in different conditions (WHO, 2001).

The ICF consists in two parts, each containing two separate but interrelated components. The first part covers functioning and disability and includes: body functioning and structure; activities and participation. The second part covers contextual factors and includes the components: environmental factors and personal factors (Cieza et al., 2002). To establish a common language, the ICF defined the following terms (WHO, 2002; p.10):

Body Functions are physiological functions of body systems (including psychological functions).

Body Structures are anatomical parts of the body such as organs, limbs and their components.

Impairments are problems in body function or structure such as a significant deviation or loss.

Activity is the execution of a task or action by an individual.

Participation is involvement in a life situation.

Activity Limitations are difficulties an individual may have in executing activities.

Participation Restrictions are problems an individual may experience in involvement in life situations.

Environmental Factors make up the physical, social and attitudinal environment in which people live and conduct their lives.

When problems in the body function or structure appears (impairment), an individual may have difficulties to execute an activity (limitations); probably, these limitations might involve problems in life situations (participation). This framework and terminology have been adopted also by adapted sports organizations including the International Paralympic Committee (IPC) in its Classification Code (IPC, 2015; Tweedy & Vanlandewijck, 2011).

1.1.2 Definition of intellectual impairment and intellectual disability

An **intellectual impairment** appears when intellectual structures or functioning are affected significantly, not being able to work normally (WHO, 2001). The American Association on Intellectual and Developmental Disabilities (AAIDD, 2010) defined **intellectual disability** as a disability characterized by significant limitations in both intellectual functioning and in adaptive behavior originated before the age of 18. The AAIDD (2010) also defined two important terms:

Intellectual Functioning: Also called intelligence, refers to general mental capacity, such as learning, reasoning, problem solving, and so on. Generally it has been measured by Intellectual Quotient (IQ) tests. An IQ score of around 70 or as high as 75 indicates a limitation in intellectual functioning.

Adaptive Behavior: Is the collection of conceptional, social, and practical skills that are learned and performed by people in their everyday lives. Standardized tests can also determine limitations in adaptive behavior:

Conceptual skills: language and literacy; money, time, and number concepts; and self-direction.

Social skills: interpersonal skills, social responsibility, self-esteem, gullibility, naïveté (i.e., wariness), social problem solving, and the ability to follow rules/obey laws and to avoid being victimized.

Practical skills: activities of daily living (personal care), occupational skills, healthcare, travel/transportation, schedules/routines, safety, use of money, use of the telephone.

The term **cognitive abilities** refers to a large variety of mental procedures as perception, memory, attention, problem solving, processing, reasoning and knowledge building (Van der Wardt, 2010; p.7); which are strongly involved with intellectual functioning. The AAIDD (2010) pointed out that additional factors related to the context must be taken into account as: community environment, individual's peers and culture. Linguistic diversity and cultural differences should also be taken into account. The WHO (2001) indicated that an impaired intelligence is considered when the ability to understand new or complex information and to learn and apply new skills is significantly reduced. This implies an intellectual disability and it results a reduced

ability to cope independently (impaired social functioning). It begins before adulthood, with a lasting effect on development.

1.2 Eligibility systems in Paralympic Sports

1.2.1 IPC eligibility position stand and Classification Code

The IPC is the global governing body of the Paralympic Movement as well as the organizer of the Summer and Winter Paralympic Games (Tweedy & Vanlandewijck, 2011). Its vision is “to enable Paralympic athletes to achieve sporting excellence and inspire and excite the World” (IPC, 2015; p.3). National Paralympic Committees (NPC), International Sport Federations (IF) and International Organizations of Sport for the Disabled (IOSDs) are members of the IPC. They are responsible to promote and to organize National and International adapted sport competitions. In case of II-basketball, INAS is the organization uncharged to promote II-basketball internationally and to organize high-level basketball competitions such as World Basketball Championships and the Global Games. The Global Games represent the largest worldwide event of high-level sports competition for II-athletes in which athletes from the entire world participate in different sports.

The IPC Classification Code is the fundamental document upon which Classification in Para-sports in the Paralympic Movement must be based (IPC, 2015; p.4). It has to be applied by all members of the Paralympic Movement including athletes, IF and IOSDs. One of the aims of the Classification Code is to define who is eligible to compete in Para-sport with the purpose to ensure that competition is fair and equal, success being determined only by the same factors that account in sport for AB-athletes (Skill, fitness,

power, endurance, tactical ability and mental focus). According to the IPC Classification Code (IPC, 2015; p.5), a classification System must:

- Clearly state which type(s) of impairment an athlete may have in order to be eligible for the sport.
- Describe processes and procedures for assessing whether an Athlete has an eligible type of impairment.
- Describe minimum impairment criteria for each eligible impairment type. It must be written in a way that can be objectively assessed.
- Describe how athletes are allocated a sport class on how much the athlete's impairment will affect their sports performance.

An athlete must not intentionally misrepresent his or her skills and/or abilities and/or the degree or nature of physical, visual or intellectual impairment to a classification panel. At this moment, the types of impairment eligible to participate in the Paralympic program are physical, visual and intellectual impairment and only for the sport modalities included in the program. As a specific evidence-based eligibility system for II-basketball has not been developed yet, II-basketball cannot be included in the Paralympic program by the moment.

1.2.2 Development of sport-specific eligibility systems

All sport-specific eligibility system, including II-basketball, need to be evidence-based, if its aim is to be included in the Paralympic program. It means that the system must have a clearly stated purpose and that empirical evidence must indicate that the methods used to identify eligible athletes will achieve the stated purpose. For this, research is needed; first, to identify how the type of impairment impact on sport-specific

performance and secondly, to establish the minimum impairment that significantly affect negatively on its performance (Tweedy & Vanlandewijck, 2011). Results from research will be the base to set the eligibility criteria of each sport. The eligibility criteria must be described in terms of type of impairment and severity of impairment. This impairment must be permanent and have to impact significantly on sport-specific performance. In addition, criteria must be sport-specific, in base of how impairment affect on performance in each sport (Tweedy & Vanlandewijck, 2011). Consequently, an athlete with an eligible impairment in a Paralympic Sport could be eligible for one sport but not for other.

Minimum criteria should exclude impairments that may cause activity limitation in training but do not directly impact on activities that are fundamental for sport performance. Also, the measure of the impairment should be resistant to training and should identify intentional misrepresentation of abilities (Tweedy & Vanlandewijck, 2011). Focusing on II-sports, the development of sport-specific tests to assess II has to take into account additional considerations (Van Biesen, 2014; p.172):

- Test's length must be appropriate (not too long), to keep athlete's attention and motivation.
- They have to be culturally neutral and remove all kind of ambiguous elements that might be understood in different ways depending on the culture.
- Instructions should be clear and easy to be understood.
- Difficulty must be suitable for individuals with II.

1.2.3 Eligibility process in II-sports

Once the eligibility criteria has been developed for a II-sport, eligibility process in each sport consists of 4 stages: primary eligibility check, sport cognition test battery, sport specific assessment and observation assessment (Kerremans, Geeraerts, Van Biesen, & Vanlandewijck, 2012; p.12)

Stage 1: Primary Eligibility Check

This is a first step needed to verify that each athlete meets the criteria for diagnosis of II (AAIDD, 2010; INAS, 2014) which are:

- Significant impairment in intellectual functioning, defined as an IQ test score of around 70 or as high as 75.
- Significant limitations in adaptive behavior as expressed in conceptual, social and practical adaptive skills.
- Evidence of the intellectual impairment before the age of 18.

INAS is uncharged to require each Nation to submit documentation of each athlete to check these criteria. This step is needed to go through the following stages of the II eligibility process (Van Biesen, 2014).

Stage 2: Sport cognition test battery

In this stage, Sport Intelligence is assessed, understanding it as those components of intelligence that play a role in sport (Van Biesen et al., 2011). To assess it, a test battery was designed by Van Biesen et al. (2011) which consisted on the evaluation of different psychological dimensions defined as key for sport performance. These dimensions are assessed by 7 different tests: reaction time, visual search, Corsi memory, Tower of London executive function, matrix reasoning, block design and finger tapping. This

battery combines computer based touch screen applications and paper and pencil tests. This stage is not sport-specific, so this test battery has been used last years (until 2015) during all eligibility process for every II-sports.

Stage 3: Sport specific assessment

In this stage, a test or test battery specific for each sport have been develop and used to assess athletes' capacities fundamental to perform in each sport (Tweedy & Vanlandewijck, 2011). Activities assessed should be those activities with major implication of intellectual functioning during sport performance. This step is relevant to determine those athletes whose impairment negatively influences performance in a given sport. As an example, in athletics, this assessment is focused on tactical race components like pacing strategies instead of physical and physiological components such as VO₂, strength and so on.

Stage 4: Observation assessment

Competition and / or game observation is a control mechanism to check that the impairment presented by the athlete and its limitations to perform in that sport are also presented in real game situations (Van Biesen, 2014). This stage should be a mechanism to ensure that no athlete has been able to misrepresent their abilities during the eligibility process, but mainly to assess impact of II in sport performance, as it is specific by nature: intellectual functioning demands are quite different between table tennis, Nordic skiing, track and field, swimming and basketball, as structural components, rules and communication issues are specific.

A complete overview of the whole ID eligibility process was described by Van Biesen (2014; p.39) and it is presented in figure 1.

Figure 1. Visual representation of the complete ID eligibility process (Van Biesen, 2014)

1.3 The role of intellectual functioning on sport performance

The main function impaired in II-athletes is intellectual functioning while performing. For this, it seems necessary to understand the relationship between intellectual functioning and sport performance and how II might affect on it.

1.3.1 Relationship between IQ and sport performance

IQ tests have been traditionally employed to assess general intelligence and to diagnose impairment on intellectual functioning (AAIDD, 2010). On the other hand, various studies have identified factors embedded in intellectual functioning (e.g., knowledge, information processing skills, memory and decision making among others) as key contributors to elite sport performance (Allard, Graham, & Paarsalu, 1980; French &

Thomas, 1987). However, it is necessary to clarify if IQ tests assess those cognitive components required to perform in sport and if there is any relationship between IQ and sport performance.

One of the first studies that explored this relationship was made by Burley & Anderson (1955), where the relationship between “jump and reach” test and IQ scores was analyzed. They found no relationship between outcomes in both measures, pointing out that outcome in “jump and reach” test was related with training, but not with IQ scores. Another study made by Railo (1969) found no relationship between physical fitness and academic achievement; however, IQ neither sport performance were measured directly in this study.

In the other side, González et al. (2007) found significant correlation between IQ and visual motor integration in children aged 4 to 10 years. In this line, Lahtinen, Rintala, & Malin (2007) found that IQ effect was significant on balance and manual dexterity. Vuijk, Hartman, Scherder, & Visscher (2010) found that children with II had more motor problems than the normative sample and it was observed that the degree of II was associated with manual dexterity, balance and ball skills; explaining certain relationship between IQ and these skills.

Goldstein & Britt (1994) and Planinsec & Pisot (2006) found evidences of positive correlations between various measures of psychomotor performance, cognitive abilities and academic achievement, but IQ was not assessed in this study. As they explained, psychomotor performance shares many common neurological mechanisms with cognitive functions. Dexter (1999) indicated that sport knowledge played an important

role in sport performance; and for this, academic ability is important for gaining such knowledge, but also in this study IQ was not analyzed. A recent systematic review (Van der Felsa et al., 2014) concluded that there is no correlation in the literature or insufficient evidence for or against many correlations between motor skills and cognitive skills.

Van Biesen (2014) manifested that the lack of consistency in the relationship between IQ and sport performance could be attributable to the conceptual breadth of intelligence and sport performance. If the relationship of IQ and sport performance were so strong, probably the world best scientists would be the world best athletes and vice versa (Van Biesen, 2014). In this line, research in intelligence assessment indicated that the ways to assess IQ is diverse and it does not assess all cognitive abilities involved on intelligence (Sparrow & Davis, 2000). According to this, to investigate the relationship of intelligence and sport performance, other measurements of intelligence are needed instead of IQ. These alternatives are presented in the following point.

1.3.2 Sport Intelligence Model

The Sport Intelligence Model emerged with the aim to identify and to assess those cognitive abilities of intelligence that are specifically required to perform in sport (Van Biesen, 2014). To identify these cognitive abilities, the model was based first on Carroll's model of intelligence (1993), but later, it was adapted to the new Cattell-Horn-Carroll (CHC) model of intelligence (McGrew, 2009; Newton & McGrew, 2010; Schneider & McGrew, 2012; Van Biesen, 2015), which is an evolution of the first one.

The CHC's model was made up of three strata: stratum I includes more than 60 discrete and specific abilities (narrow abilities); stratum II is composed by key areas of intelligence (broad abilities: fluid intelligence, Quantitative Knowledge, Crystallized intelligence, Short-Term Memory, Visual Processing, Long-Term Retrieval, Processing Speed, Correct Decision Speed, Reading/Writing) and Stratum III is a single general intelligence factor: *G-factor* (Newton & McGrew, 2010). Parts in this system are interrelated and a deficit in any part will likely affect the functioning of the entire system. However, the degree to which an impaired cognitive ability lowers the functioning of the whole system is not similar for all cognitive abilities and it depends on the affected ability's centrality on *G-factor* (Bergeron & Floyd, 2006). According to this, an athlete with impairment in cognitive abilities relevant in sport performance but with low centrality (low implication on G-factor) could have more limitations to perform a sport than an athlete with more impaired G-factor but not these cognitive abilities. For this, to develop a Sport Intelligence model was needed to assess athletes' cognitive abilities that are best required to perform in sport.

Van Biesen (2014) designed the Sport Intelligence model using also the three strata. From CHC's model, there were selected those cognitive abilities that play a role in sport. This selection was made in three steps: 1) Expert psychologists from KU Leuven and Loughborough University made a referenced and revised selection of cognitive abilities individually, resulting in more than 95% consensus. 2) A large-scale testing of sport-intelligence was performed in a group of more than 300 II-athletes to strengthen the conceptual model. 3) A Delphi technique with a panel of 6 experts was employed to check this model. Finally, Sport Intelligence Model was composed by 4 broad abilities in stratum II (from 8 presented in CHC's model) and 20 narrow abilities in stratum I

(from more than 60 presented in CHC's model). In addition, a final component which was not part of CHC's original model was included to operationalize the application of the selected abilities within a general sport context: executive functioning, visuo-motor abilities and attention-concentration skills (Van Biesen, 2015). The resulting Sport Intelligence Model is presented in figure 2.

Figure 2. Sport Intelligence model. Adapted from Van Biesen (2015)

To better understand each one of these abilities, we will explain them, retrieved from the Institute for Applied Psychometrics (McGrew, 2003):

Fluid Intelligence

Reasoning: Ability to start with stated assertions (rules, premises, or conditions) and to engage in one or more steps leading to a solution to a problem. The processes are deductive as evidenced in the ability to reason and draw conclusions from given general conditions or premises to the specific.

Induction: Ability to discover the underlying characteristic from a specific problem or a set of observations; also, to apply a previously learned rule to the problem.

Memory

Memory Span: Ability to attend to, register, and immediately recall temporally ordered elements and then reproduce the series of elements in correct order.

Working Memory: Ability to temporarily store and perform a set of cognitive operations on information that requires divided attention and the management of the limited capacity resources of short-term memory.

Meaningful Memory: Ability to note, retain, and recall information there is a meaningful relation between the bits of information, the information comprises a meaningful story or connected discourse, or the information relates to existing contents of memory.

Visual Processing

Visualization: The ability to apprehend a spatial form, object, or scene and match it with another spatial object, form, or scene with the requirement to rotate it in two or three dimensions.

Spatial Relations: Ability to rapidly perceive and manipulate visual patterns or to maintain orientation with respect to objects in space. It may require the identification of an object when viewed from different angles or positions.

Spatial Scanning: Ability to quickly and accurately survey (visually explore) a wide or complicated spatial field or pattern and identify a particular configuration (path) through the visual field.

Length Estimation: Ability to accurately estimate or compare visual lengths or distances without the aid of measurement instruments.

Closure Speed: Ability to quickly identify a familiar meaningful visual object from incomplete visual stimuli, without knowing in advance what the object is.

Processing Speed/Reaction time speed

Perceptual speed: Ability to rapidly and accurately search, compare and identify visual elements presented side-by-side or separated in a visual field. This ability may be an *intermediate* stratum ability (between narrow and broad) defined by four narrow sub-abilities: (1) *Pattern Recognition*, the ability to quickly recognize simple visual patterns; (2) *Scanning*, ability to scan, compare, and look up visual stimuli; (3) *Memory*, ability to perform visual perceptual speed tasks that place significant demands on immediate short-term memory, and (d) *Complex*, ability to perform visual pattern recognition tasks that impose additional cognitive demands such as spatial visualization, estimating and interpolating, and heightened memory span loads.

Rate of test taking: Ability to rapidly perform tests which are relatively easy or over learned. This ability is not associated with any particular type of test content stimuli.

Simple Reaction Time: Reaction time to the onset of a single stimulus (visual or auditory) that is presented at a particular point of time.

Choice Reaction Time: Reaction time to the onset of one of two or more alternative stimuli, depending on which alternative is signaled.

Based on this model, a battery test was developed and validated by Van Biesen (2014) to assess Sport Intelligence in II-athletes. This battery was included in Stage 2 of the eligibility systems of II-sports (see point 1.2.3 of this chapter).

1.3.3 Influence of II on motor skills and fitness

First studies found in the literature analyzing the capacity of individuals with II to carry out physical activities were focused on the relationship between II and motor skills and fitness. In the side of motor skills, Carmeli, Bar-Yossef, Ariav, Levy, & Liebermann (2008) found that upper body (hand-eye) coordination was poor in adults with II, particularly when a quick response to perceptual (visual) stimuli was required. Hartman, Houwen, Scherder, & Visscher (2010) manifested that children with II were impaired in qualitative motor skills and in higher-order executive functions. Golubovic, Maksimovic, Golubovic, & Glumbic (2012) found that children with II performed poorer in balance skills compared with AB-children and explained these differences by the child's inability to react adequately to visual and proprioceptive information.

In the side of fitness, several studies reported poor levels on general standard fitness tests in individuals with II (Carmeli et al., 2008; Cuesta-Vargas, Paz-Lourido, & Rodriguez, 2011; Frey, Stanish, & Temple, 2008; Graham & Reid, 2000; Van de Vliet et al., 2006). Cardiovascular fitness was reported by Pitetti, Yarmer, & Fernhall (2001) to be lower in 20m shuttle run test comparing with matched AB-individuals. Strength was also reported to be lower in individuals with II by Borji, Zghal, Zarrouk, Sahli, & Rebai (2014). In this last study, they found lower scores in voluntary activation level, lower root mean square values of vastus lateralis, vastus medialis and rectus femoris muscles. They suggested that these differences were related to a central nervous system failure to activate motor units and to some abnormal intrinsic muscle properties. These lower results could be also attributed to other factors including (a) sedentary lifestyle, (b) poor motivation to perform a test (c) the lack of possibilities to take part into physical activities (d) difficulties to accurate fitness assessment in this population, (e)

physical characteristics such as short stature, postural control problems, and cardiovascular insufficiency (f) chronotropic incompetence (misbalance between maximal heart rate and metabolic levels at maximal or submaximal effort) and (g) reduced strength (Borji et al., 2014; Graham & Reid, 2000; Stanišić, 2012; Van de Vliet et al., 2006). Several studies indicated that athletes with higher degree of II scored lower in motor skills and fitness tasks (Elmahgoub, Van de Velde, Peersman, Cambier, & Calders, 2012; Golubovic et al., 2012; Guidetti, Franciosi, Gallotta, Emerenziani, & Baldari, 2010; Lejčarová, 2009). Also, it was found a relationship between the etiology of II with level of motor skills and fitness (Lejčarova, 2008).

According to the previous results, it seems that II influences negatively on motor skills, fitness and physical activity factors; consequently, II might negatively impact on sport performance. However, it is necessary to be careful in generalizing these results to the overall II-population, because we can mislead attributing characteristics to individuals who actually do not present it. In the study of Vuijk et al. (2010), they compared two groups of children with and without II performing the Movement Assessment Battery for Children (MABC) (Schoemaker, Niemeijer, Flapper, & Smits-Engelsman, 2012). They found that children with II had significantly more motor problems than the normative sample. Furthermore, there was a relationship between degree of II and scores in manual dexterity, ball skills and balance skills. However, it is necessary to take into account that from the obtained results, 18.2% of tested children with mild intellectual disabilities and 40.0% of children with borderline intellectual functioning did not present motor problems in the overall MABC test results. According to this, it is not possible to generalize that all individuals with II have limitations on motor skills and fitness. In this line, the study of Golubovic et al. (2012) found better scores of

children with borderline intellectual functioning in motor skills compared with mild II, but, surprisingly with their hypothesis, children with mild ID scored better in long jump test, which requires speed, good coordination and explosive movement. This manifests that the relationship between intellectual functioning, motor skills and fitness is not strictly linear and it depends on many factors. In this line, the capacity of II-athletes to improve in simple reaction time (Yildirim, ErbahÇEcİ, Ergun, Pitetti, & Beets, 2010) and sport-specific skills like martial arts (Maslesa, Videmsek, & Karpljuk, 2012) or basketball skills (Stanišić, BeriĆ, Bojić, Nurkić, & Kocić, 2012; Tsimaras et al., 2009) suggests that training and experience are important factors to take into account.

1.3.4 Evidences of the influence of II on sport performance

One of the first studies dealing with II-athletes in order to identify how II might impact on sport performance was carried out by Van de Vliet et al. (2006). This study focused in the relationship of physical fitness and II like in the previous point; however, in this case authors compared physical fitness profile between high-performance II-athletes and physical education students using the EUROFIT test. They found that male II-athletes scored better for running speed and flexibility and worse for strength and muscle endurance levels than AB-athletes. Female II-athletes didn't perform different from AB-athletes for flexibility, running speed and upper body muscle endurance, but they performed worse for strength measures. II-athletes also presented poorer cardio respiratory endurance. Data from this study also revealed that male II-athletes had more differentiated profile depending on the athlete's sport discipline than female II-athletes. These results seemed to go in the line of previous studies; however, when data were compared individually, some II-athletes performed better scores than some AB-athletes.

In the previous study it emerged a conclusion found for the first time in the literature, which indicates limitations of II-athletes on specific components of sport performance in high-level competitions (e.g. table tennis, basketball and football). These limitations referred to decision-making processes, comprehension of the game situations and person-environment interaction. As authors stated: (Van de Vliet et al., 2006; p.423) *“these latter components are largely influenced by ID. Coaches report that, even after many years of training, these components remain an ongoing concern in both training and competition”*. This conclusion represented an emerging interest in order to analyze how II might influence on a given sport performance and authors pointed out that those components of sport performance with high implication of different cognitive abilities seemed to be those components most negatively influenced by II.

In recent years, literature in this line has increased, especially in sports such as athletics, swimming and table tennis. In athletics, Willwacher, Potthast, Müller, & Brüggemann, (2011) identified that II-athletes performed below the level of world class and even intermediate AB-athletes in the modality of shot put. The analysis of different kinematic variables from the technique revealed that II-athletes reduced the length of the accelerative path and consequently release speed was lower. In swimming, Einarsson (2008) found that II-swimmers performed lower than AB-swimmers in 200m freestyle race in the variables final time, clean swimming speed, stroke length, turning time, start time (time from 0-15 m) and reaction time. In addition, it was observed that II-swimmers had more decline in their stroke length during the race than AB-swimmers. No differences were found in stroke rate. Another study in 100m freestyle race (Daly, Einarsson, Van de Vliet, & Vanlandewijck, 2006) revealed that II-swimmers lost significantly more speed in the middle of the race than international AB-participants.

However, patterns related to race speed, stroke rate and stroke length of II-swimmers did not appear to be different comparing with AB-swimmers and rest of classes in Paralympic Games. These results suggest that probably sport-specific technique acquisition and performance might be negatively influenced by II impact.

Research in table tennis was larger than previous sports in number of references. Van Biesen et al. (2010) investigated the capacity of elite II-table tennis players to adapt their service/return to specific ball spin characteristics. Athletes played 16 sets of 15 identical serves that they had to return to a fixed target. Elite II-table tennis players were significantly less proficient than AB-athletes; however, both groups demonstrated a comparable progression in learning. In another study (Van Biesen, Mactavish, Pattyn, & Vanlandewijck, 2012), technical proficiency on II-athletes was analyzed on this sport. They used a test-battery that included 10 sets of five basic and five advanced technical skills. AB-table tennis players scored significantly better, suggesting that impaired cognitive functioning may have a direct bearing on technical proficiency in sport. Tactical proficiency was also addressed in a new study (Van Biesen, Mactavish, & Vanlandewijck, 2013) in which each player performed 60 semi-standardized rallies against the same opponent. Players were told that 12 sets of five identical services would be delivered, and their goal was to return the service with the intention of 'winning the point'. Results revealed lower proficiency scores of II-athletes respect to AB-athletes. In these studies II-athletes were matched with AB-athletes according to training volume.

