UNIVERSITAT DE BARCELONA

Control de la carga externa del Microciclo Estructurado

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Cualquier persona puede afirmar cualquier cosa, pero empezará a tener sentido eso comunicado cuando esté verificado con unas intervenciones prácticas de alta coherencia con lo anteriormente expresado. Así esa persona comenzará a diferenciar lo que siente con lo que vive, o lo individual con lo colectivo, lo teórico con la práctica, las palabras con la imagen y acaso el poder investigar sobre todo ello, que le hará diferenciar la realidad con un punto de vista. Sólo así nos iremos enriqueciendo con la propia experiencia y acceder al fin, al intemporal conocimiento científico.

Paco Seirul·lo

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Resumen

El entrenamiento en los deportes de equipo y en concreto en el fútbol, ha estado influenciado por diferentes teorías y modelos de planificación. Bajo este influjo, el Microciclo Estructurado se propone como unidad conceptual ajustándose al ciclo competitivo semanal. Las características del rival, la identificación de cargas o las necesidades del equipo, llevan a la Microestructura a proponer una gestión de la periodización del entrenamiento en diferentes fases. La importancia de esta metodología en el mundo del deporte y en la estructura social contemporánea nos motiva a analizar esta propuesta innovadora de una forma cuantitativa, buscando las características que la definan de forma precisa para facilitar su aplicación rigurosa y sistemática. Por este motivo el objetivo de esta tesis fue identificar las características de los diferentes parámetros de la carga externa que definen el ME: como son la Planificación, la competición y las situaciones simuladoras preferenciales (Partidos de entrenamiento y Juegos de posición) usando la tecnología GPS como herramienta de recogida de datos. En los diferentes estudios participaron jugadores de fútbol (20.5 ± 1.8 años, 178.4 ± 6.6 cm, 69.7 ± 6.1 kg) pertenecientes al equipo filial de un club de la 1ª división española, durante la temporada 2015-2016. Los jugadores se agruparon de acuerdo con su posición de juego habitual durante la competición: centrales (DC), laterales (DL), pivotes (PIV), interiores (INT) y delanteros (DEL). Las variables registradas para cuantificar la carga externa fueron: la distancia total recorrida (DT, m); la distancia recorrida a alta velocidad (DAV, m>19.8 km^{-1}); la distancia recorrida en sprint (SPR, m >25.2 km^{-1}); el número de aceleraciones de alta intensidad (ACC, n>3 $m{\cdot}s^{-2}$, número); el número de desaceleraciones de alta intensidad (DECC, n<–3 $m{\cdot}s^{-2}$, número); la potencia metabólica media (PM, $W{\cdot}kg^{-1}$), y la distancia recorrida a alta PM (DAPM, m>25.5 $W{\cdot}kg^{-1}$). De los resultados de los diferentes estudios presentados se puede concluir que las actividades que realiza un jugador de fútbol son estocásticas y multidimensionales, por lo tanto, es necesario considerar las actividades individuales y posicionales que definen el proceso de entrenamiento, ajustando estas necesidades a las exigencias que demanda la competición en todos sus registros.

Palabras clave: fútbol, entrenamiento, planificación, GPS, escenarios de máxima exigencia.

Resum

L'entrenament en els esports d'equip i en concret en el futbol, ha estat influenciat per diferents teories i models de planificació. Sota aquest influx, el Microcicle Estructurat es proposa com a unitat conceptual ajustant-se al cicle competitiu setmanal. Les característiques del rival, la identificació de càrregues o les necessitats de l'equip, porten a la Microestructura a proposar una gestió de la periodització de l'entrenament en diferents fases. La importància d'aquesta metodologia en el món de l'esport i en l'estructura social contemporània ens motiva a analitzar aquesta proposta innovadora d'una forma quantitativa, buscant les característiques que la defineixin de forma precisa per facilitar la seva aplicació rigorosa i sistemàtica. Per aquest motiu l'objectiu d'aquesta tesi va ser identificar les característiques dels diferents paràmetres de la càrrega externa que defineixen el ME: com són la Planificació, la competició i les situacions simuladores preferencials (Partits d'entrenament i Jocs de posició) usant la tecnologia GPS com a eina de recollida de dades. En els diferents estudis van participar jugadors de futbol (20.5 ± 1.8 anys, 178.4 ± 6.6 cm, 69.7 ± 6.1 kg) pertanyents a l'equip filial d'un club de la 1ª divisió espanyola, durant la temporada 2015-2016. Els jugadors es van agrupar d'acord amb la seva posició de joc habitual durant la competició: centrals (DC), laterals (DL), pivots (PIV), interiors (INT) i davanters (DEL). Les variables registrades per quantificar la càrrega externa van ser: la distància total recorreguda (DT, m); la distància recorreguda a alta velocitat (DAV, m>19.8 km^{-1}); la distància recorreguda en esprint (SPR, m> 25.2 km^{-1}); el nombre d'acceleracions d'alta intensitat (ACC, n>3 $m{\cdot}s^{-2}$, nombre); el nombre de deceleracions d'alta intensitat (DEC, n<-3 $m{\cdot}s^{-2}$, nombre); la potència metabòlica mitjana (PM, $W{\cdot}kg^{-1}$), i la distància recorreguda a alta PM (DAPM, m>25.5 $W{\cdot}kg^{-1}$). Dels resultats dels diferents estudis presentats es pot concloure que les activitats que realitza un jugador de futbol són estocàstiques i multidimensionals, per tant, cal considerar les activitats individuals i posicionals que defineixen el procés d'entrenament, ajustant aquestes necessitats a les exigències que demana la competició en tots els seus registres.

Paraules clau: futbol, entrenament, planificació, GPS, escenaris de màxima exigència.

Abstract

The training in team sports and specifically in football, has been influenced by different theories and planning models. Under this influence, the Structured Microcycle is proposed as a conceptual unit adjusting to the weekly cycle. The characteristics of the rival, the identification of loads or the needs of the team, lead the Microstructure to propose a periodization management of the training in different phases. The importance of this methodology in the world of sport and in the contemporary social structure motivates us to analyze this phenomenon in a quantitative way, looking for the characteristics that define it precisely and with the possibility of being applied systematically. For this reason, the objective of this thesis was to identify the characteristics of the different parameters of the external load that define the SM: Planning, competition and preferential simulation situations (training games and position games) using GPS technology as a tool for collecting data. In the different studies, soccer players participated (20.5 ± 1.8 years, 178.4 ± 6.6 cm, 69.7 ± 6.1 kg) belonging to the subsidiary team of a club from the Spanish 1st division, during the 2015-2016 season. The players were grouped according to their usual playing position during the competition: central defender (CD), fullback (FB), midfielder (MF), wide midfielder (WMF) and forward (FW). The variables recorded to quantify the external load were: the total distance travelled (TD, m); the distance travelled at high speed (HSR, m>19.8 km^{-1}); the distance travelled in sprint (SPR, m> 25.2 km^{-1}); the number of high-intensity accelerations (ACC, n>3 $m{\cdot}s^{-2}$, number); the high intensity decelerations number (DEC <-3 $m{\cdot}s^{-2}$, number); the average metabolic power (AMP, $W{\cdot}kg^{-1}$), and the distance travelled to high metabolic power (HMLD, m> 25.5 $W{\cdot}kg^{-1}$). From the results of the different studies presented it can be concluded that the activities carried out by a soccer player are stochastic and multidimensional, therefore, it is necessary to consider the individual and positional activities that define the training process, adjusting these needs to the demands which are required by the competition in all its registers.

Keywords: soccer, training, planning, GPS, high demand scenarios.

Nada abrevia la distancia entre la ignorancia y el conocimiento, solo el anhelo de querer saber.

Paco Seirul·lo

Índice de contenidos

Abreviaturas

ACC – Aceleraciones

DAPM – distancia recorrida a alta potencia metabólica

DAV – Distancia recorrida a alta velocidad

DC – Defensa central

DEC – Desaceleraciones

DEL – Delanteros

DL - Defensa lateral

DT – distancia total recorrida

EE – Entrenamiento Estructurado

EME – Escenarios de máxima exigencia

GPS – Global Positioning System

HD – Humano deportista

INT – interiores

JRs – Juegos reducidos

ME – Microciclo Estructurado

PEM – Partidos de entrenamiento modificados

PIV – Pivote

PM – Potencia Metabólica

SPR – Distancia recorrida en sprint

SSP - Situaciones simuladoras preferenciales

Capítulo 1

Introducción

El entrenamiento en los deportes de equipo y en concreto en el fútbol, ha estado influenciado por diferentes teorías y modelos de planificación. Esta evolución ha sido en gran medida un reflejo de lo acontecido en otras áreas del conocimiento humano (Arjol, 2012). Desde el Modelo de Matveiev (2001), el Modelo de entrenamiento por bloques de Verkhoshansky (2002), o la Periodización Táctica de Vitor Frade, analizado por Acero, Peñas y Lalín (2013) hasta el Método Estructurado de Seirul·lo (2017), han sido diversas las metodologías e ideologías llevadas a cabo en los deportes colectivos.

El modelo propuesto por Paco Seirul·lo contempla en su formulación, Teorías de la Complejidad, Teoría de Sistemas, Pensamiento Complejo o de Ecología Profunda (Capra, 1998, citado en Arjol, 2012). Es constatable que en las dos últimas décadas la Periodización Táctica y el Entrenamiento Estructurado se han asociado con el máximo éxito deportivo (Arjol, 2012); así mismo en el caso de la metodología liderada por Seirul·lo, parece haberse sabido adaptar al paso del tiempo, mejorando sus prestaciones y consiguiendo la admiración del mundo del deporte y en concreto de los deportes de interacción en espacio compartido (Seirul·lo, 2017; Tarragó, Massafred, Seirul·lo y Cos, 2019).

“La propuesta del Modelo estructurado, encuentra refugio en las ciencias de la complejidad, basado en el cognitivismo y la visión estructural del ser humano que sitúa al jugador como el centro del proceso de entrenamiento” (Mallo, 2015). Según Roca (2008), mediante el entrenamiento se debe fomentar las adaptaciones del jugador al mismo y conseguir que el sujeto evolucione en cada una de sus estructuras, las cuales son: la estructura bioenergética, la estructura condicional, la estructura cognitiva, la estructura creativo-expresiva, la estructura mental, la estructura coordinativa, la estructura emotivo-volitiva y la estructura socio afectiva (Seirul·lo, 1987, 1998, 2000, 2002, 2005, 2012, citado en Mallo, 2015; Tarragó et al., 2019).

En cuanto a la Planificación, las ligas regulares conllevan que las competiciones se produzcan en un periodo largo, realizándose con gran regularidad y cantidad, otorgando esta circunstancia al ME (Microciclo Estructurado) un papel protagonista en las planificaciones deportivas en los deportes colectivos (Acero et al., 2013). En el Entrenamiento Estructurado de Seirul·lo, se propone el ME como unidad conceptual básica para los ciclos preparatorio y competitivo, ajustándose al ciclo entre competiciones. "Su ordenamiento pretende crear secuencias e interrelaciones entre sí, de tal modo que cada microciclo será consecuencia del anterior y la referencia para el siguiente, de acuerdo a las estrategias organizativas propuestas" (Arjol, 2012).

Según Seirul·lo (2011), las características del rival, la identificación de cargas o las necesidades del equipo, llevan a la Microestructura a proponer una gestión de la periodización de cargas en diferentes fases. En cuanto a la temporada, se contemplan dos ciclos, organizados de diferente manera; ciclo de Pretemporada y ciclo Competitivo (Seirul·lo, 1998); dichos ciclos se distribuyen en cinco tipos de microciclo: Microciclo Preparatorio, Microciclo de Transformación dirigido, Microciclo de Transformación especial, Microciclo de Mantenimiento y el Microciclo de Competición (Roca, 2008). Cada microciclo está compuesto por una serie de sesiones, las cuales dependerán del número de partidos jugados por semana (Mallo, 2015), estas sesiones conforman dos curvas diferenciadas, en cuanto a intensidad y volumen de carga (Bompa, 2003). El volumen aumenta, alcanzando su nivel más alto en el ecuador del microciclo, bajando su carga en los dos días previos a la competición (Seirul·lo, 2011). Si nos referimos a la intensidad del entrenamiento, guarda una relación directa con el componente táctico de las tareas propuestas, en este caso irá alternándose, llegando a su máximo en la sesión previa a la competición (Seirul·lo, 2005; Tarragó et al., 2019). Los días del microciclo pueden ser: de recuperación, de estimulación, optimización, de activación y de competición (el partido; Seirul·lo, 2011).

Obras como las de Seirul·lo (1998, 2000, 2002, 2005, 20011), Roca (2008), Arjol (2012), Acero et al. (2013), Mallo (2015) y Tarragó et al. (2019) que tratan sobre la Microestructura, hacen una valoración cualitativa de los contenidos de la misma, sin centrarse en el análisis cuantitativo. Son los cualitativos los parámetros que definen la dinámica de cargas del modelo del microciclo propuesto por Seirul·lo. La importancia de esta metodología en el mundo del deporte y en la estructura social contemporánea lleva a considerar la importancia de analizar este fenómeno de una forma cuantitativa, buscando las características clave o relevantes que lo definan de forma precisa y permitan la posibilidad de aplicarse de forma rigurosa y sistemática.

1.1 Escenarios de máxima exigencia en competición:

Varios estudios han descrito las demandas de la competición de fútbol (Castellano et al., 2014; Di Salvo et al., 2007), sirviendo como punto de referencia para comparar con las demandas del entrenamiento (Owen et al., 2017; Stevens, de Ruiter, Twisk, Savelsbergh y Beek, 2017) o tareas dentro de la sesión (Beenham et al., 2017; Casamichana, Castellano y Castagna., 2012; Dellal et al., 2012; Giménez, Del Coso, Leicht y Gómez, 2017). Sin embargo, las tareas de entrenamiento diseñadas para replicar las demandas promedio de los partidos, probablemente provoquen que los jugadores no estén preparados para las fases más exigentes que se presenten en el partido (Gabbett et al., 2016). No es irrelevante señalar que a estos escenarios de máxima exigencia se vienen denominando en inglés como "worst case scenario", pero hemos preferido una traducción que, aun no siendo literal (peores escenarios posibles), no carga de connotaciones negativas la exigencia física sino que busca sencillamente mostrarla o explicarla; en los artículos publicados en lengua anglosajona nos hemos referido a este concepto como "most demanding passage", expresión muy bien acogida y entendida entre los autores anglosajones que han colaborado en los artículos que constituyen esta tesis y otros.

Las fases más exigentes del partido se han estudiado utilizando diferentes metodologías. Dividir el partido en períodos predefinidos de 15 minutos (Carling y

Dupont, 2011) o 5 minutos (Bradley y Noakes, 2013; Di Mascio y Bradley, 2013) ha mostrado picos de actividad más altos que el promedio del partido. Por ejemplo, algunos jugadores alcanzaron valores cercanos a 140 $m \cdot min^{-1}$ para la distancia recorrida y más de 40 $m \cdot min^{-1}$ de distancia cubierta a alta velocidad (DAV) en períodos de 5 minutos (Bradley y Noakes, 2013). Sin embargo, la fase más exigente del partido puede no ocurrir dentro de estos bloques predefinidos. Por lo tanto, estos métodos subestiman el escenario más exigente en la competición (Varley, Elias y Aughey, 2012). Un enfoque más práctico y preciso sería establecer el escenario de máxima exigencia (EME) del partido usando el método de rolling average o moving average. Actualmente, facilitado por la incorporación de la tecnología GPS, ha sido posible aplicar esta técnica (Varley et al., 2012). Mediante este proceso se rueda, segundo a segundo (o frame a frame, según cual sea la unidad de muestreo), el periodo o intervalo escogido (e.g., 1, 3, 5 o 10 min), con el que detectar los valores más altos de la(s) variable(s) física(s) tomada(s) a estudio (e.g., distancia recorrida por encima de 14 $Km \cdot h^{-1}$). Para el caso que nos ocupa, ambas magnitudes (el periodo de tiempo y la variable de rendimiento físico) siguen la relación matemática representada por la ley potencial o Power Law (Katz y Katz, 1999). A medida que la duración del periodo escogido es mayor se reduce el valor de la variable física. De manera específica, en el fútbol, periodos cercanos o superiores a 15 min muestran valores en la variable condicional muy similares a los valores medios que se aportan en una parte o el partido completo (Lacome et al., 2017). Este procedimiento se aplicó al fútbol gaélico (Malone, Solan, Hughes y Collins, 2017), Rugby League (Delaney et al., 2016), el fútbol australiano (Delaney et al., 2017) y el fútbol europeo (Delaney et al., 2018; Lacome, Simpson, Cholley, Lambert y Buchheit, 2018). Delaney et al. (2018) encontraron diferencias entre los defensas centrales, los mediocampistas y los delanteros, con los defensas centrales cubriendo la menor distancia y la potencia metabólica (PM) más baja, mientras que los centrocampistas realizaron un mayor número de aceleraciones (ACC) y desaceleraciones (DEC). La carrera a alta velocidad fue mayor en delanteros y centrocampistas (Delaney et al., 2018), todas ellas tomando como referencia la competición.

La distancia ($m \cdot min^{-1}$), la DAV (> 5.5 $m \cdot s^{-1}$), la PM promedio, los valores absolutos de ACC y DEC se han utilizado para definir los EME (Delaney et al., 2016; Delaney et al., 2018; Lacome et al., 2018). La inclusión de variables que integran la actividad desarrollada a alta velocidad y las ACC/DEC a alta intensidad podría ser de interés para configurar estos períodos.

Hasta la fecha, la mayoría de las investigaciones sobre el fútbol solo han cuantificado variables de actividad aisladas. Sin embargo, una comprensión de otras actividades que ocurren dentro de las fases de juego más exigentes también puede ser importante. En el fútbol, la actividad del jugador es multidireccional, multidimensional e iterativa. En consecuencia, una descripción detallada de la actividad realizada por los jugadores durante esta fase más exigente del partido sería de interés para los profesionales del deporte. Por ejemplo, dos jugadores podrían obtener los mismos valores de PM promedio ($W \cdot kg^{-1}$) durante un período de tiempo determinado, pero la actividad realizada por los jugadores podría ser muy diferente (en un caso, las acciones de alta intensidad podrían ser el resultado de mayor DAV, y en otro caso las acciones de alta intensidad podrían deberse a un mayor número de ACC o DEC).

Esta información tiene una aplicación práctica importante para la prescripción de entrenamiento, ya que puede servir como un punto de referencia al diseñar y evaluar las demandas de las tareas de entrenamiento que se imponen a los jugadores.

1.2 Modelo de planificación contemporáneo

El fútbol incorpora movimientos impredecibles durante los partidos donde los jugadores hacen la transición entre los esfuerzos de alta intensidad multidireccionales y de baja intensidad (Bradley y Ade, 2018). La carrera de alta intensidad en los partidos ha aumentado en un tercio en algunas ligas durante la última década (Barnes, Archer, Hogg, Bush y Bradley, 2014), por lo que los jugadores deben estar preparados para hacer frente a tales demandas. Una forma de manejar tales demandas podría ser optimizar la estructura del entrenamiento mediante la manipulación del volumen y la intensidad entre los ciclos de competición (Malone et al., 2015). La tecnología del sistema de posicionamiento global (GPS) es ampliamente utilizada en el fútbol, ya que proporciona a los cuerpos técnicos una estimación de la carga externa experimentada por los jugadores (Anderson et al., 2016; Buchheit y Simpson, 2017; Gaudino et al., 2015). El uso de dicha tecnología en el entrenamiento y la competición permite a los entrenadores no solo comprender los distintos requisitos del partido en las distintas posiciones de juego, sino también reconocer las necesidades de preparación para los roles individuales dentro del equipo (Carling, 2013; Castellano, Alvarez-Pastor y Bradley, 2014; Mallo, Mena, Nevado y Paredes, 2015).

Uno de los principales objetivos de los técnicos que trabajan en el fútbol de élite es la periodización del entrenamiento (Krustrup, Mohr, Ellingsgaard y Bangsbo, 2005; Mallo y Dellal, 2012; Mohr et al., 2008). La periodización es la forma a partir de la cual los contenidos y las cargas se presentan en la forma de la sesión de entrenamiento y el microciclo semanal (Akenhead, Harley y Tweddle, 2016; Anderson et al., 2016; Malone et al., 2015). A pesar de que las preparaciones generales y específicas posicionales son clave, los cuerpos técnicos aún tienen que lograr un delicado equilibrio entre estimular a los jugadores lo suficiente para una adaptación positiva sin elevar el riesgo de lesión (Drew y Finch, 2016; Gabbett et al., 2016; Gabbett y Whiteley, 2017). El consenso general es que las métricas de carga son más bajas en la sesión previa al día de competición, lo que confirma el concepto de reducción progresiva o tapering (Coutts, Reaburn, Piva y Murphy, 2007; Fessi et al., 2016; Owen, Djaoui, Newton, Malone y Mendes, 2017). Sin embargo, existen datos limitados sobre los patrones de carga después de la competición para jugadores con participación completa en el partido versus tiempo de juego parcial o nulo. Esto es particularmente importante ya que los jugadores con tiempo de juego reducido requerirán una sesión de entrenamiento que replique o se aproxime a las cargas de competición, mientras que los jugadores que completen el partido requerirán una sesión de restauración (Owen et al., 2017; Stevens et al., 2017). Por lo tanto, sería beneficioso para los entrenadores más investigación sobre estrategias de carga el día después de la competición, ya que les proporcionaría un marco práctico aplicable para sus jugadores y sesiones de entrenamiento.

El entrenamiento del fútbol ha evolucionado sustancialmente en la última década debido a los conceptos y modelos de entrenamiento contemporáneos (Issurin, 2010). El ME es una unidad de entrenamiento semanal dictada por la evolución de los jugadores, el estado de recuperación física de la competición y los requisitos de la periodización. Aunque los elementos de la planificación están controlados, algunos son variables y a veces ocurren de manera impredecible. La variabilidad de los componentes de carga a través del microciclo no se ha explorado suficientemente en la literatura, a pesar de un gran volumen de estudios que cuantifican la variabilidad de la competición (Busch, Archer, Hogg y Bradley, 2015; Carling, Bradley, McCall y Dupont, 2016). Los cambios en los estímulos y la carga son importantes para las adaptaciones de entrenamiento dentro del entorno de los deportistas de élite (Fransson et al., 2018).

Otra área que aún no se ha cubierto en detalle es la contextualización del microciclo, ya que la mayoría de los estudios no proporcionaron detalles específicos de las sesiones de entrenamiento (por ejemplo, la sesión de entrenamiento del día anterior al partido se denominó MD-1 o preparación táctica pre-partido).

Específicamente, las fases sistemáticas del ME son muy exclusivas de la filosofía del Fútbol Club Barcelona y proporcionarían una mayor comprensión a los profesionales del mundo del deporte. También se necesitan estudios adicionales que detallen los patrones de carga y las sesiones de entrenamiento de diversos clubes europeos, dado que el conjunto de estudios proviene principalmente de los clubes de la Premier League inglesa (Anderson et al., 2016; Malone et al., 2015). Esto es relevante ya que las diferencias en las demandas de la cultura y competición a lo largo de las ligas podrían dar lugar a variaciones de carga, en un intento de optimizar el rendimiento (por ejemplo, modelo de juego, numero de competiciones, descansos a mitad de temporada…).

1.3 Situaciones Simuladoras Preferenciales

El Entrenamiento Estructurado (EE) tiene como objetivo, fundamento y medida el ser humano que hace deporte. Sus propuestas son la optimización del Humano deportista (HD), otorgándole altos niveles de "interacción" en la competición de ese "juego". La optimización en el EE supone la interactividad, cooperación y sinergias entre la totalidad de sistemas que conforman las Estructuras de los HD (Mallo, 2015), de manera que ese "todo global" interactuando, les concede una capacidad funcional diferente que ninguna de ellas dispone por separado. Con ello identificamos y diferenciamos el EE como práctica de entrenamiento específica, para los llamados "Deportes de equipo" (Seirul·lo, 2002).

