Universidad del País Vasco / Euskal Herriko Unibertsitatea

MDe — Master eta Doktorego Eskola / Escuela de Máster y Doctorado / Master and Doctoral School

PROGRAMA DE DOCTORADO

Facultad de Educación y Deporte

Departamento de Educación Física y Deportiva

Cuantificación de las respuestas físicas y fisiológicas y análisis de la fatiga inducida por los partidos oficiales en árbitros de fútbol

TESIS DOCTORAL

Presentada por

Daniel Castillo Alvira

Vitoria, 2017

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Dirigida por

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Vitoria, 2017

A mi padre y a mi madre por brindarme la oportunidad de decidir y apoyarme en todas mis decisiones

A mi tía por su lucha a la vida y a mi abuela por su carácter indomable

A mi hermano por transmitirme calma en todo momento

A mi fiel compañera en este viaje, a ti Silvia

PREFACIO Y AGRADECIMIENTOS

De niño, lo confieso, me gustaba ir a clase y aprender junto a mis amigos, pero sobre todo, ansiaba y soñaba con las sesiones de educación física. Desde pequeñito sentía que amaba el mundo de la actividad física y del deporte. Era capaz, tanto de estar ininterrumpidamente jugando con mis amigos a cualquier juego, como de aprenderme el nombre de todos los jugadores y entrenadores de la Liga de fútbol.

Mi vida siempre ha estado unida al deporte, y especialmente al fútbol. Mis inicios fueron en el patio del colegio y en los campos de tierra donde se jugaba el campeonato interescolar. Fantásticos recuerdos con mis amigos de la infancia y de mi primer entrenador, Gofi. Especial cariño guardo al C.D. Tudelano, ocho años vistiendo su camiseta con orgullo con distintos entrenadores (Jose Luis, Antonio, Catalán, Manolo, Zubi, etc.). Así mismo, recuerdo mis primeros contactos con el arbitraje cuando Eusebio nos designaba los partidos y mis primeros pasos como entrenador en el C.D. Lakua con unos chavales que contagiaban su sonrisa.

Mi madre, a quien no le gusta el fútbol, aun no ha visto el gol de Iniesta de la final del Mundial de Sudáfrica, y mi padre, quien siempre asistía a los partidos para jugar la partida de mus con los demás padres, son quienes me inculcaron el amor por el deporte formativo como un medio para disfrutar y divertirse. Mi hermano, alumno aventajado, siempre me acompañó allá donde el fútbol me llevaba.

Esta tesis doctoral ha sido realizada gracias al apoyo de numerosas personas que me han aportado aquello que necesitaba para lograr este reto. De este modo, quisiera agradecer de forma muy especial a todos los profesores de la Facultad de Educación y Deporte de la Universidad del País Vasco (UPV/EHU) que tras doce años en esta "casa" me han aportado su "granito de arena" para crecer como persona y como profesional, y especialmente a Asier por las interminables charlas sobre fútbol en los rincones del "IVEF", a Guillermo porque en su locura siempre encuentras consejos para la vida, a Raúl por su cercanía cuando la he necesitado y a Julen por su predisposición en mi formación predoctoral. También agradezco a todos mis compañeros de la universidad las experiencias vividas durante estos años maravillosos de carrera universitaria. Agradezco enormemente a Aarón, Alex y Luisja por todos los momentos que hemos compartido juntos.

No puedo olvidarme de todos aquellos que han convivido conmigo estos años en Vitoria, del fútbol base del Deportivo Alavés, a Endika e Ibon por apostar por mí, a Popi, Polvo, Mikel, Aimar, Ibai, Odei, Iván, Jorge y Amaya, por todos los momentos compartidos dentro y fuera de los terrenos de juego.

Al Comité Navarro de Árbitros de Fútbol, por vuestro interés y colaboración para que esta tesis haya sido posible. Siempre me habéis dado facilidades para llevar a cabo todos los pasos de este minucioso proyecto de investigación. Alberto, Edu y Julio por permitirme disfrutar de vuestros éxitos.

Agradezco a toda mi familia por haber comprendido mis ausencias en las reuniones familiares. Agradezco a mi "tío" Pedro por llamarme todas las semanas, por interesarse por mí como si fuese un hijo y por despertarme para ver a Nadal y a Gasol. A Cris por ser como mi hermana mayor.

A la Escuela Ribera de Fútbol por haberme inculcado vuestros valores: trabajo en equipo, convivencia, motivación y esfuerzo. Muy agradecido por formar parte de vosotros y encantado de seguir enganchado a nuevos retos.

Agradezco a Jesús López Bailo su interés por mi persona y su capacidad para contagiar amor por el deporte.

A todos mis amigos. A Rodés, Royo, Galgo, Jorge, Edu, Nacho, Jose Ignacio y David, porque ya son doce años fuera de casa y hemos tenido que compartir la mayoría de nuestros hobbies desde la distancia.

Agradezco a Asier Los Arcos por su magnífica acogida en el C.A. Osasuna, por nunca olvidarse de ese alumno que pasó por Tajonar y por haber compartido tareas de investigación en este periodo de mi vida.

A mis directores de tesis doctoral. A Javier Yanci Irigoyen por ser el modelo donde fijarme, su organización, trabajo inteligente y practicidad han sido claves en mi formación predoctoral. A Jesús Cámara Tobalina por transmitirme que la perfección está en los pequeños detalles, sus profundas revisiones han aportado calidad a este trabajo.

Por último, quisiera agradecer a Silvia por haber comprendido que luchar por un sueño nunca fue tarea fácil y siempre haberme demostrado su cariño y respeto por todas mis decisiones.

Es justamente la posibilidad de realizar un sueño lo que hace que la vida sea interesante.

(Paulo Coelho)

DECLARACIÓN:

Yo, Daniel Castillo Alvira soy el autor de esta tesis doctoral, que junto con la ayuda de mis dos directores Javier Yanci Irigoyen y Jesús Cámara Tobalina, he participado desde el minucioso trabajo del diseño de la investigación hasta la redacción del documento final. He abordado cada paso del plan de trabajo de forma exhaustiva y sistemática. Para ello, y como parte del presente proyecto, he asistido a treinta partidos de fútbol oficiales de la Tercera División Española (Grupo XV) durante la temporada 2014-2015, donde he recogido todos los datos con seriedad, rigurosidad y profesionalidad. La toma de datos me ha requerido, a mi entender, de una alta capacidad de concentración, atención y sobre todo, de la habilidad para responder de forma rápida y resolutiva a situaciones imprevistas generadas durante la competición. Durante la toma de datos he sido el responsable de solicitar el material necesario a la Facultad de Educación y Deporte de la Universidad del País Vasco (UPV/EHU), de gestionar la compra de material desechable así como de la realización de los informes individualizados para los colegiados. Posterior a cada toma de datos he realizado el análisis e interpretación de los mismos. Estas tareas las he realizado a la vez que llevaba a cabo una exhaustiva lectura de todas las publicaciones indexadas en el *Journal Citation Report* (JCR) sobre el arbitraje.

En una fase posterior he contrastado los resultados obtenidos con los presentes en la literatura científica. De esta forma, he ido elaborando y redactando los estudios que conforman los capítulos 3, 4, 5 y 6. Nada de esto hubiera sido posible sin la guía de mis directores. A ellos les debo mi formación durante este periodo; ellos se han involucrado en orientarme desde el diseño del estudio hasta su publicación en revistas científicas. Durante este proceso he colaborado con investigadores especialistas en el área de estudio que, desde diferentes enfoques, han ayudado a mejorar la calidad del trabajo. Además, he diseñado otros proyectos de investigación cuyos resultados los he presentado como artículos científicos, comunicaciones orales y posters en congresos nacionales e internacionales. Ninguno de estos resultados forman parte de la presente tesis doctoral.

Las investigaciones llevadas a cabo han sido financiadas por el Gobierno Vasco mediante el Programa de Formación de Personal Investigador no doctor del Departamento de Educación, Política Lingüística y Cultura (números de referencia: PRE_2013_1_896, PRE_2014_2_54, PRE_2015_2_0007 y PRE_2016_2_0061). Además, la UPV/EHU proporcionó parte del material gracias a la financiación del proyecto “Evaluación del proceso de entrenamiento y la

competición en el fútbol de formación durante el periodo 2012-14 (Código 13523)" cuyo investigador principal fue el Dr. Julen Castellano Paulis.

Esta tesis doctoral así como cada uno de los artículos publicados que la conforman no presentan conflicto de intereses por parte de los autores ni familiares.

CONSEJOS PARA LA LECTURA:

Esta tesis doctoral está elaborada y presentada en formato de compendio de publicaciones. En un primer capítulo, a modo de introducción, he presentado un resumen de la literatura científica que aborda tanto las respuestas físicas y fisiológicas de los árbitros y asistentes durante los partidos de fútbol, así como del análisis de la fatiga que le supone a los colegiados el arbitraje de los partidos. Seguidamente, en un segundo capítulo, he planteado los objetivos y las hipótesis de la tesis.

Posteriormente, he presentado cuatro estudios científicos publicados o aceptados para su publicación en revistas internacionales indexadas en la lista JCR. Todos los estudios han sido redactados en el idioma (inglés) requerido por las revistas donde se han publicado. A pesar de que he mantenido el formato exigido por las revistas científicas para la bibliografía citada dentro del texto y para la lista de referencias bibliográficas, he unificado el formato del texto para facilitar la lectura de la tesis. Todos los estudios presentados en esta tesis doctoral siguen una misma temática basada en la descripción de las respuestas físicas y fisiológicas y el análisis de la fatiga inducida por los partidos oficiales en árbitros de fútbol. En el capítulo 3, he incluido el primer estudio titulado *The influence of soccer match play on physiological and physical measures in soccer referees and assistant referees*. En él se analiza la influencia de los partidos de fútbol en la fatiga atendiendo a indicadores de rendimiento físico y fisiológico en los árbitros. El segundo estudio, *Impact of official matches on soccer referees' horizontal-jump performance* conforma el capítulo 4. En dicho estudio se determina el impacto de la competición en el rendimiento del salto horizontal en los colegiados. En el capítulo 5, he presentado el tercer estudio, titulado *Relationships between internal and external match load indicators in soccer match officials*, que examina las asociaciones entre las variables de carga interna y externa durante los partidos de fútbol. En el capítulo 6, he expuesto el cuarto estudio titulado *Football match officials do not attain maximal sprinting speed during matches*, donde se comparan las velocidades máximas alcanzadas por los árbitros tanto en competición como en test específicos.

En el capítulo 7 presento a modo de conclusión los resultados más relevantes de cada estudio. Además, en los capítulos 8, 9 y 10 he redactado las aplicaciones prácticas y transferencia al conocimiento, las limitaciones y las futuras líneas de investigación de la tesis doctoral, respectivamente.

Por último, en el capítulo 11 he insertado las referencias bibliográficas utilizadas, excluyendo aquellas propias de los estudios, y en el capítulo 12, denominado como anexos, he incluido el índice de calidad de las revistas donde se han publicado o han sido aceptados para publicación los estudios presentados en esta tesis doctoral, la carta de aceptación del Comité de Ética para las Investigaciones relacionadas con Seres Humanos (CEISH) de la UPV/EHU en versión original, un listado de otras publicaciones científicas, capítulos de libro, comunicaciones orales, posters presentados en congresos y jornadas nacionales e internacionales, todas ellas relacionadas con la temática de la tesis doctoral, que he realizado en el período de formación predoctoral.

Abreviaturas:

Castellano

AA = árbitros asistentes.

AC = árbitros de campo.

CEISH = Comité de Ética para las Investigaciones relacionadas con Seres Humanos.

CNAF = Comité Navarro de Árbitros de Fútbol.

CTA = Comité Técnico de Árbitros.

dRPE = esfuerzo percibido diferenciado.

FC = frecuencia cardiaca.

FC_{med} = frecuencia cardiaca media.

FC_{max} = frecuencia cardiaca máxima.

FIFA = Federación Internacional de Fútbol Asociado.

GPS = sistemas de posicionamiento global.

RPE = percepción subjetiva del esfuerzo.

UPV/EHU = Universidad del País Vasco.

Inglés

AR = assistant referees.

BMI = body mass index.

CL = confidence limits.

CMJ = bilateral countermovement jump.

CMJD = unilateral countermovement jump with the dominant leg.

CMJND = unilateral countermovement jump with the non-dominant leg.

COD = change of direction.

CV = coefficient of variation.

dRPE = differential perceived exertion.

ES = effect size.

FIFA = Federation International of Football Associations.

FR = field referees

GPS = global positioning system.

High-Acc = high-intensity accelerations.

High-Dec = high-intensity decelerations.

HSR = high speed running.

HJ = horizontal jump with two legs.

HJ*left* = horizontal jump with left leg.

HJ*right* = horizontal jump with right leg.

HR = heart rate.

HR_{max} = maximum heart rate.

HR_{mean} = mean heart rate.

ICC = intraclass correlation coefficient.

IF = Impact Factor.

LSST = linear straight sprinting test.

ML = match load.

Moderate-Acc = moderate-intensity accelerations.

Moderate-Dec = moderate-intensity decelerations.

PL = player load.

RPE_{mus} = rating of perceived muscular exertion.

RPE_{res} = rating of perceived respiratory exertion.

SD = standard deviation.

SLST = straight line sprint test.

TD = total distance.

TL = training load.

$TRIMP_{EDW}$ = Edwards' heart rate derived training impulse.

UEFA = Union of European Football Associations.

Vel_{max} = maximum velocity.

Vel_{mean} = mean velocity.

ÍNDICE DE CONTENIDOS

Capítulo 1

Introducción

Si quieres que algo se haga, encárgaselo a una persona ocupada.

Proverbio chino

Capítulo 1. Introducción

Un total de 270 millones de personas, aproximadamente el 4% de la población mundial (Population Matters, 2017), participan activamente en el fútbol de manera profesional, semi-profesional o amateur (FIFA, 2016b). El fútbol es un deporte que tiene la capacidad de influir sobre millones de personas y países al mismo tiempo debido a que actúa como fenómeno económico, político, cultural, solidario y educativo (Alcaide, 2009). El arbitraje ha tomado un papel relevante dentro del mundo del fútbol ya que la actuación del colectivo arbitral es indispensable para el desarrollo de los partidos, sobre todo, porque los árbitros son los encargados de hacer cumplir la normativa establecida en cada competición (FIFA, 2000; Samuel, Galily, & Tenenbaum, 2015). Considerando que alrededor de dos millones de colegiados son los encargados de oficiar los partidos de fútbol en todas las competiciones del mundo (FIFA, 2016a), un análisis de las exigencias físicas y fisiológicas durante el desempeño de la actividad arbitral puede ser relevante con el fin de conocer los requerimientos del arbitraje durante la competición.

El interés científico por conocer el rendimiento físico durante los partidos y el perfil de condición física de los árbitros de fútbol ha crecido de forma sustancial a lo largo de las últimas dos décadas (Weston, 2015). La búsqueda en una de las bases de datos relevantes desde el punto de vista científico (PubMed) con los términos (*soccer* OR *football* AND *referees* OR *match officials*) muestra que hasta el año 1997 solamente dos investigaciones científicas habían sido publicadas (Catterall, Reilly, Atkinson, & Coldwells, 1993; Johnston & McNaughton, 1994), sin embargo, en los últimos veinte años han sido publicados aproximadamente setenta y cinco artículos en revistas internacionales abordando temáticas muy variadas (Boullosa, Abreu, Tuimil, & Leicht,2012; Castagna, Bendiksen, Impellizzeri, & Krustrup, 2012; Castagna, Bizzini, Povoas, & D'Ottavio, 2017; Da Silva & Fernandez, 2003; Gabrilo, Ostojic, Idrizovic, Novosel, & Sekulic, 2013; Houssein et al., 2016; Kordi, Chitsaz, Rostami, Mostafavi, & Ghadimi, 2013; MacMahon, Helsen, Starkes, & Weston, 2007; Mallo, Frutos, Juarez, & Navarro, 2012; Reilly & Gregson, 2006). Estos datos muestran el interés de la comunidad científica por ampliar el conocimiento sobre el arbitraje desde diferentes enfoques (cuantificación de las demandas físicas y fisiológicas en competición, efectividad de programas de entrenamiento, perfil de condición física y de antropometría, lesiones, etc.).

El árbitro de campo (AC) junto con los dos árbitros asistentes (AA) son los encargados de controlar los comportamientos y conductas de los jugadores así como de garantizar la aplicación de las diecisiete reglas del juego que conforman el reglamento de la Federación Internacional de Fútbol Asociado (FIFA), las cuales, se han ido desarrollando progresivamente y adaptando a la evolución del fútbol (IFAB, 2016). Los árbitros, además de tomar decisiones durante los partidos (MacMahon et al., 2007; Weston, 2015) deben interactuar con los jugadores en el terreno de juego (Weston, Castagna, Impellizzeri, Rampinini, & Abt, 2007; Weston, Drust, & Gregson, 2011). Los árbitros deben ser capaces de seguir el ritmo de juego (Weston et al., 2012) para estar cerca de la jugada, y de esta manera, tener una mayor probabilidad de éxito en sus decisiones durante el desarrollo de los partidos (Mallo et al., 2012). Por ello, consideramos especialmente necesario investigar sobre los métodos de cuantificación de las demandas físicas y fisiológicas que suponen los partidos de fútbol para los colegiados.

Uno de los aspectos más investigados del arbitraje es el relacionado con la optimización del entrenamiento siendo el principal objetivo, mejorar el rendimiento del árbitro (Casajus & Gonzalez-Aguero, 2015; Castagna, Abt, & D'Ottavio, 2005; Krustrup & Bangsbo, 2001; Weston, Gregson, et al., 2011; Yanci, Los Arcos, Grande, & Casajús, 2016). Resulta fundamental el uso de instrumentos de medida que permitan conocer de forma precisa la carga soportada por los árbitros durante la competición, y de esta forma, adaptar los entrenamientos a las necesidades individuales (Castagna, Impellizzeri, Chaouachi, Bordon, & Manzi, 2011; Costa et al., 2013; Mallo, Navarro, Garcia-Aranda, & Helsen, 2009; Weston, Drust, Atkinson, & Gregson, 2011; Weston, Drust, & Gregson, 2011). Partiendo de este conocimiento, se pueden establecer programas de entrenamiento adecuados dirigidos hacia las cualidades condicionales específicas (Mujika, 2013; Weston, 2013). Así, en los deportes colectivos, distintas variables se han tenido en cuenta, pudiendo ser clasificadas en función de si hacen referencia al análisis de las demandas físicas y fisiológicas (carga externa e interna, respectivamente) (Ade, Fitzpatrick, & Bradley, 2016; Akenhead, Hayes, Thompson, & French, 2013; Arcos, Martinez-Santos, Yanci, Mendiguchia, & Mendez-Villanueva, 2015; Arcos, Yanci, Mendiguchia, & Gorostiaga, 2014; Bradley et al., 2013; Buchheit et al., 2014; Castagna, Varley, Povoas Araujo, & D'Ottavio, 2016; Dalen, Ingebritsen, Ettema, Hjelde, & Wisloff, 2016; Dellal et al., 2012; Mendez-Villanueva & Buchheit, 2011; Meylan, Trewin, & McKean, 2016; Sarmento et al., 2014) o al rendimiento en determinados test físicos y parámetros fisiológicos antes y después de los partidos (Andersson et al., 2008; Boullosa & Tuimil, 2009; Boullosa, Tuimil, Alegre, Iglesias, & Lusquinos, 2011; Clemente, Muñoz, & Melus, 2011; Cortis et al., 2013; Cortis et al., 2011; Freitas, Nakamura, Miloski, Samulski, &

Bara-Filho, 2014; Gathercole, Sporer, Stellingwerff, & Sleivert, 2015; Johnston, Gabbett, Jenkins, & Hulin, 2014; Krustrup, Zebis, Jensen, & Mohr, 2010; Mooney, Cormack, O'Brien B, Morgan, & McGuigan, 2013; Nagahara, Morin, & Koido, 2016; Nedelec et al., 2014; Povoas et al., 2014; Rahnama, Reilly, Lees, & Graham-Smith, 2003; Skof & Strojnik, 2006; Stackhouse, Binder-Macleod, & Lee, 2005; Tessitore, Cortis, Meeusen, & Capranica, 2007; Thorlund, Aagaard, & Madsen, 2009; Tur & Gonzalez-Haro, 2011).

La carga externa e interna que les supone jugar a los jugadores de fútbol ha sido ampliamente estudiada (Ade et al., 2016; Arcos et al., 2015; Arcos et al., 2014; Barnes, Archer, Hogg, Bush, & Bradley, 2014; Bradley et al., 2013; Bradley, Di Mascio, Peart, Olsen, & Sheldon, 2010; Bradley, Lago-Penas, & Rey, 2014; Bradley et al., 2009; Bush, Barnes, Archer, Hogg, & Bradley, 2015; Campos-Vazquez et al., 2015; da Mota, Thiengo, Gimenes, & Bradley, 2016; Di Salvo et al., 2010; Di Salvo, Gregson, Atkinson, Tordoff, & Drust, 2009; Harley et al., 2010; Los Arcos, Méndez-Villanueva, Yanci, & Martínez-Santos, 2016; McLaren, Graham, Spears, & Weston, 2016; Paul, Bradley, & Nassis, 2015; Sparks, Coetzee, & Gabbett, 2016; Suarez-Arrones et al., 2015; Weston, Batterham, et al., 2011). Sin embargo, solamente algunos estudios científicos se han centrado en el análisis de las demandas físicas y fisiológicas en el colectivo arbitral (Castagna & Abt, 2003; Castagna, D'Ottavio, & Abt, 2003; Costa et al., 2013; Krustrup et al., 2009; Mallo, Navarro, García-Aranda, & Helsen, 2009a; Weston et al., 2007; Weston, Drust, Atkinson, et al., 2011; Weston, Drust, & Gregson, 2011). Estos estudios han puesto de manifiesto que arbitrar es una actividad exigente desde los puntos de vista físico y fisiológico durante competiciones nacionales e internacionales de alto nivel. Dado que en varios países los árbitros de categoría no profesional ofician partidos prácticamente cada fin de semana en las competiciones de categorías inferiores y de niveles competitivos más bajos (Ardigó, 2010), podría ser interesante conocer las respuestas físicas y fisiológicas no solo de árbitros de alto nivel sino también de árbitros de categoría amateur.

