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THE EFFECT OF BIOLOGICAL MATURATION IN YOUNG SOCCER PLAYERS

Doctoral thesis

A dissertation presented by

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Directed by

Dr. Manuel Moya Ramón

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El Dr. Manuel Moya Ramón, profesor Contratado Doctor en la Universidad Miguel Hernández de Elche, hace constar que el trabajo de investigación titulado "THE EFFECT OF BIOLOGICAL MATURATION IN YOUNG SOCCER PLAYERS" realizado por el doctorando D. Iván Peña González, ha sido supervisado bajo su dirección y autorizado para su defensa como Tesis Doctoral en esta Universidad ante el tribunal correspondiente.

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UNIVERSIDAD MIGUEL HERNÁNDEZ DE ELCHE

Programa de Doctorado en Deporte y Salud

THE EFFECT OF BIOLOGICAL MATURATION IN YOUNG SOCCER PLAYERS

Doctoral Thesis

A dissertation presented by

Iván Peña González

Director:

Dr. Manuel Moya Ramón

A quien me enseñó que hace más quien quiere que quien puede,
a quien me enseñó a pensar antes de actuar
y a quien me hizo intentar ser un referente, sin saberlo.

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y la muleta los días cojos.

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ABBREVIATION GLOSSARY

χ^2	Chi Square
APHV	Age at Peak Height Velocity
CA	Chronological Age
CEE	Coaches' Efficacy Expectations
CFI	Confirmatory Fit Index
CG	Control Group
CI	Confidence Interval
CMJ	Countermovement Jump
EER	Efecto de la Edad Relativa
ES	Effect Size
IFI	Incremental Fit Index
PCExp	Physical Condition Expectations
PHV	Peak Height Velocity
PP	Peak Power
PPExp	Physical Performance Expectations
PVC	Pico de Velocidad de Crecimiento
Q	Birth Quartile
RA	Relative Age
RAE	Relative Age Effect

RM	Repetition Maximum
RMSEA	Root Mean Square Error of Approximation
SD	Standard Deviation
SPExp	Soccer Performance Expectations
SRMR	Standardized Root Mean Square Residual
ST	Strength Training

ABSTRACT

RESÚMEN

ABSTRACT

Youth soccer, as other areas of society, is structured in 1-year groups, looking to create fair and equal practice and competition between the participants. However, this classical system of grouping players at early ages has some negative effects when identifying and selecting a young talented player. The differences in the chronological age between players who are born in the same year (known as relative age) and more interestingly the differences in biological maturation of these players are two of the main factors, together with the coaches' expectations of their players' abilities, which are influencing the young soccer player selection and development.

Although the chronological age between players of a soccer team differs in less than one year, the biological differences between them, because of a different maturity status, may suppose an anthropometrical and physical performance advantage of those players who are advanced in their maturation process. These advantages, produced by a different maturity status, are temporal and may create a bias in the talent identification and selection process when using the grouping system which is currently being used, which based on the chronological age, is neither fair nor equal.

The aims of the present thesis were (1) to report the possible existence of a bias in the talent identification and selection process that favours the earlier born players and the relationship of this effect with anthropometrics and physical performance; (2) to assess the possible differences in anthropometrics and physical performance, as well as in the adaptations to the strength training, between players with different maturity status and (3) to report the differences in the coaches' efficacy expectations between players with different maturity status. A last aim of this thesis was to propose a theoretical model to group players within a club based on their maturity status, their physical performance and their coaches' expectations.

The major findings of the thesis included: (1) a reported bias in the soccer participation, that favours players who were born in the first months of the selection year; (2) that the maturity status of young soccer players affect their physical performance whereas the birth quartile does not discriminate the players with better performance in physical tests; (3) that coaches do not perceive the advantages in physical performance of players with advanced maturity status; (4) that players with an advanced maturity status show better results in anthropometrics and physical performance variables than less mature players and (5) that players with different maturity status have different adaptations to specific strength-training programs.

The results of this thesis indicate that the maturity status of the young soccer players must be assessed and controlled for a better talent identification and selection process, as well as for improving the long-term development programs. These findings may help coaches and soccer professionals to understand the current biases in soccer participation and in the players' selections process better, and it could be useful for the soccer clubs to group their players into more homogeneous teams, taking into account their maturity status, to create fairer and equal conditions in the youth soccer practice.

Keywords: Soccer, youth, maturity status, relative age effect, talent identification and selection process, coaches' efficacy expectations.

RESUMEN

El fútbol a edades tempranas, como otros ámbitos de la sociedad, se estructura en grupos de 1 año de edad cronológica, buscando crear una práctica y competición más justa e igualitaria entre los participantes. Sin embargo, este clásico sistema de agrupación de jugadores a edades tempranas presenta algunos efectos negativos a la hora de identificar y seleccionar a jóvenes jugadores con talento. Las diferencias en la edad cronológica entre jugadores que han nacido en un mismo año (conocido como edad relativa) así como las diferencias en la maduración biológica de estos jugadores son dos de los principales factores que, junto con las expectativas de eficacia de los entrenadores acerca de las habilidades de sus jugadores, están influyendo en la selección y el desarrollo de los jóvenes jugadores de fútbol.

A pesar de que la edad cronológica entre jugadores de un mismo equipo difiere en menos de un año, las diferencias biológicas entre ellos, debido a un estado madurativo distinto, puede suponer una ventaja antropométrica y de rendimiento físico para aquellos jugadores más avanzados en su maduración biológica. Estas ventajas producidas por un estado madurativo distinto son temporales y pueden crear un sesgo en el proceso de identificación y selección de talentos, a la vez que hace del actual sistema de agrupación de jugadores, basado en la edad cronológica, un sistema poco justo e igualitario.

Los objetivos de la presente tesis doctoral fueron (1) informar acerca de la posible existencia de un sesgo en el proceso de identificación y selección de talentos en fútbol que favorece a los jugadores nacidos en los primeros meses del año, así como de la relación de este efecto con las medidas antropométricas y de rendimiento físico; (2) evaluar las posibles diferencias en las medidas antropométricas y de rendimiento físico, así como en las adaptaciones al entrenamiento de fuerza, entre jugadores con diferente estado madurativo y (3) analizar las diferencias en las expectativas de eficacia del entrenador acerca de jugadores con distinto estado madurativo. Un último objetivo de esta tesis fue proponer un modelo teórico para agrupar a los jugadores de un club de fútbol basado en el estado madurativo y el rendimiento físico de los jugadores, así como en las expectativas de eficacia del entrenador.

Los principales hallazgos de esta tesis incluyen: (1) un sólido sesgo en la participación en fútbol que favorece a aquellos jugadores nacidos antes durante el año de selección; (2) que el estado madurativo de los jóvenes jugadores de fútbol afecta a su rendimiento físico mientras que el cuartil de nacimiento no discrimina entre aquellos jugadores con mejor o peor rendimiento en los test físicos; (3) que los entrenadores no perciben las ventajas en el rendimiento físico de los jugadores con un estado madurativo más avanzado; (4) que los jugadores con un estado madurativo más avanzado tienen mejores valores antropométricos y de rendimiento físico que los jugadores con un estado madurativo menos avanzado y (5) que los jugadores con un estado madurativo distinto tienen distintas adaptaciones para programas de entrenamiento de la fuerza concretos.

Los resultados obtenidos en esta tesis indican que el estado madurativo de los jóvenes jugadores de fútbol debe ser evaluado y controlado para un mejor proceso de identificación y selección de talentos, así como para mejorar los programas de desarrollo a largo plazo del deportista. Estos hallazgos pueden permitir que los entrenadores y profesionales del fútbol comprendan mejor los sesgos que influyen en la participación de este deporte y en el proceso de selección de jugadores, pudiendo incluso ayudar a los clubes de fútbol a crear grupos o equipos más homogéneos que tengan en cuenta el estado madurativo y que permitan una práctica del fútbol en igualdad de condiciones en fútbol a edades tempranas.

Palabras Clave: *Fútbol, edades tempranas, estado madurativo, efecto de la edad relativa, proceso de identificación y selección de talentos, expectativas de eficacia.*

GENERAL INTRODUCTION

GENERAL INTRODUCTION

In most areas of the society, as in school or sports, people are grouped by their age, creating 1-year cohorts with the aim of establishing equal conditions between the participants of the same group. Although there are some countries with different "cut-off dates", the 1st of January is the most accepted and reported cut-off date for school and sports (Yagüe, de la Rubia, Sánchez-Molina, Maroto-Izquierdo, & Molinero, 2018). However, this classical system of grouping people, especially at early ages, may imply some negative effects that can result in differences in the development process of people in a same age group. One of the classical and widely reported negative effects of this age-grouping system is the possible differences in the sports participation, learning and development, associated to the relative age between people who are born in different months of the same year (Musch & Grondin, 2001). More recently, investigations in sports field are focusing their interest on the possible differences associated to different maturity status at early ages and how these can influence the talent identification and selection process as well as the long-term athlete development (Lloyd & Oliver, 2012).

In addition to this, other factors may influence the talent identification, the players' selection and development processes in sports at early ages. In this regard, coaches and scouts of youth clubs and academies are the main responsible of selecting a young athlete for even further support, and their expectations about these athletes play a crucial role in the talent identification and selection process (Hancock, Adler, & Côté, 2013).

RELATIVE AGE EFFECT

One of the most important and reported issue in youth sports, particularly in soccer, is the relative age effect (RAE). The differences in the chronological age between the young players who are born in different months of the same year is known as relative age (RA) (Dixon, Horton, Weir, Dixon, & Horton, 2011). For example, between two players who are born in January and December respectively, the difference in their RA is of almost twelve months. The consequences that these differences in RA have between players of the same selection year refers to the RAE and it results in an overrepresentation of these players in sports (Yagüe et al., 2018).

The RAE means a bias in sport participation, making the early born players more likely to be selected for a team and for talent development programmes (Vincent & Glamser, 2006), while the late born players are more likely to drop-out of sport (Delorme, Boiche, & Raspaud, 2010). In the field of soccer, this effect has been reported in lots of leagues and categories, both nationally and internationally (Augste & Lames, 2011; Bliss & Birckley, 2012; Jiménez & Pain, 2008; Kirkendall, 2014; Mujika et al., 2009).

Although the RAE has been widely studied, there is a lack of consensus about the reasons for the higher selection of players who are born in the first months of the selection year. Some studies suggest anthropometrical and physical performance differences between players who are born in different quartiles of the year as the only explanation of this bias, but an advanced maturation (on average) of the early born players could be the reason of these differences. However, other studies reported no differences between players born in different quartiles of the year when the maturation was analysed as co-variable (Carling, Le Gall, Reilly, & Williams, 2009; Deprez et al., 2013).

Other explanations, from the psychological field, try to explain the RAE from the *self-fulfilling prophecy* (Merton, 1948). A recent theoretical model considers that the *Matthew*, the *Galatea* and the *Pygmalion* effects may take part in the selection of young players by means of the previous expectations of coaches about their players (Hancock, Adler, & Côté, 2013). In this sense, the RAE may be partially explained by a greater perception of the ability of coaches about the relatively early-born players.

BIOLOGICAL MATURATION

From the moment of birth, people experience non-lineal changes in their body dimensions and composition called growth (Hermanussen, Geiger-Benoit, Burmeister, & Sippell, 1988; Lampl, Veldhuis, & Johnson, 1992). Together with this growing process, we can also find the biological maturation process. Maturation refers to the process leading to adulthood and it takes into account those structural and functional changes in the body during the growing process. The appearance of pubic hair as well as the ossification of the cartilage are clear examples of the progressive changes in the body due to the maturation process (Radnor et al., 2018). Likewise, the maturity status makes reference to the current moment of the progress of maturation, while the maturity timing refers to the velocity of this process (Malina, Bouchard, & Bar-Or, 2004; Malina, Rogol, Cumming, Coelho E Silva, & Figueiredo, 2015; Malina et al., 2004). Inter-individual differences exist for the status and timing of biological maturation and children may be categorised as “early-matures”, if their biological maturation is ahead of their chronological age, “average-matures”, if their maturation coincides with their chronological age, or “late-matures”, if their maturation is behind their chronological age (Lloyd, Oliver, Faigenbaum, Myer, & De Ste Croix, 2014). These variations in the biological maturation between children with the same chronological age may contribute to anthropometrical and physical performance differences between them, which is relevant in the field of sport.

Given the reported importance of the maturity assessment in sport, a regular assessment of the maturity status of the young soccer players in order to take into account the effect of the training and/or the biological maturation in the physical performance is recommended (Lloyd et al., 2014). The development of an appropriate training stimulus, the optimization of the training adaptations and the reduction of the risk injury are the main reasons for controlling the maturity status of the players (Lloyd & Oliver, 2012; Lloyd et al., 2015).

Traditionally, the skeletal age assessment, which examines the ossification development of the cartilage, has been the best maturational index. However, this evaluation is costly, requires trained radiographers or qualified medical personal, and needs expensive and specific equipment (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002). The assessment of the dental age or the morphological age shows similar limitations of applicability in the sports field. Another usual way to assess the maturity status of children has been the sexual age evaluation as for example with the “Tanner criteria”. This method takes the sexual maturation into account via observations of secondary sexual characteristics as pubic hair, or enlarged breasts or widened hips in females (Brooks-Gunn & Warren, 1988). Nevertheless, the evaluation of the sexual maturation out of the medical field may be considered intrusive for adolescents and parents. Somatic age assessment seems to be the most applicable method to evaluate the maturity status of the adolescents as it is easy, inexpensive and non-intrusive.

In the sports field, the most commonly used maturity status indicator is the assessment of the years from/to the peak height velocity (PHV). The PHV provides us with an accurate landmark of the young athletes’ maturation and it refers to the maximum velocity of growing in height during adolescence, as well as other body dimension velocities (Mirwald et al., 2002; Sherar, Mirwald, Baxter-Jones, & Thomis, 2005) (Figure 1). The equation 3 proposed by Mirwald et al., (2002) to calculate the “maturity offset” gives us the years “from” or “to” the individual PHV (which is on average at 12 years in girls and at 14 years in boys), providing a global view of the individual maturity-related differences between children. For this evaluation it is necessary to know the age, weight, height, sitting height and the leg length of the adolescent (Mirwald et al., 2002; Sherar et al., 2005). One of the limitations of this measurement is that the growth and maturation processes in young people is non-lineal, thus a regular evaluation is necessary. In addition to this, the somatic maturity assessment by the PHV is mainly accurate for average-mature boys from 12 to 16 years old (Malina & Kozieł, 2014).

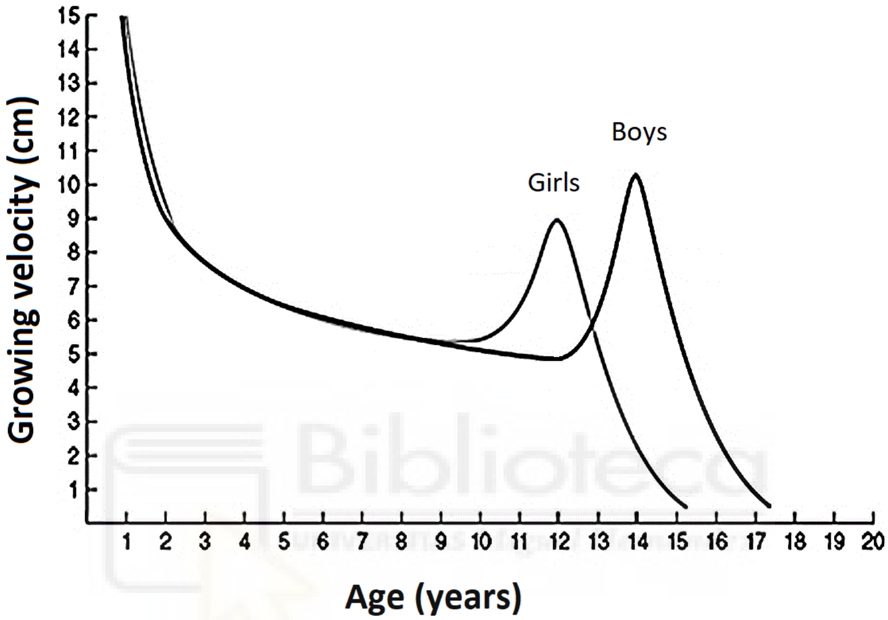

Figure 1. Peak height velocity for girls and boys (rewritten from Tanner et al., 1966).

TALENT IDENTIFICATION AND TRAINING PROGRAMS

Soccer clubs, scouts and coaches try to identify players, at early ages, with the potential of succeeding in the future, with the aim of ensuring that they receive specialised coaching and training to accelerate their development process (Gil et al., 2014; Williams & Reilly, 2000). However, the reality is that nowadays talent identification process is unstructured, poorly defined and lacks consensus (Vaeyens, Lenoir, Williams, & Philippaerts, 2008). The fact is that identifying a young player as talented is complex as in soccer, the later success depends on many internal (i.e.

psychological, physiological, etc.) and external factors (i.e. coaching, injuries, culture, etc.) (Reilly, Williams, Nevill, & Franks, 2000).