Results of all the above mentioned studies suggested that future researches in this line should assess the implication of II on sport-specific performance factors, especially regarding to technical and tactical components.

1.3.5 Athletes with II performing basketball

First studies found in the literature which referred to the participation of II-athletes on basketball were focused on the benefits that basketball practice can generate for these athletes. These studies revealed that basketball practice can improve maladaptive behavior (Gençöz, 1997) or physical fitness parameters (Tsikriki, Batsiou, Douda, & Antoniou, 2007) such as strength (Tsimaras et al., 2009) or cardiovascular endurance (Stanisic, Kocic, Aleksandrovic, Stankovic, & Radovanovic, 2012; Tsikriki et al., 2007).

Further and more focused research on II-basketball demonstrated the positive effect of specific training programs on basketball skills (Castagno, 2001; Stanišić et al., 2012; Tsikriki et al., 2007). Some studies used a test battery to assess basketball-skills around four main skills: ball handling, reception, passing and shooting (Baldari et al., 2009). These tests were used to classify II-basketball players into four levels: I to IV increasing the difficulty of the four main skills; and also to assess II-athlete's improvement through a basketball-specific training program (Franciosi, Gallotta, Baldari, Emerenziani, & Guidetti, 2012; Guidetti, Franciosi, Emerenziani, Gallotta, & Baldari, 2007). In these studies a negative correlation between level of II and scores was assessed in the tests, indicating that athletes with lower II obtained higher scores in the different skills. The relationship between these skills and physical factors was studied by Franciosi, Guidetti, Gallotta, Emerenziani, & Baldari (2010). It was found that greater explosive leg power

and upper-body muscular strength and endurance had significant contributions to ball handling; explosive leg power had significant positive contribution in reception and shooting and the forearm muscular strength and upper-body muscular strength and endurance had significant contributions to passing skills.

These studies contributed to understand how II-players can improve their basketball skills and also to make an approach to how to classify them according to these skills. However, it was needed to analyze how II-athletes perform basketball during real competition and which components of the game were more negatively affected by II, in order to assess the influence of II on basketball performance. To address this need, a recent study (Polo, Pinilla, Pérez-Tejero, & Vanlandewijck, 2014) administrated a questionnaire to 17 coaches experienced in II-basketball competitions (9.2 ± 9.8 years experience) to identify those factors. Coaches' answers reported that individual and collective offensive tactics are the factors in which II-athletes presented more limitations, instead of others like physical skills or individual technical skills, frequently reported in the literature. Other studies started to analyze II-basketball performance during high-level competitions. Pérez-Tejero, Pinilla, & Vanlandewijck (2015) identified differences between successful and unsuccessful teams in game-related statistics, finding that successful teams significantly made more steals, assists, 2-points shots successful and they had better 2-points shot percentage than unsuccessful teams. In this study, when game-statistics were compared to similar studies in AB-basketball, II-athletes seemed to perform less shooting efficiency, to take more rebounds and to commit more turnovers per game. In this line, Pinilla, Pérez-Tejero, Van Biesen, & Vanlandewijck (2015) also indicated these differences when game-related statistics

were analyzed per playing position and they reported higher performance variability in II-basketball players when compared with the literature in AB-players.

These studies appeared as first approach to understand how II-players perform basketball; however, to develop basketball-specific eligibility systems it is still needed to investigate the influence of II on basketball performance and in those activities fundamental to perform in this sport (Tweedy & Vanlandewijck, 2011). To do this, first it is necessary to identify which are these fundamental activities to perform in basketball and the role of intellectual functioning on them, topic addresses in the next chapter.

2. The Role of Intellectual Functioning in Basketball Performance

To analyze the role of intellectual functioning in basketball performance, first, it is necessary to define performance in this sport and secondly, to identify which are the fundamental activities involved in basketball (Tweedy & Vanlandewijck, 2011). In this line, this chapter aims to review the state of the art in the literature regarding this topic.

2.1 Indicators of basketball success

Success in basketball is determined by basketball official rules (FIBA, 2014b; p.5):

“The team that has scored the greater number of points at the end of playing time shall be the winner”.

The final purpose of each team during a game is to score into the opponent's basket (offensive actions) and to avoid the opponents to score in their basket (defensive actions). Consequently, the two teams will work to find the best way to reach this objective. In this line, research in basketball has tried to analyze the most efficient ways to success in this sport. As result of these researches, different indicators of performance have been described in the literature. Nadori (1993) suggested that the analysis of the competition is the best way to measure athlete's real performance. To do this, observational analysis has been employed to identify different performance indicators of basketball: game-related statistics and game actions, both best related with success.

2.1.1 Game-related statistics which best contribute to success in basketball

Official game-related statistics are frequently used by coaches during the game to check performance indicators from their team and their opponents. These statistics usually gather the following variables according to the International Basketball Federation (FIBA, 2005): 2- and 3-point field-goals (both successful and unsuccessful), free-throws (both successful and unsuccessful), offensive and defensive rebounds, steals, turnovers,

assists, blocks, and personal fouls. Basketball research has compared these variables between successful (win) and unsuccessful teams (lose) from different levels, ages and gender to identify which variables contributed best to success. Main results found in the literature analyzing game-related statistics are presented in table 1.

Table 1. Game related statistics which best contributed to success in the basketball literature

Authors	Competition	Variables
(Trninic, Dizdar, & Luksic, 2002)	Euroleague 1992 to 2000	- Defensive rebounds - Field goals - Free throws - Assists
(Gómez, Lorenzo, Sampaio, Ibáñez, & Ortega, 2008)	Spanish professional league (ACB), season 2004-2005	<i>Balance games</i> - Defensive rebounds <i>Unbalance games</i> - Successful 2-points field-goals. - Defensive rebounds - Assists
(García, Ibáñez, Martínez, Leite, & Sampaio, 2013)	ACB season 2007-2008	- Assists - Defensive rebounds - Successful 2-point field goals - Successful 3-point field goals
(García et al., 2013)	ACB Finals 2007-2008	- Defensive rebounds
(S. J. Ibáñez et al., 2008)	Spanish basketball league (LEB) 2000- 2006	- Assists - Steals - Blocks
(Parejo, García, Antúnez, & Ibáñez, 2013)	Spanish amateur league (EBA), season 2005 -2006	- 2-points shots missed - Free throws scored - Defensive rebounds - Assists - Personal fouls
(Lorenzo, Gómez, Ortega, Ibáñez, & Sampaio, 2010)	U-16 European Championships	- Successful 2-points field-goals. - Defensive rebounds
(M. A. Gómez, Lorenzo, Sampaio, & Ibáñez, 2006)	Woman Spanish League. Season 2004 - 2005	- Successful 2 point field-goals - Defensive rebounds - Assists

Assists, defensive rebounds and successful 2-point field goals have been identified in various studies as variables discriminating from successful and unsuccessful teams. Authors explained assists and successful 2-point as a result of teamwork (passing) and good decision making to reach the best options to score (Ibáñez et al., 2008; Trninic, Dizdar & Luksic, 2002). A successful defensive rebounding probably let a team more opportunities to play a fast-break and to shoot with low defensive pressure (Gómez, Lorenzo, Sampaio & Ibáñez, 2006). Also, it reduces the chances for the opponents' efficiency by not allowing them an extra ball possession, decreasing their number of shots attempted (Lorenzo, Gómez, Ortega, Ibáñez & Sampaio, 2010). However, the identified variables were not the same for all competitions, which seems to indicate that, probably, the variables which best contribute to success depend on the level and nature of the competition (García, Ibáñez, Feu, Parejo, & Cañadas, 2009; Sampaio, Godoy, & Feu, 2004). Parejo, García, Antúnez & Ibáñez (2013) pointed out that a high number of variables discriminating between successful and unsuccessful teams in a competition represent a high heterogeneity between teams in these competitions. This fact could be observed in the previous studies cited in lower levels of competitions.

2.1.2 Game actions related to offensive and defensive efficiency

Apart from game-related statistics, there are actions, behaviors or decisions that also contribute to success. Some of these actions have been analyzed in the literature and they have been classified into offensive and defensive actions.

2.1.2.1 Offensive actions

Number of efficient passes was related with success in the European Basketball Championships; probably due to their contribution to increase number of assists in

successful teams (Calatayud, Sánchez, & Capsi, 2007). In this line, possessions in which a pass was given to the center were more efficient in other study (Courel, Sánchez, Ortega, Piñar, & Cárdenas, 2012). As Ibáñez, Feu, García, Perejo, & Cañadas, (2009) explained, assists are the best indicators of teamwork and they are useful to find the best positions to shoot. In addition, they highlighted the importance of making correct decisions. They found that successful shots were those preceded by dribbling, taken within the zone regardless of the defensive pressure, with different techniques: standard jump shot, hook shot with or without jump, layup or semi-hook layup, or slam dunk.

Previous results indicated that one offensive objective in basketball is to reach the best position to shoot under low defensive pressure. To get this, Arias (2012) highlighted the importance of 1 on 1 situations to divide and destabilize the defense as previous requirement to generate a shot opportunity. In addition, it is also required an effective teamwork, which is more necessary as the level of competition increases (Ortega, Salado, & Sainz de Baranda, 2013). In this line, Jiménez & Moreno (2007) found that the most tactical situations played in high level competitions were based on tactical concepts instead of plays. Vaquera, Cubillo, García-Tormo, & Morante (2012) indicated that pick is the tactical concept best used in offensive situations. In this line, Manzano, Lorenzo, & Pacheco (2005) analyzed the Spanish National Competition (ACB) in 2001 season and detected that possessions in which there was a pick was higher (70%) than those in which there weren't any (30%). In addition, possessions in which a pick was made were more successful (70.2%) than those in which they weren't made (60.03%).

2.1.2.2 Defensive actions

Successful rebounds, both offensive and defensive, were significantly related with the superiority in the number of players fighting for it (Ribas, Navarro, Tavares, & Gómez, 2011). As it was observed previously, especially defensive rebounds were a variable which significantly contributed to success in several competitions. However, the greater number of rebounds is not only related with this fact, but with the number of opportunities to rebound because of the high defensive pressure on opponent's shots (Trninic et al., 2002).

Álvarez, Ortega, Gómez, & Salado (2009) analyzed defensive performance indicators in the 2008 Olympic Games. Their results indicated that the most effective defense was the half-court zone defense. Also they found that a) the type of defense most used was quarter-court man-on-man; b) transition pressure was used in 23.83% of the game phases; c) defensive switches were done in 7.85% of the game phases; d) helping on defense was used in 60% of the game phases; e) inside passes were taken in 30.9% of the game phases; f) 38.9% of the shots were done with high opposition; and g) points were scored in 42.28% of the game phases. During ACB competition, Battaglia, Sánchez, Borrás, & Jiménez (2009) revealed that major efficiency on pick defense was found using vertical flash and 2 on 1 (when defending the player who makes the pick); and going behind and then 2 on 1 (when defending the picked player). In other study, defense effectiveness in close games at the end of the last quarter was demonstrated to be higher when intentionally fouling than playing tight defense (Annis, 2006).

The identified indicators of success in basketball across different studies and level of competitions let us better understand basketball performance and to highlight that:

- Game indicators best related with success are those that let teams to score with less defensive pressure and those that increase defensive pressure in the defensive phase.
- These indicators are the result of previous actions, which require to think tactically, to collaborate and to execute efficiently these actions.

Success in these indicators depends on collective and individual factors (Trninic et al., 2002); consequently, to understand the role of intellectual functioning on basketball, it seems necessary to identify which are the collective and individual components of basketball performance and how intellectual functioning might be involved on them.

2.2 Collective components of basketball performance

Official rules in basketball regulate that this sport is played by two teams in a defined space and time (Faubert, 2013; FIBA, 2014b; Giménez, 2007). As a result of this, performance is influenced by many individual, collective and contextual factors interacting at the same time (Araujo, Davids, & Hristovski, 2006). This provides basketball the nature of team sport, highlighting the relevancy of collective actions and the individual role in the team to reach these actions. For Gréhaigne & Godbout (1995; p.168), team sport has three inseparable characteristics:

A strength relationship: Two teams fight in the exchange of an object. In this fight, athletes have to decide, to risk for winning and to stay for not to lose.

Variety of motor skills: Athletes have to domain a certain variety of skills to success.

Individual and collective strategies: There are explicit and implicit decisions, taken in group, under a framework of reference, with the aim to win.

These three previous characteristics demand the athlete to decide, to learn, to select different motor skills and to perform collective strategies. Somehow, it seems to indicate that performance on team sports do not depend only in actions but in decisions. Decisions that are oriented to reach an objective: to win. To reach this objective, Gréhaigne, Godbout, & Bouthier (1999; p.168) explained that teams use three fundamental components: strategy, tactics and schemas of play. Strategy refers to the elements discussed in advance to organize the team to reach a common objective. Tactics are a punctual adaptation to a game situation, and schemas of play are automated actions to solve fast and efficiently standardized game situations. Main features of strategy, tactics and schemas of play for both offensive and defensive are present in figure 3.

Figure 3. Main features of strategy, tactics and schemas of play (Gréhaigne et al., 1999; p. 168).

According to this model, intellectual functioning seems to participate actively developing an optimal individual and collective strategy, selecting the best tactics and learning and performing schemas of play. Tactic efficiency requires the capacity to decide quickly and to find successful solutions (Gréhaigne et al., 1999). In these processes, also knowledge is necessary. Thomas, French and Humpries (1986; p.259) affirmed that sport performance is “*a complex product of cognitive knowledge about the present situation and past events combined with the athlete’s ability to perform the required sport ability*”.

During the game, the knowledge of the operating game configurations allows players to know the constraints, regularities and constants. Therefore, it allows the player to detect and to analyze new situations that arise in every moment (unexpected event). However, decisions made by the players are also influenced by their context and the values of the group of pertinence (Gréhaigne, Godbout, & Bouthier, 2001), taking part in the process multiple interactions of different elements as it is presented in figure 4.

Figure 4. Analysis of complexity of team sports (Bouthier, 1993) in (Gréhaigne et al., 2001).

To perform individual and collective strategies, it is needed to know them previously. According to Anderson (1976), there are two kinds of knowledge:

Declarative Knowledge: It is the knowledge based on facts. It is understood as a network based on nodules and relationships. Each nodule expresses a concept and the relationship represents the association between concepts.

Procedimental Knowledge: It is understood as a procedures system. The procedures are carried out if the sequences of action are activated through the relationships with the declarative knowledge.

Declarative knowledge is needed to develop procedimental knowledge (Anderson, 1982; Chi & Rees, 1983), but both need to be learned and recorded in the memory. For Gréhaigne & Godbout (1995), knowledge in team sports is supported around three categories of knowledge: rules of action, rules of game organization and motor skills (based on perceptive and motor-sensitive capacities). Rules of action are the set of basic principles of tactic knowledge that ensure an efficient action in invasive team's sport using a ball. These rules defined a framework of theoretical success in team sports related to keeping the ball, playing in movement, exploiting and creating available space, creating uncertainty, defending the target, regaining possession of the ball and challenging the opponent's progression. One example or rule of action *to keep the ball is protecting the ball using one's body as obstacle*. Play organization rules cover organization principles that may facilitate the elaboration of a strategy. These are related to (a) the logic of the activity, (b) the dimensions 'of the play area, (c) the distribution of players on the field, and (d) a differentiation of roles. One example of play organization during the game is *playing into a weak axis of the opponent's defense*. Motor capacities are needed to perform the previous rules with success and they refer to two large

categories of problems related to (a) the perceptual and decisional activity of the player, and (b) the motor skills which the player possesses or must develop.

Figure 5. System of knowledge in team sports (Gréhaigne & Godbout, 1995; p.496)

To improve tactical knowledge, learning capacities are needed but also the capacity to analyze a situation, to plan solutions, to evaluate the effectiveness of their actions and to be able to make judgment about the consequences of their action (Gréhaigne & Godbout, 1995)

Refoyo (2001; p.32) defined basketball as a collaboration-opposition sport in which there are three fundamental elements required to perform in this sport: technique, tactic and strategy. These elements go partially in line with those presented by Gréhaigne & Godbout, 1995 and were described as:

Technique: It is composed by the amount of individual basketball-specific skills which can be offensive and defensive. Riera (1999) introduced the term of collective technique when these skills involve the interaction of two colleagues (eg. Pass, Pick, etc.).

Tactic: It consists on the solution of a game situation against an opponent for which technical skills are used. These solutions can be carried out individually and collectively.

Strategy: It is a previous plan established to reach the main objective by anticipating the game situations that can emerge during the competition.

Characteristics of these components are presented in table 2.

Table 2. Characteristics of strategy, tactic and technique (Riera, 1999) in Refoyo (2001)

	STRATEGY	TACTIC	TECHNIQUE
Definition	Planification	Fight	Execution
It relates to:	Globality	Opponent	Environment and objectives
Objective	Main	Immediate	Efficiency

According to these three characteristics, intellectual functioning seems to be especially involved in both tactical and strategy components processing the information to recognize a game situation, to solve it and to elaborate and follow a plan. In addition, success in these variables does not only depend on the player's abilities but on how these abilities are integrated in teamwork.

2.3 Individual components of basketball performance

To understand the influence of intellectual functioning on individual basketball performance, first, we will present an overall view of all individual components of basketball performance, and secondly, we will identify those components in which intellectual functioning seem to be best involved according to the literature.

2.3.1 Core determinants of sport proficiency

Williams & Reilly (2000) proposed a model (figure 6) including the core determinants of sport proficiency. Although this model was originally developed to assess

performance in soccer, it has been adopted as the holistic framework for examining the core determinants in other sports (Malina, 2008; Van Biesen et al., 2010).

Figure 6. Core determinants of sport proficiency (Williams & Reilly, 2000)

According to this model, there are three main features in which intellectual functioning seem to be directly involved: perceptual and cognitive skills, psychological skills and game intelligence. In basketball, one of the activities more relevant to success in which these three main features seem to be strongly involved is decision making (Alarcón et al., 2009; Araujo & Esteves, 2009; Bar-Eli & Tractinsky, 2000; Jiménez, 2007).

2.3.2 Implication of intellectual functioning on decision making process

An optimal decision is preceded by “understanding” and “acting” fast with economy (Gréhaigne & Godbout, 1995) and it is determined by individual (e.g. individual strategies, cognitive map or basic knowledge, tactic knowledge, game resources,

location and position) and collective factors (e.g. collective strategy, strength relationship and competences network) interrelated strongly in teamwork (Gréhaigne et al., 2001). In addition, there are a number of different decision agents (coaches, players, referees, etc.), tasks (play-calling, ball allocation, etc.), and contexts (during play, during timeout, etc.) influencing each decision (Johnson, 2006). Although different models of decision making process have been explained in the literature, most of them identified three main common phases that are carried out sequentially in each decision: perception, decision and execution (Marteniuk, 1974; Sánchez Bañuelos, 1984). In figure 7 these phases are presented and, although it is a very simplified draw of decision making process, this common framework will let us better understand particularities of each model presented in the literature.

Figure 7. Phases of decision making in sport (Marteniuk, 1974; Sánchez Bañuelos, 1984)

Gréhaigne et al. (2001) developed the **operative model of decision making**, which gave special relevancy to how athletes perceive a situation and which are the information resources from which an athlete elaborates a decision. In this model, athletes manage all input information (perceived) and they execute a final decision which is carried out through the motor competencies. This model highlights the role of cognition and the importance of knowledge to make a successful decision (figure 8).

Figure 8. An operative model of decision making (Gréhaigne et al., 2001; p.69)

Another model was explained by Moreno, Fuentes, Del Villar, Iglesias, & Julián (2003) under the **Information Processing Theory**. It manifests that team sports are characterized by a quickly and accurate response with time deficit in a dynamic and changing environment. The processes of decision making are divided in two phases:

1. **Cognitive Stadium:** In this stadium there are also two phases. The first phase includes the decision's preparation and the second includes the act of decision. In the first phase, information comes from the game and the context. With this information, the athlete has to select an option, taking into account his auto-perception of how he can perform this action and the consequences of the action. In the second phase, the action is selected and the order to be executed is sent.
2. **Motor-Cognitive Stadium:** This consists in the execution of the decision. In this phase, the athlete has also a feedback from his decision which will contribute to improve future decisions.

This model grouped together perception and decision into the same stadium in which intellectual functioning is strongly required. However, this model includes a factor to take into account which is self-perception. This suggests that the way to perceive a situation is also psychologically influenced in addition to all sensitive inputs.

From a holistic perspective, the influence of contextual factors was taken into account to understand how an athlete perceives a situation and how final decisions might be influenced by how it is perceived. Different studies revealed that contextual factors such as relationship between offensive and defensive athlete, experience on this situation, athlete's and opponent's skills, result in this moment and location (McMorris & Graydon, 1997); level of fatigue (Tenenbaum, Yuval, Elbaz, Bareli, & Weinberg, 1993; Thomson, Watt, & Liukkonen, 2009) or cultural values and motivation (Gréhaigne et al., 2001) were influencing on decision making. In this line, Araujo (2009) supported that the development of decisional behavior is not a linear and normative. Decision making process is not just a result of cognitive calculations as if it were computer software. Also individual's preferences were pointed out as factor influencing decision making (Busemeyer & Johnson, 2003; Busemeyer, Ryan, & Johnson, 2006). These studies revealed that input received by an athlete in a sport situation not only comes from the situation as previous models indicated, but also from the context and from the own athlete, in base to his experience and knowledge.

Markus Raab (2002) described decision making process from a dynamic perspective in which decisions are the result of computing all factors in favor or against to select one or another decision. This author was based on the **Decision Field Theory** developed by

Bussemeyer & Townsend (1993) and expanded by Townsend & Bussemeyer (1995). This model proposes three systems: the motor system, the decision system, and the valence system. As Raab (2002) explained, in one side there are goal approach motivation values ($Mr1-Mr3$) and in the other side there are goal avoidance motivation values ($Mp1-Mp3$). These represent the motivational values of the consequences of different alternatives of actions. These alternatives are filtered through attention weights and they represent the anticipated value of the actions ($V1$ and $V2$). All alternative actions with their specific valence are integrated in the decision system in which the state of preference is calculated. Afterwards, the resulting decision is send by the decision system to the motor system, which carries out the option with the highest preference. (Johnson, 2006) pointed out that attention shifts among dimensions, valences accumulate to produce an overall level of activation (preference) for each option. When the preference for one option exceeds some threshold level of activation, this option is then the “winner of the race,” meaning that it takes a significant weight among other options and then it is chosen. This process received empirical support on the level of individual neurons, suggesting that such an accumulation-to-threshold model may represent the way the brain determines responses to differentially rewarding stimuli. Raab (2002) indicated that fast decisions are more likely to be generated by perception-based information whereas slow decisions are likely to be caused by knowledge-based processes. Besides that, it was indicated that perceptive processes (mostly assumed to be faster) will overrule preferences under time pressure. In this line, Diederich (1997) also pointed out that in time pressure situations, decisions are made with the highest preference at the start of the process.

Figure 9. Model of Decision Field Theory from Busemeyer & Townsend (1993)
adapted by Raab (2002)

Another perspective of decision making was presented by Araujo et al. (2006) in the **ecological dynamics of decision making** in sport. Decision making processes were considered part of goal-directed behavior influenced by functional constraints at the scale of the environment-athlete relationship. Decisions depend on the context and the interaction with the player's colleagues or their opponents. As an example, it is probably that in a situation, a colleague allows the occurrence of passing when he or she is in a position where the pass is possible (the relationship between the players to pass) and then, the player with the ball decides to pass (Araujo, 2009). According to this theory, Correia et al. (2012) reported the effect of changing spatial- temporal variables of the environment on decision making. In the same line, Johnson (2006) pointed out that sports situations possess external dynamics; at one moment, some information may be available (e.g., goalie position) that is not available in the next moment (e.g., due to obstruction).