La cuantificación de la carga externa (distancia recorrida, tipo, intensidad y duración de los desplazamiento, etc.) e interna (respuesta de la frecuencia cardiaca, consumo de oxígeno, acumulación de ácido láctico, variaciones bioquímicas, etc.) durante los partidos de fútbol (Gómez-Tamayo, 2016) permite valorar las demandas de la competición, proporciona información específica para el diseño de estrategias de entrenamiento y facilita la planificación y periodización de las sesiones de entrenamiento (Weston, 2015). Por ello, cuantificar las demandas físicas y fisiológicas que suponen las tareas de entrenamiento y la competición es importante de cara a aplicar una adecuada dosis de entrenamiento, y de esta manera, optimizar el rendimiento y minimizar el riesgo de lesión de los deportistas (Barrett et al., 2016; Drew & Finch, 2016; Mujika, 2013; Weston, 2013; Wilson, Byrne, & Gissane, 2011).

Los AC de algunas ligas europeas de fútbol (España, Italia, Inglaterra y Alemania) recorren aproximadamente una distancia de 11-12 km por partido, de los cuales, casi 1 km es cubierto a muy alta velocidad (> 19,8 $km \cdot h^{-1}$) (Weston, 2015) y realizan entre 21,3-30,5 sprints a una velocidad superior a 25,2 $km \cdot h^{-1}$ (Barbero-Alvarez, Boullosa, Nakamura, Andrin, & Weston, 2014; Barbero-Alvarez, Boullosa, Nakamura, Andrin, & Castagna, 2012). Además, los AC realizan un total de 1269 cambios de ritmo durante los partidos de la primera división danesa (Krustrup & Bangsbo, 2001). Sin embargo, los AA, debido a que su actividad está limitada a la mitad del campo, tienen un patrón de movimiento basado en carreras breves e intensas intercaladas con largos periodos de baja intensidad (Krustrup et al., 2009). Los AA recorren alrededor de 5-6 km durante un partido, de los cuales, casi 500 m son cubiertos a alta velocidad (> 18 $km \cdot h^{-1}$) (Mallo, Navarro, Garcia-Aranda, Gilis, & Helsen, 2008; Mallo, Navarro, García-Aranda, & Helsen, 2009b). Además, llevan a cabo un total de 1053 cambios de ritmo y aproximadamente 20 sprints por partido (Krustrup, Mohr, & Bangsbo, 2002).

La frecuencia cardiaca (FC) es el método más utilizado para cuantificar la carga interna del árbitro de fútbol cuando desempeñan su función durante los partidos (Costa et al., 2013). La FC media (FC_{med}) obtenida por los árbitros de fútbol en competición se corresponde aproximadamente a un 83-89% de la FC máxima (FC_{max}) individual que los AC alcanzan en los partidos, siendo un 83% de la FC_{max} en la Premier League (Weston 2006), un 84% de la FC_{max} en la liga Eccelenza de Italia (Tessitore et al., 2007), un 85% de la FC_{max} en árbitros internacionales de la FIFA (Krustrup & Bangsbo, 2001; Weston, Drust, & Gregson, 2011) y un 89% de la FC_{max} en la serie A y B italiana (Castagna, Abt, & D`Ottavio, 2002; D'Ottavio & Castagna, 2001). Por su parte, los AA registran un valor de FC_{med} que se corresponde con el 77% de la FC_{max} individual (Mallo et al., 2009b). Además, también se ha utilizado la percepción subjetiva del esfuerzo (RPE) para cuantificar la carga interna, un método útil y sencillo de aplicar por los preparados físicos. Los AC declaran valores de 7,8 ± 0,8 al final de los partidos de la Premier League (Weston, Bird, Helsen, Nevill, & Castagna, 2006) y valores de 6,9 ± 0,8 en la Segunda División de Inglaterra (Weston et al., 2006). Además, se ha observado que el RPE es un método válido y fiable en árbitros de fútbol pudiendo ser registrado inmediatamente al final del ejercicio, 30 minutos después o 7 horas más tarde tras la finalización del mismo (Castagna et al., 2017).

Mientras que la cuantificación de las respuestas físicas y fisiológicas son relativamente fáciles de aplicar, debido a que existe tecnología apropiada para realizarlo, la influencia de factores tales como la edad (Bangsbo, Mohr, & Krustrup, 2004; Castagna, Abt, D'Ottavio, & Weston, 2005; Weston, Castagna, Impellizzeri, Rampinini, & Breivik, 2010), la experiencia (Weston et al., 2006; Weston, Drust, Atkinson, et al., 2011), el nivel competitivo (Castagna, Abt, & D'Ottavio, 2004, 2005; Yanci et al., 2016), el nivel de condición física (Bartha, Petridis, Hamar, Puhl, & Castagna, 2009; Casajus & Castagna, 2007; Castagna, Abt, & D'Ottavio, 2002; Krustrup et al., 2002; Tessitore et al., 2007; Weston, Castagna, Helsen, & Impellizzeri, 2009) e incluso la actividad de los jugadores (Weston et al., 2007; Weston, Drust, & Gregson, 2011) hace que su interpretación sea más compleja. A esto se une la gran variabilidad existente en el rendimiento físico durante los partidos especialmente en las distancias recorridas a altas velocidad y a velocidad sprint (Weston, Drust, Atkinson, et al., 2011).

El análisis de la carga externa e interna con pruebas de rendimiento físico realizadas antes y después de los partidos (Figura 1) es necesario para determinar la fatiga durante la competición. Por un lado, diversos estudios han analizado varios parámetros de rendimiento físico tales como la aceleración, la velocidad y la potencia del tren inferior, como una medida directa de la fatiga relacionada con el partido (Andersson et al., 2008; Cortis et al., 2013; Nagahara et al., 2016; Nedelec et al., 2014; Tessitore et al., 2007), y por otro lado, otras investigaciones han valorado las respuestas obtenidas en marcadores fisiológicos (Bangsbo, Iaia, & Krustrup, 2007; Krustrup & Bangsbo, 2001; Romagnoli et al., 2016). Se ha observado que en la parte final de los partidos los AC y AA reducen su rendimiento, caracterizado por un descenso de las respuestas físicas y fisiológicas, aspecto que puede estar influenciado tanto por una fatiga central como periférica, producida entre otros aspectos, por el alto número de acciones de corta duración (aceleraciones, desaceleraciones y cambios de dirección) que deben realizar los árbitros para satisfacer las demandas del juego (Krustrup & Bangsbo, 2001; Mallo et al., 2009a; Weston, Batterham, et al., 2011). Por este motivo, varios investigadores han centrado sus esfuerzos en conocer la evolución del rendimiento en la capacidad neuromuscular medida mediante la capacidad de aceleración y el salto vertical antes y después de los partidos (Krustrup et al., 2002; Tessitore et al., 2007). A pesar de que en un estudio previo (Krustrup & Bangsbo, 2001) no se observó una pérdida de rendimiento en el salto vertical tras la finalización de los partidos, sí se constató un descenso en la capacidad de aceleración, que está determinada en gran medida por una manifestación de la fuerza en el eje antero-posterior (Kugler & Janshen, 2010). Por tanto, podría ser interesante analizar si también se produce un descenso en la capacidad de generar fuerza en el eje horizontal tras el desarrollo de los partidos. Debido a que se ha encontrado una manifestación de la fuerza distinta en cada eje (vertical y antero-posterior), es necesario realizar más investigación para esclarecer este fenómeno. La acumulación de fatiga a lo largo del partido puede tener como consecuencia el incremento de la posibilidad de lesión (Barrett et al., 2016; Drew & Finch, 2016; Gabbett, 2017; Murray, Gabbett, & Townshend, 2016). Por tanto, aunque la condición física no es el único factor de rendimiento en el arbitraje, acreditar un alto nivel de condición física es muy recomendable para los árbitros de fútbol (FIFA, 2000; Weston et al., 2012). Así, establecer programas específicos de entrenamiento físico para los árbitros podría conllevar un retraso en la aparición de la fatiga durante los partidos, tanto en AC como en AA, favoreciendo una mejor colocación de los colegiados que contribuyese positivamente en su toma de decisiones durante los encuentros, especialmente al final de los mismos (Weston et al., 2012).

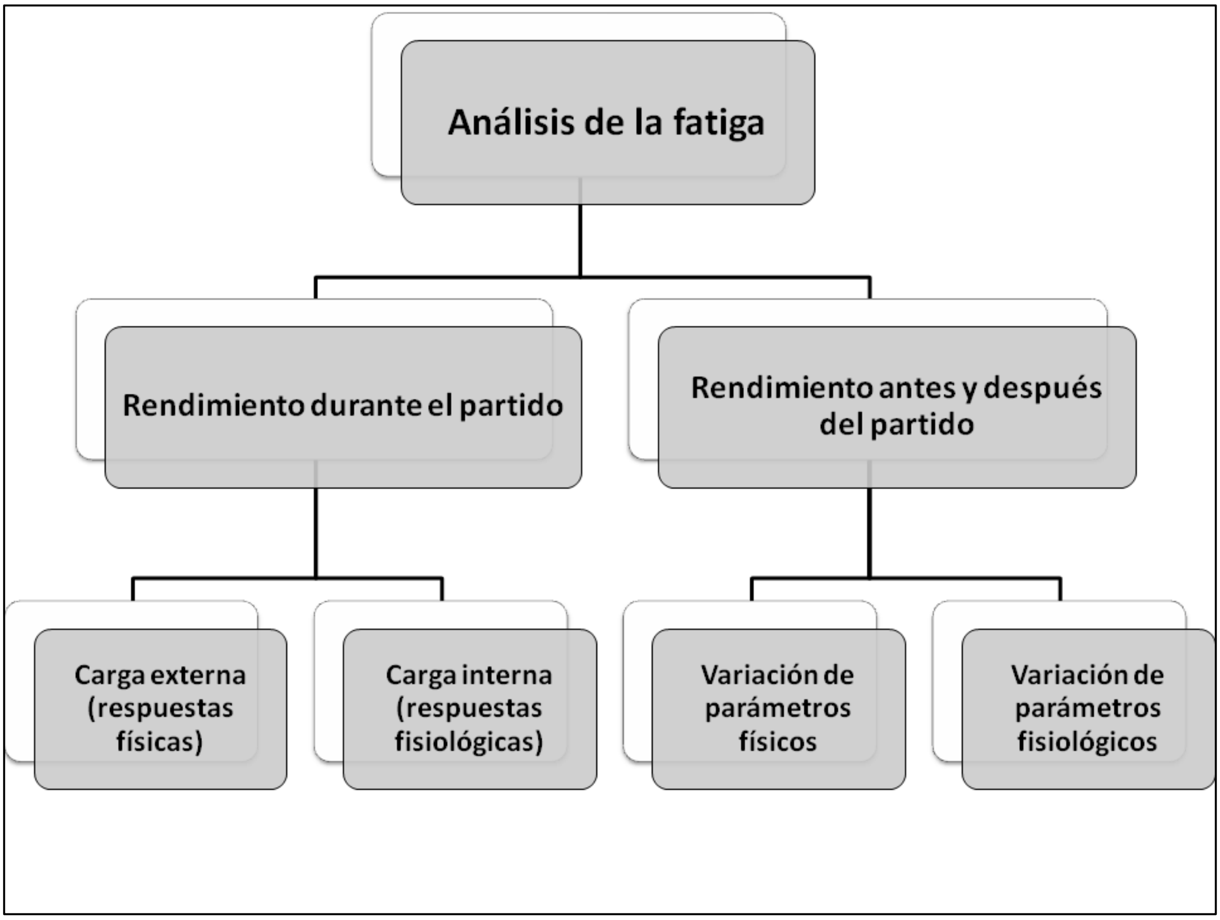

Figura 1. Análisis de la fatiga inducida por los partidos de fútbol.

Los árbitros, independientemente de la categoría en la que arbitren, han de superar unas pruebas físicas en distintos momentos a lo largo de la temporada, cuyos resultados junto con los informes técnicos de los partidos elaborados por los Comité de Árbitros correspondientes (internacionales, nacionales, autonómicos o provinciales) les habilitan para ejercer su actividad, y en su caso, ascender o descender de categoría. Por tanto, la propia organización arbitral establece que tanto los AC como los AA deben estar físicamente bien preparados (Weston et al., 2012; Yanci, Reina, Granados, Salinero, & Los Arcos 2014; Yanci-Irigoyen, 2014) y deben superar las pruebas físicas que propone cada comité de arbitraje que a su vez están basadas en las propuestas que realiza la FIFA (Weston et al., 2012). Así, una inadecuada preparación física en este colectivo podría limitar sus acciones durante los partidos y también podría influir negativamente en un descenso de categoría. En este sentido, son necesarios programas de entrenamiento que estén basados en mejorar la actividad que realizan los árbitros durante los partidos y especialmente aquellos que estén enfocados en la mejora de las acciones de alta intensidad (Mallo et al., 2009a).

Capítulo 2

Objetivos e Hipótesis

El éxito comienza por la voluntad.

Rudyard Kipling

Capítulo 2. Objetivos e hipótesis

Los objetivos de esta tesis doctoral fueron:

- Objetivo 1: Cuantificar el impacto de los partidos de fútbol en los árbitros de campo y árbitros asistentes atendiendo a indicadores de rendimiento físico y fisiológico.
    - Hipótesis 1: Debido a que algunas investigaciones habían manifestado un descenso de la potencia del tren inferior en futbolistas (Andersson et al., 2008; Nedelec et al., 2014; Tur & Gonzalez-Haro, 2011), la hipótesis de este primer estudio fue que los árbitros y asistentes de fútbol podrían sufrir una pérdida de rendimiento físico y fisiológico después de arbitrar, debido a la fatiga que el partido les produce.
- Objetivo 2: Cuantificar el impacto de los partidos de fútbol en el rendimiento de salto horizontal bilateral y unilateral en árbitros de campo y árbitros asistentes.
    - Hipótesis 2: Teniendo en cuenta que Krustrup y col. (2001) no observaron una pérdida en el rendimiento de salto vertical durante el desarrollo del partido, pero sí encontraron un descenso del rendimiento de la capacidad de esprintar después de los partidos, la hipótesis de nuestro segundo estudio fue que los árbitros y asistentes de fútbol podrían tener una pérdida de rendimiento en el salto horizontal (eje antero-posterior) después de los partidos debido a la carga que les supone la actividad de arbitrar.
- Objetivo 3: Describir la carga interna y externa que supone arbitrar partidos oficiales y analizar la relación entre los distintos métodos de cuantificación de la carga de partido en árbitros de fútbol.
    - Hipótesis 3: Atendiendo a los resultados contradictorios obtenidos en estudios previos (Costa et al., 2013; Weston et al., 2006; Mallo et al., 2009a) que examinaban las asociaciones entre variables de carga externa e interna y a la falta de literatura disponible en relación a determinadas variables (p. e. PL, dRPE), una de las hipótesis de este tercer estudio fue que no existirían asociaciones importantes entre las variables de carga externa y carga interna ni en árbitros de campo ni en árbitros asistentes.
- Objetivo 4: Examinar la utilidad del esfuerzo percibido diferenciado (dRPE) como herramienta para monitorizar la carga interna en árbitros de fútbol.

- Hipótesis 4: En estudios previos se había validado la utilidad del dRPE en deportistas de deportes de equipo como método para cuantificar la carga interna (Los Arcos et al., 2016; Weston, 2015), por lo que la hipótesis de esta tesis fue que el esfuerzo percibido diferenciado (p. e. RPE_{res} y RPE_{mus}) podría ser un método útil para monitorizar la carga de partido.

- Objetivo 5: Analizar las diferencias entre las velocidades máximas alcanzadas por los árbitros de fútbol en los partidos de competición oficial y en un test de esprint.
  - Hipótesis 5: Dado que D'Ottavio y Castagna (2001) mostraron que durante los partidos de fútbol los esprints que realizaban los árbitros no duraban más de cuatro segundos, la hipótesis de la tesis doctoral fue que los árbitros de fútbol posiblemente no alcanzarían velocidades máximas durante los partidos oficiales.

- Objetivo 6: Determinar las diferencias existentes entre árbitros de campo y árbitros asistentes en el rendimiento de tests de esprint de 20 y 30 metros de distancia.
  - Hipótesis 6: Considerando que otras investigaciones (Krustrup et al., 2002) no mostraron diferencias significativas entre árbitros de campo y árbitros asistentes en la capacidad de esprint en una distancia de 30 metros, la hipótesis fue que los árbitros de campo y los árbitros asistentes tendrían un rendimiento similar en el sprint de 30 metros.

Capítulo 3

The influence of soccer match play on physiological and physical performance measures in soccer referees and assistant referees

Lo importante no es el éxito sino el camino.

Andrés Iniesta

Estudio 1

The influence of soccer match play on physiological and physical performance measures in soccer referees and assistant referees

Daniel Castillo, Javier Yanci, Jesús Cámara and Matthew Weston

Journal of Sports Sciences

2016, 34(6), 557-563

Capítulo 3. Estudio 1

The influence of soccer match play on physiological and physical performance measures in soccer referees and assistant referees

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Abstract

The aim of this study was to quantify the acute impact of soccer match officiating on selected physiological and physical performance measures. Twenty-four officials from the Spanish National 3rd Division participated in this study. External global positioning system and internal (heart rate) load data were collected for each match official during 8 official matches. Pre- and post-matches, the referees were assessed for tympanic temperature, blood lactate, 15- and 30-m sprint speeds and unilateral (dominant and non-dominant legs) and bilateral vertical jump performances. For referees, the acute physiological and physical performance effects of officiating (post-match value minus pre-match value) were large increases in blood lactate (1.7 mmol·l^{-1}; ±90% confidence limit, 0.9 mmol·l^{-1}; effect size, ES = 4.35), small increases in 15-m sprint (0.09; ±0.04 s; ES = 0.53) and 30-m sprint speeds (0.14; ±0.08 s; ES = 0.39) and a small increase in non-dominant leg jump performance (2.1; ±1.4 cm; ES = 0.31). For assistant referees, there was a small decrease in tympanic temperature (−0.3°C; ±0.2°C; ES = −0.65) and small increases in blood lactate (0.4; ±0.3 mmol·l^{-1}; ES = 0.66), 15-m sprint speed (0.06; ±0.04 s; ES = 0.47), 30-m sprint speed (0.11; ±0.16 s; ES = 0.49) and bilateral countermovement jump height (3.4; ±1.5 cm; ES = 0.45). Taken together, these data demonstrate that the physical demands of soccer officiating are sufficient to elicit increases in blood lactate and small decrements in sprint performance and, thereby, provide some evidence for match-related fatigue.

Key words: match officials; field-testing; fatigue; sprinting; jumping.

Introduction

Soccer is an intermittent sport during which players have to be able to perform high-speed running actions during a match as an important prerequisite for successful participation (Reilly, Bangsbo, & Franks, 2000). While the physical (external load) and physiological (internal load) demands of soccer players have been extensively studied (Bangsbo, 1994; Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011; Impellizzeri et al., 2013; Stolen, Chamari, Castagna, & Wisloff, 2005; Weston, Drust, & Gregson, 2011), there are fewer studies focusing on soccer referees (Costa et al., 2013; Weston, Drust, Atkinson, & Gregson, 2011). Of the available literature, soccer referees cover approximately 10–12 km (Krustrup et al., 2009; Weston, Castagna, Helsen, & Impellizzeri, 2009), with a corresponding mean match heart rate (HR) of 85–90% of maximal HR (%HR_{max}) (D'Ottavio & Castagna, 2001; Weston, Castagna, Impellizzeri, Rampinini, & Breivik, 2010). Furthermore, the match referees match activity profiles appear to be driven by the activity profiles of the players (Weston, Batterham, et al., 2011). In contrast to the referees whose majority of movements are linear, assistant referees mostly perform activities of a multidirectional nature, limited to half of the length of the field; therefore, the total distance covered by the assistants represents approximately half of the total distance covered by the referees (Mallo, Navarro, García-Aranda, & Helsen, 2009a), with a substantially lower mean match HR (~77%HR_{max}) (Helsen & Bultynck, 2004).