Anthropometrical and physical performance attributes were traditionally the main factors that coaches and scouts took into account when selecting a player (Carling et al., 2009). Nevertheless, as we saw in the previous section, the maturity status of players may suppose inter-individual differences in anthropometrics and physical performance that are temporal and which do not determine their later performance (Beunen & Malina, 2008). For this reason, assessing the anthropometrical and physical performance of young players without taking into account their maturity status is only useful to identify the players with high performance levels, but it excludes those players with later maturation (Unnithan, White, Georgiou, Iga, & Drust, 2012).

In soccer, the typical actions that determine the performance in the match are mainly related with strength and velocity (i.e. sprinting, jumping, kicking, and changing of direction, among others). In addition, the performance in this kind of strength and velocity tasks are strongly related to the maturity status of the player, as the muscle structure and neuromuscular factors change during the maturation process (Radnor et al., 2018). A temporal advantage in strength and velocity performance in early maturing players, which is related to their advanced maturity status, may be confused as physical talent by coaches. The problem is that when the young soccer players are grouped by their chronological age, the maturity status may be different between the members of the group, and a same practice may not suppose the same training stimulus for all the players. In this regard, the training adaptations will be different for the players with different maturity status (Meylan, Cronin, Oliver, Hopkins, & Contreras, 2014; Radnor, Lloyd, & Oliver, 2017). In a certain way, grouping players by their chronological age may mean a disadvantage in the talent identification and selection process.

COACHES' EFFICACY EXPECTATIONS

Technical and tactical skills are gaining importance in the current talent identification process, but the technical and tactical assessment is carried out by the subjective evaluation of the players by the scouts or coaches. Coaches and scouts try to detect the players with the technical and tactical skills, or even with the psychological skills, to succeed in soccer, and they take their decisions relying on their "eye" or their expert knowledge of the sport. In this regard, the expectations of the coaches on their players' abilities take on prominence in the talent identification and selection processes.

Since in the current talent identification and selection process the ultimate decision to belong to a team is taken by coaches and scouts, it is necessary to know their perceptions and expectations about their players. From the psychological field, there are theories and models that try to help us explain some of those issues that arise in the players' selection process.

The *Self-fulfilling Prophecy* described by Merton in 1948 (based on the Thomas theorem in 1928) is summarised in a simple sentence: "If men define situations as real, they are real in their consequences" (Merton, 1948). Within this paradigm, we can find two sources supporting the Self-fulfilling Prophecy: The *Pygmailion* effect and the *Galatea* effect (Hancock, Adler, et al., 2013). The first one, the Pygmalion effect, refers to the perception that the greater the expectation placed on an individual, the greater the result that individual will attain. In the sport field, it is usually placed in coach-athlete relationship. This effect may explain coach selections in a team, favouring those players in whom coaches placed their best expectations (Hancock, Adler, et al., 2013). On the other hand, the Galatea effect relates to the own athletes' expectations about himself, coming from those better expectations of his coach (Hancock, Adler, et al., 2013). In this regard, both the coach and the player will act, and consequently, their behaviour will be directed at fulfilling the expectations of the coach, placed on the player.

Regarding the perceptions of coaches about their players' skills, the Coaches' Efficacy Expectations have been previously defined as the trainer's confidence in the player's abilities to perform given tasks and in each player's capacities and skills regarding the playing requirements (Leo, Sánchez-Miguel, & Sánchez-Oliva, 2013). These coaches' expectations of their players are important for our better knowledge about the decisions of coaches when selecting a player for a team. The subjective evaluation of coaches about their players' abilities may be a good tool if it is integrated in a multivariate approach to the selection process (Reilly et al., 2000). However, as a single variable to take a decision in the players' selection process, the coaches' expectations may increase and stabilize the RAE (Hancock, Adler, et al., 2013) and even affect the coaches' behaviours to be consistent with the initial perception of players' abilities (Fernley, 2012; Musch & Grondin, 2001).

AIMS AND HYPOTHESES OF THE THESIS

OBJETIVOS E HIPÓTESIS DE LA TESIS

AIMS AND HYPOTHESES OF THE THESIS

One of the most important wishes of this thesis was to work with and for the youth soccer clubs, trying to *bring science closer to the pitch* and making the research field interesting for the youth soccer professionals.

In this regard, youth soccer clubs make an effort in trying to detect the young players with the enough potential to achieve a high level of performance in the future to ensure that they receive specialized and individualized training and trying to reduce the dropouts in their teams. The social aim of this thesis was to collaborate in the talent identification and selection process of some youth soccer clubs, evaluating their players and reporting the results obtained in the investigations, teaching their coaches about new methodologies with young soccer players and advising the coaches and clubs when necessary.

To our knowledge, the relative age effect, the maturation-related differences between young players and the coaches' efficacy expectations about their players are some features that influence the talent identification and selection process in soccer. Thus, the main objective of the present thesis was to assess those variables that may bias the young players' selection process, highlighting the biological maturation and its relationship with the physical performance of the young soccer players from U12 to U16 categories.

An ultimate aim of this thesis was to propose a novel system to help soccer professionals decide the best group or team to practice for players from U12 to U16. With this theoretical tool, coaches could give advice to the better aggrupation of their players within the club depending on the players' maturity status, their physical performance level and their technical and tactical abilities perceived by their coaches.

The specific aims of this thesis were:

- To report the possible existence of RAE in the youth soccer clubs and academies of the city of Elche.
- To analyse the effect of the birth quartile and the maturation in anthropometric and physical performance variables.
- To assess the possible anthropometrical and physical performance differences for players with different maturity status.
- To design a strength-training programme destined to the improvements in strength and speed of young soccer players who are prior to their PHV.
- To report the possible different adaptations to a strength-training program related to the maturity status.
- To analyse the coaches' efficacy expectations and the relationship of these expectations with RAE and maturation.
- To analyse the coaches' efficacy expectations for players with different maturity status.
- To present a novel aggrupation approach, consisting of advising the correct training aggrupation of the young soccer players within a club.

To achieve the aims of the thesis, three studies were carried out:

1. Relative age effect, biological maturation and coaches' efficacy expectations in young male soccer players.
2. Soccer coaches do not perceive the physical advantage of maturity-advanced players.

3. Effect of biological maturation on strength-related adaptations in young soccer players.

In addition to the three studies, a new future researching line was proposed and detailed as:

4. Young soccer players' aggrupation by their maturity status, physical performance and the expectations of their coaches: A first approach.

In the first study, the birth distribution of players in each studied category was described, and the effect of the birth quartile and the biological maturation in anthropometrics, physical performance and coaches' efficacy expectations were examined. The second study showed the anthropometrical and physical performance differences between players with different maturity status, as well as the coaches' efficacy expectations for the different maturity groups. The third study showed the adaptations of players with different maturity status to a strength-training program. The new proposal for young soccer players' aggrupation is presented as a future research line with the aim of introducing the combination of these variables as the main features to take into account when selecting a player for a team, improving the talent identification and players' selection and development processes.

The hypotheses of these studies and, consequently, of this thesis were:

- Players born in the first quartiles of the year will be overrepresented in the sample. So an unbalanced distribution of players born in different quartiles of the year is expected, favouring those players born earlier.
- The effect of the birth quartile in anthropometrics and physical performance will be smaller than the effect of maturation.
- Players with an advanced maturity status will obtain better results for anthropometrics and physical performance than the other maturity groups.

- Players who are before their PHV will improve their strength and speed values more than the other maturity groups after a specific strength-training programme.
- Coaches' efficacy expectations will be greater for early-born player as well as for maturity-advanced players.
- The new proposed tool for the young soccer players' aggrupation will create more homogeneous groups, giving all players the same opportunities to succeed and improving the talent identification, selection and development processes in soccer.

OBJETIVOS E HIPÓTESIS DE LA TESIS

Uno de los deseos más importantes de esta tesis fue investigar por y para los clubes de fútbol base, tratando de *acercar la ciencia al campo* y haciendo que el ámbito científico pudiera ser interesante para los profesionales del fútbol base.

En lo que respecta al fútbol base, los clubes centran sus esfuerzos en detectar aquellos jugadores jóvenes con el potencial para tener éxito en el futuro para asegurarse de que reciben un entrenamiento individualizado, así como en tratar de reducir el número de abandonos deportivos en sus equipos. El objetivo social de esta tesis fue colaborar con algunos de estos clubes de fútbol base en el proceso de identificación y selección de talentos, evaluando a sus jugadores y aportándoles los resultados obtenidos en las investigaciones, tratando de enseñar nuevas metodologías a sus entrenadores acerca del entrenamiento con jugadores a edades tempranas y aconsejando a entrenadores y clubes cuando fuera necesario.

Hasta donde sabemos, el efecto de la edad relativa (EER), las diferencias relacionadas con la maduración entre jugadores jóvenes y las expectativas de eficacia del entrenador hacia sus jugadores son algunas de las variables que influyen en el proceso de identificación y selección de talentos en fútbol. Por tanto, el objetivo principal de la presente tesis fue evaluar esas variables que pueden sesgar el proceso de selección de jugadores a edades tempranas, haciendo hincapié en la maduración biológica y en su relación con el rendimiento físico de los jóvenes jugadores de fútbol en categorías Sub 12 hasta Sub 16.

Un último objetivo de esta tesis fue proponer un sistema novedoso que ayude a los profesionales del fútbol base a decidir el mejor grupo o equipo en el cual incluir a un jugador desde Sub 12 hasta Sub 16. Mediante esta herramienta los entrenadores tendrían una mejor visión sobre cómo distribuir a sus jugadores dentro del club en función de su estado madurativo, su rendimiento físico y de las expectativas de eficacia del entrenador hacia ellos.

Los objetivos específicos de esta tesis fueron:

- Informar acerca de la posible existencia del EER en los clubes de fútbol base de la ciudad de Elche.

- Analizar el efecto del cuartil de nacimiento y de la maduración en las medidas antropométricas y el rendimiento físico.

- Evaluar las posibles diferencias en medidas antropométricas y en el rendimiento físico asociadas a un estado madurativo distinto.

- Diseñar un programa de entrenamiento de la fuerza destinado a la mejora de la fuerza y la velocidad de jóvenes jugadores de fútbol con un estado madurativo previo a su pico de velocidad de crecimiento (PVC).

- Reportar las posibles diferencias en las adaptaciones a un programa de entrenamiento de la fuerza relacionadas con el estado madurativo.

- Analizar las expectativas de eficacia del entrenador hacia sus jugadores y su relación con el EER y la maduración.

- Analizar las posibles diferencias en las expectativas de eficacia del entrenador entre jugadores con distinto estado madurativo.

- Presentar una novedosa propuesta de agrupación, que consista en aconsejar acerca de la correcta agrupación de los jóvenes jugadores de fútbol dentro de un club.

Para conseguir alcanzar los objetivos de esta tesis, se llevaron a cabo tres estudios:

1. Relative age effect, biological maturation and coaches' efficacy expectations in young male soccer players.
2. Soccer coaches do not perceive the physical advantage of maturity-advanced players.
3. Effect of biological maturation on strength-related adaptations in young soccer players.

Además de los tres estudios, se propuso y se detalló una nueva línea de investigación para desarrollar en el futuro:

4. Young soccer players' aggrupation by their maturity status, physical performance and the expectations of their coaches: A first approach.

En el primer estudio, se describió la distribución de jugadores nacidos en cada cuartil del año para cada categoría estudiada, y se examinó el efecto del cuartil de nacimiento y de la maduración biológica en las medidas antropométricas, el rendimiento físico y las expectativas de eficacia del entrenador. El segundo estudio mostró las diferencias antropométricas y de rendimiento físico entre jugadores con distinto estado madurativo, así como las diferencias en las expectativas de eficacia del entrenador entre grupos madurativos. El tercer estudio mostró las adaptaciones de jugadores con distinto estado madurativo para un programa de entrenamiento de la fuerza.

La nueva propuesta de agrupación de jóvenes jugadores de fútbol se presenta como una futura línea de investigación con el objetivo de introducir la combinación de las variables previamente tratadas como las características principales a tener en cuenta a la hora de seleccionar jugadores, mejorando los procesos de identificación y selección de talentos, así como de los programas de desarrollo a largo plazo.

Las hipótesis de estos estudios y, consecuentemente, de esta tesis fueron:

- Los jugadores nacidos en los primeros cuartiles del año estarán representados en mayor medida en la muestra de estudio, de tal manera que se espera una distribución desequilibrada de jugadores nacidos en los distintos cuartiles del año que favorezca a lo nacidos en los primeros meses.

- El efecto del cuartil de nacimiento en las medidas antropométricas y de rendimiento físico será menor que el efecto del estado madurativo sobre estas mismas variables.

- Los jugadores con un estado madurativo avanzado obtendrán mayores resultados para las medidas antropométricas y de rendimiento físico que los demás grupos madurativos.

- Los jugadores con un estado madurativo previo a su PVC mejorarán en mayor medida sus valores de fuerza y velocidad que los grupos madurativos después de un programa de entrenamiento de fuerza específico.

- Las expectativas de eficacia del entrenador serán mayores para los jugadores nacidos en los primeros meses del año, así como para los jugadores con un estado madurativo más avanzado.

- La nueva herramienta propuesta para la agrupación de los jóvenes jugadores de fútbol creará grupos más homogéneos, permitiendo las mismas oportunidades de tener éxito a todos los jugadores y mejorando los procesos de identificación, selección y desarrollo de talentos en fútbol.

STUDY 1

Relative Age Effect, Biological Maturation and Coaches' Efficacy Expectations in Young Male Soccer Players

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STUDY 1

ABSTRACT

Purpose: The talent identification and selection process in young male soccer players is mainly focused on anthropometrics and physical performance, but social factors are also considered in this process. The purpose of this study was to test the existence of the relative age effect and its possible influence on anthropometrics and physical performance and to analyze coaches' efficacy expectations. ***Method:*** Data for 564 young male soccer players (M_{age} = 13.7 ± 1.5 years; M_{weight} = 53.7 ± 11.6 kg; M_{height} = 160.2 ± 11.6 cm) included their birth quartile, maturity status, anthropometrics, a physical test battery, and coaches' efficacy expectations. ***Results:*** Early-born players were overrepresented ($p < .05$). Early-born players were not statistically taller, heavier, or better at physical performance ($p > .05$) when maturation and chronological age were controlled as confounding factors. However, coaches expected more from early-born players ($p < .05$), and the inferential analysis showed likely to very likely worthwhile differences between the coaches' expectations for players born in the first quartile of the year and those born in the fourth quartile of the year. ***Conclusions:*** Anthropometrical and physical performance variables were not affected by birth quartile, and coaches' efficacy expectations were related to the relative age effect.

Keywords: Talent identification, physical performance, peak height velocity.

INTRODUCTION

In soccer, clubs try to identify players who will potentially succeed at an early age to ensure they receive specialized coaching and training to accelerate the development process (Gil et al., 2014; Williams & Reilly, 2000). Traditionally, clubs have paid attention to anthropometric characteristics and physical performance as predictors of future success in soccer (Carling et al., 2009). Furthermore, other factors such as birth month or maturation timing can influence the selection of players at early ages in soccer due to the belief that early-born players perform better or have a temporary physical advantage (Figueiredo, Coelho E Silva, Cumming, & Malina, 2010; Hancock, Adler, et al., 2013; Leo et al., 2013).

Soccer is generally structured according to chronological ages (CAs) in groups based on specific cutoff dates with the intention of creating "fair" competitive levels. Athletes who were born in the first months of their age groups are overrepresented in sports and in soccer specifically. This effect is known as the relative age effect (RAE), and those players born in the first months of their age groups are more likely to be selected for elite teams and for talent development programs than are those born later in the year (Augste & Lames, 2011; Bliss & Birckley, 2012; Jiménez & Pain, 2008; Kirkendall, 2014; Mujika et al., 2009). However, previous research has shown that caution is necessary when estimating physical performance differences between players born in different months of the year because of the diverse results obtained when comparing the outputs in physical tests between early-born and late-born players (Carling et al., 2009; Deprez et al., 2013). Similarly, data have shown physical performance differences between players with different biological maturity and have favored the early maturers (Cripps, Hopper, & Joyce, 2016; Vandendriessche et al., 2012), making them eligible for even greater support (Malina et al., 2000).