El EE se organiza en las unidades microestructurales mediante las Situaciones Simuladoras Preferenciales (SSP; Seirul·lo, 2017). Se trata de generar eventos y conjuntos de situaciones que predispongan a un estado de acción y respuesta en un entorno creado que invita a la imitación de comportamientos que serán simuladores del juego-deporte, y que inciden de forma preferencial en los diferentes sistemas según la intención de la tarea, propuesta por medio de criterios, espacios-tiempos diversos y número de jugadores en interacción. Estas situaciones se definirán y se extraerán de la observación e interpretación del juego real entre el entrenador y cada jugador (Tarragó et al., 2019).

De este modo, las SSP se definen como:

- *Situaciones Simuladoras*: Permiten reproducir las experiencias, sensaciones e interacciones de los acontecimientos del juego. Dada la alta complejidad del deporte, debemos generar secuencias de variada aproximación a los entornos de la competición.

- *Situaciones Preferenciales*: Deberán tener cierta preferencia y acento a favor de alguna de las diferentes Estructuras implicas en la tarea que conforman a los HD. Esta preferencia proporciona una deseada situación práctica para obtener el objetivo de la sesión. Para ello los sistemas pertenecientes a la Estructura Preferente deberán entrar en interacciones de alta variedad con sistemas de otras Estructuras afines sinérgicas.

Las características y capacidades de los HDs serán la guía de su proceso de entrenamiento mediante las estructuras y fundamentalmente a través de las SSP (Seirulo, 2017). La optimización en el EE supone la interactividad, cooperación y asociaciones entre la totalidad de sistemas que conforman las Estructuras de los HD. Las SSP serán optimizadoras para el HD, y se han de proponer mediante tareas globales, preferentemente en grupo, y no con el objetivo de aprender el ejercicio sino el "juego" (Seirul·lo, 2015); se construyen los diferentes episodios del entrenamiento según la orientación central de la sesión, pudiendo ser relativamente independientes en una misma sesión. Cada SSP requiere la intervención de diferentes sistemas o estructuras del HD que el entrenador deberá identificar. Cada jugador debe poner en acción aquellos sistemas que mejor respondan a la situación creada de acuerdo al propio proceso de autoorganización a lo largo de su vida, por lo que cada jugador lo afrontará optimizándose de manera diferenciada (Tarragó et al., 2019).

Repetir tareas en las mismas condiciones de práctica no provocan las "fluctuaciones" necesarias en los sistemas implicados para modificar su estado. Solo por "variación" en las condiciones de ejecución, nos aseguramos provocar las fluctuaciones necesarias que ocasionen un cambio de funcionalidad en los sistemas comprometidos (Seirul·lo, 2017). Por introyección y retroacciones se podrán optimizar la totalidad de las Estructuras que conforman al HD siempre que se practique en "repeticiones en variación" (Seirul·lo, 2015). Por lo tanto, más de lo bueno no es siempre mejor, sino que hay que priorizar variabilidad y especificidad en los estímulos para que el HD los pueda gestionar, entendiendo al HD como el medio y el fin (Tarragó et al., 2019).

A modo de resumen, las características que identificarán las SSP propuestas por el EE serán:

- Globales, contextuadas en el juego.
- Específicas de ese deporte.
- Variadas.
- Cualitativas, luego de pocas repeticiones
- De exigencia diferenciada.
- Ajustadas a las necesidades del HD que las practica.

1.4 Partidos de entrenamiento modificados

El fútbol es un deporte de alta intensidad con períodos largos, ≈70% del tiempo total de partido, en rangos de baja intensidad (Osgnach, Poser, Bernardini, Rinaldo y Di Prampero, 2010). La distancia total recorrida oscila entre 9.5 y ≈ 12 km en un partido de competición (Akenhead, Hayes, Thompson y French, 2013; Mallo et al., 2015), de los cuales una distancia entre 220 y 1900 m está cubierta a alta velocidad (≈ 19.8 $km \cdot h^{-1}$) mientras que entre 200 y 500 m están cubiertos a sprint (≈ 25.0 $km \cdot h^{-1}$) con una duración promedio de entre 2 y 4 segundos por un jugador profesional (Akenhead et al., 2013; Mallo et al., 2015; Osgnach et al., 2010). En el transcurso del juego, los jugadores cambian de actividad alrededor de 1400 veces (Krustrup et al., 2005; Mohr et al., 2008), lo que puede implicar ACC y DEC en algunos casos de alta intensidad (2.5 $m \cdot seg^{-2}$) entre 50 y 100 veces por partido (Dalen, Jørgen, Gertjan, Havard y Ulrik, 2016; Mallo et al., 2015). Finalmente, para completar la descripción del perfil de demanda condicional de un jugador de fútbol en competición, los jugadores también realizan desplazamientos laterales que abarcan aproximadamente el 6% de la distancia total cubierta (Da Silva, Kirkendall y Neto, 2007) y alrededor de 10 saltos por partido (Nedelec et al., 2014).

Una de las ventajas de los partidos de entrenamiento modificados (PEM) es que pueden modificarse para ajustar su carga e intensidad (Clemente, Martins y Mendes, 2014), algo que podría tenerse en cuenta al programar sesiones de entrenamiento. Modificaciones del espacio, modificaciones de interacción (número de jugadores), reglas cambiantes… son parámetros que pueden variar la carga de los PEM y adaptarse a las necesidades requeridas por los cuerpos técnicos (Castellano y Casamichana, 2016).

El EME se ha comparado recientemente con los formatos de juego de entrenamiento en fútbol (Lacome et al., 2018). Para ello, se han calculado las variables que describen la intensidad de desplazamiento (por ejemplo, distancia total o DAV por minuto) y el trabajo mecánico (AU por minuto) en tareas reproducidas en 4vs4, 6vs6, 8vs8 y 10vs10. El estudio concluyó que los formatos de PEM sobre estimulan las variables de trabajo mecánico de demanda musculo esquelética con respecto a los EME en competición y sub-estimulan la DAV. Además, los grupos posicionales que estuvieron más y menos sobrecargados durante los PEM fueron el defensor central y el centrocampista respectivamente. Sin embargo, para conocimiento de los autores, no hay estudios de investigación en los que se analicen los EME considerando varias variables dependientes simultáneamente.

1.5 Los juegos reducidos en fútbol

Los juegos reducidos (JRs) se utilizan ampliamente en el entrenamiento de fútbol con el objetivo de estimular al mismo tiempo una variedad de aspectos técnico-tácticos y físicos. En este sentido, la implementación de diferentes JRs ha demostrado su eficacia en el desarrollo de resistencia aeróbica y anaeróbica, agilidad y fuerza en jugadores de diferentes niveles (Brandes, Heitmann y Muller, 2012; Casamichana y Castellano, 2010; Halouani, Chtourou, Gabbett, Chaouachi y Chamari, 2014).

Si bien la preparación física en el fútbol por lo general puede apuntar a diferentes objetivos como factores emotivos, cognitivos o socio-afectivos, mejorar el rendimiento físico relacionado con el juego es el objetivo principal. Las demandas condicionales de la competición presentan cierta variabilidad entre jugadores e intrajugadores (Carling, 2013; Di Salvo et al., 2007). Una de las variables que puede influir mucho en la actividad física del jugador durante el partido es la posición que ocupa el jugador en el campo (Castellano et al., 2014; Di Salvo et al., 2007). Por lo tanto, parece aconsejable que las propuestas de entrenamiento destinadas a mejorar el rendimiento físico relacionado con el juego, aborden eficazmente las demandas específicas a nivel posicional. En este sentido, los JRs presentan menores demandas de carreras de alta velocidad y acciones de sprint, y mayores demandas de ACC y DEC que la competición (Beenham et al., 2017; Casamichana et al., 2012; Dellal et al., 2012; Giménez et al., 2017), siendo la magnitud de estas diferencias aumentadas cuando se reduce el número de jugadores y / o las dimensiones del espacio de juego se reducen (Casamichana y Castellano, 2010; Hill-Haas, Coutts, Rowsell y Dawson, 2009), pues incide constantemente el jugador oponente en esa posición.

Las posibles diferencias que los JRs podrían imponer en las diferentes posiciones de juego siguen en gran parte sin ser exploradas. Recientemente, Lacome et al. (2018) compararon las demandas de los partidos con las impuestas por diferentes JRs y partidos modificados, teniendo en cuenta la posición ocupada por los jugadores en la competición. Los principales hallazgos revelaron que, cuando se compara con la fase más exigente en competición, las diferencias sustanciales dependen de la posición ocupada por los jugadores durante la competición, con defensores centrales y mediocampistas siendo los más estimulados y poco estimulados durante los JRs con respecto al partido, respectivamente.

Entre la gran variedad de tareas específicas de fútbol (por ejemplo, JRs, PEM, juegos condicionados, etc.) actualmente disponibles, los JRs se utilizan para desarrollar habilidades de juego combinadas. En estos ejercicios, el objetivo genérico es mantener la posesión del balón, sin objetivos ni porteros implicados, pero los cuatro momentos del juego (es decir, organización ofensiva, organización defensiva y ambas, transiciones ofensivas y defensivas) están presentes. Además, la estructura espacial y las tareas tácticas asociadas con las diferentes posiciones de juego, aunque simplificadas en comparación con un juego 11vs11, se pueden mantener. Hasta la fecha, aún no se ha llevado a cabo una evaluación exhaustiva de las demandas condicionales de los JRs, en comparación con las demandas del partido, específicas para cada posición.

1.6 Objetivos de la tesis

El objetivo principal de esta tesis fue identificar las características de los diferentes parámetros de la carga externa que definen el ME: Competición, Planificación y SSP (Partidos y Juegos de posición; JP) usando la tecnología GPS como herramienta de recogida de datos.

Un total de 4 artículos originales (3 publicados y 1 en revisión) en revistas indexadas en la ISI web of knowledge constituyen el cuerpo principal de la presente tesis, de los cuales se proceden cuatro objetivos específicos. Cada uno de estos artículos se presenta como capítulos individuales siguiendo el formato de publicación o el solicitado por cada revista para su admisión.

En los siguientes 4 capítulos se presentan los objetivos específicos que corresponden a los cuatro artículos que conforman el cuerpo de esta tesis:

- Estudio I: Identificar los EME de los partidos de fútbol, describiendo estos períodos a través de diferentes variables, y determinar las diferencias entre las posiciones a través de tres variables criterio, y en diferentes ventanas de tiempo, perteneciente al artículo titulado: "Positional Differences in the Most Demanding Passages of Play in Football Competition", el articulo fue publicado en la revista: Journal of Sports Science and Medicine.

- Estudio II: Determinar la carga externa de un equipo de fútbol en la posición de juego y relativa a la competición utilizando el ME como estructura de planificación y examinar la carga y variación del día siguiente de la competición para jugadores con más de 60 o menos de 60 minutos jugados en el partido anterior, correspondiente al artículo titulado: "Quantification of a professional football team's external load using Microcycle Structure", publicado en la revista: Journal of Strength and Conditioning Research.

- Estudio III: Cuantificar la carga externa de entrenamiento a la que están expuestas las diferentes posiciones durante diferentes partidos de entrenamiento en comparación con el EME, incluido en el artículo titulado: "Positional demands for various-sided games with goalkeepers according to the most demanding passages of match play in football", publicado en la revista: Biology of sport.

- Estudio IV: Cuantificar la carga externa de entrenamiento a la que están expuestas las diferentes posiciones durante diferentes JP en comparación con el EME, desarrollado en el artículo titulado: "Physical demands of ball possession games in relation to the most demanding passage of the official match", enviado a la revista Journal of Sports Science and Medicine, actualmente en revisión

Capitulo 2

Métodos

2.1 Participantes

En los diferentes estudios participaron jugadores de fútbol (20.5 ± 1.8 años, 178.4 ± 6.6 cm, 69.7 ± 6.1 kg) pertenecientes al equipo filial de un club de la 1ª división española, durante la temporada 2015-2016. Los jugadores en los diferentes artículos se agruparon de acuerdo con su posición de juego habitual durante la competición: centrales (DC), laterales (DL), pivotes (PIV), interiores (INT) y delanteros (DEL). En el Estudio I participaron veinticuatro jugadores profesionales de fútbol (edad; 20 ± 2 años, masa corporal: 70.2 ± 6.1 kg y estatura: 1.78 ± 0.64 m). En el Estudio II, fueron incluidos veintitrés jugadores de fútbol profesional (edad: 20 ± 2 años, masa corporal: 70.2 ± 6.3 kg y estatura: 1.78 ± 0.06 m). En el Estudio III, se recolectaron datos de 21 jugadores de fútbol (edad: 20 ± 1 años, masa corporal: 70.2 ± 6.5 kg y estatura: 1.79 ± 0.06 m). Mientras que en el Estudio IV, los datos fueron recolectados de 25 jugadores de fútbol (edad: 20 ± 2 años, masa: 69.7 ± 6.1 kg y estatura: 1.78 ± 0.66 m). Los datos utilizados surgieron de la monitorización diaria del jugador durante la temporada. Por lo tanto, no se requirió autorización del comité de ética, como se detalla en artículos publicados con anterioridad (Lacome et al., 2018; Winter y Maughan, 2009). Sin embargo, los estudios se ajustaron a las recomendaciones de la Declaración de Helsinki y los jugadores proporcionaron su consentimiento antes de participar en los diferentes estudios.

2.2 Software y dispositivo GPS

Las demandas condicionales de los jugadores fueron monitorizadas durante cada estudio, utilizando dispositivos Global Positioning System (GPS) portátiles con una frecuencia de muestreo de 10 Hz, integrando otros sensores como un acelerómetro tridimensional de 100 Hz, un giroscopio tridimensional y una brújula digital tridimensional. El dispositivo portátil (Viper Pod, 50 g, 88 × 33 mm, Statsports Viper, Irlanda del Norte), ha sido utilizado en estudios anteriores (Bowen, Gross, Gimpel y

Li, 2017; Fox, Patterson y Waldron, 2017). La precisión de estos dispositivos ha sido estudiada recientemente, con errores del 2.53 ± 6.03% en la estimación de la distancia recorrida, mejorando la precisión (%) a medida que aumenta la distancia recorrida y disminuye la velocidad del desplazamiento (Beato, Bartolini, Ghia y Zamparo, 2016). Para evitar el error interdispositivo, cada jugador llevó el mismo dispositivo GPS durante el periodo de tiempo estudiado (Buchheit, et al., 2014; Castellano, Casamichana, Calleja-González, San Román y Ostojic, 2011). El modelo de GPS utilizado en estos estudios fue ubicado en un chaleco diseñado específicamente, dentro de un bolsillo situado en el centro de la parte superior de la espalda, justo por encima de los omóplatos. Después de finalizar cada sesión de entrenamiento o partido, los datos fueron extraídos a través del software específico (Viper, Statsports, Irlanda, Versión 1.2).

2.3 Variables externas (GPS)

Las variables registradas para cuantificar la carga externa de los diferentes artículos presentados en esta tesis fueron:

- La distancia total recorrida (**DT**, metros).
- La **DAV** (m >19.8 km^{-1}).
- La distancia recorrida en sprint (**SPR**, m > 25.2 km^{-1}). El sprint debe mantenerse durante al menos 1 segundo y se detiene cuando la velocidad cae por debajo de 80% del umbral de sprint.
- El número de **ACC** de alta intensidad (>3 $m{\cdot}s^{-2}$, número). La actividad de ACC se mide sobre la base del cambio en los datos de la velocidad GPS utilizando los métodos estadísticos establecidos. Para contar como una aceleración, el aumento de velocidad debe ocurrir durante al menos medio segundo con aceleración máxima en el período de al menos 0.5 $m{\cdot}s^{-2}$. La aceleración termina cuando el jugador deja de acelerar.
- El número de **DEC** de alta intensidad (<–3 $m{\cdot}s^{-2}$, número). Como en el caso de la actividad de la ACC, la disminución de velocidad debe ocurrir durante

al menos medio segundo para una actividad que se contará como DEC. Además, la DEC máxima en el período debe ser de al menos 0.5 $m{\cdot}s^{-2}$.

- La **PM** media ($W{\cdot}kg^{-1}$). Se basa en el gasto de energía por los jugadores. Las medidas combinan el gasto de energía asociado con velocidad constante de actividad, así como la aceleración y la desaceleración de la actividad. La PM es la energía gastada por el jugador por segundo por kg. La PM es la energía gastada por el jugador por segundo por kg basado en correr sobre hierba (la unidad es $W{\cdot}kg^{-1}$), y fue obtenida utilizando los cálculos energéticos detallados previamente (Di Prampero et al., 2005; Osgnach et al., 2010).
- La distancia recorrida a alta PM (**DAPM**, m >25.5 $W{\cdot}kg^{-1}$), representa la distancia recorrida (m) por un jugador cuando su PM (consumo de energía por kilogramo por segundo) es superior al valor de 25.5 $W{\cdot}kg^{-1}$.

Capítulo 3

Estudio I: Positional Differences in the Most Demanding Passages of Play in Football Competition.

Martín-García, A., Casamichana, D., Díaz, A. G., Cos, F., & Gabbett, T. J. (2018). Positional Differences in the Most Demanding Passages of Play in Football Competition. *Journal of Sports Science & Medicine*, 17(4), 563.

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Research article

Positional Differences in the Most Demanding Passages of Play in Football Competition

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Abstract
The aim of this investigation was to determine the position and duration specific activity of the most demanding passages of play in football players. Global positioning system data were collected from twenty-three football players across a competitive season. A total of 605 individual match files were analysed. Players were categorised based on positional groups; full-back (FB), central defender (CD), midfielder (MF), wide midfielders (WMF) and forwards (FW). The most demanding passage of a match play was analysed using a rolling average method, where maximal values were calculated for four different time durations (1', 3', 5' and 10') using distance ($m \cdot min^{-1}$), high metabolic load distance (HMLD) and average metabolic power (AMP) as variables of interest. Using distance as the criterion variable, MF and WMF positions covered greater distance, and fewer sprinting meters (>7.0 $m \cdot s^{-1}$, $m \cdot min^{-1}$). With HMLD as the criterion variable, the values for WMF and MF positions were higher than the CD and FW positions. The MF and WMF positions performed more high-intensity accelerations and decelerations when the criterion variable was AMP. These results provide an understanding of the most demanding passages of play to inform training practices for specific football playing positions.

Key words: Team sports, match demands, peak intensity, global position system.

Introduction

Several studies have described the demands of football competition (Castellano et al., 2014; Di Salvo et al., 2007), serving as a benchmark for comparison with training demands (Owen et al., 2017; Stevens et al., 2017) or tasks within training (Beenham et al., 2017; Casamichana et al., 2012; Dellal et al., 2012; Giménez et al., 2017). However, training tasks designed to replicate the average demands of matches will likely result in players being underprepared for the most demanding phases of football match-play (Gabbett et al., 2016).

The most demanding phases of the match have been studied using different methodologies. Dividing the match in to predefined periods of 15 minutes (Carling and Dupont, 2011) or 5 minutes (Bradley and Noakes, 2013; Di Mascio and Bradley, 2013) has shown higher activity peaks than the match average, with intensity being higher as the duration of the studied period decreased. For example, some players reached values of close to 140 $m \cdot min^{-1}$ for distance covered and more than 40 $m \cdot min^{-1}$ of distance covered at high speed in 5-minute periods (Bradley and Noakes, 2013). However, the most demanding passage of match-play may not fall completely within these pre-defined blocks. Therefore, these methods underestimate the most demanding passage of match-play (Varley et al., 2012).

Alternatively, a more practical and accurate approach would be to establish the most demanding passage of match-play using the rolling method (or moving average method). This procedure has been applied to Gaelic Football (Malone et al., 2017b), Rugby League (Delaney et al., 2016), Australian Football (Delaney et al., 2017a) and European football (Delaney et al., 2017b; Lacome et al., 2017). Delaney et al. (2017b) found differences between central defenders, wide midfielders, and forwards, with central defenders covering the least distance and the lowest metabolic power, while wide midfielders performed a greater number of accelerations and decelerations. High-speed running was greatest in forwards and wide midfielders (Delaney et al., 2017b).

Distance ($m \cdot min^{-1}$), distance covered at high speed (>5.5 $m \cdot s^{-1}$), average metabolic power, absolute values for acceleration and deceleration, and mechanical work have all been used to characterise the most demanding passages of play (Delaney et al., 2016; Delaney et al., 2017b; Lacome et al., 2017). The inclusion of variables that integrate the activity developed at high speed and accelerating/decelerating at high-intensity could be of interest to configure these periods. In this sense, high metabolic load distance (HMLD) is of interest, since it represents the distance covered (m) by a player when their metabolic power (energy consumption per kilogram per second) is above the value of 25.5 $W \cdot kg^{-1}$ (Tierney et al., 2016). This value of 25.5 corresponds to when a player is running at a constant speed of 5.5 $m \cdot s^{-1}$ on grass or when they are performing significant acceleration or deceleration activity (e.g. if they are accelerating from 2 to 4 $m \cdot s^{2}$ over 1 second).

To date, most football research has only quantified isolated activity variables. However, an understanding of other activities occurring within the most demanding passages of play is also important. In football the activity of the player is multidirectional, multidimensional and iterative. Consequently, a detailed description of the activity performed by players during these most demanding passage of match-play would be of interest to managers, fit-

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ness coaches and team medical staff. For example, two players could obtain the same average metabolic power (AMP; W·kg^{-1}) values over a given period of time, but the activity performed by the players could be vastly different (in one case, high intensity actions could be the result of greater high speed distance, and in another case the high intensity actions could be due to a higher number of accelerations or decelerations).

This information has significant practical application for the prescription of training, since it can serve as a benchmark when designing and evaluating the demands of the training tasks that are imposed on football players. Therefore, the purpose of this research was to identify the most demanding passage of match-play in football competition describing these periods through different variables, and determine the differences among positions through different criterion variables, and in different moving average durations.

Methods

Design

An observational, retrospective cohort study was conducted during the 2015-2016 competitive season. Global positioning system (GPS) files were collected from a professional male soccer team during match-play. Position-specific activities for the most demanding passage of match-play were established using different criterion variables, and in different moving average durations.

Subjects

Twenty-three professional football players (age: 20 ± 2 yr, mass: 70.2 ± 6.3 kg and stature: 1.78 ± 0.06 m) from the same Spanish 2nd B division team volunteered for this study. Data was collected throughout 37 competitive matches of the 2015-2016 competitive season (13 wins, 15 losses, 9 draw, final position 11th). A total of 605 individual global positioning system (GPS) files from match data of a professional male soccer team were collected. Each match was 90 min in duration, separated into two 45-min halves. Players were grouped according to their playing position, as central defenders (CD: n = 3; 95 GPS files), full backs (FB: n = 5; GPS 139 files), midfielders (MF: n = 3; GPS 101 files), wide midfielders (WMF: n = 5; GPS 110 files) and forwards (FW: n = 7; GPS 160 files). The mean (± SD) number of observations per player was 26.3 ± 12.4. A typical training week consisted of 5 field sessions. The training week typically used the following schedule: session +1: recovery from the previous game for the players who competed for more than 60 minutes and compensatory session for the players who competed less than 60 minutes in the game; session -4: strength oriented training session with SSG in reduced space; session -3: training oriented towards endurance development/maintenance; session -2: training with tasks with tactical-technical objective; and session -1: activation drills replicating the tactical profile of competition, with low conditioning load and some set piece drills. These data arose from the daily player monitoring in which player activities were routinely measured over the course of the season, thus no authorization was required from an institutional ethics committee (Lacome et al., 2017). Data arose as a condition of the players' employment whereby they were assessed daily. Nevertheless, this study conformed to the Declaration of Helsinki and players provided informed consent before participating.

Procedures

The STATSports software (Version 1.2) was then used for the computation of a moving average over each criterion variable (distance, HMLD and AMP), using four different durations (1', 3', 5' and 10'), and the maximum value for each duration was recorded. As a result, for each match, maximum values using three criterion variables were calculated for each of the 4 moving average durations. These four different durations were analysed because they correspond to the usual duration of the training drills in the team studied. Descriptive statistics and analysis were then calculated based on positions of play. These data were then averaged across all observations per position for between-group analysis.