Refereeing activity can be influenced by fatigue (Mallo, Navarro, Garcia-Aranda, Gilis, & Helsen, 2008), which is hardly surprising given the high physical and physiological match demands, and, therefore, the challenge to those involved in the physical preparation of soccer match officials is to ensure training programmes are devised to ensure that officials can cope with the high physical match demands by keeping up with play at all times to attain optimal positioning when making key decisions (Weston et al., 2012). As such, an understanding of match-related fatigue will help to inform match officials' physical training programmes. Given that fatigue is difficult to discern from match analysis data (Weston et al., 2012), some authors have used match-induced changes in physiological measures (e.g. blood lactate) in an attempt to understand the fatigue implications of matches (Krustrup, Mohr, & Bangsbo, 2002; Krustrup et al., 2009). Moreover, even though body temperature plays an important role in physical performance (West, Cook, Beaven, & Kilduff, 2014), its influence in elite players seems to be unclear in team sports. Owing to the lack of literature regarding this issue, it would be interesting to perform an assessment soccer match officials' match-induced change in temperature.

To provide direct evidence of development of fatigue during elite soccer games, it is necessary to combine motion analyses with physical performance tests performed before and after games (Krustrup, Zebis, Jensen, & Mohr, 2010). As such, some studies have compared the differences in post- match vs. pre-match values in certain key physical performance measures, namely sprinting speed and explosive leg power, as an indirect measurement of match-related fatigue (Andersson et al., 2008; Cortis et al., 2013; Krustrup et al., 2002, 2010; Nedelec et al., 2014; Tessitore, Cortis, Meeusen, & Capranica, 2007). Despite some authors observing substantially slower 30-m sprint times post-match when compared with pre-match values for assistant referees (Krustrup et al., 2002), as yet, there is no scientific evidence regarding the impact of a match on the referees' sprint speed. Some researchers have observed a significant decrease in explosive leg power, as determined by the vertical jump test, following a match in soccer players (Andersson et al., 2008; Nedelec et al., 2014; Tur & Gonzalez-Haro, 2011), and, owing to the high physiological stress imposed upon match officials, the power performance of the lower limbs is no doubt of relevance to the refereeing activity (Tessitore et al., 2007). The influence of match activities on the jump performance of referees is equivocal, however (Tessitore et al., 2007); therefore, further research is needed. Furthermore, many match activities require unilateral propulsion (e.g. rapid direction changes), and, therefore, an examination of lower limb functional strength asymmetry better represents the specific power requirements of match play movements (Maulder & Cronin, 2005).

Ultimately, a better understanding of match-related changes in referees' and assistant referees' physiologies and speed/power performances can inform the development of specific training strategies aimed at maximising on-field performance. Accordingly, the aim of this study was to quantify the acute impact of soccer match officiating on selected physiological and physical performance measures.

Methods

Participants

Twenty-four soccer match officials officiated on 8 official soccer matches of the Spanish National 3rd Division across the 2014– 2015 soccer season. The match officials had at least 10 years of officiating experience, with a minimum of 6 years at this particular level of competition. The 24 match officials constituted 8 field referees (25.6 ± 5.3 years; 182.8 ± 6.6

cm; 77.0 ± 8.9 kg; 22.4 ± 1.7 kg·m^{-2}) and 16 assistant referees (32.3 ± 9.6 years; 175.4 ± 4.1 cm; 74.4 ± 8.3 kg; 23.8 ± 2.8 kg·m^{-2}). All the participants trained at least 3 times a week and were involved in refereeing on average twice per month. This investigation was performed in accordance to the Declaration of Helsinki, approved by the Ethics Committee of University of the Basque Country (UPV/EHU) and met the ethical standards in Sport and Exercise Science Research (Harriss & Atkinson, 2013).

Design

The effects of soccer matches on jump and sprint performances and on physiological measures were evaluated (Figure 1). Pre-match, blood lactate concentration and tympanic temperature were measured, and following these measurements, all match officials undertook a 15-min standardised warm up, consisting of 7-min slow jogging and strolling locomotion, followed by progressive sprints and static stretching. The time separating the end of the warm up and the start of the match was 30 min, during which the physical performance measures were under-taken in the following order: bilateral countermovement jump (CMJ), unilateral CMJ and sprint tests. Internal HR and external match loads (total distance covered and running mean speed) were collected for every match. All physiological and performance measures were then repeated immediately post-match (Figure 1) in the same order.

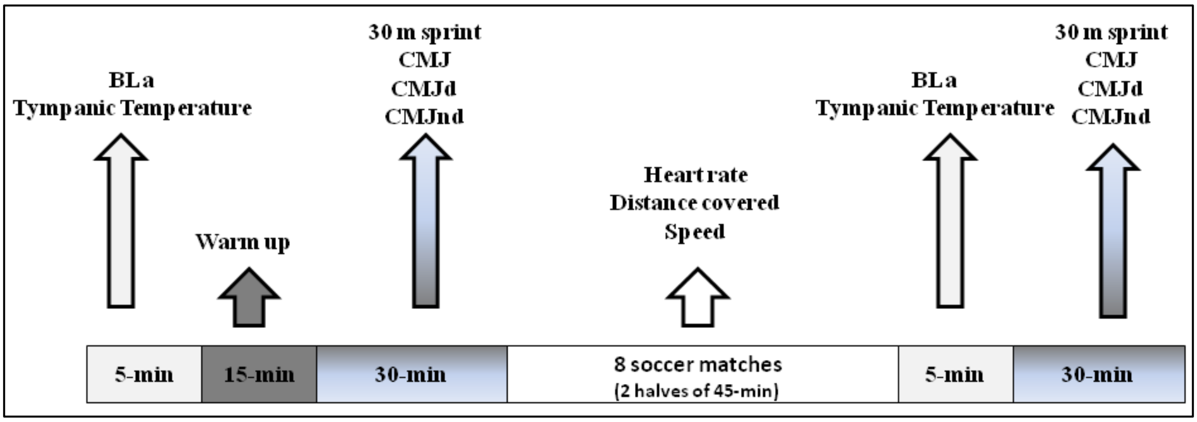

Figure 1. Temporal sequence of the fitness performances and measures obtained during each soccer match.

LA: blood lactate; CMJ: countermovement jump; CMJD: unilateral countermovement jump with the dominant leg; CMJND: unilateral countermovement jump with the non-dominant leg.

Procedures

Blood lactate and temperature. Capillary blood samples (Lactate Plus™; Nova Biomedical, USA) were collected from the earlobe to determine the blood lactate concentration, following the protocol of Boullosa, Abreu, Tuimil, and Leicht (2012). Tympanic temperature (ThermoScan™ 5 IRT 4520; Braun GmbH, Kronberg, Germany) was also measured (Hamilton, Marcos, & Secic, 2013).

Physical performance evaluation. The participants performed 2 CMJs on a force platform sampling at 500 Hz (Quattro Jump™; Kistler, Switzerland) with 2 legs, 2 unilateral CMJs with the dominant leg and 2 unilateral jumps with the non-dominant leg (Newton et al., 2006). The highest jump was used to determine the dominance of the lower limbs (Newton et al., 2006). The dominant and non-dominant legs were matched with strong and weak limbs, respectively. Two maximal jumps of each test were recorded, interspersed with, approximately, 10 s rest between jumps and 90 s rest between the tests. The highest jump was used for further analysis. Jump height was calculated from the flight time by means of the following formula: $h = gt^2/8$ (Young, 1995). Coefficient of variation (CV) for the jump tests was calculated (CMJ: 6.1 ± 5.7%, CMJ with dominant leg: 6.5 ± 7.2% and CMJ with non-dominant leg: 3.6 ± 3.6%). Following the jumps, 30-m sprint tests were performed (Figure 1) on grass, and match officials wore their own soccer boots for this test. The participants' starting position was 0.5 m behind the first timing gate (Polifemo Radio Light; Microgate™, Bolzano, Italy). The time was automatically activated as the participants passed the first gate, that is, at the 0-m line. Split times were recorded at 15 m and 30 m. The match officials were asked to run as fast as possible from the start line, and to eliminate the reaction time, the participants started when ready. Each match official performed two trials interspersed with a 90-s rest period. The best performance was then used for analysis. CV for the acceleration tests was calculated (15-m sprint: 1.3 ± 1.3%, 30-m sprint: 0.8 ± 0.6%).

Internal match loads. The match officials' HR was recorded continuously during the matches (Polar Team System™, Kempele, Finland) at 5-s intervals. The HR during the 15-min half-time period was excluded from the analysis. Intensities of effort were subsequently calculated and expressed as percentages of maximal HR (HR_{max}).

External match loads. All the match officials were equipped with global positioning system devices (MinimaxX v4.0; Catapult Innovations™, Melbourne, Australia) operating at the sampling frequency of 10 Hz. The data are presented for entire match where the mean distances covered and mean speeds were monitored (Costa et al., 2013).

Statistical analysis

Results are presented as mean ± standard deviations (SD). The CV (Atkinson & Nevill, 1998) was used to assess the variability of the CMJs and the sprint tests. The dominant to non-dominant ratio of the various measures were deter-mined using the formula (dominant leg – non-dominant leg)/pick the call dominant leg × 100 (Newton et al., 2006). Prior to analyses, plots of the residuals versus the predicted values of all variables revealed no clear evidence of non-uniformity of error. In athletic research, it has been argued that it is not whether an effect exists but how big the effect is that matters and that the use of the P value alone provides no information about the direction or size of the effect or the range of feasible values (Hopkins, Marshall, Batterham, & Hanin, 2009). Therefore, we elected to use effect sizes (ES), with uncertainty of the estimates shown as 90% confidence intervals, to quantify the magnitude of the difference between post-match and pre-match physiological and physical performance measures. The ES were classified as trivial (<0.2), small (0.2–0.6), moderate (0.6–1.2), large (1.2–2.0), very large (2.0–4.0) and extremely large (>4.0) (Hopkins et al., 2009). A threshold value of 0.2 between-subject standard deviations was set as the smallest worthwhile change, and inference was then based on the disposition of the confidence interval for the mean difference to this smallest worthwhile effect; the probability (per cent chances) that the true difference between tests is substantial (beneficial/detrimental) or trivial was calculated as per the magnitude-based inference approach (Batterham & Hopkins, 2006). These percentage chances were then qualified via probabilistic terms and assigned using the following scale: 25–75%, possibly; 75–95%, likely; 95–99.5%, very likely; >99.5%, most likely (Hopkins et al., 2009). Inference was classified as unclear if the 90% confidence limits (CL) overlapped the thresholds for the smallest worthwhile positive and negative effects (Hopkins et al., 2009). The mean differences, confidence intervals, effect sizes and magnitude-based inferences were calculated using a custom-made spreadsheet (Hopkins, 2006). The relationships between the relative change (%) of the referees' physiological performances and the match demands were examined using correlation coefficients, with 90% CL. The following scale of magnitudes was used to interpret the magnitude of the correlation coefficients: <0.1, trivial; 0.1– 0.3, small; 0.3–0.5, moderate; 0.5–0.7, large; 0.7–0.9, very large; >0.9, nearly perfect (Hopkins et al., 2009).

Results

The referees' and assistant referees' external and internal match loads are presented in Table 1. For the referees (Table 2), the physiological and physical performances effects of match play were a possibly extremely large increase in blood lactate, a very likely small increase in the 15-m sprint time, a likely small increase in the 30-m sprint time and a likely small increase in non-dominant leg CMJ height. For the assistant referees (Table 3), the effects of match play were likely small increases in tympanic temperature, blood lactate and the 15-m sprint time and very likely small increases in the 30-m sprint time and bilateral CMJ height. For both the referees, the effects for all the remaining measures were unclear. The relationships between the match loads and the change in physiological and performance measures for the referees and assistant referees are presented in Table 4. The relationships between the post-match changes in the physiological and the performance measures were unclear to large for total match distance, mean match speed and mean match HR.

Table 1. Internal and external soccer match loads of referees and assistant referees.

	Referees	Assistant referees
Total distance covered (m)	10,053± 1,165	5,305± 497
Mean speed (km · h^{-1})	6.1± 0.9	3.2± 0.3
HR_{max} (bpm)	185± 9	169± 14
HR_{mean} (bpm)	161± 11	133± 17
$\%HR_{mean}$	86.8± 3.2	78.8± 5.0

Note: HR_{max}: maximum HR value; HR_{mean}: mean HR.

Table 2. Descriptive statistics and mean differences (post-match value minus pre-match value) in the referees' physiological and physical performance measures, along with effect sizes and qualitative inferences.

	Pre-match (mean ± SD)	Post-match (mean ± SD)	Mean difference; ±90% CL	Effect size; ±90% CL	Qualitative inference
Physiological measures					
Tympanic temperature (ºC)	36.9 ± 0.5	36.8 ± 0.5	−0.1; ± 0.7	−0.17; ± 0.41	Unclear
Blood lactate (mmol · l−1)	1.4 ± 0.3	3.0 ± 1.5	1.7; ± 0.9	4.35; ± 2.22	Possibly extremely large
Performance measures					
15-m sprint (s)	2.43 ± 0.15	2.52 ± 0.16	0.09; ± 0.04	0.53; ± 0.26	Very likely small
30-m sprint (s)	4.34 ± 0.31	4.47 ± 0.33	0.14; ± 0.08	0.39; ± 0.24	Likely small
CMJ (cm)	30.6 ± 6.5	30.5 ± 7.7	−0.1; ± 1.9	−0.02; ± 0.26	Unclear
CMJD (cm)	18.7 ± 5.5	19.4 ± 6.2	0.7; ± 1.3	0.12; ± 0.21	Trivial
CMJND (cm)	17.1 ± 6.0	19.2 ± 6.8	2.1; ± 1.4	0.31; ± 0.21	Likely small
Imbalance (%)	9.1 ± 10.4	6.1 ± 6.1	−3.0; ± 7.1	−0.26; ± 0.60	Unclear

Note: CMJ: countermovement jump; CMJD: dominant leg countermovement jump; CMJND: non-dominant leg countermovement jump.

Table 3. Descriptive statistics and mean differences (post-match value minus pre-match value) in the assistant referees' physiological and physical performance measures, along with effect sizes and qualitative inferences.

	Pre-match (mean ± SD)	Post-match (mean ± SD)	Mean difference; ±90% CL	Effect size; ±90% CL	Qualitative inference
Physiological measures					
Tympanic temperature (ºC)	36.8 ± 0.4	36.5 ± 0.7	−0.3; ± 0.2	−0.65; ± 0.46	Likely small
Blood lactate (mmol · l−1)	1.4 ± 0.6	1.8 ± 0.6	0.4; ± 0.3	0.66; ± 0.53	Likely small
Performance measures					
15-m sprint (s)	2.58 ± 0.12	2.64 ± 0.13	0.06; ± 0.04	0.47; ± 0.29	Likely small
30-m sprint (s)	4.58 ± 0.21	4.69 ± 0.24	0.11; ± 0.16	0.49; ± 0.23	Very likely small
CMJ (cm)	29.5 ± 7.2	32.9 ± 8.9	3.4; ± 1.5	0.45; ± 0.19	Very likely small
CMJD (cm)	15.8 ± 3.1	15.8 ± 2.9	0.1; ± 0.9	0.02; ± 0.27	Unclear
CMJND (cm)	14.5 ± 2.9	14.8 ± 4.0	0.3; ± 1.1	0.10; ± 0.35	Unclear
Imbalance (%)	8.5 ± 8.1	10.5 ± 8.8	1.9; ± 5.5	0.23; ± 0.64	Unclear

Note: CMJ: countermovement jump; CMJD: dominant leg countermovement jump; CMJND: non-dominant leg countermovement jump.

Table 4. Correlations (±90% confidence limits) for total match distance, mean match speed and mean match HR (expressed as a % of maximal HR) with the % match change (post-match value minus pre-match value) in physiological and physical performance measures.

	Total distance covered (m)	Mean speed (km · h−1)	%HRmax
% Tympanic temperature	0.21; ± 0.33, Unclear	0.21; ± 0.33, Unclear	−0.03; ± 0.34, Unclear
% Blood lactate	0.62; ± 0.22, Likely large	0.64; ± 0.21, Likely large	0.60; ± 0.23, Likely large
% 15-m sprint	0.26; ± 0.32, Likely small	0.25; ± 0.33, Unclear	0.32; ± 0.31, Possibly moderate
% 30-m sprint	0.25; ± 0.33, Unclear	0.25; ± 0.33, Unclear	0.32; ± 0.31, Possibly moderate
% CMJ	−0.49; ± 0.27, Likely moderate	−0.47; ± 0.27, Likely moderate	−0.34; ± 0.31, Possibly moderate
% CMJD	0.12; ± 0.34, Unclear	0.11; ± 0.34, Unclear	0.11; ± 0.34, Unclear
% CMJND	0.33; ± 0.31, Possibly moderate	0.33; ± 0.31, Possibly moderate	−0.07; ± 0.34, Unclear
% Imbalance	−0.20; ± 0.33, Unclear	−0.20; ± 0.33, Unclear	0.10; ± 0.34, Unclear

Note: CMJ: countermovement jump; CMJD: dominant leg countermovement jump; CMJND: non-dominant leg countermovement jump; HR_{max}: maximum HR value.

Discussion

The aim of our study was to quantify the acute effects of soccer match officiating on selected physiological and performance measures. In spite of the fact that internal and external match loads and the changes on the physiological and performance variables have been researched in team sports players (Cortis et al., 2011, 2013; Nedelec et al., 2014; Povoas et al., 2014; Tur & Gonzalez-Haro, 2011), no clear scientific evidence has been found of their influence on soccer match officials. As such, this is the first study to quantify the acute effects of match play on physiological and physical performance measures in soccer referees and assistant referees. Our main findings were that match play induced some physiological perturbations and a small decrement in sprint performance, both in the referees and assistant referees, although this performance decrement did not extend to jump performance.

Quantifying the match performance of referees and assistant referees during competitive match play enables an assessment of whether or not match officials are able to meet the physical and physiological demands of the matches and provides specific information for the training programme design (Weston, 2015). In our study, we observed that soccer referees covered a distance of almost twice that of assistant referees. Accordingly, other studies reported a total distance of 10,270 ± 900 m and 6760 ± 830 m in international matches (Krustrup et al., 2009) and a total distance of 10,197 ± 952 m and 5819 ± 381 m during the America's Cup (Barbero-Alvarez, Boullosa, Nakamura, Andrin, & Castagna, 2012) for referees and assistant referees, respectively; 10,218 ± 643 m in the Confederation Cup Germany for referees (Mallo, Navarro, Garcia-Aranda, & Helsen, 2009b); 11,770 ± 808 m in the Premier League for referees (Weston, Drust & Gregson, 2011); and 6137 ± 539 m in Under 17 World Cup Finland for assistant referees (Mallo et al., 2008). Furthermore, Costa et al. (2013) reported similar mean speed value for referees as was observed in this study (6.5 ± 0.9 km · h^{-1}). With regard to internal match loads, our results concurred with the majority of studies reporting a mean HR response equivalent to the 85–90% of HR_{max} (Barbero-Alvarez et al., 2012; Helsen & Bultynck, 2004; Krustrup et al., 2009; Weston & Brewer, 2002).

Since the physiological and physical demands of a match are disparate for referees and assistant referees, we, therefore, recommend that referees and assistant referees do not undergo similar specific programmes to improve their physical conditioning. Specifically, greater external and internal match loads imposed upon soccer referees, when compared with assistant referees, necessitate an increased reliance upon aerobic energy provision during matches, and this should be trained for accordingly. The detailed breakdown of an elite referee's training activity over an 8-year period presented by Weston, Gregson, et al. (2011) provides a template for the design of match officials' training given that this programme helped an elite soccer referee progress to the pinnacle of his sport by refereeing the FIFA World Cup and UEFA (Union of European Football Associations) Champions League finals. Whereas, for the assistant referees, focus should be upon improving sprint and repeated-sprint ability and the efficiency of sideways movements, as they perform as much sprinting and more sideways running than their referee counterparts (Krustrup et al., 2009).

In this study, blood lactate increased substantially post-match when compared with pre-match, and this was observed both for the referees and assistant referees. This finding suggests that anaerobic system is stimulated during matches (Krustrup et al., 2009). The higher blood lactate increase observed for the referees in comparison with the increase observed in assistant referees, no doubt reflects the higher physical and physiological match demands imposed on referees. In this study, post-match lactate values were lower than the values obtained by Krustrup et al. (2009) (referees: 4.6 ± 3.3 mmol · l^{-1}, assistant referees 2.8 ± 2.6 mmol · l^{-1}) following international matches. These differences could well reflect the marked difference in standard of matches officiated in the respective studies, as in this study, national-level match officials referees participated, whilst in the study done by Krustrup et al. (2009), the participants were international standard match officials. Although some authors have observed that the body temperature increased in the fourth bout of a small-sided game in team sports (Weston et al., 2014; Yanci, Iturricastillo, & Granados, 2014), in this study, we found no match-induced increases in body temperature.

A reduced physical capacity at the end of a soccer match can be considered an indirect measurement of match-related fatigue (Cortis et al., 2013). For example, sprint tests performed before and after elite male and female soccer matches games have demonstrated that peak running speed and repeated sprint performance deteriorate considerably during games (Krustrup et al., 2006, 2010). Our findings demonstrated small post-match decrements in the sprint performance of soccer referees and assistant referees, suggesting that, in this particular cohort, the physical demands of match play were sufficient to induce fatigue. While this is a novel finding for soccer referees, Krustrup et al. (2002) also reported a reduction in post-match sprint performance of similar magnitude (2.7%) in the assistant referees. We did not, however, observe any match-induced impairments in our measures of jump performance; this finding is consistent with the work of other researchers when examining the match-induced changes in vertical jump performance in regional soccer referees (Tessitore et al., 2007) and male and female soccer players (Cortis et al., 2013; Krustrup et al., 2010).