In recent years, there has been an increasing interest in how relative age and maturity status influence the identification and selection process, but selecting a player is ultimately dependent on the staff (i.e., coaches or scouts) who decides which players stay on the team at the beginning and during the season and which players play every week. Coaches' selection decisions are related to RAE, and it has been shown that the greater the process to select the players of a team, the greater the RAE (Hancock, Ste-Marie, & Young, 2013). For this reason, factors other than better physical performance by early-born players can affect the occurrence of RAE—for example, coaches' expectations about their players. A recent theoretical model (Hancock, Adler, et al., 2013) that considers the Matthew, Galatea, and Pygmalion effects (expectation from others aligns with the outcome) has explained how coaches' expectations can result in RAE and affect the present and future behavior of coaches. The Pygmalion effect may amplify and confirm this relative age advantage if coaches' behaviors are consistent with the initial perception of children's abilities (Fernley, 2012; Jochen Musch & Grondin, 2001). In this regard, coaches' efficacy expectations (CEE) reflect a trainer's confidence in a player's abilities to perform given tasks and in each player's capacities and skills regarding playing requirements (Leo et al., 2013).

The aims of this study were to (a) test the existence of RAE in young male soccer players and the possible influence of this phenomenon on the anthropometrics and physical performance measures taking into account the maturity status of players, and (b) analyze CEE and the relationship between these expectations and the RAE and maturity status.

METHODS

Participants

Five hundred sixty-four young soccer players (M_{age} = 13.7 ± 1.5 years; M_{weight} = 53.7 ± 11.6 kg; M_{height} = 160.2 ± 11.6 cm) from Spain were evaluated during 2015 and 2016. Four voluntary-based soccer clubs with different levels of competition (national, regional, and local levels) were measured. The measurements were always conducted in the same competitive period (in February), and no player was represented on more than one level. The sample included a range of categories from U12 to U16 (U12, players born in 2003–2004, *n* = 149; U14, players born in 2001–2002, *n* = 188; and U16, players born in 1999–2000, *n* = 227). Players were evaluated using a battery of standard anthropometric and physical performance tests, and CEE were measured using a tailor-made questionnaire based on the recommendation of Bandura (2006). For the purposes of the present study, players were grouped by CA in a 1-year cohort (January 1–December 31). The participants assented to participate in the study, and written informed consent was obtained from their parents/guardians. The study was approved by an ethics committee (DPS.EC.01.17) and conformed to the recommendations of the Declaration of Helsinki.

Test Procedures

All testing was completed during 17:00 h to 21:00 h, and all tests were carried out in the same place, in the same order, and using the same testing devices and operators. Anthropometric measurements were performed before the physical performance test in the laboratory, and testing conditions were standardized (20 ± 1ºC). Body height and sitting height were measured with a fixed stadiometer (± 0.1 cm; SECA LTD, Hamburg, Germany). Leg length was obtained from Body Height

– Sitting Height, and body mass was measured with a digital scale (± 0.1 kg; Oregon Scientific® GA101/GR101, Oregon Scientific, Inc., Brea, CA, USA).

Physical tests were performed on an outdoor synthetic grass soccer pitch. Testing began after a 10-min standard warm-up. Participants were verbally encouraged throughout the tests and were asked to perform at their maximal effort. The test battery was composed of two repetitions of the CMJ test without arm swing (Bosco, Luhtanen, & Komi, 1983), the 30-m dash in a straight line, an agility T-test (Semenick, 1990), and one repetition of the Yo-YoIR1 test (Bangsbo, Iaia, & Krustrup, 2008).

Chronological Age and Maturity Status

Players were divided into four quartiles (from Quartile 1 to Quartile 4) according to their birth month. Estimation of maturity status was calculated by the maturity-offset measure (Equation 3 of Mirwald, Baxter-Jones, Bailey, & Beunen, 2002), which is a non-invasive and inexpensive method based on anthropometric variables. This measurement predicts the years from/to peak height velocity (PHV) and provides an accurate benchmark of maximum growth during adolescence (Mirwald et al., 2002; Sherar et al., 2005) It is mainly accurate for boys aged 12 years to 16 years old who are average in maturation (Malina & Kozieł, 2014). Age at PHV (APHV) was calculated as *Chronological Age (CA) – Predicted Years From/to PHV*, and the result is an indicator of biological maturity representing the time of maximum growth during adolescence.

Coaches' Efficacy Expectations

To assess coaches' efficacy perception, a tailor-made questionnaire based on the recommendation of Bandura (2006) was used. Coaches were asked their degree of confidence in their players' ability to achieve the best result in each physical test and in their players' soccer-playing ability (Bandura, 2006). Coaches scored each question using a Likert scale ranging from 1 (“no confidence”) to 5 (“maximum confidence”).

To analyze the CEE relationship between the different physical performance tests and find a unique factor to explain the “*physical performance expectations*” (PPExp), this questionnaire was validated in previous work (Peña-González, Fernandez-Fernandez, Moya-Ramón, & Cervelló, 2017) using an exploratory factor analysis. The solution showed the CEE factor of PPExp. The eigenvalue was 2.90, and the explained variance of the PPExp factor was 72.65%. The Cronbach’s alpha for the four variables was .87, showing good internal reliability.

To confirm this structure, in the present study, a one-factor confirmatory factor analysis was performed, and it showed an adequate fit ($\chi2 = 0.98$, $p > .05$; $\chi2/df = 0.49$; Comparative Fit Index = 1.00, Incremental Fit Index = 1.00, root mean square error of approximation = .01, standardized root mean square residual = .01).

Statistical Analyses

A chi-square test was used to test the statistical difference between the observed and expected birth distribution with the percentage of births in each quartile in Spain in 2015 being used as the expected distribution (Instituto Nacional de Estadística, 2015).

A one-way analysis of variance with a Bonferroni post-hoc test was used to compare all anthropometrical, physical performance, and expectations variables across birth quartiles, and a multivariate analysis of covariance (MANCOVA) was carried out for each age category using birth quartile as the main factor and APHV and CA as covariables. The anthropometrical variables and the physical performance test were used as dependent variables. Another MANCOVA without separate age categories was performed with the same factor and covariables but using the CEE as a dependent variable.

A contemporary method described by Hopkins was used to calculate the probability that a difference between groups was clinically beneficial, trivial, or harmful according to the confidence limits (Hopkins, Marshall, Batterham, & Hanin, 2009). The smallest worthwhile difference in means in standardized (Cohen's *d*) units was set at 0.2, representing the hypothetical smallest difference between Q1 and Q4. This data analysis provides a qualitative descriptor according to the chances of benefit (Hopkins et al., 2009).

All calculations were performed using Microsoft Excel (Microsoft, Seattle, WA) and SPSS Statistics® (Statistical Package for the Social Sciences, Version 17.0, IBM Corp., Armonk, NY, USA), and the level of significance was set at $p < .05$.

RESULTS

Birth Date Distribution

The distribution of birth dates in the analysed soccer players and the distribution of births in Spain are shown in Table 1. Results showed a skewed distribution toward Q1 in both the total sample and each age group compared with Quartile 2 (Q2), Quartile 3 (Q3), and Q4. Regarding births in Spain, there was a balanced distribution.

Table 1. Birth quartile distribution across U12, U14 and U16 age categories.

	Q1 (%)	**Q2 (%)**	**Q3 (%)**	**Q4 (%)**	**Total Number**	**χ^2 (Q1-Q4)**	
U12	59*#$ *(39.6)*	34$ *(22.8)*	34$ *(22.8)*	227 *(14.8)*	149	174.02	*p*<.05
U14	71*#$ *(37.8)*	45$ *(23.9)*	45$ *(23.9)*	27 *(14.4)*	188	152.01	*p*<.05
U16	86*#$ *(37.9)*	58 *(25.6)*	40 *(17.6)*	43 *(18.9)*	227	113.52	*p*<.05
Total Sample	216*#$ *(38.3)*	137$ *(24.3)*	119$ *(21.1)*	92 *(16.3)*	564	139.69	*p*<.05
Total births in Spain (2015)	102.026 *(24.3)*	102.884 *(24.5)*	108.593 *(25.8)*	106.787 *(25.4)*	420.290		

* Statistically different from Q2; # Statistically different from Q3; $ Statistically different from Q4

Anthropometric and Physical Performance Tests

The MANCOVA demonstrated that the APHV and CA, as co-variables, were significantly confounding the anthropometrical and physical performance variables along the different age categories (CA, F = 21.17–27.35, $p < .05$; APHV, F = 58.64–95.67, $p < .05$). Nevertheless, the MANCOVA did not show significant differences between the birth quartiles for the anthropometrical variables and the physical performance test when APHV and CA were controlled as confounding factors. Table 2 shows the specific anthropometrical and physical performance variables in which APHV and CA were significant confounding factors and those variables that were significantly different according to the quartile with APHV and CA as co-variables. The post-hoc differences between birth quartiles are also shown in Table 2.

Coaches' Efficacy Expectations

The CEE were significantly different according to quartile when APHV and CA were set as co-variables (F = 2.40, $p < .05$). The APHV was a significant confounder factor (F = 4.53, $p < .05$) but the CA (F = 1.13, $p > .05$) was not. Table 3 shows the specific CEE in which APHV and CA were significant confounding factors and those expectations, which were significantly different according to the quartile with APHV and CA as co-variables.

Figure 1 includes the practical/clinical differences, which are expressed in standardized (Cohen's *d*) units, between the CEE from Q1 and Q4. All the coaches' expectations for Q1 about the physical test and about the ability to play soccer were likely or very likely different from their expectations for Q4.

Table 2. Anthropometric and Physical Performance Variables of U12, U14 and U16 soccer players across the four Birth Quartiles (Q1, Q2, Q3 and Q4).

Variable	Q1	Q2	Q3	Q4	ES (Q1-Q4)	Covariates F(CA)	Covariates F(APHV)	F(Q)
U12								
Height (cm)	151.2 ± 7.9	148.3 ± 9.6	147.8 ± 7.4	146.3 ± 7.5	0.63	73.84 *	273.35 *	0.56
Weight (kg)	45.8 ± 8.6	44.1 ± 9.3	41.7 ± 6.9	43.3 ± 6.5	0.31	83.36 *	251.63 *	0.97
CMJ (cm)	29.3 ± 4.3	29.2 ± 4.3	28.3 ± 4.1	25.7 ± 5.3	0.78	0.01	2.54	2.69 *
30-m (s)	5.05 ± 0.28$^{\$}$	5.13 ± 0.29	5.23 ± 0.30	5.31 ± 0.45	0.78	14.94 *	8.02 *	0.41
T-test (s)	9.82 ± 0.56	9.93 ± 0.57	9.94 ± 0.60	10.29 ± 0.70	0.78	3.70	2.07	0.83
Yo-Yo IR1 (m)	812.3 ± 320.1	796.9 ± 333.1	747.7 ± 310.8	755.6 ± 405.1	0.16	1.44	2.90	0.22
U14								
Height (cm)	158.6 ± 9.3	160.1 ± 8.2	157.8 ± 8.8	155.73 ± 7.1	0.33	71.99 *	252.73 *	0.39
Weight (kg)	51.2 ± 8.7	52.9 ± 10.5	50.6 ± 10.6	48.7 ± 8.8	0.28	76.83 *	387.34 *	0.59
CMJ (cm)	30.6 ± 5.5$^{\$}$	30.6 ± 5.3$^{\$}$	29.8 ± 5.3	27.3 ± 4.5	0.63	6.81 *	0.82	1.34
30-m (s)	4.81 ± 0.28$^{\$}$	4.81 ± 0.30$^{\$}$	4.87 ± 0.31	5.05 ± 0.38	0.77	32.45 *	20.86 *	1.61
T-test (s)	9.44 ± 0.51$^{\$}$	9.46 ± 0.59$^{\$}$	9.59 ± 0.51	9.96 ± 0.71	0.90	12.23 *	0.01	2.94 *
Yo-Yo IR1 (m)	949.1 ± 346.7	947.9 ± 400.4	845.7 ± 294.9	796.9 ± 341.5	0.44	0.01	0.76	1.76
U16								
Height (cm)	171.8 ± 6.8	169.6 ± 7.1	166.8 ± 10.6	165.9 ± 7.4	0.85	48.08 *	180.28 *	0.74
Weight (kg)	64.6 ± 7.9$^{\#\$}$	62.8 ± 8.1	59.6 ± 9.2	58.8 ± 9.1	0.69	48.89 *	186.41 *	0.24
CMJ (cm)	35.9 ± 5.0	34.8 ± 5.5	34.4 ± 5.5	33.7 ± 4.7	0.44	31.38 *	6.81 *	0.38
30-m (s)	4.46 ± 0.21$^{\#\$}$	4.48 ± 0.24$^{\$}$	4.62 ± 0.28	4.65 ± 0.26	0.83	46.87 *	43.05 *	0.68
T-test (s)	8.80 ± 0.48$^{\$}$	8.87 ± 0.40	8.99 ± 0.56	9.10 ± 0.48	0.62	34.42 *	5.94 *	0.01
Yo-Yo IR1 (m)	1396.7 ± 634.8$^{\$}$	1350.9 ± 673.5	1101.8 ± 476.4	987.1 ± 497.6	0.68	11.64 *	0.30	1.05

ES: Effect Size; CA: Chronological age; APHV: Age at peak height velocity; $^{\#}$ Statistically different from Q3; $^{\$}$ Statistically different from Q4. *p < .05;

Table 3. Coaches' Efficacy Expectations about their players across the four Birth Quartiles (Q1, Q2, Q3 and Q4).

Coaches' efficacy expectations	Q1	Q2	Q3	Q4	ES (Q1- Q4)	Co-variates		F(Q)
						F(CA)	F(APHV)	
CMJ	3.75 ± 0.83#$	3.48 ± 0.85	3.40 ± 0.94	3.23 ± 1.05	0.58	0.24	12.73 *	7.01 *
30-m	3.82 ± 0.89$	3.51 ± 0.89	3.60 ± 0.91	3.33 ± 1.01	0.53	1.60	0.56	5.70 *
T-test	3.76 ± 0.88$	3.56 ± 0.87	3.70 ± 0.89	3.39 ± 1.00	0.40	0.27	0.16	3.11 *
Yo-Yo IR1	3.67 ± 0.96	3.57 ± 0.89	3.64 ± 1.00	3.33 ± 0.98	0.35	0.01	0.03	1.93
SP	3.92 ± 0.80$	3.68 ± 0.86	3.83 ± 0.96	3.48 ± 1.17	0.47	0.50	1.48	3.69 *
PP	3.75 ± 0.76	3.53 ± 0.75	3.59 ± 0.83	3.32 ± 0.92	0.53	0.37	1.59	5.00 *

CA: Chronological age; APHV: Age at peak height velocity; #Different from Q3; $Different from Q4.
* $p < .05$;

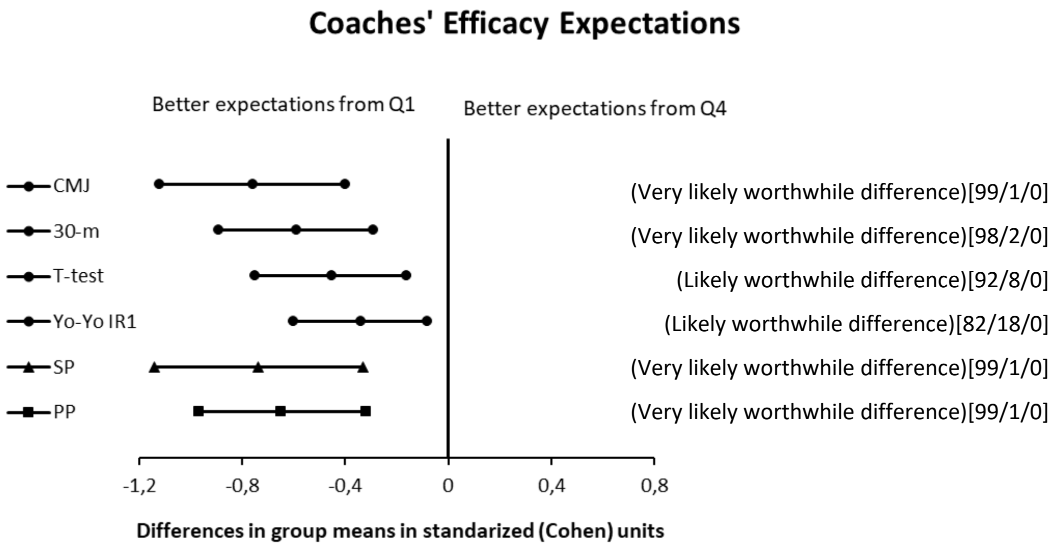

Figure 2. Coaches' efficacy expectation comparisons of early-born (Q1) and late-born (Q4) players.

DISCUSSION

The main results in this study suggest that RAE is a multifactorial effect and that a physical performance advantage due to month of birth and maturity status are not the only variables producing this effect. These findings lead one to question whether early-born players have a clear advantage and introduce coaches' expectations as another factor that is related to RAE.