The role of the environment in decision making was also indicated in the **Fast and frugal heuristic (FFH)** approach to athlete decisions. This model, made up by Gigerenzer & Goldstein (1996), assumed that decision making is matched to the environments within the individual make this decision (Bennis & Pachur, 2006). FFH model indicates that to solve a problem (heuristic), decisions have to be made with high speed (fast), which is given by the individual's capacity to use less information or require fewer cognitive steps (frugal). FFH tends not to require complicated cognitive processing, such as weighting and integrating multiple cues (Bennis & Pachur, 2006). In other ways, but with similar concept, it have been called intuitive decision making (Dane, Rockmann, & Pratt, 2012). FFH are relevant to sport and they are especially useful in fast-paced dynamic sports in which there are limited information to make quick decisions. In this model, heuristic refers to a rule of thumb that a person uses to solve a problem. This rule of thumb, proposed by Johnson & Raab (2003), suggests that for familiar, yet ill-defined tasks, a person should simply choose one of first options that comes to mind, instead of generating and evaluating all possible options (Hepler & Feltz, 2009). Comparing this with previous models, this model focuses on decision phase and reduces perception and decision phases to pattern recognition and intuitive action. This was also supported by Craig & Watson (2011), who exposed that an athlete recalls "similar" patterns from a stored bank of previously experienced patterns. In some way, recall patterns in intuitive decisions seem similar to the action rules presented by Gréhaigne & Godbout (1995) in the construction of tactical knowledge.

As we have just seen, decision making can be approached from different perspectives; however, in all of them it has been presented the strong implication of different cognitive abilities in decision making to recognize a situation and to decide fast. According to this, athletes with limitations on intellectual functioning might present

limitations in those processes involving decision making; consequently, they might also present limitations on collective and individual tactics as it was reported by experienced II-basketball coaches (Polo et al., 2014).

To identify which cognitive abilities are best involved in sport decision making, Tenenbaum (2003) proposed a decision making model in which described the flow of the process and matched each stage with its respective cognitive components (figure 10.). This model was also applied in the basketball-specific literature to describe decision making processes in this sport (Jiménez, 2007; Moreno et al., 2003; Stella, Peacock, & Chuan, 2012).

Figure 10. Decision making process and its cognitive components (Tenenbaum, 2003)

Additionally, in table 3, it is presented a review of those cognitive abilities that were indicated in the literature to be required in decision making process in sport. In this table, it is necessary to notice that working memory capacity represents a domain free

limitation in the ability to control attention and it is predictive of an individual's capability of staying focused, avoiding distraction and impulsive errors (Engle, 2002). This capacity could be also understood as a combination of different cognitive abilities like attention, to focus in a tactical decision and concentration, to block out irrelevant auditory distraction.

Table 3. Cognitive abilities involved in decision making in sport

COGNITIVE ABILITIES	REFERENCES
Attention	Memmert (2011)
General creative thinking	Memmert (2011)
Selective attention	Craig & Watson (2011); Kioumourtzoglou, Kourtessis, Michalopoulou, & Derri (1998); McMorris & Beazeley (1997) and Ripoll (1991)
Anticipation capacity	Craig & Watson (2011); Furley & Memmert (2012); Gorman, Abernethy, & Farrow (2013) Kioumourtzoglou et al. (1998); Ripoll (1991); Tenenbaum et al. (1993) Ward & Williams (2003)
Choice reaction time	Tenenbaum et al. (1993)
Concentration	Bouthier (1993); Furley & Memmert (2012)
Memory	Busemeyer & Johnson, 2003; Furley & Memmert (2012)
Self-control	Gréhaigne et al. (2001)
Visual search	Fadde (2002); Ripoll (1991); Ripoll, Kerlirzin, Stein, & Reine (1995)
Semantic and sensoro-motor visual function	Ripoll (1991)
Working memory capacity	Furley & Memmert (2012)
Knowledge	Garganta (2001); Gréhaigne & Godbout (1995),
Recognition of patterns	Fadde (2002); Garganta (2001); Garland & Barry (1991); Gorman et al. (2013)
Learning	Faubert (2013)

2.3.3 Nature of decision making in basketball

Going back again to the basketball official rules (FIBA, 2014a), they regulate actions permitted and forbidden in basketball, being the spectrum of possible decisions determined by these rules (Gréhaigne & Godbout, 1995; Lorenzo, 2000). Although creativity can be useful to solve new emerging situations discovering new solutions (Giménez, 2007; Memmert & Perl, 2009), normally, the number of decisions a player can make in basketball are similar to the number of basketball skills a player can carry out, which it is usually quite large (Lorenzo, 2000).

The player needs to know all possible solutions, to be able to perform it and to decide which one select to solve a game situation. In this line, French & Thomas (1987) found that the factor best related with decision making in basketball was the knowledge of the game. This enhanced the implication of intellectual functioning for building this knowledge (learning), recalling it (memory) and solving the situation appropriately (perception and decision). Although it is not our aim to deepen into the different classifications of basketball skills, it is important to highlight the large number of possibilities that exist to solve a game situation. Based on Jiménez (2007) and Refoyo, (2001), these skills can be offensive and defensive; and both individual and collective. One example of this classification is presented in table 4 according to the tactical objective of the skills.

Table 4. Classification of decisions according to the tactical objectives (Jiménez, 2007).

Phase	Objective	Example of decisions	
		Player with ball	Player without ball
Offensive	Progress towards the basket	- To dribble	- To receive
		- To pass	- To go away from the defender
		- To feint	- To distribute spaces
		- To pivot	- To generate spaces
			- To pick
	Keep the ball possession		- To help
		- To dribble	
		- To pass	- To help
		- To feint	- To receive a pass
Defensive	To score to the basket	- To stay with the ball	
		- To shoot	- To make a screen
		- To feint	- To get a position for shooting.
	To avoid the other team to progress	- To take a rebound	
		- To press the ball.	
		- To defend the pass line.	
	To steal the ball	- To press the ball.	
		- To steal the ball.	
		- To force a mistake.	
	To avoid the other team to score	- To protect the rebound.	
		- To block a shoot.	
		- To press the shoot.	

According to Refoyo (2001), based on Ruíz & Sánchez (1997), the difficulty of a decision in basketball can have different levels, depending on the number of elements to analyze during a game situation:

- Number of decisions to take.
- Number of alternatives in the task.
- Number of alternatives as motor responses.
- Speed required making the decision.
- Level of uncertainty in the decision making.

- Level of physical risk making the decision.
- Variability in the sequence of the decisions.
- Number of elements to remember to make the decision.

The combination of all these elements may result a large number of possible game situations. For this, in order to analyze the nature of decision making in basketball, research focused on the least complex game situations in order to be applied to understand more complex situations. In this line, Gómez & Lorenzo (2006) described those variables involved in decision making process on 1 on 1:

Perceptive variables

- *Defender distance:* When the defensive player is placed one arm distance from the offensive player, it can be considered that defensive intensity is high.
- *Defender feet position:* It has to be taken into account to obtain advantage in 1 on 1 situation. Offensive player should consider if feet are at the same height or one foot is more advanced (weak feet) than the other (strong feet).
- *Hands position and movement:* Taking it into account offensive player can avoid that defensive player steals the ball and also it can be taking advantage from this.
- *Object's distance:* It is the distance to the basket. It can be further than 3 points line, 2 points area or 3 seconds area.

Decision variables

- To make a feint to progress to the basket.
- To make explosive starts.
- To shoot.

- To dribble changing the direction.
- To swing.
- To progress backwards to the basket.

Execution variables

- Right: When selected technical skill is performed fluently and the player takes advantage to shoot to the basket.
- Wrong: When selected technical skill is not performed fluently and the player doesn't take advantage to shoot to the basket.

These variables highlighted the importance for a player to perceive quickly the perceptive variables, to select as fast as possible one of the possibilities and to perform it correctly. However, how can be evaluated which is the best decision in each game situation? To try to answer this question, Refoyo (2001) elaborated what he defined as “decisional maps”. These maps represent different standardized and frequently repeated game situations in which the player with the ball plays 1 on 1, 2 on 2, 2 on 1 and 3 on 2. In each situation, the possibilities the player has are presented and evaluated as correct or incorrect, according to the circumstances. The criteria to establish decisions correct were set by a panel of 17 basketball experts. These maps follow the same concept as the “action rules” defined by Gréhaigne & Godbout (1995) that defined which were the correct actions to ensure a successful tactical decision. However, the model presented by Refoyo (2001; p.62-66) is basketball-specific and each game situation is clearly defined. Each map consists of four variables:

Game situation: It establishes the number of offensive (first number) and defensive players (second number) involved in the action.

Advantage situation: It is consider when the defender is far enough that the offensive player is able to pass, to shoot or to dribble without the possibility of the defender to interrupt the ball's trajectory.

Possibilities of action: These are the actions that the offensive player with ball can perform according to the advantage situation. It refers to basketball skills.

Kind of decision: It defines correct or incorrect if the action carried out is appropriate according to the advantage situation.

These maps are presented below as they were presented by Refoyo (2001; p.62-66):

1) 1 on 1 situation

Game Situation	Advantage Situation	Possibilities of Action	Kind of Decision
1 on 1	Advantage	To Shoot	Correct
		Not to shoot	Incorrect
	Disadvantage	To dribble	Correct
		To shoot	Incorrect

Figure 11. Map of decision making in 1 on 1 situations (Refoyo 2001; p.62)

2) 2 on 2 situations

Game Situation	Advantage Situation	Possibilities of Action		Kind of Decision	
2 on 2	Advantage	To Shoot		Correct	
		Defensive help	Disadvantage respect to the help.	Pass	Correct
				To shoot	Incorrect
			Advantage respect to the help.	Pass	Incorrect
				To shoot	Correct
	Disadvantage	To shoot		Incorrect	
		To pass		Correct	

Figure 12. Map of decision making in 2 on 2 situations (Refoyo 2001; p.64)

3) 2 on 1 situations

Game Situation	Advantage Situation	Possibilities of Action	Kind of Decision
2 on 1	Advantage	To Shoot	Correct
		To pass	Incorrect
	Disadvantage	To shoot	Incorrect
		To pass	Correct

Figure 13. Map of decision making in 2 on 1 situations (Refoyo 2001:65)

4) 3 on 2 situations

Game Situation	Advantage Situation	Possibilities of Action	Kind of Decision
3 on 2	Advantage	To Shoot	Correct
		Defensive help	Disadvantage respect to the help
			Advantage respect to the help
		Pass	Correct
		To shoot	Incorrect
	Disadvantage	Pass	Incorrect
		To shoot	Correct
		To shoot	Incorrect
		To pass	Correct

Figure 14. Map of decision making in 3 on 2 situations (Refoyo 2001:66)

Although these maps represent general rules to reach the best option to score; not a good decision is always followed by a successful shot neither a bad decision is always followed by a missed shot. We could consider these maps as a framework to understand the relationship between the advantage/disadvantage situation and the correct decision.

However, apart from these proposals, each decision in basketball should be understood in its context (Ruiz & Arrauza, 2005), which frequently is characterized to present a high variability (Cárdenas & Pintor, 2001). As an example, in a game with 7 seconds remaining to the end of the game and one point advantage against the opponents, and winners in offense, it would be better to protect the ball and to stay rather than shooting even with the defender is 3 meters away without possibility to defend the shot.

2.3.4 Factors influencing player's decision in basketball

2.3.4.1 Situational factors

One of the needs expressed in the literature to understand basketball player's decision making, is to analyze it from an ecological perspective (Araujo et al., 2006), taking into account the interaction with the environment during decision making. As Lago (2010) indicated, situational factors like score, time remaining to the end of the game or time remaining on the shot clock might modify team's strategy and player's decision. In addition, individual decisions might be influenced by coaches' indications to follow the team's plan. Opponent's level also is taken into account when a player makes a decision. As it is well known, some players (especially centers) look for a mismatch advantage in which due to a defensive change, a player is matched with a smaller player, taking advantage to play 1 on 1. Given the same game situation, would a small player play 1 on 1 against a taller defender? Or, would he look for other teammates to pass the ball, or to shoot?

2.3.4.2 Game Position

Player's position usually determines the area in which the player often plays; consequently, the type of interaction with their teammates and their opponents, the

distance to the basket or even skills are specific for each position. Game-related statistics reflected also significant differences between player's position (Sampaio, Janeira, Ibáñez, & Lorenzo, 2006). During the 2000-2001 play-off final series of the ACB (Spanish professional league) it was found that centers and guards were discriminated by offensive tasks, with emphasis on assists; 3-point field-goals, both successful and unsuccessful and offensive rebounds. According to Lorenzo (2000), these are the principal roles and game differences presented in the main basketball positions:

Guard: They spend more time with the ball, so they are usually skilled players using the ball. One of the most important roles is to lead the team, to be able to keep calm, to read the game and to have a deep tactical knowledge. Players in this position are like a coach in the court. The most important skills in this position are:

- Defensive movements, with rhythm changes, defensive flashes and pick defense.
- Offensive high speed movements with ball and rhythm changes.
- Jump to steal the ball during a pass.
- Shots in different positions and ways to execute it.

Forward: Players in this position usually play on both sides of the offensive court over the 3 points line. These players are especially skilled to shoot, to dribble fast to the basket and to play different systems of play in which different kind of picks are included. Also they are relevant in defensive balance and fast breaks. They don't lead the team as guards, but they have to work for creating advantages, to play reduced game situations and to coordinate with their teammates (timing).

Center: These players play closer to the basket than the other players. They work in reduced spaces and they need quick and short movements to generate advantages against a defense that usually has high intensity. They are important players to score due to the proximity to the basket and also to defend offensive and defensive rebounds.

These differences seem to indicate that player's decisions during the game will be conditioned by the player's role. As an example, probably, after a 3-point shot attempted from a forward player, a center will decide to fight for the rebound while a guard will decide to keep defensive balance.

2.3.4.3 Psychological factors

Apart from situational variables, psychological factors have been also reported in the literature to influence significantly decision making. Ortega, Olmedilla, Sainz de Baranda, & Gómez (2009) analyzed the relationship between level of self-efficacy of the player with the ball in basketball with various performance indicators and individual participation of 187 youth player in competition. They found that a high level of self-efficacy predicted in 74.2% of the variance the results in participation and performance variables. Especially, those variables which were significantly discriminated were: 2-point field goal attempts, successful 3-point field goals, personal fouls received, offensive phases in which the player participated, total time of ball possession, points scored, total number of ball possessions, free throw attempts, passes, successful free throws, successful 2-point field goals, minutes played, 2-point field goal attempts and rebounds.

The “Hot Hand” phenomenon in basketball has been also indicated in the literature to influence player’s decision although its effectiveness has been discussed in the literature against (Gilovich, Vallone, & Tversky, 1985) and in favor (Bocskocsky, Ezekowitz, & Stein, 2014). This phenomenon explains players’ believe that they should “feed the hot hand”, by giving the ball to a player more often if that player has hit a number of shots in row. It has been attributed to a fast and frugal heuristic for deciding how to allocate shots between members of a team (Bruce, 2001).

Chelladurai, Haggerty, & Baxter (1989) compared the decision style choices between coaches and basketball players making decisions to solve a problem. Although it was not addressed directly during basketball game situations, it was observed that decision style choices were diverse. Players’ decisions were influenced by the interactions of (a) quality requirement *and* coach's information, (b) coach's information and acceptance requirement, and (c) acceptance requirement and team integration. According to these results, decision style choices seem to influence the weight a decision takes over the rest of the possibilities when an athlete measures the weight of each decision as it was explained in the valence’s system of Raab (2003).

2.3.4.4 Team factors

Bourbousson, Poizat, Saury, & Seve (2011) analyzed how cognition of individual members of a team coordinates to produce a team performance and how the shared knowledge changes during team activity. As they exposed, team cognition has been understood in terms of how individual actions are coordinated (focused on the communication processes) and also how cognition is shared among team members like: mental models, team situation awareness and a common frame of reference. During the

game, players act continuously with little opportunity to communicate verbally about upcoming actions; however, to ensure coordinated team actions, basketball plays are used. Basketball plays are prepared action series for each team member, ordered in time and space, explicitly taught and practiced previously (Bourbousson, Poizat, Saury, & Seve, 2010). According to this, decisions are also conditioned by team's objectives, which requires all players to work in the same line (Araujo & Esteves, 2009)

2.3.4.5 Experience

Experience determines the condition of expert, and it is suggested that it takes 10.000 hours of practice to become an expert, what it means at least 10 years' experience, 20 hours per week and 50 weeks per year (Ericsson & Charness, 1994; Gréhaigne et al., 2001). Experience has been attributed as the major predictor of successful decision making (Tenenbaum et al., 1993). Due to the larger experience, experts develop more declarative and procedural knowledge (Garganta, 2001; Gréhaigne & Godbout, 1995) which contributes to experts to spend less time to recognize a game situation (Garland & Barry, 1991; Ripoll et al., 1995). Experts develop better and more accurate criteria to organize the information they receive (Garland & Barry, 1991) and they are able to pick up more relevant information from earlier display cues than novices (Abernethy & Russell, 1987). These capacities let experts to carry out faster and accurate decisional processes (Berry, Abernethy, & Côté, 2008; Garganta, 2001), but also a major repertory of motor solutions to solve a game situation makes experts more efficient during the game (Garland & Barry, 1991). These abilities identified in experts have been also associated with an improvement in their perceptual and cognitive skills. In this sense, differences between experts and novices have been found in visual search capacities abilities (Mann, Williams, Ward, & Janelle, 2007), anticipation capacity

(Gorman et al., 2013; Tenenbaum et al., 1993; Ward & Williams, 2003) and their ability to develop a metacognitive learning (Faubert, 2013). Kioumourtzoglou et al., (1998) demonstrated that in basketball, experts were better on prediction and selective attention than novices. Gómez & Lorenzo (2006) found that experts committed fewer mistakes and they had more variety of decisions than novices. In addition, novices specially made more mistakes in 1 on 1 situation analyzing the defender distance and distance to the basket. Sporis, Sango, Vucetic, & Maaina (2006) indicated that novices used slower game actions than experts, consequently, they were exposed to higher defensive pressure.

Differences related to experience have several implications to understand factors influencing on decision making: (1) it demonstrates that cognitive abilities involved on decision making can be improved through training and experience, (2) understanding the way an athlete have been trained (time and quality), probably we could better understand athlete's decision making and (3) the role of experience improving decision making capacity is determined by the nature of the sport practiced.

2.4 Sport Intelligence Model in basketball

As it was observed in previous studies, the implication of intellectual functioning seems inherent to the nature of basketball (Alarcón et al., 2009; Karalejic & Jakovljevic, 2008; Karalejic, Jakovljevic, & Mandic 2009). To better understand the role of intellectual functioning on basketball, in table 5, it is presented a literature review to identify how cognitive abilities of the Sport Intelligence Model (Van Biesen, 2015) might be involved on those fundamental activities required to perform in basketball.

Table 5. Implication of Sport Intelligence on fundamental basketball activities.

BROAD ABILITIES	NARROW ABILITIES	IMPLICATION ON BASKETBALL
1. Fluid Intelligence	Induction	To analyze opponent's style of play, predict behavior and to understand collective game situations. (Gréhaigne & Godbout, 1995; Gréhaigne et al., 1999; McMorris, 2004).
	Reasoning	To anticipate new situations and to solve a problem taking into account the contextual conditions (Furley & Memmert, 2012; Karalejic & Jakovljevic, 2008; Kioumourtzoglou et al., 1998; Ripoll et al., 1995; Tenenbaum et al., 1993).
2. Memory	Memory span	To follow coach's indications and to follow team's strategies. Especially after a time-out or a break. (Gréhaigne & Godbout, 1995; Gréhaigne et al., 1999)
	Working memory	To control attention focusing on tactical decision making (Engle, 2002; Furley & Memmert, 2012)
	Meaningful memory	To build basketball knowledge, technical and tactical concepts and to apply it when necessary. (Alarcón, Cárdenas, Miranda, Ureña, & Piñar, 2010; Bussemeyer & Johnson, 2003; Garganta, 2001; Trninic, Karalejic, Jakovljevic, & Jelaska, 2010)
3. Visual Processing	Visualization	To score and to find an appropriate space to pass the ball. (Ripoll, 1991)
	Spatial relations	To follow a basketball play from different positions, to transfer a drawn play into the court. To recognize the same pattern in different positions. (Allard et al., 1980; Chen, Chou, Fu, Lee, & Lin, 2012; Gorman et al., 2013; Gréhaigne & Godbout, 1995)
	Spatial scanning	To select quickly the important visual information from the game. (Craig & Watson, 2011; Kioumourtzoglou et al., 1998; McMorris, 2004; Ripoll, 1991)
	Length estimation	To adapt player's skills with the context and to anticipate trajectories. (Craig & Watson, 2011; Furley & Memmert, 2012; Gorman et al., 2013; Kioumourtzoglou et al., 1998; Ripoll, 1991; Tenenbaum et al., 1993; Ward & Williams, 2003)
	Closure speed	To recognize where the ball is although it is not clearly visible. To recognize player's posture or actions partially hidden. (Gréhaigne et al., 2001)

4. Processing Speed/Reaction time speed	Perceptual speed		To perceive and recognize quickly a pattern during the game (Allard et al., 1980; Chen et al., 2012; Gorman et al., 2013; Gréhaigne & Godbout, 1995)
	Rate of test taking		To control athlete's capacity to perform tests in general (McGrew, 2003)
	Simple time	reaction	To react fast to given sensorial (visual and additive) stimuli in actions like: initial jump, to steal a ball or to fight for a rebound (Ghuntla, Mehta, Gokhale, & Shah, 2012)
	Choice time	reaction	To decide fast depending on the stimuli that appears during the game (Alarcón et al., 2010; Ghuntla et al., 2012)

Most of literature cited before explained theoretical models of how different cognitive abilities might be required to perform in basketball. There seem to be certain agreement between different authors. However, to identify the implication of these cognitive abilities on basketball performance it is necessary to measure these abilities and basketball performance and, then, to analyze the relationship between both components. In this line, three studies have been found in the literature that directly analyzed this relationship.

Jakovljevic (1996) studied the influence of the specific basketball motor skills and cognitive abilities on success of basketball. They assessed basketball skills through 15 tests which cover six fields of basketball technique: ball handling, dribbling, passing, shooting, whole actions and movement without the ball. To assess cognitive abilities they used domino test (D-48) to estimate general factor of intelligence and four covering perceptive factor of intelligence: visual spacialisation, perceptive differentiation and logical conclusions, perceptive identification and structuralisation and perceptive analysis and logical conclusions. Success for all 87 high quality junior basketball players was established by expert criterion. This value was gotten as a mean value out of ten marks given by ten independent observers (alpha homogeneity and

reliability estimator was 0.978). In their results, basketball skills and cognitive abilities explained significantly 64% of success variance. By comparison of coefficient of determination (R^2) of simultaneous influence both factors, the value of partial influences of specific basketball skills was $R^2=0.57$ and cognitive abilities was $R^2=0.49$. A linear regression model including all variables identified the following as significant contributors to success: mikan drill in 30 seconds, direction change in dribble, perceptive analysis and logical conclusion; and general intelligence. According to these results, they explained that in given situations, the player must have precise perceptive analysis of events in the court to decide quickly and adequately. In addition, they expressed that if we accept the theory that intelligence is adaptability of a person in new and sudden situations, then, general intelligence is very important in basketball game which is full of quick changes.

When variables were processed stepwise, variables were ordered according to their level of significance of influence on success in basketball as following: perceptive analysis and logical conclusion, direction change in dribble, mikall drill in 30 seconds, shot from five perimeter positions in 60 seconds, general intelligence and perceptive differentiation and logical conclusion. The implication of perceptive differentiation and logical conclusions was explained because the player perceives during the game the situations in multitude of movements and actions of his own and opponent players. He must differentiate typical and atypical elements and activities of players and to find the best solutions. According to these results, they indicated that it is not enough to have high quality specific basketball skills but also to know to use it efficiently (tactics). Probably, this is in line with II-basketball coaches opinion (Polo et al., 2014), in the

importance of tactics when assessing main limitations during basketball game experienced by II-basketball players.

With similar aim and methodology, Karalejic & Jakovljevic (2008) evaluated the relationship between cognitive abilities of the best 80 junior Serbian basketball players and their success. Player's success variable was also established by expert's criteria (grades 1 to 10) and the sample was divided into three groups at the base of the grades of their successfulness. Group 1 was made of the 17 best players (who got grades from 8 to 10), group 2 of 37 average ones (grades 5 to 7.99), group 3 of 26 (grades less than 5). The same cognitive abilities were assessed with the following tests:

- **General intelligence:** Evaluated by Domino test D-48
- **Visual Spatialisation:** Evaluated by S1 test from SVPN-1 battery; this evaluates spatial relations or simultaneous education of spatial relations.
- **Perceptive differentiation and logical conclusion:** was evaluated with test of geometric differences P1 (from battery SVPN-1).
- **Perceptive identification:** was obtained on the basis of F1 test results.
- **Perceptive analysis and logical conclusions:** evaluated on the basis of F2 test results (test of square puzzle).