Our data, therefore, suggest that the referees and assistant referees were indeed able to cope the physical match demands that are most closely aligned to explosive vertical jump performance. This is not surprising given that match officials perform relatively few match-related actions in the vertical plane. Match officials may, however, experience higher levels of fatigue on the horizontal axis given that their match-related movements' actions constitute forward, backward and sideways running, thus suggesting that horizontal jump tests could provide further insight into match-related fatigue. Ultimately, our findings of impaired sprint performance yet no change in jump performance are consistent with previous work and provide further evidence that fatigue development in soccer is a highly specific phenomenon (Krustrup et al., 2010).

Examining the associations between external and internal loads provides can provide insight into the underlying causes of match-related fatigue. In this study, we found large associations between total match distance, mean match speed and mean match HR with the match-induced change in blood lactate, yet unclear to moderate associations between match running variables with the changes in sprint and CMJ performance. As such, it is likely that the sprint and CMJ variations are more related to short-term actions involving the neuromuscular system as opposed to global match loads. Therefore, it would be interesting to quantify the short-term and high-intensity actions in match officials. Surprisingly, the correlation between the internal and external match loads was higher with non-dominant leg CMJ height, suggesting that external match loads have a differential effect on bilateral and unilateral jump performances.

The primary limitation of our study is the low sample size of matches, especially given the high variability of referees' match running performances previously reported (Weston, Drust, & Gregson, 2011). We did, however, find small match-induced changes in physical performance despite this low sample size. As a result, we have provided the first piece of evidence for match-related fatigue in soccer referees, and such data are valuable to scientists and coaches alike as the data help to inform the specifics of match-related conditioning. Further limitations of our work are that it remains to be seen whether these findings extend to match officials at the highest levels of the game and that a more elongated profiling of the response to match play was not performed. Finally, we were unable to quantify the impact of the match-related impairment in sprint performance on match running capacity. As such, we encourage future work to provide more detailed analyses of match running performance (e.g.

5- or 15-min segments) when evaluating the acute effects of soccer match officiating on selected physiological and performance measures.

Practical applications

In this study, referees and assistant referees recorded impaired sprint performance following matches suggesting that physical training to offset the match-related decline in this specific aspect of physical performance is advised. Repeated-sprint training, therefore, has obvious appeal for those involved in the training of soccer match officials, as such training is a time-efficient method for enhancing several components of match-related fitness, namely speed, power and the ability to per-form repeated bouts of high-intensity running and sprinting (Taylor, Macpherson, Spears, & Weston, 2015; Weston, 2015). We have recommended that referees and assistant referees undertake different training regimes given the substantial disparity in their match external and internal loads and that this difference should relate not only to the prescription training activities but also to overall training volume.

Conclusion

Soccer referees cover more distance and record a higher mean running speed than the assistant referees, suggesting a necessity for the planning specific training programmes for referees and assistant referees to improve their physical performance. We observed a small decrement in post-match 15- and 30-m sprint performance when compared with pre-match, both in the referees and assistant referees; yet, no negative changes were found for the bilateral and unilateral jump capacities. The decrease in the sprint performance could be considered as an indicator of match-related fatigue. Finally, a horizontal jump test assessed pre- and post-match would be interesting to further assess match-related fatigue in soccer referees and assistant referees.

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Capítulo 4

Impact of official matches on soccer referees' horizontal-jump performance

Es un placer disputar cada día el partido de mi vida.

Carles Puyol

Estudio 2

Impact of official matches on soccer referees' horizontal-jump performance

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Science and Medicine in Football

Aceptado el 23 de Abril de 2017

Capítulo 4. Estudio 2

Impact of official matches on soccer referees' horizontal-jump performance

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Abstract

The aim of this study was to quantify the acute impact of soccer-match officiating on the bilateral and unilateral horizontal-jump performance of field and assistant referees. Thirty-six match officials were evaluated during 12 official soccer matches in a Spanish national division (i.e. Third Division). Participants were classified as field referees (FR) (n = 12) and as assistant referees (AR) (n = 24). Before (Pre-match), at half-time (Rest-match) and immediately after the matches (Post-match), match officials performed two horizontal jumps with two legs (HJ) and two jumps with right leg (HJ*right*) and left leg (HJ*left*). HJ performance was significantly decreased from Pre- to Rest-match and from Pre- to Post-match (p = 0.001-0.02; ES = 0.26-0.45, small), both in FR and AR. Also, in FR the leg asymmetry (LA) increased in Rest-match compared to Pre-match (p = 0.15, ES = -1.02, large) and in Post-match related to Rest-match (p = 0.07, ES = -0.65, moderate), but not significantly. It was found a very large association (0.72; ±0.09, p < 0.01, Most likely) between the distance covered at high-intensity decelerations (<-2.5 $m \cdot s^2$) and the decrement in HJ capacity from the rest period to post-match in FR. Besides, it was also observed a large association (0.66; ±0.10, p < 0.05, Most likely) between high-intensity accelerations (>2.5 $m \cdot s^2$) (High-Acc) and leg asymmetry variation (%Δ LA) from pre- to rest-match in FR. Soccer refereeing might induce match-related fatigue in the muscles involved in the horizontal axis.

Key words: match officials; effect; competition; power; jumping.

Introduction

Soccer refereeing is a high-demanding physical activity in terms of total distance covered, high-intensity running and short-term specific actions performed during official matches (Weston, 2015). During an international competition, field referees (FR) covered a total distance of approximately 11 km, of which 1539 ± 115 m were at a speed above 18 km·h^{-1}, and 698 ± 288 m consisted of accelerations above 1.5 m·s^{-2} (Barbero-Alvarez, Boullosa, Nakamura, Andrin, & Weston, 2014; Barbero-Alvarez, Boullosa, Nakamura, Andrin, & Castagna, 2012). Thus, almost 25% of the total match distance is covered by short high-intensity actions. In addition, FR have been shown to achieve maximum velocities of 31.8 ± 1.40 km·h^{-1} during Premier League matches (Weston, Drust, Atkinson, & Gregson, 2011). Otherwise, assistant referees (AR) mostly perform activities of a multidirectional nature, limited to half of the length of the field; therefore, both the total distance covered (5752 ± 554 m) and the number of accelerations (56 ± 10) performed by AR represent approximately half of those performed by FR (Barbero-Alvarez et al., 2014; Mallo, Navarro, García-Aranda, & Helsen, 2009a). Match officials, among other factors, should meet the high physical-match demands by keeping up with play at all times to attain optimal positioning when making key decisions (Weston et al., 2012).

Physical performance tests, such as vertical jumping and sprinting speed, performed before and after team-sports matches, have been used to provide direct evidence of development of fatigue (Andersson et al., 2008; Cortis et al., 2013; Edholm, Krustrup, & Randers, 2014; Nagahara, Morin, & Koido, 2016; Nedelec et al., 2014). Likewise, some studies have compared differences in Pre-, Rest-, and Post-values in match officials as an indirect measurement of match-related fatigue (Castillo, Yanci, Cámara, & Weston, 2016; Krustrup & Bangsbo, 2001; Tessitore, Cortis, Meeusen, & Capranica, 2007). Despite that some authors did not observe a loss of vertical-jump performance after soccer matches in either FR or AR (Castillo et al., 2016; Krustrup & Bangsbo, 2001; Tessitore et al., 2007), very likely small differences were found on the linear straight sprinting test (LSST) from pre-match to post-match (Castillo et al., 2016). During a soccer match, match officials perform several dynamic movements (i.e. accelerations, decelerations, changes of direction [CODs]) (Castillo et al., 2016; Mallo et al., 2009a), which require high muscle activation of the rectus femoris, vastus medialis, vastus lateralis, biceps femoris, semitendinosus and gastrocnemius (Spiteri et al., 2013; Spiteri et al., 2015). Therefore, since accelerations, decelerations and CODs are involved with a relevant requirement of strength in the horizontal axis (Kugler & Janshen, 2010; Mero, 1998; Spiteri, Newton, & Nimphius, 2015; Yanci, Los Arcos, Mendiguchia, & Brughelli, 2014), the difference observed in the pre-post match in the LSST (Castillo et al., 2016) could be due to the fatigue produced in the muscles involved in horizontal axis performance. The acceleration and deceleration capacity and the CODs have an important horizontal propulsive impulse (Yanci et al., 2014; Spiteri et al., 2015). Nevertheless, there is no scientific evidence analysing the impact of match actions performed on the horizontal-jump performance. Thus, it would be interesting to know whether these differences are also produced in the horizontal-jump performance. This knowledge would help physical trainers of match officials to implement appropriate training programmes, minimizing the accumulated fatigue of the muscles involved in the horizontal axis.

The influence of match activities on jump performance has been continuously evaluated by its influence on the performance of the lower limbs as bilateral modality (Castillo et al., 2016; Tessitore et al., 2007). However, most of the specific actions (i.e., CODs, acceleration, deceleration, sprints and sideways and backwards movements) have been shown not to have a similar impact on the performance of each lower limb of both players and match officials (Impellizzeri, Rampinini, Maffiuletti, & Marcora, 2007; Newton et al., 2006). Thereby, some researchers have assessed the unilateral jump performance on the vertical (Benjanuvatra, Lay, Alderson, & Blanksby, 2013; Carling, Le Gall, & Malina, 2012; Los Arcos et al., 2014; Yanci et al., 2014) and the horizontal axes (Los Arcos et al., 2014; Maulder & Cronin, 2005; Ramirez-Campillo et al., 2015; Yanci et al., 2014) in athletes of different sport modalities. However, no scientific research has been found analysing this aspect in match officials. Therefore, it would be advisable to analyse the effect of soccer matches, not only on the bilateral horizontal jump (HJ), but also on the unilateral horizontal jump and leg asymmetry (LA). Determining the influence of soccer match demands on the bilateral and unilateral HJ capacity would help physical trainers of match officials design training programmes based on the performance of each lower limb.

Therefore, the aim of this study was to quantify the impact of soccer matches on the bilateral and unilateral horizontal-jump performance of field and assistant referees. Taking into consideration that, in a previous study, a decrease in sprint performance (action with a high component of horizontal strength) after matches was observed, but not in the vertical jump performance (Castillo et al., 2016), the hypothesis was that match-related fatigue is mainly produced by the force applied to the horizontal axis. Given that HJ tests have been shown to be valid, reliable and sensitive, in assessing propulsive forces on the horizontal axis (Maulder and Cronin, 2005; Ramirez-Campillo et al., 2015) and that LA may affect both the match performance and the risk of injury (Newton et al., 2006), it could be interesting to analyse the influence of soccer match play (pre-, rest-, post- match) on the accumulated fatigue and LA in match officials, as measured by the performance of horizontal jumps.

Methods

Participants

Thirty-six match officials, who were classified as FR and as AR (Table 1) and who officiated during 12 official soccer matches in the Spanish National Division (i. e. Third Division) throughout the season 2014-2015, participated in this study after giving their informed consent. They had at least ten years of refereeing experience and six years of refereeing at this competitive level. Match officials trained at least three times a week and were involved in refereeing twice a month. This investigation, performed in accordance with the Declaration of Helsinki (2013), was approved by the Ethics Committee of the University of the Basque Country (UPV/EHU) and met the ethical standards in Sport and Exercise Science Research (Harriss & Atkinson, 2013).

Table 1. Characteristics of the match officials (All), field referees (FR) and assistant referees (AR).

	All	FR	AR
n	36	12	24
Age (years)	29.6 ± 7.8	28.4 ± 7.0	30.8 ± 9.9
Body Mass (kg)	75.5 ± 7.1	74.1 ± 8.9	76.2 ± 6.1
Height (cm)	177.8 ± 6.5	177.4 ± 7.1	178.0 ± 6.3
BMI ($kg \cdot m^{-2}$)	23.9 ± 2.2	23.5 ± 2.1	24.1 ± 2.3

BMI: body mass index.

Design

The effects of soccer matches on HJ performance were evaluated (Figure 1). Match officials undertook a 20-minute standardized warm-up, consisting of slow jogging and strolling locomotion, followed by progressive sprints and jumps. Before (Pre-match), at half-time (Rest-match) and immediately after the matches (Post-match), officials performed two bilateral horizontal jumps (HJ) and two unilateral jumps with each leg. The internal load (Edwards' heart rate) was measured with heart rate (HR) monitors and the external load (velocities, accelerations and decelerations) with global positioning systems (GPS) during the first and second halves of the matches. Match officials were fully habituated with testing procedures prior to this investigation.

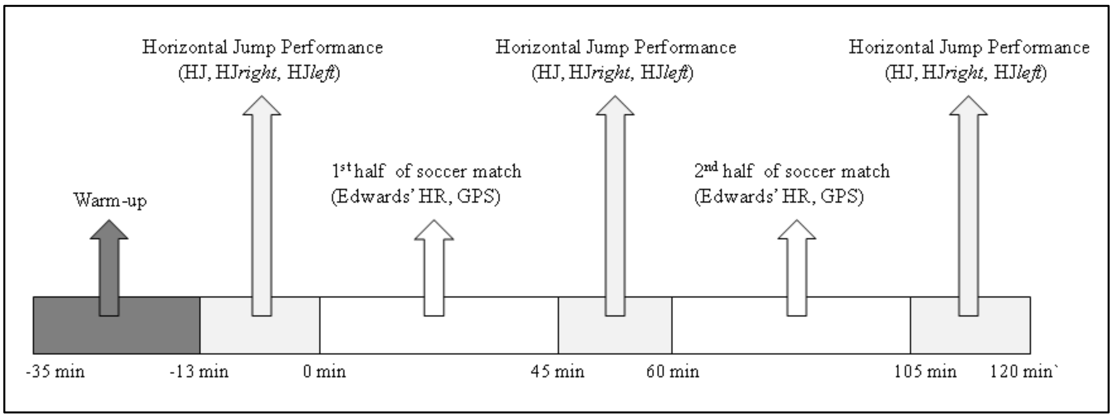

Figure 1. Temporal sequence of the horizontal-jump performances and match loads obtained during matches.

HJ = horizontal-jump performance; HJright = horizontal-jump performance with right leg; HJleft = horizontal-jump performance with left leg; Edwards' HR = time spent in Edwards' zones of heart rate intensity; GPS = global positioning system.

Procedures

Horizontal-jump performance evaluation. Participants performed two bilateral and two unilateral HJ with the right leg (HJright) and left leg (HJleft) (Ramirez-Campillo et al., 2015). They performed the HJ, starting from a standing position, swinging their arms and bending their knees to provide maximal forward drive. A takeoff line was drawn on the ground, positioned immediately adjacent to a jump sandbox. Using a metric tape measure, the jump-length measurement was determined from the takeoff line to the nearest point of landing contact (i.e., back of the heels) (Loturco et al., 2015). Two maximal jumps of each test were recorded, interspersed with an approximately 30-second rest between jumps and a two-minute rest between tests (bilateral and unilateral). The best jump was used for further analysis (Maulder & Cronin, 2005). Leg asymmetry, right to left ratio (LA), was determined using the formula: LA = [(right leg score – left leg score)/right leg score] x 100 (Newton et al., 2006). Coefficient of variation (CV) for the jump tests was calculated (HJ: 1.44 ± 1.83%, HJright: 1.30 ± 1.10% and HJleft: 1.65 ± 1.47%). Intraclass correlation coefficients (ICCs) were also calculated (HJ: 0.93, HJright: 0.96 and HJleft: 0.89).

Internal match load. Match officials' HR was continuously recorded during matches (Polar Team System™, Kempele, Finland) as average 5-second values. HR during the 15-minute rest period was not recorded. Individual maximal HR (HR_{max}) was taken from the maximum value exhibited during match play (Costa et al., 2013). HR responses were grouped into five categories of intensity of effort as follows: (a) 50–60% HR_{max}; (b) 61–70% HR_{max}; (c) 71–80% HR_{max}; (d) 81–90% HR_{max}; (e) 91–100% HR_{max} (Costa et al., 2013; Edwards, 1993). Time spent in each intensity was also registered.

External match load. Match officials were equipped with GPS devices (MinimaxX v4.0, Catapult Innovations™, Melbourne, Australia), operating at a sampling frequency of 10 Hz. Maximum velocity (Vel_{max}), mean velocity (Vel_{mean}) (Costa et al., 2013), distance covered at high-intensity decelerations (<-2.5 m·s^2) (High-Dec), at moderate-intensity decelerations (-2.5 / -1 m·s^2) (Moderate-Dec), at high-intensity accelerations (>2.5 m·s^2) (High-Acc), at moderate-intensity accelerations (-2.5 / -1 m·s^2) (Moderate-Acc) were registered.

Statistical analysis

Results are presented as means ± standard deviations (SD). The CV (Atkinson & Nevill, 1998) was used to assess the variability of the horizontal jumps. ICCs were calculated to determine test-retest reliability. The normal distribution of the results of the variables applied was tested using the Kolmogorov-Smirnov test, and statistical parametric techniques were carried out. A t test for independent samples was used to compare the results of internal and external match load between FR and AR in each half. The repeated measures analysis of variance (ANOVA) with the Bonferroni pos hoc test was used to compare results among HJ Pre-Rest-Post performance in each group (FR and AR), independently. The percentage of change (Δ%) between the Pre-Rest, Pre-Post and Rest-Post bilateral and unilateral HJ performance was calculated using the formula: Δ% = [(Mean 2-Mean 1)/Mean 1] x 100. Practical significance was assessed by calculating Cohen's effect size (Cohen, 1988). Effect sizes (ES) of above 0.8, between 0.8 and 0.5, between 0.5 and 0.2 and lower than 0.2 were considered as large, moderate, small, and trivial, respectively. The relationships between the change (Δ%) of the soccer referees' HJ performances and the internal and external match demands were examined using correlation coefficients, with 90% confidence limits (CL). The following scale of magnitudes was used to interpret the magnitude of the correlation coefficients: <0.1, trivial; 0.1–0.3, small; 0.3–0.5, moderate; 0.5–0.7, large; 0.7–0.9, very large; >0.9, nearly perfect (Hopkins, Marshall, Batterham, & Hanin, 2009). The data analysis was carried out using the Statistical Package for Social Sciences (version 21.0 for Windows, SPSS® Inc, Chicago, IL, USA). Statistical significance was set at $p < 0.05$.

Results

FR spent more time in the 91-100% Edwards' zone than AR ($p < 0.01$; ES = 0.98-1.24, large), both in the first and second halves during official matches. Furthermore, FR spent more time in the 81-90% zone than AR ($p < 0.05$) during the first half. Otherwise, FR spent less time in the HR zones between 60- and 80% of the FC_{max} ($p < 0.01$; ES = -2.86 / -1.39, large). Likewise, FR registered higher values of Vel_{max} ($p < 0.05$) during the first half but not significantly during the second half ($p > 0.05$). Otherwise, FR registered higher values of Vel_{mean} than AR in both halves ($p < 0.01$; ES = 5.68-7.52, large). Furthermore, FR also covered higher distance at Moderate-Dec and Moderate-Acc than AR in both halves ($p < 0.01$; ES = 1.60-3.73, large). However, the distance covered at High-Dec and High-Acc was similar ($p > 0.05$; ES = -0.09-0.32, trivial to small), both for FR and AR during both the first and the second halves.

Table 2. Internal and external match demands registered during soccer matches on field (FR) and assistant (AR) soccer referees.

	1st half (Mean ± SD)		p; ES	2nd half (Mean ± SD)		p; ES
	FR	AR		FR	AR	
50-60%HR_{max} (min)	0.09 ± 0.33	0.63 ± 1.56	0.25; -1.62 Large	0.03 ± 0.11	0.91 ± 2.22	0.07; -7.96 Large
61-70%HR_{max} (min)	0.60 ± 1.15	3.90 ± 4.21	0.001; -2.86 Large	1.58 ± 2.70	6.12 ± 5.61	0.001; -1.68 Large
71-80%HR_{max} (min)	4.95 ± 3.75	12.77 ± 4.47	0.001¸-2.08 Large	7.42 ± 6.07	15.86 ± 6.24	0.001; -1.39 Large
81-90%HR_{max} (min)	22.80 ± 6.00	18.85 ± 5.22	0.05; 0.66 Moderate	21.06 ± 4.56	18.27 ± 6.45	0.19; 0.61 Moderate
91-100%HR_{max} (min)	16.43 ± 7.85	8.73 ± 4.09	0.001; 0.98 Large	17.13 ± 7.45	7.93 ± 4.87	0.001; 1.24 Large
Vel_{max} (km·h^{-1})	24.76 ± 1.70	23.19 ± 2.27	0.04; 0.93 Large	24.57 ± 2.79	23.14 ± 2.39	0.12; 0.51 Moderate
Vel_{mean} (km·h^{-1})	6.32 ± 0.43	3.11 ± .51	0.001; 7.52 Large	6.08 ± 0.53	3.09 ± 0.60	0.001; 5.68 Large
High-Dec. (m)	26.05 ± 9.28	25.93 ± 8.60	0.97; 0.01 Trivial	24.73 ± 12.77	23.14 ± 9.42	0.67; 0.12 Trivial
Moderate-Dec. (m)	166.16 ± 12.69	125.26 ± 24.36	0.001; 3.22 Large	161.69 ± 11.31	119.47 ± 32.01	0.001; 3.73 Large
High-Acc. (m)	51.71 ± 8.13	49.12 ± 12.48	0.52; .32 Small	51.53 ± 6.20	52.07 ± 13.62	0.87; -0.09 Trivial
Moderate-Acc. (m)	166.90 ± 17.25	139.30 ± 23.84	0.001; 1.60 Large	162.27 ± 17.44	131.45 ± 21.82	0.001; 1.77 Large

SD: standard deviation; HR_{max}: maximum heart rate; Vel_{max}: maximum velocity; Vel_{mean}: mean velocity; High-Dec.: distance covered at high decelerations intensity; Moderate-Dec.: distance covered at medium decelerations intensity; High-Acc.: distance covered at high accelerations intensity; Moderate-Acc.: distance covered at medium accelerations intensity; ES: effect size.