An unbalanced distribution was reported among players born in Q1, Q2, Q3, and Q4 and favored those players born earlier in the selection year. These results are consistent with previous research analyzing RAE in Spain (Mujika et al., 2009), and abroad (Helsen, Winckel, & Williams, 2005; Kirkendall, 2014). Controversial explanations about the causes of RAE have been reported in the bibliography and suggest that physical performance differences are primarily responsible for RAE in soccer (Bliss & Brickley, 2011), whereas other studies have shown no differences in physical and/or anthropometrical parameters according to birth month (Carling et al., 2009; Deprez et al., 2013). In the present study, we tried to evaluate not only the birth quartile as the main factor producing the RAE, but also the effect of other confounding factors such as the maturity status of players or the coaches' perceptions of players' abilities. In this regard, early-born players did not have better results in physical performance tests in the U12 category compared with their later-born peers, so the classical reason for a clear advantage of early-born players seemed to be insufficient to explain the RAE, and social theories such as the model of Hancock, Adler, et al. (2013) should be integrated in the RAE explanation.

In the present study, players from different quartiles were not statistically different in anthropometrical and physical performance tests when APHV and CA were controlled as co-variables. Similarly, Deprez et al. (2013) did not show significant differences between the four quartiles in anthropometric and anaerobic performance characteristics in U13 to U17 young Belgian soccer players. Moreover, APHV was a significant co-variable for height, weight, and the 30-m sprint test in all age categories, as well as for CMJ and the T test in U16 players, showing that the maturity status of players is the main factor affecting the anthropometrics and physical performance of players, not the birth quartile. According to "the youth physical development model," players with a maturity advantage are more likely to perform better on physical tasks as a result of adaptations related to maturation like an increase in androgen concentrations, fiber-type differentiation, resting adenosine triphosphate, creatine phosphate levels, and the architectural development of musculotendon units (Lloyd & Oliver, 2012).

However, when APHV and CA were set as controlling co-variables, CEE were significantly different between birth quartiles except for the Yo-YoIR1 expectations. In addition, when comparing CEE between Q1 and Q4 without confounding factors, the differences were likely to very likely in the inferential analysis. Therefore, for the physical performance test and in general the ability to play soccer, coaches had greater expectations in players who had been born in the first quartiles of the year. This important finding is in agreement with the idea that the RAE is at least partially influenced by social agents (Hancock, Adler, et al., 2013).

The RAE is partially attributable to CEE for two reasons. Firstly, coaches and scouts are responsible for selecting players to promote or to be place on a team or club. This selection process may be biased because of the perception that those players born in the first months of the year have physical performance or soccer ability advantages. This first point reinforces the idea that coaches must be cautious around the PHV period because maturation-related effects during these years can influence the physical performance of players and the perception of coaches about the ability of their players. Secondly, and in agreement with Hancock, Adler, et al. (2013) in the Pygmalion effect theory, more favorable efficacy expectations of coaches lead to an increase in sports performance. This effect was included in the self-fulfilling prophecy described by Merton in 1948 as "the false definition of the situation evoking a new behavior which makes the original false conception come true" (p. 195). In other words, a strongly held belief about a player in this case may sufficiently influence the player so that his reactions ultimately fulfill and confirm the coaches' expectations. These effects were identified in a recent qualitative study that showed that coaches' expectations related to physical potential were crucial to providing opportunities and attention to the "best performers" (Andronikos, Elumaro, Westbury, & Martindale, 2015).

The findings of the present study are in line with the idea that social agents as coaches are creating a biased selection process of players because coaches expected more from those early-born players in both the physical performance test and the ability to play soccer, but those early-born players were not significantly better on the physical performance test than the late-born players. However, they are more likely to be selected for a team (Jiménez & Pain, 2008) and are more unlikely to drop out from playing (Delorme et al., 2010).

CONCLUSION

The results of the present study confirm that CEE are related to the RAE. The birth quartile is not a discriminating factor for better physically performing players, whereas the maturity status of the players does affect their physical performance.

In practice, it is necessary to (a) evaluate as objectively as possible the ability of players, while avoiding the subjective perception and selection of players; and (b) take into account maturity status together with the birth quartile of players, while providing optimal practice according to their age from/to PHV and the same opportunities to succeed and not comparing players with different maturity statuses.

More research on this topic is necessary to clarify why coaches expect more from early-born players and how professionals can change this potentially wrong perception. In future research, it is necessary to include professional scouts to evaluate their expectations about unknown players and compare them to expectations from the players' coaches.

WHAT DOES THIS ARTICLE ADD?

Coaches, scouts, and staff have to decide which players at an early age have the special skills or characteristics needed to be on their club or team and to be successful in soccer in the future. The talent identification and selection process is often a subjective process in which previous expectations of the selector (e.g., the coach) could influence the decision. The belief that relative older players (players who were born in the first months of the year) are either taller or heavier or even the belief that they have better physical performance is the main factor driving the RAE. This belief usually does not take into account the players' maturational timing. In this research, we found birth quartile did not determine players' height, weight, or physical performance on different tests when maturity status was controlled. Nevertheless, coaches still expected more from the relative older players.

This work encourages coaches and technical staff to evaluate the maturity status of players (as easily as possible) in categories near the PHV to achieve a global view of their players' possibilities. Moreover, an objective evaluation of players' abilities is necessary to obtain reliable information about their physical performance.

STUDY 2

Soccer Coaches do Not Perceive the Physical Advantages of Maturity-Advanced Players

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STUDY 2

ABSTRACT

In soccer, players are usually grouped by chronological age, but a different maturity status between them may influence their anthropometrics and physical performance. Coaches could mistake this maturity-related advantage as talent and identify and select the players with this advanced maturity status for even better support. The aim of this study was both, to assess the physical differences between players with different maturity status and to analyze the coaches' efficacy expectations about their players. The maturity status of 122 U14 to U16 soccer players was estimated with the peak height velocity (PHV) and their anthropometrics and physical performance was evaluated. The coaches' efficacy expectations were registered before the testing session. Players with advanced maturity status were taller, heavier and better in physical performance than those which were around or before their PHV ($p < .05$). However, coaches' efficacy expectations were not statistically different between players with different maturity status, except for strength expectations. This work reveals coaches do not perceive the physical performance advantage of players with an advanced maturity status and an objective evaluation of the physical performance and the maturity status is necessary in youth soccer for the talent identification and selection process.

Keywords: Maturation, Coaches' expectations, Peak height velocity

INTRODUCTION

In the sports field, as in soccer, young players are grouped into 1-year cohorts based on their chronological age, trying to create a fair system for the athletes, giving the members the same opportunities of succeeding in the group (Cobley, Baker, Wattie, & Mckenna, 2009). However, there are some negative effects associated with this grouping system, as the relative age effect, that means an overrepresentation of players born in the first months of the selection year (Mujika et al., 2009).

While the current grouping system for young players accepts a certain degree of conditional equality between players of the same age group, there are anthropometrical differences, like weight and height, as well as physical performance differences between players with the same age. These differences are related to a different maturity and growing status (Beunen & Malina, 1988; Lloyd, Radnor, De Ste Croix, Cronin, & Oliver, 2016). The practical meaning of maturation in this context refers to structural and functional changes in the young player body during the growing process as, for example, the ossification of the cartilage (Radnor et al., 2017).

The most commonly used indicator to evaluate the maturity status of a young player, is the Peak Height Velocity (PHV), and which provides us with a landmark about the maximum growth velocity in height (Mirwald et al., 2002; Sherar et al., 2005). The PHV is usually placed at 12 years in girls and at 14 years in boys, and the estimation of the years from or to the PHV is especially accurate in boys from 12 to 16 years old (Malina & Kozieł, 2014).

Inside a team we can find players with the same chronological age but with different maturity status and this may mean a bias in talent identification and selection process. We may confuse “talent” with a temporal advantage of those players with an advanced maturity status or early matures. Nowadays, scouts and coaches try to identify at early ages the potential to succeed, with the aim of maximizing their players' performance in the future (Jiménez & Pain, 2008). The main attribute that coaches and scouts take into account to select a player is their technical and tactical ability, but anthropometrics and physical performance, which are susceptible to be dependent on their maturity status, also have to be taken into account when selecting a player (Carling et al., 2009). However, the ultimate decision of the coach or technical staff to select a player depends on their perception and expectations about the players' ability. Specifically, the assessment of the coaches' efficacy expectation is a good tool that reflects the confidence of the trainer to their players' abilities, capacities and skills regarding the requirements to perform specific tasks or regarding the playing requirements (Leo et al., 2013). The aim of this study was to assess the possible physical differences associated to players with different maturity status in young male soccer players as well as to assess the coaches' efficacy expectations from their players, relating it with the objective evaluation of the physical performance of the players.

METHODS

Participants

122 young male soccer players (13.48 ± 1.03 years; weight: 52.95 ± 9.87 kg; height: 162.44 ± 10.71 cm) from the first and second Spanish U14 and U16 categories participated in the study. The participants' anthropometrics and physical performance were evaluated, while their coaches were asked for their efficacy expectations of the players. The participation was voluntary and the players and their parents/guardians were informed about the protocol, signing a written consent. The study was approved by an Ethics Committee and conformed to the recommendations of the Declaration of Helsinki.

Measures

A tailor-made questionnaire was created according to the recommendations of Bandura (2006) to assess the coaches' efficacy expectations (Bandura, 2006). Coaches answered five Likert-questions (from 1 to 5) about their confidence in the players' ability to perform each physical test and in the players' ability to play soccer (*soccer performance expectations*, *SP*). In a previous work, the questionnaire was validated showing a single factor between the coaches' expectations in the different physical performance tests. This factor was called *Physical Condition Expectations (PC)* (Peña-González, Fernández-Fernández, Moya-Ramón, & Cervelló, 2018). In the current study, the Cronbach alpha of the four items was 0.87, showing a good internal reliability.

The estimation of the maturity status was carried out with the equation 3 of Mirwal et al., (2002). It is an inexpensive and non-invasive way to calculate the maturity-offset, based on anthropometrical variables. This measurement predicts the years from/to the PHV and provides an accurate benchmark of the maximum growth during adolescence (Mirwald et al., 2002; Sherar et al., 2005). This assessment is more accurate for boys from 12 to 16 years old, and for those who are among average maturing (Malina & Kozieł, 2014).

Procedure

Testing sessions were always in the same place and time, in the same order and using the same devices. Anthropometrics were measured for the first time, in standardized conditions (20 ± 1ºC) in the laboratory. Body height and sitting height were measured with a fixed stadiometer (± 0.1 cm, SECA LTD., Germany), and the leg length was the result of body height minus sitting height. Body mass was measured with a digital scale (± 0.1 kg, Oregon scientific® GA101/GR101).

After the anthropometrical measurements, players carried out a warm-up consisting of jogging and squat movements with different loads. The estimation of the half-squat repetition maximum (RM) was performed through the velocity of the movement using a linear encoder (T-Force System, Ergotech, Murcia, Spain) with a 3RM load (González-Badillo & Sánchez-Medina, 2010). After the RM test, players had three minutes of rest before the evaluation of the peak power output (PP). For the estimation of the PP, players were encouraged to perform three half-squats as fast as possible, using the 60% of the maximum load (RM).

The 30-meter dash in a straight line and the agility T-test (Semenick, 1990) were performed in an outdoor synthetic-grass soccer pitch, and players used specific soccer boots. A specific warm-up consisting in accelerations, decelerations and changes of directions was performed along for minutes before the outdoor tests. The time during the 30-m dash and the agility T-test were measured using photoelectric cells (Datalogic S6 Series, Bologna, Italy) which started a digital timer. Participants started from a standing position 30 cm behind the photocell. Players were encouraged to perform the tests at their maximal effort.

Statistical analysis

For the analysis, players were grouped based on their maturity status into three different groups: Pre-PHV (n=46; <0.5 years to PHV), Mid-PHV (n=60; >0.5 years to and <0.5 years from PHV) and Post-PHV (n=16; >0.5 years from PHV).

Two one-way analysis of variance (ANOVA) were used to compare all anthropometrical, physical performance and coaches' expectations variables according to the maturity status. A Bonferroni, as a post-hoc test, was carried out to analyze the differences between the three maturity groups. Effect size (ES) in all variables was calculated with the *Cohen's d* between Pre- and Post-PHV as trivial (<0.25), small (0.25 - 0.50), moderate (0.50 - 1.0), and large (>1.0) (Rhea, 2004).

All calculations were performed using Microsoft Excel (Microsoft, Seattle, Washington, USA) and SPSS Statistics® (Statistical Package for the Social Sciences, Version 17.0), and the level of significance was set at $p < .05$.

RESULTS

The ANOVA analysis showed statistical differences ($p < .05$) between the maturity groups in the anthropometrical variables (weight and height) and in the physical performance tests (RM, PP, 30-m sprint and T-test) favouring players with an advanced maturity status. The Bonferroni analysis showed the Post-PHV were taller, heavier and better in all physical tests than Pre- and Mid-PHV, except in the T-test (Table 4). However, coaches' efficacy expectations were not statistically different between maturity groups, except in RM, in which Post- and Mid-PHV groups had better expectations than Pre-PHV, and in PP, in which only Post-PHV had better expectations than Pre-PHV (Table 5).

Table 4. Players' outcomes according to the maturity group (mean ± standard deviation).

	Pre-PHV (n=46)	Mid-PHV (n=60)	Post-PHV (n=16)	ES (Pre vs Post-PHV)
Weight (kg)	43.9 ± 5.7	56.6 ± 6.5*	65.3 ± 7.5*§	3.41
Height (cm)	151.9 ± 5.6	166.9 ± 6.3*	176.1 ± 7.3*§	3.95
RM (kg)	50.4 ± 9.0	68.2 ± 16.1*	101.6 ± 20.8*§	3.89
PP (W)	508.7 ± 145.7	658.1 ± 189.8*	1071.9 ± 267.6*§	3.02
30-m (s)	4.99 ± 0.31	4.64 ± 0.27*	4.43 ± 0.22*§	1.91
T-test (s)	9.35 ± 0.47	8.81 ± 0.45*	8.54 ± 0.29*	1.85

ES: Effect size; PHV: Peak height velocity.
*Statistically different with Pre-PHV; §Statistically different with Mid-PHV

Table 5. Coaches' efficacy expectations according to the maturity group (mean ± standard deviation).

	Pre-PHV (n=46)	Mid-PHV (n=60)	Post-PHV (n=16)	ES (Pre vs Post-PHV)
RM	3.11 ± 0.83	3.78 ± 0.90*	3.79 ± 0.70*	0.84
PP	3.16 ± 0.80	3.93 ± 0.84	3.79 ± 0.89*	0.76
30-m	3.27 ± 1.07	3.78 ± 1.16	3.64 ± 1.15	0.34
T-test	3.40 ± 0.92	3.72 ± 1.07	3.57 ± 0.94	0.18
PC	3.16 ± 0.86	3.42 ± 1.41	3.23 ± 1.49	0.07
SP	3.62 ± 1.09	4.02 ± 0.96	3.71 ± 0.61	0.09

ES: Effect size; PHV: Peak height velocity.
*Statistically different with Pre-PHV

DISCUSSION

In the present work, the anthropometrical and physical performance differences between the young players with different maturity status is highlighted. Furthermore, no systematic differences in the coaches' efficacy expectations were found between maturity groups, except for the strength-related tests between Pre-PHV and the other maturity groups.

The results of the current study showed significant differences between players with different maturity status in weight and height as well as in physical performance tests. Those players with an advanced maturation obtained better results in all test than those who were around or before their PHV. Likewise, the Pre-PHV group obtained the worse results in comparison with the other groups. These results are in agreement with the previous revised bibliography, both nationally (Soarez, Fragoso, Massuça, & Barrigas, 2012) and internationally (Meylan et al., 2014). The main reasons of the different physical performance between players with the same age, but with different maturity status, are explained by structural differences in the muscles (as different fibre type composition or muscle size), as well as by neuromuscular differences in the fibre recruitment (Radnor et al., 2017). Additionally, the better anthropometrics or physical performance of the early matures is not the only issue in a team grouped by chronological age. On the other hand, the adaptations for the training are different between players with different maturity status (Lloyd et al., 2015; Meylan et al., 2014).

Those differences in the physical performance as well as in the adaptations to training make the difficulties of the classical grouping system based on the chronological age evident. One of the main issues of this grouping model is the possibility to identify a young player as a future talent wrongly due to a temporal maturity advantage (Beunen & Malina, 1988). Likewise, those players with a temporal disadvantage due to late maturity are less likely to be identified and selected as a future talent, and these players could not only produce the same physical performance with a specific training planification when they reach same maturity stage that their mates but even surpass them.