The variables recorded were the distance covered per minute in competition (m·min^{-1}), distance covered at high speed (HSR; >5.5 m·s^{-1}, m·min^{-1}), distance covered at sprint (SPR; >7.0 m·s^{-1}, m·min^{-1}), the number of high-intensity accelerations (ACC; >3 m·s^{2}, n·min^{-1}), the number of high-intensity decelerations (DEC; <-3 m·s^{2}, n·min^{-1}), the average metabolic power (AMP: W·kg^{-1}) and the high metabolic load distance (HMLD; >25.5 W·kg^{-1}, n·min^{-1}). AMP is the energy expended by the player per second per kg for the player based on running on grass (the unit is W·kg^{-1}) and was calculated using the energetic calculations detailed previously (di Prampero et al., 2005; Osgnach et al., 2010). HMLD represents the distance covered (m) by a player when their metabolic power (energy consumption per kilogram per second) is above the value of 25.5 W·kg^{-1}.

This method allowed the computation of a number of output variables for each player, including distance (m·min^{-1}). Distance was representative of the traditional model, where accelerated running is ignored (Delaney et al., 2016). Composite variables combining multiple physical factors were also considered. The HMLD sums up high speed running distance (>4.0 m·s^{-1}) and also includes the distance covered when the player is involved in high acceleration/deceleration activities (set by the manufacturer at >2 m·s^{2} by default). HMLD represents the distance covered (m) by a player when their metabolic power (energy consumption per kilogram per second) is above the value of 25.5 W·kg^{-1}. HMLD is an estimation of energetic cost, based on the movement profile of the athlete. It is a metric calculated by the STATSports software algorithm and is considered to measure all activity above a metabolic power of 25.5 W·kg^{-1} (Dunbara et al., 2015; Osgnach et al., 2010).

The activity profile of players were monitored during each official match using a portable 10 Hz GPS unit (Viper Pod, 50 gr, 88 x 33 mm, Statsports Viper, Northern Ireland) as used in previous studies (Bowen et al., 2017; Fox et al., 2017). The accuracy of these devices has been studied recently, with 2.53 ± 6.03% estimation error in distance covered, with accuracy (%) improving as the distance covered increases and the speed of movement decreases (Beato et al., 2016). In order to avoid interunit error, each player trained with the same GPS device during the whole study period (Castellano et al., 2011; Nicolella et al., 2018). The GPS model used in this study was worn in a purpose designed vest, inside a mini pocket positioned in the centre area of the upper back, just above the shoulder blades, and thus, not affecting mobility of the upper limbs and torso.

Upon completion of each match, GPS data were extracted using proprietary software (Viper, Statsports, Ireland). A total of 605 individual match files were obtained.

The team systematically played in a 1-4-3-3 formation, with a goalkeeper, two FB, two CD, a MF, two WMF and three FW. Goalkeepeers and players with less than 10 records were not included in the analysis. Only data from players who completed the full match were analysed in order to limit the effect of pacing strategies (Carling and Dupont, 2011).

Statistical analysis

The data are presented as means and standard deviations (mean ±SD). The homogeneity of variances was examined by means of the Levene's test. The presence of significant differences was determined by means of a 1-tailed repeated-measures analysis of variance, applied to each of the dependent variables in relation to the position (CD, FB, MF, WMF and FW). Whenever a significant difference was found, a post hoc Bonferroni's test were used, whereas a Dunnett's T3 post hoc test was applied when the variances were not homogeneous. Effect sizes (ES) were calculated to determine meaningful differences. Magnitudes of difference were classed as trivial (<0.2), small (>0.2–0.6), moderate (>0.6–1.2), large (>1.2– 2.0) and very large (>2.0–4.0) (Batterham and Hopkins, 2006). All the statistical analysis were performed using SPSS 16.0 (SPSS Inc., Illinois, USA) for Windows, with significance being set at $p < 0.05$.

Results

Table 1 shows the mean ± SD values of the different variables for the specific positions in the game, including the significant differences ($p < 0.05$) in the four analyzed periods of time (1´, 3´, 5´ and 10´) using distance as the criterion variable. MF and WMF positions covered greater distance and fewer meters at sprint (>7.0 $m·s^{-1}$, $m·min^{-1}$). In the case of HSR, FB covered the greatest distance, reaching values of 47.2 ± 24.0 $m·min^{-1}$ in the 1' period.

Table 1. The most demanding passage of a match play for each position using distance (DIS; $m·min^{-1}$) for four different time durations (1', 3', 5' and 10').

		Position						
Time	Variables	CD	FB	MF	WMF	FW	AVERAGE	ES;p
1 min	DIS	181.9±16.4	195.3±15.7^{a,b}	204.0±15.4^{a,b}	201.1±19.0^{a,b}	180.9±20.4	191.6±19.7	ES: 0.1-1.2; p<0.001
	HSR	35.5±24.2	47.2±24.0^{c}	29.8±22.1	35.8±19.9	37.8±21.6	38.3±23.1	ES: 0.3-0.4; p=0.004
	SPR	11.6±19.1	14.0±17.3	6.1±11.0	7.2±12.5	11.5±14.2	10.6±15.6	ES: 0.1-0.5; p=0.076
	AMP	17.2±1.7	18.9±1.6^{a,b}	18.9±1.4^{a,b}	19.1±1.9^{a,b}	17.6±2.4	18.3±1.9	ES: 0.4-1.1; p<0.001
	HMLD	59.3±17.0	70.4±17.9^{a}	65.9±16.3	69.7±16.6^{a}	61.8±17.8	65.5±17.7	ES: 0.1-0.6; p=0.003
	ACC HI	2.7±1.5	2.8±1.5	2.6±1.3	3.3±1.8	2.8±1.7	2.8±1.6	ES: 0.3-0.6; p=0.241
	DEC HI	2.8±1.6	3.7±1.5^{a}	3.4±1.5	3.8±1.9^{a}	3.5±1.6	3.5±1.6	ES: 0.1-0.6; p=0.031
	ACC+DEC HI	5.6±2.8	6.6±2.6	6.0±2.4	7.2±3.2	6.3±3.0	6.4±2.8	ES: 0.2-0.5; p=0.081
3 min	DIS	143.4±9.7	151.9±9.1^{a,b}	161.3±8.5^{a,b,e}	156.6±15.6^{a,b}	138.4±15.9	149.1±14.7	ES: 0.4-1.7; p<0.001
	HSR	11.7±8.9	19.7±9.4^{a,c,d}	12.5±7.2	15.0±7.8	17.4±8.8^{a}	15.8±9.1	ES: 0.2-0.9; p<0.001
	SPR	2.6±4.6	4.4±5.4^{c}	1.7±2.9	2.1±3.1	4.1±4.3	3.2±4.4	ES: 0.1-0.6; p=0.005
	AMP	13.3±0.9	14.4±1.1^{a,b}	14.8±0.7^{a,b}	14.6±1.5^{a,b}	13.3±1.6	14.0±1.4	ES: 0.2-1.9; p<0.001
	HMLD	30.7±8.0	39.9±9.2^{a}	37.8±6.8^{a}	38.9±9.8^{a}	36.1±9.4^{a}	36.8±9.4	ES: 0.1-1.0; p<0.001
	ACC HI	2.5±0.9	2.3±0.9	2.6±1.2	2.7±1.1	2.3±1.1	2.5±1.0	ES: 0.1-0.4; p=0.182
	DEC HI	2.6±0.8	2.7±0.9	3.1±0.7	2.9±0.8	2.7±1.2	2.7±1.0	ES: 0.3-0.7; p=0.191
	ACC+DEC HI	5.1±1.6	5.1±1.6	5.7±1.6	5.6±1.7	4.9±2.2	5.3±1.8	ES: 0.1-0.4; p=0.140
5 min	DIS	132.7±8.3	139.3±8.1^{a,b}	149.7±6.8^{a,b,e}	146.4±16.0^{a,b}	127.7±13.6	137.9±13.7	ES: 0.3-1.9; p<0.001
	HSR	8.3±4.9	14.6±6.2^{a,c,d}	9.3±5.3	11.5±5.3	13.2±6.2^{a,c}	11.8±6.1	ES: 0.2-1.1; p<0.001
	SPR	1.5±2.3	3.4±3.4^{a}	1.6±2.8	1.9±2.4	2.9±3.0	2.4±2.9	ES: 0.2-0.6; p=0.001
	AMP	12.3±0.7	13.1±0.9^{a,b}	13.8±0.6^{a,b,e}	13.6±1.5^{a,b}	12.1±1.5	12.9±1.3	ES: 0.2-1.4; p<0.001
	HMLD	25.4±4.9	32.8±6.3^{a}	31.9± 5.4^{a}	33.9±8.7^{a,b}	29.3±7.8^{a}	30.6±7.5	ES: 0.1-1.2; p<0.001
	ACC HI	2.2±0.6	2.2±0.7	2.8±0.8^{b,e}	2.7±0.9^{b}	2.1±1.1	2.4±0.9	ES: 0.1-0.7; p<0.001
	DEC HI	2.3±0.6	2.6±0.7	3.1±0.7^{a,b}	2.8±0.9^{a}	2.4±1.0	2.6±0.8	ES: 0.4-1.2; p<0.001
	ACC+DEC HI	4.5±1.1	4.9±1.4	5.9±1.5^{a,b,e}	5.5±1.6^{a}	4.5±1.9	4.9±1.6	ES: 0.3-0.8; p<0.001
10 min	DIS	122.6± 7.4	128.2±8.1^{a,b}	139.7±7.8^{a,b,e}	135.2±15.6^{a,b,e}	117.0±13.1	127.3±13.4	ES: 0.4-2.0; p<0.001
	HSR	6.4±3.3	11.3±3.9^{a,c,d}	6.8±3.1	8.9±3.9^{a}	11.2±4.3^{a,c,d}	9.3±4.3	ES: 0.0-1.3; p<0.001
	SPR	1.2±1.4	2.6±2.5^{a,c,d}	0.8±1.5	1.3±1.7	2.4±2.3^{a,c}	1.8±2.1	ES: 0.1-0.8; p<0.001
	AMP	11.3±0.7	12.1±0.9^{a,b}	12.9±0.6^{a,b,e}	12.6±1.5^{a,b}	11.0±1.4	11.9±1.3	ES: 0.3-1.6; p<0.001
	HMLD	21.9±3.6	27.7±4.9^{a,b}	27.0±4.7^{a}	28.8±7.7^{a,b}	24.7±6.1	26±6.1	ES: 0.2-1.1; p<0.001
	ACC HI	2.2±0.4	2.2±0.7	2.6±0.5^{a,b,e}	2.5±0.8^{b}	1.9±0.9	2.2±0.8	ES: 0.1-0.9; p<0.001
	DEC HI	2.2±0.5	2.5±0.6^{a,b}	2.8±0.5^{a,b}	2.6±0.7^{a,b}	2.1±0.9	2.4±0.7	ES: 0.3-0.9; p<0.001
	ACC+DEC HI	4.5±0.9	4.7±1.3	5.4±0.9^{a,b}	5.1±1.5	4.0±1.8	4.7±1.4	ES: 0.2-0.9; p<0.001

CD = central defender; FW = forward; MF = midfielder; WMF = wide midfielder; FB = full back; a > CD; b > FW; c > MF; d > WMF; e > FB; DIS = distance $·min^{-1}$; HSR = high speed Running $·min^{-1}$ (>5.5 $m·s^{-1}$, $m·min^{-1}$); SPR = sprint $·min^{-1}$ (>7.0 $m·s^{-1}$, $m·min^{-1}$); HMLD = high metabolic load distance $·min^{-1}$; AMP = average metabolic power; ACC = accelerations $·min^{-1}$ (>3 $m·s^{2}$, $n·min^{-1}$); DEC = decelerations $·min^{-1}$ (<-3 $m·s^{2}$, $n·min^{-1}$); HI = high intensity.

Table 2. The most demanding passage of a match play for each position using relative metabolic load distance (HMLD; m·min^{-1}) for four different time durations (1’, 3’, 5’, and 10’).

Time	Variables	CD	FB	MF	WMF	FW	AVERAGE	ES;p
		Position						
1 min	DIS	163.6±24.9	175.5±21.4	189.8±18.6[a,b,e]	187.5±23.7[a,b]	160.0±26.3	173.5±26.0	ES: 0.1-0.7; p<0.001
	HSR	47.2±19.3	55.9±20.2	45.2±22.6	48.3±16.4	49.4±19.9	49.9±19.8	ES: 0.3-0.5; p=0.069
	SPR	19.1±20.5	18.3±18.1	12.7±17.2	11.4±12.5	18.8±16.6	16.6±17.4	ES: 0.0-0.5; p=0.085
	AMP	16.3±2.4	18.1±2.1[a,b]	18.5±1.8[a,b]	17.7±2.2[a,b]	16.5±2.8	17.5±2.5	ES: 0.2-1.0; p<0.001
	HMLD	67.7±12.8	79.7±16.0[a,b]	77.0±13.2[a]	79.7±11.2[a]	72.2±14.9	75.2±14.8	ES: 0.0-0.8; p<0.001
	ACC HI	3.4±1.6	3.5±1.7	3.6±1.7	3.9±1.8	3.2±1.7	3.5±1.7	ES: 0.2-0.4; p=0.319
	DEC HI	3.0±1.7	4.0±1.6[a,b]	3.9±1.6	3.9±1.8[a,b]	3.1±1.4	3.6±1.7	ES: 0.1-0.6; p=0.001
	ACC+DEC HI	6.5±2.8	7.6±2.9	7.5±2.9	7.9±3.0[b]	6.3±2.8	7.1±2.9	ES: 0.1-0.5; p=0.015
3 min	DIS	131.9±16.2	141.1±14.6[a,b]	151.2±11.4[a,b,e]	147.6±16.4[a,b]	128.3±17.2	138.8±17.6	ES: 0.2-1.5; p<0.001
	HSR	18.9±9.4	24.3±9.0[a,c]	18.2±9.5	20.8±7.1	23.7±7.9[a,c]	21.7±8.8	ES: 0.1-0.6; p=0.001
	SPR	5.1±6.5	6.6±6.6	3.6±5.6	4.8±5.1	7.7±5.7[c]	5.8±6.1	ES: 0.2-0.7; p=0.013
	AMP	12.7±1.5	13.9±1.4[a,b]	14.3±1.0[a,b]	14.3±1.7[a,b]	12.7±1.7	13.5±1.7	ES: 0.0-0.9; p<0.001
	HMLD	36.6±6.9	44.6±7.1[a,b]	42.4±6.3[a]	45.3±7.6[a,b]	40.6±7.9	41.9±7.9	ES: 0.1-1.2; p<0.001
	ACC HI	2.7±0.8	2.6±1.0	2.9±1.0[b]	2.9±1.1[b]	2.2±0.9	2.6±0.9	ES: 0.0-0.7; p<0.001
	DEC HI	2.5±0.9	2.9±1.0	3.1±0.9[a]	3.1±1.0[a,b]	2.6±0.9	2.8±0.9	ES: 0.0-0.6; p<0.001
	ACC+DEC HI	5.2±1.5	5.6±1.8	6.1±1.7[b]	6.1±1.9[b]	4.8±1.6	5.5±1.8	ES: 0.0-0.7; p<0.001
5 min	DIS	123.2±12.8	131.3±11.4[a,b]	142.4±9.0[a,b,e]	140.9± 5.3[a,b,e]	118.2±14.9	129.9±15.9	ES: 0.1-2.0; p<0.001
	HSR	13.7±6.4	18.3±6.2[a,c]	12.7±5.9	15.5±5.6	18.1±6.3[a,c]	16.1±6.5	ES: 0.0-0.9; p<0.001
	SPR	4.1±4.3	4.8±4.2[c,d]	2.4±3.3	2.5±2.7	5.1±4.3[c,d]	4.0±3.9	ES: 0.1-0.7; p=0.001
	AMP	11.7±1.1	12.8±1.1[a,b]	13.4±0.8[a,b,e]	13.4±1.6[a,b]	11.5±1.6	12.5±1.5	ES: 0.0-1.4; p<0.001
	HMLD	29.3±4.7	36.5±5.6[a,b]	35.7±4.6[a]	38.1±7.5[a,b]	33.2±6.8[a]	34.5±6.7	ES: 0.2-1.4; p<0.001
	ACC HI	2.4±0.7	2.3±0.8	2.8±0.9[b]	2.8±1.0[b,e]	2.2±1.1	2.5±0.9	ES: 0.0-0.6; p<0.001
	DEC HI	2.3±0.6	2.7±0.7[a]	3.0±0.7[a,b]	2.9±0.8[a,b]	2.4±0.9	2.6±0.8	ES: 0.1-1.1; p<0.001
	ACC+DEC HI	4.7±1.1	5.1±1.3	5.9±1.5[a,b]	5.8±1.7[a,b]	4.6±1.9	5.1±1.6	ES: 0.1-0.7; p<0.001
10 min	DIS	115.6±11.9	122.9±9.1[a,b]	135.1±9.1[a,b,e]	132.1±13.4[a,b,e]	110.5±14.3	121.9±14.8	ES: 0.3-2.0; p<0.001
	HSR	8.9±4.2	13.6±4.3[a,c]	8.6±3.2	11.7±3.9[a,c]	13.2±4.3[a,c]	11.6±4.5	ES: 0.1-1.3; p<0.001
	SPR	2.1±2.4	3.3±2.8[c,d]	1.2±1.4	1.7±1.7	3.6±2.7[a,c,d]	2.6±2.5	ES: 0.1-1.0; p<0.001
	AMP	10.8±1.1	11.8±1.0[a,b]	12.6±0.7[a,b,e]	12.4±1.3[a,b]	10.6±1.4	11.5±1.4	ES: 0.2-1.7; p<0.001
	HMLD	23.4±3.6	29.8±4.5[a,b]	29.2±4.0[a]	31.5±6.6[a,b]	26.6±5.7[a]	28.0±5.7	ES: 0.3-1.5; p<0.001
	ACC HI	2.3±0.5	2.2±0.7	2.8±0.6[a,b,e]	2.6±0.8[b]	1.9±0.9	2.3±0.8	ES: 0.3-1.1; p<0.001
	DEC HI	2.1±0.6	2.5±0.6[b]	2.8±0.6[a,b]	2.5±0.7[b]	2.1±0.7	2.4±0.7	ES: 0.5-1.1; p<0.001
	ACC+DEC HI	4.5±0.9	4.7±1.2	5.6±1.0[a,b,e]	5.1±1.5[b]	4.0±1.7	4.7±1.4	ES: 0.4-1.1; p<0.001

CD = central defender; FW = forward; MF = midfielder; WMF = wide midfielder; FB = full back; a > CD; b > FW; c > MF; d > WMF; e > FB; DIS = distance ·min^{-1}; HSR = high speed Running ·min^{-1} (>5.5 m·s^{-1}, m·min^{-1}); SPR = sprint ·min^{-1} (>7.0 m·s^{-1}, m·min^{-1}); HMLD = high metabolic load distance ·min^{-1}; AMP = average metabolic power; ACC = accelerations ·min-1 (>3 m·s^{2}, n·min^{-1}); DEC = decelerations ·min-1 (<-3 m·s^{2}, n·min^{-1}); HI = high intensity.

Table 2 presents the mean ± SD values using HMLD as the criterion variable. In FW and WMF positions their HMLD was greater than the other positions. In the WMF and MF positions AMP was higher than the CD and FW positions in each one of the periods analyzed.

Table 3 shows the most demanding passages of play when AMP was used as the criterion variable. FB, MF and WMF positions covered the greatest distance. FB and FW positions covered more HSR distance, while the FB position ran the greatest distance at sprints. Higher accelerations and decelerations at high intensity values were performed by the MF and MFO positions in the 3’ and 10’ periods (ES: 0.5-1.2).

Discussion

The main findings of this study were that during the most demanding passage of match-play, physical demands are position-dependent. CD and FW reported lower locomotive demands in comparison to WMF, FB and MF, and HMLD values in WMF and FB were higher than other positions during all epochs (1´, 3´, 5´ and 10´).

Differences in the most demanding passage of play among player position have previously been observed in football (Delaney et al., 2017b) as well as in other team sports such as Rugby League (Delaney et al., 2016) and Gaelic football (Malone et al., 2017b). When distance covered was used as the criterion variable, WMF and MF covered greater distance independent of the selected duration, with values as high as 200 m·min^{-1} during 1 minute epochs. These results are similar to those obtained in professional Australian players (Delaney et al., 2016) and higher than those recorded in French professional footballers (Lacome et al., 2017). The teams studied in the previous work (Lacome et al., 2017; Delaney et al., 2017b) used the same playing system (1-3-4-3), but the classification of positions was different. Our study did not differentiate between strikers and wingers (Lacome et al., 2017), or between midfielders and wide midfielders (Delaney et al., 2017b). Despite these differences, previous studies also found that MF players cover the greatest distance whereas CD report the lowest values (Lacome et al., 2017; Delaney et al., 2017b).

One of the main original findings of this work is that the most demanding passages of play values are defined based on both the criterion variable, and other variables that may help to understand the demands of the critical moments of match-play. When the players reach their peak values in any criterion variable (e.g. in distance covered),

Table 3. The most demanding passage of a match play for each position using relative average metabolic power (AMP; W·kg^{-1}) for four different time durations (1’, 3’, 5’, and 10’).