HJ performances at Pre-, Rest- and Post-match play are presented in Table 3. HJ performance was significantly decreased from Pre- to Rest-match and from Pre- to Post-match (Δ% = -3.66/-2.40; p = 0.001-0.02; ES = 0.26-0.45, small), both in FR and AR. Likewise, both FR and AR showed worse values on the HJ*right* performances from Pre- to Rest-match (Δ% = -2.79/-1.91; p = 0.001; ES = 0.22-0.34, small). Likewise, AR also showed the worst HJ*right* performance from Pre- to Post-match (p = 0.02), and FR also decreased the HJ*right* performance from Pre- to Post-match (p = 0.14), but not significantly. However, these changes on the HJ*left* performances (Δ% = -3.53 / -1.66; p = 0.07-0.49; ES = 0.17-0.45, trivial-small) were not observed. In addition, in FR the LA increased in Rest-match compared to Pre-match (p = 0.15) and in Post-match compared to Rest-match (p = 0.07), but not significantly. However, these changes were also not observed for AR (Δ% = -15.69 / -4.50; p = 1.00, ES = 0.03-0.11 trivial).

Table 3. Pre-, Rest- and Post-match horizontal jump performance on field (FR) and assistants (AR) soccer referees.

	Referee	Pre-match (mean ± SD)	Rest-match (mean ± SD)	Post-match (mean ± SD)	Pre-Rest match		Rest-Post match		Pre-Post match	
					p; ES	Δ%	p; ES	Δ%	p; ES	Δ%
HJ (cm)	FR	189.08 ± 15.23	183.08 ± 15.68	182.17 ± 14.28	0.001; 0.39 Small	-3.17	1.00; 0.06 Trivial	-0.50	0.01; 0.45 Small	-3.66
	AR	189.08 ± 15.58	184.13 ± 18.42	184.54 ± 17.00	0.02; 0.28 Small	-2.62	1.00; -0.02 Trivial	0.23	0.01; 0.26 Small	-2.40
HJ*right* (cm)	FR	170.08 ± 14.11	165.33 ± 13.95	165.58 ± 12.61	0.001; 0.34 Small	-2.79	1.00; -0.02 Trivial	0.15	0.14; 0.32 Small	-2.65
	AR	170.54 ± 14.89	167.29 ± 15.12	168.04 ± 16.21	0.001; 0.22 Small	-1.91	0.38 ; - 0.05 Trivial	0.45	0.02; 0.18 Trivial	-1.47
HJ*left* (cm)	FR	172.17 ± 13.42	168.25 ± 14.12	166.08 ± 15.76	0.14 ; 0.29 Small	-2.27	0.09; 0.15 Trivial	-1.29	0.07; 0.45 Small	-3.53
	AR	172.92 ± 16.96	170.04 ± 14.35	169.67 ± 14.81	0.49; 0.17 Trivial	-1.66	1.00; 0.03 Trivial	-0.22	0.14; 0.19 Trivial	-1.88
LA (%)	FR	2.98 ± 1.92	4.94 ± 3.81	4.22 ± 2.92	0.15; -1.02 Large	66.02	0.85; 0.19 Trivial	-14.49	0.07; -0.65 Moderate	41.96
	AR	4.84 ± 7.10	4.08 ± 3.68	4.62 ± 4.66	1.00; 0.11 Trivial	-15.69	0.98; -0.15 Trivial	13.27	1.00; 0.03 Trivial	-4.50

SD: standard deviation; ES: effect size; HJ: horizontal jump performance; HJright: horizontal jump performance with right leg; HJleft: horizontal jump performance with left leg; LA: leg asymmetry.

Significant associations between internal (time spent in each intensity of effort) or external match loads (Vel_{max}, Vel_{mean}, distance covered at Moderate-Dec and at Moderate-Acc) and %Δ HJ performances (Pre-Rest, Pre-Post, and Rest-Post) have not been found. However, it was found a very large significant association (0.72; ±0.09, $p < 0.01$, Most likely) in FR between the distance covered at High Dec (<-2.5 m·s2) and the decrement in HJ capacity from rest- to post-match and a large significant association (0.66; ±0.10, $p < 0.05$, Most likely) observed between High Acc (>2.5 m·s2) and %ΔLA from pre- to rest-match.

Discussion

The aim of this study was to quantify the impact of a soccer match on the horizontal-jump performance of both field and assistant referees. Although the acceleration capacity and vertical jump performance have been used as indicators of neuromuscular fatigue in soccer referees (Castillo et al., 2016; Krustrup & Bangsbo, 2001; Tessitore et al., 2007), to the best of our knowledge, this is the first investigation that analysed the effects of an official soccer match on the bilateral and unilateral horizontal-jump capacity of FR and AR. The decrease of HJ performance, both at rest and at the end of the matches, confirms the hypothesis of our study. However, different effects of match play were found in the lower-limb performances; whereas HJ*right* decreased after the first half in both FR and AR, but it also decreased significantly after the end of the match in AR but not in FR.

Previous studies did not find match-related fatigue in the vertical-jump performance of national and international match officials (Castillo et al., 2016; Tessitore et al., 2007). Nevertheless, Castillo et al. (2016) found worse results on the acceleration capacity (i.e., 15- and 30-m linear, straight sprint test) after officiating official national matches. Given that on the acceleration phase some mechanisms could be related to the force applied on the horizontal axis, these authors suggested match-related fatigue on the horizontal axis, both in FR and AR. However, no scientific literature has analysed the impact of soccer matches on the HJ performance in match officials. Our results are in line with previous findings observed in professional soccer players (Edholm et al., 2014), due to a decrease in the bilateral HJ was found in our study on both FR and AR after each half in comparison to before the match. Both the decrease observed in the bilateral HJ capacity and the very large association in FR between the distance covered at High Dec (<-2.5 $m \cdot s^2$) and the decrement in HJ capacity from rest to post-match, suggests that refereeing activity can induce neuromuscular fatigue, especially in the muscles involved in the horizontal axis. Therefore, it would be interesting for physical trainers of match officials to implement specific training programmes in order to minimize the loss of strength of the muscles involved in the actions performed on the horizontal axis. Due to the evidence of match-related fatigue on the horizontal nature that has been observed (Castillo et al. 2016 and present study), it would be necessary to implement specific training programmes to ameliorate the leg muscle performance involved in soccer refereeing. It has been demonstrated that combining vertical and horizontal drills and plyometric training programmes induces greater soccer-specific performance improvements in soccer players (Ramirez-Campillo et al. 2015). In addition, other authors have observed that HJ training programmes do also ameliorate the HJ capacity in soccer players (Rosas et al. 2016). Thus, it would be interesting to analyse the effects of these HJ training programmes in both FR and AR officiating at different standards of play.

FR and AR also showed worse performance in the HJ*right* at the end of the first half compared to before the match (Δ% = -2.79/-1.91). Nevertheless, this decrease was not shown in the HJ*left*. To date, no scientific research has been published considering the discrimination of each lower limb. It is hard to understand the cause of the accumulated fatigue in the right leg, whereas this fact has not been observed in the left leg. Some factors, such as AR performing the most relevant actions close to the penalty box, where the decisions have a higher repercussion and movements are based on sideways displacements (Mallo, Navarro, Garcia-Aranda, Gilis, & Helsen, 2008), and FR performing higher specific actions (i.e., CODs, accelerations and decelerations) on the right limb, have influenced performance in the lower limbs. Nevertheless, further studies that analyse the specific actions in FR and AR and the magnitude of strength in limbs (i.e., right and left) during matches are necessary to understand this issue. It is likely that the knowledge of the external demands in terms of strength produced with each limb would help specific trainers to understand the decrement on the HJ*right* performance.

Previous studies of several sports reported that LA may not only affect the performance but also could increase incidence of injury (Askling, Karlsson, & Thorstensson, 2003; Maulder & Cronin, 2005; Orchard, Marsden, Lord, & Garlick, 1997; Yamamoto, 1993). Therefore, analysing this parameter in match officials throughout matches may provide complementary information. This knowledge could be relevant for physical trainers in applying appropriate strength strategies to the match officials' training programmes. In our study, FR, in contrast to AR, showed higher values of LA at the end of the first and the second halves compared to before the matches (Δ% = 66.02 and 41.96, respectively), however these differences were not statistically significant ($p > 0.05$; -1.02/-0.65 large to moderate). Previous researches, as well as our study, reported different external and internal match loads for FR and AR. In fact, similarly to our study, FR demonstrated higher Vel_{max} match values but not significantly (Castillo, Cámara, Castellano, & Yanci, 2016b) and higher Vel_{mean} than AR at national and international levels (Castillo et al., 2016a; Costa et al., 2013). Also, FR carried out more short-specific actions than AR (Barbero-Alvarez et al., 2012; Barbero-Alvarez et al., 2014) but regrettably these authors did not differentiate among intensities of accelerations and decelerations. In our study, FR also achieved higher values of Vel_{max} and Vel_{mean} and covered more distance at moderate accelerations and decelerations than AR. With regard to internal match loads, our results concurred with the HR responses of the study of Costa et al. (2013), where the time spent at 90-100% of HR_{max} was higher for FR than AR. These differences could partially explain the higher LA observed in FR. Therefore, it seems appropriate to differentiate the training programmes of FR and AR, based on the different external and internal load demands and on the different evolution of the LA throughout official matches. Furthermore, the large association observed between High Acc (>2.5 $m \cdot s^2$) and % Δ LA from pre- to rest-match in FR should be considered in order to implement training programmes. Further studies are required to analyze the actions that may facilitate the increase of the LA during matches and whether higher LA could be associated with lower physical performance. In addition, it would also be relevant to analyse the relation between the increases of LA and the probability of injury risk to match officials.

This study is not exempt of limitations. The main one, generally, considering the lack of significant association between some performance variables during matches (HR and kinematic analysis) and %Δ HJ performance (Pre-Rest, Pre-Post and Rest-Post), we cannot affirm that a decrement in HJ capacity could be associated with physical and physiological demands, in terms of accelerations, decelerations, maximum velocities and heart rate intensities, during match play. Thus, further research involving a higher number of participants would be necessary to analyse whether the external and internal match demands are associated with a modification in the HJ performance and LA. On the other hand, considering that the external workload and the tolerance to fatigue could be influenced by the competitive level of the referees, it would be interesting to analyze whether there is a fatigue in the actions produced in the horizontal axis on high-standard soccer referees. Furthermore, considering that the change in speed over time (i.e. acceleration) decreases with increasing running speed, and maximal acceleration occurs at the beginning of the action in soccer players (Sonderegger, Tschopp, & Taube, 2016), it would be interesting to determine the changes in the accelerations and decelerations in order to assess the individual intensity thresholds. Thus, actions performed at high and low initial running speeds would not be biased by changes in the acceleration.

Conclusions

Match officials showed decrements on the bilateral horizontal-jump performance after the first and the second halves with compared to before the matches, so soccer refereeing may induce match-related fatigue in the muscles involved in the horizontal axis. In addition, FR and AR decreased the horizontal-jump performance with the right leg at the end of the first half, but only in AR was a significant decrease observed at the end of the match. This issue may suggest that assistant referees may be influenced by greater stress produced by the specific actions of the force applied with the right leg.

Practical Applications

As practical application for physical trainers of match officials, specific training programmes should be implemented based on both bilateral and unilateral strength in the muscles involved in the actions performed in the horizontal axis. In addition, further studies to analyse the relation between leg asymmetry and injury risk are warranted.

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Capítulo 5

Relationships between internal and external match load indicators in soccer match officials

Puedo aceptar el fracaso, todos fracasan en algo. Pero no puedo aceptar no intentarlo.

Michael Jordan

Estudio 3

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International Journal of Sports Physiology and Performance

2016 Dec 5:1-21. DOI: 10.1123/ijspp.2016-0392

Capítulo 5. Estudio 3

Relationships between internal and external match load indicators in soccer match officials

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Abstract

The aims of this study were to describe the internal and external match load (ML) of refereeing activity during official matches and also to investigate the relationship among the methods of ML quantification across a competitive soccer season. A further aim was to examine the usefulness of differential perceived exertion (dRPE) as a tool for monitoring internal ML in soccer referees. Twenty field referees (FR) and 43 assistant referees (AR) participated in this study. Data were collected from 30 competitive matches (FR = 20 observations, AR = 43 observations) and included measures of internal (Edwards' heart rate derived training impulse [$TRIMP_{EDW}$]), external (total distance covered [TD], distance covered at high speeds [HSR] and player load [PL]) ML, differentiated ratings of perceived respiratory [$sRPE_{res}$ ML] and leg muscle [$sRPE_{mus}$ ML] exertion). Internal and external ML were all greater for FR when compared to AR (-19.7 to -72.5); with differences ranging from very likely very large to most likely extremely large. The relationships between internal ML and external ML indicators were, in most cases, unclear for FR ($r < .35$) and small to moderate for AR ($r < .40$). We found substantial differences between RPE_{res} and RPE_{mus} scores in both FR (.6 AU; ±90% confidence limits .4 AU) and AR (.4; ±.3 AU). These data demonstrate the multifaceted demands of soccer refereeing and thereby highlight the importance of monitoring both internal and external ML. Moreover, dRPE represent distinct dimensions of effort and may be useful in monitoring soccer referees ML during official matches.

Key words: perceived exertion; heart rate; training load; referee; GPS.

Introduction

Quantifying the physical and physiological loads imposed by specific training drills and competition is important to understand the dose-response nature of the training process, with regards to optimizing the performance of athletes [1,2]. An accurate and detailed understanding of competition demands can provide sport scientists and practitioners with an objective framework to prescribe the optimum training dose [3,4]. Training loads (TL) and match loads (ML) may be expressed in terms of both external (physical demands, such as total distance covered, distance at certain velocities, accelerations, etc.) [5-8] and internal (physiological demands, such as heart rate [HR] and ratings of perceived exertion [RPE]) [9-12] components. Indeed, these ML indicators have been extensively analyzed using in both soccer players [9,10,13,14] and in match officials [12,15,16].

As a result of recent developments in microsensor technology, some authors [17-19] have suggested that player load (PL) - a vector magnitude representing the sum of accelerations recorded in the three principal axes of movement - could be a more suitable measure of external ML than locomotive demands alone, which neglect both energetically taxing changes in speed and the three-dimensional nature of movement and impacts typical to soccer players and officials [18]. Likewise, while RPE represent a practical and valid measure of internal load [1,20], differential RPE (i.e. central [‘respiratory’: $sRPE_{res}$] and peripheral [‘muscular’: $sRPE_{mus}$] exertion) have gained recent attention within the team sport literature as measures which may improve the accuracy and sensitivity of internal load measurement by discriminating global perceived exertion into its specific physiological mediators [9,21-23]. Furthermore, these subjective measures may be useful to sport scientists as they are inexpensive, accessible at all levels and are not prohibited by the rules of competition [1]. While dRPE and PL have the potential to enhance the monitoring of internal and external loads during intermittent, stochastic activities such as team sport competition, there is no literature available to date which quantifies these measures in soccer referees during official matches [24,25]. This information could provide unique and novel insights into the specific physical and physiological demands of match officials during competitive fixtures.

Knowledge of the relationships between internal and external ML permits for a better understanding of the dose-response nature of training and competition [1]. Weston et al. [12] observed a moderate association between HR and RPE in field referees (FR, r = .49), while Costa et al. [26] observed small to moderate correlations between total distance covered and internal load measures (Edwards’ HR-derived training impulse [$TRIMP_{EDW}$], r = .22 and session-RPE [sRPE] TL, r = .38). Despite this, only a few studies [27,28] have examined the internal-external ML relationships in assistant referees (AR). Given the recent development and use of novel measures of internal (i.e. $sRPE_{res}$ and $sRPE_{mus}$) and external (i.e. PL) ML, the relationships between these variables and also traditional ML measures are of interest [9,19]. While an examination of such may further advocate the criterion-related validity of dRPE and PL as useful monitoring tools in team sport players and match officials, this information is also likely to be useful to those responsible for the programming, monitoring and evaluation of TL in team sport match officials.

Therefore, the main purposes of this study were to describe internal and external match load of refereeing activity during official matches and to also investigate the relationship among the methods of match load quantification across a competitive soccer season on match officials. A further aim was to examine the usefulness of dRPE as a tool for monitoring internal match loads in soccer referees.

Methods

Participants

Sixty-three soccer match officials who officiated in thirty soccer matches of the Spanish National Third Division across the 2014–15 competitive soccer season participated in this study. Match officials had at least ten years of officiating experience, with a minimum of six years at this particular level of competition. Of the 63 match officials, 20 were FR (age: 27.70 ± 6.20 yr, stature: 177.63 ± 6.74 cm, body mass: 74.07 ± 8.54 kg, BMI: 23.46 ± 2.18 $kg \cdot m^{-2}$) and 43 were AR (age: 30.68 ± 9.60 yr; stature: 176.15 ± 5.62 cm; body mass: 75.05 ± 7.81 kg; BMI: 24.21 ± 2.51 $kg \cdot m^{-2}$). All match officials trained at least three times a week and were involved in refereeing on average three times per month. This investigation was performed in accordance to the Declaration of Helsinki and was approved by the Ethics Committee of the University of the Basque Country (UPV/EHU).

Design

We used an observational design to examine the relationships between internal and external match load indicators in match officials. Data were collected from 30 competitive matches (FR = 20 observations, AR = 43 observations) and included measures of internal ($TRIMP_{EDW}$,

$sRPE_{res}$ ML, $sRPE_{mus}$ ML) and external (total distance covered [TD], distance covered at high speeds [HSR] and PL) ML. Prior to the start of each match, the match officials performed a standardized 15 minutes warm-up including running, progressive sprints and stretching. However, this data was not included in the overall analysis.

Internal Loads. To quantify $TRIMP_{EDW}$, match officials' HR was recorded continuously during the matches (Polar Team System™, Kempele, Finland) at 5 s intervals. HR during the 15 min half-time period was excluded from the analysis. Intensities of effort were subsequently calculated and expressed as percentages of each match official known maximal heart rate (HR_{max}) obtained during the match [26]. The total time (min) spent in 5 arbitrary intensity zones was summated and multiplied by a specific weighing factor. These were: 1 for 50–60% HR_{max}, 2 for 60–70% HR_{max}, 3 for 70–80% HR_{max}, 4 for 80–90% HR_{max} and 5 for 90–100% HR_{max}. The sum all 5 intensity zones represented $TRIMP_{EDW}$ [29].

Using the CR10 scale, match officials provided differentiated ratings for their perceived respiratory (i.e. breathlessness; $sRPE_{res}$) and leg muscle ($sRPE_{mus}$) exertion [4]. To calculate the RPE-derived ML, each score was multiplied by the match duration (min) as per Foster et al. [30]. Match officials were fully habituated with the RPE procedures and scaling methods prior to this investigation.

External Loads. Referees' match activities were monitored using microsensor units containing a 10 Hz global positioning system (GPS) and a 100 Hz triaxial accelerometer (MinimaxX v4.0, Catapult Innovations™, Melbourne, Australia). Microsensor units were harnessed in a tight-fit vest which was worn by the match officials throughout the games. The microsensor devices were activated 15 min prior to the start of each match, in accordance with the manufacturer's recommendations. Data were downloaded post-match to a PC and analysed using a customized software package (Logan Plus v.4.4, Catapult Innovations™) [19]. We used TD (m) and HSR (> 13 $km \cdot h^{-1}$) distance (m) recorded from the GPS within the microsensor units as our indicators of running-based external MLs [28]. Additionally, PL was computed as vector magnitude representing the sum of accelerations recorded in the anterior-posterior, mediolateral and vertical planes of movement, measured by the microsensor units' 100 Hz tri-axial piezoelectric linear (Kionix: KXP94). The reliability and validity of these microsensor units for the measurement of TD, HSR and PL are reported elsewhere [31,32].

Data analysis

Results are presented as means ± standard deviations (SD). Prior to analyses, plots of the residuals versus the predicted values of all variables revealed no clear evidence of non-uniformity of error. To compare the differences in internal and external ML between FR and AR, a magnitude-based inference approach was used [33]. Data were log transformed and subsequently back transformed to represent the between-referee differences in ML' as accurate percentages. Standardized thresholds of .2, .6, 1.2, 2.0 and 4.0 multiplied by the pooled between-referee SD were used to anchor small, moderate, large, very large and extremely large differences, respectively. Uncertainty in the estimates was then calculated based on the disposition of the 90% confidence limits (CL) for the respective mean difference in the relation to the standardized thresholds. The probability (percent chances) that the true between-referee differences in internal and external ML were the observed magnitude were then qualified via the following probabilistic terms: 25–75%, possibly; 75–95%, likely; 95–99.5%, very likely; >99.5%, most likely [33]. Inferences were classified as unclear if the 90% CL overlapped the thresholds for both substantially positive and negative thresholds by ≥5%. Between-subject correlations were calculated to examine the relationships between internal and external ML. For referees with repeated match samples, the mean value for each ML variable was used in replacement of the original data (n = 20, range = 2–4 matches). The following scale of magnitudes was used to interpret the correlation coefficients: <0.1, trivial; .1–0.3, small; .3–.5, moderate; .5–.7, large; .7–.9, very large; >.9, nearly perfect [33]. Confidence limits (90%) for the correlations were constructed using a bias corrected accelerated bootstrapping technique of 2000 samples with replacement from the original data (SPSS™ v.21, Armonk, NY: IBM Corp.). Magnitude-based inferences were subsequently applied to qualify the uncertainty in the correlation estimates, using the method previously described [33].