The results about the coaches' efficacy expectations show us important findings about the perception of coaches of their players because these results show that, in general, they are not able to perceive differences in the physical performance between players with different maturity status. These findings highlight the importance of performing a regular assessment of the maturity status and the physical performance of the young players throughout childhood and adolescence, in a way that it may establish an identification and selection process of players as objective as possible, taking the maturity and growing differences into account. Finally, new approaches for this issue are suggesting the possibility of new grouping models for young athletes, based on their maturity characteristics (Cumming et al., 2018; Cumming, Lloyd, Oliver, Eisenmann, & Malina, 2017). The aim of these new ideas for grouping young players is trying to eliminate the possible bias derived from the anthropometrical and physical performance maturity-related differences.

As a conclusion, the talent identification and selection process of young players is commonly structured based on the criteria of the soccer experts as coaches or scouts. They usually decide the players with the potential to succeed in the future using subjective evaluation of the players. In the present study, coaches were not able to perceive the physical performance differences between players with different maturity status. For this reason, a systematic evaluation of the maturity status and the physical performance is necessary for each identification and selection process of young soccer players. Moreover, the coaches' efficacy expectations could be interesting for the tactical evaluation of the players, but future research of the ability of the coaches to perceive the tactical skills of their players is necessary. It is strongly recommended to integrate the evaluation of the maturity status, the physical performance, the technical ability and the tactical coaches' efficacy expectations, to try to create fair talent identification and selection process as well as trying to create fair training groups.

STUDY 3

Effect of Biological Maturation on Strength-Related Adaptations in Young Soccer Players

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STUDY 3

ABSTRACT

Strength training is crucial for soccer players' long-term development at early ages and the biological maturation may influence specific strength-training adaptations. The aim of this study was to propose a strength-training programme for the strength development of pre-pubertal players and to analyse the adaptations to this training programme in players with different maturity status. One hundred and thirty young male soccer players participated in an 8-week strength-training programme consisting in two sessions per week, which was conducted prior to their normal soccer training. Three maturity groups were defined according the years from/to their peak height velocity (PHV) as Pre-, Mid- and Post-PHV. Initial differences between the maturity groups were found in anthropometrical (weight and height) and physical performance variables (RM, PP, 30-m sprint and T-test). The strength-training programme was beneficial for the three maturity groups ($p<0.05$) with general greater improvements for the Pre- and Mid-PHV groups, with *large* effects in RM, PP and T-test, than for the Post-PHV group (*moderate* effects). The strength-training programme proposed in the present study seems to be positive for the strength-related development in young soccer players especially for Pre- and Mid-PHV players. The differences in the training adaptations for players with different maturity status suggest the individualization of the training stimulus for the correct long-term development of the players.

Keywords: Maturation; Peak height velocity; Coaches' expectations; Youth.

INTRODUCTION

Physical performance demands in soccer are related with maximal and explosive strength actions (Asadi, Ramirez-Campillo, Arazi, & Sáez de Villarreal, 2018; Stølen, Chamari, Castagna, & Wisløff, 2005). It is for this reason that strength training has become crucial in the players' long-term development (Lloyd et al., 2014; Moran, et al., 2017a; Radnor et al., 2017) and its evaluation can be used as a physical performance indicator in talent identification and selection processes at early ages (Asadi et al., 2018). Plyometric and resistance training methods have been reported as effective for the improvement of the strength-related actions in soccer, such as jumping, sprinting or changes of direction (Moran et al., 2017b; Radnor et al., 2017; Sáez de Villarreal, Suarez-Arrones, Requena, Haff, & Ferrete, 2015). In this regard, plyometric training methodologies seem to achieve soccer-specific adaptations mainly by neuromuscular improvements (Asadi et al., 2018; Chaouachi, Othman, Hammami, Drinkwater, & Behm, 2014) while resistance training is related with structural adaptations.

With the aim of creating a fair system to identify and select future talented soccer players at early ages, the structure of soccer has traditionally grouped young players into 1-year-categories. However, in the sports research field, there is an increasing interest in the idea that supports that inter-individual differences in biological maturation between players of the same category may influence the strength-related performance as well as the specific adaptations to the strength training (Asadi et al., 2018; Meylan et al., 2014).

Previous investigations reported greater adaptations to strength programmes, with plyometric and/or resistance training methodologies, for post-pubertal players and these support the idea of the "window of opportunity" of those players advanced in their maturation (Meylan et al., 2014; Moran et al., 2017a; Moran et al., 2017b). This period of accelerated gains in strength for post-pubertal players is supported by rapid gains in muscle mass due to an increment of androgen concentrations (Lloyd & Oliver, 2012). Nevertheless, contemporary long-term athlete development models have shown strength training to be important in pre-adolescence, highlighting a neural plasticity associated with pre-pubertal players that supports muscular strength development in these years through gains in neuromuscular adaptations as intra- and intermuscular coordination (Lloyd & Oliver, 2012).

In the sports field, soccer trainers and coaches of pre-adolescent teams try to design strength programmes for the long-term development of their players. Controversy in the results of previous research about the adaptations to strength training between different maturity status groups of athletes leads to a lack of consensus about the strength training method in pre-pubertal period. Soccer specific adaptations to a plyometric training in combination with the normal soccer training showed greater gains in strength related abilities for more mature players (Asadi et al., 2018), while school-aged populations have shown greater improvements in strength for pre- and post-pubertal players (Lloyd et al., 2016; Meylan et al., 2014; Moran et al., 2017b; Radnor et al., 2017).

Taking the controversy about the maturity-related adaptation for a strength-training programme into account, this study aimed to propose a strength-training programme based on the contemporary long-term athlete development models for the strength improvement of pre-pubertal soccer players. The aim of the present study was to report the initial differences between young soccer players with different maturity status and also to analyse the physical performance adaptations according to their maturity status for a specific strength-training programme.

METHODS

Participants

One hundred and thirty young male soccer players from the first and second level of the Spanish regular league competition participated in the study. Mean ± standard deviation for the initial measurements of the sample are shown in Table 6. For the inclusion in the study, the participants must have attended a minimum of the 80% of the programme sessions. All players participated voluntarily in the study and their parents/guardians signed an informed consent. The study was approved (DPS.EC.01.17) by a Research Ethic Committee conforming to the recommendations of the Declaration of Helsinki.

Table 6. Initial measurement of players' outcomes according to the maturity group (mean ± standard deviation).

	CG (n=20)	Pre-PHV (n=43)	Mid-PHV (n=36)	Post-PHV (n=31)
CA (years)	13.2 ± 1.1	12.8 ± 0.4	13.8 ± 0.6*§	14.6 ± 0.50*§ #
Height (cm)	158.2 ± 11.1	154.9 ± 6.2	165.9 ± 4.8*§	171.9 ± 10.4*§ #
Weight (kg)	50.5 ± 10.3	45.4 ± 5.7*	55.8 ± 5.0§	62.3 ± 6.6*§ #
RM (kg)	66.1 ± 17.5	50.8 ± 12.4*	73.4 ± 17.1§	87.9 ± 15.4*§ #
PP (W)	648.8 ± 235.1	544.2 ± 183.6	796.0 ± 239.7*§	951.6 ± 231.1*§ #
30-m sprint (s)	5.0 ± 0.4	4.8 ± 0.2*	4.6 ± 0.2*§	4.5 ± 0.2*§
T-test (s)	9.3 ± 0.6	9.3 ± 0.5	8.7 ± 0.3*§	8.6 ± 0.4*§

CA: Chronological age; *Statistically different from control group (CG); §Statistically different from Pre-PHV; #Statistically different from Mid-PHV

Procedure

A pre- post-test intervention design was carried out with an 8-week strength programme between pre- and post- testing sessions. As a result of the intervention, changes in physical performance of the young players between the pre- and post-test were assessed, and between-group analyses were carried out to compare the changes between maturity groups. All the participants were already familiarized with the physical performance tests and with the strength training. Each testing session was separated from the previous and following training session by at least 48 hours. The normal soccer training sessions of the teams consisted in technical and tactical exercises designed by the coach, and strength-related tasks were not allowed in these field sessions. During the intervention (8 weeks), players performed three normal training sessions (soccer-specific trainings in the field) plus two strength-training (ST) sessions per week.

Players' anthropometrical parameters as weight (kg), height (cm) and sitting height (cm) were initially evaluated. After the anthropometrical assessment, players performed a standardized warm-up, consisting in squat movements with different loads. The one repetition maximum strength (RM) and the peak power output (PP) in the half-squat exercise were estimated indirectly (González-Badillo & Sánchez-Medina, 2010) using a Smith Machine (Technogym Trading, Gambettola, Italy) and recorded with a linear encoder (T-Force System, Ergotech, Murcia, Spain).

The time during a 30-m dash in a straight line and the agility T-test (Semenick, 1990) were measured using photoelectric cells (Datalogic S6 Series, Bologna, Italy). Participants initiated the tests from a standing position 30 cm behind the photocell, which started a digital timer. Players performed two attempts with a 2-minute rest between trials, and the best of the two trials was used for analysis.

Maturity Status

Despite having some limitations and although new prediction equations are appearing in these last years, the assessment of the years from/to the peak height velocity (PHV) is the most commonly used indicator of the somatic maturation in the sports field (Kozieł & Malina, 2018). The PHV indicates the theoretical benchmark of the maximum growth in height during adolescence which occurs, on average, around the age of 14 in males and 12 in females (Malina, Bouchard, & Bar-Or, 2004). The prediction of the years from/to the PHV, also called "maturity offset", gives us an accurate reference of the maturity status of the young athlete (Mirwald et al., 2002; Sherar et al., 2005) and it is especially accurate in boys from 12 to 16 years old with an "on average" maturation (Malina & Kozieł, 2014).

For the later analysis, players were grouped into three maturity groups according to their years from/to PHV. Maturity groups were defined with the same name as in other studies for the easy understanding of the reader: Pre-PHV (n=43; <0.5 years to PHV), Mid-PHV (n=36; >0.5 years to and <0.5 years from PHV) and Post-PHV (n=31; >0.5 years from PHV). Additionally, a control group (CG) was created with Pre-, Mid- and Post-PHV players (n=20). The CG did not carry out the ST programme but participated in the normal soccer-specific training with their teams.

Strength Training Programme

During the ST programme all players carried out three normal soccer-training sessions of 90 minutes of duration per week plus two extra ST sessions per week, consisting in 20-minutes of a combination of plyometric and resistance exercises (see Table 7), which were conducted prior to the normal soccer training. With the aim of designing a strength programme for the development of pre-pubertal players, the external load was small but the movement velocity required was maximal, looking for neuromuscular adaptations rather than structural ones. The CG performed the normal soccer training but not the extra ST work. Each training session was carried out at the same time of the day and one investigator supervised all ST sessions. Prior to each ST session, players carried out a standardised warm-up consisting in five minutes of running and three minutes of dynamic stretching. The ST programme was divided into two 4-week-long periods labelled Block 1 and Block 2. The aim of dividing the ST programme into two blocks was to increase the initial load of some exercises. Players were encouraged to perform the exercises at maximal velocity and to repeat the exercise as many times as possible in 30 seconds. The work/rest ratio was set as 1:1.

Table 7. Exercises and progression during the eight weeks of the ST

	Block 1 (Weeks 1-4)	**Block 2** (Weeks 5-8)
Semi-squat	*Without external load*	With a 10-kg disc
Lunge	*Without external load*	With a 5-kg ball
Side lateral lunge	*Without external load*	With a 5-kg ball
Single-leg squat (right)	*Without external load*	*Without external load*
Single-leg squat (left)	*Without external load*	*Without external load*
Dead lift	*Without external load*	With a 10-kg bar
Hip-thrust	*Without external load*	With a 5-kg ball
Multi-jumping	Two-legs jumping on an agility ladder	One-leg jumping on an agility ladder
Hip-rotation	With an elastic band	With an elastic band

Statistical Analysis

Data for the initial measurement of the players as well as for the pre- post-test analysis was reported as Mean ± SD. Differences in each group for physical performance tests were reported as the percentage of change, while the comparison in the pre- post-test changes between groups was reported with the effect sizes.

An initial one-way analysis of the variance (ANOVA) was carried out to compare the initial measurement between the three maturity groups and the CG, and a post-hoc analysis (Bonferroni) was used to report the initial statistical differences between groups. A paired-samples t-test was used for the analysis of the pre- post-test differences in each maturity group as well as in the CG for each physical performance test. The effect sizes of the between groups comparison about the training adaptations were analysed as trivial (< 0.19), small (0.20–0.49), moderate (0.50–0.79) and large (> 0.80) (Cohen, 1992). For the standardised effects of the ST programme, a magnitude-based inference analysis with a specific spreadsheet, “Compare two groups means” (www.sportsci.org), was used. For this analysis, the smallest worthwhile difference in means in standardised units (Cohen’s d) was set at 0.2, representing the hypothetical smallest difference. The qualitative descriptor according to the chance of benefit was provided for the better understanding as possibly (25 to 75%); likely (75 to 95%); very likely (95 to 99.5%); most likely (>99.5%) (Hopkins et al., 2009).

All calculations were performed using Microsoft Excel (Microsoft, Seattle, Washington, USA) and SPSS Statistics® (Statistical Package for the Social Sciences, Version 17.0), and the level of significance was set at $p < .05$.

RESULTS

The ANOVA with the post-hoc analysis showed initial differences between the different maturity groups (Pre- < Mid- < Post-PHV) as well as with the CG (Table 6).

The statistical differences shown in the paired-samples t-test are reported in Table 8, as well as the effect size (95% CI) with the magnitude of the training effect, the descriptive probability of the benefit and the percentage of the change after the application of the ST programme. Significant differences for RM, PP and T-test were found between pre- and post-test evaluation for Pre-, Mid- and Post-PHV ($p < 0.05$) while no significant differences were found for the CG.

Table 9 shows the standardized pairwise comparison of the adaptations to the ST programme between groups. *Moderate* to *large* effects in the adaptations for RM and PP was shown in each maturity group when compared with the CG, and even these effects seem to be significant when CI does not cut cero. However, only *moderate* effects in the adaptations for the ST programme were shown in T-test between Pre-PHV and the CG without cutting cero. The rest of the pairwise effects with the CG were *trivial* and *small*. *Moderate* to *large* effects in the adaptations to the ST programme were found between the Pre- and Mid-PHV groups with the Post-PHV for the RM and PP tests, and the CI without cutting cero indicates the significant differences in the adaptations to the ST programme between these maturity groups.

Table 8. Changes in physical performance for the different maturity status groups and control group (CG).

	PRE	POST	ES (95% CI)	Training effect	Probability of benefit	% of change
RM (kg)						
CG	66.1 ± 17.5	67.0 ± 17.4	-0.05 (-0.67; 0.57)	Trivial	*Likely*	4.9
Pre-PHV	50.8 ± 12.4	67.2 ± 11.2*	-1.39 (-1.83; -0.92)	Large	*Most likely*	32.3
Mid-PHV	73.4 ± 17.1	93.3 ± 18.5*	1.91 (1.34; 2.45)	Large	*Most likely*	27.1
Post-PHV	87.9 ± 15.4	100.8 ± 18.2*	-0.77 (-1.27; -0.24)	Moderate	*Most likely*	14.7
PP (w)						
CG	648.8 ± 235.1	719.1 ± 241.3	-0.30 (-0.91; 0.33)	Small	*Possibly*	14.6
Pre-PHV	544.2 ± 183.6	695.3 ± 162.1*	-0.87 (-1.29; -0.44)	Large	*Most likely*	27.8
Mid-PHV	796.0 ± 239.7	994.3 ± 224.1*	-0.85 (-1.33; -0.36)	Large	*Most likely*	24.9
Post-PHV	951.6 ± 231.1	1085.0 ± 243.8*	-0.56 (-1.06; -0.05)	Moderate	*Most likely*	14.0
30-m sprint (s)						
CG	5.1 ± 0.4	5.0 ± 0.6*	0.20 (-0.43; 0.81)	Small	*Possibly*	2.0
Pre-PHV	4.8 ± 0.2	4.8 ± 0.2	0.00 (-0.41; 0.41)	Trivial	*Possibly*	0.0
Mid-PHV	4.6 ± 0.2	4.5 ± 0.2*	0.50 (0.03; 0.96)	Moderate	*Very likely*	2.2
Post-PHV	4.5 ± 0.2	4.5 ± 0.2	0.00 (-0.50; 0.50)	Trivial	*Possibly*	0.0
T-test (s)						
CG	9.3 ± 0.6	9.1 ± 0.5	0.36 (-0.27; 0.98)	Small	*Possibly*	2.1
Pre-PHV	9.3 ± 0.5	8.9 ± 0.3*	0.97 (0.53; 1.39)	Large	*Most likely*	4.3
Mid-PHV	8.7 ± 0.3	8.4 ± 0.4*	0.85 (0.36; 1.32)	Large	*Most likely*	3.4
Post-PHV	8.6 ± 0.4	8.4 ± 0.4*	0.50 (-0.01; 1.00)	Moderate	*Very likely*	2.3

*(p<0.05): Significantly different from PRE

Table 9. Pairwise comparison of the standardized effects in Cohen units (95% CI) for the changes between maturity groups.