Results in this study indicated that group 1 was significantly different from group 2 and 3 while differences between groups 2 and 3 were very small. The obtained discriminant function in this study indicated that perceptive analysis and logical conclusions and general intelligence were the variables which best discriminated to success. With these athletes, it was also studied the relationship between the evaluated cognitive skills and different basketball skills assessed through 15 tests that covered most basketball

activities: shooting, passing, dribbling, playing without a ball in attack and defense play (Karalejic et al., 2009). In this study, a canonical correlation root indicated significant correlation between both areas ($R^2=0.529$). Variables included in this root from the basketball abilities area were: throwing the ball with two hands technique from chest, drive to the basket for 30s, direction change in dribbling, dynamic shooting for 30s, reverse movement for 30s, precision shooting and dribbling slalom. From the area of cognitive ability variables the included variables were: perceptual identification, perceptual analysis and logical conclusion and visual spatialization. As authors explained, these results are based on basketball skills that require agility and precision, and ability of fast perception. For this, athletes need the ability of simultaneous reduction of spatial relations, speed of shape perception and ability of manipulation in perceptual space, as well as visualization and fine differentiation and conclusion on perceptive material.

According to these three studies, we can conclude that (1) cognitive and basketball skills explains basketball success significantly, but not totally; and that (2) perceptive analysis, logical conclusion and general intelligence seem to be those cognitive abilities best related with basketball success.

2.5 Objectives of the research and research hypothesis

To synthesize the main findings in the literature around the development of eligibility systems in II-basketball and the role of intellectual functioning on basketball, we can highlight that:

- It is needed to develop II-basketball specific eligibility systems to ensure “fair play” during II-basketball competitions. Doing this, only II-athletes with

significant limitations to perform in basketball could participate in these competitions.

- These systems must be evidence-based and basketball-specific. For this, it is needed to demonstrate the negative influence of II on basketball performance and in those fundamental activities required to perform in this sport.
- Basketball is a team sport in which performance is the result of multiple interactions and depends on collective and individual factors.
- Technique, tactics and strategy are the main components of basketball performance and they are based on individual/collective and offensive/defensive actions.
- A large number of studies identified a strong implication of intellectual functioning on different fundamental activities required to perform in basketball: recognition and understanding a game situation, decision making and problem solving. These activities are usually carried out under time and space pressure.

To the author's knowledge, with the existing literature at this moment, it is not possible to determine how II influences basketball performance and to define which minimum impairment is needed to make an athlete present significant limitations to perform in basketball. At this moment, eligibility criterion in II-basketball competitions worldwide is only based on "Primary eligibility check" (INAS, 2014). As it was observed previously, this is a non-sport-specific criterion; consequently, at present it is only possible to ensure that athletes participating in these competitions have an II but not necessarily significant limitations to perform in basketball. Due to this, it is a must to investigate the influence of II on basketball performance and to develop II-basketball

eligibility systems based on these evidences. In addition, this research could bring a great number of positive implications for this sport:

- To ensure “fair play” during II-basketball competitions.
- To have the possibility to re-include II-basketball in the Paralympic program.
- To develop categories of basketball competitions based on level of impairment on those abilities relevant to perform in this sport.
- To understand more in deep the implication of intellectual functioning on basketball performance, been able to transfer this knowledge to AB-basketball.
- To contribute II-basketball coaches to transfer findings from this research to training and competition.

This research is a personal challenge for the author because it is exciting to have the possibility to unify all our experience in basketball as player (8 years), coach (7 years) and referee (15 years); and our experience working with people with intellectual disabilities (8 years) in order to contribute with II-basketball development. Once the author understood how complex basketball could be for an athlete with II, we saw how spectacular this sport can be regarding people empowering their abilities, even having limitations in their functioning. According to the presented needs in the literature and these personal motivations, the general objective of the present dissertation is:

“To analyze the influence of Intellectual Impairment on basketball performance”

To reach this objective, the present dissertation is divided into 4 specific objectives addressed in 4 different studies:

Figure 15. Objectives of the research

In figure 16, it is presented the relationship of the objectives of the present dissertation with the identified components of basketball performance:

Figure 16. Relationship between the objectives of the present dissertation with the components of basketball performance.

Our main research hypothesis is that Intellectual Impairment will cause limitations on fundamental basketball activities determinant for basketball performance. According to this, the hypothesis of each study was:

- 1) Game-related statistics from II and AB-players competitions will present significant differences, showing different ways to perform basketball (Chapter 3)
- 2) Elite II-players will present limitations to recognize and order different basketball game sequences as fast and accurate as AB-players with similar experience and training volume (Chapter 4).
- 3) Elite II-basketball players will make slower and less accurate decisions compared to AB-players matched by experience and training volume (Chapter 5).
- 4) II-basketball players decide significantly slower and less effectively in realistic basketball conditions in the field than their AB-peers (Chapter 6).

OUTLINE

The present dissertation is composed of a general introduction (Chapter 1) and a review of the literature in order to investigate the role of intellectual functioning on basketball performance (Chapter 2). These are followed by four studies to address the objective of the research (Chapter 3 to 6) and a final chapter includes, a summary and the conclusions obtained from the whole research (Chapter 7).

Chapter 3: Basketball game-related statistics that discriminate between players with intellectual impairment and able-bodied players

This chapter compares directly game-related statistics from elite II players and AB-basketball players under 16 years old and U-18 during competition. This study checks whether II and AB-players perform basketball in a similar way or not, and determines which variables differences II and AB-players and its influence on basketball success.

Chapter 4: How intellectual impairment influences on basketball players' capacity to recognize and order a game sequence?

In this study a group of elite II-players and a control group of AB-players are compared through a test in which they were asked to order fast and accurate different sequences of basketball represented by photographs. Also, different sub-samples of AB-players under development (U-14, U-16 and U-18) participated in order to compare II-players with the developmental curve of the abilities assessed in this test.

Chapter 5: Influence of intellectual impairment on decision making in basketball

This study followed the methodology applied in Chapter 4 but assessing decision making in a sample of II and AB-players through a computerized test.

Chapter 6: Influence of intellectual impairment (II) on basketball players' capacity to solve a game situation: towards evidence-based classification systems in II-basketball

In this chapter, II and AB-players were compared solving different standardized basketball game situations presented in a field test. To solve each situation, players had to make decisions and to execute them efficiently to score.

Table 6. Overview of total number of participants (N), II-players, AB-players and their level of competition per study.

Chapter	Total N	II	AB	Level of competition
3	301	63	238	II: World II-basketball Championships (Ankara 2013). AB: Spanish U-16 Championships (95 players) and Spanish U-18 Championships (175 players).
4	220	92	128	II: World II-basketball Championships (Ankara 2013) and Global Games (Guayaquil, 2015). AB: Spanish and Belgium regional competitions (U-14=30; U-16=23; U-18=29; Senior=46).
5	223	93	130	II: World II-basketball Championships (Ankara 2013) and Global Games (Guayaquil, 2015). AB: Spanish and Belgium regional competitions (U-14=31; U-16=25; U-18=30; Senior=44).
6	76	38	38	II: Global Games (Guayaquil, 2015). AB: Spanish regional competition (U-18=8; U-21=20; Senior=10).

3. Basketball game-related statistics that discriminate between players with intellectual impairment and able-bodied players.

Pinilla, J.; Pérez-Tejero, J. & Van Biesen, D. (In press). Basketball game-related statistics that discriminate between players with intellectual impairment and able-bodied players. *Revista de Psicología del Deporte*, In press.

ABSTRACT

The development of evidence-based eligibility systems in basketball for athletes with intellectual impairment (II) requires investigating the influence of II on performance. Due to this, the present study aimed to compare game-related statistics from II and able-bodied (AB) competitions. The World Men II-Basketball Championship 2013 (n=13 games and 63 players) and the Spanish Men AB-Basketball Championships 2014 under 16-years-old (n=10 games and 95 players) and under 18-years-old (n=18 games and 175 players) were analyzed. Team and individual statistics were normalized to 100 ball possessions and to 40 minutes played respectively. One-way ANOVA and *post hoc* Tukey tests were conducted to compare II and AB-teams. Also, a discriminant analysis was employed to identify which variables discriminated them best. The Kruskal-Wallis and U Mann-Whitney tests were applied to compare the II and AB individual game-related statistics. II-teams played more ball possessions per game ($p<0.05$) and the variables which best discriminated II and AB-teams were: 2-point unsuccessful shots $|SC=-0.384|$, 3-point successful $|SC=0.456|$, 3-point unsuccessful $|SC=-0.399|$, free-throws successful $|SC=0.319|$ and fouls $|SC=0.454|$. In all playing positions II-players presented more 2-point unsuccessful and lower shooting percentage in all kind of shots. II-guards attempted more field shots and made more turnovers than their peers, showing an unbalanced roles' distribution compared with AB-players. These results confirmed that II and AB-players perform basketball in different ways.

INTRODUCTION

Recent studies have demonstrated the negative influence of intellectual impairment (II) on performance in sports such as track and field, swimming and table-tennis (Burns, 2015; Van Biesen et al., 2012; Van Biesen et al., 2013). Thus, organizing specific sport competitions for II-athletes seems necessary to provide them the opportunity to reach sport excellence in equal conditions (IPC, 2015). To be eligible for II-competition, the impairment of the II-athletes should be documented and the impact of II on sport-specific performance should be proven (IPC, 2015; Tweedy and Vanlandewijck, 2011). This is proven by eligibility systems which were developed for each sport based on how impairment negatively impacts on performance in each sport. Moreover, these systems are required for all sports included in the Paralympic program. As these systems were developed in table tennis, swimming and track and field, participation of II-athletes returned to the Paralympics in London 2012, creating a new class for II-athletes in each of these sports (Burns, 2015). In II-basketball, these systems have not been developed yet. Current eligibility is based on primary eligibility check, which proves that athletes present the diagnosis of intellectual disability, but they are not based on sport-specific criteria. Due to this fact, to develop these systems is relevant to guarantee that only athletes having significant limitations to perform basketball participate in specific II-competitions. Also, developing these systems is relevant to re-include II-basketball in the Paralympic program. This article is a contribution to the development of these systems, studying the impact of II on basketball performance.

Performance in basketball is about defeating your opponent. According to the Official Rules (FIBA, 2014; p.5), *“The team that has scored the greater number of points at the end of playing time shall be the winner”*. Performance depends on multiple interactions

between teammates and opponents in which both individual and collective actions are relevant (García, Ibáñez, Cañadas and Antúnez, 2013). Technique, tactics and strategy are key components of basketball performance (Sampedro, 1999); but they also depend on individual capacities in different areas: fitness, cognition and psychological skills (Refoyo, Sampedro and Sillero, 2009). Different studies highlighted that intellectual functioning is relevant to perceive a situation, to decide and to carry out effective motor solutions (García et al., 2013; Tenenbaum, 2003). Jakovljevic (1996) demonstrated that perceptive differentiation and logical conclusions were the cognitive abilities best related with success in basketball.

Previous studies in II-basketball found significant relationship between athletes' intellectual quotient and proficiency in four basketball skills: ball handling, reception, pass and shooting (Guidetti, et al., 2007). However, another study pointed out that II influences more negatively tactics than technique (Polo, et al., 2014). In this line, a recent study compared II and AB-players' capacity to solve 8 standardized basketball game situations played on court (Pinilla et al., 2016). In this study, II-players decided slower, made more dribbles and ended the situations less successfully (scoring or giving a correct pass). According to these evidences, II might negatively influence performance during competition.

Pérez-Tejero et al., (2015) compared game-related statistics in high-level II-basketball competitions between successful and unsuccessful teams. In this study authors discussed that II-teams seemed to present lower shooting percentages, more rebounds and more turnovers than AB-teams in previous studies from the literature (Gómez, Lorenzo, Ortega, Sampaio and Ibáñez, 2009; Trninic et al., 2002). A further study found

that variability of game-related statistics in II-competitions was higher than in AB-competitions, suggesting that II-players' performance was more dispersed (Pinilla et al., 2015). The aforementioned studies seem to indicate that II and AB-players played basketball in a different way, probably influenced by II. However, these differences were based on the comparison of different studies, not being possible to calculate statistical differences. In this study, data from II and AB-competitions were collected and analyzed by the same researches and the statistical analysis could be done based on the raw data of both the II and AB sample. The aim of the present study was to explore the differences in team and individual game-related statistics between II and AB-competitions and to identify which variables best discriminate them. The hypothesis is that game-related statistics from II and AB-players competitions will present significant differences, showing different ways to perform basketball.

METHOD

Sample and variables

Data were collected from the Men's II-Basketball World Championships (Turkey, 2013) and from the Spanish Men's AB-Championships under 16-years-old (U-16) and under 18-years-old (U-18) held in 2014. Number of games and participants were: II-championships, 13 games (all games played), 6 teams and 63 players; U-16, 10 games (from 1/4 finals on), 8 teams and 95 players and U-18, 18 games (from 1/8 finals on), 16 teams and 175 players. The following game-related statistics were gathered per team and player in each game: 2-point shots successful, unsuccessful and percentage; 3-point shots successful, unsuccessful and percentage; free throws successful, unsuccessful and percentage; offensive rebounds, defensive rebounds, assists, fouls, steals, turnovers, blocks and points scored. These variables were gathered through *FIBA Live Statistics*

Software by experienced officials who followed the International Basketball Federation descriptors of each variable (FIBA, 2005). Also, playing position and minutes played per player were gathered in each game. Only players who participated more than 10 minutes during the game were included in the analysis. Consequently, number of observations (statistics from one player in one game) included in this study was: 194 from II-players (Guards=42, Forwards=85, Centers=67) and 438 from AB-players (Guards=107, Forwards=194, Centers=137). To check reliability of game-related statistics a sub-sample of 10% of the games were randomly selected and analyzed by an expert in basketball analysis with more than five years' experience. Intraclass Correlation Coefficients (ICC) obtained was higher than 0.94 in all variables.

Data processing

Team variables per game were normalized to 100 ball possessions played in order to account for game rhythm contamination, allowing to compare teams' efficiency per ball possession even between different games (Gómez, Lorenzo, Sampaio, Ibáñez and Ortega, 2008). Team variables were divided by the number of ball possessions played during the game and multiplied by 100. Oliver's equation (2004) was used to calculate ball possessions (BP): $BP = (\text{field-goals attempted}) - (\text{offensive rebounds}) + (\text{turnovers}) - 0.4 \times (\text{free-throws attempted})$. Individual variables from each game were normalized to 40 minutes played in order to compare player's performances independently the time played (Vanlandewijck et al., 2004).

Statistical Analyses

The following descriptive statistics were calculated from team and individual variables: mean, standard deviation, range, variance and variability coefficient. The Shapiro-Wilk

and Kolmogorov-Smirnov tests were performed to explore the normality of team statistics ($n < 50$) and individual statistics ($n > 50$) respectively. Normal distribution was confirmed in the team variables but not in the individual variables. To compare II, U-16 and U-18 team game-related statistics one-way ANOVA and *post hoc* Tukey tests were employed. Brown-Forsythe robust test complemented this analysis to avoid assumptions of type I errors. In order to analyze the effect size (ES) of the differences between samples, eta-square was calculated. In addition, different discriminant functions were calculated to identify which variables discriminated best between II and AB-teams. The structural coefficients (SC's) obtained from the discriminant functions were used to identify these variables (Ntoumanis, 2001). Level of significance for the discrimination was set at SC above $|0.30|$ (Tabachnick and Fidell, 2005). Kruskal-Wallis test was employed to identify differences in individual game-related between the three groups of players (guard, forward and center) from II and AB-players. U-Mann Whitney tests were used to explore paired-matched differences between two playing positions from the same sample and to compare II and AB individual statistics from players in the same playing positions. In order to identify the effect size of individual differences, Cliff's Delta was calculated (Macbeth, Razumiejczyk and Ledesma, 2011). Statistical analyses were performed using PASW statistics 20 (SPSS Inc., Chicago, IL, USA). Statistical significance was set at $P < 0.05$.

RESULTS

In table 7, descriptive game-related statistics from II, U-16 and U-18-teams are presented and compared through one-way ANOVA and *post hoc* Tukey test, indicating significant differences ($p < 0.05$) between II and AB-team statistics in different variables.

Table 7. Descriptive game-related statistics normalized to 100 ball possessions and ANOVA between II, U-16 and U-18 competitions

Variable	II-teams	U-16-teams	U-18-teams	F	ANOVA	ES η^2
Possessions	72.9 (12.8)	60.7 (9.9)	59.9 (8.1)	13.86*	II>U-16, U-18	0.26
2-pt successful	25.7 (10.4)	30.4 (7.7)	31.8 (9.2)	3.43*	U-18>II	0.08
2-pt unsuccessful	52.6 (12.0)	46.8 (13.5)	37.0 (8.7)	15.6*	II>U-18	0.28
2-pt percentage	32.8 %	39.4 %	46.2 %			
3-pt successful	4.6 (3.6)	9.4 (4.7)	11.5 (5.7)	15.5*	U-16, U-18>II	0.28
3-pt unsuccessful	17.8 (8.3)	25.6 (8.9)	27.4 (8.0)	10.5*	U-16, U-18>II	0.21
3-pt percentage	20.5 %	26.9 %	29.6 %			
FT successful	13.7 (9.1)	22.3 (10.8)	24.8 (14.0)	6.84*	U-16, U-18>II	0.148
FT unsuccessful	13.4 (9.5)	13.4 (8.3)	12.7 (5.8)	0.07		0.00
FT percentage	50.6 %	62.5 %	66.1 %			
Off. Reb.	22.5 (10.4)	26.6 (17.9)	20.2 (9.9)	1.7		0.04
Def. Reb.	41.6 (16.1)	41.7 (11.2)	41.7 (13.2)	0.00		0.00
Assists	15.3 (9.8)	16.8 (6.4)	19.4 (8.2)	1.93		0.05
Fouls	25.5 (6.9)	33.9 (6.7)	36.5 (9.6)	14.00*	U-16, U-18>II	0.26
Steals	16.5 (8.9)	15.7 (6.3)	15.1 (5.9)	0.33		0.01
Turnovers	32.6 (14.6)	28.7 (10.3)	27.5 (9.3)	1.51		0.04
Blocks	4.8 (4.4)	6.4 (5.2)	4.8 (3.4)	1.12		0.03

* $p < 0.05$

Based on the mean number of ball possessions played per game, the calculated mean length of ball possessions in each competition was: 16.98 ± 3.0 seconds in II-teams, 20.31 ± 3.3 seconds in U-16 teams and 20.41 ± 2.8 seconds in U-18 teams. Regarding variability of game-related statistics, variability coefficient was 50.7% in II-teams, 41.1% in U-16 teams and 38.6% in U-18 teams. This coefficient seemed to decrease as the level of competition increased. However, no significant differences were found between the three groups ($p > 0.05$).

In table 8 it is presented the SCs values of the game-related statistics obtained from the different discriminant functions calculated: a comparison of II with all AB-teams and an independent comparison of II-teams with U-16 and U-18 teams. The three calculated

functions were significant ($p < 0.001$) and SCs over above $|0.30|$ indicates the variables that significantly contributed to discriminate AB and II-team's statistics.

Table 8. Discriminant analysis SC from II and AB-teams (U-16 and U-18).

Game-related statistics	II and all AB teams	II and U-16	II and U-18
2-pt successful	.227	.207	.177
2-pt unsuccessful	-.384*	-.187	-.429*
3-pt successful	.456*	.474*	.394*
3-pt unsuccessful	.399*	.369*	.329*
Free-throws successful	.319*	.352*	-.225
Free-throws unsuccessful	-.023	-.004	-.025
Defensive rebounds	.002	.003	.001
Offensive rebounds	.001	.119	-.062
Assists	.141	.070	.130
Steals	-.067	-.045	-.057
Turnovers	-.151	-.123	-.120
Blocks	.052	.138	.001
Fouls	.454*	.499*	.357*
Eigenvalue	1.613	1.558	3.206
Wilk's Lambda	.383	.391	-.238
Canonical Correlation	.786	.78	.87
Chi-squared	71.069	35.7	77.57
Significance	0.001	0.001	0.001
Reclassification	95.1%	95.7%	96.8%

* SC discriminant value $> |0.30|$

The comparison between II and AB-individual statistics showed that in the three playing positions (guard, forward, center), II-players committed significantly ($p < 0.05$) more 2-point unsuccessful and that AB-players scored more 3-point shots. Descriptive game-related statistics per 40 minutes played and significant differences ($p < 0.05$) between II and AB-players per playing position and between positions from the same sample (II or AB) are presented in table 9.

Table 9. Descriptive individual game-related statistics related to 40 minutes played and significant differences between II and all AB-players (both U-16 and U-18) according to player's position

Variable	Guard (g)				Forward (f)				Center (c)				Intra-sample differences			
	II-players	AB-players	Sig.	ES Cliff	II-players	AB-players	Sig.	ES Cliff	II-players	AB-players	Sig.	ES Cliff	II	ES Cliff	AB	ES Cliff
Minutes	28.7 (9.8)	23.2 (6.8)	II>AB	0.33	24.2 (9.2)	23.0 (7.0)			25.5 (8.2)	21.2 (7.3)	II>AB	0.29	G>F	0.26	G, F>C	0.16
2-pt successful	4.1 (3.1)	2.6 (2.3)	II>AB	0.43	2.9 (3.2)	3.7 (3.3)	AB>II	0.17	3.8 (3.6)	4.6 (3.3)			G>F	0.24	C>F>G	0.36
2-pt unsuccessful	8.3 (6.9)	4.5 (3.4)	II>AB	0.34	6.7 (5.0)	4.8 (3.4)	II>AB	0.21	7.1 (4.0)	5.1 (3.5)	II>AB	0.28				
2-pt percentage	33.1 %	36.6%			30.2%	43.5%			34.9 %	47.4 %						
3-pt successful	0.9 (1.3)	1.6 (1.7)	AB>II	0.23	0.9 (1.6)	1.5 (2.0)	AB>II	0.19	0.2 (0.5)	0.5 (1.1)	AB>II	0.12	G, F>C	0.24	F>C	0.30
3-pt unsuccessful	3.6 (4.4)	4.1 (3.2)			3.2 (3.5)	3.6 (3.2)			0.6 (1.0)	1.6 (2.0)	AB>II	0.24	G, F>C	0.51	G, F>C	0.45
3-pt percentage	20 %	28.1%			22.0 %	29.4 %			25 %	23.8 %						
FT successful	2.3 (2.7)	2.9 (2.8)			1.7 (2.6)	2.8 (3.3)	AB>II	0.20	1.5 (2.1)	2.3 (3.1)						
FT unsuccessful	2.3 (2.8)	1.1 (1.4)	II>AB	0.27	1.5 (2.1)	1.5 (2.2)			2.2 (2.9)	1.6 (2.3)						
FT percentage	50 %	72.5 %			53.2 %	65.1 %			40.5 %	59.0 %						
Offensive rebounds	1.9 (2.4)	1.1 (1.6)			2.5 (2.9)	2.7 (3.1)			4.7 (4.1)	3.8 (3.3)			C>G, F	0.38	C>F>G	0.55
Defensive rebounds	5.1 (4.4)	3.8 (2.9)			4.2 (3.9)	4.8 (4.2)			7.8 (4.7)	5.8 (4.1)	II>AB	0.25	C>G, F	0.47	C>G, F	0.22
Assists	3.8 (4.5)	3.4 (2.8)			1.9 (2.0)	2.1 (2.2)			1.3 (1.5)	1.1 (1.6)			G>F, C	0.26	G>F>C	0.54
Fouls	3.6 (3.1)	4.1 (3.0)			3.6 (2.7)	3.9 (2.8)			4.7 (3.5)	5.1 (3.7)			C>F	0.28	C>G, F	0.18
Steals	2.9 (2.9)	2.3 (2.2)			2.5 (2.6)	2.0 (1.9)			1.8 (1.7)	1.2 (1.5)	II>AB	0.19			G, F>C	0.24
Turnovers	6.8 (5.3)	4.3 (3.3)	II>AB	0.24	3.8 (3.6)	2.9 (2.4)			4.3 (3.8)	3.0 (2.6)			G>F, C	0.30	G>F, C	0.24
Blocks	0.4 (1.3)	0.3 (0.7)			0.3 (0.7)	0.5 (1.0)	AB>II	0.13	1.2 (1.8)	0.9 (1.5)			C>G, F	0.30	C>G	0.17
Points	13.1 (8.0)	12.7 (6.6)			10.2 (9.4)	14.5 (9.7)	AB>II	0.13	9.7 (8.3)	12.9 (8.4)	AB>II	0.23	G>F, C	0.23		

* Significant differences (p<0.05)

The calculated variability coefficients indicated that mean variability in all variables were higher in II-players in all playing positions (II-guards: 113.7% vs AB-guards: 95.8%; II-forwards: 114.4% vs AB-guards: 100.1% and II-centers: 108.5% vs AB-centers: 107.8%). However, these differences were not significant ($p>0.05$). A comparison of number of field shots attempted by II and AB-players per playing positions is presented in figure 17. II-guards attempted significantly more 2-point shots than AB-guards ($p<0.05$) and in the three playing positions, AB-players took more 3-point shots.