		Position						
Time	**Variables**	**CD**	**FB**	**MF**	**WMF**	**FW**	**AVERAGE**	**ES;p**
1 min	DIS	172.2 ± 16.4	189.9 ± 15.6^{a,b}	200.2 ± 16.1^{a,b,e}	195.2 ± 21.2^{a,b}	175.3 ± 24.6	186.3 ± 21.3	ES: 0.3-1.7; p<0.001
	HSR	32.3 ± 22.3	46.9 ± 22.8^{a,c}	31.2 ± 19.6	37.8 ± 18.9	40.3 ± 20.2	38.9 ± 21.6	ES: 0.3-0.7; p=0.001
	SPR	8.7 ± 15.5	16.7 ± 16.9^{a,c,d}	7.6 ± 13.4	7.7 ± 10.8	12.9 ± 12.6	11.4 ± 14.6	ES: 0.3-0.6; p=0.003
	AMP	17.7 ± 1.4	19.4 ± 1.7^{a,b}	19.7 ± 1.1^{a,b}	19.6 ± 1.7^{a,b}	18.1 ± 2.2	18.9 ± 1.9	ES: 0.1-1.6; p<0.001
	HMLD	60.5 ± 14.7	73.6 ± 16.7^{a,b}	72.2 ± 15.6^{a}	72.4 ± 15.6^{a,b}	63.3 ± 17.9	68.2 ± 22.2	ES: 0.1-0.8; p<0.001
	ACC HI	3.8 ± 1.8	3.4 ± 1.6	4.1 ± 1.6	3.8 ± 1.9	3.4 ± 1.7	3.6 ± 1.7	ES: 0.2-0.4; p=0.293
	DEC HI	3.8 ± 1.6	4.3 ± 1.3	4.8 ± 1.6^{a,b}	4.8 ± 1.7^{a,b}	3.8 ± 1.6	4.2 ± 1.6	ES: 0.0-0.6; p=0.001
	ACC+DEC HI	7.5 ± 3.0	7.7 ± 2.6	8.9 ± 2.9	8.5 ± 3.0	7.2 ± 2.9	7.9 ± 2.9	ES: 0.1-0.6; p=0.034
3 min	DIS	139.4 ± 13.3	148.7 ± 9.6^{a,b}	158.5 ± 9.7^{a,b,e}	156.7 ± 12.7^{a,b,e}	136.8 ± 15.7	146.9 ± 15.1	ES: 0.2-1.6; p<0.001
	HSR	12.9 ± 9.3	19.9 ± 8.3^{a,c}	12.8 ± 6.3	17.2 ± 7.5	19.1 ± 7.4^{a,c}	16.9 ± 8.4	ES: 0.1-0.9; p<0.001
	SPR	3.3 ± 5.6	4.5 ± 5.1	1.9 ± 3.9	3.1 ± 4.5	4.9 ± 4.1^{c}	3.8 ± 4.8	ES: 0.1-0.7; p=0.025
	AMP	13.3 ± 1.2	14.6 ± 1.1^{a,b}	15.0 ± 0.7^{a,b}	15.0 ± 1.2^{a,b}	13.5 ± 1.6	14.2 ± 1.4	ES: 0.0-1.4; p<0.001
	HMLD	32.3 ± 7.6	41.1 ± 7.8^{a}	39.1 ± 6.9^{a}	42.5 ± 9.5^{a,b}	37.8 ± 8.5^{a}	38.6 ± 8.9	ES: 0.2-1.2; p<0.001
	ACC HI	2.8 ± 0.9	2.6 ± 0.9	3.4 ± 1.3^{b,e}	3.1 ± 1.1^{b}	2.5 ± 1.1	2.8 ± 1.1	ES: 0.2-0.8; p<0.001
	DEC HI	2.8 ± 0.9	3.3 ± 1.0	3.6 ± 1.0^{a,b}	3.3 ± 0.9	2.9 ± 1.2	3.1 ± 1.1	ES: 0.3-0.8; p=0.005
	ACC+DEC HI	5.6 ± 1.6	5.9 ± 1.7	7.0 ± 2.2^{a,b}	6.3 ± 1.7	5.4 ± 2.2	5.9 ± 1.9	ES: 0.4-0.7; p=0.001
5 min	DIS	130.1 ± 11.5	137.5 ± 8.8^{a,b}	147.8 ± 7.7^{a,b,e}	147.2 ± 12.4^{a,b,e}	125.9 ± 13.7	136.6 ± 14.1	ES: 0.1-1.9; p<0.001
	HSR	8.2 ± 5.4	15.2 ± 5.9^{a,c,d}	9.5 ± 4.8	11.9 ± 5.4^{a}	14.4 ± 6.1^{a,c}	12.3 ± 6.2	ES: 0.1-1.2; p<0.001
	SPR	1.9 ± 2.9	3.4 ± 3.3^{d}	1.7 ± 2.8	1.8 ± 2.2	3.2 ± 3.4	2.5 ± 3.1	ES: 0.1-0.5; p=0.004
	AMP	12.3 ± 0.9	13.3 ± 0.9^{a,b}	13.9 ± 0.6^{a,b,e}	13.9 ± 1.2^{a,b}	12.2 ± 1.5	13.1 ± 1.3	ES: 0.0-1.2; p<0.001
	HMLD	26.3 ± 4.7	34.2 ± 6.2^{a}	32.9 ± 5.9^{a}	35.8 ± 8.3^{a,b}	30.7 ± 7.4^{a}	31.9 ± 7.4	ES: 0.2-1.4; p<0.001
	ACC HI	2.6 ± 0.6	2.5 ± 0.7	3.1 ± 0.9^{b,e}	2.9 ± 0.9^{b,e}	2.3 ± 1.1	2.6 ± 0.9	ES: 0.2-0.8; p<0.001
	DEC HI	2.6 ± 0.8	2.9 ± 0.7	3.2 ± 0.7^{a,b}	3.1 ± 0.9^{a,b}	2.6 ± 1.0	2.8 ± 0.9	ES: 0.1-0.8; p=0.001
	ACC+DEC HI	5.2 ± 1.3	5.4 ± 1.3	6.3 ± 1.5^{a,b}	6.1 ± 1.6^{a,b}	4.9 ± 2.0	5.5 ± 1.6	ES: 0.1-0.8; p<0.001
10 min	DIS	120.5 ± 11.2	127.4 ± 8.5^{a,b}	138.3 ± 8.4^{a,b,e}	136.8 ± 11.3^{a,b,e}	116.5 ± 13.2	126.7 ± 13.6	ES: 0.1-1.9; p<0.001
	HSR	6.2 ± 3.4	11.7 ± 3.8^{a,c,d}	6.9 ± 3.1	9.6 ± 4.1^{a,c}	11.4 ± 3.7^{a,c}	9.5 ± 4.3	ES: 0.1-1.5; p<0.001
	SPR	1.3 ± 1.8	2.8 ± 2.5^{a,c,d}	1.1 ± 1.5	1.2 ± 1.6	2.6 ± 2.2^{a,c,d}	1.9 ± 2.1	ES: 0.1-0.8; p<0.001
	AMP	11.2 ± 0.9	12.2 ± 0.9^{a,b}	12.8 ± 0.7^{a,b,e}	12.8 ± 1.1^{a,b,e}	11.1 ± 1.3	11.9 ± 1.3	ES: 0.0-1.5; p<0.001
	HMLD	22.1 ± 3.8	28.3 ± 4.7^{a,b}	27.3 ± 4.5^{a}	30.2 ± 7.1^{a,b}	25.3 ± 5.8^{a}	26.6 ± 5.9	ES: 0.3-1.4; p<0.001
	ACC HI	2.4 ± 0.4	2.3 ± 0.6	2.7 ± 0.5^{a,b,e}	2.7 ± 0.8^{b}	2.0 ± 0.9	2.4 ± 0.8	ES: 0.0-0.8; p<0.001
	DEC HI	2.3 ± 0.5	2.7 ± 0.6^{b}	2.9 ± 0.5^{a,b}	2.7 ± 0.7^{a,b}	2.2 ± 0.9	2.5 ± 0.7	ES: 0.3-0.9; p<0.001
	ACC+DEC HI	4.7 ± 0.9	4.9 ± 1.2	5.7 ± 0.9^{a,b,e}	5.4 ± 1.4^{a,b}	4.3 ± 1.8	4.9 ± 1.4	ES: 0.2-0.9; p<0.001

CD = central defender; FW = forward; MF = midfielder; WMF = wide midfielder; FB = full back; a > CD; b > FW; c > MF; d > WMF; e > FB; DIS = distance ·min^{-1}; HSR = high speed Running ·min^{-1} (>5.5 m·s^{-1}, m·min^{-1}); SPR = sprint ·min^{-1} (>7.0 m·s^{-1}, m·min^{-1}); HMLD = high metabolic load distance ·min^{-1}; AMP = average metabolic power; ACC = accelerations ·min-1 (>3 m·s^{2}, n·min^{-1}); DEC = decelerations ·min-1 (<-3 m·s^{2}, n·min^{-1}); HI = high intensity.

they perform other activities that must be considered when designing training tasks to prepare players for the most demanding passages of play. For example, in the 3’ period WMF traveled a distance of 156 m·min^{-1}, with 15 m·min^{-1} covered in HSR, while also performing 2-3 high-intensity accelerations and decelerations per minute. Designing training tasks based only on the criterion variable, may limit specifity and underestimate the actual demands of the most demanding passages of match-play.

HSR is frequently monitored by physical trainers (Akenhead and Nassis, 2016) because of its relation to the incidence of injury (Malone et al., 2017a). Although HSR was not used as a criterion variable in our study, we observed similar values to those reported by Delaney et al. (2017b) when we applied the HMLD as the criterion variable, with FB reaching values close to 50 m·min^{-1} when the applied time frame was 1 minute. Our results are in agreement with those obtained by Delaney et al. (2017b), with FB and FW performing the most HSR. However, Delaney et al. (2017b) found that the lowest amount of HSR was recorded by the CD and WMF, while in our work the MF had significantly lower values than the FB and FW. Perhaps were the non-use of HSR as the criterion variable can explain differences between the present and previous (Delaney et al., 2017b) studies. In this sense, it should be noted that the values in our study (Distance, HMLD, AMP) could be higher if we had used HSR as a criterion variable. We must take into account that absolute criteria have been used to define the actions of HSR, without considering the maximum capacities of the athlete (Sweeting et al., 2017), such as the player's peak speed (Buchheit et al., 2013).

The AMP represents a theoretical approximation of the energy cost of team sports where in addition to the speed of running, the energetic cost of accelerating and decelerating is considered (Osgnach et al., 2010). This indicator presents some controversy in the literature (Buchheit et al., 2015), although it has been presented in different studies (di Prampero et al., 2005; Osgnach et al., 2010). When AMP is used as a criterion variable, CD and FW values are significantly lower than the other positions. Delaney et al. (2017a) indicates that the CD have significantly lower values than the remaining positions. The role played by the FW according to the type of game played by the team (Fernandez-Navarro et al., 2016) and/or playing system (Bradley et al., 2011) can explain these differences and may affect the physical demands on players. The FW activity in a formation like the one used in the current team (Fernandez-Navarro et al., 2016), could reduce AMP with respect to another team where return runs and counterattacking predominates. In addition, differences in playing systems (1 vs. 2 vs. 3 FW) could explain differences in results.

AMP and HMLD variables take into account high-intensity actions performed at high and low displacement speeds. Therefore, they are variables that can reach a certain value through different mechanisms, such as small amounts of HSR and high frequencies of accelerations / decelerations, or with large amounts of HSR and a low frequency of accelerations / decelerations. In our study, we observed similar AMP values obtained by the CD and FW, with a tendency towards greater HSR and a lower frequency of accelerations / decelerations in the FW. Therefore, these measurements that summarize the energy expenditure or the player activity must always be considered with other variables at the same time in order to provide information on how the values have been obtained (Delaney et al., 2017a).

Previous studies have shown that player accelerations and decelerations during a match are positional dependent (Varley et al., 2012). Although acceleration and deceleration measurements typically have low reliability (Buchheit et al., 2013), sports scientists frequently report such activities (Akenhead and Nassis, 2016). In our study, the maximum values obtained when AMP was used as the criterion variable, were similar to when HMLD was used as the criterion variable. The frequency of high-intensity accelerations and decelerations represents smaller values in FW and CD, a finding that is consistent with that found by Delaney et al. (2017a). These results might suggest that FW and CD may require fewer accelerations and decelerations in training. However, MF and WMF were the position with the greatest acceleration and deceleration demands in this study. Given that the MF and WMF players frequently compete between opposition lines (especially the WMF), their efforts are likely to be of shorter duration, and therefore, with a higher frequency of activity changes.

In addition, as the time window increased, the intensity of all movement variables decreased in all positions and the differences among positions also increased. For example, during short duration passages (i.e. 1 min), there were no significant differences among positions for HSR and SPR when the criterion variables were distance and HMLD. However, when the duration was 10 minutes, in all cases the differences among positions were significant. It appears that reducing the time window homogenizes the physical demands imposed on players.

Some of the main limitations of this research refer to the fact that the most demanding passage of play in football competition have been studied using the criterion variables of HMLD, AMP and TD. It is likely that, if the most demanding passage of competition had been identified from the highest value of other variables (e.g. HSR), the observed results may have been different. Secondly, while differences were observed among positions for high-intensity actions within the criterion variable, these differences were typically small to moderate in magnitude, suggesting that some generic training may be warranted, even among players from contrasting positions. Finally, as different GPS devices sample at different frequencies and use different software algorithms in data processing, the accuracy of some of the variables analysed (e.g. ACC and DEC) are dependent on the device used. The accuracy of different GPS devices (Buchheit et al., 2014), should be considered when comparing different studies (Carling et al., 2012).

Conclusion

The activities that a football player performs are both stochastic and multidimensional; it is therefore necessary to consider the individual activities that comprise the most demanding passages of match-play. Our data should help coaches to design training situations that replicate and even surpass the most demanding passages of match-play, attending to positional requirements and adapting these phases to the duration of training drills.

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References

Akenhead, R. and Nassis, G.P. (2016) Training load and player monitoring in high-level football: current practice and perceptions. *International Journal of Sports Physiology and Performance* **11,** 587-593.

Batterham, A.M. and Hopkins, W.G. (2006) Making meaningful inferences about magnitudes. *International Journal of Sports Physiology and Performance* **1,** 50-57

Beato, M., Bartolini, D., Ghia, G. and Zamparo, P. (2016) Accuracy of a 10 Hz GPS Unit in Measuring Shuttle Velocity Performed at Different Speeds and Distances (5–20 M). *The Journal of Human Kinetics* **54,** 15-22.

Beenham, M., Barron, D.J., Fry, J., Hurst, H.H., Figueirdo, A. and Atkins, S. (2017) A comparison of GPS workload demands in match play and small-sided games by the positional role in youth soccer. *The Journal of Human Kinetics* **57,** 129-137.

Bowen, L., Gross, A.S., Gimpel, M. and Li, F.X. (2017) Accumulated workloads and the acute: chronic workload ratio relate to injury risk in elite youth football players. *British Journal of Sports Medicine* **51,** 452-459.

Buchheit, M., Haddad, H.A., Simpson, B.M., Palazzi, D., Bourdon, P.C., Salvo, V.D. and Mendez-Villanueva, A. (2014) Monitoring accelerations with GPS in football: time to slow down? *International Journal of Sports Physiology and Performance* **9,** 442-445.

Buchheit, M., Manouvrier, C., Cassirame, J. and Morin, J.B. (2015) Monitoring locomotor load in soccer: is metabolic power, powerful? *International Journal of Sports Medicine* **36,** 1149-1155.

Buchheit, M., Simpson, B. and Mendez-Villanueva, A. (2013) Repeated high-speed activities during youth soccer games in relation to changes in maximal sprinting and aerobic speeds. *International Journal of Sports Medicine* **34,** 40-48.

Bradley, P.S., Carling, C., Archer, D., Roberts, J., Dodds, A., Di Mascio, M., Diaz, A.G., Peart, D. and Krustrup, P. (2011) The effect of playing formation on high-intensity running and technical profiles in English FA Premier League soccer matches. *Journal of Sports Sciences* **29,** 821-830.

Bradley, P.S. and Noakes, T.D. (2013) Match running performance fluctuations in elite soccer: indicative of fatigue, pacing or situational influences? *Journal of Sports Sciences* **31,** 1627-1638.

Carling, C. and Dupont, G. (2011) Are declines in physical performance associated with a reduction in skill-related performance during professional soccer match-play? *Journal of Sports Sciences* **29,** 63-71.

Carling, C., Le Gall, F. and Dupont, G. (2012) Analysis of repeated high-intensity running performance in professional soccer. *Journal of*

Sports Sciences **30,** 325-336.

Casamichana, D., Castellano, J. and Castagna, C. (2012) Comparing the physical demands of friendly matches and small-sided games in semiprofessional soccer players. *The Journal of Strength & Conditioning Research* **26,** 837-843.

Castellano, J., Alvarez-Pastor, D. and Bradley, P.S. (2014) Evaluation of research using computerised tracking systems (Amisco® and Prozone®) to analyse physical performance in elite soccer: A systematic review. *Sports Medicine* **44,** 701-712.

Castellano, J., Casamichana, D., Calleja-González, J., San Román, J. and Ostojic, S.M. (2011) Reliability and accuracy of 10 Hz GPS devices for short-distance exercise. *Journal of Sports Science and Medicine* **10,** 233.

Delaney, J.A., Duthie, G.M., Thornton, H.R., Scott, T.J., Gay, D. and Dascombe, B.J. (2016) Acceleration-Based Running Intensities of Professional Rugby League Match Play. *International Journal of Sports Physiology and Performance* **11,** 802-809.

Delaney, J.A., Thornton, H.R., Burgess, D.J., Dascombe, B.J. and Duthie, G.M. (2017a) Duration-specific running intensities of Australian Football match-play. *Journal of Science and Medicine in Sport* **20,** 689-694.

Delaney, J.A., Thornton, H.R., Rowell, A.E., Dascombe, B.J., Aughey, R.J. and Duthie, G.M. (2017b) Modelling the decrement in running intensity within professional soccer players. *Science and Medicine in Football* **2,** 86-92.

Dellal, A., Owen, A., Wong, D.P., Krustrup, P., van Exsel, M. and Mallo, J. (2012) Technical and physical demands of small vs. large sided games in relation to playing position in elite soccer. *Human Movement Science* **31,** 957-969.

Di Mascio, M. and Bradley, P.S. (2013) Evaluation of the most intense high-intensity running period in English FA premier league soccer matches. *The Journal of Strength & Conditioning Research* **27,** 909-915.

di Prampero, P.E., Fusi, S., Sepulcri, L., Morin, J.B., Belli, A. and Antonutto, G. (2005) Sprint running: a new energetic approach. *Journal of Experimental Biology* **208,** 2809-2816.

Di Salvo, V., Baron, R., Tschan, H., Montero, F.C., Bachl, N. and Pigozzi, F. (2007) Performance characteristics according to playing position in elite soccer. *International Journal of Sports Medicine* **28,** 222-227.

Dunbara, J., Rosenb, B., Gimpelb, M. and Jehanlia, A. (2015) 11 Salivary cortisol is highly correlated with training intensity in English Premier League players. *International Research in Science and Soccer II*, 104.

Fernandez-Navarro, J., Fradua, L., Zubillaga, A., Ford, P.R. and McRobert, A.P. (2016) Attacking and defensive styles of play in soccer: analysis of Spanish and English elite teams. *Journal of Sports Sciences* **34,** 2195-2204.

Fox, R., Patterson, S.D. and Waldron, M. (2017) The relationship between heart rate recovery and temporary fatigue of kinematic and energetic indices among soccer players. *Science and Medicine in Football* **1,** 132-138.

Gabbett, T.J., Kennelly, S., Sheehan, J., Hawkins, R., Milsom, J., King, E., Whiteley, R. and Ekstrand, J. (2016) If overuse injury is a 'training load error', should undertraining be viewed the same way? *British Journal of Sports Medicine* **50,** 1017-1018.

Giménez, J.V., Del-Coso, J., Leicht, A.S. and Gomez, M.A. (2017) Comparison of the movement patterns between small-and large-side games training and competition in professional soccer players. *The Journal of Sports Medicine and Physical Fitness,* Epub ahead of print.

Lacome, M., Simpson, B.M., Cholley, Y., Lambert, P. and Buchheit, M. (2017). Small-Sided Games in Elite Soccer: Does One Size Fits All? *International Journal of Sports Physiology and Performance* **13,** 1-24.

Malone, S., Roe, M., Doran, D.A., Gabbett, T.J. and Collins, K. (2017a) High chronic training loads and exposure to bouts of maximal velocity running reduce injury risk in elite Gaelic football. *Journal of Sports Science and Medicine* **20,** 250-254.

Malone, S., Solan, B., Hughes, B. and Collins, K. (2017b) Duration specific Running performance in Elite Gaelic Football. *The Journal of Strength & Conditioning Research,* Epub ahead of print.

Nicolella, D. P., Torres-Ronda, L., Saylor, K. J. and Schelling, X. (2018) Validity and reliability of an accelerometer-based player tracking device. *PloS one* **13**, e0191823.

Osgnach, C., Poser, S., Bernardini, R., Rinaldo, R. and Di Prampero, P.E. (2010) Energy cost and metabolic power in elite soccer: a new match analysis approach. *Medicine and Science in Sports and Exercise* **42,** 170-178.

Owen, A.L., Djaoui, L., Newton, M., Malone, S. and Mendes, B. (2017) A contemporary multi-modal mechanical approach to training monitoring in elite professional soccer. *Science and Medicine in Football* **1,** 216-221.

Stevens, T.G., de Ruiter, C.J., Twisk, J.W., Savelsbergh, G.J. and Beek, P.J. (2017) Quantification of in-season training load relative to match load in professional Dutch Eredivisie football players. *Science and Medicine in Football* **1,** 117-125.

Sweeting, A.J., Cormack, S.J., Morgan, S. and Aughey, R.J. (2017) When Is a Sprint a Sprint? A Review of the Analysis of Team-Sport Athlete Activity Profile. *Frontiers in Physiology* **8,** 432.

Tierney, P.J., Young, A., Clarke, N.D. and Duncan, M.J. (2016) Match play demands of 11 versus 11 professional football using Global Positioning System tracking: Variations across common playing formations. *Human Movement Science* **49,** 1-8.

Varley, M.C., Elias, G.P. and Aughey, R.J. (2012) Current match-analysis techniques' underestimation of intense periods of high-velocity running. *International Journal of Sports Physiology and Performance* **7,** 183-185.

Key points

- Physical demands are position-dependent during the most demanding passage of match-play
- Reducing the time window homogenizes the physical demands imposed on players
- We need information about different variables to understand the actual demands of the most demanding passages of match-play

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Capítulo 4

Estudio II: Quantification of a professional football team’s external load using Microcycle Structure.

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Quantification of a Professional Football Team's External Load Using a Microcycle Structure

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Abstract

Martín-García, A, Gómez Díaz, A, Bradley, PS, Morera, F, and Casamichana, D. Quantification of a professional football team's external load using a microcycle structure. *J Strength Cond Res* XX(X): 000–000, 2018—The aims of this study were to (a) determine the external load of a football team across playing position and relative to competition for a structured microcycle and (b) examine the loading and variation the day after competition for players with or without game time. Training and match data were obtained from 24 professional football players who belonging to the reserve squad of a Spanish La Liga club during the 2015/16 season using global positioning technology ($n = 37$ matches and $n = 42$ training weeks). Training load data were analyzed with respect to the number of days before or after a match (match day [MD] minus or plus). Training load metrics declined as competition approached (MD-4 > MD-3 > MD-2 > MD-1; $p < 0.05$; effect sizes [ES]: 0.4–3.1). On the day after competition, players without game time demonstrated greater load in a compensatory session (MD + 1C) that replicated competition compared with a recovery session (MD + 1R) completed by players with game time (MD + 1C > MD + 1R; $p < 0.05$; ES: 1.4–1.6). Acceleration and deceleration metrics during training exceeded 50% of that performed in competition for MD + 1C (80–86%), MD-4 (71–72%), MD-3 (62–69%), and MD-2 (56–61%). Full backs performed more high-speed running and sprint distance than other positions at MD-3 and MD-4 ($p < 0.05$; ES: 0.8–1.7). The coefficient of variation for weekly training sessions ranged from ~40% for MD-3 and MD-4 to ~80% for MD + 1R. The data demonstrate that the external load of a structured microcycle varied substantially based on the players training day and position. This information could be useful for applied sports scientists when trying to systematically manage load, particularly compensatory conditioning for players without game time.

Key Words soccer, training, fatigue, team sport, GPS, periodization

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Introduction

Football (soccer) incorporates unpredictable movements during matches where players transition between multidirectional high-intensity efforts and low-intensity activity (9). High-intensity running during matches has increased by a third in some leagues across the past decade (6); thus, players must be robust enough to cope with such demands. One way of handling such demands could be to optimize training structure through manipulating volume and intensity of competition cycles (35). Accordingly, global positioning system (GPS) technology is widely used within football because it provides practitioners with an estimate of the external load experienced by players (4,12,27,37). Using such technology within training and competition enables coaches to not only understand the distinct game requirements of various playing positions but to also recognize the conditioning needs for the individual roles within the team (15,17,34). As midfielders (MFs) cover twice the high-intensity game distance compared with central defenders (CDs) (11), it is not surprising that research has focused on position-specific training (40). Although, limited data exist on training loads relative to match play across position, and such information could aid practitioners considering a position-specific approach (10).

One of the main objectives of staff working in elite football is the periodization of training (31,33,37). This presents itself in the form of the training day and the weekly microcycle

(3,4,35). Although general and position-specific preparations are key, applied staff still have to strike a fine balance between loading the players enough for positive adaptation without elevating the risk of injury (22,25,26). The general consensus is that load metrics are lower in the session before competition, confirming the concept of tapering (19,23,40). However, limited data exist on the loading patterns after competition for players with game time vs. partial or no game time. This is particularly important because players with reduced game time will require a training session that replicates competition loads, whereas those players completing the game will require a recovery session instead (40,43). Therefore, more research on loading strategies the day after a game would be advantageous for coaches, as it would provide them with a practical framework.

Football conditioning has evolved substantially over the past decade because of contemporary training concepts and models (29). The structured microcycle is a weekly training unit that is dictated by the players' schedule, physical recovery status, and conditioning requirements. Although elements of the schedule are controlled, some are variable and occur in an unpredictable manner. The variability in load metrics across the microcycle has not been explored sufficiently within the literature, despite a plethora of studies quantifying competition variability (14,16). Changes in stimuli and load are important for training adaptations within the elite setting (24). Another area that has yet to be covered in detail is the contextualization of the microcycle, with most studies failing to provide any specific details of training sessions (e.g., the training session held the day before the match was referred to as match day [MD]-1 and included tactical preparation with set pieces). To the authors' knowledge, this study is one of the first to contextualize external load using a unique microcycle from one of Europe's leading football clubs. Specifically, the systematic phases of the microcycle are very unique to this club philosophy and would provide added insight to practitioners. Additional studies are also needed detailing loading patterns and training practices from various European competitions, given that the body of evidence is primarily from English Premier League clubs (1,4,35). This is relevant because differences in culture and competition demands across leagues could result in distinct loading variations in an attempt to optimize performance (e.g., styles of play, number of games, and midseason breaks). Accordingly, the aims of this study were to (a) determine the external load of a football team across playing position and relative to competition for a structured microcycle and (b) examine the loading and variation the day after competition for players with or without game time.