	Control vs Pre-PHV	Control vs Mid-PHV	Control vs Post-PHV
RM	-1.51 (-2.08; -0.90)	-1.09 (-1.65; -0.49)	-1.01 (-1.59; -0.39)
PP	-0.54 (-1.08; 0.00)	-0.57 (-1.11; 0.00)	-0.15 (-0.71; 0.42)
30-m sprint	0.27 (-0.27; 0.80)	-0.07 (-0.62; 0.48)	0.23 (-0.35; 0.79)
T-test	-0.76 (-1.30; -0.20)	-0.33 (-0.88; 0.22)	-0.23 (-0.79; 0.34)
	Pre-PHV vs Mid-PHV	Pre-PHV vs Post-PHV	Mid-PHV vs Post-PHV
RM	0.18 (-0.27; 0.62)	0.92 (0.43;1.40)	0.60 (0.10; 1.09)
PP	0.18 (-0.26; 0.62)	0.51 (0.03; 0.98)	0.51 (0.01; 1.00)
30-m sprint	-0.33 (-0.77; 0.12)	-0.07 (-0.53; 0.40)	0.28 (-0.21; 0.76)
T-test	0.43 (-0.03; 0.87)	0.54 (-0.06; 1.01)	0.11 (-0.38; 0.59)

DISCUSSION

The main results in this study suggest that a strength-training (ST) programme focused on neuromuscular adaptations (i.e. carried out at maximal voluntary velocity) rather than on the structural improvements (i.e. hypertrophy strategies) is beneficial for the strength development in youth soccer with generally greater improvements in Pre- and Mid-PHV groups. To our knowledge, it is the first reported specific ST programme for young soccer players that shows a general benefit in the adaptations for Pre- and Mid-PHV rather than Post-PHV players, and it could help professionals and coaches of pre-pubertal soccer players. A specific plyometric training programme for soccer players by Asadi et al., (2018) showed greater gains in jump and sprint performance for Post-PHV players. In addition, other references agree with the idea that Post-PHV have greater adaptations to the strength training, but these references were carried out without a soccer-specific population (Meylan et al., 2014; Moran et al., 2017a). On the other hand, greater adaptations to a strength training programme for Pre-PHV boys was also shown in previous research (Lloyd et al., 2016; Radnor et al., 2017) but also with school-aged population and not with soccer players. Anywise, the present study agrees with all these studies in the idea the idea of the importance of different physical performance and different training adaptations of young athletes with different maturity status in talent identification and selection processes (Lloyd & Oliver, 2012).

Moreover, the improvements in the physical performance of young players are not only due to the prescription of the strength training but also to the natural development of young people (Meylan et al., 2014). In this regard, this study showed percentages of change from 2.0 to 14.6 in the different physical performance tests for the CG. These differences were *trivial* to *small* and with *possibly* to *likely* probability of benefit.

For the maximal and power strength evaluation (RM and PP), Pre- and Mid-PHV players had greater adaptations (24 to 32% of change with *large* effects) to the proposed ST programme than Post-PHV players (around 14% of change with *moderate* effects). Not only the magnitude of changes was reported but the standardized effects in the adaptation comparisons were also shown, with *moderate* to *large* effects in the Pre- vs Post-PHV and in the Mid- vs Post-PHV groups. Nevertheless, statistical analysis showed significant differences between pre- and post-test in all maturity groups. Thus, the proposed ST programme may be addressed to young soccer players from 12 to 15 years old to improve their maximal and explosive strength, highlighting the greater improvements of Pre-PHV players. Although the present ST programme was designed aiming to improve the physical performance of the Pre-PHV players in a greater extent, other possible reasons of the greater improvement of the Pre- than the Post-PHV in RM and PP may be the initial differences between these groups. In this regard, and in line with the results by Radnor et al., (2017), the proposed ST programme could be an insufficient strength stimulus to allow greater improvements for Post-PHV players. Post-PHV players may require, in function of their physical performance, more specific training stimulus (Radnor et al., 2017).

Controversial results were found for the speed-related tests, as the 30-m sprint and the agility T-test. Although the relationship between the strength and speed improvements have been widely reported (Comfort, Stewart, Bloom, & Clarkson, 2014), the improvements in RM and PP shown in the present study were not joined by linear sprint improvements in the same maturity groups. Although some changes in pre- post-test analysis are statistically significant, *trivial* and *small* effects are shown for these changes. The changes shown in linear sprint in this study cannot support a clear benefit of the application of this ST programme. A possible explanation of this result is the high training stimulus of the current soccer-specific sample to speed-related tasks in their usual soccer training. In this regard, the present ST programme may be insufficient for the speed development of these young soccer players. On the other hand, each maturity group had similar adaptations after the proposed ST programme for the T-test than for the RM and PP (*large* effects ($p < 0.05$) in Pre- and Mid-PHV with *most likely* probability of benefit and *moderate* effects ($p < 0.05$) in Post-PHV with *very likely* probabilities of benefit). The controversy about the improvements in the agility T-test without clear improvements in linear sprint may be explained by the strength transference in agility tasks, the same as the change of direction, due to an efficient stretch-shortening cycle (Moran et al., 2017b).

One of the main limitations of the present study was the control of the soccer-specific training loads. Players attended their usual soccer trainings with their usual team (with their chronological age peers) and differences between the soccer-specific training loads may appear. The authors tried to cushion this bias by blocking any kind of strength training during the soccer-specific training. In addition to this, the aggrupation of players by maturity status for the analysis usually appears in the bibliography as: Pre-PHV < -1 and Post-PHV > 1 in their maturity offset. The present study aimed to reduce the biological differences between groups to perform a more exhaustive analysis. However, due to the error associated with the maturity offset formula, the number of players classified into a wrong group may increase in comparison with other studies. The initial differences between groups, together with the small standard deviation in weight and height, indicated that the maturity groups were initially homogeneous, and thus the associated error in the PHV offset calculation (Mirwald et al., 2002) was relatively controlled.

CONCLUSION

Given the relevance of strength in soccer, a strength-training programme focused on neuromuscular adaptations and carried out during eight weeks (twice per week) was shown in this study to be effective to improve strength-related physical performance in young soccer players, with generally greater improvements in Pre- and Mid-PHV players. The maturity-related physical performance differences, together with the differences in the adaptations to the strength training reported in this study, could be very useful for professionals in soccer in which it is very common that players with different maturity status practice and compete together. Individualized training stimulus for players with different maturity status may be successful in long-term soccer players' development programs and may help soccer clubs in the identification and selection process of players at early ages.

Research Proposal

Young soccer players' aggrupation by their maturity status, physical performance and the expectations of their coaches: A first approach.

RESEARCH PROPOSAL

ABSTRACT

Grouping young athletes by maturity-related features is taking on importance in team sports. The contemporary proposal of bio-banding recommends this kind of aggrupation by maturity status rather than by chronological age favouring a fairer competition between young athletes and giving the same opportunities to succeed in soccer in the long-term. The aim of this approach was to provide a new system to help soccer coaches and clubs decide the best aggrupation of their players taking into account their maturity status, their physical performance level and their coaches' efficacy expectations.

INTRODUCTION

Educative-related systems have usually organised kids into learning groups in function of their chronological age. The field of sports is not an exception, and young people have traditionally been grouped into 1-year cohorts according to their age. The aim of this categorization is to create a fair system in which young athletes practice, compete and learn in theoretically equal conditions (Cobley et al., 2009). However, this classical system of grouping has some negative effects, as for example, the relative age effect (RAE) that refers to the advantages of players born earlier in the selected year (Deprez et al., 2013). Those players born in the first months of the year are overrepresented in soccer and have better opportunities and support to be selected for development programmes (Augste & Lames, 2011; Bliss & Birckley, 2012; Jiménez & Pain, 2008; Kirkendall, 2014; Mujika et al., 2009). Although an advantage in anthropometrical and physical performance variables has traditionally been suggested for the early born players, no differences in these variables have been reported when the maturation was controlled (Carling et al., 2009; Deprez et al., 2013).

Another problem related to the current age-aggrupation system are the players' differences in physical performance and the adaptations to the training due to inter-individual differences in the maturity status (Asadi et al., 2018; Meylan et al., 2014; Moran et al., 2017b; Radnor et al., 2017). For this reason, in a recent research, players perceived their experience in a tournament as positive when they were grouped by their maturity status (Cumming et al., 2018). The authors called this concept Bio-Banding. These maturity-related differences in physical performance and in training adaptations make soccer professionals and researchers be increasingly interested in the relationship between the results in the physical performance and the assessment of the maturity status of young players (Till, Morris, Emmonds, Jones, & Cobley, 2018). The physical performance evaluation of young players allows to soccer professionals to compare players among each other, but including the players' maturity status is necessary if you want a good tool to be able to detect without bias the possible advantages or disadvantages in players (Till et al., 2018).

All these differences between young soccer players, grouped together in the same team only based on their date of birth, result in a bias in the talent identification, selection and development processes. It is due to a wrongly perception of coaches and scouts that these may perceive the temporal physical advantages of the maturity-advanced players as talent (Beunen & Malina, 2008; Bliss & Birckley, 2012; Cripps et al., 2016; Vandendriessche et al., 2012). Aiming identifying players with the potential to achieve a high performance level in the future, coaches and scouts (the main responsible of detecting the talented players and selecting them for a club) try to use their experience and their sport knowledge to perceive the abilities of the players, relying on "their eye" or "their practical sense" (Christensen, 2009). For the talent identification and selection process, the coaches and scouts' perceptions are interesting in order to evaluate players' abilities that are difficult to measure (e. g. specific tactical skills), but they do not seem to be able to detect the physical performance differences between players (Peña-González, Moya-Ramón, Fernández-Fernández & Cervelló, 2019). This fact reveals that coaches' evaluation of players should be part of a bigger model of players' evaluation and it must take technical and tactical expectations of coaches into account. In this regard, the "Coaches' Efficacy Expectations" reflect a trainer's confidence in their player's abilities to perform given tasks as well as the confidence in each player's capacities and skills regarding the playing requirements (Leo et al., 2013).

Given the limitations perceived in the talent identification and selection process due to the unfair age-grouping system, the purpose of this approach was to provide a novel tool to help soccer professionals (i.e. coaches and soccer club coordinators) decide the best group or team to practice for players from U12 to U16. This regrouping tool tries to give a piece of advice to maintain, promote or downgrade from their current group, depending on the players' maturity status, their physical performance level and the technical and tactical abilities perceived by their coaches.

METHOD OF THE REGROUPING TOOL

An assessment of the maturity status, physical performance evaluation and the assessment of the coaches' efficacy expectations are necessary for this proposal to create a relative player profile for the comparison among players in a group. The data was normalized by Z-Scores (Z-score = [Player Score – Mean Score] / Standard Deviation) (Till et al., 2018). The standardization of the data with the Z-scores allows for the comparison between the different tests with different units of measurements.

First, an anthropometrical assessment to calculate the maturity status by means of the maturity offset proposed by Mirwald et al., (2002) it is necessary. This includes the evaluation of height, weight and sitting height, with the estimation of the leg length using the total height minus the sitting height. For the evaluation of the physical performance, five field tests with easy procedures are proposed with the aim that they could be carried out in all contexts. In addition, the coaches' efficacy expectations are collected to evaluate the technical, tactical and players' general skills to play soccer. The purpose of these three parts of the tool is to categorize each player as normal, early or late mature; normal, better or worse physical performer; and normal, better or worse technical/tactical performer, awarding 0, +1 or -1, respectively. If a player gets +2 (or more) in the sum of the three components, this player will be recommended for *promotion* to the next group. If, to the contrary, a player gets -2 (or less) in the sum of the three components, this player will be recommended for *downgrade* to the group below. If the addition results in +1, 0 or -1, the player will be proposed to *maintain* in the same group.

MATURITY STATUS ASSESSMENT

During the growing process, children and adolescents experience non-linear changes in their body composition and sizes as well as, indirectly, in their physical performance (Beunen & Malina, 1988; Hermanussen et al., 1988; Lampl et al., 1992). The maturation process refers to those changes that are related with the structure and function of the organism during the growing process (e. g. the ossification of cartilage) that lead to the adulthood or adult state (Malina et al., 2004; Malina et al., 2015).

To assess the maturity status of the players, the maturity offset proposed by Mirwald et al., (2002) is used in this tool. It is the most commonly used indicator for the somatic maturity in the sports field and it provides the years from or to the peak height velocity (PHV). PHV refers to the exact point of maximum growing velocity in height during the adolescence (Mirwald et al., 2002; Sherar et al., 2005). This point of maximum growing velocity occurs on average at the age of 12 years in girls and 14 in boys, thus the years from/to the PHV provide us a reference of the maturity status of the player, allowing the maturity comparison between players with the same chronological age. To evaluate the years from/to the PHV, it is necessary to know the date of birth of the participant, to calculate the decimal age, as well as anthropometrical measurements like weight, height, sitting height and the estimation of leg length. Taking into account that this measurement is mainly accurate for boys from 12 to 16 years of age (Malina & Kozieł, 2014), the present tool was created for male teams from U12 to U16.

If a player has an average maturation timing, his years from/to the PHV should be: around -1.0 in U13, 0.0 in U14, 1.0 in U15 and 2.0 in U16. For this reason, players will be proposed to *maintain* in their current group if they are between -2.0 and 0.0 years to their PHV in U13, between -1.0 and 1.0 in U14, between 0.0 and 2.0 in U15 and if they are more than 1.0 in U16. If a player of any of these categories is below the lower limit, he will be proposed to *downgrade* to the team below. On the contrary, if a player of any of these categories is above the upper limit, he will be proposed to *promote*.

During a year, the maturity status of the players change and the velocity of these maturity changes is different in each player. For that reason, a periodical evaluation of the maturity status of the players is important (Kozieł & Malina, 2018).

PHYSICAL PERFORMANCE EVALUATION

A physical performance battery is proposed to evaluate the young players and to create a relative player profile to compare between players and between different physical characteristics. The tests proposed for the physical performance evaluation are: (1) the countermovement jump (CMJ) (Bosco et al., 1983), (2) the 30-m linear sprint, (3) the agility T-test (Semenick, 1990), (4) the dribbling ability using the same T-test with ball and (5) the specific endurance with the Yo-Yo IR1 (Bangsbo et al., 2008). For the evaluation of CMJ the use of a contact platform to calculate the height of the jump in centimetres is preferable, but classical evaluation without specific material is allowed. In the same way, the use of the photocells to calculate the time in the 30-m sprint, T-test and T-test with ball is suggested, but the evaluation with manual chronometer is allowed if it is applied in the same way with all participants.

For the physical performance data processing, ±0.5 Z-score was set as the limit for being in the "average" or to be classified as "better performer" or "worse performer" in each physical performance test. If a player is classified as "better performer" in at least three of the five physical tests, the player will obtain "+1 point" and be recommended for *promote* to the next group. On the contrary, if a player is classified as "worse performer" in at least three of the five physical tests, the player will obtain "-1 point" to be recommended for *downgrade* to the group below. If the player is between the ±0.5 Z-score or he does not get the "+1 or -1 point" in the physical performance tests, he will obtain a "0 point", recommending to *maintain* the player in the current group.

ASSESSING THE COACHES' EFFICACY EXPECTATIONS

The coach of the measured group should answer three simple questions about their own confidence in each player's technical, tactical and soccer performance:

1. Indicate, honestly, the confidence you have in your player's technical abilities.
2. Indicate, honestly, the confidence you have in your player's tactical abilities.
3. Indicate, honestly, the confidence you have in your player's soccer abilities.

Each question is scored by coaches using a Likert scale from 0 ("no confidence") to 5 ("maximum confidence") following the recommendations of Bandura (2006).

As in the physical performance evaluation, Z-scores are used to standardize the results in the coaches' efficacy expectations. ±1 Z-score was set as the limit for being inside the "average" or to be classified as "better performer" or "worse performer" in technical and tactical abilities. When a player is classified as "better performer" in at least two of the three coaches' efficacy expectations, this player obtains "+1 point" to be recommended for *promotion* to the next group, while if he is classified as "worse performer" in at least two of the three coaches' expectations, he will obtain "-1 point", to be recommended for *demotion* to the team below. If the player does not get the "+1 or -1 point" in coaches' efficacy expectations, he will obtain a "0 point", which recommends to *maintain* the player in his current training group.

PRACTICAL EXAMPLE

With the aim of making this grouping system easier for coaches and trainers, the authors are creating a supplemental Microsoft Excel® file. An example of how this new tool will work is provided.

Tables 10, 11 and 12 collect the anthropometrical assessment, the maturity status, the physical performance and the coaches' efficacy expectations from three teams of a same soccer club. Players 2.1, 2.5 and 2.10 are going to be analysed to give an example of each possibility provided by this system.

Table 10. Descriptive data of players from Team 1 (U13).