Figure 17. Comparison of field shots attempted by II and AB-players per playing position

DISCUSSION

The aim of the present study was to compare individual and team game-related statistical indicators of performance between II and AB-competitions. In line with the

established hypothesis and with conclusions from previous studies (Pérez-Tejero et al., 2015), results confirmed that II and AB-players presented significant differences performing basketball during competition, showing that II and AB-players perform basketball indifferent ways.

Differences in number of possessions indicated that game rhythm in II-games was higher than in AB-games. The relationship between game rhythm and success was not significant in other studies (Ibáñez et al., 2008), but some authors indicated that playing a higher pace leads to more unforced errors (García, Ibáñez, Martínez, Leite and Sampaio, 2013). Playing more ball possessions per game indicates that II-players spent less time during the offensive phases until they shot. Probably, they employed less collective actions, they made more errors (Lorenzo et al., 2010) or they just executed faster than AB-players the same number of actions. However, the lower shooting percentages of II-teams and the lack of differences found in number of turnovers or steals per ball possession between II and AB-teams suggest that the higher game rhythm in II-teams might be consequence of a poorer shot selection. Also, a lower shooting efficiency might be explained by a higher defensive pressure. Nevertheless, the lower number of fouls made by II-teams does not support this fact. Probably, II-players shot fast even with low defensive pressure, not tiring out the defenders by penetrating neither interacting with their teammates to prepare the shot (Gómez et al., 2009). It seems that II-players played “in a hurry”, probably as a consequence of lower tactical discipline or limitations in problem solving capacity (Trninic et al., 2002; Pinilla et al., 2016).

Percentage in free-throws, in which shooting selection is not so much involved, was also lower in II-teams. This could be explained by possible limitations of II-athletes to concentrate, to perform an efficient technique (Gómez et al., 2009), to have good confidence (Trninic et al., 2002) or by employing less time training this skill. Number of 3-point shots scored and missed by II-teams was lower and also discriminated between II and AB-teams. This result suggests the balance between inside and outside actions differences II and both U-16 and U-18 teams performing basketball; II-teams playing closer to the basket. As Trninic et al. (2002) manifested, systems of play of the successful teams contain balance between inside and outside play, providing good opportunities to draw fouls, to carry out 3-point power plays and to have more chances to get offensive rebounds.

Comparing II-teams' statistics with both U-16 and U-18 teams independently, it was detected that differences grew bigger and variability was reduced when results were compared with U-18 teams. With regards to previous studies, it seems that performance becomes more compacted (less variability) and differences between II and AB-teams bigger while the level of competition increases (Pérez et al., 2015; Pinilla et al., 2015). As a methodological issue, it is important to take into consideration that normalizing game-related statistics to 100 ball possessions, differences refer to how II and AB-teams play each ball possession. However, as number of ball possessions was significantly higher in II-teams in this study; probably, if two AB and II-games were compared directly, it might occur that several variables are higher in II-players (e.g. turnovers, steals, shots missed, etc...) because the influence of game rhythm but not as a result of lower efficiency presented in each ball possession.

Individual analysis provided deeper information about how II and AB-players perform basketball per playing position. In this point it is important to take into account that individual results refer to 40 minutes played. Also, players were observed in different games; consequently, the same player could present different ranges of performance throughout different games instead of a mean value from all the games. According to this, it was observed that individual performance variability was high in both AB and II-samples and game-related statistics did not follow a normal distribution.

In all playing positions was observed that II-players missed more 2-point shots, they presented lower shooting percentages and AB-players scored more 3-point shots. These results seem to support team's results. In the sample of AB-players, the closer to the basket the playing position was, the number of 2-point shots attempted increased and 3-point shots attempted decreased, showing a clear distribution of playing roles (Escalante, Saavedra and García-Hermoso, 2010). However, II-players did not follow the same distribution, especially analyzing 2-point shots attempted in guards. These results suggest that II- guards, as responsible of handling and distributing the ball, might not distribute the ball as much as AB-players. Probably, they decided to shoot more times instead of passing the ball to reach better shooting opportunities (Sampaio, Janeira, Ibáñez and Lorenzo, 2006). In addition, the higher number of total field goals attempted by II-forwards compared with II-centers seems to point out that guard's behavior was reproduced by forwards when they received the ball, providing II-guards with fewer opportunities to shoot. This seems to support the idea that reduced time per ball possession found in II-teams could be due to II-player's decision to shoot fast with

reduced number of collective actions. This fact also seems to unbalance the points contribution per playing position compared with AB-players.

The higher number of turnovers presented by II-guards, as responsible to handle the ball, could be consequence of lower skills and difficulties on problem solving capacity, decision-making, anticipation or the lack of a controlled style of play (García et al., 2013; Lorenzo et al., 2010) that usually involves more bad passes and poor dribbling skills (Gómez et al., 2009). Moreover, an excessive use of ball dribbling, normally presented in less effective teams (Gómez et al., 2006), could increase turnovers and steals. In this line, II-centers stole higher number of balls than AB-centers. Although steals represents a measure of defensive pressure (Gómez et al., 2009; Ibáñez et al., 2008); limited offensive skills or tactics could provide the opponents with more opportunities to steal the ball. In addition, a consequence of steals and turnovers could be a high number of fast breaks, increasing the number of ball possessions in II-games and the high number of shots attempted by II-guards with relative high success (Sampaio et al., 2006).

The statistical contrast performed in this study comparing II and AB-team and individual game-related statistics provides innovate insight for better understanding the influence of II on basketball performance as it is needed to develop evidence-based eligibility systems for this sport (Tweedy and Vanlandewijck, 2011).

CONCLUSIONS

This study confirmed the game-related statistics from II and AB-players during competition differ significantly in several variables, showing differences in the way II and AB-players perform basketball. II-teams were characterized by playing higher game rhythm, obtaining lower shooting percentages, attempting and scoring less 3-point shots and by making less fouls per ball possession. In addition, individual results showed unbalanced distribution of roles in II-players compared with AB-players. II-guards attempted more shots and made more turnovers than their peers. These results could be consequence of a negative influence of II to carry out activities which are fundamental performing this sport as e.g.: to read the situations, to make decisions or to elaborate team actions. Results from this study provide scientific evidences that contribute to develop eligibility systems in II-basketball and contributes to orientate further research.

4. How intellectual impairment influences on basketball players' capacity to recognize and order a game sequence?

ABSTRACT

This study aimed to analyze the influence of II on players' ability to recognize and order a basketball game sequence. 92 male elite II-basketball players (age=26.3±7 years) and 128 able-bodied (AB) players from different age groups competing at amateur level participated in this study: under-14 (U-14) years old (n=30, age=13.2±1.0 years); U-16 (n=23, age=15.2±0.4 years); U-18 (n=29, age=17.7±0.5 years) and senior (n=46, age=23.4±5.2 years). A test was designed in which players had to order as fast and accurate as possible 12 series of photographs that contained a basketball game sequence, all of them presented in a wrong order. Two hypotheses were stated: (1) II-players will present significant limitations in the abilities assessed compared with a control group of AB-players matched by experience and training volume and (2), II-players might perform these abilities close or below AB-players under development. A t-test confirmed that the mean time II-players spent to solve each situation (41.2s±20.2s) was significantly ($p<0.001$) higher than in AB-senior players (19.2s±5.9s) and also II-players ordered less series correctly (II=6.7±3.6 series vs AB=9.35±1.5 series, $p<0.001$). The calculated discriminant function was significant ($p<0.001$, canonical correlation=0.719) and classified correctly 84.1% of the players according to their predicted group. The second hypothesis was also confirmed, II-players required significantly ($p<0.001$) more time even than U-14 players (22.7±5.5) to solve the situations and reaching accuracy levels lower than U-16 players (9.74±1.9). These results demonstrate the negative influence of II to recognize and order a basketball game sequence and potentially contribute to the development of eligibility systems for this sport.

INTRODUCTION

Recent studies identified limitations of basketball players with intellectual impairment (II) to reach similar performance levels to able-bodied (AB) players during competition (Pérez-Tejero et al., 2015; Pinilla et al., 2015). These studies were relevant to demonstrate the negative influence of II on basketball performance; however, as authors indicated, it is still needed to analyze how II influences on those cognitive processes relevant to perform in basketball. To investigate this is crucial for the development of II-basketball eligibility systems (Tweedy & Vanlandewijck, 2011). These systems are needed to determine, based on the influence of athletes' impairment on basketball performance, which players can participate in II-basketball competitions. This is necessary to guarantee equal opportunities to success in these competitions (Tweedy & Vanlandewijck, 2011) and also, it is a condition for all Para-sports aiming to be included in the Paralympic Program (IPC, 2015).

Differences found in basketball performance between II and AB-teams in previous studies indicated that II-teams performed lower shooting efficiency in all kind of shots (2-point shots, 3-point shots and free throws), they played faster each ball possession (Pérez-Tejero et al., 2015) and performance variability was higher compared to AB-teams (Pinilla et al., 2015). Literature in AB-basketball pointed out that differences between teams in these variables could be related with a lower number of collective actions (Lorenzo et al., 2010), lower interaction between teammates to seek the best option to shoot (Gómez, Jiménez, Sánchez, & Leo, 2009) and the lack of a controlled style of play (Lorenzo et al., 2010). In addition, a lower tactical discipline and problem solving capacity (García et al., 2013; Trninic et al., 2002), limitations in player's ability

to anticipate events (Lorenzo et al., 2010) or lower accuracy on decision making (Gómez et al., 2008) were individual factors that might underlay the differences indicated previously. At the moment, these factors remain unknown in II-basketball players.

Furthermore, it was stated in the literature that, as the level of competition increased, the collective game systems employed became more relevant (Ortega et al., 2013). These systems require a strong teamwork and the development of tactical concepts (Jiménez & Moreno, 2007). Success on offensive tactics depends on individual and collective strategies and on decisions made in base of a team's framework of reference to win (Gréhaigne & Godbout, 1995). It also depends on a high number of complex interactions between teammates, the opponents and contextual factors during the game (Gréhaigne et al., 1999). Due to this complexity, it seems that a correct intellectual functioning is needed on basketball tactics. In this line, previous studies found differences in cognitive abilities between experts and novices in basketball (Kioumourtzoglou, Kourtessis, Michalopoulou, & Derri, 1998) and a positive relationship between cognitive development and success in this sport (Karalejic & Jakovljevic, 2008). Regarding these studies, it seems congruent that II-basketball coaches indicated that individual and collective tactical offense were those components of basketball performance in which II-players presented higher limitations (Polo et al., 2014). Consequently, it seems necessary to investigate how II might influence on those cognitive processes involved in basketball tactics.

The individual player's role in a collective action is relevant to reach the team's tactical objectives, and for this, individual actions need to be coordinated in time and purpose with the team. To reach this coordination, players require basketball-specific knowledge to understand each playing situation (Gréhaigne et al., 1999) and to read it fast (Gréhaigne et al., 2001). Each play situation is composed of a sequence of actions in which players need to recognize the most important components of the sequence to understand the overall situation and to anticipate future actions (Lorenzo et al., 2010). This requires the implication of several cognitive abilities coordinated and integrated in the different phases of the play (Tenenbaum, 2003). Due to that individuals with II present significant limitations in the overall intellectual functioning (WHO, 2002), it is expected that II-players will present also limitations in these processes. However, to the authors' knowledge, it has not been addressed yet in the scientific literature. For all of the above mentioned, the aim of the present study was to analyze the influence of II on players' ability to recognize and order a basketball game sequence in a fast and accurate way. The first hypothesis is that elite II-players will present limitations to recognize and order different basketball game sequences as fast and accurate as AB-players with similar experience and training volume. The second hypothesis is that II-players might carry out these activities close or below young AB-players under development.

METHOD

Participants

Ninety two male II-basketball players (N=92, age=26.3±7 years) and one hundred twenty eight male AB- basketball players (N=128, age=18.2±5.2 years) took part in this study. The sample of II-players represented 100% of players who participated in the II-

World Basketball Championships (Ankara, Turkey 2013) and 81.7% of the players who competed at the II-basketball competition in the Global Games (Guayaquil, Ecuador 2015). Both championships were organized by the International Sports Federation for Para-athletes with intellectual disability (INAS) and they represent the highest basketball competition for II-players in the world. A total of 8 countries participated in these championships: Venezuela, France, Portugal, Japan, Australia, Poland, Greece and Turkey. All players in these competitions met the criteria from the American Association on Intellectual and Developmental Disabilities (AAIDD, 2010) for diagnosis of Intellectual Disability which are: significant limitations on intellectual functioning ($IQ \leq 75$) and on adaptive behaviors manifested before the age of 18. To prove the first hypothesis a control group of AB-senior players (over 18 years old; $n=46$, $age=23.4 \pm 5.2$ years) matched by experience (years playing basketball and the accumulated experience of hours trained) and training volume (hours trained per week and number of months trained per year) was selected. To prove the second hypothesis, the sample of the control group was increased with players under development from different age groups: under-14 (U-14) years old ($n=30$, $age=13.2 \pm 1.0$ years); under-16 (U-16) years old ($n=23$, $age=15.2 \pm 0.4$ years); under-18 (U-18) years old ($n=29$, $age=17.7 \pm 0.5$ years). All AB-players competed at amateur competitions in Spain or Belgium. In table 10, experience and training volume is presented for each group.

Table 10. Sample's basketball experience and training volume

	II-players	U-14	U-16	U-18	Senior
Years playing	9.8 (6.3)	5.9 (1.9)	4.8 (2.1)	8.7 (3.5)	14.2 (5.1)
Total experience (hours)	2411 (2307)	1257 (706)	1030 (548)	1898 (1090)	2555 (1961)
Hours per week	6.3 (4.6)	6.1 (1.3)	5.4 (1.2)	5.3 (1.8)	5.4 (1.8)
Months per year	9.6 (2.2)	9.7 (0.5)	9.9 (0.3)	9.7 (0.7)	9.3 (1.8)

Instrument Design

A specific test was developed to assess player's ability to recognize and order a basketball game sequence. In this test, 12 series of photographs containing a game situation were sequentially presented to the players. Each situation was split into 4 to 6 photographs and these photographs were presented in a standardized order to the players, who had to put them into the correct order as fast as possible (figure 18).

Figure 18. Example of a game sequence: presentation and solution

Three more series of photographs were designed, one to demonstrate the athletes how the test works and two series (trials) to check that athletes have correctly understood the task. The photographs used in this test were obtained from different game situations played in the highest Belgium basketball league "Pro-league". Game situations were selected into complete agreement by 3 basketball professors from the KU Leuven (Belgium), with more than 15 years experienced each of them. The content of the game situations used in this test included the following basketball specific concepts: transitions, inbounds, rebounds, rules, direct and indirect picks, offensive superiority and inferiority. The test was designed increasing the complexity of the series from 1 to

12 by increasing the difficulty of the concepts included in the photographs and the number of photographs presented in each series. The series of photographs used in the demonstration and the two trials contained 4 images. From the 12 series of the test, series 1 to 6 contained 4 photographs, series from 7 to 9 contained 5 photographs and series from 10 to 12 contained 6 photographs. The photographs selected to represent a game situation were not lapsed by a fixed time but by determinant moments in the game in which the tactical situation could explain, according to experts' agreement, the transition between one photograph and the following one.

Procedures

The task given to the player was to order the series of photographs as fast and accurate as possible into the correct sequence. During the demonstration and the two trials, the player could ask any question to the test administrator, but it was not allowed once the test started. Players' coach could help the player during the explanation to fully understand target test and procedure, but they were not allowed to assist the player once the test started. To present each series to the player, he was asked to turn round while the tester put the series in a standardized order on a table. Once the photographs were ready, the player was asked to turn around again to order them correctly. At this moment the test administrator started the stopwatch and he stopped it when the player said "finished". After each series, the test administrator recorded in a score sheet the time used by the player to order the series (in tenths of a second) and if it was correctly ordered. If the series was not ordered correctly, the solution given by the player was also recorded in the score sheet. The test was administrated in a quiet room in a

comfortable position for the player to manipulate the photographs. No feedback of the test results was given to the player at any time.

Statistical Analyses

Kolmogorov-Smirnov test confirmed normal distribution of the variables gathered in this study. In addition, descriptive statistics (means, standard deviations and variability coefficients) from all variables gathered in the test were calculated for II and AB-players in the different age groups. Also, for each series, it was calculated the percentage of II and AB-senior players that correctly ordered each sequence of photographs. To prove the first hypothesis, a t-student test was performed firstly to check that there were not differences between II and AB-players in training volume neither experience and secondly to compare the test results in both samples in through the variables: mean time to perform the test, time to perform each series and the number of series ordered correctly. Effect size (ES) of the differences was calculated by Hedges' g (Rosenthal, 1994). A discriminant function including the time that players employed to solve each situation and the accuracy obtained in each sequence was calculated. The structural coefficients (SC's) obtained from the different discriminant functions were used to identify the variables which best discriminated between AB and II players (Ntoumanis, 2001). Level of significance for the discrimination between both groups was set at SC above $|0.30|$ (Tabachnick & Fidell, 2005). Leave-one-out classification was conducted to validate the discriminant models (Norušis, 2004). This consists of a cross-validation model in which each case is classified by the functions derived from all cases other than that case.

To prove the second hypothesis, the Kruskal Wallis test was employed, due to that some samples presented less than 30 players, to explore the differences between all II-players and all AB-players grouped by age. To identify paired-matched differences between groups the U Mann-Whitney test was employed. In addition, Spearman correlation was calculated to explore the relationship between the different age groups and general outcomes in the test. All statistical analyses were performed using PASW statistics 20 (SPSS Inc., Chicago, IL, USA). Statistical significance was set at $P < 0.05$.

Ethics approval

All participants signed an informed consent to participate in the present study and it was approved by the KU-Leuven ethical committee.

RESULTS

Before proving the hypothesis 1, it was checked that there were no significant differences between II and AB-senior players in the accumulated experience ($p=0.73$) neither training volume per month ($p=0.58$) or week ($p=0.2$). Results obtained by II and AB-senior players performing the test revealed that the mean time to solve each series by II-players ($41.2s \pm 20.2s$) in the whole test was significantly higher ($p < 0.001$) than the time employed by AB-senior ($19.2s \pm 5.9s$; $ES=1.31$).

These differences ($p<0.001$) were also confirmed comparing the time that II and AB-senior players employed to solve each of the 12 situations as it is presented in figure 19. In this figure it can also be observed through the standard deviations the higher variability presented by II-players respect to their AB-players counterparts.

Figure 19. Time employed by II and AB-senior basketball players to solve each sequence

With regard to the number of series that II and AB-senior players ordered correctly, the differences were also significant ($p<0.001$). II-players ordered 6.7 ± 3.6 series correctly and AB-senior 9.35 ± 1.5 series ($ES=0.86$). In figure 20, the percentage of II and AB-senior players that correctly solved each series is presented. In all the series the percentage of II-players who solved successfully each situation was higher.

Figure 20. Percentage of II and AB-athletes that successfully ordered each series

The calculated discriminant function included time employed to solve each sequence of photographs and accuracy ordering them. This function was significant ($p < 0.001$), with a canonical correlation of 0.719. The calculated discriminant function was:

$$D = t_1 * 0,012 + C_1 * 1,133 + T_2 * 0,056 + C_2 * -0,087 + T_3 * 0,004 + C_3 * 0,371 + T_4 * -0,02 + C_4 * -0,856 + T_5 * -0,006 + C_5 * 0,339 + T_6 * 0,011 + C_6 * -0,478 + T_7 * 0,033 + C_7 * -0,169 + T_8 * -0,007 + C_8 * -0,24 + T_9 * 0,018 + C_9 * -0,468 + C_{10} * -0,508 + T_{11} * -0,011 + C_{11} * -0,089 + T_{12} * 0,001 + C_{12} * 0,12 - 1,558.$$

Where T_n = time employed to order the series “n”; C = accuracy of the order established in series “n” (0=incorrect, 1=correct).

When results from each player were introduced into this function a “D value” was obtained. This value represents the proximity of the player’s outcomes in the test with the reference values from II or AB-senior players. When the calculated “D value” was

higher than -0.363, the player was classified as “II-player” and, when it was lower, the player was classified as “AB-player”. This function classified 84.1% of the players correctly according to their initial group of pertinence: AB or II-players. The structure coefficients indicated that the variable time employed to decide in each photograph and accuracy on series 10 and 11 were the variables which significantly $|SC| > 0.30$ contributed to discriminate II and AB-senior players. Leave-one out classification validated this model and classified correctly 78.3% of the grouped cases.

To prove hypothesis two, the outcomes from II-players were compared with the different samples of AB-players grouped by age through Kruskal Wallis tests. Results indicated that there were differences ($p < 0.001$) between groups in the variables mean time and number of correct decisions. Descriptive statistics from the test's outcomes per group and pair-matched differences detected by *U Mann Whitney tests* are presented in table 11.

Table 11. Test scores overall comparison per competition level

	II	U-14	U-16	U-18	Senior	Significance
Mean Time	41.2 (20.2)	22.7 (5.5)	25.7 (7.4)	18.9 (6.7)	19.2 (5.6)	II>Senior, U18> U16, U14
Correct	6.99 (3.4)	8.43 (1.7)	9.74 (1.9)	9.1 (1.5)	9.4 (1.5)	II<U16, U18 and Senior. U14<Senior

To situate II-players' results in this test respect to the different age groups of AB-players, a comparison between groups' outcomes is presented in figure 21. II-players spent significantly ($p < 0.001$) more time to solve each sequence even compared with AB-players in very early developmental stage (U-14) and ordered less situations than players from U-16 group on. In the evolution of AB-players' results per age group, a Spearman correlation revealed that age group significantly correlated ($p < 0.001$) with the time employed to solve each sequence ($r_s = -0.326$).

Figure 21. Mean time and number of correct series ordered by II-players and the different subsamples of AB-players grouped by age.

DISCUSSION

The purpose of the present study was to analyze the influence of II on players' ability to recognize and order a basketball game sequence in a fast and accurate way. The first hypothesis was confirmed, elite II-players presenting significant limitations to order as fast and accurate a basketball game sequence as their AB-counterparts matched by training volume and experience. A high effect size supported these differences. The second hypothesis was also confirmed; being II-players' recognizing and ordering different basketball game sequences slower even AB-players in early stages of their development (U-14) and less accurate than players under 16 years old and on.

The nature of basketball indicates that this sport is played under a limited space and time (Faubert, 2013; FIBA, 2014). This implies that the information received from the game is constantly changing with multiple variables interacting at the same time

(Araujo et al., 2006). Due to this, time seems to be a relevant variable for basketball performance, manifested in terms of time to recognize a situation and time to carry out an action (Berry, Abernethy, & Côté, 2008; Garland & Barry, 1991; Ripoll et al., 1995). In addition, to recognize the sequence of actions is needed to understand the situation and anticipate future movements (Lorenzo et al., 2010); consequently, limitations presented by II-players in this study seem to have negative implications on basketball performance. Probably, these effects might explain the differences found in previous studies between game-related statistics in II and AB-players during competition (Pérez-Tejero et al., 2015; Pinilla et al., 2015).

Furthermore, in the sample of II-players, it was observed a higher variability in the outcomes from the test. Previous studies testing cognitive abilities in AB and II-children also found a large variety of performance patterns in the population with II (Bergeron & Floyd, 2006). Also, far from testing conditions, II-basketball players presented a higher variability in game-related statistics than AB-players during competition (Pinilla et al., 2015). This similarity along different studies suggest to be analyzed in further research to understand intra-group differences in samples of individuals with II. Probably, differences on the etiology of the impairment or its severity might influence II-patterns solving different cognitive tasks (Armatas, 2009). In this line, Guidetti et al. (2007) found that the severity of II, classified into mild, moderate, severe and profound, was also related with the development of technical components of basketball performance: ball handling, reception, passing and shooting.