Results

The FR' and AR' internal and external MLs are presented in Table 1. Internal and external ML were all greater for FR when compared to AR, with differences ranging from very likely very large to most likely extremely large. Analysis of match $sRPE_{mus}$ and $sRPE_{res}$ scores revealed that for the FR, the difference between RPE_{mus} (7.1 ± 1.1 AU) and RPE_{res} (6.6 ± 1.1 AU) was likely small/ possibly moderate (.6; ±90% confidence limits .4 AU). For AR, the difference between RPE_{mus} (4.2 ± 1.5 AU) and RPE_{res} (3.8 ± 1.3 AU) was likely small (.4; ±.3 AU).

Table 1. Differences in internal and external match loads (ML) between field (FR) and assistant (AR) referees.

ML Method	Raw data (mean ± SD)		Between-referee Difference	
	FR	AR	Mean difference (%; ±90% CL)	Qualitative inference
Internal				
$TRIMP_{EDW}$ (AU)	390 ± 34	315 ± 41	-19.7; ±3.2	Very likely very large
$sRPE_{res}$ ML (AU)	613 ± 789	356 ± 106	-44.1; ±4.4	Likely extremely large
$sRPE_{mus}$ ML (AU)	665 ± 81	398 ± 129	-43.0; ±4.9	Likely extremely large
External				
TD (m)	9991 ± 657	5219 ± 594	-48.0; ±1.7	Most likely extremely large
HSR (m)	2783 ± 630	793 ± 268	-72.5; ±3.0	Most likely extremely large
PL (AU)	938 ± 125	493 ± 101	-48.2; ±3.1	Most likely extremely large

CL = confidence limits; $TRIMP_{EDW}$ (AU) = Training impulse according to Edwards (1993); $sRPE_{res}$ ML = perceived respiratory match load; $sRPE_{mus}$ ML = perceived muscular match load; TD = total distance; HSR = distance covered at high speeds (> 13 $km.h^{-1}$); PL = Player Load.

The relationships amongst internal and external MLs for FR and AR are presented in Tables 2 and 3, respectively. For FR, the relationships between internal and external load measures ranged from unclear to possibly moderate, while the relationships amongst internal and external load measures ranged from unclear to possibly very large (Table 2). For AR, the relationships between internal and external load measures ranged from unclear to likely moderate, while the relationships amongst internal and external load measures ranged from unclear to likely very large and likely large to very likely very large, respectively (Table 3).

Table 2. Relationships (r; ±90% CL) between and amongst internal and external match loads for field referees (n = 20)

ML Method		Internal			External		
		$sRPE_{res}$ ML	$sRPE_{mus}$ ML	$TRIMP_{ED}$	TD	HSR	PL
Internal	$sRPE_{res}$ ML	-					
	$sRPE_{mus}$ ML	.77; ±.19 VL*	-				
	$TRIMP_{EDW}$	.04; ±.46 ?	-.27; ±.51 ?	-			
External	TD	.31; ±.32 M*	.20; ±.32 ?	.35; ±.41 M*	-		
	HSR	.10; ±.33 ?	.10; ±.26 ?	.00; ±.38 ?	.71; ±.20 VL*	-	
	PL	.28; ±.38 ?	.27; ±.31 ?	.13; ±.42 ?	.23; ±.47 ?	-.14; ±.66 ?	-

CL = confidence limits; $TRIMP_{EDW}$ (AU) = Training impulse according to Edwards (1993); $sRPE_{res}$ ML = perceived respiratory match load; $sRPE_{mus}$ ML = perceived muscular match load; TD = total distance; HSR = distance covered at high speeds (> 13 $km.h^{-1}$); PL = Player Load.

Correlation magnitude: ? = unclear; S = small; M: moderate; L = large; VL = very large; NP = near perfect.
Uncertainty of the correlation magnitude: * = possibly (25%–75% [likelihood of the true correlation being…]); ** = likely (75%–95%); *** = very likely (95%–99.5%); **** = most likely (>99.5%).

Table 3. Relationships (r; ±90% CL) between and amongst internal and external match loads for assistant referees (n = 43)

ML Method		**Internal**			**External**		
		$sRPE_{res}$ ML	$sRPE_{mus}$ ML	$TRIMP_{ED}$	TD	HSR	PL
Internal	$sRPE_{res}$ ML	-					
	$sRPE_{mus}$ ML	.77; ±.17 VL**	-				
	$TRIMP_{EDW}$	.16; ±.23 ?	.11; ±.23 ?	-			
External	TD	.22; ±.21 S**	.26; ±.20 S**	.32; ±.28 M*			
	HSR	.36; ±.23 M**	.40; ±.21 M**	.36; ±.25 M*	.82; ±.12 VL***	-	
	PL	.11; ±.23 ?	.19; ±.23 S**	.26; ±.25 S**	.77; ±.14 VL**	0.67; ±.16 L**	-

CL = confidence limits; $TRIMP_{EDW}$ (AU) = Training impulse according to Edwards (1993); $sRPE_{res}$ ML = perceived respiratory match load; $sRPE_{mus}$ ML = perceived muscular match load; TD = total distance; HSR = distance covered at high speeds (> 13 $km.h^{-1}$); PL = Player Load.

Correlation magnitude: ? = unclear; S = small; M: moderate; L = large; VL = very large; NP = near perfect.
Uncertainty of the correlation magnitude: * = possibly (25%–75% [likelihood of the true correlation being…]); ** = likely (75%–95%); *** = very likely (95%–99.5%); **** = most likely (>99.5%).

Discussion

The aims of this study were to describe the match loads (ML) of soccer field and assistant referees across a competitive season of official matches and also to investigate the relationships between methods of internal and external ML quantification. A further aim was to examine the usefulness of differential ratings of perceived exertion (dRPE) as a tool for monitoring internal ML in soccer referees. The results of our study showed that, a) FR attain considerably higher internal and external MLs when compared with AR, b) the relationships between internal ML and external ML indicators were, in most cases, unclear for FR and small to moderate for AR, and c) dRPE represent distinct dimensions of effort in soccer referees during official matches.

Given the different roles undertaken by FR and AR during match play, and considering that assistant refereeing is limited to half of the length of the field, external ML performed by AR represents approximately half of the external ML performed by FR [34]. Resultantly, AR also incur substantially lower internal ML when compared with FR [34]. These notions are in agreement with our current data, which shows that internal and external ML were ~20–40% and ~50–70% lower, respectively, in AR when compared with FR. Others have reported total match distances of ~10,000 and ~5,000 m for FR and AR, respectively, across various levels of soccer competition [16,35]. Likewise, Krustrup et al. [36] noted that both TD covered (FR, 10,270 ± 900 vs. AR, 6,760 ± 830 m) and distance covered above 18 $km \cdot h^{-1}$ (FR, 1,920 ± 580 vs. AR, 970 ± 520 m) were more than double for FR when compared with AR. Regarding internal ML, the typical match intensity is greater for FR (85–90% HR_{max}) when compared with AR (77–79% HR_{max}) [12,35].

A unique aspect of the current study was the ability to quantify novel methods of internal and external ML indicators (i.e. dRPE and PL, respectively) in soccer referees during official matches. Differential RPE provide information on the perceived central (respiratory) and peripheral (leg muscle) internal ML' [4,9,21,22], while PL represents the sum of external load incurred from multiplanar activities such as running (footfalls), acceleration/decelerations, changes of direction, and impacts to name a few [18,32]. Our data again show that FR incurs greater PL and report greater dRPE when compared with their AR counterparts. Taken together, these data support and add to the literature surrounding the demands of soccer match officials during competition. Knowledge of these different internal and external match responses could help inform the planning and progression of appropriate in-season training loads designed to prepare match officials for the physical and physiological requirements of competition [34].

Examination of the relationships between internal and external ML may help physical trainers of soccer referees know whether both ML methods are necessary to quantify match demands or use only one method is enough to quantify and organize the appropriate training doses, based on the desired training responses that are specific to match demands [1]. The results of our investigation are in agreement with others, who have typically reported unclear/trivial through to moderate correlations between internal ML and intensity with external ML indicators in soccer referees [15,26,27,37]. Costa et al. [26] observed small and moderate associations between TD covered and both $TRIMP_{EDW}$ (r = .22) and sRPE ML (r = .38) in Brazilian FR. Catteral et al. [37] reported a trivial correlation (r = .15) between TD and mean $\%HR_{max}$ in professional FR, although Mallo et al. [28] reported a moderate association (r = .50) between mean $\%HR_{max}$ and the time spent running at high speeds (>18 $km \cdot h^{-1}$) in international FR. Likewise, moderate relationships (r = .31) have also been observed in international AR between mean $\%HR_{max}$ and the total number of high-intensity activities (>13 $km \cdot h^{-1}$) [27]. It is likely that the associations between internal and external ML could be moderated by factors such as the individual fitness level of the referee and also acute physiological stress incurred as a result of physical (i.e. recent training, nutrition, etc.) and social (i.e. travel, sleep, etc.) factors. This may be one explanation for the typically low (unclear to moderate) correlations observed in our current investigation and within the work of others [10,19]. Due to associations between internal and external load measures were ranged from unclear to possibly moderate in our study, it seems that these constructs measure distinctly different match demands. We therefore recommend concurrent measures of match internal and external loads to help fully understand the true dose-response of referees' during team-sports matches [22].

In line with the aims of our investigation, we chose to explore the associations between measures of internal and external ML only, rather than measures of internal intensity (i.e. sRPE, mean $\%HR_{max}$, blood lactate concentration) and external ML. We feel that the latter may be conceptually unsound, given that measures of training and match load encompasses both the intensity and volume of the session. Consequently, the calculation of ML indicators (i.e. $sRPE_{res}$ ML, $sRPE_{mus}$ ML, $TRIMP_{EDW}$) provides a more robust index for investigation rather than intensity alone [38]. Nonetheless, the work of others coincides with those results reported in our study, in which the relationships between internal and external ML indicators were typically more prominent in AR when compared with FR. The physical and physiological demands of a match are very different for FR and AR due to their disparate roles taken on the field. These findings may therefore be explained by the relatively short (one half of the field) and linear running patters of AR in comparison with the stochastic and multi-directional movements of FR. The latter is likely to induce more variable match demands and associated internal responses, which could have mitigated the magnitude of the relationships between internal and external ML.

In our investigation, we chose not to pool our sample of match officials due to the very large / extremely large differences in internal and external ML between these two groups. When concentrating on a more homogeneous subset of match officials (i.e. FR and AR), the strengths of relationships between internal and external ML are likely to be much lower than a pooled analysis which may result in spuriously high correlations that are only useful for confirming already obvious between-group differences [39]. We acknowledge that our study involved a relatively small sample size, particularly for FR (n = 20), and our analysis of the relationships between internal and external ML was therefore restricted to a between-referee comparison. To determine if higher internal ML loads are associated with higher external ML, a within-subject design is the appropriate method as it permits the analysis of within-subject changes by removing between-subject differences [40]. We therefore recommend future work in this area to utilize larger sample sizes and different competitive levels (i.e. elite referees) involving several repeated measures per referee, as well as examining the factors that may reasonably moderate the relationships between internal and external match loads, such as individual referee characteristics (e.g. physical fitness and acute physiological stress) and match-related contextual variables [12,27,28,36,41,42].

This is the first study in which dRPE have been collected on professional soccer referees to quantify internal ML. In our study, RPE_{res} and RPE_{mus} scores were in the range of 6-7 ('very hard'). These ratings are typically lower than global RPE reported in elite soccer referees and may explained by differences in competition standard [12]. A key finding of our investigation was the substantial differences observed between $sRPE_{res}$ and $sRPE_{mus}$ scores in both FR and AR. Match official perceived their leg muscle exertion to be greater than respiratory exertion - a finding consistent with soccer and Australian Football players [22]. The results of our correlation analysis also suggest that there remains approximately 40% unexplained variance between $sRPE_{res}$ and $sRPE_{mus}$ during official competition. Taken together, these data indicate that while $sRPE_{res}$ and $sRPE_{mus}$ may not be mutually exclusive, dRPE do represent distinct internal constructs that are perceived differently by sub-elite soccer match officials. The very large correlation observed between $sRPE_{res}$ ML and $sRPE_{mus}$ ML is not surprising given that the augmentation of central and peripheral exertion during exercise is closely related [43], particularly during high-intensity intermittent activities [23,44]. The substantial differences in the magnitudes of the relationships between $sRPE_{res}$ and $sRPE_{mus}$ with external ML' indicate that these measures may each be influenced by dissimilar external loads. In agreement with others [4,21-23,45], we therefore believe our data supports the notion that dRPE represent a worthwhile addition to the monitoring of ML in soccer referees. Disassociations between $sRPE_{res}$ and $sRPE_{mus}$ may help assist in the monitoring and planning of training loads by informing individualized training or post-match recovery strategies [22,23]; although such ideas warrant further investigation in both sub-elite and elite soccer match officials. Consequently, we encourage the collection of these measures in both future practice and research surrounding team-sport match officials.

Conclusions

Field referees attain considerably higher internal and external MLs when compared with AR during official competition, suggesting that the planning and progression of training activities should be different for these two groups. We found that the relationships between internal and external ML indicators were, in most cases, unclear for field referees and small to moderate for assistant referees, suggesting that these two factors are somewhat independent of one another in sub-elite referees. Finally, dRPE represent distinct dimensions of effort perception in soccer referees during official matches.

Practical Applications

Considering that FR covered almost twice total and high speed running ($>13 km \cdot h^{-1}$) distance, and registered higher internal loads (i.e. $sRPE_{res}$ ML, $sRPE_{mus}$ ML, $TRIMP_{EDW}$) than AR, we suggest that FR and AR should undertake different training regimes not only in relation to prescription training activities but also to overall training volume. Our data also highlights the importance monitoring both internal and external loads during matches and training to help manage workloads and prescribe appropriate training and recovery activities. Differential RPE could be a useful addition to the monitoring and programming of soccer referees' training loads.

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Capítulo 6

Football match officials do not attain maximal sprinting speed during matches

Mi inspiración es la pasión por todo lo que hago.

Rafa Nadal

Estudio 4

Football match officials do not attain maximal sprinting speed during matches

Daniel Castillo, Jesús Cámara, Julen Castellano and Javier Yanci

Kinesiology

2016, 48(2), 207-212

Capítulo 6. Estudio 4

Football match officials do not attain maximal sprinting speed during matches

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Abstract

The aims of this study were, first, to analyse the differences between referees and assistant referees in 20- and 30-metre straight line sprinting test performance and in the maximum speeds registered in football matches; and, second, to analyse the differences between the maximum speeds registered in matches and in the straight line sprinting test. Twenty referees from the Spanish Third Football Division participated in this study. Participants were classified as field referees (FR; n=12, age=30.0±6.7 years; body height=178.1±6.6 cm; body mass=73.7±8.3 kg; BMI=23.2±1.8 $kg \cdot m^{-2}$) and assistant referees (AR; n=8, age=26.0±7.9 years; body height=177.2±7.3 cm; body mass=75.1±8.8 kg; BMI=23.9±3.1 $kg \cdot m^{-2}$). The maximum speed of each referee during an official competition match (Vmax match) and during a straight line sprint test (SLST) (Vmax 30 m sprint) was recorded using a global positioning system (GPS). The results show that no significant differences were found between FR and AR in the SLST (p>.05, d=.13-.14). However, large effect sizes were found in the maximum speeds recorded in matches (p<.076, d=.96). Furthermore, the maximum speeds of the FR and AR in the matches were significantly lower than the maximum speeds registered in the 30 -m SLST (p<.01, d=2.32-2.51). Bearing in mind that field referees and assistant referees do not achieve the maximum speed registered in a 30-metre sprint test in actual football matches, the performance in such accreditation tests does not reflect the characteristics of actions they perform during matches.

Key words: sprinting; speed; soccer; GPS; performance.

Introduction

Soccer refereeing is an intermittent activity for field and assistant referees because they have to be able to carry out actions at high speed during matches in order to assume the best position on the soccer field and, consequently, to ensure a proper course of the game (Castagna, Abt, & D'Ottavio, 2007). Although many studies have analysed physical (external load) and physiological (internal load) demands of playing football (Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011; Impellizzeri, et al., 2013; Weston, et al., 2011a; Weston, Drust, Atkinson, & Gregson, 2011b), few studies have focussed on analyzing these aspects in football referees (Costa, et al., 2013; Weston, et al., 2012). The referees are in charge of regulating the behaviour of players and coaches and have the authority to enforce the rules of the game (Castagna, Impellizzeri, Bizzini, Weston, & Manzi, 2011). Given the work they have to perform, referees require well-developed physical and physiological qualities to be able to respond to the demands of the game (Barbero-Alvarez, Boullosa, Nakamura, Andrin, & Castagna, 2012). However, many of the fitness tests observed in the scientific literature did not significantly correlate with match activities (total distance covered, high -intensity running and sprinting distance) (Mallo, Navarro, García-Aranda, & Helsen, 2009). Obviously, the evaluation of elite-standard referees should be specific and related to activities performed during matches (Weston, Castagna, Helsen, & Impellizzeri, 2009).

In a football match referees cover a total of 11,770±808 m, of which 889±327 m are covered at a high speed (>19.8 $km \cdot h^{-1}$) and they perform a total of 21.3-30.5 sprints (>25.2 $km \cdot h^{-1}$) during the course of a match (Weston, et al., 2012). It has also been observed that for 13.2% of the total match time, the referee is moving backwards or sideways (D'Ottavio & Castagna, 2001b). In contrast, the activities of assistant referees are characterized by brief and intense forward and sideway movements, interspersed with long periods of moving at low intensity (Krustrup, et al., 2009). The knowledge of physical demands imposed on field (FR) and assistant referees (AR) during official matches could help personal trainers design adequate training programs. Besides, Committees of Soccer Referees could establish tests for accrediting these officials according to the actual demands of the sporting activity. Insight into the mean and maximal speeds attained by field and assistant referees in official matches could help physical trainers design training strategies to ensure an appropriate external training load (TL); however, few studies have measured and presented maximal speeds attained by field referees during football matches (Costa, et al. 2013; Weston, et al., 2011). Still, none have addressed them in assistant referees.

D`Ottavio and Castagna (2001a) showed that in football matches referees' sprints rarely lasted more than 4 seconds. In spite of this, most studies have involved tests of sprinting over distances of 40 metres (Fernandez, da Silva, & Arruda, 2008; Mallo, et al., 2009; Weston, et al., 2009) and 50 metres (Bartha, Petridis, Hamar, Puhl, & Castagna, 2009; Casajus & Castagna, 2007; da Silva, 2011). Further, the Fédération Internationale de Football Association (FIFA) uses a test of 6x40 metres to assess sprinting capacity in football referees. Since the maximum speed during a 40-metre sprint test has been observed to be much higher than that attained during a soccer match, it seems reason-able to use shorter sprinting distances to determine better the referees' maximum speed capacity during soccer matches. In this line, D`Ottavio and Castagna (2001b) proposed the assessment of sprinting speed capacity in referees over shorter distances. In fact, several studies have used shorter distances such as 5, 15 metres (Yanci-Irigoyen, 2014; Yanci, Los Arcos, Grande, & Casajús, 2016) and 30 metres (Krustrup, Mohr, and Bangsbo, 2002; Castillo, Yanci, Cámara, & Weston, 2016).

In spite of the fact that Krustrup and colleagues (2002) analysed sprinting speed in a 30-metre sprint test, observing that the performance of the assistants in this test decreased after the matches (before: 4.74±.08 seconds; after: 4.92±.07 seconds), we have found only one other study where distances of less than 40 metres were analysed (Castagna, Bendiksen, Impellizzeri, & Krustrup, 2012). Bearing in mind the scarcity of information avail-able on sprinting capacity in sprints lasting about 4 seconds and the importance of measuring physical qualities in conditions which are as similar as possible to those of a football match, we considered it would be worthwhile for the improvement of physical preparation of match officials to analyse referees' performances in sprints over distances less than 40 metres.

Therefore, the objectives of this study were, on the one hand, to analyse the differences between the maximum movement speeds reached by referees both in matches and in a sprint test, and on the other hand, to determine the differences in performance between field referees and assistant referees in 20-metre and 30-metre sprint tests.