	Age (yr)	Weight (kg)	Height (cm)	PHV	CMJ (cm)	30_m (s)	T-test (s)	Dribbling (s)	Yo-YoIR1 (m)	Tech-Exp	Tact-Exp	Soccer Exp
Player_1.1	13.3	63.4	176.7	0.69	24.9	4.91	10.30	13.99	1040	2	4	3
Player_1.2	13.7	64.1	164.9	0.14	27.7	5.58	10.38	15.01	320	2	3	4
Player_1.3	13.8	44.2	156.9	-0.98	31.0	4.91	10.55	14.70	280	3	2	3
Player_1.4	13.2	51.3	164.5	-0.57	24.0	5.38	11.25	14.10	320	3	3	2
Player_1.5	13.3	40.5	143.3	-1.26	30.6	5.26	10.86	14.98	320	5	2	3
Player_1.6	13.5	48.1	153.5	-1.38	25.7	4.93	10.27	14.45	480	3	4	2
Player_1.7	13.2	51.5	162.3	-0.69	32.5	5.10	9.78	13.15	240	5	3	5
Player_1.8	13.1	51.2	156.7	-0.90	32.3	4.80	9.90	13.75	400	4	2	4
Player_1.9	13.9	40.3	151.3	-1.47	28.2	4.88	10.45	13.59	280	5	4	5
Player_1.10	13.2	45.3	152.7	-0.70	22.7	5.33	11.15	14.28	360	4	2	2
Player_1.11	13.3	56.3	157.3	-1.05	27.5	5.20	10.47	15.98	360	3	3	3
Player_1.12	14.0	43.7	151.4	-1.38	26.5	5.30	10.35	13.94	320	4	3	5
Player_1.13	13.4	45.4	149.0	-0.96	26.2	5.33	10.90	15.08	280	2	3	3
Player_1.14	14.0	42.0	156.3	-0.71	26.3	5.55	10.33	13.83	320	2	4	3
Player_1.15	13.3	49.4	156.7	-0.77	20.8	5.36	10.47	13.46	360	3	3	2

Tech-Exp: Technical Expectations; Tact-Exp: Tactical Expectations; Soccer Exp: Soccer Expectations.

Table 11. Descriptive data of players from Team 2 (U14).

	Age (yr)	Weight (kg)	Height (cm)	PHV	CMJ (cm)	30_m (s)	T-test (s)	Dribbling (s)	Yo-YoIR1 (m)	Tech-Exp	Tact-Exp	Soccer Exp
Player_2.1	14.7	57.1	166.5	0.59	28.0	5.00	10.49	14.05	640	4	3	4
Player_2.2	14.3	74.0	185.0	1.88	31.0	4.65	9.52	12.76	680	2	4	4
Player_2.3	14.9	54.3	164.1	-0.21	29.4	5.15	10.29	13.87	760	3	2	2
Player_2.4	14.6	59.0	168.7	0.32	33.2	4.83	9.59	14.40	560	3	3	3
Player_2.5	14.4	52.7	163.0	-0.10	37.5	4.66	9.52	12.90	760	4	4	5
Player_2.6	14.9	44.4	159.0	0.11	34.6	5.10	10.07	13.44	400	3	3	3
Player_2.7	15.0	90.4	183.5	2.11	27.0	5.17	10.27	13.48	320	3	3	2
Player_2.8	14.1	37.4	147.0	-1.16	33.0	5.15	10.18	13.56	400	4	4	5
Player_2.9	14.4	68.4	174.4	0.48	28.9	4.84	9.87	13.16	640	2	3	3
Player_2.10	14.2	53,9	173,0	-1.36	26.2	5.19	10.27	14.41	320	2	1	2
Player_2.11	14.3	63.0	177.6	0.82	29.6	5.05	9.99	14.13	600	3	3	3
Player_2.12	14.4	66.2	169.0	1.07	27.8	4.98	10.03	14.09	400	3	3	3
Player_2.13	14.4	63.5	173.4	0.84	27.3	4.96	9.58	14.24	600	2	3	2
Player_2.14	14.7	45.9	154.0	-0.80	29.6	5.11	10.20	14.64	320	3	4	3
Player_2.15	13.4	61.4	170.5	0.10	29.2	5.10	10.28	14.77	600	4	3	2

Tech-Exp: Technical Expectations; Tact-Exp: Tactical Expectations; Soccer Exp: Soccer Expectations.

Table 12. Descriptive data of players from Team 3 (U15).

	Age (yr)	Weight (kg)	Height (cm)	PHV	CMJ (cm)	30_m (s)	T-test (s)	Dribbling (s)	Yo-YoIR1 (m)	Tech-Exp	Tact-Exp	Soccer Exp
Player_3.1	15.6	55.1	170.0	1.18	33.8	4.86	9.71	12.94	960	2	4	4
Player_3.2	15.9	59.5	167.1	1.64	39.0	4.64	9.20	11.88	920	5	5	5
Player_3.3	15.3	64.2	177.3	0.95	30.5	4.84	9.72	12.98	680	3	3	3
Player_3.4	16.0	68.1	177.5	1.82	35.5	4.98	9.35	12.22	1240	3	5	4
Player_3.5	15.0	72.7	179.3	1.52	30.3	4.89	9.50	12.32	680	5	5	5
Player_3.6	15.0	55.7	154.9	0.69	43.4	4.77	9.30	12.12	960	5	5	5
Player_3.7	14.9	55.7	167.2	0.63	37.0	4.94	9.83	13.08	680	5	5	5
Player_3.8	15.0	66.9	173.4	1.00	36.1	4.51	9.70	12.80	1120	5	5	5
Player_3.9	15.0	52.4	177.1	0.85	38.0	4.77	9.33	12.32	680	3	4	5
Player_3.10	15.6	74.1	182.0	2.32	32.0	4.73	9.76	13.09	720	1	2	1
Player_3.11	16.0	69	176.8	1.62	44.0	4.83	9.82	14.89	560	1	2	2
Player_3.12	15.6	55.1	170.2	1.18	33.8	4.86	9.74	12.94	960	2	4	4
Player_3.13	15.9	59.5	167.0	1.64	39.0	4.64	9.20	11.88	920	5	5	5
Player_3.14	15.3	64.2	177.4	0.95	30.5	4.84	9.72	12.98	680	3	3	3
Player_3.15	16.0	68.1	177.5	1.82	35.5	4.98	9.35	12.22	1240	3	5	4

Tech-Exp: Technical Expectations; Tact-Exp: Tactical Expectations; Soccer Exp: Soccer Expectations.

Table 13. Example 1 (Player 2.1). Recommended to maintain.

		U13		**U14**		**U15**		**Z-Scores**		
Player_2.1		M	SD	M	SD	M	SD	**U13**	**U14**	**U15**
Physical Performance										
CMJ (cm)	28.0	26.9	3.4	30.2	3.2	35.9	4.3	0.31	-0.68	-1.82
30_m (s)	5.00	5.20	0.25	5.00	0.18	4.80	0.13	0.81	-0.02	-1.52
T-test (s)	10.49	10.54	0.44	10.01	0.32	9.55	0.23	0.12	-1.49	-4.05
Dribbling (s)	14.05	14.29	0.73	13.86	0.62	12.71	0.74	0.33	-0.31	-1.80
Yo-YoIR1 (m)	640	370	188	533.33	158	864	216	1.43	0.67	-1.03
							Recommendation based on the physical performance		**0**	
Expectations										
Technical	4	3.1	1.1	3.2	0.9	3.4	1.5	0.80	0.85	0.40
Tactical	3	2.9	0.7	3.1	0.7	4.0	1.1	0.09	-0.18	-0.94
Soccer	4	3.1	1.0	3.2	1.0	3.9	1.2	0.85	0.79	0.11
							Recommendation based on the coaches' expectations		**0**	
Maturity Status										
PHV	0.59	-0.77	0.57	0.31	0.99	1.32	0.49			
							Recommendation based on the maturity status		**0**	
							Final Recommendation		**0**	
								Recommended to maintain		

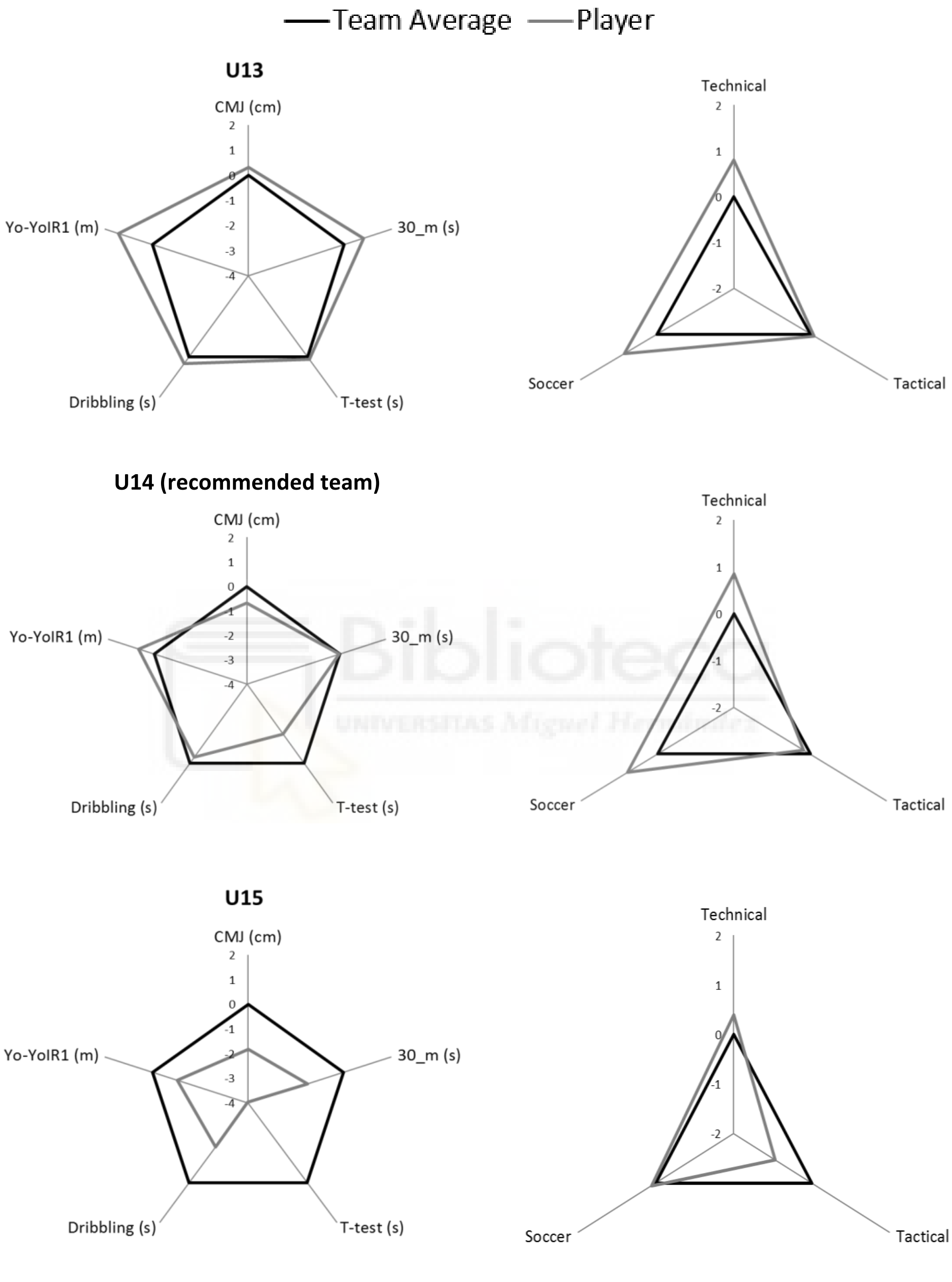

Figure 3. Comparison of the players' physical performance and coaches' expectations with different team averages.

Table 14. Example 2 (Player 2.5). Recommended to promote.

		U13		U14		U15		Z-Scores		
Player_2.5		M	SD	M	SD	M	SD	**U13**	**U14**	**U15**
Physical Performance										
CMJ (cm)	37.5	26.9	3.4	30.2	3.2	35.9	4.3	3.13	2.33	0.37
30_m (s)	4.66	5.20	0.25	5.00	0.18	4.80	0.13	2.17	1.90	1.12
T-test (s)	9.52	10.54	0.44	10.01	0.32	9.55	0.23	2.33	1.52	0.13
Dribbling (s)	12.90	14.29	0.73	13.86	0.62	12.71	0.74	1.92	1.55	-0.26
Yo-YoIR1 (m)	760	370	188	533	158	864	216	2.07	1.43	-0.48
Recommendation based on the physical performance									**+1**	
Expectations										
Technical	4	3.1	1.1	3.2	0.9	3.4	1.5	0.85	0.80	0.40
Tactical	4	2.9	0.7	3.1	0.7	4.0	1.1	1.17	1.56	0.00
Soccer	5	3.1	1.0	3.2	1.0	3.9	1.2	1.77	1.83	0.95
Recommendation based on the coaches' expectations									**+1**	
Maturity Status										
PHV	-0.10	-0.77	0.57	0.31	0.99	1.32	0.49			
Recommendation based on the maturity status									**0**	
Final Recommendation									**+2**	
Recommended to promote										

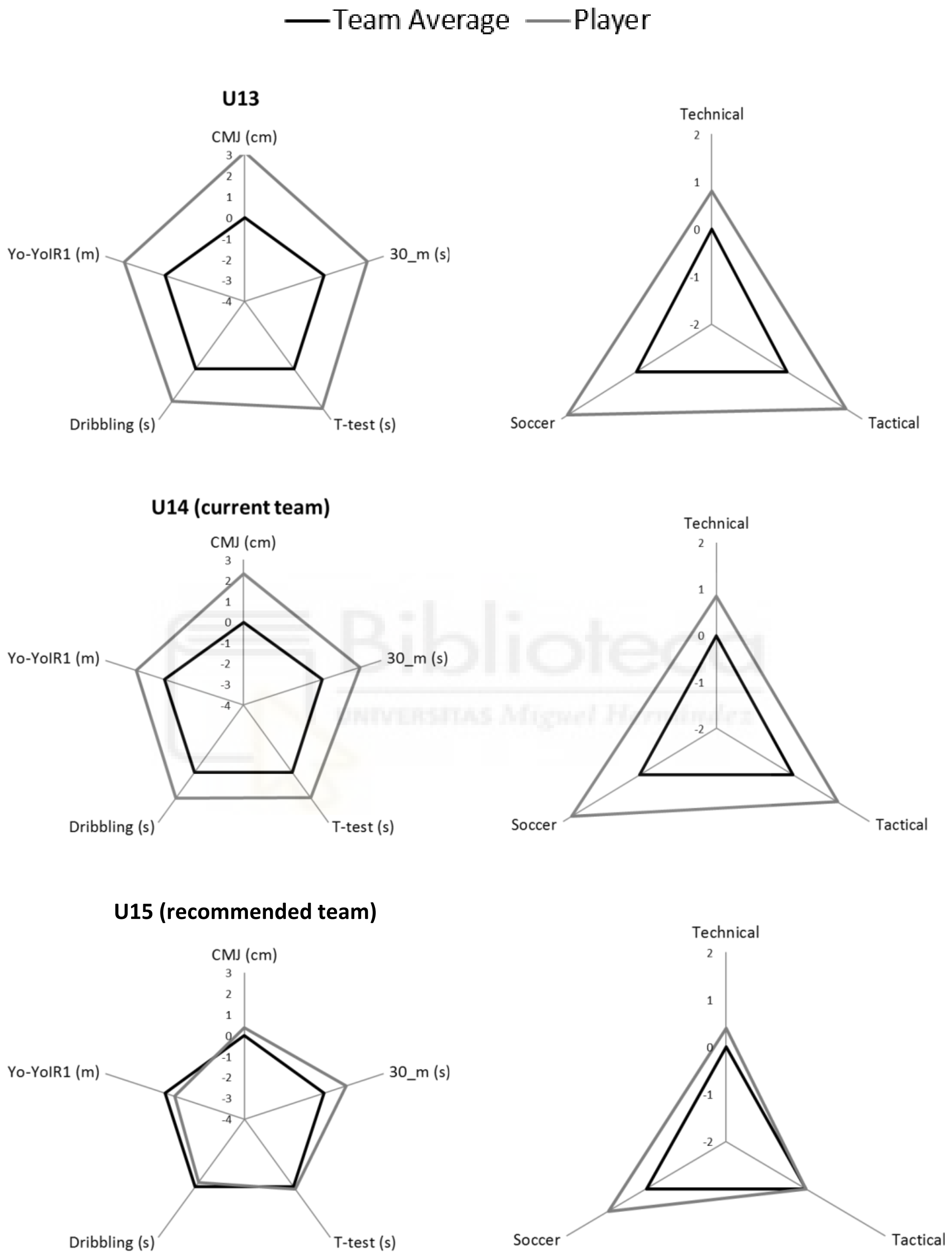

Figure 4. Comparison of the players' physical performance and coaches' expectations with different team averages.