Results proving the first hypothesis can potentially contribute to the development of eligibility systems in II-basketball. As Tweedy and Vanlandewijck (2011) stated, to develop these systems in Para-sport, it is needed to investigate the influence of the impairment on the fundamental activities required to perform the sport and to determine the minimum impairment that significantly affect on performance. The negative influence of II was proved but also the calculated discriminant function established a cut point from which it is possible to determine in future tested athletes whether their ability to recognize and order different basketball game sequences is closer to the reference sample of AB-senior or II-players, who presented significant limitations in this ability.

Results proving the second hypothesis highlighted the magnitude of the II influence on the abilities assessed in this study, placing II-players' ability to recognize and order a game sequence below the ability from young AB-players under development. The relationship found in this study between the age group and the test scores in AB-players was in line with previous studies that found higher development of basketball-specific cognitive abilities (Kioumourtzoglou et al., 1998; Laurent, Ward, Williams, & Ripoll, 2006; Ripoll et al., 1995), better capacity to process fast the information from the game (Garland & Barry, 1991) and to solve faster and more accurate new situations by experts compared with novices (Berry et al., 2008; Dežman, Trninic, & Dizdar, 2001). According to this, it seems that the abilities analyzed in this study can be determinant for basketball performance.

Results from this study are original and relevant to develop evidence-based eligibility systems in II-basketball. Those sports in which these systems have been developed

(swimming, athletics and table-tennis) are II-sports already included in the Paralympic program (Burns, 2015; Van Biesen, Mactavisch, & Vanlandewijck, 2014; Van Biesen et al., 2012; Van Biesen et al., 2013; Van Biesen et al., 2010). In addition, from this study emerge new questions to be addressed in future research: (1) how the abilities assessed in this study contributes to basketball performance during competition? (2) which cognitive abilities underlay players' ability to recognize and order a basketball game sequence?

CONCLUSIONS

The present study evidenced the negative influence of II on player's ability to recognize and to order a basketball game sequence. Specially, this effect was observed in the time and accuracy with which II-players performed these processes compared with a control group of AB-players. Results from this study are relevant to develop II-basketball eligibility systems and let us apply them to establish a cut point to determine which players present significant limitations to recognize and to order in a fast and accurate way a given basketball game sequence.

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The present study has the endorsement and the support of IPC and INAS. In addition, this study is part of the research project: "Assessment tools development of sport intelligence: applications to international basketball eligibility systems for players with intellectual disability" subsidized by the Spanish Ministry of Economy and Competitiveness (reference number DEP2012-33649).

5. Influence of intellectual impairment on decision making in basketball

ABSTRACT

To analyze the influence of intellectual impairment (II) on basketball performance is needed as part of the development of evidence-based eligibility systems for this sport. This study aimed to analyze the influence of II on decision making in basketball. Decision making was compared from a sample of 93 elite II-basketball players (18 ± 5.1 years old) and a control group of 130 AB-players from different ages: under-14 years old (U-14; $n=31$, $\text{age}=13.2 \pm 1.0$), under-16 years old (U-16; $n=25$, $\text{age}=15.2 \pm 0.4$); under-18 years old (U-18; $n=30$, $\text{age}=17.7 \pm 0.5$), and senior ($n=44$, $\text{age}=23.2 \pm 5.1$). First, II-players were compared with the AB-senior players matched by training volume and experience and secondly with the different sub-samples of AB-players in order to establish the developmental age of II-players. Decision making was assessed through a basketball specific test in which athletes had to decide from 20 different basketball situations (photographs) the action that the player holding the ball should perform: to pass, dribble or shoot. Results were analyzed performing sequentially a T-test for independent samples; a discriminant analysis and a One-Way ANOVA. II-players decided significantly ($p < 0.001$) slower (3.76 ± 1.8 seconds per photograph) and less accurate (15.72 ± 2.8 correct decisions from 20) than the AB-senior sample (1.46 ± 0.5 seconds and 17.9 ± 1.2 correct decisions). The calculated discriminant function classified correctly 91.2% of the sample into their predicted group, II or AB-senior, based on the players' test scores. The comparison with the different age groups of AB-players revealed that results from II-player were placed even below the youngest group (U-14) in the developmental curve. These results are relevant evidences that might potentially contribute to develop evidence-based eligibility systems in II-basketball.

INTRODUCTION

In the London 2012 Paralympics, sports for athletes with intellectual impairment (II) were re-included in the Paralympic Program (Burns, 2015). This inclusion provided II-athletes the opportunity to join the largest worldwide events in adapted sports, achieving sporting excellence, inspiring and exciting the world (IPC, 2015). Thanks to the development of evidence-based and sport-specific eligibility systems, swimming, athletics and table-tennis for II-athletes were added to the Paralympic Program. These eligibility systems are needed to ensure that only athletes with an impairment that significantly impacts on sport performance participate in adapted sport competitions for athletes with this kind of impairment (Tweedy & Vanlandewijck, 2011). To develop these systems for swimming, athletics and table-tennis, researchers investigated the influence of II on sport-specific performance.

In athletics, Tilinger (2013) compared II and AB world records across 19 athletic events in high level competitions, finding that II-records were between 8.2% and 45.3% lower than AB-records. The more technical or cognitively demanding the event became, the more differences increased (e.g. jumping and throwing events). When race performance parameters were compared between II and AB-sprinters, II-sprinters took slower and shorter strides; reducing velocity and acceleration in comparison with AB-sprinters (Andrews, Goosey-Tolfrey, & Bressan, 2009). In shot put events, Willwacher et al. (2011) performed a kinematic analysis comparing II and AB-athletes, finding that II-athletes reduced the length of the accelerative path and consequently, release speed was lower.

In swimming, II-athletes performed lower than AB-athletes in 200m freestyle race in the variables: final time, clean swimming speed, stroke length, turning time, start time (time from 0-15 m) and reaction time (Einarsson, 2008). Daly et al. (2006) compared international II and AB-athletes during 100m freestyle race by analyzing the speed patterns during the race divided into 4 segments. These authors found that II-athletes lost significantly more speed between the second and third segment than international AB-participants, which is a variable strongly related to race success.

In table-tennis, II-athletes presented lower technical proficiency than AB-athletes adapting their service according to different ball spins (Van Biesen et al., 2010) and to perform basic and advanced strokes (Van Biesen et al., 2012). In addition, II-athletes presented significant limitations in tactical proficiency when playing 60 semi-standardized rallies against the same opponent (Van Biesen et al., 2013). These studies highlighted that technical and tactical factors were the sport performance components more negatively affected by II. As Tweedy and Vanlandewijck (2011) stated, eligibility systems must be sport-specific; consequently, to develop eligibility systems for other sports aiming to be included in the Paralympic program, as basketball, it is required to investigate how II influences on performance in each sport.

Previous studies in II-basketball observed that II-players at high-level competition seemed to present lower shooting efficiency, more rebounds, less assists and more turnovers per game than AB-players (Pérez-Tejero et al., 2015). Differences in these variables were explained in the literature to be related to unforced errors (García et al., 2013), less collective actions preparing the shot (Lorenzo et al., 2010) and lower

accuracy in decision making (Gómez et al., 2008). Probably, a negative influence of II on those cognitive abilities required performing basketball could explain these differences. Polo et al., (2014) analyzed experienced II-basketball coaches' opinion about the influence of II on basketball performance, finding that coaches pointed to collective and individual offensive tactics as game components more negatively affected by II.

A further step in this research line is to investigate the influence of II on those basketball activities which requires a high cognitive implication. Decision making has been one of the most cognitive demanding activity reported in the specific literature from this sport (Araujo et al., 2006; Williams, 2000; Tenenbaum, 2003). In this regard, decision making has been positively associated with expertise development in different studies (Garganta, 2001; Tenenbaum et al., 1993) and success (Karalejic & Jakovljevic, 2008).

The aim of the present study was to assess the influence of II on decision making in basketball. A first hypothesis is that II-basketball players will make slower and less accurate decisions compared to AB-players with similar experience and training volume. A second hypothesis is that II-players might perform decisions similar or below young AB-players in early developmental stages.

METHOD

Participants

Ninety three male II-basketball players (N=93, age=27±7 years) and one hundred and thirty AB-players (N=130, age=18.0±5.0 years) participated in this study. All II-players represented 100% of participants at the World Basketball Championships (Turkey 2013) and 81.7% of participants at the Global Games (Ecuador 2015). These competitions were organized by the International Federation for Para-athletes with Intellectual Disability (INAS). II-players participated from 8 countries (Venezuela, France, Portugal, Japan, Australia, Poland, Greece and Turkey) and all of them met the criteria from the American Association on Intellectual and Developmental Disabilities (AAIDD, 2010) for diagnosis of Intellectual Disability: significant limitations in intellectual functioning ($IQ \leq 75$) and in adaptive behavior manifested before the age of 18. The sample of AB-players participated in Belgium and Spanish competitions in different levels according to their age: under-14 years old (U-14; n=31, age=13.2±1.0), under-16 years old (U-16; n=25, age=15.2±0.4); under-18 years old (U-18; n=30, age=17.7±0.5), and senior (n=44, age=23.2±5.1). Experience (years playing basketball and the accumulated experience of hours trained) and training volume (hours trained per week and number of months trained per year) were checked in both groups as it is presented in table 12.

Table 12. Sample's experience and training volume

	II-players	U-14	U-16	U-18	Senior
Years playing	9.8 (6.3)	5.48 (2.1)	4.8 (2.0)	8.6 (3.5)	14.0 (5.1)
Total experience (hours)	2411 (2307)	1286 (631)	1041 (527)	1878 (1105)	2320 (2019)
Hours per week	6.3 (4.6)	5.9 (1.4)	5.5 (1.2)	5.4 (1.8)	4.9 (1.7)
Months per year	9.6 (1.6)	9.7 (0.5)	9.9 (0.3)	9.8 (0.7)	9.5 (2.2)

Instrument Design

To assess II- and AB-players' decision making capacity, a touch-screen computerized basketball test was designed. The test consisted of twenty different basketball game situations presented to the player in screen size photographs. For each photograph presented, the player tested had to decide if the player in possession of the ball has to shoot, to dribble or to pass the ball. To explain this test, one demonstration and four trials were designed. To present each game situation, first, a shot clock appeared on the top of the screen with the remaining possession time. After 2 seconds, a photograph with the game situation was presented, where the ball was highlighted with a yellow circle that disappeared after 2 seconds (Figure 22).

Figure 22. Example of photograph

Figure 23. Shot, Dribble, Pass pictograms

As soon as players decided which action to make in that situation, they had to press the space bar. On space bar pressed, a new screen appeared with three pictograms representing shot, dribble and pass (Figure 23). Players had to touch the screen indicating their decision on the selected option: shot, dribble or pass. After ensuring that the player was ready for the next photograph, the experimenter initiated the next photograph. Variables recorded in this test were: decision made and time (milliseconds) employed by the players to decide in each situation. Photographs of the game situations

were obtained from official games at the highest Belgium basketball league “Pro-league”. All the photographs, shot clock time and correct decision for each game situation were selected with complete agreement by 3 basketball professors from the KU Leuven (Belgium) with more than 15 years of basketball experience. This selection was blinded checked by 6 basketball professors from the Technical University of Madrid and 1 professor from the University of Extremadura (both in Spain). All of them had more than 20 years of basketball experience. Basketball professors were asked to indicate for each photograph which is the best decision to take as the ball handler. Professors presented a high agreement, ICC=0.94. After this check, specific software for touch screen computers was developed by the KU Leuven to administrate the test. This software contained a menu with 4 buttons to access to personal data form, demonstration, trial and test administration.

Procedures

To administrate the test, a quiet room and one touch screen computer (ASUS All-in-one EeeTop ET1611DUT, screen 15.6”) were used. Players were seated in front of the computer in a comfortable position from which they could easily manipulate the computer. First, personal data from the player were gathered: name, surname, birth date, country, team, hand dominance, playing position and test administrator. Afterwards, a demonstration was presented to explain the test step by step. The last part of the introduction consisted of a trial with four game situations in order to check that the test was correctly understood. The actual test consisted of the presentation of the 20 game situations in a standardized sequence with randomized level of difficulty. All test administrators were trained to conduct the test in a standardized way.

Statistical Analyses

Kolmogorov-Smirnov was employed to check data normality. Descriptive statistics (mean and standard deviation) were calculated in II and AB-players per age group for the variables decision time and number of correct decisions made.

To prove hypothesis one, first, a t-test for independent samples was applied to check that the II and AB-senior players were comparable by not presenting differences in training volume neither experience. The same test was conducted to compare the time employed by II and AB-senior players to decide in each photograph and the number or correct decisions made during the test. Effect size (ES) of the differences was calculated by Hedges' *g* (Rosenthal, 1994). Also, the percentage of II and AB-senior players that decided correctly in each photograph was calculated. A discriminant analysis was carried out to identify which variables discriminated best from II and AB-players. The structural coefficients (SC's) obtained from the discriminant function were used to identify these variables (Ntoumanis, 2001) and level of significance for the discrimination between both groups was set at SC above $|0.30|$ (Tabachnick & Fidell, 2005). Leave-one-out classification was conducted to validate the discriminant models (Norušis, 2004).

To prove hypothesis two, the Kruskal Wallis test was employed, due to that some samples presented less than 30 players, to explore the differences between all II-players and all AB-players grouped by age. To identify paired-matched differences between groups the U Mann-Whitney test was employed. In addition, Spearman correlation was calculated to explore the relationship between the different age groups and general

outcomes in the test. All statistical analyses were performed using PASW statistics 20 (SPSS Inc., Chicago, IL, USA). Statistical significance was set at $P<0.05$.

Ethics approval

All participants signed an informed consent to participate in the present study. The study was approved by the KU Leuven ethical committee.

RESULTS

Before proving the hypothesis 1, it was checked that there were no significant differences between II-players and the sample of AB-senior players in the accumulated experience ($p=0.84$), training volume per month ($p=0.68$) neither per week ($p=0.1$). After this first step, it was confirmed that II-athletes decided significantly ($p<0.001$) slower (3.76 ± 1.8 seconds per photograph; $ES=1.53$) and less accurate (15.72 ± 2.8 correct decisions; $ES=0.91$) than the AB-senior sample (1.46 ± 0.5 seconds and 17.9 ± 1.2 correct decisions).

Mean time that both groups employed to decide in each photograph is presented in Figure 24. In all the situations II-players required significantly ($p<0.001$) more time to decide. In addition, the higher standard deviations found in II-players seem to indicate that these athletes present higher variability performing the test.

Figure 24. Comparison of the decision time between II and AB-senior players per photograph

In figure 25 the percentage of II and AB-senior players that decided correctly in each photograph is compared. In all the photographs a higher percentage of AB-senior players decided correctly except in photograph 13; however, results in this photograph were much lower than in the other photographs for both samples.

Figure 25. Percentage of II and AB-senior players who decided correctly in each situation

The calculated discriminant function included time and accuracy of the decision of all II and AB-senior players in each game situation, except from situation 13 due to the low scores obtained. This function was significant ($p < 0.001$), with a canonical correlation of 0.769. The calculated discriminant function was:

$$D = Dt1 * -0.058 + Dc1 * 0.637 + Dt2 * -0.127 + Dc2 * 0.241 + Dt3 * 0.113 + Dc3 * 0.302 + Dt4 * 0.066 + Dc4 * -0.031 + Dt5 * 0.006 + Dc5 * -0.056 + Dt6 * -0.028 + Dc6 * 0.054 + Dt7 * -0.131 + Dc7 * 0.152 + Dt8 * -0.085 + Dc8 * 0.637 + Dt9 * -0.223 + Dc9 * -0.502 + Dt10 * 0.074 + Dc10 * -0.091 + Dt11 * -0.086 + Dc11 * -0.375 + Dt12 * 0.11 + Dc12 * 1.115 + Dt14 * -0.198 + Dc14 * 3.332 + Dt15 * -0.074 + Dc15 * -0.088 + Dt16 * 0.371 + Dt17 * -0.328 + Dc17 * -0.057 + Dt18 * -0.091 + Dc18 * -0.054 + Dt19 * 0.128 + Dc19 * 1.022 + Dt20 * -0.005 + Dc20 * 0.755 - 4.024.$$

Where Dtn = decision time in photograph “n”; Dcn = accuracy of the decision in photograph “n” (0=incorrect, 1=correct).

When results from each player were introduced into this function a “D value” was obtained. This value represents the proximity of the player’s outcomes in the test with the reference values from II or AB-players. When the calculated “D value” was higher than 0.457, the player was classified as “AB-player” and, when it was lower, the player was classified as “II-player”. This function classified 91.2% of the players correctly according to their initial group of pertinence: AB or II-players. The structure coefficients indicated that the variable time employed to decide in each photograph, except in photograph 19, was the variable which significantly $|SC| > 0.30$ contributed to best discriminate between II and AB-players were.

To prove hypothesis two, the outcomes from II-players were compared with the different samples of AB-players grouped by age. All the groups were compared through Kruskal Wallis tests, indicating that there were differences between groups in the variables mean time ($p < 0.001$) and number of correct decisions ($p < 0.001$). Test's outcomes per group and differences detected between groups through *U Mann Whitney tests* are presented in table 13.

Table 13. Test scores overall comparison per competition level

	II	U-14	U-16	U-18	Senior	Significance
Mean Time	3.76 (1.8)	2.0 (0.7)	2.0 (0.9)	2.11 (1.3)	1.46 (0.5)	II>All AB-groups.
Correct	15.72 (2.8)	16.5 (2.2)	17.3 (1.8)	17.7 (1.4)	17.9 (1.2)	II<U-16, U-18 and Senior. U-14<Senior

In order to situate II-players' results compared with the different AB-groups, figure 26 presents a comparison between groups' outcomes in the test. In this figure, II-players' outcomes were below the obtained by AB-players even in early developmental stages. In addition, it was observed that outcomes in this test improved progressively in AB-players as the age group increased. A Spearman correlation revealed that there were significant correlations ($p < 0.001$) between the age group and number of correct decisions made ($r_s = 0.269$) and the mean time employed to decide in each photograph ($r_s = -0.331$).

Figure 26. Mean test scores per age group

DISCUSSION

The purpose of the present study was to assess the influence of II on decision making in basketball. Results confirmed the first hypothesis, showing that II-players made slower and less accurate decisions compared to AB-players with similar experience and training volume. These differences were supported by a high effect size. The second hypothesis was also confirmed, situating II-players' outcomes on decision making under outcomes from AB-players, even in early developmental stages (U-14).

Basketball is played in a constantly changing environment in which it is crucial to decide correctly but also to do it in a short time (Araujo et al., 2006). According to the *Information Proccessign Theory* (Sánchez Bañuelos, 1984; Moreno et al., 2003; Marteniuk, 1974) or the model of decision making in sports presented by Tenenbaun (2003), decision making requires a high cognitive implication to perceive the situation, to process it and to ellaborate an adequate decision. Due to this, the limitations presented by II-players in this study might put them in disadvantage competing against AB-players at high level competitions. Previous studies identified II-baskebtall players' limitations on tactics (Polo et al., 2014) and found relevant differences between II and AB-players in game-related statistics during competition (Pérez-Tejero et al., 2015; Pinilla et al., 2015). Probably, the influence of II on decision making might be one of the factors explaining these facts although further research should be performed to contrast this relationship.

These evidences justify the need of organizing specific II-basketball competitions. Results from this study provides relevant information to determine eligibility criteria to

participate in these competitions; firstly, because the present results are evidences of the influence of II on one fundamental basketball activity: decision making, which is a determinant step in the eligibility systems development (Tweedy & Vanlandewijck, 2011). Secondly, because results provide reference groups of II and AB-players performing the decision making tests, so future players might be compared. The obtained discriminant function let us to determine in a new player, by calculating the “D” value, whether he or she decide closer to the reference group of AB or II-players.

In the sample of athletes who participated in this study, this function classified correctly 91.2% of them into their predicted group, highlighting that decision making discriminates II and AB-players strongly. However, in Para-sports, eligibility is applicable individually and not in groups, due to this, the 8.8% of the sample not classified correctly might represent II-players not having limitations on decision making in basketball or AB-players having these limitations. These overlap in results between II and AB-players suggests that eligibility must be sport-specific (Tweedy & Vanlandewijck, 2011; IPC, 2015) because it is possible that some II-players present limitations in general intelligence but not in those specific cognitive abilities required to perform in basketball. In this line, recent studies have developed new intelligence assessment tools based on the cognitive abilities determinant for sport performance (Van Biesen, Mactavisch, McCulloch, Lanaerts and Vanlandewijck, 2016) instead of general assessments of intelligence like IQ tests.

With regard to the second hypothesis, comparing II-players with different groups of AB-players from different ages denotes where II-players’ ability to make decisions in

basketball is placed respect to the sample of AB-players and provides a deeper perspective about the degree of influence of II on decision making. Regarding the results, the negative influence of II on decision making persisted even comparing the sample of II-players with young players 3 age categories under their AB-counterparts matched by experience and training volume. From this analysis, it is also highlighted the positive relationship found between the age group and the tests' outcomes in the sample of AB-players. This relationship goes in line with previous studies in which expertise development was associated with a better decision making capacity (Kioumourtzoglou, Derri, Tzetzis, & Theodorakis, 1998; Tenenbaum, 2003). As these studies indicated, this relationship confirms the relevancy of this capacity performing basketball.

Results from this study suppose a potential contribution for the development of II-basketball eligibility systems, a step which is needed to re-include this modality in the Paralympic Program. Further research is still needed to analyze the characteristics of the players who overlapped the results of this study and to determine whether they present limitations performing basketball or not. Also, as it is being developed in previous studies regarding classification in Para-sports, it is needed to develop systems to check misrepresentation when performing this test (Deuble, Connick, Beckman & Tweedy, 2015).

CONCLUSIONS

This study was relevant to confirm the negative influence of II on decision making in basketball. II-players presented limitations to make decisions as fast and accurate as

AB-players. Results from this research contribute to the development of eligibility systems in II-basketball through the development of a sport-specific tool, to assess a fundamental basketball activity highly cognitive demanding as decision making is, and to provide the possibility to set an eligibility criteria based on these results. To develop these systems is relevant to ensure equal opportunities to success for all athletes participating in II-basketball competitions and also to have the possibility to re-include this sport in the Paralympic Program.

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6. Influence of intellectual impairment (II) on basketball players' capacity to solve a game situation: towards evidence-based classification systems in II-basketball

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ABSTRACT

Basketball for athletes with intellectual impairment (II) requires the development of evidence-based eligibility systems to guarantee that only athletes with significant limitations performing basketball participate in these competitions. In addition, this is needed to re-include II-basketball in the Paralympic program. To do this, it is required to investigate how II impacts on fundamental basketball activities. To address this need, the aim of this study was to compare able-bodied (AB) and II-players' capacity to solve a game situation. A field test was designed *ad hoc* in which 38 elite II-players from France, Portugal, Australia and Japan who participated in the Global Games (2015) and 38 AB-basketball players competing in Spanish competitions, had to solve 8 standardized game situations. Results indicated that II-players spent significantly ($p < 0.05$) more time to decide ($0.92 \pm 0.2s$) than AB-players ($0.63 \pm 0.1s$) and to execute the solution (II: $3.01 \pm 0.4s$; AB: $2.56 \pm 0.3s$). Also, II-players made more rule infractions (II: 7.11 ± 1.4 ; AB: 7.71 ± 0.7), more feints (II: 1.37 ± 1.4 ; AB: 0.3 ± 0.6), more dribbles (II: 15.08 ± 3.9 ; AB: 12.29 ± 2.3) and they performed less successful solutions (II: 4.42 ± 1.5 ; AB: 5.39 ± 1.3). However, no differences were found in number of correct decisions made. Decision time, number of dribbles and situations in which they succeeded were the variables that best discriminated between II and AB-players. These results confirmed the negative influence of II on players' capacity to solve a basketball game situation. The calculated discriminant function let us establish the minimum scores from this test that indicates significant limitations on the capacity to solve a game situation. These scores are applicable to determine eligibility criteria in II-basketball worldwide.