Methods

Experimental Approach to the Problem

Global positioning system data were collected from 37 competitive matches and 42 training weeks during the 2015–16 season. This enabled absolute and relative external training loads to be quantified across the microcycle for various playing positions. Players were excluded from further analysis if they had completed <10 training sessions and did not complete a full competitive match. Sessions were performed on a natural grass surface within a pitch dimension of 105 × 68 m. Table 1 shows the duration of each session during a typical training week and the total number of observations across playing position. The team systematically played in a 4-3-3 formation, with two full backs (FB), two central defenders (CD), one midfielder (MD), two offensive midfielders (OMF) and three forwards (FW). A total of 490 individual observations were obtained across position: CD: n=3; GPS=104, FB: n=6; GPS=145, MF: n=3; GPS=45, OMF: n=5; GPS=121 and forwards FW: n=7; GPS=90.

Subjects

Twenty-four professional outfield football players participated in this study (age; 20 ± 2 years, body mass; 70.2 ± 6.1 kg, and stature; 1.78 ± 0.64 m; all measurements mean ± *SD*). Players belonged to a reserve squad of a Spanish La Liga club that also competed in the Union of European Football Associations (UEFA) Champions League. Data arose as a condition of the players' employment, whereby they were assessed daily; thus, no authorization was required from an institutional ethics committee (16,32,45). Nevertheless, this study conformed to the Declaration of Helsinki, and the players provided informed consent before participating.

Table 1. The duration and total number of files across different positions and sessions.*

Session	Duration (h:min)	CD	FB	MF	OMF	FW	Total files
MD + 1C	1:15 ± 0:11	9	11	2	19	5	46
MD + 1R	1:08 ± 0:07	12	18	7	5	10	52
MD-4	1:17 ± 0:09	21	29	9	24	15	98
MD-3	1:23 ± 0:11	21	29	9	24	15	98
MD-2	1:20 ± 0:10	20	29	9	25	15	98
MD-1	1:01 ± 0:12	21	29	9	24	15	98

*Data are presented across position: central defender (CD), full back (FB), midfielder (MF), offensive midfielder (OMF), forward (FW), and total number of files for all positions combined. Data are also present across training day: MD + 1C = match day +1 compensatory; MD + 1R = match day +1 recovery; MD-4 = match day-4; MD-3 = match day-3; MD-2 = match day-2; MD-1 = match day-1. Data are mean ± *SD*.

Procedures

Structured Microcycle. The microcycle was adjusted to the players' schedule, physical recovery status, and conditioning requirements. The programming of the football content was typically cyclical, but the external load was varied based on the factors above and the objectives of each seasonal phase. To optimize adaptation across the various phases of the season, staff constantly altered the structure and composition of the microcycle, so that the individual and collective performances were not impacted. Because of variations in the number of days between matches (40,43), this study only analyzed training weeks where players had 6 days between successive matches, and the training week composed of 5 training sessions that had a clear focus on an upcoming match (35). Based on the recommendations of Akenhead et al. (3), training load data were analyzed with respect to the number of days before or after a match (MD minus or plus). The training sessions that are contextualized below were composed of integrated content (e.g., tactical, technical, and physical factors were amalgamated):

MD + 1 was the session the day after competition where players split into 2 training groups. The first group included players who had completed >60 minutes of competition. The aim of this session was to regenerate from the previous match, so the recovery term was used: MD + 1R. Players conducted low-impact activity combined with regeneration exercises. The second group included players who had completed <60 minutes of competition. This group worked within a technical circuit followed by a positional game and a small-sided game (SSG) with goalkeepers (area: 30–60 m^{-2} per player). This session attempted to replicate competition loads, so the compensatory term was used: MD + 1C. MD-4 was the session 4 days before competition and aimed to develop the players' strength and power capabilities. This consisted of a gym workout followed by positional games and an SSG with goalkeepers (area: 25–50 m^{-2} per player). MD-3 was the session 3 days before competition and aimed to tactically prepare players for the next match. The structure consisted of a moderate-intensity positional game (area: 70–100 m^{-2}) and concluded with a 11 vs. 11 match (72 × 65 m). MD-2 was the session 2 days before competition. The load was focused on technical-tactical elements. The structure of the session was as follows: control and passing sequences, a positional game with a low number of players per team, and tactical exercises. MD-1 was the session before competition and was primarily geared toward activation drills replicating the tactical competition scenarios and concluded with set pieces.

External Load Variables. Activity profiles of players were monitored during each match and training session using a portable 10-Hz GPS unit (Viper Pod, 50 gr, 88 × 33 mm; Statsports Viper; Northern Ireland). Each unit was placed in a specially designed vest, inside a mini pocket positioned between the shoulder blades. Quantifying the devices' accuracy indicated a 2.5% estimation error in distance covered, with accuracy improving as the distance covered increased and the speed of movement decreased (8). To avoid interunit error, each player used the same device during the study period (13,18). On completion of each match and session, GPS data were extracted using proprietary software (Viper, Statsports). The total (TD; m), high-speed running (HSR; m > 19.8 $km \cdot h^{-1}$), and sprint distances (SPR; m > 25.2 $km \cdot h^{-1}$) were quantified. The speed thresholds used have been established based on previous studies (40,42,44). The following variables were also quantified: the number of intense accelerations/decelerations (ACC/DEC; >3 $m \cdot s^{-2}$), average metabolic power (AMP; $W \cdot kg^{-1}$), and high metabolic load distance (HMLD; m > 25.5 $W \cdot kg^{-1}$). The intensity thresholds used have been established based on previous studies (42). Average metabolic power was the energy expended by a player per second, per kg of body mass (20,36,39) and HMLD represented the distance covered by a player when their metabolic power exceeded 25.5 $W \cdot kg^{-1}$. The mean value of each training session was expressed in absolute values and relative to the mean external load registered during competitive matches: (mean training session external load × 100) ÷ mean competitive-match external load.

Statistical Analyses

All statistical analyses were conducted using SPSS for Windows 16.0 (SPSS, Inc., Chicago, USA). Homogeneity of variance was examined by conducting the Levene's test. One-way analyses of variance were used to evaluate differences in dependent variables across various periods of the microcycle and playing positions. In the event of a difference occurring, Bonferroni post hoc tests were used to identify any localized effects, or a Dunnett's T3 post hoc tests were applied when variances were not homogeneous. Effect sizes (ES) were calculated to determine meaningful differences. Magnitudes of difference were classed as trivial (<0.2), small (>0.2–0.6), moderate (>0.6–1.2), large (>1.2–2.0), and very large (>2.0–4.0) (7). The coefficient of variation (CV) was quantified to assess the variation in the microcycle (5). Values are presented as mean ± *SD* unless otherwise stated. Alpha was set at $p < 0.05$.

Results

Absolute Training Load Analysis

Table 2 presents the absolute external load values obtained from each training sessions across playing position. When comparing the 2 training groups on the day after competition, MD + 1C demonstrated greater external loads than MD + 1R for TD, HMLD, AMP, ACC, and DEC ($p <$ 0.05; ES: 1.4–1.6) but not for the distance covered in HSR or SPR ($p > 0.05$; ES: 0.1–0.2). External load in MD-4 to MD-1 declined as competition approached ($p < 0.01$) for TD (ES: 1.2–3.1), HSR (ES: 1.4–1.8), SPR (ES: 0.4–1.1), HMLD (ES: 1.5–3.0), AMP (ES: 1.5–3.0), ACC (ES: 0.7–

TABLE 2. Absolute training load metrics for professional soccer players.*

Variable	Position	MD + 1C	MD + 1R	MD-4	MD-3	MD-2	MD-1
TD (m)	CD	5,207.8 ± 618.5*,↑,♠	3,574.4 ± 1,154.4	4,769.6 ± 565.7↑,♠	5,463.4 ± 1,297*,↑,♠	4,084.8 ± 569.1	2,725.4 ± 512.3
	FB	5,383.4 ± 742.5*,↑,♠	4,227.6 ± 971.4♠	5,149.2 ± 803.5*,↑,♠	5,632.5 ± 1,162.6*,↑,♠	4,423.4 ± 680.5e	2,737.3 ± 580.7
	MF	5,412.8 ± 736.9♠	3,900.8 ± 868.9	5,510.7 ± 1,149.1*,↑,♠	5,828.5 ± 1,060.6*,↑,♠	4,207.0 ± 399.6	2,842.8 ± 376.2
	OMF	5,255.3 ± 915.5↑,♠	4,248.6 ± 971.8♠	5,472.4 ± 1,089.7↑,♠	5,726.3 ± 1,451.7↑,♠	4,327.9 ± 664.3♠	2,667.6 ± 694.6
	FW	4,727.4 ± 757.1*,♠	3,143.6 ± 1,054.8	4,874.1 ± 854.2*,↑,♠	5,407.6 ± 854*,↑,♠	3,838.9 ± 403.5♠	2,396.8 ± 687.5
	ALL	5,226.1 ± 790.2*,↑,♠	3,826.5 ± 1,068.9♠	5,123.2 ± 904.5*,↑,♠	5,602.8 ± 1,205.7*,↑,♠	4,220.6 ± 620.2♠	2,675.3 ± 601.7
HSR (m)	CD	122.6 ± 111.2	136.7 ± 112.9	216.5 ± 119.7↑,♠	154.5 ± 106.1↑,♠	57.8 ± 59.5	43.4 ± 45.7
	FB	192.9 ± 137.7	191.8 ± 141.0e,♠	371.2 ± 153.2a,c, d,e,Δ,*,↑,♠	278.4 ± 125.3a,c,↑,♠	133.7 ± 91.8a,c,e	64.6 ± 70.6
	MF	34.8 ± 2.1	84.83 ± 107.4	170.9 ± 75.9Δ,↑,♠	145.8 ± 71.2Δ,♠	51.5 ± 51.8	25.1 ± 27.4
	OMF	131.5 ± 112.8	102.7 ± 84.4	189.9 ± 102.8↑,♠	198.1 ± 100.1↑,♠	81.1 ± 58.3	49.7 ± 59.7
	FW	106.6 ± 103.7	30.2 ± 40.0	177.4 ± 130.7*,↑,♠	263.5 ± 102.9a,Δ,*,↑,♠	68.4 ± 43.4	45.9 ± 47.6
	ALL	106.7 ± 103.7♠	125.0 ± 123.3♠	245.6 ± 148.6Δ,*,↑,♠	217.7 ± 118.5Δ,*,↑,♠	87.3 ± 73.9♠	49.9 ± 56.9
SPR (m)	CD	13.7 ± 26.3	14.8 ± 24.2	53.4 ± 52.5c,♠	25.5 ± 34.2	11.3 ± 36.2	6.3 ± 15.6
	FB	41.1 ± 54.9	37.3 ± 51.1	104.6 ± 61.8a,c, d,e,*,⊕,↑,♠	55.9 ± 46.1c,d,♠	23.7 ± 37.9	13.4 ± 21.5
	MF	0.4 ± 0.5	17.6 ± 31.5	10.3 ± 10.1	17.1 ± 21.5	6.7 ± 11.7	0.0 ± 0.0
	OMF	26.3 ± 47.2	9.6 ± 19.6	27.5 ± 33.2↑	17.7 ± 21.1	4.4 ± 9.2	7.7 ± 21.3
	FW	20.7 ± 42.4	4.2 ± 9.4	38.3 ± 56.9	40.7 ± 35.4*,↑,♠	6.7 ± 8.8	5.9 ± 14.7
	ALL	25.7 ± 44.3	20.5 ± 36.5	55.9 ± 59.6Δ,*,⊕,↑,♠	34.2 ± 37.9↑,♠	12.1 ± 27.9	8.1 ± 18.4
ACC (no)	CD	157.6 ± 45.9*,↑,♠	53.5 ± 40.4	122.2 ± 31.1*,♠	115.4 ± 36.4*,♠	96.2 ± 22.7	60.4 ± 15.4
	FB	167.1 ± 58.6*,♠	88.9 ± 47.5e	135.3 ± 40.5*,♠	129.3 ± 51.2*,♠	123.6 ± 46.0e*,♠	67.3 ± 23.5e
	MF	194.5 ± 23.3	54.6 ± 35.1	148.6 ± 45.2♠	127.1 ± 38.2↑,♠	106.6 ± 38.0	68.4 ± 18.8e
	OMF	127.0 ± 54.5♠	84.0 ± 46.1	127.0 ± 28.5♠	119.2 ± 44.2♠	100.8 ± 33.3♠	54.7 ± 24.1
	FW	114.6 ± 35.5*,♠	38.2 ± 39.8	111.5 ± 36.8*,♠	96.9 ± 33.9*,♠	81.7 ± 23.0*,♠	41.9 ± 18.1
	ALL	144.2 ± 54.3*,↑,♠	65.9 ± 46.0	128.1 ± 36.5*,↑,♠	118.7 ± 43.5*,♠	104.2 ± 37.3*,♠	58.9 ± 22.4
DEC (no)	CD	150.9 ± 35.4*,!,⊕,↑,♠	42.5 ± 31.1	104.4 ± 24.3*,♠	97.8 ± 35.1*,♠	84.7 ± 23.4*,♠	56.6 ± 13.8
	FB	157.1 ± 61.4*,♠	85.9 ± 45.6e	125.8 ± 35.5a,*,♠	123.3 ± 46.2♠	119.3 ± 41.8a,e,♠	65.2 ± 22.2e
	MF	180.0 ± 7.1*,♠	58.6 ± 37.5	131.6 ± 45.5*,♠	108.2 ± 28.1	103.2 ± 41.9	66.3 ± 18.3
	OMF	119.7 ± 47.1♠	66.8 ± 42.9	116.0 ± 28.3♠	107.9 ± 58.9♠	95.9 ± 33.3♠	52.6 ± 21.8
	FW	112.4 ± 28.5*,♠	36.2 ± 41.5	100.3 ± 27.5*,♠	92.9 ± 27.7*,♠	80.3 ± 25.5*,♠	42.7 ± 18.5
	ALL	136.6 ± 49.3*,⊕,↑,♠	60.8 ± 44.0	115.4 ± 32.8*,↑,♠	108.0 ± 40.9*,♠	98.8 ± 36.5*,♠	56.9 ± 20.9

*Data are presented across position: (A) central defender (CD), (B) full back (FB), (C) midfielder (MF), (D) offensive midfielder (OMF), (E) forward (FW), and (F) for all positions combined (ALL). TD = total distance; HSR = high-speed running (>19.8 $km\cdot h^{-1}$); SPR = sprint (>25.2 $km\cdot h^{-1}$); ACC = accelerations (>3 $m\cdot s^2$); DEC = decelerations (<−3 $m\cdot s^2$). Data are mean ± *SD*.

a > CD; b > FB; c > MF; d > OMF; e > FW; $p < 0.05$.

Δ > MD + 1C; * > MD + 1R; ! > MD-4; ⊕ > MD-3; ↑ > MD-2; ♠ > MD-1; $p < 0.05$.

2.3), and DEC (ES: 0.5–2.1). Limited positional differences were evident for TD across the microcycle, with the exception of FB loading higher in MD-2 compared with FW ($p < 0.05$; ES: 1.0). Similarly, FB also covered more distance in HSR compared with other positions at MD-4, MD-3, and MD-2 ($p < 0.05$; ES: 0.8–1.3) and distance SPR at MD-4 and MD-3 ($p < 0.05$; ES: 0.9–1.7). Differences were evident between FB vs. CD and FW at MD-4 and MD-2 for the variable HMLD ($p < 0.05$; ES: 0.9–1.2). Lower values for AMP were found for FW at MD-2 compared with FB, in addition to CD and FB at MD-1 ($p < 0.05$; ES: 0.9–1.1). Full back produced more ACC than FW at MD-1 ($p < 0.01$; ES: 1.1) and DEC in MD-4, MD-2, and MD-1 compared with CD and FW ($p < 0.05$; ES: 0.7–1.1). The CV for absolute training load values was highly associated with the training session, load metric, and playing position. For instance, the CV for weekly training sessions ranged from 41 to 45% when averaged across all load metrics and positions in MD-3 and MD-4 to 79% for MD + 1R. Similarly, the CV for weekly external training load metrics when averaged across all training sessions and positions ranged from 19 to 20% for TD and AMP to >85% for the distance covered in HSR and SPR. The CV across weekly external training load metrics and sessions ranged from 49% for FB to 62% for FW.

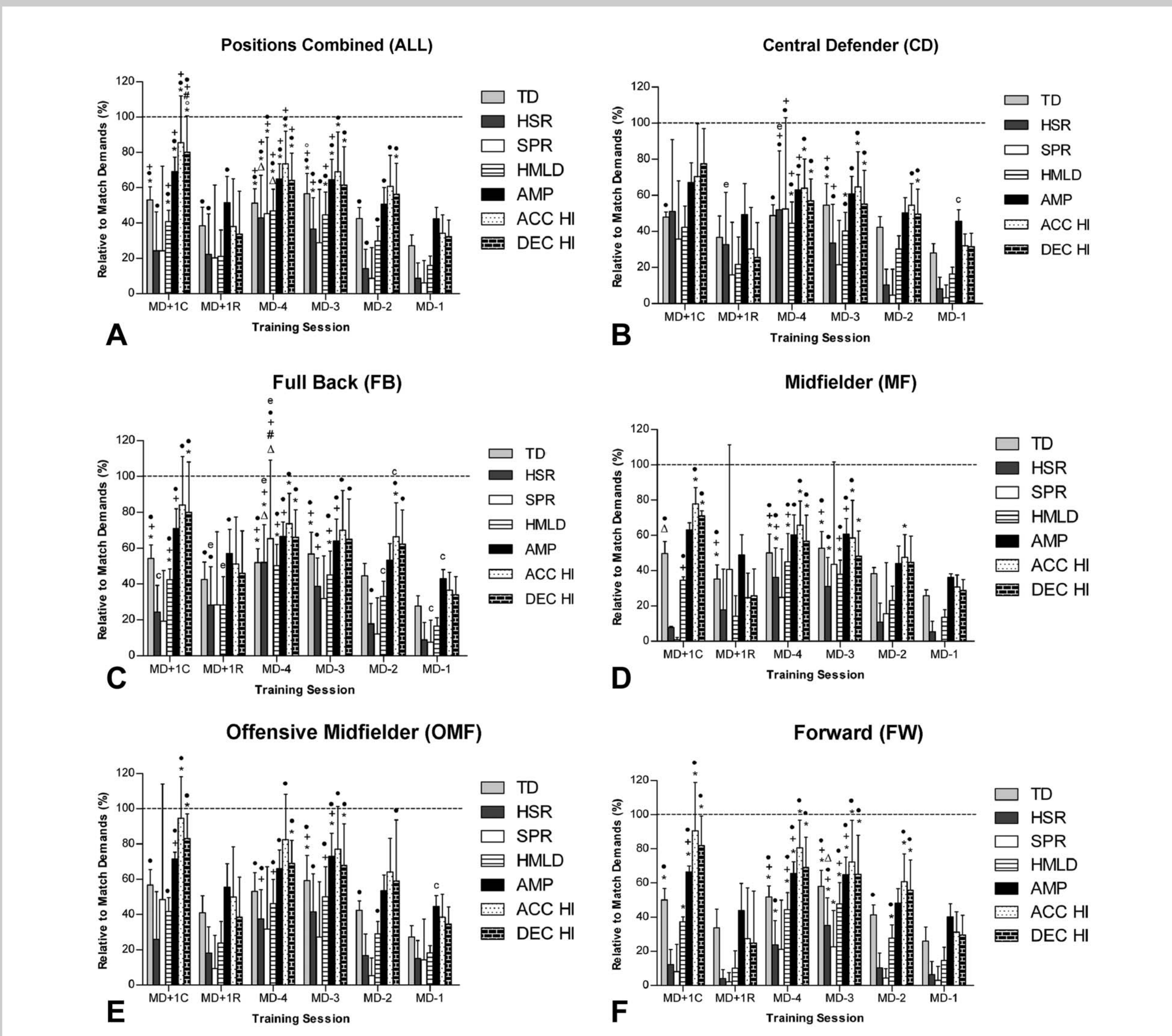

Figure 1. Training load metrics for professional players relative to competitive match play. Data are presented across position: (A) positions combined (all), (B) central defender (CD), (C) full back (FB), (D) midfielder (MF), (E) offensive midfielder (OMF), and (F) forward (FW). TD = total distance; HSR = high-speed running (>19.8 km·h^{-1}); SPR = sprint (>25.2 km·h^{-1}); HMLD = high metabolic load distance; AMP = average metabolic power; ACC = accelerations (>3 m·s^2); DEC = decelerations (<−3 m·s^2); and MD = match day. Data are mean ± *SD*. a > CD; b > FB; c > MF; d > OMF; e > FW; $p < 0.05$. Δ > MD + 1C; * > MD + 1R; ° > MD-4; # > MD-3; + > MD-2; • > MD-1; $p < 0.05$.

Relative Training Load Analysis

Figure 1A–F present the training load metrics relative to match play and across playing position. A multitude of external load metrics in MD + 1C were found to exceed 50% of match play values, and these included TD (53%), AMP (69%), ACC (86%), and DEC (80%; Figure 1A). The TD (57%) in MD-3 most resembled match values, but lower values were found for HSR (37%) and SPR (29%). The session that produced the greatest HSR (43%) and SPR (45%) distances relative to competition was MD-4 (Figure 1A). Moreover, the frequency of DEC and ACC bouts during training exceeded 50% of that performed in matches in MD + 1C (80–86%), MD-4 (71–72%), MD-3 (62–69%), and MD-2 (56–61%). Full back covered more SPR distance relative to match play at MD-4 (65%), and this was different to FW (21%; $p < 0.01$; ES: 1.1; Figure 1C, F). Similarly, FB also demonstrated the highest relative load values for HMLD (33%) at MD-2 compared with other positions (23–29%, $p < 0.05$ ES: 0.9–1.2). Differences were also evident at MD-1 for AMP between CD, FB, and OMF (43–46%) vs. MF (36%; $p < 0.01$; ES: 1.5–1.7; Figure 1B–F). The CV for training loads relative to match play was highly associated with the training session, load metric, and playing position. For instance, the CV for weekly training sessions ranged from 37 to 41% when averaged across all load metrics and positions in MD-3 and MD-4 to 82% for MD + 1R. Similarly, the CV for weekly external training load metrics when averaged across all training sessions and positions ranged from 18 to 19% for TD and AMP to >80% for HSR and SPR. The CV across weekly external training load metrics and sessions ranged from 46% for FB to 61% for FW.

Discussion

The aims of this study were to (a) determine the external load of a football team across playing position and relative to competition for a structured microcycle and (b) examine the loading and variation the day after competition for players with or without game time. A novel aspect of this study was the marked difference in load at MD + 1 between players completing the majority of the game (>60 minutes) vs. players with partial or no game time (<60 minutes). Although Stevens et al. (43) demonstrated that the load of nonstarter sessions was generally lower than regular training, this study failed to provide a practical solution. This is a pertinent point because intermittent running capacity of starters can be ~40% better than nonstarters (46); thus, strategies to maintain the physiological capacities of nonstarters would be a welcome addition to the literature. This study found players without game time undertook a training session that tried to replicate competition loads (MD + 1C), while players with game time completed a recovery session instead (MD + 1R). As a competitive match has been found to be an important stimulus for power development in starters vs. nonstarters (38), MD + 1C may offset reductions in this component, as it produced the highest ACC/DEC load of the microcycle. The elevated load for MD + 1C could be attributed to the small number of players used in this session, which results in an increase in the number of ball touches, dribbles, and duels (41). Although the SSG approach used in MD + 1C elevated TD, HMLD, AMP, ACC, and DEC (exceeds 50% of match play in all these metrics) in players with limited game time, it did not develop HSR and SPR qualities. Ade et al. (2) found that running-based drills elevated HSR and SPR compared with SSG drills, but the latter produced more ACC and DEC. Thus, future research should implement a mixed strategy of SSG and running-based drills to establish if this provides the best training stimulus for players with limited game time.