Table 15. Example 3 (Player 2.10). Recommended to go down.

		U13		U14		U15		Z-Scores		
Player_2.10		M	SD	M	SD	M	SD	**U13**	**U14**	**U15**
Physical Performance										
CMJ (cm)	26.2	26.9	3.4	30.2	3.2	35.9	4.3	-0.22	-1.25	-2.24
30_m (s)	5.19	5.20	0.25	5.00	0.18	4.80	0.13	0.06	-1.10	-2.99
T-test (s)	10.27	10.54	0.44	10.01	0.32	9.55	0.23	0.62	-0.81	-3.10
Dribbling (s)	14.41	14.29	0.73	13.86	0.62	12.71	0.74	-0.16	-0.89	-2.29
Yo-YoIR1 (m)	320	370	188	533	158	864	216	-0.27	-1.35	-2.51
Recommendation based on the physical performance									**-1**	
Expectations										
Technical	2.00	3.1	1.1	3.2	0.9	3.4	1.5	-1.03	-1.28	-0.93
Tactical	1.00	2.9	0.7	3.1	0.7	4.0	1.1	-2.85	-2.87	-2.81
Soccer	2.00	3.1	1.0	3.2	1.0	3.9	1.2	-1.10	-1.18	-1.57
Recommendation based on the coaches' expectations									**-1**	
Maturity Status										
PHV	-1.36	-0.77	0.57	0.31	0.99	1.32	0.49			
Recommendation based on the maturity status									**-1**	
Final Recommendation									**-3**	
Recommended to downgrade										

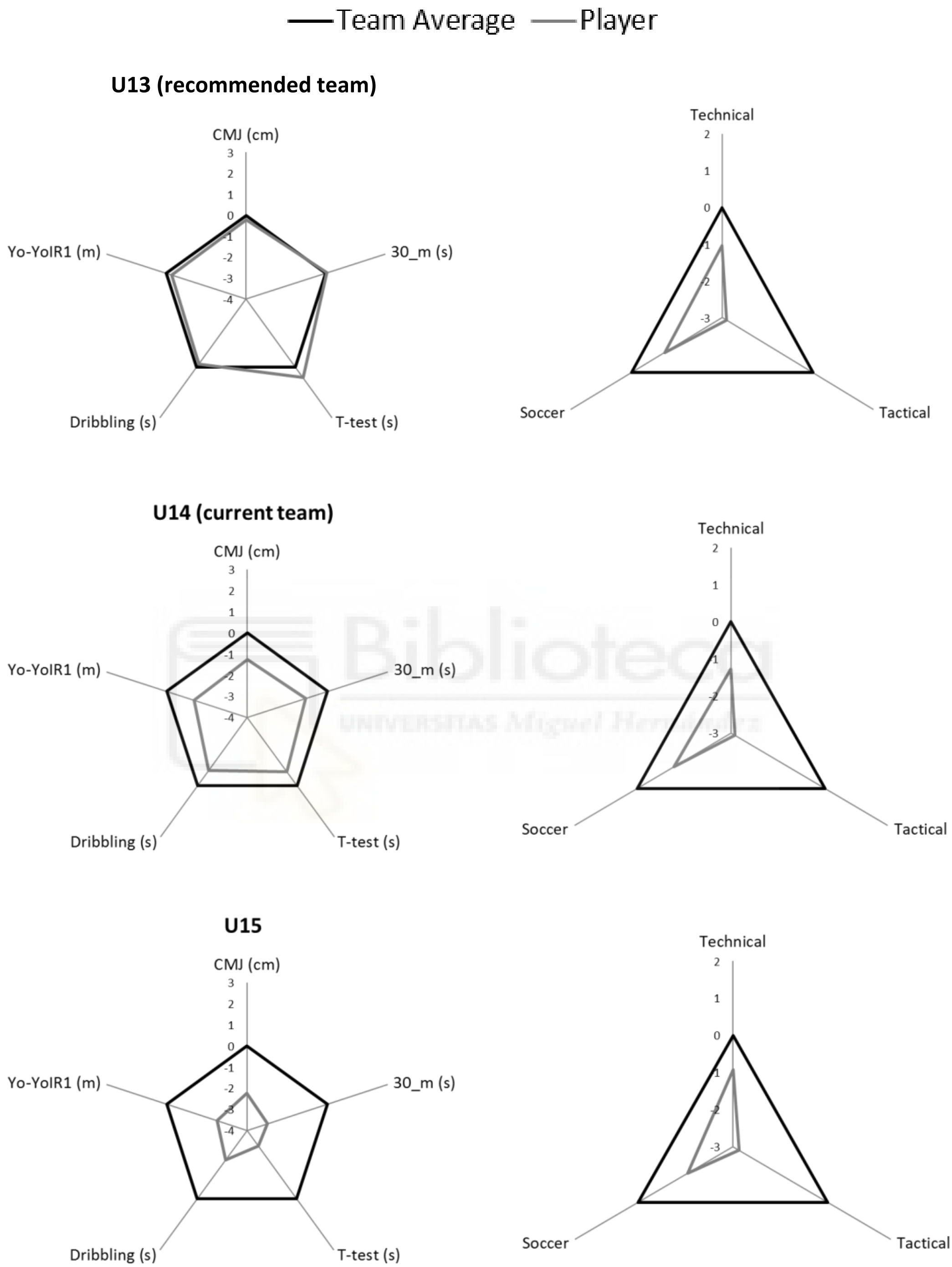

Figure 5. Comparison of the players' physical performance and coaches' expectations with different team averages.

Tables 13, 14 and 15 show the physical performance, coaches' expectations and maturity status of three players from team 2 as example. In each table, the average and the standard deviation of their current team (U14), the team below (U13) and the next team (U15) are reported. The last columns show the players' values normalized with Z-scores for each team. Figures 3, 4 and 5 show the players' normalized data for physical performance and for the coaches' expectations to compare them with the average values of each team.

This first approach to the young soccer players' aggrupation by their maturity status, physical performance and coaches' efficacy expectations presents some limitations. The main limitation of this proposal is that the limits for the classification of the players as "average", "better" or "worse" performers in physical tests and in coaches' expectations are set based on the authors experience. More research about the variance explained by each variable is needed for the improvement of this tool. This physical test battery is proposed based on the easy methods and materials to carry it out and because it evaluates the most important attributes of soccer, but other physical test may be used. In the same way, the years from/to the PHV was chosen as this method is the most used for the maturity evaluation, but other maturity assessments are possible.

The general aim of this proposal is to start a research line to investigate how the maturity status, the physical performance and the technical/tactical attributes of the players interact and influence the identification of talented players, the selection process of those players and the development programs for those players.

EPILOGUE

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EPILOGUE

GENERAL CONCLUSIONS

The general aim of the present thesis was to assess the main variables that may bias talented young soccer players' identification and selection processes, highlighting the biological maturation differences between players and relating these maturity-related differences with the physical performance and the training adaptations of young soccer players. In this regard, the main conclusions from this thesis include: (1) a reported bias in the current studied sample for the soccer participation, favoring the early born players, (2) anthropometrical and physical performance differences between young players with different maturity status, as well as (3) different adaptations to the strength training, and (4) the importance of the coaches' expectations in the talent identification and selection process.

The first study of the present thesis analysed the birth distribution of the young soccer players and the effect of the biological maturation and the date of birth in the anthropometrics, in the physical performance tests and in the coaches' efficacy expectations. The second study, analysed the anthropometrical and physical performance and coaches' expectations differences between players with different maturity status. The third study, carried out a strength-training program to evaluate the differences in physical adaptations of players with different maturity status. The future research line suggests new method for grouping young soccer players regarding their maturity status, their physical performance and the expectations of their coaches about them.

The findings of the present thesis may help coaches and soccer professionals understand the current biases in the talent identification and selection process better, and it may be useful for the soccer clubs to reduce the relative age effect, to individualize the training stimulus regarding the maturity status and even to create more homogeneous groups and teams, allowing a fairer youth soccer practice.

The major contributions of the present thesis were:

1. Young soccer participation is biased by the date of birth, favoring players born earlier in the selected year.

2. The birth quartile is not a discriminating factor for physically performing better players, whereas the maturity status of the players does affect the physical performance.

3. Anthropometrical and physical performance variables are different between players with different maturity status, favoring those more mature players.

4. Players with different maturity status have different adaptations to different strength-training programs.

5. Coaches do not perceive the physical performance advantage of players with an advanced maturity status.

THESIS LIMITATIONS

The present doctoral thesis includes some limitations that may be the starting point of future research lines and projects in the Analysis and Training Optimization Laboratory of the Sports Research Center of the Miguel Hernández University of Elche. These study limitations and future research projects are presented:

1. *The evaluation of the Learning Effect of RM and PP tests.* All the coaches and trainers of the teams that participated in the studies with evaluation of the RM and PP in squat movement affirmed that their players were strongly familiarized with this kind of exercise and movement. However, large individual changes in the results of these tests between the different testing sessions made us think that a learning effect of the test may have influenced the improvement. The learning effect in RM and PP tests in young athletes

has not been investigated and the results could show us if a familiarization process is necessary or how many familiarization sessions are necessary in these tests for this population.

2. *The soccer-specific training loads*. Although the strength training was supervised to the correct administration for the strength-training loads in all teams during the monitoring period of teams in the third study, coaches of the teams were free to prepare and design their soccer-specific trainings in the pitch. This fact might mean differences in total training loads between teams. The authors tried to control this limitation by blocking any kind of strength training during the soccer-specific training. In future analysis of the adaptations of young players with different maturity status, all training stimulus, as soccer-specific training loads, and not only the strength-training program loads must be collected.

3. *Maturity classification of young players*. In this thesis, players have been classified into three maturity groups according to their PHV. In previous studies the aggrupation of players by maturity status for the analysis usually appears as: Pre-PHV < -1 to the PHV and Post-PHV > 1 from the PHV. However, the grouping limits in the present thesis was set at -0.5 and 0.5 respectively. The purpose of reducing the PHV difference between players was (1) to reduce the chronological age dispersion of the participants and (2) to reduce the biological differences between groups to perform a more exhaustive analysis, making the results more solid.

4. *The coaches' efficacy expectations assessment.* The validity of this measure was reported in previous bibliography and the reliability values in the different studies of this thesis support its use. However, for further evaluation of the coaches' expectations in soccer, the same people must evaluate all

players from all teams if the purpose is to compare different players between teams, due to the possible inter-individual differences between coaches or evaluators.

EPÍLOGO

CONCLUSIONES GENERALES

El objetivo general de esta tesis fue identificar aquellos aspectos que influyen en el proceso de identificación y selección de talentos en fútbol, haciendo hincapié en las diferencias madurativas entre jugadores y relacionando esas diferencias madurativas con el rendimiento físico y las adaptaciones al entrenamiento en jóvenes jugadores de fútbol. En este sentido, entre las principales conclusiones de esta tesis se incluyen: (1) un sesgo en la participación de jóvenes jugadores de fútbol que favorece a los nacidos en los primeros meses del año, (2) diferencias en las medidas antropométricas y de rendimiento físico entre jugadores con diferente estado madurativo, así como (3) diferente adaptaciones al entrenamiento de fuerza, y (4) la importancia de las expectativas de eficacia del entrenador en el proceso de identificación y selección de talentos en fútbol.

El primer estudio de esta tesis analizó la distribución de los jugadores por cuartil de nacimiento y el efecto de la maduración biológica y del cuartil de nacimiento en las medidas antropométricas, el rendimiento físico y las expectativas de eficacia del entrenador hacia los jugadores. En el segundo estudio, se analizaron las diferencias en las medidas antropométricas, el rendimiento físico y las expectativas de eficacia del entrenador entre jugadores con estados madurativos distintos. En el tercer estudio, se llevó a cabo un programa de entrenamiento de la fuerza para evaluar las diferencias en las adaptaciones al entrenamiento de jugadores con distinto estado madurativo. En la futura línea de investigación, se propuso un nuevo método para agrupar a los jóvenes jugadores de fútbol en función del estado madurativo, el rendimiento físico y las expectativas de eficacia del entrenador.

Los hallazgos de la presente tesis doctoral pueden ayudar a entrenadores y profesionales del fútbol base a entender mejor los actuales sesgos en los procesos de identificación y selección de jóvenes talentos en fútbol. Además, estos resultados pueden ser útiles para los clubes de fútbol base para reducir el efecto de la edad relativa, individualizar el entrenamiento en función del estado madurativo e incluso para crear grupos de entrenamiento y equipos más homogéneos, permitiendo una práctica más igualitaria y justa en el fútbol base.

Las principales contribuciones de esta tesis fueron:

1. La participación en fútbol base está sesgada por la fecha de nacimiento, favoreciendo a los jugadores que nacen en los primeros meses del año.

2. El cuartil de nacimiento no es un factor que determina el rendimiento físico de los jugadores, mientras que el estado madurativo de los jugadores si afecta el rendimiento físico.

3. Las variables antropométricas y de rendimiento físico son diferentes entre jugadores con distinto estado madurativo, con mayores valores para los jugadores con un estado madurativo más avanzado.

4. Los jugadores con distinto estado madurativo tienen distintas adaptaciones a diferentes programas de entrenamiento de la fuerza.

5. Los entrenadores no son capaces de percibir la ventaja en el rendimiento físico de los jugadores con un estado madurativo avanzado.

LIMITACIONES DE LA TESIS

Esta tesis doctoral incluye algunas limitaciones que pueden suponer un punto de partida para futuras líneas de investigación y proyectos en el Laboratorio de Análisis y Optimización del Entrenamiento del Centro de Investigación del Deporte de la Universidad Miguel Hernández de Elche. Estas limitaciones y futuros posibles proyectos se presentan a continuación:

1. *La evaluación del Efecto Aprendizaje de los test de RM y PP.* Todos los entrenadores y preparadores físicos de los equipos que participaron en los estudios que evaluaban el RM y el PP en sentadilla afirmaron que sus jugadores estaban muy familiarizados con esta clase de ejercicios y movimientos. Sin embargo, grandes cambios individuales en los resultados de estos test entre las diferentes sesiones de evaluación pueden hacernos pensar que un posible efecto aprendizaje puede estar influyendo en estas mejoras. El efecto aprendizaje en los test de RM y PP en jóvenes deportistas no ha sido investigado hasta ahora y los resultados podrían mostrarnos si es necesario un proceso de familiarización antes de evaluar estos test o cuántas sesiones de familiarización harían falta en esta población.

2. *Las cargas de entrenamiento específico de fútbol.* Aunque durante el periodo de entrenamiento y evaluación de los equipos en el tercer estudio se supervisó que el entrenamiento de fuerza se realizara correctamente en todos los equipos, los entrenadores de estos equipos tenían libertad para preparar y diseñar sus entrenamientos específicos de fútbol. Este hecho pudo suponer diferencias en las cargas totales de entrenamiento semanal entre equipos. Los autores trataron de contrarrestar esta posible limitación no permitiendo ningún tipo de entrenamiento de la fuerza durante los entrenamientos específicos de fútbol. En futuras investigaciones sobre las adaptaciones al entrenamiento de jóvenes jugadores de fútbol, todos los estímulos de entrenamiento deberían ser controlados y todas las cargas de entrenamiento analizadas.

3. *La clasificación de los jóvenes jugadores en función de su estado madurativo.* En esta tesis, los jugadores fueron clasificados en tres grupos madurativos de acuerdo a su PHV. En estudios previos, la agrupación de estos jugadores por su estado madurativo fue: Pre-PHV < -1 año para el PVC

y Post-PHV > 1 año desde el PHV. Sin embargo, los límites para la agrupación en los artículos presentados en esta tesis fueron -0.5 and 0.5 respectivamente. El objetivo de reducir este rango fue (1) disminuir la dispersión de los datos de edad cronológica de los participantes y (2) reducir las diferencias biológicas entre grupos para realizar un análisis más exhaustivo, de tal forma que los resultados fueran más sólidos.

4. *La evaluación de las expectativas de eficacia del entrenador.* La validez de esta medida está mostrada por la bibliografía previa y los valores de fiabilidad presentados en los distintos trabajos de esta tesis avalan su uso. Sin embargo, para evaluaciones futuras de las expectativas de eficacia sobre los jugadores de fútbol, las mismas personas deberían evaluar a todos los jugadores si el objetivo es comparar estas expectativas entre jugadores de distintos equipos debido a posibles diferencias entre entrenadores a la hora de evaluar esta medida.

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Hoy creces un poco más,

Es inevitable sentir este orgullo que recorre todo el corazón,

Aún niño, pero con una convicción ya forjada; y es que hoy nos da una gran lección ese tu gran esfuerzo.

Marc Téllez González