INTRODUCTION

Basketball is a sport in which there are a high number of interactions between teammates and their opponents in reduced time and restricted space (Araujo et al., 2006; Araujo & Esteves, 2009). Therefore, players should read and decide fast during the game (Alarcón et al., 2010; Tenenbaum et al., 1993). These processes require high participation of different cognitive abilities (Jakovljevic, 1996; Karalejic & Jakovljevic, 2008), due to this, basketball players with intellectual impairment (II) might present limitations to achieve similar performance levels compared to able-bodied (AB) players. In this line, previous studies demonstrated that II-players achieved lower shot efficiency than AB-players, they played higher game rhythm and they made more turnovers during competition (Pinilla et al., 2015). Because these variables were found as relevant to performance success (Pérez-Tejero et al., 2015), II-players competing with AB-players in high level competitions might be disadvantaged. Consequently, the development of II-basketball competitions seems necessary to provide II-players the opportunity to compete in equal conditions achieving their maximum level of performance.

The Paralympic Games represent the biggest worldwide sport event for athletes with physical, visual and intellectual impairment. The International Federation for Para-athletes with Intellectual Disability (INAS) and the athletes they represent were banned from Paralympic competition because the eligibility system in place was proven to have major flaws. The re-inclusion of II-athletes in the Paralympics was very recent in London 2012 (Burns, 2015); however, II-basketball is not included yet in the program. One necessary requirement to re-include II-basketball in the Paralympics is to develop an evidence-based eligibility system which ensures that only athletes with significant

impact of II on basketball performance participate in specific II-competitions (IPC, 2015). To develop such a system, it is needed to investigate how II impacts on fundamental basketball activities and to identify the minimum impairment needed to significantly affect these activities (Tweedy & Vanlandewijck, 2011).

Basketball is a sport in which tactical components (individual and collective) are relevant (Sampedro, 1999) and it requires a high decision making capacity to effectively solve the situations that occur during the game (Jiménez et al., 2009; Stella et al., 2012). Different theories in literature can be found explaining the cognitive processes involved in decision making in sport. The *Operative Model of Decision Making* (Gréhaigne et al., 2001) highlights the relevance of perceptive processes in decision making. The *Information Processing Theory* (Moreno et al., 2003) considers the decision making process being divided in two stages: a cognitive stage (perception and processing) and a motor-cognitive stadium (execution). However, other more recent theories indicated that the decision making process is not just a result of cognitive calculations comparable to computer software: also individual's preferences and contextual factors are also relevant in this process (Busemeyer & Townsend, 1993; Raab, 2002; Busemeyer & Johnson, 2003). In addition, the *Fast and Frugal Heuristic* (FFH) approach of decision making (Bennis & Pachur, 2006; Gigerenzer & Goldstein, 1996) indicated that to solve a problem (heuristic), decisions have to be made with high speed (fast), which is given by the individual's capacity to use less information or require fewer cognitive steps (frugal). Other authors called this *Intuitive Decision Making* (Dane et al., 2012).

One model frequently used in the literature (Jiménez, 2007; Moreno et al., 2003; Stella et al., 2012) to explain basketball decision making process is the model presented by Tenenbaum (2003; figure 27).

Figure 27. Decision making process and its cognitive components (Tenenbaum, 2003)

Despite the differences found between these models, all of them agree that to solve a game situation, athletes need to follow three key fundamental stages: perception, decision and execution. These three stages require a high involvement of intellectual functioning (Alarcón et al., 2010; Tenenbaum et al., 1993). As Burns (2015) suggested, investigating the impact of II on sport performance, research should be oriented on how II influences those activities relevant to perform in a given sport that has a high cognitive load, which is the case for II basketball. For authors' knowledge, still no reference in the literature has studied this influence. Therefore, the aim of the present

study was to compare II and AB basketball player's capacity to solve basketball game situations. A recent study revealed that well trained II-athletes performed significantly worse than AB-athletes in a generic cognitive test to assess executive functions and cognitive abilities relevant to sport (Van Biesen, Mactavish, McCulloch, Lenaerts & Vanlandewijck, 2016); based on this study, it can be hypothesized that II-basketball players decide significantly slower and less effectively in realistic basketball conditions than their AB-peers.

METHOD

Participants

Thirty eight elite male II-basketball players (age=26±7 years) and a control group of thirty eight male AB-players (age=19±7 years) participated in this study. II-players represented four countries: France, Portugal, Australia and Japan; competing at the 2015 Global Games (Ecuador) organized by the International Federation for Para-athletes with Intellectual Disabilities (INAS). All II-players met the criteria for diagnosis of Intellectual Disability (AAIDD, 2010): significant limitations on intellectual functioning ($IQ \leq 75$) and on adaptive behavior manifested before the age of 18. AB-players from the control group participated in AB-competitions in Spain at regional level in two different categories: under-18 (U-18; $n=8$, age=17±1) and senior ($n=30$, age=20±3). Experience and training volume was checked in all groups.

Research Design

To assess basketball player's capacity to solve basketball game situations, a field test was designed *ad hoc* in which the tested players had to play different standardized game

situations looking for the most successful solution. To develop this test, first, 16 game situations including different 1-on-1, 2-on-1, 2-on-2 and 3-on-2 situations were designed by a basketball expert (12 years of experience). These situations were blinded reviewed by four basketball professors from the Technical University of Madrid (UPM) with more than 20 years experience each one. Game situations were selected if 100% of agreement was reached on the following two criteria: (1) the game situation represented a real situation that can occur during a game and (2) there was only one clear correct decision to solve the situation: to shoot, to dribble or to pass. Final selection was composed by 11 game situations: three 1-on-1 situations, three 2-on-1 situations and five 2-on-2 situations. From this selection, to explain the test, one situation was employed for demonstration (1-on-1) and two situations were used for trials (2-on-1 and 2-on-2). For data collection, 8 game situations were used. To administer the test, three basketball players were trained to reproduce the situations as presented in the test protocol which was previously designed and piloted by two basketball experts. According to this protocol, 1-on-1 situations were played first, followed by 2-on-1 situations and 2-on-2 situations.

Each situation was played in three stages: “ready”, “set” and “play”. In the “ready” position, the tested player had to hold the ball, standing in front of the basket, 60cm far from the 3-point line (8.57 meters from the baseline). In this stage, defensive testers were placed on the left of the tested player and the offensive tester was placed on his right. To differentiate offensive and defensive players, colored t-shirts were used. Once the testers and the tested player were ready, the test administrator said “positions”. Here, the “set” stage started and testers had to move to the position in which they had to start

playing the situation. In this phase, the tested player had to keep in the “ready” position. Once the testers reached the “set” position, the test administrator made a visual signal with his hand while he said “play”. In this moment, the “play” stage started; testers reproduced the situation as indicated in the protocol and the tested player had to solve the situation as fast and as accurate as possible (figure 28).

Figure 28. Example of the three stages in a 2-on-2 situation

Procedures

To perform the test, one court, one ball, 4 colored t-shirts (2 different colors), 4 cones, one measuring tape, one video camera, one tripod, one pen, one personal data sheet and three trained testers were needed. The following personal data were collected: name, surname, birth date, country, team, position, hand preference, date, experience playing basketball (years) and training volume (hours per week and months per year). Also II-basketball player's team quality (final team classification at the 2015 Global Games) was registered. France was the best classified team from the teams participating in this study, followed by Portugal, Australia and Japan.

Data Collection

The following data were collected in each of the eight selected situations: time employed by the testers in the “set” stage, player’s decision made, decision time, execution time, rule violations, dribbles, feints and success. Time variables were measured through video frame analysis with an accuracy of 0.04 seconds (25 Hz). The time used by the testers in the “set” stage was calculated from the frame in which testers started to move until the test administrator gave the hand signal. Decision time was calculated from this moment until the ball left the tested player’s hands. Execution time was calculated from this moment until the ball touched the basketball ring, the ball was scored, lost or received by the offensive tester. Accuracy of the decisions was collected according to the criteria established in the test protocol. A successful execution was considered if the tested player scored into the basket or if a successful pass was given to the offensive tester. In addition, number of dribbles made, feints used and rule violations were collected to explore how players executed the different eight situations.

Statistical Analyses

Normal distribution of data collected was confirmed through Kolmogorov-Smirnov test. Descriptive statistics (mean and standard deviation) were calculated for all variables and a t-student test was performed to identify differences between II and AB-players in these variables and regarding experience and training volume. Pearson correlation was calculated to explore the relationship between contextual variables and test outcome. Differences between subgroups of AB-sample regarding their level of competition were calculated through U-Mann Whitney test. Finally, a discriminant analysis was carried out and the obtained structural coefficients (SC’s) from the

discriminant function were used to identify the variables which best discriminated between II and AB-players performing the test (Ntoumanis, 2001). Level of significance was set at SC above $|0.30|$ (Tabachnick & Fidell, 2005). Leave-one-out classification was conducted to validate the discriminant models (Norušis, 2004). All statistical analyses were performed using PASW statistics 20 (SPSS Inc., Chicago, IL, USA). Statistical significance was set at $P < 0.05$.

Ethics approval

All participants signed an informed consent. The study was approved by INAS, IPC and the KU-Leuven ethical committee.

RESULTS

In order to control possible effects of differences administrating the test, no differences were found in the time employed by the testers in the “set” stage when the test was administrated in AB and II-players. In addition, no relationship was found between this variable and any of the player’s variables performing the test.

Descriptive statistics (mean and standard deviation) and differences between II and AB-players in the variables collected in the test are presented in table 14. AB-players decided and executed significantly faster ($p < 0.05$), they made less infractions, less feints, less dribbles and they solved successfully more game situations. No differences were found between II and AB-players in number of correct decisions made.

Table 14. Differences between II and AB players performing the test

	II	Sig.	AB
Mean decision time in each situation	0.92s (0.2)	>	0.63s (0.1)
Mean execution time in each situation	2.1s (0.4)	>	1.94s (0.2)
Mean time to solve each situation	3.01s (0.4)	>	2.56s (0.3)
Number of correct decisions	7.11 (1.1)	=	7.29 (0.9)
Number of situations with no rule infractions	7.11 (1.4)	<	7.71 (0.7)
Number of feints made	1.37 (1.4)	>	0.3 (0.6)
Number of dribbles made in the whole test	15.08 (3.9)	>	12.29 (2.3)
Number of successful solutions	4.42 (1.5)	<	5.39 (1.3)

Sig. $p < 0.05$ and direction of the significance

To visualize these differences, in figure 29 is presented a time line representing the average time II and AB-players employed in each stage of the test.

Figure 29. Time line comparing II and AB-players in each situation

Results from training volume and experience indicated that II-players played 12.4 ± 6.2 years, 5.8 ± 5.6 hours a week of training and 11.1 ± 1.1 months per year of training, with an accumulated experience of 2899 ± 2545 hours; U-18 AB-players played 4.0 ± 2.8 years, 4.3 ± 0.5 hours a week and 9.0 ± 0 months per year, with an accumulated

experience 582 ± 284 hours and senior AB-players played 9.1 ± 2.9 years, 5.3 ± 1.8 hours a week and 9.6 ± 0.7 months per year, with an accumulated experience 2061 ± 1064 hours. The effect of training volume and experience on the test outcome was checked and the significant correlations found are presented in table 15.

Table 15. Relationship between training volume and experience with the test outcome

Test Variables	II-players		AB-players	
	Months / year	Years	Months/ year	Total experience
Decision time	0.50	-0.48		
Execution time			-0.34	
Dribbles	-0.34			-0.52
Correct decisions				0.41
Success	0.40			

* Significant correlation ($p < 0.05$)

In addition, the relationship between different variables from the field test was explored finding that, in II-players, number of dribbles correlated significantly ($p < 0.05$) with mean execution time ($r = 0.75$), mean decision time ($r = -0.34$) and success ($r = -0.44$). Furthermore, a significant correlation ($p < 0.001$) between team quality and mean decision time was found ($r = 0.70$). Players from France and Portugal decided significantly faster ($p < 0.05$) than players from Australia and Japan; however, Japan solved more game situations successfully than France and Portugal ($p < 0.05$). No relationship was observed between playing position (guard, forward and center) and test outcomes in II and AB-players.

According to the level of competition, senior AB-players decided significantly ($p < 0.05$) better, faster and they used less dribbles solving the game situations than U-18 players. When results between II-players and both sub-groups of AB-players were compared

separately, differences were higher when compared with senior players instead of U-18 players (Figure 30). Even, II-players obtained better scores in number of correct decisions than U-18 players, but these differences were not significant ($p>0.05$).

Figure 30 Differences between II and AB-players per level of competition

The calculated discriminant function was significant ($p<0.001$) and the canonical correlation was 0.924. The values of the function were:

$$\begin{aligned}
 D = & Dt1 * 1,756 + Ex1 * 0,668 + Dec1 * 0,718 + Rl1 * 1,291 + Dr1 * 0,324 + Sc1 * - \\
 & 0,406 + Dt2 * 2,521 + Ex2 * -1,083 + Rl2 * 0,777 + Dr2 * 0,486 + Sc2 * -0,374 + Dt3 * 3,945 + Ex3 * - \\
 & 0,798 + Dec3 * 0,501 + Dr3 * -0,379 + Sc3 * -0,781 + Dt4 * 0,805 + Ex4 * - \\
 & 0,509 + Rl4 * 0,78 + Dr4 * 0,694 + Sc4 * -0,946 + Dt5 * 0,721 + Ex5 * -0,177 + Dec5 * 0,303 + Rl5 * - \\
 & 1,122 + Dr5 * 0,383 + Sc5 * 0,767 + Dt6 * 0,052 + Ex6 * 0,482 + Dec6 * -0,097 + Dr6 * - \\
 & 0,707 + Sc6 * -0,582 + Dt7 * -0,188 + Ex7 * -0,096 + Dec7 * 0,737 + Rl7 * - \\
 & 0,195 + Dr7 * 0,755 + Sc7 * -0,508 + Dt8 * 0,110 + Ex8 * -0,171 + Dec8 * - \\
 & 1,572 + Rl8 * 1,195 + Dr8 * -1,128 + Sc8 * -0,116 - 7,914
 \end{aligned}$$

Where Dtn= decision time in situation “n”; Exn execution time; Decn= accuracy of the decision; Rln=rule violation; Drn= number of dribbles; Scn= success.

When this function was applied in each player using the scores obtained in the test, a “D value” was obtained. This value represents the proximity of player’s performance in the test with the reference values from II or AB-players. When the calculated “D value” was higher than -0.0325, the player was classified as II-player and, when it was lower, the player was classified as AB-player. The power of this function to classify II and AB-players was extremely high because it classified 98.6% of the players correctly according to their initial group of pertinence: AB or II-players.

The analysis of the SC of all the variables indicated that those variables with $SC \geq |0.30|$ were the variables that significantly contributed to discriminate between II and AB-players in the test (table 16).

Table 16. Structural coefficients of the test’s variables for every field test situation (1-8).

Game situation	1	2	3	4	5	6	7	8
Decision time	.611*	.783*	-.766*	.480*	.856*	.923*	.582*	-.615*
Execution time	.336*	-.166	-.288	.436*	.209	.068	.248	-.051
Decision correct	.058	.00	.334*	.00	.080	-.114	.168	.468*
Dribbles	.434*	.010	-.290	.388*	.402*	-.030	.485*	-.180
Success	-.130	-.242	.464*	-.833*	.042	-.081	.008	.448*
Correct Decision	Shot	Dribble	Pass	Shot	Dribble	Pass	Shot	Pass
Eigenvalue	.915	.489	.550	.249	.458	.384	.550	.474
Wilk’s Lambda	.522	.672	.645	.801	.686	.722	.645	.678
Canonical Correlation	.691	.573	.596	.446	.561	.527	.596	.567
Chi-square	45.82	28.24	30.89	.446	26.23	22.91	30.88	27.36
Significance	.001	.001	.001	.05	.001	.001	.001	.001
Reclassification	80%	74.7%	82.7%	68.5%	78.4%	70.7%	80%	73.3%

* $SC \geq |0.30|$

DISCUSSION

The aim of the present study was to compare II and AB player's capacity to solve a basketball game situation. In line with our hypothesis, II-players solved the situations less successfully and they took more time to decide and to execute the actions. However, correctness of the decisions made reached similar levels than AB-players.

Following the three common phases observed in the different models of decision making: perception, decision and execution (Gréhaigne et al., 2001); the obtained results provided insight of the influence of II in these processes involved in basketball. The lack of differences found between the time the testers used to move from the "ready" stage to the "set" stage when the test was administrated to II and AB-players ensured that visual stimuli given to the players to perceive the game situation was similar. In this test, the variable decision time assessed the time players employed in a cognitive stadium like presented in the *Information Processing Theory* (Moreno et al., 2003) that included the perceptive and decisional processes the players carried out since the test administrator gave the signal and the ball left the player's hands. According to the model of decision making in sports from Tenenbaum (2003), in this time players had to use visual strategies, attention location, selection process, anticipation, process for making decisions and decision elaboration. In this time, also knowledge (French & Thomas, 1987) and tactical skills seem to be required (Gréhaigne & Godbout, 1995; Ibáñez, 2004) to find the best solution to the given situation. Results in this phase indicated that II-players, at the level of complexity presented in the standardized situations, can reach similar levels of correct decisions than AB-players; however, it

seems that II negatively influences on player's capacity to process the same information as fast as AB-players.

During the execution phase, player's had to use effectively the most appropriate skills to solve the situation (Jiménez, 2007). But also, according to Tenenbaum's model (2003), once the players started the action, they had to keep in alert about the possibilities presented during the game situation. II-players spent more time than AB-players in this phase, they made more dribbles, they made more infractions and they achieved less successful solutions. Probably, II might also influence on technical proficiency of II-basketball players as it was found in II-table tennis players (Van Biesen et al., 2012) that could explain these differences; however, as technical skills were not assessed in this study it can not be confirmed yet. Besides, according to Tenenbaum's model (2003), once player's decide, they need to continuously read the situation. As II-players required more time to process the information to decide, probably, they also needed more time to continuously read the situation during the execution. The higher number of dribbles in II-players could explain that they did this to have more time to process the information. In addition, results from II-players indicated that players who required more time to decide also required more dribbles to carry out the solution (see Table 2).

The presented limitations found in II-players to achieve AB-players outcomes in this field test confirmed II-player's limitation to solve a game situation as effectively as AB-players, being this activity fundamental to perform in basketball (Alarcón et al., 2009; Tallir, Musch, Valcke, & Lenoir, 2005; Tenenbaum, 2003; Trninic et al., 2002). These results goes in line with those presented by Polo et al.(2014) that indicated that, for II-

basketball coaches' opinion, II-players presented limitations especially on collective and individual offensive tactics.

The positive relationship found in AB-players between level of performance, experience and decision making capacity was in line with the findings in the literature and reinforces the validity of the abilities assessed in this test to perform basketball (Kioumourtzoglou et al., 1998; Kioumourtzoglou et al., 1998; Tenenbaum, 2003). However, in II-players, contrary to what it might be expected; no relationship was found between experience and the test outcomes. Probably, other factors such as the diversity of the impairment's etiology or degree of impairment (Armatas, 2009) might have more influence on decision making capacity than experience.

The relationship found between team quality, decision time and success solving the different game situations seemed to indicate that in II-basketball, success is more related with speed than accuracy making decisions. Moreover, decision time is the only variable whose structural coefficient contributes significantly in all of the situations presented in the test (Table 3). From the participating teams in this study, those worse classified solved the situations more successfully than those teams better classified; however, these teams decided faster. These evidences seem to go in line with the analysis of game-related statistics made in elite II-basketball competitions in which it was found that rhythm was faster, shot efficiency was lower and players committed more turnovers and steals per game compared with similar studies in AB-competitions (Pérez-Tejero et al., 2015; Pinilla et al., 2015).

The development of this field test and the results obtained are relevant for the development of II-basketball eligibility systems. As it is required for classification in Para-sport, eligibility systems must be sport-specific, and for this, specific assessment tools must be designed to evaluate the impact of II on the fundamental activities of each sport (Tweedy & Vanlandewijck, 2011). The presented results confirm the negative influence of II to solve a basketball game situation on the field, in addition, the discriminant analysis performed confirmed the validity of each game situation to discriminate II and AB-players according to the abilities assessed in this test. Moreover, the calculated discriminant function let us determine, in base of the evidences analyzed, which is the minimum impairment required to present significant limitations in the capacity to solve a basketball game situation comparing with the control group of AB-players. To establish this “minimum impairment” is the final aim of the development of eligibility systems, which is needed to guarantee equal opportunities to success of all athletes participating in Para-sport. Although, future research is needed to investigate the relationship between the abilities assessed in this study with outcome from the competition and also to investigate the influence of II on other basketball fundamental activities; results from this study let us to establish a first specific eligibility criteria in basketball that can be applicable worldwide. In addition, the development of these criteria might strongly contribute to re-include II-basketball in the Paralympic Games.

CONCLUSIONS

Findings in the present study confirmed that II-basketball players presented significant limitations on their capacity to solve basketball game situations compared with their AB-peers. This activity is fundamental to perform in basketball and it requires athletes

to perceive the situation, to decide and to execute effectively. Results in this study highlighted that II-players spent more time making decisions, executing solutions and their success solving the situations was lower. Multivariate analysis let us use this test to classify II and AB players according to their capacity to solve a game situation, being these results applicable to determine specific eligibility criteria in II-basketball. Establishing these criteria, equal opportunities to success in future II-basketball competitions could be ensure and also, it could contribute to re-include II-basketball in the Paralympic Program.

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7. Summary, Conclusions and Future Perspectives

7.1 Summary of the present findings and conclusions

The purpose of the present research work was to investigate the influence of II on basketball performance. To address this aim, the present dissertation was divided into different studies based on four main hypotheses:

- 5) Game-related statistics from II and AB-players competitions will present significant differences, showing different ways to perform basketball (Chapter 3)
- 6) Elite II-players will present limitations to recognize and order different basketball game sequences as fast and accurate as AB-players with similar experience and training volume (Chapter 4).
- 7) Elite II-basketball players will make slower and less accurate decisions compared to AB-players matched by experience and training volume (Chapter 5).
- 8) II-basketball players decide significantly slower and less effectively in realistic basketball conditions in the field than their AB-peers (Chapter 6).

These studies were sequentially ordered comparing II and AB-players under different conditions: competition (Chapter 3), simulation testing (Chapter 4 and 5) and field testing (Chapter 6). Competition observation provided realistic information of the players' outcomes as it represents the real context in which athletes perform as high as possible (Nadori, 1993). Simulation testing let analyze players' ability to carry out the fundamental basketball activities which requires a high cognitive implication by isolating the cognitive process from the technical or fitness components. Last, field testing provided relevant information about players' capacity to combine cognitive and executive process oriented to solve a situation played in the field.

In figure 16, the relationship between the different studies carried out in this research work with the components of basketball performance is represented.

Figure 16. Relationship between the objectives of the present dissertation with the components of basketball performance.

Hypothesis 1: Game-related statistics from II and AB-players competitions will present significant differences, showing different ways to perform basketball (Chapter 3)

The first study (Chapter 3) revealed that II-players played basketball in a different way than AB-players from the categories U-16 and U-18. II-teams played more ball possessions per game ($p<0.05$) and the variables which best discriminated II and AB-teams were: 2-point unsuccessful shots | $SC=-0.384$ | , 3-point successful | $SC=0.456$ | ,

3-point unsuccessful $|SC=-0.399|$, free-throws successful $|SC=0.319|$ and fouls $|SC=0.454|$. In all playing positions II-players presented more 2-point unsuccessful and lower shooting percentage in all kind of shots. II-guards attempted more field shots and made more turnovers than their peers, showing an unbalanced roles' distribution compared with AB-players. A question that might emerge from these results is: Do these differences represent limitations on basketball performance or just a different way to play basketball?

In previous studies in which game-related statistics were compared between AB-players at different competition level it was observed that players from upper levels obtained higher shooting percentages (Sampaio et al., 2004; Pinilla, et al., 2016). In the present study, it was also observed that differences were higher when the sample of II-players was compared with the sub-sample of U-18 AB-players instead of U-16 players. Due to these differences it seems that the lower shooting percentage in II-players represents a limitation on basketball performance. The variables that significantly discriminated $|SC>0.30|$ II and AB-players were straightly related with shooting percentage in terms of shots successful and unsuccessful. Also the balance between 2-point and 3-point shots observed in previous studies increased with the level of competition (Sampaio et al., 2004). As Trninic et al. (2002) manifested, systems of play of the successful teams contain balance between inside and outside play, providing good opportunities to draw fouls, to carry out 3-point power plays and to have more chances to get offensive rebounds. According to this, it seems that the unbalance between 2-point and 3-point shots found in II-players represent a limitation to perform basketball at high level.

Differences in game rhythm were not directly related with success in previous studies but these differences were relevant in this study. Some authors indicated that playing a higher pace leads to more unforced errors (García et al., 2013) and that it represents a lower use of collective actions (Lorenzo et al., 2010).