Another major finding of this study was that training loads were greatest 4 days before matches (MD-4) with selected metrics approaching competition loads. Interestingly, these studies' training time for MD-4 was ~12 minutes lower than that reported within the literature (43). Moreover, metrics such as TD, HSR, SPR, and ACC also differed substantially from those reported by others across various stages of the training week (43). This is probably because of variations in the competitive standards of players and the training methodologies used across studies. But despite these possible differences in the training methodology, this study still found that the central component of the microcycle produced the greatest load, resulting in a marked difference from MD-2 and MD-1, a finding supported by a plethora of literature (3,40,43). Varying training parameters in this way seems to be the preferred practice for attempting to optimize physiological adaptations and the performance of elite players (28,30,40). This was very evident when observing the CV for weekly training sessions, as this ranged ~40% for players when averaged across all metrics and positions in MD-3 and MD-4. Although these are the most intense sessions within the microcycle, whereby players are expected to produce repeated intense efforts, variation was still present, as the coaches constantly adjusted sessions because of the players' schedule, physical recovery status, and conditioning requirements for that week. Moreover, HSR and SPR distances are the metrics illustrating the most variability within the microcycle (>80%), which is consistent with the variability found in SSG formats (60–140%) (2) but lower than competition variability (20–30%) (14,16). The large variability in load across sessions and metrics seems to be a combination of the inherent unpredictable nature of game-based training and the strategies used by coaches to vary the stimulus for players to create training adaptations.

The tactical role of a player seems to be a powerful determinant of their match physical performance, so it is imperative that the conditioning stimulus has a positional element to it (15,17,21). In this study, the distance covered in HSR and SPR for MD-4 and MD-3 clearly demonstrated positional variation, whereby FB produced the greatest load and the lowest CV within the microcycle. This would be advantageous for FB to enable them to cope with modern game requirements because they cover a greater proportion of HSR and SPR in activities such as running the channel and overlapping than other positions (9). Moreover, HSR and SPR distance by FB has increased by ~40% in European leagues in the past decade (6), as a dual role requires them to be defensive out of possession but conduct offensive in possession actions such as overlapping to cross. Similarly, FW and OMF demonstrated ACC and DEC loads in MD-4 and MD-3 that were closest to competition values. Both of these offensive positions are expected to ACC and DEC rapidly while dribbling, running in behind, and breaking into the box, which are activities to exploit space to score and create opportunities for teammates (9). Thus, it seems that the positional stimulus at MD-4 and MD-3 is particularly preparing FB, FW, and OMF for their distinct tactical roles.

In this study, all metrics decreased progressively on the days before competition, particularly in MD-2 and MD-1. Numerous studies using an English Premier League sample have reported similar trends, particularly demonstrating that MD-1 has the lowest load (3,4,35). However, some differences do exist across studies for various training days highlighting the need to document load data from other European leagues. The consistent finding of a drop in MD-1 clearly indicates a tapering strategy, whereby coaches reduce training volume and intensity when competition approaches (40). However, most studies have failed to provide any specific context associated with each training day, and this has limited the application of such data. As this study contextualized each training day, the decline in load as competition approached was related to players moving from intense positional drills and SSG in MD-4 to low-load activation drills and set pieces in MD-1. From a positional perspective at MD-1, FW differed from CD, FB, and MF for metrics such as AMP, ACC, and DEC. Given that these data were contextualized, it was evident that the FW's activation and set piece work were geared toward finishing and efforts on goal, which are primarily technical and tactical in nature. Although activation and set piece work for CD, FB, and MF typically involved running-based activities with some attacking and defensive situations added to replicate match scenarios, future research should attempt to further contextualize match loads, so that applied staff can visualize where the load of each day comes from (e.g., 70% of ACC load in MD-3 was from SSG's) and how the tactical and technical components modulate effort and impact injuries.

In summary, this study demonstrated that (a) the compensatory session (MD + 1C) was more intense than the recovery session (MD + 1R) the day after competition, (b) loads were greatest 4 days before matches (MD-4) with selected metrics approaching competition loads, (c) the external load of the microcycle varied substantially based on the players tactical role in the team, and (d) the CV for weekly training sessions was generally large across all elements of the microcycle. This information could be useful for applied sports scientists when trying to systematically manage load, particularly compensatory conditioning for players without game time.

Practical Applications

Gaining knowledge of external training loads relative to the game is important for applied practitioners, particularly when attempting to optimize position-specific loads. For instance, applying a similar HSR load to FB and MF could potentially lead to overloading the latter position and underloading the former position. Such discrepancies in load across position could impact competition performances and increase the risk of injury. Thus, quantifying loads relative to competition demands could be an advantageous strategy that coaches use within their training periodization models. As competitive match play is an important stimulus for developing the physiological capacities of players regularly completing games, it is imperative that practical strategies are implemented to offset any reductions in the fitness of players getting limited game time. Thus, MD + 1 could be an ideal day to compensate for the reduced competition load in players with limited game time, in addition to the elevated stimulus within MD-4 and MD-3 of the microcycle.

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References

1. Abbott, W, Brickley, G, Smeeton, and Nicholas, J. Positional differences in GPS outputs and perceived exertion during soccer training games and competition. *J Strength Cond Res*, 2018. Epub ahead of print.
2. Ade, J, Harley, J, and Bradley, PS. The physiological response, time-motion characteristics and reproducibility of various speed endurance drills in elite youth soccer players: Small sided games vs generic running. *Int J Sports Physiol Perform* 9: 471–479, 2014.
3. Akenhead, R, Harley, JA, and Tweddle, SP. Examining the external training load of an English Premier League football team with special reference to acceleration. *J Strength Cond Res* 30: 2424–2432, 2016.
4. Anderson, L, Orme, P, Di Michele, R, Close, GL, Morgans, R, Drust, B, et al. Quantification of training load during one-, two-and three-game week schedules in professional soccer players from the English Premier League: Implications for carbohydrate periodisation. *J Sport Sci* 34: 1250–1259, 2016.
5. Atkinson, G and Nevill, AM. Statistical methods for assessing measurement error (reliability) in variables relevant to sports medicine. *Sports Med* 26: 217–238, 1998.
6. Barnes, C, Archer, DT, Hogg, B, Bush, M, and Bradley, PS. The evolution of physical and technical performance parameters in the English Premier League. *Int J Sports Med* 35: 1095–1100, 2014.
7. Batterham, AM and Hopkins, WG. Making meaningful inferences about magnitudes. *Int J Sports Physiol Perform* 1: 50–57, 2006.
8. Beato, M, Bartolini, D, Ghia, G, and Zamparo, P. Accuracy of a 10 Hz GPS unit in measuring shuttle velocity performed at different speeds and distances (5–20 M). *J Hum Kinet* 54: 15–22, 2016.

9. Bradley, PS and Ade, JD. Are current physical match performance metrics in elite soccer fit for purpose or is the adoption of an integrated approach needed? *Int J Sports Physiol Perform* 13: 656–664 2018.
10. Bradley, PS, Mascio, MD, Mohr, M, Fransson, D, Wells, C, Moreira, A, et al. Can modern trends in elite football match demands be translated into novel training and testing modes? *Aspertar Sports Med J* 7: 46–52, 2018.
11. Bradley, PS, Sheldon, W, Wooster, B, Olsen, P, Boanas, P, and Krustrup, P. High-intensity running in English FA Premier League soccer matches. *J Sport Sci* 27: 159–168, 2009.
12. Buchheit, M and Simpson, BM. Player-tracking technology: Half-full or half-empty glass? *Int J Sports Physiol Perform* 12: S2–S35, 2017.
13. Buchheit, M, Simpson, B, and Mendez-Villanueva, A. Repeated high-speed activities during youth soccer games in relation to changes in maximal sprinting and aerobic speeds. *Int J Sports Med* 34: 40–48, 2013.
14. Bush, MD, Archer, DT, Hogg, R, and Bradley, PS. Factors influencing physical and technical variability in the English Premier League. *Int J Sports Physiol Perform* 10: 865–872, 2015.
15. Carling, C. Interpreting physical performance in professional soccer match-play: Should we be more pragmatic in our approach? *Sports Med* 43: 655–663, 2013.
16. Carling, C, Bradley, PS, McCall, A, and Dupont, G. Match-to-match variability in high-speed running activity in a professional soccer team. *J Sports Sci* 34: 2215–2223, 2016.
17. Castellano, J, Alvarez-Pastor, D, and Bradley, PS. Evaluation of research using computerised tracking systems (Amisco and Prozone) to analyse physical performance in elite soccer: A systematic review. *Sports Med* 44: 701–712, 2014.
18. Castellano, J, Casamichana, D, Calleja-González, J, San Román, J, and Ostojic, SM. Reliability and accuracy of 10 Hz GPS devices for short-distance exercise. *J Sports Sci Med* 10: 233, 2011.
19. Coutts, A, Reaburn, P, Piva, TJ, and Murphy, A. Changes in selected biochemical, muscular strength, power, and endurance measures during deliberate overreaching and tapering in rugby league players. *Int J Sports Med* 28: 116–124, 2007.
20. di Prampero, PE, Fusi, S, Sepulcri, L, Morin, JB, Belli, A, and Antonutto, G. Sprint running: A new energetic approach. *J Exp Biol* 208: 2809–2816, 2005.
21. Di Salvo, V, Baron, R, Tschan, H, Montero, FC, Bachl, N, and Pigozzi, F. Performance characteristics according to playing position in elite soccer. *Int J Sports Med* 28: 222–227, 2007.
22. Drew, MK and Finch, CF. The relationship between training load and injury, illness and soreness: A systematic and literature review. *Sports Med* 46: 861–883, 2016.
23. Fessi, MS, Zarrouk, N, Di Salvo, V, Filetti, C, Barker, AR, and Moalla, W. Effects of tapering on physical match activities in professional soccer players. *J Sport Sci* 34: 2189–2194, 2016.
24. Fransson, D, Nielsen, TS, Olsson, K, Christensson, T, Bradley, PS, Fatouros, IG, et al. Skeletal muscle and performance adaptations to high-intensity training in elite male soccer players: Speed endurance runs versus small-sided game training. *Eur J Appl Physiol* 118: 111–121, 2017.
25. Gabbett, TJ, Kennelly, S, Sheehan, J, Hawkins, R, Milsom, J, King, E, et al. If overuse injury is a "training load error," should undertraining be viewed the same way? *Br J Sports Med Bjsports* 50: 1017–1018, 2016.
26. Gabbett, TJ and Whiteley, R. Two training-load paradoxes: Can we work harder and smarter, can physical preparation and medical be teammates? *Int J Sports Physiol Perform* 12: S2–S50, 2017.
27. Gaudino, P, Iaia, FM, Strudwick, AJ, Hawkins, RD, Alberti, G, Atkinson, G, et al. Factors influencing perception of effort (session rating of perceived exertion) during elite soccer training. *Int J Sports Physiol Perform* 10: 860–864, 2015.
28. Impellizzeri, FM, Rampinini, E, Coutts, AJ, Sassi, AL, and Marcora, SM. Use of RPE-based training load in soccer. *Med Sci Sports Exerc* 36: 1042–1047, 2004.
29. Issurin, VB. New horizons for the methodology and physiology of training periodization. *Sports Med* 40: 189–206, 2010.
30. Kelly, VG and Coutts, AJ. Planning and monitoring training loads during the competition phase in team sports. *Strength Cond J* 29: 32, 2007.
31. Krustrup, P, Mohr, M, Ellingsgaard, HE, and Bangsbo, J. Physical demands during an elite female soccer game: Importance of training status. *Med Sci Sports Exerc* 37: 1242–1248, 2005.
32. Lacome, M, Simpson, BM, Cholley, Y, Lambert, P, and Buchheit, M. Small-sided games in elite soccer: Does one size fits all? *Int J Sports Physiol Perform* 13 :568–576, 2018.
33. Mallo, J and Dellal, A. Injury risk in professional football players with special reference to the playing position and training periodization. *J Sports Med Phys Fitness* 52: 631–638, 2012.
34. Mallo, J, Mena, E, Nevado, F, and Paredes, V. Physical demands of top-class soccer friendly matches in relation to a playing position using global positioning system technology. *J Hum Kinet* 47: 179–188, 2015.
35. Malone, JJ, Di Michele, R, Morgans, R, Burgess, D, Morton, JP, and Drust, B. Seasonal training-load quantification in elite English premier league soccer players. *Int J Sports Physiol Perform* 10: 489–497, 2015.
36. Malone, JJ, Lovell, R, Varley, MC, and Coutts, AJ. Unpacking the black box: Applications and considerations for using GPS devices in sport. *Int J Sports Physiol Perform* 12: S2–S18, 2017.
37. Mohr, M, Krustrup, P, Andersson, H, Kirkendal, D, and Bangsbo, J. Match activities of elite women soccer players at different performance levels. *J Strength Cond Res* 22: 341–349, 2008.
38. Morgans, R, Di Michele, R, and Drust, B. Soccer match play as an important component of the power-training stimulus in Premier League players. *Int J Sports Physiol Perform* 20: 1–3, 2017.
39. Osgnach, C, Poser, S, Bernardini, R, Rinaldo, R, and Di Prampero, PE. Energy cost and metabolic power in elite soccer: A new match analysis approach. *Med Sci Sports Exerc* 42: 170–178, 2010.
40. Owen, AL, Djaoui, L, Newton, M, Malone, S, and Mendes, B. A contemporary multi-modal mechanical approach to training monitoring in elite professional soccer. *Sci Med Football* 1: 216–221, 2017.
41. Owen, AL, Wong, DP, McKenna, M, and Dellal, A. Heart rate responses and technical comparison between small-vs. large-sided games in elite professional soccer. *J Strength Cond Res* 28: 2104–2110, 2011.
42. Rampinini, E, Alberti, G, Fiorenza, M, Riggio, M, Sassi, R, Borges, T, et al. Accuracy of GPS devices for measuring high-intensity running in field-based team sports. *Int J Sports Med* 36: 49–53, 2015.
43. Stevens, TG, de Ruiter, CJ, Twisk, JW, Savelsbergh, GJ, and Beek, PJ. Quantification of in-season training load relative to match load in professional Dutch Eredivisie football players. *Sci Med Football* 1: 117–125, 2017.
44. Tierney, PJ, Young, A, Clarke, ND, and Duncan, MJ. Match play demands of 11 versus 11 professional football using Global Positioning System tracking: Variations across common playing formations. *Hum Mov Sci* 49: 1–8, 2016.
45. Winter, EM and Maughan, RJ. Requirements for ethics approvals. *J Sports Sci* 27: 985, 2009.
46. Young, WB, Newton, RU, Doyle, TLA, Chapman, D, Cormack, S, Stewart, C, et al. Physiological and anthropometric characteristics of starters and non-starters and playing positions in elite Australian Rules Football: A case study. *J Sci Med Sport* 8: 333–345, 2005.

Capítulo 5

Estudio III: Positional demands for various-sided games with goalkeepers according to the most demanding passages of match play in football.

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Positional demands for various-sided games with goalkeepers according to the most demanding passages of match play in football

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ABSTRACT: The main aim was to determine the differences between four training games and competitive matches (CM) according to position and compared to the most demanding passages (MDP) of competitive match play. Global Positioning System data were obtained from 21 football players belonging to the reserve squad of a Spanish La Liga club during the 2015/16 season. The training games were small-sided games (SSGs) with 5 and 6 and large-sided games with 9 and 10 outfield players per team. The players were categorized based on positional groups: full back (FB), central defender (CD), midfielder (MF), offensive midfielder (OMF), and forward (FW). The variables recorded were the distance covered (DIS), DIS at high speed (HSR; >19.8 km·h^{-1}), DIS at sprint (SPR; >25.2 km·h^{-1}), high metabolic load distance (HMLD; >25.5 W·kg^{-1}) all in m·min^{-1}, average metabolic power (AMP; W·kg^{-1}) and number of high-intensity accelerations (ACC; >3 m·s^{-2}) and decelerations (DEC; <-3 m·s^{-2}), both in n·min^{-1}. The MDP was analysed using a rolling average method for AMP as a criterion variable, where maximal values were calculated for time windows of 5 and 10 minutes of CM and after that compared with the training game formats. As the SSG format increases, all the rest of the variables increase and the number of cases with significant interposition differences also increases (effect size [ES]: DIS: 0.7-2.2; HSR: 0.7-2.1; SPR: 0.8-1.4; HMLD: 0.9-2.0; AMP: 0.8-1.9; ACC: 0.8-1.7; DEC: 0.5-1.7). The large-sided game 10v10 + 2 goalkeepers over-stimulates sprint values relative to MDP (all: 121.0% of MDP, ES=0.5-1.8). This study provides useful information for coaching staff on the heightened impact of different training game formats on physical load, considering positional differences in relation to the MDP of competitive match play.

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INTRODUCTION

Football is a sport with high-intensity episodes combined with long periods, approximately 70% of the total match time, in low-intensity ranges [1]. The total distance covered ranges between 9.5 and ~12 km in a competitive match [2-3], of which a distance between 220 and 1900 m is covered at high speed (~19.8 km·h^{-1}) while distances between 200 and 500 m are covered at sprint (~25.0 km·h^{-1}) [1-2-3]. In the course of the game the players change activity around 1400 times [4-5], which might entail accelerations and decelerations in some cases of high intensity (2.5 m·s^{-2}) between 50 and 100 times per game [3-6]. However, all these values are an average of the mean activity performed by a player in competition [9].

It is known that the intra- and inter-player variability of physical demand is high [7], especially to the extent that the speed ranges chosen for the analysis are higher due to contextual variables involved in games [8]. Then the average values usually used to describe the physical performance pattern of competing players may hide most demanding passages of play (MDP) that exceed these values [9] and which, if not addressed, might underestimate some periods of real competitive match (CM) intensity. To describe the MDP in competition in both rugby league [10] and football [11] a number of time windows have been proposed [12] for calculating the power law relationship [13], while the rolling average [14] is the best way to find the most intense periods of a CM. A number of variables have been used to describe this MDP in football such as m·min^{-1} [11-15], metabolic power and cumulative accelerations and decelerations [16]. However, to the authors' knowledge there are no research studies in which the MDP are analyzed considering several dependent variables simultaneously.

One of the advantages of various-sided training games is that they can be modified to adjust their load and intensity [17], something which might be considered when scheduling training sessions. The MDP have recently been compared with training game formats in football [11-15]. To do this, variables that describe displacement intensity (e.g. total distance or distance at high speed per minute) and mechanical work (AU per minute) in tasks played at 4v4, 6v6, 8v8 and 10v10 have been calculated. The study concluded that SSG formats over-stimulated musculoskeletal demand mechanical work variables with respect to the MDP in competition and under-stimulated the distance covered at high speed.

The existence of a positional profile in competition demands is not new [7]; the MDP are also specific to the position occupied by the player on the playing field [15-18]. Interest is growing [11] in learning whether, as in the case of competition, SSGs stimulate different positional groups in a particular way. Specifically, in this paper [11], the positional groups that were most and least overloaded during SSGs were central defender and midfielder respectively. However, due to their training applications, it would be handy to be able to describe the MDP using several variables simultaneously.

The main aim was to estimate the differences between four training game formats with goalkeepers and CM according to position-specific activity and duration compared to MDP using AMP as a criterion variable. This study might help coaches to learn whether proposed tasks underload, replicate or overload the requirements of the MDP of competitive match play, something which might be considered when scheduling training sessions.

MATERIALS AND METHODS

Participants

Data were collected for 21 football players (20.4 ± 1.2 years, 1.79 ± 0.06 m, 70.2 ± 6.5 kg) belonging to the reserve squad of a Spanish La Liga club. The players were grouped according to their playing position as central defender (CD: n=4), full back (FB: n=6), midfielder (MF: n=3), offensive midfielder (OMF: n=3), and forward (FW: n=5). Although ethics committee clearance was not required [19], prior to the commencement of the study all the subjects were informed of the aims and requirements of the research and the players gave their informed consent for participation in the research study. The study conformed nevertheless to the recommendations of the Declaration of Helsinki.

Design

GPS (Global Positioning System) data were collected during the 2015/16 competitive season to establish the position-specific demands of small-sided games, large-sided games and CM, expressing their demands relative to practice time ($m \cdot min^{-1}$ or $n \cdot min^{-1}$) and values relative to the MDP of competitive match play (% of MDP). For calculating the MDP, the time-window was 5 min for the small-sided games (SSG5: small-sided game 5v5 + 2 goalkeepers (Gks) and SSG6: small-sided game 6v6 + 1 joker + 2 goalkeepers) and 10 min for the large-sided games (LSG9: large-sided game 9v9 + 2 goalkeepers; LSG10 and CM); the time windows used are the usual ones for each game format. These data were drawn from the daily player monitoring in which player activities were routinely measured over the course of the season.

Based on the recommendations of Akenhead et al. [2], training load data were analysed with respect to the number of days before or after a match (MD minus or plus). The training sessions that are contextualized below were composed of integrated content (e.g. tactical, technical and physical factors were amalgamated): MD+1 was the session the day after the competition where players split into two training groups. The first group included players who had completed >60 min of competition. The aim of this session was to recover from the previous match, so the recovery term was used: MD+1R. Players conducted low-impact activity combined with recovery exercises. The second group included players who had completed <60 min of competition. This group worked within a technical circuit followed

TABLE 1. Number of records in each game format and competitive matches according to the players' position.

Player's position	SSG5	SSG6	LSG9	LSG10	Official match	Total
CD	10	9	27	34	42	122
FB	18	26	31	41	60	176
MF	12	13	22	24	40	111
OMF	8	10	20	23	34	95
FW	9	15	24	32	51	131
Total	57	73	124	154	227	635

CD = central defender; FB = full back; MF = midfielder; OMF = offensive midfielder; FW = forward; SSG5 = small-side game 5v5 + 2 goalkeepers; SSG6 = small-side game 6v6 + 1 joker + 2 goalkeepers; LSG9 = large-sided game 9v9 + 2 goalkeepers; LSG10 = large-sided game 10v10 + 2 goalkeepers.

by a positional game and a small-sided game (SSG) with goalkeepers (area: 30-60 m^2 per player). This session attempted to replicate competition loads, so the compensatory term was used: MD+1C. MD-4 was the session four days before the competition and aimed to develop the players' strength and power capabilities. This consisted of a gym workout followed by positional games and an SSG with goalkeepers (area: 25-50 m^2 per player). MD-3 was the session three days before the competition and aimed to tactically prepare players for the next match. The structure consisted of a moderate intensity positional game (area: 70-100 m^2) and concluded with an 11 v 11 match (72 × 65 m). MD-2 was the session two days before the competition. The load was focused on technical-tactical elements. The structure of the session was as follows: control and passing sequences, a positional game with a low number of players per team, and tactical exercises. MD-1 was the session before the competition and was primarily geared towards activation drills replicating the tactical competition scenarios and concluded with set pieces [20].

Data were collected throughout 37 CM (13 wins, 15 losses, and 9 draws). The team usually played in a 1-4-3-3 formation, with a Gk, two FBs, two CDs, one MF, two OMFs and three FWs. Only data from players who completed the 1st or 2nd half of the CM were analysed. Players with fewer than 6 full halves completed were not included in the analysis and nor were Gks.

Physical Variables

The variables recorded were the distance covered ($m \cdot min^{-1}$), distance covered at high speed running (HSR: >19.8 $km \cdot h^{-1}$, $m \cdot min^{-1}$); distance covered at sprinting (SPR: >25.2 $km \cdot h^{-1}$, $m \cdot min^{-1}$); the number of high-intensity accelerations and decelerations (ACC/DEC: > 3 $m \cdot s^{-2}$, $n \cdot min^{-1}$); the high metabolic load distance (HMLD: >25.5 $W \cdot kg^{-1}$, $m \cdot min^{-1}$); and the average metabolic power (AMP: $W \cdot kg^{-1}$); the intensity thresholds used were established based on previous studies [1-21-22-23].