Methods

Participants

Twenty official referees from the Spanish Third Football Division, Group XV (age=28.40±7.26 years; body height=177.75±6.69 cm; body mass=74.30±8.34 kg; BMI=23.51±2.37 kg·m^{-2}) took part in this research during the 2014/15 season, after having been informed about the characteristics of the study and having given their written consent. All the referees had at least ten years of experience in refereeing and had been in action for at least six seasons at this competitive level. The participants were classified according to their function into two groups: field referees (FR; n=12, 30.0±6.7 years; body height=178.1±6.6 cm; body mass=73.7±8.3 kg; BMI=23.2±1.8 kg·m^{-2}) and assistant referees (AR; n=8, 26.0±7.9 years; body height=177.2±7.3 cm; body mass=75.1±8.8 kg; BMI=23.9±3.1 kg·m^{-2}). This research was carried out according to the criteria established by the Declaration of Helsinki (2013) and was approved by the Ethics Committee of the University of the Basque Country (UPV/EHU).

Procedure

The maximum speed of each referee was recorded during official competition matches (Vmax match) and during a straight line sprint test (SLST) (Vmax 30 m sprint). The SLST took place five days before the start of the season. Recordings were made during twelve matches in the period between September and December of the 2014/2015 season.

Both in the tests and in the matches, the field and assistant referees wore a jacket with a pocket on their backs where a GPS monitoring device was inserted operating at a frequency of 10 Hz (MinimaxX 4.0, Catapult Innovations®, Melbourne, Australia). Data were collected during what were considered to be good GPS conditions in terms of the weather and satellite conditions (number of satellites = 10.0±.2 and 10.3±.4 for 20- and 30-metre sprints during testing sessions, respectively, and 10.1±.2 during match plays). Castellano, Casamichana, Calleja-González, San Román, and Ostojic (2011) assessed the reliability (coefficient of variation, CV=.7%) and accuracy (standard error of measurement, SEM=5.1%) of the devices used in this study in short distance runnings. All the referees performed a similar warm-up before the matches and the SLST, which consisted of seven minutes of gentle jogging followed by sprints and passive stretching.

Straight Line Sprint Test (SLST). The referees carried out three SLSTs of 30 metres at maximum intensity (Krustrup, et al., 2002) with a 90-second rest between each (Gorostiaga, et al., 2009). The subjects positioned themselves 0.5 metres behind the start line (Yanci-Irigoyen, 2014) and, when they felt ready, ran as fast as they could to the finish line which was the total of 30 metres away. Mean speed was measured over the first 20 metres (V_{mean} 20 m sprint) and over the total of 30 metres (V_{mean} 30 m sprint) attending to the average speed registered in each distance. Maximum speed was also registered (Vmax 30 m sprint) as the highest speed achieved during the 30-metre sprint. The best 30-metre trial was used for statistical analysis. The CVs obtained for the V_{mean} 20 m sprint, V_{mean} 30 m sprint and Vmax 30 m sprint were .79±.38%, .93±.56% and 2.03±.56%, respectively. All the measures were registered using a GPS monitoring device operating at a frequency of 10 Hz (MinimaxX 4.0, Catapult Innovations®, Melbourne, Australia).

Football matches. Vmax match was recorded for all the FR and AR. Only the AR who carried out the SLSTs were chosen for our study. So, although twelve FR and twenty-four AR refereed a total of twelve matches, only eight AR participated in this study. Since the other sixteen AR did not perform the SLST, due to the second-chance examinations of soccer game rules, we decided not to consider them for the study. All the matches analysed were played at four different sports facilities of similar dimensions (100x64 metres) and the same playing surface (the third generation artificial turf).

Statistical analysis

The results are presented as means (M) ± standard deviation (SD). The coefficient of variation (CV) = $(SD \cdot M^{-1})$ x 100 (Atkinson & Nevill, 1998) was used to assess the reproducibility of the 30 m sprint test. A *t*-test for independent samples was used to compare the results (time variables obtained in the 20 and 30 metres sprints: V_{mean} 20 m sprint, V_{mean} 30 m sprint, V_{max} 30 m sprint and V_{max} match) between FR and AR. A *t*-test for related samples was used to analyse the differences between the variables of maximum speed in the matches and in the sprint tests (V_{max} match and V_{max} 30 m sprint) independently for each group (FR, AR, and the whole group). Practical differences were assessed using Cohen's d effect size (large: >.8; moderate: between .8 and .5; small: between .5 and .2; trivial <.2) (Cohen, 1988). Pearson's correlation coefficient (r) with a confidence interval (CI) of 95% was used to observe the relation between the variables Vmax 30 m sprint and Vmax match. Relationships between Vmax 30 m sprint and Vmax match were examined using correlation coefficients, with 90% confidence limits (CL). The following scale of magnitudes was used to interpret the values of the correlation coefficients: <.1, trivial; .1-.3, small; .3-.5, moderate; .5-.7, large; .7-.9, very large; >.9, nearly perfect (Hopkins, Marshall, Batterham, & Hanin, 2009). The data analysis was carried out using the Statistical Package for Social Sciences (version 21.0 for Windows, SPSS® Inc, Chicago, IL, USA). Statistical significance was set at $p<.05$.

Results

The results obtained by the total number of field and assistant referees (n=20) in the Vmax 30 m sprint was 29.45±1.67 km·h^{-1}. The recorded mean speed for the total number of field and assistant referees in the 20 and 30 m sprints was 23.93±1.20 and 25.66±1.36 km·h^{-1}, respectively. Total mean time for the whole sample in covering the 20 and 30 metres was 3.02±0.27 s and 4.21±.29 s, respectively. No significant differences were observed (p>.05) between FR and AR in the time needed to cover 20 and 30 metres, in the V_{mean} 20 m sprint and V_{mean} 30 m sprint or in the V_{max} 30 m sprint and the effect sizes were trivial (d<.14) (Table 1).

Both the field and assistant referees achieved values of Vmax 30 m sprint that were higher than those attained during the matches (p<.01, FR: 29.64±1.32 vs 26.34±2.27 km·h $^{-1}$, d=2.51, Vmax match=88.37% Vmax 30 m sprint; AR: 29.15±2.15 vs 24.16±2.62 km·h^{-1}, d=2.32, Vmax match=82.88% Vmax 30 m sprint). In the total sample of referees, significant differences were also observed between Vmax 30 m sprint and Vmax match (All: 29.45±1.67 vs 25.47±2.59 km·h^{-1}, p=.00, d=2.39). The Vmax match corresponds to 86.49±8.62% of the Vmax 30 m sprint. Furthermore, although FR did not demonstrate higher Vmax match values than AR (26.34±2.27 vs 24.16±2.62 km·h^{-1}, p=.076), the effect size was large (d=.96). Small and moderate correlations were observed between Vmax 30 m sprint and Vmax match (All: r=.292, p=.211; FR: r=.446, p=.146; AR: r=.106, p=.803).

Table 1. Results of the straight line sprint tests taken by the field (FR) and assistant referees (AR).

Variables	FR	AR	Difference of means (%)	d
20 m sprint (s)	3.02±0.28	3.00±0.31	0.67	.14
V_{mean} 20 m sprint (km·h^{-1})	23.86±1.12	24.02±1.40	0.67	.14
30 m sprint (s)	4.20±0.28	4.19±0.30	0.62	.13
V_{mean} 30 m sprint (km·h^{-1})	25.60±1.23	25.76±1.72	0.62	.13

Note. d: effect size; V_{mean}: mean velocity recorded; V_{max}: maximum velocity attained.

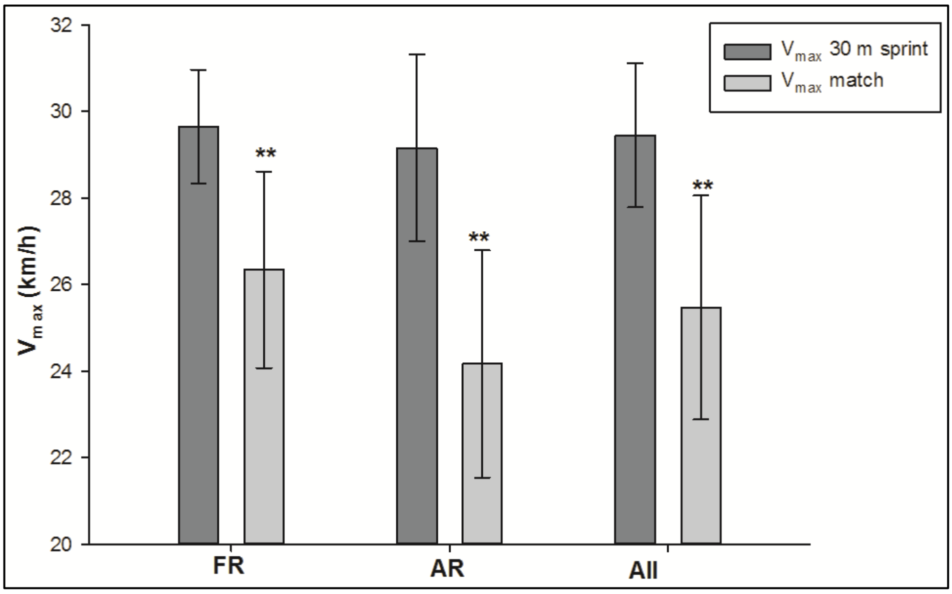

Figure 1. Maximum velocities (V_{max}) reached in the 30 m sprint test and in the football matches differentiating between total sample (All), field referees (FR) and assistant referees (AR).

Discussion and conclusions

Sprint capacity has already been studied in foot-ball referees (Costa, et al., 2013; Krustrup, et al., 2002), and some authors have compared physical condition (da Silva, 2011) and activity in competition (Mallo, Navarro, Garcia-Aranda, Gilis, & Helsen, 2008) between field referees and assistants. However, we have found no studies which determined V_{mean} and V_{max} in straight line sprint tests nor Vmax in field and assistant referees in the official Spanish football competitions. Thus, the objectives of this study were to analyse the differences between the maximum speed reached during matches and sprint tests (i.e. 20 and 30 metres) and to determine the differences in performance between FR and AR in a 20-metre and a 30-metre sprint test and in the maximum speed attained during matches. This is the first study that compares the maximum speed achieved by FR and AR in official matches and in a sprinting test. The main results of this study show that the maximum speeds reached by both the FR and AR in the matches were significantly lower than those recorded in the 30-metre straight line sprint test. Furthermore, no significant differences were found between FR and AR in the SLST but for the differences in the maximum running speed reached in the matches.

Although a previous study had analysed maximum velocity in football referees in matches (Costa, et al., 2013), our study is the first to analyse this aspect also in assistant referees. During the matches we observed Vmax of 26.34±2.27 km·h^{-1} in the case of the field referees. These results are higher (by 26.3%) than those recorded by Costa et al. (2013) (19.4±1.4 km·h^{-1}). Equally, the results of the assistant referees were also higher (by 19.7%) than those reported by Costa et al. (2013) in the field referees. On the other hand, Weston et al. (2009) obtained higher maximum velocities (by 15.0%) in elite-standard soccer referees than in our study. These differences could be due to the different measurement instruments used in these studies or to the difference in the categories of the referees studied. Since sprint capacity seems to be lower at non-professional competitive-levels (i.e. Third Division), it seems appropriate to evaluate the sprint capacity in distances below 40 metres. Given that maximum speeds achieved during matches by soccer referees depend on the competitive level, it would be useful to adjust the tests' sprinting length to respective competitive level.

Straight line sprint tests have often been used to assess sprinting capacity in footballers (Carling, Le Gall, & Malina, 2012; Haugen, Tonnessen, & Seiler, 2013; Tonnessen, Hem, Leirstein, Haugen, & Seiler, 2013). However, fewer studies on football referees have been found (Bartha, et al., 2009; Mallo, et al., 2009; Weston, et al., 2009). The results obtained in the current study by the field and assistant referees were similar to those observed by Krustrup et al. (2002) (4.21±.29 vs 4.34±.35 s, respectively). Previous research had used distances of more than 40 m (Bartha, et al., 2009; da Silva, 2011; Weston et al., 2009), possibly because maximum velocity cannot be attained over a distance of 30 metres (Buchheit, Simpson, Peltola, & Mendez-Villanueva, 2012). Sprinting tests over distances of 15 and 30 metres have been used to evaluate acceleration capacity in soccer referees (Castillo, et al., 2016; Yanci, et al., 2015); however, the relationship between Vmax match and sprinting tests has not been studied.

The results of our study show that the field and assistant referees reach values of Vmax in matches that are clearly lower than those observed in the straight line sprint test over 30 metres (FR, difference of means=3.30±2.05 km·h^{-1}, 11.1%; and AR, difference of means=4.99±3.21 km·h^{-1}, 17.1%). Although FIFA has established a test to assess sprint capacity over a distance of 40 metres, attending to our mentioned results, it might be interesting to assess this quality over shorter distances, especially in lower categories. We suggest considering the maximum velocities achieved at each competitive level in order to design appropriate sprinting tests.

According to our results both the field and assistant referees did not carry out actions at maximum speed during matches. Perhaps it would not be necessary to perform maximum velocity tests. It may be more interesting to analyse more specific actions such as changes of direction, sideways running and sprinting over short distances. Although more research is needed to corroborate the results of our study, the lower maximum velocity reached during matches suggests that it may not be necessary to use tests over a distance of more than 30 m for football field and assistant referees. Soccer referees do not achieve their maximum speeds during official matches in the observed national division; thus, acceleration capacity seems to be more relevant than maximum velocity. Therefore, tests over shorter distances may be more interesting and foot-ball refereeing – specific (Arcos, Yanci, Mendiguchia, & Gorostiaga, 2014).

Interestingly, in our study although the field referees attained maximum velocities which were higher (8.3%, d=.96) than those of the assistant referees in the matches (26.34±2.27 $km \cdot h^{-1}$ vs 24.16±2.62 $km \cdot h^{-1}$, respectively), their performance in SLST was not better. These results agree with those of da Silva (2011) who did not find differences between the field and assistant referees in a 50 m test either. Also, these results are consistent with the results obtained in previous studies which stated that the activity carried out by field referees and assistant referees (metres covered, running intensity, time spent in different zones related to percentages of maximum heart rate) is not the same (Helsen & Bultynck, 2004; Krustrup, et al., 2009; Mallo, et al., 2009). This suggests that physical demands of matches imposed on the field and assistant referees should be taken into account. Similar sprinting performance of FR and AR could be due to their equal physical training. However, physical demands in the competition are different. Thus, it could be necessary to carry out specific training to improve sprinting capacity in AR. Therefore, fitness coaches should include specific strategies in the training to improve acceleration capacity attending to physical demands of football matches imposed on FR and AR. This is in accordance with the idea of Mendez Villanueva and Buchheit (2013) who affirmed that as long as a soccer player is able to do his “job” satisfactorily on the field, all other (physical) considerations are secondary. In our study, although assistant referees obtained a high performance in a sprint test, they did not reach their maximum speeds during competition due to their activity is limited to the half of the field and their physical requirements imposed on the game.

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Capítulo 7

Conclusiones

Vale la pena pelear por nuestros sueños. Vale la pena equivocarse y levantarse.

Manuel Carrasco

Capítulo 7. Conclusiones

Las conclusiones de esta tesis doctoral son las siguientes:

- Los árbitros de campo recorren más distancia y registran un valor de velocidad media mayor que los árbitros asistentes durante el desarrollo de los partidos oficiales. De esta manera, se sugiere la necesidad de diseñar programas de entrenamiento específicos tanto para árbitros de campo como para árbitros asistentes con el fin de mejorar su rendimiento físico durante la competición.
- Se observa un descenso en la capacidad de esprintar en distancias de 15 y 30 metros después del partido cuando se compara con el rendimiento registrado antes del mismo, tanto en árbitros de campo como en árbitros asistentes. El descenso observado en el rendimiento de esprint podría ser considerado como un indicador de fatiga ocasionada por el partido. Sin embargo, no se encuentra una pérdida de rendimiento en la capacidad de salto vertical bilateral y unilateral.
- Los árbitros muestran un descenso en el rendimiento de salto horizontal bilateral después de la primera y la segunda parte cuando se compara con el rendimiento registrado antes del partido. Por tanto, la actividad de arbitrar puede provocar fatiga en la musculatura implicada en el eje antero-posterior.
- Los árbitros registran un descenso en el rendimiento de salto horizontal con la pierna derecha al final de la primera parte, pero solamente en los árbitros asistentes se observa un descenso al final del partido. Este hecho podría sugerir que los árbitros asistentes pueden tener una mayor implicación durante el juego de la extremidad inferior derecha y en consecuencia una fatiga debido a que las acciones específicas y más relevantes que realizan se producen hacia su lado derecho donde se encuentra el área de penalti.
- Las asociaciones entre los indicadores de carga interna y externa son, en la mayoría de los casos, poco claras para los árbitros de campo y de pequeñas a moderadas para los árbitros asistentes, lo que sugiere que estos métodos de cuantificación de la carga aportan información distinta en árbitros no profesionales.
- Diferenciar el esfuerzo percibido (dRPE) en respiratorio y muscular representa distintas dimensiones de la percepción del esfuerzo en árbitros de fútbol durante partidos de competición oficial.

- Los árbitros de campo y los árbitros asistentes alcanzan claramente menores valores de velocidad máxima en los partidos que en un test de esprint de 30 metros en línea recta.
- A pesar de que los árbitros de campo alcanzan mayores valores de velocidad máxima en los partidos que los árbitros asistentes, el rendimiento en el test de esprint en línea recta no es mejor.

Capítulo 8

Aplicaciones prácticas y transferencia del conocimiento

Si no puedes sobresalir con talento, triunfa con esfuerzo.

Dave Weinbaum

Capítulo 8. Aplicaciones prácticas y transferencia del conocimiento

Como aplicaciones prácticas derivadas de estas investigaciones señalamos las siguientes:

- Considerando que los árbitros de campo cubrieron casi el doble de distancia total y distancia a alta intensidad (>13 km·h^{-1}), y registraron mayores valores de carga interna (p. e. $sRPE_{res}$ ML, $sRPE_{mus}$ ML, $TRIMP_{EDW}$) que los árbitros asistentes, sugerimos que árbitros de campo y árbitros asistentes deberían llevar a cabo un régimen de entrenamiento distinto no solamente en relación a la prescripción del entrenamiento sino también atendiendo al volumen total de entrenamiento.
- Los árbitros de campo y árbitros asistentes registraron un descenso en la capacidad de esprintar después de los partidos, por lo que se recomienda un entrenamiento físico adecuado para compensar dicha disminución. Por lo tanto, se recomienda a los preparadores físicos de árbitros de fútbol la inclusión de programas de entrenamiento que se centren en la mejora de la capacidad para repetir esprints, ya que se ha demostrado que estos programas pueden ser eficientes para mejorar varios componentes relacionados con el rendimiento en el partido tales como la velocidad, la potencia y la habilidad para mantener las carreras de alta intensidad y los esprints a lo largo del partido (Taylor, Macpherson, Spears y Weston, 2015; Weston, 2015).
- Además, los preparadores físicos de árbitros de fútbol deberían implementar programas específicos de entrenamiento basados en mejorar la fuerza en los músculos implicados en las acciones realizadas en el eje antero-posterior.
- Los resultados obtenidos en esta tesis doctoral ponen de manifiesto la importancia de monitorizar tanto las cargas externas como internas durante los partidos y entrenamientos con el fin de controlar el trabajo realizado y prescribir estrategias de entrenamiento adecuadas.
- Diferenciar el RPE podría ser una estrategia útil para monitorizar la carga de los partidos y entrenamientos y programar más adecuadamente los estímulos de entrenamiento de los árbitros de fútbol.
- Aunque la FIFA ha establecido un test de esprint en línea recta de 40 metros para valorar la capacidad de esprintar en árbitros de campo y árbitros asistentes, parece interesante valorar esta cualidad en distancias más cortas especialmente en categorías provinciales.

- Los preparadores físicos deberían incluir entrenamiento específico basado en mejorar la capacidad de aceleración atendiendo a las demandas físicas que les supone a los árbitros de campo y a los árbitros asistentes los partidos de fútbol.

Como actividades complementarias a la confección de esta tesis doctoral, los resultados que se iban encontrando se facilitaban al CNAF. Además, durante este periodo de formación predoctoral hemos realizado charlas informativas con los propios colegiados y los preparadores físicos de los comités donde se les ha ido informando sobre estos resultados y se ha debatido sobre sus posibles aplicaciones prácticas.

Capítulo 9

Limitaciones

No vivo ni en pasado ni en futuro. Tengo solo el presente y eso es lo único que me interesa. Si puedes permanecer siempre en el presente serás un hombre feliz.

Paulo Coelho

Capítulo 9. Limitaciones

Esta tesis doctoral no está exenta de limitaciones. La principal limitación es el número de árbitros y asistentes analizados durante la competición, dado que la temporada competitiva se desarrolla en 38 jornadas y que 32 árbitros de campo son elegidos para oficiar dichos partidos, quizás hubiera sido más interesante la posibilidad de acceder a todos ellos. Sin embargo, hemos respetado los principios éticos de una investigación y solo aquellos árbitros de campo y árbitros asistentes que firmaron el consentimiento informado y declaraban su disposición de participar de forma voluntaria fueron considerados como participantes de la investigación. Además, aunque se ha intentado llevar a cabo una rigurosa, organizada y profesional toma de datos a lo largo de 30 partidos oficiales durante la temporada 2014-2015 y en cuatro instalaciones deportivas similares, el hecho de la utilización de material móvil puede provocar pequeños errores metodológicos. Así mismo, a pesar de que se ha respetado el horario (16:00-18:00) de la disputa de los partidos, las condiciones climatológicas son imprevisibles y este aspecto ha podido afectar al rendimiento de los árbitros tanto en competición como en los test físicos.