All these differences confirmed that II-players played basketball in a different way than AB-players at the level of competition of U-16 and U-18 and that these differences are related with game variables determinant for basketball success. The IPC Classification Code determines that to be eligible in Para-sports an impairment must impact on sports performance (IPC, 2015; Tweedy & Vanlandewijck, 2011) and this impact seems to be manifested in this study. These results justified the need to investigate in deep the influence of II to carry out fundamental basketball activities.

Hypothesis 2: Elite II-players will present limitations to recognize and order different basketball game sequences as fast and accurate as AB-players with similar experience and training volume (Chapter 4).

To determine eligibility in one Para-sport it is needed to investigate the limitation that impairments directly cause on fundamental activities of this sport (Tweedy & Vanlandewijck, 2011). As II is characterized by impacting on overall intellectual functioning (AAIDD, 2010), to orientate this research it seemed convenient to analyze the impact of II on those basketball activities which are more cognitive demanding. This study (Chapter 4) confirmed that II-players presented significant limitations to recognize and order a basketball game sequence compared to a control group of AB-

players matched by training volume and experience. The mean time spent by II-players to solve each of the 12 situations presented in this study was significantly ($p<0.001$) higher (II: 41.2 ± 20.2 s vs AB: 19.2 ± 5.9 s). Mean time spent by II players was more than the double of the time spent by AB-players. Also, II-players ordered correctly less sequences than AB-players (II= 6.7 ± 3.6 series vs AB= 9.35 ± 1.5 series, $p<0.001$). In this study also a second hypothesis was proved: II-players might perform this ability close or below AB-players under development. A sample of AB-players under development composed by players under-14 (U-14) years old ($n=30$, age= 13.2 ± 1.0 years); U-16 ($n=23$, age= 15.2 ± 0.4 years) and U-18 ($n=29$, age= 17.7 ± 0.5 years) also participated in this study in order to situate II-players' ability to recognize and order a game-sequence in the developmental curve of AB-players carrying out this ability. II-players required significantly ($p<0.001$) more time even than U-14 players (22.7 ± 5.5) to solve the situations and ordered less sequences than U-16 players (9.74 ± 1.9 , $p<0.001$).

During the game, each play situation is composed of a sequence of actions in which players need to recognize the most important components to understand the overall situation and to anticipate future actions (Lorenzo et al., 2010). Players require basketball-specific knowledge (Gréhaigne et al., 1999) and they need to read the situation fast (Gréhaigne et al., 2001). This requires the implication of several cognitive abilities coordinated and integrated in the different phases of the play (Tenenbaum, 2003). According to these authors, the activity assessed in this study is determinant for basketball performance. In this line, the correlation found between time employed to solve the sequences and the each group ($r_s=-0.326$, $p<0.001$) indicated the relevancy of the abilities assessed in this study on players' development.

Hypothesis 3: Elite II-basketball players will make slower and less accurate decisions compared to AB-players matched by experience and training volume (Chapter 5).

Decision making has been one of the most cognitive demanding activities reported in the specific literature from this sport (Araujo et al., 2006; Williams, 2000; Tenenbaum, 2003). In this regard, decision making has been positively associated with success (Karalejic & Jakovljevic, 2008) and expertise development (Garganta, 2001; Tenenbaum et al., 1993).

Through this study hypothesis 3 was also confirmed, II-players presenting significant limitations to make decisions compared with their counterparts of AB-players matched by training volume and experience. From the 20 photographs presented in a computerized test, II-players decided significantly ($p < 0.001$) slower (3.76 ± 1.8 seconds per photograph) and less accurate (15.72 ± 2.8 correct decisions) than the control group of AB-players (1.46 ± 0.5 seconds and 17.9 ± 1.2 correct decisions). In line with the previous study, II-players spent a mean time even more than double than the time spent by AB-players. Also a developmental curve of decision making was built to prove a second hypothesis: II-players might perform this ability close or below than AB-players under development. This curve was based on AB-players' outcomes in this test from different age categories: under-14 years old (U-14; $n=31$, $\text{age}=13.2 \pm 1.0$), under-16 years old (U-16; $n=25$, $\text{age}=15.2 \pm 0.4$) and under-18 years old (U-18; $n=30$, $\text{age}=17.7 \pm 0.5$). The comparison of II-players' outcomes respect to this curve situated

them even below U-14 players in the variable time (U-14: $2.0s \pm 0.7$; $p < 0.001$) and below U-16 players in number of correct decisions made (U-16: 17.3 ± 1.8 , $p < 0.001$).

The correlation calculated between age group categories in AB-players and the test's outcomes indicated that the time employed to perform this test ($r_s = -0.331$, $p < 0.001$) and the number of correct decisions made ($r_s = 0.269$, $p < 0.001$) are relevant for athletes' development.

These two previous studies (Chapter 4 and 5) represented II-players' limitations to perform basketball-specific cognitive activities which are determinant for basketball success as it was indicated in the literature. In both activities it was observed a significant limitation on II-players' accuracy solving each situation but especially on the time II-players required to elaborate a solution. These studies were carried out in testing conditions by isolating the cognitive processes from the executive component. According to the *Information Processing Theory* (Moreno et al., 2003) and the phases of decision making process proposed by Sánchez Bañuelos (1984) it seems that given a similar "Input" of information, II-players required more time to process this information and to elaborate a solution. Also, it seems that, despite employing more time to process the information, the "Output" elaborated is not always as accurate as the output provided by AB-players.

Figure 7. Phases of decision making in sport (Marteniuk, 1974; Sánchez Bañuelos, 1984)

As different authors highlighted, to elaborate a fast and accurate motor solution in basketball, in which environment is continuously changing (Duarte et al., 2006), it is determinant for basketball success (Garganta, 2001; Tenenbaum et al., 1993; Karalejic & Jakovljevic, 2008).

Hypothesis 4: II-basketball players decide significantly slower and less effectively in realistic basketball conditions in the field than their AB-peers (Chapter 6).

This study connects the findings found in previous studies at cognitive and competitive level and aimed to prove whether II-players, who presented significant limitations to carry out different cognitive activities, also present limitations to play different game situations in the field. In this study, a sample of elite II-players and a control group of AB-players matched by experience and training volume were asked to solve 8 different basketball game situations in the field (from 1 on 1 to 2 on 2) that were presented to the players in a standardized way. II-players spent significantly ($p < 0.05$) more time to decide ($0.92 \pm 0.2s$) than AB-players ($0.63 \pm 0.1s$) and to execute the solution (II: $3.01 \pm 0.4s$; AB: $2.56 \pm 0.3s$; $p < 0.05$). Also, II-players committed significantly ($p < 0.005$) more rule infractions (II: 7.11 ± 1.4 ; AB: 7.71 ± 0.7), more feints (II: 1.37 ± 1.4 ; AB: 0.3 ± 0.6), more dribbles (II: 15.08 ± 3.9 ; AB: 12.29 ± 2.3) and they performed less successful solutions (II: 4.42 ± 1.5 ; AB: 5.39 ± 1.3). However, no differences were found in number of correct decisions made.

This study confirmed that the limitations presented by II-players in previous studies in testing conditions (Chapter 4 and 5) are also presented in field conditions by employing

more time to initiate a motor solution. In addition, II-players also present limitation to carry out a motor solution as fast and accurate as their counterparts of AB-players. During the execution phase, player's had to use effectively the most appropriate skills to solve the situation (Jiménez, 2007) but also, according to Tenenbaum (2003), once the players started the action, they had to keep in alert about the possibilities presented during the game situation.

These studies (Chapter 3 to 6) analyzed the influence of II on basketball performance and its fundamental activities in different contexts: competition (Chapter 3), testing conditions (Chapter 4 and 4) and field testing (Chapter 6). These approaches provided a global perspective of the influence of II on basketball performance and highlighted the impact of II on players' ability to process the information provided by the game and to elaborate an appropriate solution in terms of accuracy and speed.

7.2 Methodological considerations

7.2.1 Assessment Tools Development

In Chapter 3, game-related statistics analysis was employed following a large research line developed in AB-basketball (Gómez et al., 2008; Ibáñez et al., 2009; Lorenzo et al., 2010). A straight relationship between game-relates statistics and basketball success was found in AB-basketball (Sampaio et al., 2004; Lorenzo et al., 2010) and also in II-basketball (Pinilla et al., 2016). In addition, the use of game-related statistics is extended at national and international competitions in both AB and II-competitions. Due to this, at a very beginning point of the present research line it seemed an appropriate tool that provided this research with the possibility to compare AB and II-

players' performance during competition in a standardized and validated way. As a result from this analysis it was possible to have a general overview of the differences between II and AB-players performing basketball (Chapter 3). In addition, the applicability of this tool was high and the resources needed were relatively low. However, although success can be explained by individual and team game-related statistics, they do not represent all actions that occur during the game that might also be determinant for basketball success. Due to this, other assessments to analyze how II-players perform basketball were needed.

Although several studies in AB-basketball highlighted the role of decision making or basketball comprehension on basketball performance (Araujo, 2013; Gréhaigne et al., 1995; French & Thomas, 1987), a lack of assessments tools applicable to the population under research was detected. Jiménez et al. (2009) assessed decision making of basketball players through interviews. Due to the language diversity and the possible limitations that the population under research might present, this method was not applicable in this study. Alarcón et al. (2009) developed an observation tool focused on analyzing the players' decisions related to the principle of facilitating passing the ball to a teammate. This was such a specific research question that also this tool was not applicable to address the aim of the present study. One of the most relevant contributions to the present research work is the decision making maps developed by Refoyo (2010). These maps provided validated criteria that determinate whether a decision was correct or not attending to the contextual factors (opponents and teammates situation in the field). These maps were a framework of reference to develop the field test applied in Chapter 6. In the side of cognitive assessment in basketball, it

was also found that that Karalejick & Jakovljevic (2008) related different cognitive abilities with basketball success. However, success in players was assessed through a scale elaborated by a panel of coaches who punctuated player's success regarding their sport development but not by analyzing players' performance during competition or through field tests.

Due to the lack of assessment tools in the literature applicable in basketball for the population under research, it was required to develop and to validate the basketball-specific tools employed in Chapters 4 to 6. These tools were developed by the KU Leuven and the Technical University of Madrid following the recommendations of Van Biesen (2014; p.172) to develop sport-specific assessment tools for II-athletes: tests that were for appropriate duration (1), were culturally neutral (2), had simple instructions (3) and to be suitable for this population (4). After the application of the different tools developed in this research, the following considerations are presented for future application of these tools.

7.2.1.1 General considerations related to the application of the assessment tools

- Test administrators must be adequately trained. They must guarantee that any the tests' application follow 100% the steps described in each test's protocol.
- Test administration required to be carried out in similar conditions: quiet room and comfortable position in tests from Chapters 4 and 5. In some cases there might be limitations to control all external factors such as: tiredness, noise, light, players' motivation, etc. However, these factors should be minimized as much as possible.

- Data accuracy depends on test administration but also on data collection and treatment. It is extremely relevant not to modify any data during the treatment and to make a double check when data collected is transferred to the database.

7.2.1.2 Considerations related to the test of series of photographs (Chapter 4)

- This is an innovative test applicable in both samples of II and AB-players and provides relevant information about players' capacity to recognize and order a game sequence.
- In general, it seems that difficulty increased progressively along the test. From series 1 to 4, AB-players seemed to increase their accuracy, probably as a result of a learning process. Series 5 and 6, which also contained 4 photographs each, increased in content difficulty respect to the previous series. Series 7, 8 and 9 contained 5 photographs each; however, series 8 seemed to be the most difficult of these series. Probably, it might be switched with series 9 in order to increase the difficulty progressively. Series 10, 11 and 12 contained 6 photographs each and it seems that in both samples the difficulty increased progressively.
- Some players, especially II-players, seemed to face the last series cognitively tired because the attention this test seems to require. Some athletes performed the last series fast but inaccurate, not attempting to try to put all the series in order. This fact was not controlled but also responds to a subjective perception of the test administrator. Due to this, a combined analysis of time and accuracy of each player seems ideal to assess efficacy and efficiency performing this test.

- The application of this test do not require a lot of resources in terms of material but some time or collaborators when it is applied in a large sample. Each administration takes around 20 to 30 minutes.
- Depending on the series, the game situation included in the photographs was played from the right to the left or vice versa. The order was considered correct if the tested player ordered the situation according to the natural order of the game (e.g. 1-2-3-4 or 4-3-2-1).

7.2.1.3 Considerations related to the decision making test (Chapter 5)

- This is also an innovate test applicable in both samples of II and AB-players and provides relevant information about players' decision making capacity.
- The test administration was easy and took between 5 to 10 minutes per player to be administrated. The most sophisticated material needed is a touch-screen computer.
- It gathers all data accurately in a folder; however, it is needed to modify correctly the personal data before starting the test. In case this information is not modified respect the previous player tested, at the end of the test the application will ask the test administrator to rewrite a previous document with the information of the test from another athlete or not to save the data collected during the last test made. This is determinant in order to not to lose information, but if these tests are applicable for eligibility this is even more relevant in order to not to make the athlete repeat the test immediately. It might provoke a learning effect. In case it happens this situation should be standardized in the protocol.
- Game situation number 13 requires a revision due to the diversity of answers given by the athletes.

- During the test, a yellow circle appeared to indicate where the ball is placed in the photograph. After 2 seconds this circle disappears and refreshes the screen by including the same photograph without the yellow circle. In some situations this can deconcentrate the tested player.
- Decision time was assessed as the time between the photographs appeared on the screen and the moment in which the player pressed the space bar. However, after pressing the space bar it was observed that some players still had doubts about their decision on the pictograms screen. This means that in this situation athletes were still deciding based on the information they had in their memory.

7.2.1.4 Considerations related to the decision field test (Chapter 6).

- This is also an innovative test applicable in field conditions. It is applicable in both II and AB-players to analyze the player's capacity to solve a game situation in the field.
- The test administration required more complexity and resources compared with the previous tests. At least it was needed the half part of a basketball court, electricity power, a camera, 3 athletes administering the test and a person recording the situations. Also, data collection from each player recording required around 40 minutes. Probably, developing specific observational software might optimize this process. This might be a disadvantage to apply this test during the eligibility process in II-basketball.
- Test administrators required to be adequately trained to follow the instructions properly and to play the game situation as it was described in the protocol.

- Test characteristics (basketball experience, sex or abilities) might condition the tested player's decision (e.g. if the test administrator fails several shots when he or she receives a pass).
- To validate a correct decision in each situation it was needed that the situations were clear. However, basketball is a complex sport with multiple options in which sometimes there is not only one correct option. At a first stage of the development of this test some 3on 3 situations were designed but they had to be deleted due to the lack of consistency of criteria to define a correct decision in each situation.
- Test administrators might feel the effects of tiredness or fatigue after administrating the test several times.

7.2.2 Statistical Analysis

Throughout the different studies (Chapter 3 to 6), the statistical analysis applied were oriented to compare two (II and AB-players) or different groups (II, U-14, U-16, U-18, Senior) in different situations. Parametric and non-parametric tests were applied according to data distribution or sample size. By applying these statistics it was possible to confirm that II causes limitations on fundamental basketball activities, but also it was analyzed which variables were more negatively influenced by II which of them best discriminated II and AB-players. This was possible by applying discriminant analyses (Tabachnick & Fidel, 2005). This consists on multivariate analyses that weight the influence of each variable to discriminate two independent samples. Using this statistical analysis had positive contributions on the present research. Firstly, Leave-one-out classification (Norušis, 2004) validated the calculated functions and secondly, a

function was calculated in each study that let classify athletes according to the scores obtained in each test.

This last point can potentially contribute to the development of basketball-specific eligibility systems as these systems require investigating which is the minimum impairment that causes sufficient activity limitations in basketball (Tweedy & Vanlandewijck, 2011). Through the calculated functions it was calculated a “cut point” from which it is possible to determine if the player’s outcomes in each test (Chapter 4 to 6) are similar to the reference values of AB-players, who represent those players without any limitation; or II-players, who presented significant limitations to carry out the activities assessed in each test. Some considerations that should be taken into account applying these statistics are:

- The cut point was set according to the reference values from the sample of players who participated in the present research work. Consequently, future athletes might be classified through this function but this function should be continuously under revision. If in the samples of reference they were included II or AB-athletes with extremely high or low functioning respect to their group of reference, these data might move the cutting point wrongly and might provoke erroneous classification in those athletes who score on the limit.
- Classification is about individuals instead groups (IPC, 2015). Due to this, athletes that were not classified correctly into their predicted group require to be analyzed individually.

In figure 31 it is presented an example of how the II and AB-senior players who participated in the decision making test (Chapter 5) were classified according to their test's outcomes. As it can be observed, some AB-players were classified as II-players and vice versa.

Figure 31. Example of classification by the discriminant functions (Chapter 5).

Also Cluster Analysis might be employed to classify athletes according to their test's outcomes; however, this kind of analysis does not weight the influence of each variable to discriminate II and AB-players. As an example, in Chapter 5 the time that the players employed to make the decisions in each situation was a variable that significantly discriminate II from AB-players in all situations; however, accuracy of the decision made was not as relevant in several situations. In this case, a classification system based on Cluster analysis would not have considered the relevancy of this variable.

7.3 Practical Implications

The development of the present research addressed the need to investigate the influence of II on basketball performance. Through the different studies it was determined the limitation that II causes on different fundamental basketball activities. To do this is a required step to develop evidence-based eligibility systems in II-basketball (IPC, 2015; Tweedy & Vanlandewijck, 2015). These systems are fundamental to ensure that the impact of Impairment is minimized and sporting excellence determines which team is ultimately victorious (IPC, 2015; p.3). In addition, the development of these systems is needed for all Para-sports included in the Paralympic Program; consequently, developing these systems in II-basketball might provide this sport with the opportunity to become Paralympic as it occurred in London 2012 for those II-sports that developed these systems: table-tennis, swimming and track and field (Burns, 2015). Furthermore, independently of the inclusion of this sport in the Paralympic Program, the tools developed in this study can have an immediate application on eligibility in II-basketball at international competitions, governed by INAS, or at national level, governed by the National Federations.

The application of the developed test in a large sample of II and AB-players also provided the research team the experience to optimize the test administration, by organizing schedules, teams and resources in order to work efficiently. This experience and knowledge developed can be transferred to the application of the employed assessment tools during the eligibility process.

The results obtained in this research can potentially contribute to determine the minimum disability criteria in II-basketball as it was presented previously. Also, the assessment tools developed fit with the eligibility process (figure 1) in II-basketball as part of the simulation testing (basketball specific intelligence) and game observation.

Figure 1. Visual representation of the complete ID eligibility process (Van Biesen, 2014; p.39)

This research was focused on the comparison of II and AB-players to determine the influence of II on basketball performance. However, in the 4 studies (Chapter 3 to 6) it was observed that II-players presented higher variability than AB-players in the results from each study. This indicated that the population with II is also diverse and the range of activity limitation highly varies from some players to others. Due to this, a further development of a classification system could be possible. Results from this research could also contribute to develop different classes according to the extent of activity limitation that II causes on each player.

In addition, these tools offers the scientific community new possibilities to analyze how basketball players carry out different fundamental basketball activities which are highly cognitive demanding. These tools are applicable in a large range of population, from II-players, players under development or elite basketball players. In addition, results presented by AB-players from the different age groups (Chapter 4 and 5) are innovate and can potentially contribute to the understanding of AB-basketball players' development. Results from this research might be useful as reference values from which future II and AB-players might be compared to determine their degree of cognitive development in basketball.

In the recent years, Inclusive Sport has emerged worldwide (Pérez et al., 2012) and nowadays it represents a new concept of sport in which everyone can participate independently of their functioning. Although it was not the aim of the present research, results are applicable to develop competitions based on the cognitive development in basketball or to organize inclusive competitions in which teams are composed by players with different cognitive abilities but ensuring that all teams present players from different ranges of cognitive development.

7.4 Limitations and Future Perspectives

7.4.1 Limitations

The development of the present research supposed a learning process due to that the research line is relatively recent and many steps were made for the first time. Below, is presented the main limitations presented in this research:

- The research project was developed step by step. It means that results obtained in a first step conditioned or orientated the following steps. This had a positive effect which is that all the steps were supported by previous results. However, a consequence of this is that in each study (Chapter 3 to 6) the sample of AB-players was different, especially in Chapters 3 and 6. This did not limit the possibility to address the aim of this research but it limits the possibility of analyzing the relationship between AB-players' outcomes in different tests and during competition.
- Results from the different studies represented a transversal analysis. Although both samples of II and AB-players were matched by training volume and experience, the effect of training on the abilities assessed still remains unknown. A longitudinal study might contribute to check test's resistance to players' training as it is required by the IPC Classification Code (IPC 2015; Tweedy & Vanlandewijck, 2011).

7.4.2 Future Perspectives

One of the strengths of this research is its capacity to orientate future steps in the same research line and to apply the evidences found:

- Eligibility systems in Para-sports also required systems to guarantee that athletes do not misrepresent their abilities during the eligibility process (IPC, 2015; Deuble et al., 2015). Due to this, investigating how to detect misrepresentation in the tests employed in this research seems to be an important step to carry out proximally.
- In line with Tweedy and Vanlandewijck (2011), minimum disability criteria should exclude impairments that may cause activity limitation in training but do not directly impact on activities that are fundamental for sport performance. In the population of II-players, some athletes might present learning limitations (AAIDD, 2010) that might limit them to acquire the knowledge needed to compete at high level in AB-basketball or to learn different systems of play. Due to this, probably this exception might be taken into consideration developing eligibility systems in this population.
- According to the results obtained in this study, it was observed that some AB-players had similar activity limitations as presented by II-players and vice versa. As the IPC stated, it is determinant to evaluate in the athletes aiming to participate in Para-sports the extent to which an impairment cause limitations on fundamental activities, in this case, in basketball (IPC, 2015; Tweedy & Vanlandewijck, 2011). Due to this, if it was demonstrated that some AB-players presented limitations on fundamental basketball activities, should not they be allowed to participate in II-basketball competitions? At the present moment, to participate in II-sports a primary eligibility check is made based on AAIDD's criteria for diagnosis of intellectual disability. However, are these criteria determinant for basketball performance? If this is not demonstrated, further

development of eligibility systems might base minimum disability criteria based on sport-specific tools by deleting the primary eligibility check. For example, in the case of wheelchair basketball the minimal handicap is determined directly by activity limitations on wheelchair basketball instead of a clinical or medical assessment.

- In some II-players participating in this study it was observed that they had other limitations as visual or hearing limitations that also might influence on the perceptive process that were determinant to carry out the activities assessed in each test. Future research might analyze this influence and take into account how multiple impairments might cause basketball activity limitations. According to this a question emerges that might orientate the framework of classification in Para-sports. At this moment, in a first step it is needed to determine the kind of impairment eligible and then to determine its influence on activity limitations (IPC, 2015; Tweedy & Vanlandewijck, 2011). Might future classification development focused only on activity limitations instead of the kind of impairment? In some sports and some cases, different impairments might lead to similar activity limitations and athletes might compete together with equal opportunities to success. In other cases, athletes present multiple impairments that cause a higher degree of activity limitation. With this new perspective probably these situations might receive a more personalized treatment.
- Although in the present research work the studies were analyzed separately, a holistic comprehension of the influence of II on basketball performance could be a strong contribution. To do this, it is suggested to analyze the relationship between outcomes from different tests and game performance in both II and AB-

samples. Also, to analyze the relationship of these outcomes with their cognitive profile as it was assessed by Van Biesen et al. (2016) it might contribute to identify the cognitive abilities that underlay the activities assessed in the different studies (Chapter 4 to 6).

- Following the research line started by Polo et al. (2014), analyzing coaches' opinion and experience might contribute to understand the influence of II on those II-players in which no significant limitations were observed in the present research. Probably, other determinant components of basketball performance not contemplated in the present work might be detected.
- If II-basketball were included in the Paralympic Program, it is expected that the interest to participate in II-basketball competitions increase in the future. Increasing the participation of more players might increase the level of competition in II-basketball and also the development of the players by increasing training in volume and quality. Due to this, research in this area seems necessary to evaluate continuously the influence of training and specialization on the activities assessed in the different tests. This highlights that research in this line should be alive and results from the present research might represent the starting point of this longitudinal research project.

7.5 Conclusions

These results demonstrated that II-players had significant limitations to perform basketball; consequently, II-players competing basketball against AB-players at high-level competitions might be in disadvantage. Results from the present research can contribute to determine the cutting point from which it could be considered that an athlete present significant limitations to perform basketball.

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