Procedure

The activity profile of the players was monitored during each training game format and CM using a portable 10 Hz GPS unit (Viper Pod, 50 g, 88 x 33 mm, STATSports Viper, Northern Ireland) as used in previous studies [24-25]. The accuracy of these devices has been studied recently, with 2.53 ± 6.03% estimation error in distance covered, with accuracy (%) improving as the distance covered increases and the speed of movement decreases [26]. The GPS model used in this study was worn in a purpose-designed vest inside a mini pocket positioned in the centre area of the upper back, just above the shoulder blades, thus not affecting mobility of the upper limbs and torso. Upon completion of each training session and CM, GPS data were extracted using the appropriate proprietary software (Viper, STATSports, Northern Ireland).

In order to calculate the intensity of the four training game formats and CM in relation to the MDP of competitive match play, the moving average duration method was used with the AMP variable. AMP is based on energy expenditure by players. The measures combine the energy expenditure associated with constant speed activity as well as acceleration and deceleration activity [1-27]. This variable has been analysed as an indicator of metabolic expenditure in previous papers [28-29-30]. Given the possible limitations of this variable, Rampinini et al. [31] analysed the recording capacity of 10 Hz GPS units and found a strong correlation with the criterion device (laser device, standard error = 2.4 to 2.9%). Therefore, this metric is a precise measure for evaluating external demands in football where high-intensity random efforts occur at both high and low speeds [16]. STATSports software was then used for the computation of a moving average over the AMP variable using two different durations (5 and 10 min) and the maximum value for each duration was recorded. As a result, for each individual match the period with the highest AMP values was selected and analysed for each of the two moving average durations.

Training game formats and competitive matches

A total of 635 individual records (n= 408 for training game formats and n= 227 for CM) were obtained. The distribution of records in each training game format and CM for each of the positions is shown in Table 1.

Only the most standardized training game formats over the season were used for analysis: 1) SSG5: dimensions: 33 x 40 m, and duration: 05:39 ± 01:12 min:s; 2) SSG6: dimensions: 33 x 40 m, and duration: 05:57 ± 01:24 min:s; 3) LSG9: dimensions: 72 x 65 m, and duration: 12:03 ± 02:44 min:s; 4) LSG10: dimensions: 105 x 65 m, and duration: 10:41 ± 02:32 min:s. Training game formats were performed on a natural grass surface and the ball was always available by prompt replacement when out with the aim of maximizing effective playing time [32]. Analysed game formats were conducted in the final part of the sessions. SSG5 and SSG6 were performed in sessions MD + 1C and MD-4, while LSG9 and LSG10 were performed in MD-3. Training game formats included the offside rule. The demands were studied according to the position of the players during match play. Data from jokers and Gks were not included in the analysis. Pauses between repetitions in the training game formats were excluded.

The SSG5 and SSG6 were relativized to the values obtained in the MDP of the CM with the time window of 5 min, while the LSG9 and LSG10 were relativized through comparison with the time window of 10 min. Also, the average of CM was compared with the MDP of 10 min. Unlike previous studies [11], the determination of MDP made possible through the moving average duration method was not used in the various-sided games with goalkeepers studied.

Statistical analysis

The data are presented as means and standard deviations (mean ± SD). The homogeneity of variances was examined by means of Levene's test. The presence of significant differences among training game formats and CM was determined by means of a 2-tailed

TABLE 2. Relative values ± SD (in min^{-1}) of the variables in the game formats and competitive matches.

Variable	Position	SSG5	SSG6	LSG9	LSG10	Official Match	ES;p
DIS	CD	103.8 ± 8.7	98.9 ± 8.5	106.9 ± 9.5$^{\otimes}$	114.7 ± 7.7$^{*,\dagger,\Delta,\otimes}$	101.3 ± 5.8^{b}	ES: 0.9-2.0; p<0.001
	FB	110.9 ± 4.2^{b}	108.7 ± 9.2^{b,c}	112.5 ± 8.2$^{\otimes}$	119.1 ± 7.7$^{*,\dagger,\Delta,\otimes}$	105.0 ± 5.9^{b}	ES: 0.8-2.1; p<0.001
	MF	109.0 ± 5.8	98.3± 12.1	117.8 ± 12.8^{a,b,†}	126.0 ± 9.5$^{a,b,e*,\dagger,\otimes}$	114.8 ± 7.5^{a,b,e,†}	ES: 0.7-2.6; p=0.004
	OMF	110.9 ± 8.7	111.6 ± 2.1^{b,c}	121.2 ± 13.2^{a,b,e}	129.6 ± 12.2$^{a,b,e,*,\otimes}$	113.9 ± 8.7^{a,b,e}	ES: 0.7-1.6; p<0.001
	FW	101.3 ± 4.9	92.6 ± 10.9	108.5 ± 11.0$^{\dagger,\otimes}$	115.5 ± 11.5$^{*,\dagger,\otimes}$	95.7 ± 11.1	ES: 0.6-2.0; p<0.001
	all	108.0 ± 7.1	101.8 ± 11.8	113.0 ± 12.0$^{*,\dagger,\otimes}$	120.2 ± 11.1$^{*,\dagger,\Delta,\otimes}$	105.4 ± 10.7	ES: 0.6-1.6; p<0.001
	ES;p	ES: 0.0-2.2; p=0.004	ES: 0.4-2.2; p=0.001	ES: 0.3-1.3; p=0.001	ES: 0.3-1.6; p=0.001	ES: 0.1-2.0; p<0.001	
HSR	CD	1.1 ± 1.1	2.2 ± 1.3	5.8 ± 3.1*,†	7.3 ± 3.7$^{c,*,\dagger,\otimes}$	4.7 ± 1.2*,†	ES: 0.4-1.9; p<0.001
	FB	2.5 ± 1.8	3.4 ± 2.8	9.7 ± 4.4$^{a,c,d,*,\dagger,\otimes}$	11.4 ± 3.7$^{a,c,*,\dagger,\otimes}$	7.0 ± 1.9^{a,c}	ES: 0.4-2.7; p<0.001
	MF	1.5 ± 1.2	2.2 ± 1.8	3.4 ± 2.5	4.5 ± 2.6*,†	4.7 ± 1.5*,†	ES: 0.1-2.2; p<0.001
	OMF	2.7 ± 1.7	2.4 ± 1.7	6.5 ± 3.9^{c,*}	9.1 ± 4.5^{c,*,†}	6.4 ± 2.1^{a,c,*}	ES: 0.6-1.7; p<0.001
	FW	1.8 ± 1.3	1.8 ± 1.8	7.1 ± 3.4^{c,*,†}	10.7± 6.0$^{c,*,\dagger,\otimes}$	6.5 ± 2.5^{a,c,*,†}	ES: 0.7-1.8; p<0.001
	all	1.9 ± 1.6	2.6 ± 2.3	6.7 ± 4.1*,†	8.9 ± 4.8$^{*,\dagger,\Delta,\otimes}$	5.9 ± 2.1*,†	ES: 0.5-1.7; p<0.001
	F(p)	ES: 0.1-1.1; p=0.083	ES: 0.4-0.6; p=0.232	ES: 0.6-1.7; p<0.001	ES: 0.1-2.1; p<0.001	ES: 0.2-1.3; p<0.001	
SPR	CD	0.1 ± 0.2	0.0 ± 0.0	1.2 ± 1.7*,†	1.9 ± 1.9^{c,*,†}	1.1 ± 0.5^{c,d,*,†}	ES: 0.4-1.7; p<0.001
	FB	0.0 ± 0.2	0.4 ± 0.9	2.0 ± 2.0^{c,*,†}	3.3 ± 2.1$^{a,c,d,*,\dagger,\otimes}$	1.6 ± 0.8^{a,c,d,*,†}	ES: 0.6-1.9; p<0.001
	MF	0.0 ± 0.1	0.2 ± 0.5	0.5 ± 1.3	0.6 ± 1.1	0.7 ± 0.5*	ES: 0.1-1.6; p=0.149
	OMF	0.1 ± 0.2	0.5 ± 0.8	0.8 ± 1.0	1.6 ± 1.6*	0.9 ± 0.5*	ES: 0.6-1.1; p=0.008
	FW	0.0 ± 0.0	0.0 ± 0.1	1.1 ± 1.1*,†	3.0 ± 2.9$^{c,*,\dagger,\Delta}$	1.5 ± 0.9^{a,c,d,*,†}	ES: 0.8-1.2; p<0.001
	all	0.0 ± 0.2	0.2 ± 0.6	1.2 ± 1.6*,†	2.2 ± 2.3$^{*,\dagger,\Delta,\otimes}$	1.2 ± 0.8*,†	ES: 0.5-1.1; p<0.001
	F(p)	ES: 0.3-0.7; p=0.622	ES: 0.1-0.9; p=0.205	ES: 0.4-0.9; p=0.005	ES: 0.1-1.5; p<0.001	ES: 0.1-1.3; p<0.001	
HMLD	CD	18.0 ± 3.7	15.3 ± 1.9	18.6 ± 4.2$^{\dagger,\otimes}$	20.6 ± 4.1†,	15.8 ± 1.8	ES: 0.5-1.4; p<0.001
	FB	22.1 ± 4.1	22.9 ± 5.4$^{a,b,c,\otimes}$	24.7 ± 5$^{a,c,\otimes}$	25.7 ± 4.9$^{a,c,\otimes}$	19.1 ± 3.1^{a,b}	ES: 0.3-1.7; p=0.004
	MF	18.5 ± 3.2	17.8 ± 4.7	19.1 ± 4.7	21.2 ± 3.7	18.8 ± 3.2^{a,b}	ES: 0.5-0.8; p=0.075
	OMF	21.3 ± 5.5	21.8 ± 4.3	25.9 ± 5.9^{a,c}	28.2 ± 5.4$^{a,b,c,*,\otimes}$	22.5 ± 4.5^{a,b,c,e}	ES: 0.4-1.3; p<0.001
	FW	19.9 ± 0.9$^{\dagger,\otimes}$	16.2 ± 3.4	22.3 ± 4.2$^{\dagger,\otimes}$	24.5 ± 5.5^{a,*,†,}	16.3 ± 4.4	ES: 0.4-1.7; p<0.001
	all	20.2 ± 4.1	19.3 ± 5.4	22.2 ± 5.6$^{\dagger,\otimes}$	24.1 ± 5.5$^{*,\dagger,\Delta,\otimes}$	18.3 ± 4.1	ES: 0.3-1.2; p<0.001
	F(p)	ES: 0.2-1.0; p=0.047	ES: 0.2-1.6; p<0.001	ES: 0.7-1.5; p<0.001	ES: 0.5-1.6; p<0.001	ES: 0.9-2.0; p<0.001	

Variable	Position	SSG5	SSG6	LSG9	LSG10	Official Match	ES;p
AMP	CD	10.2 ± 0.9	9.5 ± 0.8	10.0 ±0.9$^{\otimes}$	10.6 ± 0.8$^{\dagger,\otimes}$	9.2 ± 0.5	ES: 0.5-2.1; p<0.001
	FB	11.2 ± 0.6$^{a,\otimes}$	11.2 ± 1.2$^{a,b,c,\otimes}$	10.9 ± 0.9$^{a,\otimes}$	11.4 ± 0.8$^{a,\otimes}$	9.8 ± 0.6^{a,b}	ES: 0.2-2.3; p<0.001
	MF	10.8 ± 0.6	9.8 ± 1.2	10.7 ± 1.2	11.4 ± 0.9$^{a,\dagger,\otimes}$	10.5 ± 0.8^{a,b,e}	ES: 0.7-1.6; p<0.001
	OMF	11.1 ± 1.1	11.1± 0.6	10.8± 1.2$^{\otimes}$	12.2 ± 1.1$^{a,b,c,e,*,\otimes}$	10.5 ± 0.8^{a,b,e}	ES: 1.1-1.8; p<0.001
	FW	10.4 ± 0.4$^{\otimes}$	9.3 ± 1.1	11.5 ± 1.2$^{a,\dagger,\otimes}$	10.9 ± 1.1$^{\dagger,\otimes}$	8.8 ± 1.2	ES: 0.5-2.2; p<0.001
	all	10.8 ± 0.8$^{\otimes}$	10.3 ± 1.4	10.3 ± 1.0$^{\otimes}$	11.2 ± 1.1$^{*,\dagger,\Delta,\otimes}$	9.7 ± 1.0	ES: 0.4-1.4; p<0.001
	F(p)	ES: 0.1-1.4; p=0.020	ES: 0.1-1.6; p<0.001	ES: 0.6-1.4; p<0.001	ES: 0.9-1.7; p<0.001	ES: 0.0-1.6; p<0.001	
ACC	CD	3.6 ± 0.8$^{\Delta,\square,\otimes}$	2.9 ± 0.6$^{\otimes}$	2.3 ± 0.4$^{\otimes}$	2.2 ± 0.4$^{\otimes}$	1.8 ± 0.2^{b}	ES: 0.9-4.6; p<0.001
	FB	4.0 ± 0.9$^{\Delta,\square,\otimes}$	4.1 ± 0.9$^{a,b,\Delta,\square,\otimes}$	2.5 ± 0.5$^{\otimes}$	2.4 ± 0.6$^{b,\otimes}$	1.7 ± 0.4^{b}	ES: 0.1-4.0; p<0.001
	MF	4.3 ± 0.7$^{\Delta,\square,\otimes}$	3.9 ± 0.9$^{b,\Delta,\square,\otimes}$	2.4 ± 0.6	2.3 ± 0.5	2.1 ± 0.4^{a,b,e}	ES: 0.5-4.5; p<0.001
	OMF	4.3 ± 0.8$^{\Delta,\square,\otimes}$	4.2 ± 1.3	3.0 ± 0.6$^{a.b.c,e,\otimes}$	2.9 ± 0.6$^{a,b,c,e,\otimes}$	2.2 ± 0.4^{a,b,e}	ES: 0.1-4.2; p<0.001
	FW	3.8 ± 0.6$^{\dagger,\Delta,\square,\otimes}$	2.7 ± 0.6$^{\Delta,\square,\otimes}$	2.1 ± 0.6$^{\otimes}$	2.1 ± 0.5$^{\otimes}$	1.4 ± 0.5	ES: 1.8-4.6; p<0.001
	all	4.0 ± 0.8$^{\Delta,\square,\otimes}$	3.6 ± 1.0$^{\Delta,\square,\otimes}$	2.5 ± 0.6$^{\otimes}$	2.3 ± 0.6$^{\otimes}$	1.8 ± 0.5	ES: 0.4-3.8; p<0.001
	F(p)	ES: 0.0-0.9; p=0.304	ES: 0.1-1.6; p<0.001	ES: 0.9-1.5; p<0.001	ES: 0.8-1.5; p<0.001	ES: 0.2-1.7; p<0.001	
DEC	CD	3.6 ± 0.4$^{\Delta,\square,\otimes}$	3.1 ± 0.8$^{\square,\otimes}$	2.2 ± 0.3$^{\otimes}$	2.1 ± 0.4	1.7 ± 0.2	ES: 0.8-7.6; p<0.001
	FB	4.2 ± 0.8$^{\Delta,\square,\otimes}$	4.4 ± 1.1$^{a,b,\Delta,\square,\otimes}$	2.7 ± 0.5$^{a,b,\otimes}$	2.5 ± 0.5$^{a,b,\otimes}$	1.9 ± 0.3^{a,b}	ES: 0.2-3.8; p<0.001
	MF	4.2 ± 0.9$^{\Delta,\square,\otimes}$	3.9 ± 1.2$^{\Delta,\square,\otimes}$	2.4 ± 0.6	2.4 ± 0.6^{b}	2.1 ± 0.4^{a,b}	ES: 0.3-3.8; p<0.001
	OMF	4.2 ± 0.6$^{\Delta,\square,\otimes}$	4.0 ± 1.1	2.8 ± 0.4$^{a,b,c,\otimes}$	2.8 ± 0.7$^{a,b,c,\otimes}$	2.1 ± 0.4^{a,b}	ES: 0.2-4.7; p<0.001
	FW	4.4 ± 0.5$^{\dagger,\Delta,\square,\otimes}$	3.1 ± 0.8$^{\Delta,\square,\otimes}$	2.2 ± 0.5$^{\otimes}$	2.0 ± 0.5$^{\otimes}$	1.6 ± 0.5	ES: 1.8-5.6; p<0.001
	all	4.1 ± 0.7$^{\Delta,\square,\otimes}$	3.8 ± 1.1$^{\Delta,\square,\otimes}$	2.5 ± 0.5$^{\otimes}$	2.4 ± 0.6$^{\otimes}$	1.8 ± 0.4	ES: 0.3-4.8; p<0.001
	F(p)	ES: 0.3-1.8; p=0.142	ES: 0.4-1.3; p=0.001	ES: 0.2-1.7; p<0.001	ES: 0.5-1.4; p<0.001	ES: 0.0-1.1; p<0.001	

CD = central defender; FB = full back; MF = midfielder; OMF = offensive midfielder; FW = forward; SSG5 = small-side game 5v5 + 2 goalkeepers; SSG6 = small-side game 6v6 + 1 joker + 2 goalkeepers; LSG9 = large-sided game 9v9 + 2 goalkeepers; LSG10 = large-sided game 10v10 + 2 goalkeepers; a > CD; b > FW; c > MF; d > OMF; e > FB; * >SSG5; † >SSG6; $^{\Delta}$ >LSG9; $^{\square}$ > LSG10; $^{\otimes}$ >competitive match; DIS = distance covered (m); HSR = distance covered at high speed running (m >19.8 $km \cdot h^{-1}$); SPR = distance covered at sprinting (m >25.2 $km \cdot h^{-1}$); HMLD = high metabolic load distance (25.5 $W \cdot kg^{-1}$); AMP = average metabolic power; ACC = number of accelerations at high intensity (n >3 $m \cdot s^{-2}$); DEC = number of decelerations at high intensity (n <-3 $m \cdot s^{-2}$).

repeated-measures analysis of variance applied to each of the dependent variables in relation to the position (CD, FB, MF, OMF and FW) and training game formats (SSG5, SSG6, LSG9, LSG10 and CM). Whenever a significant difference was found, post hoc Bonferroni's test was used, whereas Dunnett's T3 post hoc test was applied when the variances were not homogeneous. All the statistical analysis was performed using SPSS 16.0 (SPSS Inc., Illinois, USA) for Windows, with significance being set at $p<0.05$. Effect sizes (ES) were calculated to determine meaningful differences with magnitudes classed as trivial (<0.2), small (>0.2-0.6), moderate (>0.6-1.2), large (>1.2- 2.0) and very large (>2.0-4.0) [33].

RESULTS

Regardless of the position occupied by the players, in Table 2 we can observe the absolute demands imposed in the different training game formats and CM studied. The meaningful differences (ES) in the variables studied between training game formats were the following: DIS: 0.6-1.6; HSR: 0.5-1.7; SPR: 0.5-1.1; HMLD: 0.4-1.2; AMP: 0.4-1.4; ACC: 0.4-3.8; DEC: 0.3-4.9. The LSG formats over-stimulate all of the variables compared with CM; nevertheless, the SSG formats only over-stimulate ACC and DEC variables.

Table 2 shows the mean ± SD of the results obtained for the four training game formats and the CM, differentiating the positional groups. ACC and DEC demands were greater in SSGs (SSG5 and SSG6; ACC: ES: 1.4-3.8; DEC: ES: 1.7-4.8). As the SSGs increase the number of players, all the rest of the variables increase and the number of cases with significant interposition differences ($p<0.05$) also increases (ES: DIS: 0.7-2.2; HSR: 0.7-2.1; SPR: 0.8-1.4; HMLD: 0.9-2.0; AMP: 0.8-1.9; ACC: 0.8-1.7; DEC: 0.5-1.7).

Figure 1 shows the different training game formats and CM by relativizing load to MDP for all players' positions. The SSG5 format over-stimulates mechanical values (ACC: 158.8%, ES: 0.3-1.0; DEC: 151.2%, ES: 1.1-1.5) while the variables DIS, HMLD and AMP over-stimulate 50% according to the MDP (DIS: 80.8%, ES: 0.2-1.7; HMLD: 66.5%, ES: 0.3-0.5; AMP: 85.0%, ES: 0.1-0.8); however, HSR and SPR did not exceed 20% according to the MDP (HSR: 17.4%, ES: 0.3-0.9; SPR: 2.4%, ES: 0.5-0.9). The results obtained in the SSG6 format of the values and the differences (ES) between positions were similar to what was observed in the SSG5 format (DIS: 77.9%, ES: 0.3-1.6; HSR: 22.7%, ES: 0.3-0.9; SPR: 10.7%, ES: 0.2-1.0; HMLD: 63.4%, ES: 0.5-1.2; AMP: 81.4%, ES: 0.5-1.3; ACC: 146.0%, ES: 0.5-1.6; DEC: 140.7%, ES: 0.5-0.9). In the LSG9, the load values were exceeded in the ACC and DEC variables close to 100% according to the MDP (ACC: 107.4%, ES: 0.2-1.0; DEC: 103.3%, ES: 0.1-0.8), while the rest of the variables did not exceed the MDP (DIS: 91.7%, ES: 0.2-0.3; HSR: 76.1%, ES: 0.1-0.8; SPR: 66.6%, ES: 0.0-0.3; HMLD: 87.7%, ES: 0.1-0.7; AMP: 92.4%, ES: 0.2-0.6). The LSG10 format over-stimulates sprint values (121.0%, ES: 0.5-1.8), while the rest of the variables have values close to 100% of MDP (DIS: 97.8%, ES: 0.7-2.3; HSR: 100.2%, ES: 0.5-2.5; AMP: 97.6%,

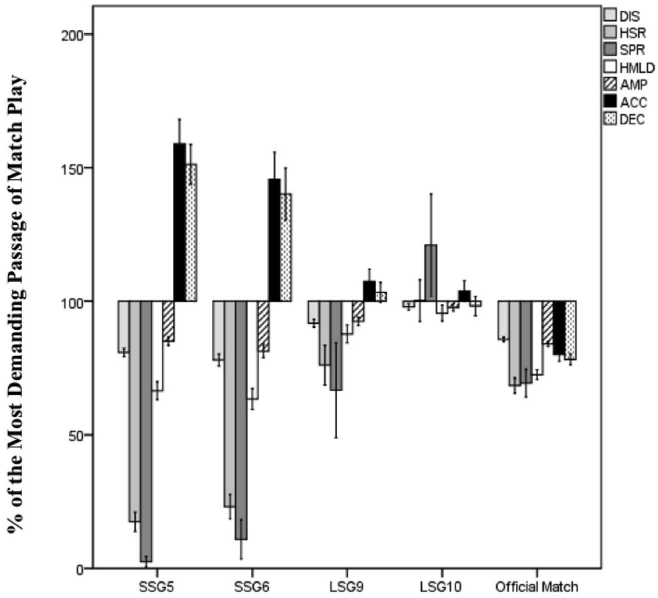

FIG. 1. Game formats and competitive match percentages (%) according to the MDP for all players' positions.
SSG5 = small-side game 5v5 + 2 goalkeepers; SSG6 = small-side game 6v6 + 1 joker + 2 goalkeepers; LSG9 = large-sided game 9v9 + 2 goalkeepers; LSG10 = large-sided game 10v10 + 2 goalkeepers; * >SSG5; † >SSG6; Δ>LSG9; □>LSG10; ⊗>competitive match; DIS = distance covered; HSR = high speed running (m >19.8 $km \cdot h^{-1}$); SPR = sprint (m >25.2 $km \cdot h^{-1}$); HMLD = high metabolic load distance (m); AMP = average metabolic power; ACC = accelerations (n >3 $m \cdot s^{-2}$); DEC = decelerations (n <-3 $m \cdot s^{-2}$).

ES: 0.6-1.8; ACC: 103.8%, ES: 0.3-0.9; DEC: 98.1%, ES: 0.5-0.6). The CM values were lower according to the MDP in all variables, obtaining values between 65 and 85% with significant differences between positions (ES) smaller compared to the other formats (DIS: 85.7%, ES: 0.3-0.6; HSR: 68.4%, ES: 0.2-0.6; SPR: 69.3.7%, ES: 0.2-0.6; HMLD: 72.4%, ES: 0.2-0.6; AMP: 83.9%, ES: 0.2-0.5; ACC: 80.1%, ES: 0.3-0.4; DEC: 78.2%, ES: 0.1-0.4).