Además, el hecho de que todos los árbitros participantes en este proyecto de investigación pertenecieran al mismo comité de árbitros, puede suponer otra importante limitación y por tanto debemos interpretar los resultados con cautela, debido a que podrían estar condicionadas por la cultura deportiva del propio comité y de los entrenamientos realizados semanalmente.

Capítulo 10

Futuras líneas de investigación

No hay nada imposible para aquel que lo intenta.

Alejandro Magno

Capítulo 10. Futuras líneas de investigación

Dado que esta es la única investigación que muestra un descenso en el rendimiento de la musculatura implicada en el eje antero-posterior en los árbitros y asistentes de fútbol no profesionales durante el desarrollo de los partidos, medido mediante test de aceleración y salto horizontal, sería interesante la aplicación de estudios científicos que repliquen el procedimiento de esta investigación. Por otro lado, es recomendable el diseño de investigaciones que analicen la relación entre la asimetría de las extremidades inferiores tanto en salto vertical como en salto horizontal y el riesgo de lesión en árbitros y asistentes de fútbol.

A pesar de que en esta tesis doctoral hemos monitorizado la carga de la competición gracias al registro de distintas variables de carga externa (p. e. distancias, velocidades, aceleraciones, deceleraciones, PL) y carga interna (p. e. RPE, FCmed, FCmax, zonas de FC), en futuras investigaciones sería interesante registrar otras variables mediante las nuevas tecnologías existente en el mercado. Además, dado la falta de literatura referente a la diferenciación del RPE en árbitros de fútbol, sería interesante realizar investigaciones que analizasen la validez de esta variable para cuantificar la carga interna en el arbitraje.

Considerando que no todos los árbitros tienen la misma capacidad de aceleración y de velocidad, al igual que se hace con el parámetro de frecuencia cardiaca, los futuros estudios deberían considerar relativizar dichas variables de carga externa atendiendo a la velocidad máxima individual obtenida por cada árbitro o asistente en un test y/o en la competición, con el objetivo de conocer la intensidad relativa de sus acciones durante el arbitraje.

Así mismo, son necesarios más estudios que investiguen acerca de la asociación entre los test físicos propuestos por la FIFA para AC y AA y las demandas físicas de la competición. Los resultados contradictorios encontrados en estudios previos unidos a los hallados de esta tesis doctoral, ponen de manifiesto la necesidad de abordar esta línea de investigación con el objetivo de ayudar a los comités a establecer una batería de test físicos que mejor refleje las demandas de la competición atendiendo a distintos niveles competitivos.

La cuantificación de la carga de entrenamientos y partidos ayuda a controlar la intensidad y volumen de entrenamientos, y de esta manera, diseñar los ejercicios más adecuados para obtener una condición física óptima y reducir el riesgo de lesión. En futuras investigaciones, se debería evaluar la efectividad de programas específicos de prevención de lesiones teniendo en cuenta el volumen e intensidad de las estrategias de entrenamiento y de los partidos.

Capítulo 11

Referencias Bibliográficas

La vida es aquello que pasa mientras tú intentas planearla.

John Lennon

Capítulo 11. Referencias bibliográficas

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Capítulo 12

Anexos

Siempre parece imposible hasta que está hecho.

Nelson Mandela

Capítulo 12. Anexos

12.1 Portadas y/o cartas de aceptación de los estudios publicados.

Journal of Sports Sciences

ISSN: 0264-0414 (Print) 1466-447X (Online) Journal homepage: http://www.tandfonline.com/loi/rjsp20

The influence of soccer match play on physiological and physical performance measures in soccer referees and assistant referees

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To cite this article: Daniel Castillo, Javier Yanci, Jesús Cámara & Matthew Weston (2016) The influence of soccer match play on physiological and physical performance measures in soccer referees and assistant referees, Journal of Sports Sciences, 34:6, 557-563, DOI: 10.1080/02640414.2015.1101646

To link to this article: http://dx.doi.org/10.1080/02640414.2015.1101646

Published online: 02 Nov 2015.

23-Apr-2017

Dear Mr Castillo:

Ref: Impact of official matches on soccer referees' horizontal-jump performance

Our reviewers have now considered your paper and have recommended publication in Science and Medicine in Football. We are pleased to accept your paper in its current form which will now be forwarded to the publisher for copy editing and typesetting. The reviewer comments are included at the bottom of this letter, along with those of the editor who coordinated the review of your paper.

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Sincerely,
Tim Meyer and Franco Impellizzeri
Editor in Chief, Science and Medicine in Football
tim.meyer@mx.uni-saarland.de, franco.impellizzeri@gmail.com

"Relationships Between Internal and External Match Load Indicators in Soccer Match Officials" by Castillo D et al.
International Journal of Sports Physiology and Performance

Note. This article will be published in a forthcoming issue of the *International Journal of Sports Physiology and Performance*. The article appears here in its accepted, peer-reviewed form, as it was provided by the submitting author. It has not been copyedited, proofread, or formatted by the publisher.

Section: Original Investigation

Article Title: Relationships Between Internal and External Match Load Indicators in Soccer Match Officials

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Journal: *International Journal of Sports Physiology and Performance*

Acceptance Date: November 2, 2016

DOI: http://dx.doi.org/10.1123/ijspp.2016-0392

FOOTBALL MATCH OFFICIALS DO NOT ATTAIN MAXIMAL SPRINTING SPEED DURING MATCHES

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Original scientific paper
UDC: 796.065:796.012.13

Abstract:

The aims of this study were, first, to analyse the differences between referees and assistant referees in 20- and 30-metre straight line sprinting test performance and in the maximum speeds registered in football matches; and, second, to analyse the differences between the maximum speeds registered in matches and in the straight line sprinting test. Twenty referees from the Spanish Third Football Division participated in this study. Participants were classified as field referees (FR; n=12, age=30.0±6.7 years; body height=178.1±6.6 cm; body mass=73.7±8.3 kg; BMI=23.2±1.8 $kg \cdot m^{-2}$) and assistant referees (AR; n=8, age=26.0±7.9 years; body height=177.2±7.3 cm; body mass=75.1±8.8 kg; BMI=23.9±3.1 $kg \cdot m^{-2}$). The maximum speed of each referee during an official competition match (V_{max} match) and during a straight line sprint test (SLST) (V_{max} 30 m sprint) was recorded using a global positioning system (GPS). The results show that no significant differences were found between FR and AR in the SLST ($p>.05$, $d=.13$-$.14$). However, large effect sizes were found in the maximum speeds recorded in matches ($p<.076$, $d=.96$). Furthermore, the maximum speeds of the FR and AR in the matches were significantly lower than the maximum speeds registered in the 30-m SLST ($p<.01$, $d=2.32$-2.51). Bearing in mind that field referees and assistant referees do not achieve the maximum speed registered in a 30-metre sprint test in actual football matches, the performance in such accreditation tests does not reflect the characteristics of actions they perform during matches.

Key words: sprinting, speed, soccer, GPS, performance

Introduction

Soccer refereeing is an intermittent activity for field and assistant referees because they have to be able to carry out actions at high speed during matches in order to assume the best position on the soccer field and, consequently, to ensure a proper course of the game (Castagna, Abt, & D'Ottavio, 2007). Although many studies have analysed physical (external load) and physiological (internal load) demands of playing football (Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011; Impellizzeri, et al., 2013; Weston, et al., 2011a; Weston, Drust, Atkinson, & Gregson, 2011b), few studies have focussed on analyzing these aspects in football referees (Costa, et al., 2013; Weston, et al., 2012). The referees are in charge of regulating the behaviour of players and coaches and have the authority to enforce the rules of the game (Castagna, Impellizzeri, Bizzini, Weston, & Manzi, 2011). Given the work they have to perform, referees require well-developed physical and physiological qualities to be able to respond to the demands of the game (Barbero-Alvarez, Boullosa, Nakamura, Andrin, & Castagna, 2012). However, many of the fitness tests observed in the scientific literature did not significantly correlate with match activities (total distance covered, high-intensity running and sprinting distance) (Mallo, Navarro, Garcia-Aranda, & Helsen, 2009). Obviously, the evaluation of elite-standard referees should be specific and related to activities performed during matches (Weston, Castagna, Helsen, & Impellizzeri, 2009).

In a football match referees cover a total of 11,770±808 m, of which 889±327 m are covered at a high speed (>19.8 $km \cdot h^{-1}$) and they perform a total of 21.3-30.5 sprints (>25.2 $km \cdot h^{-1}$) during the course of a match (Weston, et al., 2012). It has also been observed that for 13.2% of the total match time, the referee is moving backwards or sideways (D'Ottavio & Castagna, 2001b). In contrast, the activities of assistant referees are characterized by brief and intense forward and sideway movements, interspersed with long periods of moving at low intensity (Krustrup, et al., 2009). The knowledge of physical demands imposed on field (FR) and assistant referees (AR) during official matches could

12.2 Índice de calidad de las revistas.

Revista	ISSN	País	Categoría	IF	Cuartil
JSS	0264-0414	Inglaterra	Ciencias del Deporte	2,888	2
Sci Med Football	2473-3938	Inglaterra	Ciencias del Deporte	2,888*	2
IJSPP	1555-0265	Estados Unidos	Ciencias del Deporte	3,352	1
Kinesiol	1331-1441	Croacia	Ciencias del Deporte	0,634	4

ISSN = International Standard Serial Number; JSS = Journal of Sports Sciences; Sci Med Football = Science and Medicine in Football; IJSPP = International Journal of Sports Physiology and Performance; Kinesiol = Kinesiology; IF = Factor de impacto de los últimos 5 años.

*Esta revista ha sido un número especial de fútbol de la revista Journal of Sports Sciences hasta el año 2015. En este momento, se encuentra en proceso de evaluación debido a su desvinculación de dicha revista.

12.3 Comité de Ética.

NAZIOARTEKO BIKAINTASUN CAMPUSA
CAMPUS DE EXCELENCIA INTERNACIONAL

Universidad del País Vasco / Euskal Herriko Unibertsitatea

IKERKETA SAILEKO ERREKTOREORDETZA
VICERRECTORADO DE INVESTIGACIÓN

INFORME DEL COMITÉ DE ÉTICA PARA LAS INVESTIGACIONES CON SERES HUMANOS, SUS MUESTRAS Y SUS DATOS (CEISH) DE LA UPV/EHU

Mª Jesús Marcos Muñoz como Secretaria del CEISH de la Universidad del País Vasco/Euskal Herriko Unibertsitatea (UPV/EHU

CERTIFICA

Que este Comité de Ética para la Investigación con Seres Humanos (CEISH), que reúne los requisitos establecidos en el BOPV de 17 de febrero de 2014*, ha evaluado la propuesta de **D. Daniel Castillo Alvira**, *CEISH/261/2014/CASTILLO ALVIRA* para la realización la Tesis Doctoral: *"Análisis morfofuncional de árbitros y asistentes de fútbol en una temprada"*, dirigida por Javier Yanci Irigoyen.

Considerando que,

La investigación presenta una justificación adecuada en cuanto a sus objetivos y fines, que proporcionarán un beneficio para la salud y el conocimiento; y por tanto, los riesgos y molestias previsibles para los sujetos están justificados para los resultados esperables.

La investigación propone una hipótesis clara, basada en principios y métodos científicos aceptados, incluyendo técnicas estadísticas adecuadas, que producirán datos fiables y válidos.

La capacidad del equipo investigador y los recursos disponibles son los adecuados para realizar la Tesis Doctoral.

El plan de reclutamiento de los sujetos previsto es el adecuado.

El procedimiento de información y obtención del consentimiento cumple con los requisitos éticos, incluyendo los modelos de hoja de información y consentimiento informado.

Se protegen los datos personales, y se ha dado de alta el fichero de investigación en la AVPD.

Se recogen los acuerdos, convenios y requisitos normativos vigentes necesarios para llevar a cabo la investigación.

El CEISH, tanto en su composición, como en su Procedimiento Normalizado de Trabajo, cumple con la Resolución de la UPV/EHU de 30 de enero de 2014 y con las Normas de Buenas Prácticas.

Ha emitido **INFORME FAVORABLE** en la sesión del CEISH celebrada el 15 de mayo de 2014 (recogido en su acta 52/2014), a que dicho proyecto de investigación sea realizado, por los siguientes investigadores:

- Daniel Castillo Alvira
- Javier Yanci Irigoyen
- Jesús Cámara Tobalina
- Pedro Sanz Arriazu

Lo que firmo en Leioa, a 26 de junio de 2014

Fdo: Mª Jesús Marcos Muñoz
Secretaria del CEISH de la UPV/EHU

Nik, Jose Luis Martín González jaunak, UPV/EHUko
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* Reglamento por el que se regulan [illegible] en la investigación y la práctica docente de la UPV/EHU

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Sarriena Auzoa, z/g
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12.4 Publicaciones científicas relacionadas con la tesis.

Otras investigaciones relacionadas con la temática de la tesis doctoral han sido publicadas por el autor de la tesis doctoral en revistas internacionales y nacionales. A continuación se adjuntan las referencias de las publicaciones dado que permiten ampliar el conocimiento científico derivado de la tesis doctoral en el ámbito de la condición física y fisiológica en el arbitraje.

Revistas internacionales:

- Castillo, D., Yanci, J., & Cámara, J. (In press). Impact of official matches on soccer referees' power performance. *Journal of Human Kinetics.*
- Castillo, D., Cámara, J., Castagna, C., & Yanci, J. (2017). Effects of the off-season period in field and assistant soccer referees' physical performance. *Journal of Human Kinetics,* 56, 159-166.
- Castillo, D., Yanci, J., Casajús, J.A., & Cámara, J. (2016). Physical fitness and physiological characteristics of soccer referees. *Science & Sport*, 31(1), 27-35.

Revistas nacionales:

- Castillo, D., Cámara, J., y Yanci, J. (2017). Comparación de la respuesta física entre un árbitro y un mediocentro durante un partido de fútbol. *Revista Internacional de Deportes Colectivos*, 29, 5-13.
- Yanci, J., Cámara, J., y Castillo, D., (2016). Análisis de la fatiga neuromuscular en árbitros y asistentes de fútbol durante partidos oficiales. *Revista Internacional de Deportes Colectivos*, 27, 38-45.
- Cámara, J., Yanci, J., y Castillo, D., (2016). Evolución de la fuerza de prensión manual en árbitros y asistentes de fútbol durante partidos oficiales. *Revista Internacional de Deportes Colectivos*, 28, 5-8.
- Castillo, D., Cámara, J., y Yanci, J. (2016). Análisis de las respuestas físicas y fisiológicas de Árbitros y asistentes de fútbol durante partidos oficiales. *Ricyde. Revista Internacional de Ciencias del Deporte*, 45, 250-261.

- Rebolé, M., Castillo, D., Cámara, J., y Yanci, J. (2016). Relación entre la capacidad cardiovascular y la capacidad de esprints repetidos en árbitros de fútbol de alto nivel. *Revista Iberoamericana de Ciencias de la Actividad Física y el Deporte*, 5(3), 46-57.
- Castillo, D., Cámara, J., y Yanci, J. (2015). Análisis de la respuesta cardiaca de árbitros de fútbol en competición: estudio de caso. *Sportis Scientific Technical Journal*, 1 (2), 182-188.

12.5 Capítulos de libro relacionados con la tesis.

Además, han sido publicados algunos capítulos en libros cuyas editoriales son de ámbito internacional y/o nacional y son presentados a continuación:

- Castillo, D., Cámara, J., & Yanci, J. (2017). Acceleration capacity measured by global positioning system devices of national and provincial soccer referees. In Torres, G. (eds), *Global Positioning System (GPS): Performance, Challenges and Emerging Technologies* (p.p. 1-7). New York: Nova Science Publishers.
- Castillo, D., Cámara, J., & Yanci, J. (2017). Validity of 10Hz global positioning system devices to measure performance in an incremental cardiovascular field test. In Torres, G. (eds), *Global Positioning System (GPS): Performance, Challenges and Emerging Technologies* (p.p. 9-17). New York: Nova Science Publishers.
- Castillo, D., y Yanci, J. (2015). Análisis del rendimiento de la capacidad de salto y aceleración de árbitros y asistentes de fútbol. En *Actas del XI Congreso Internacional de Ciencias del Deporte y la Educación Física* (p. 24). Pontevedra: Sportis Formación Deportiva.
- Castillo, D., y Yanci, J. (2015). Análisis de la respuesta cardiaca de árbitros de fútbol en competición: estudio de caso. En *Actas del XI Congreso Internacional de Ciencias del Deporte y la Educación Física* (p. 24). Pontevedra: Sportis Formación Deportiva.
- Castillo, D., Cámara, J., y Yanci, J. (2015). Influencia de la competición en el dolor muscular percibido en árbitros de fútbol. En Del Valle, M. E. (eds), *Archivos de medicina del deporte* (p. 320). Pamplona: Federación Española de Medicina del Deporte (FEMEDE).
- Castillo, D., Cámara, J., y Yanci, J. (2015). Relaciones entre la capacidad de aceleración, cambio de dirección y resistencia en árbitros de fútbol. En Del Valle, M. E. (eds), *Archivos de medicina del deporte* (p.p. 320-321). Pamplona: Federación Española de Medicina del Deporte (FEMEDE).

12.6 Comunicaciones y posters relacionados con la tesis.

En estos años de formación Predoctoral se ha asistido a congresos nacionales e internacionales así como a jornadas de ámbito nacional e internacional donde se han presentado algunos resultados de la tesis doctoral:

- Castillo, D., Cámara, J. y Yanci, J. (2016, Mayo). Comparación de la respuesta física entre un árbitro y un mediocentro durante un partido de fútbol. Comunicación presentada en *IV Congreso Internacional de Actividad Física y Deportes*, Zaragoza, España.
- Yanci, J., Cámara, J. y Castillo, D. (2016, Mayo). Análisis de la fatiga neuromuscular en árbitros y asistentes de fútbol durante partidos oficiales. Comunicación presentada en *IV Congreso Internacional de Actividad Física y Deportes*, Zaragoza, España.
- Cámara, J., Yanci, J. y Castillo, D. (2016, Mayo). Evolución de la fuerza de prensión manual en árbitros y asistentes de fútbol durante partidos oficiales. Comunicación presentada en *IV Congreso Internacional de Actividad Física y Deportes*, Zaragoza, España.
- Castillo, D., Cámara, J. y Yanci, J. (2015, Noviembre). Influencia de la competición en el dolor muscular percibido en árbitros de fútbol. Comunicación presentada en *VI Jornadas de Medicina del Deporte de la Sociedad Española de Medicina del Deporte*, Bilbao, España.
- Castillo, D., Yanci, J. y Cámara, J. (2015, Junio). Efecto de un partido oficial en la capacidad de salto de un árbitro de fútbol. Poster presentado en *I Congreso Nacional sobre Preparación Física en Fútbol*, Valladolid, España.
- Castillo, D., Yanci, J. y Cámara, J. (2015, Junio). Respuesta fisiológica durante la realización del Yo-Yo test en árbitros de fútbol. Comunicación presentada en *I Congreso Nacional sobre Preparación Física en Fútbol*, Valladolid, España.
- Castillo, D., Yanci, J. y Cámara, J. (2015, Junio). Descripción de la carga interna y externa en árbitros asistentes durante un partido oficial. Comunicación presentada en *I Congreso Nacional sobre Preparación Física en Fútbol*, Valladolid, España.
- Castillo, D. y Yanci, J. (2015, Mayo). Análisis del rendimiento de la capacidad de salto y aceleración de árbitros y asistentes de fútbol. Poster virtual presentado en *XI*

Congreso Internacional de Ciencias del Deporte y Educación Física, Pontevedra, España.

- Castillo, D. y Yanci, J. (2015, Mayo). Análisis de la respuesta cardiaca de árbitros de fútbol en competición: estudio de caso. Poster virtual presentado en *XI Congreso Internacional de Ciencias del Deporte y Educación Física*, Pontevedra, España.
- Castillo, D. y Yanci, J. (2015, Abril). Condición física y fisiológica en árbitros y asistentes de fútbol. Proyecto de investigación. Poster virtual presentado en *X Concentración Técnica de árbitros de Tercera División y árbitros asistentes de Segunda B de fútbol y II Concentración de árbitros de Segunda B de fútbol sala*, Pamplona, España.

12.7 Otras actividades de investigación.

A lo largo de este proceso de formación Predoctoral, el doctorando ha participado en otros actividades de investigación:

- Participación en la revisión de artículos científicos en revistas de internacionales.
    - Journal of Sports Sciences, Marzo 2017. Impact Factor (IF): 2.142
    - Science and Medicine in Football, Febrero, 2017. IF: 2.142
    - International Journal of Sports Physiology and Performace. Febrero, 2017. IF: 3.042
    - Journal of Science and Medicine in Sport. Agosto, 2016. IF: 3.76
    - Journal of Sports Engineering and Technology. Febrero, 2016. IF: 0.456
    - Sports. Abril, Junio y Octubre 2016.
    - Biology of Sport. Enero, 2016. IF: 1.135
    - Pediatric Exercise Science. Marzo, 2016. IF: 1.495
- Miembro del comité científico de la revista.
    - Journal of Orthopedic Research and Therapy. 2016.
    - British Journal of Ortophaedics and Sports Medicine. 2017.
- Miembro del Research Staff en el World Championship Qualification Tournament organizado por la International Federation of Cerebral Palsy Football (IFCPF).