Finally, Table 3 shows the mean ± SD of the training game formats and CM relative to the MDP according to the position. The variables such as ACC (SSG5: 158.8 %, ES: 1.1; SSG6: 146.0%, ES: 3.4) and DEC (SSG5: 151.2%, ES: 1.0; SSG6: 140.7%, ES: 3.8) showed a high percentage load relative to MDP. In HSR the values relative to MDP are close to 100.0% (all: 100.0%, ES: 0.5-2.5). In DIS, FB obtains the highest values with significant differences ($p<0.05$) compared to MF and OMF in SSG5 (ES: 1.4-1.7) and with MF in SSG6 (ES: 1.6). In HSR, in LSG9 and LSG10, MF shows the lowest values obtaining significant differences ($p<0.05$) with CD, FB (ES: -0.8 and - 0.8, respectively) and CD (ES: -0.8).

In CM, MF in SPR obtains the highest values according to the MDP (80.5%, ES: 0.6). FB shows in SSG6 the highest values in HMLD (ES: 1.1) and AMP (ES: 1.1-1.3). In ACC, significant interposition differences (p<0.05) are observed in SSG6 (ES: 1.3-1.5), LSG9 (ES: 1.1) and LSG10 (ES: 0.7-1.0).

TABLE 3. Game formats and competitive match percentage according to the MDP.

Variable	Position	SSG5 (%)	SSG6 (%)	LSG9 (%)	LSG10 (%)	Official Match (%)	ES;p
DIS	CD	82.2 ± 6.9	78.3 ± 6.7	90.7 ± 8.1$^{*,\dagger,\otimes}$	97.4 ± 6.6$^{*,\dagger,\Delta,\otimes}$	86.1 ± 4.9†	ES: 0.9-2.9; p<0.001
	FB	83.3 ± 3.1^{c,d}	81.6 ± 6.9^{c}	91.9 ± 6.7$^{*,\dagger,\otimes}$	97.4 ± 6.3$^{*,\dagger,\Delta,\otimes}$	86.3 ± 4.9*,†	ES: 0.8-2.4; p<0.001
	MF	77.4 ± 4.1	69.8 ± 8.6	90.3 ± 9.8*,†	96.5 ± 7.3$^{*,\dagger,\otimes}$	87.9 ± 5.7*,†	ES: 0.7-3.4; p<0.001
	OMF	77.4 ± 6.1	77.8 ± 1.5	91.0 ± 9.9*	97.3 ± 9.2$^{*,\dagger,\otimes}$	85.5 ± 6.5	ES: 0.7-2.3; p<0.001
	FW	82.1 ± 6.4	78.7 ± 11.8	93.3 ± 9.5$^{*,\dagger,\otimes}$	100.4 ± 10$^{*,\dagger,\otimes}$	83.2 ± 9.6	ES: 0.7-2.1; p<0.001
	ES;p	ES: 0.2-1.7; p=0.012	ES: 0.3-1.6; p=0.004	ES: 0.2-0.3; p=0.505	ES: 0.4-0.5; p=0.359	ES: 0.3-0.6; p=0.019	
HSR	CD	12.1 ± 12.6	24.0 ± 14.8	91.2 ± 48.4^{c,*,†}	113.5 ± 56.7$^{c,*,\dagger,\otimes}$	73.1 ± 1.9*,†	ES: 0.4-2.0; p=0.004
	FB	17.8 ± 12.6	24.2 ± 20.2	88.4 ± 39.9$^{c,*,\dagger,\otimes}$	103.1 ± 34.2$^{*,\dagger,\otimes}$	63.9 ± 16.9*,†	ES: 1.5-2.9; p<0.001
	MF	19.3 ± 14.9	29.5 ± 21.6	55.3 ± 41.1*	73.6 ± 41.7*,†	76.9 ± 24.7*,†	ES: 0.1-2.5; p<0.001
	OMF	24.3 ± 14.5	21.4 ± 17.9	69.2 ± 42.4*	97.5 ± 47.7*,†	68.9 ± 22.8*	ES: 0.6-1.9; p<0.001
	FW	13.1 ± 9.9	13.7 ± 13.1	69.3 ± 33.7*,†	104.5 ± 58.9$^{*,\dagger,\otimes}$	63.2 ± 24.3*,†	ES: 0.7-1.7; p<0.001
	ES;p	ES: 0.3-0.9; p=0.328	ES: 0.3-0.9; p=0.249	ES: 0.1-0.8; p=0.013	ES: 0.2-0.8; p=0.041	ES: 0.2-0.6; p=0.018	
SPR	CD	2.6 ± 7.3	0.5 ± 1.6	79.6 ± 109.8*,†	124.0 ± 122.0*,†	69.0 ± 34.5*,†	ES: 0.4-1.1; p<0.001
	FB	1.4 ± 5.0	11.7 ± 23.6	74.7 ± 76.3*,†	121.5 ± 80.1$^{*,\dagger,\otimes}$	59.1 ± 30.3*,†	ES: 0.6-1.8; p=0.004
	MF	2.1 ± 7.3	21.3 ± 52.1	64.6 ± 174.8	90.1 ± 154.3	80.5 ± 45.2^{a,e,*,†}	ES: 0.1-0.7; p=0.104
	OMF	7.3 ± 13.2	33.3 ± 48.8	57.5 ± 77.9	116.8 ± 119.7*	67.6 ± 41.5*	ES: 0.6-1.1; p=0.006
	FW	0.4 ± 0.0	1.2 ± 4.6	53.7 ± 53.4*,†	143.7 ± 140.2$^{*,\dagger,\Delta}$	72.9 ± 46.9*,†	ES: 0.8-1.2; p<0.001
	ES;p	ES: 0.3-0.8; p=0.343	ES: 0.2-0.9; p=0.193	ES: 0.1-0.3; p=0.875	ES: 0.2-0.4; p=0.610	ES: 0.2-0.6; p=0.011	
HMLD	CD	69.6 ± 14.5	58.9 ± 7.6	85.8 ± 19.3†	95.5 ± 19.1$^{*,\dagger,\otimes}$	73.4 ± 8.6†	ES: 0.5-2.1; p=0.004
	FB	69.0 ± 12.8	71.5 ± 16.9^{b}	92.6 ± 18.8$^{*,\dagger,\otimes}$	96.3 ± 18.4$^{*,\dagger,\otimes}$	71.7 ± 11.5	ES: 0.2-1.6; p<0.001
	MF	63.3 ± 11.1	60.8 ± 16.3	78.9 ± 19.6†	87.4 ± 15.1*,†	77.5 ± 13.4^{b,†}	ES: 0.5-1.7; p<0.001
	OMF	61.7 ± 16.1	63.1 ± 12.4*	87.4 ± 19.9$^{*,\dagger,\otimes}$	95.3 ± 18.5	75.1 ± 15.2^{b}	ES: 0.4-1.9; p=0.004
	FW	66.7 ± 2.9	54.4 ± 11.5	91.5 ± 17.1$^{*,\dagger,\otimes}$	100.6 ± 22.5$^{*,\dagger,\otimes}$	66.9 ± 18.1†	ES: 0.4-2.6; p<0.001
	ES;p	ES: 0.0-0.5; p=0.525	ES: 0.5-1.1; p=0.009	ES: 0.1-0.7; p=0.093	ES: 0.2-0.7; p=0.158	ES: 0.2-0.7; p=0.005	

Variable	Position	SSG5 (%)	SSG6 (%)	LSG9 (%)	LSG10 (%)	Official Match (%)	ES;p
AMP	CD	85.4 ± 7.5	79.5 ± 6.6	91.2 ± 8.5$^{\dagger,\otimes}$	96.9 ± 7.2$^{*,\dagger,\otimes}$	84.3 ± 4.8	ES: 0.7-2.5; p=0.004
	FB	87.1 ± 5.2	87.4 ± 9.4^{b,c}	93.4 ± 7.5$^{*,\otimes}$	97.6 ± 7.4$^{*,\dagger,\otimes}$	83.9 ± 5.3	ES: 0.8-2.2; p<0.001
	MF	82.5 ± 5.0	74.9 ± 9.4	89.5 ± 10†	94.9 ± 7.5$^{*,\dagger,\otimes}$	85.8 ± 6.5†	ES: 0.6-2.4; p<0.001
	OMF	82.1 ± 8.0	83.2 ± 4.2	92.6 ± 9.8$^{*,\otimes}$	97.7 ± 8.5$^{*,\dagger\otimes}$	84.5 ± 6.4	ES: 0.6-1.9; p<0.001
	FW	86.8 ± 3.7	77.2 ± 9.0	94.9 ± 9.4$^{\dagger,\otimes}$	100.4 ± 10.4$^{*,\dagger,\otimes}$	81.3 ± 10.6	ES: 0.6-1.8; p<0.001
	ES;p	ES: 0.1-0.8; p=0.153	ES: 0.5-1.3; p=0.001	ES: 0.2-0.6; p=0.276	ES: 0.3-0.6; p=0.180	ES: 0.2-0.5; p=0.022	
ACC	CD	143.4 ± 33.9$^{\Delta,\square,\otimes}$	116.8 ± 25.8$^{\otimes}$	98.7 ± 18.3$^{\otimes}$	96.0 ± 16.8$^{\otimes}$	79.2 ± 7.3	ES: 0.9-4.0; p=0.004
	FB	166.8 ± 39.8$^{\Delta,\square,\otimes}$	171.1 ± 38.9$^{a,b,*,\Delta,\square,\otimes}$	113.5 ± 24.1$^{\otimes}$	108.9 ± 26.2$^{c,\otimes}$	80.0 ± 19.8	ES: 1.7-2.4; p<0.001
	MF	153.1 ± 24.3$^{\Delta,\square,\otimes}$	140.8 ± 33.2$^{\Delta,\square,\otimes}$	94.1 ± 24.7	90.2 ± 22.0	81.1 ± 15.1	ES: 0.4-3.9; p<0.001
	OMF	153.1 ± 30.4$^{\otimes}$	148.3 ± 45.9	117.7 ± 22.6$^{c,\otimes}$	113.7 ± 24.7$^{a,c,\otimes}$	85.5 ± 16.9	ES: 0.1-3.0; p<0.001
	FW	176.9 ± 30.8$^{\dagger,\Delta,\square,\otimes}$	123.9 ± 29.7$^{\otimes}$	110.7 ± 34.3$^{\otimes}$	107.5 ± 26.8$^{\otimes}$	76.4 ± 28.7	ES: 1.7-3.5; p<0.001
	ES;p	ES: 0.3-1.9; p=0.231	ES: 0.2-1.9; p<0.001	ES: 0.2-1.0; p=0.005	ES: 0.2-1.0; p=0.001	ES: 0.3-0.4; p=0.079	
DEC	CD	144.4 ± 17.1$^{\Delta,\square,\otimes}$	124.5 ± 31.9$^{\otimes}$	100.2 ± 15.2$^{\otimes}$	93.8 ± 19.3$^{\otimes}$	77.8 ± 9.6	ES: 0.8-5.8; p=0.004
	FB	152.4 ± 28.7$^{\Delta,\square,\otimes}$	159.1 ± 39.9$^{\Delta,\square,\otimes}$	109.3 ± 21.4$^{\otimes}$	99.7 ± 17.6$^{\otimes}$	78.3 ± 12.7	ES: 0.2-3.3; p<0.001
	MF	142.4 ± 31.1$^{\Delta,\square,\otimes}$	129.4 ± 40.6$^{\otimes}$	91.9 ± 22.5	93.6 ± 25	80.8 ± 14.3	ES: 0.4-3.2; p<0.001
	OMF	143.8 ± 22.4$^{\Delta,\square,\otimes}$	137.6 ± 37.1	108.2 ± 16.0$^{\otimes}$	110.0 ± 27.2$^{\otimes}$	82.7 ± 15.9	ES: 0.2-3.5; p<0.001
	FW	181.1 ± 21.1$^{\dagger,\Delta,\square,\otimes}$	129.2 ± 33$^{\Delta,\square,\otimes}$	104.5 ± 26.4$^{\otimes}$	94.3 ± 24.6$^{\otimes}$	73.5 ± 22.9	ES: 1.8-4.8; p<0.001
	ES;p	ES: 1.1-1.4; p=0.026	ES: 0.6-0.9; p=0.042	ES: 0.1-0.8; p=0.029	ES: 0.5-0.6; p=0.033	ES: 0.1-0.4; p=0.095	

CD = central defender; FB = full back; MF = midfielder; OMF = offensive midfielder; FW = forward; SSG5 = small-side game 5v5 + 2 goalkeepers; SSG6 = small-side game 6v6 + 1 joker + 2 goalkeepers; LSG9 = large-sided game 9v9 + 2 goalkeepers; LSG10 = large-sided game 10v10 + 2 goalkeepers; a > CD; b > FW; c > MF; d > OMF; e > FB; * >SSG5; † >SSG6; $^{\Delta}$>LSG9; $^{\square}$>LSG10; $^{\otimes}$>competitive match; DIS = distance covered (m); HSR = high speed running (m >19.8 $km{\cdot}h^{-1}$); SPR = sprint (m >25.2 $km{\cdot}h^{-1}$); HMLD = high metabolic load distance (m >25 $W{\cdot}kg^{-1}$); AMP = average metabolic power ($W{\cdot}kg^{-1}$); ACC = accelerations (n >3 $m{\cdot}s^{-2}$); DEC = decelerations (n <-3 $m{\cdot}s^{-2}$).

DISCUSSION

The main purpose of this study was to examine the demands on the players in different game formats according to their position, setting out the results relative to the minutes of play ($m{\cdot}min^{-1}$ or $n{\cdot}min^{-1}$) and relative to the percentage (%) of the MDP of competitive match play. To our knowledge, no study has used different variables to describe the MDP of match play based on the use of AMP as a criterion variable. The main conclusions of the paper are: 1) there are different demands on the players depending on their position on the field in the training game formats and CM; 2) training game formats present different demands on the players, increasing them as the number of players in the training game format rises, except for the ACC and DEC variables, where the values are reduced; 3) the average values of the CM variables in the training game formats are between 70% and 80% of the MDP; 4) LSG10 played with a 10-minute duration replicate most of the demands of the MDP, achieving over-stimulating sprint demands, whilst the training game formats with the lowest number of players over-stimulate ACC and DEC; and 5) demands related to the MDP also vary depending on the position of the player. The demands, in relative or absolute terms/values, related to the demands of maximum effort in competition vary according to the position of the players in the field: from these absolute criteria in small formats and with relative criteria in large formats, the differences between demands are reduced in different game positions.

Currently, prescribing training based on a game's average demands might leave some of the most demanding phases of the game uncovered, with a potential drop in poor performance and an increase in injury risk [9-15]. The results of this study support the hypothesis that the average demands of CM are between the values from 70 to 80% of MDP and are also position-dependent. Following the training planning proposal of Martin-Garcia et al. [20], SSG5 and SSG6 are in MD-4 and LSG9 and LSG10 are in MD-3.

The results show that over-stimulation and under-stimulation of MDP demands were replicated partially in a similar way during the game formats. It can be observed that in the situations in which a smaller number of players participated (SSG5 and SSG6), high-intensity acceleration and deceleration demands reached values of 150% with respect to the MDP. These results support the hypothesis that SSGs might be game formats in which players stimulate their ability to perform high-intensity acceleration and deceleration actions [34]. In contrast, and in line with previous papers [35], the variables that represent the locomotive variables (DIS, HSR and SPR) are not stimulated in game formats with few players, providing under-stimulation of actions carried out at high speed [36], while increasing their demand as game size and the number of players involved increase, reaching approximate values of 125% in the sprint variable in LSG10. The development of the sprint variable in the LSG10 format may be due to the reduced number of interruptions; the players' training dynamic is more joyful without the pressure of competition.

The results show that the demands imposed in different game formats differ according to the position occupied by the players in competition when the demands are expressed in absolute values [15] and also in relative values (% of MDP). It should be noted that physical demands have an opposite effect in their interpretation depending on whether they are considered as relative or absolute values. While in formats with few players (e.g., SSG5 and SSG6) the demands are similar in absolute values between positional groups, differences emerge when they are relativized to a percentage with respect to the MDP. In contrast, there were no positional group-based differences between LSG9 and LSG10 when expressed relative to the MDP in the distance covered by the players, while there were significant differences when the results were expressed in absolute values.

The use of training matches that replicate the structure of competition is a common practice in football training. This type of LSG is usually held in the mid-week sessions [17], at which general principles of the game are addressed with inter-sectoral relationships, looking for higher specificity that encourages learning transference [37]. The results of this research study show that intensity in LSG formats in relation to the MDP was the highest for all the variables except for ACC and DEC. During this type of game format, the players are able to reproduce the MDP (values close to 100% of MDP) and even exceed these values (all players in LSG10; 121%) in the distance covered at sprint. Once again it was found that the demands in LSG formats were position-dependent, respecting the differences between positions in the MDP, because the differences between positions were reduced when the demands were expressed as a percentage of MDP.

One of the main limitations of this paper is that the MDP was only studied using the AMP criterion variable in the period of greatest demand. It is likely that if the MDP had been identified based on the highest value of other variables, the values obtained with respect to the MDP would have been different. In addition, we believe that using more time windows (e.g., 1, 3, 7, 12 or 15 minutes) would have made it possible to explore in greater depth how the values relating to the competition percentage vary, as has been proposed in a previous paper [11] when the authors analysed total distance, the distance covered at high speed and the mechanical load in different training game formats and CM.

This study provides useful information for coaching staff on the impact of game formats on physical load, taking into account positional differences in relation to the MDP of competitive match play. The results highlight the importance of expressing the demands of the game formats relative to the MDP of each position. Only the acceleration and deceleration variables greatly exceed the values in the MDP during the SSGs, while the demands of other variables do not do so in any cases; however, they are the formats where the greatest number of players over-stimulate the HSR and SPR variables.

PRACTICAL IMPLICATIONS

Based on these results, it may be necessary to include varied types of tasks to overload the player during the training process. Distance, distance covered at high speed and distance covered when sprinting are the variables that have the lowest MDP percentage while performing the game formats studied, especially in the smallest formats of training games. Hence it may be necessary to design other types of tasks where these variables can be stimulated or complemented with other types of activities where they can be stimulated.

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REFERENCES

1. Osgnach C, Poser S, Bernardini R, Rinaldo R, di Prampero PE. Energy cost and metabolic power in elite soccer: a new match analysis approach. Med Sci Sports Exerc. 2010;42(1):170-8.
2. Akenhead R, Hayes PR, Thompson KG, French D. Diminutions of acceleration and deceleration output during professional football match play. J Sci Med Sport. 2013;16(6):556-561.
3. Mallo J, Mena E, Nevado F, Paredes V. Physical demands of top-class soccer friendly matches in relation to a playing position using global positioning system technology. J Hum Kinet. 2015; 47(1):179-188.
4. Krustrup P, Mohr M, Ellingsgaard H, Bangsbo J. Physical demands during an elite female soccer game: importance of training status. Med Sci Sports. 2005; 37(7):1242-1248.
5. Mohr M, Krustrup P, Andersson H, Kirkendal D, Bangsbo J. Match activities of elite women soccer players at different performance levels. J Strength Cond Res. 2008; 22(2):341-349.
6. Dalen T, Jørgen I, Gertjan E, Havard HG, Ulrik W. Player load, acceleration, and deceleration during forty-five competitive matches of elite soccer. J Strength Cond Res. 2016; 30(2):351-359.
7. Castellano J, Blanco-Villaseñor A. Análisis de la variabilidad del desplazamiento de futbolistas de élite durante una temporada competitiva a partir de un modelo lineal mixto generalizado. Cuad Psico Deporte. 2015;15(1):161-168.
8. Gregson W, Drust B, Atkinson G, Salvo VD. Match-to-match variability of high-speed activities in premier league soccer. Int J Sports Med. 2010; 31(4):237-242.
9. Gabbett TJ, Kennelly S, Sheehan J, Hawkins R, Milsom J, King E, Ekstrand J. If overuse injury is a 'training load error', should undertraining be viewed the same way? Br J Sports Med. 2016;50:1017-1018.
10. Delaney JA, Duthie GM, Thornton HR, Scott TJ, Gay D, Dascombe BJ. Acceleration-Based Running Intensities of Professional Rugby League Match Play. Int J Sports Physiol Perform. 2016; 11(6):802-809.
11. Lacome M, Simpson BM, Cholley Y, Lambert P, Buchheit M. Small-Sided Games in Elite Soccer: Does One Size Fit All? Int J Sports Physiol Perform. 2017;1-24.
12. Delaney JA, Thornton HR, Burgess DJ, Dascombe BJ, Duthie GM. Duration-specific running intensities of Australian Football match-play. J Sports Sci Med. 2017;20(7):689-694.
13. Katz J, Katz L. Power laws and athletic performance. J Sports Sci. 1999; 17(6):467-476.
14. Varley MC, Elias GP, Aughey RJ. Current match-analysis techniques' underestimation of intense periods of high-velocity running. Int J Sports Physiol Perform. 2012;7(2):183-185.
15. Abbott W, Brickley G, Smeeton NJ. Positional differences in GPS outputs and perceived exertion during soccer training games and competition. J Strength Cond Res. 2018.
16. Delaney JA, Thornton HR, Rowell AE, Dascombe BJ, Aughey RJ, Duthie GM. Modelling the decrement in running intensity within professional soccer players. Sci Med in Football. 2017;1-7.
17. Clemente FM, Lourenço Martins FML, Mendes RS. Developing aerobic and anaerobic fitness using small-sided soccer games: Methodological proposals. J Strength Cond Res. 2014; 36(3):76-87.
18. Martín-García A, Casamichana D, Díaz AG, Cos F, Gabbett, TJ. Positional Differences in the Most Demanding Passages of Play in Football Competition. J Sports Sci Med. 2018;17(4):563.
19. Winter EM, Maughan RJ. Requirements for ethics approvals. J Sports Sci. 2009; 27:985.
20. Martín-García A, Gómez Díaz A, Bradley PS, Cos F, Casamichana D. The Quantification of a Professional Football Teams External Load Using a Microcycle Structure. J Strength Cond Res. 2018;32(12):3511-3518.
21. Owen AL, Djaoui L, Newton M, Malone S, Mendes B. A contemporary multi-modal mechanical approach to training monitoring in elite professional soccer. Sci Med in Football. 2017; 1(3):216-221.
22. Stevens TG, de Ruiter CJ, Twisk JW, Savelsbergh GJ, Beek PJ. Quantification of in-season training load relative to match load in professional Dutch Eredivisie football players. Sci Med in Football. 2017;1-9.
23. Tierney PJ, Young A, Clarke ND, Duncan MJ. Match play demands of 11 versus 11 professional football using Global Positioning System tracking: Variations across common playing formations. Hum Mov Sci. 2016;49:1-8.
24. Bowen L, Gross AS, Gimpel M, Li FX. Accumulated workloads and the acute: chronic workload ratio relate to injury risk in elite youth football players. Br J Sports Med. 2016;51(5):452-459.
25. Fox R, Patterson SD, Waldron M. The relationship between heart rate recovery and temporary fatigue of kinematic and energetic indices among soccer players. Sci Med in Football. 2017; 1(2):132-138.
26. Beato M, Bartolini D, Ghia G, Zamparo P. Accuracy of a 10 Hz GPS Unit in Measuring Shuttle Velocity Performed at Different Speeds and Distances (5-20 M). J Hum Kinet. 2016;54(1):15-22.
27. di Prampero, PE, Fusi S, Sepulcri L, Morin JB, Belli A, Antonutto G. Sprint running: a new energetic approach. J Exp Biol. 2005;208(14):2809-16.
28. Brown DM, Dwyer DB, Robertson SJ, Gastin PB. Metabolic power method: Underestimation of energy expenditure in field-sport movements using a global positioning system tracking system. Int J Sports Physiol Perform. 2016; 11(8):1067-1073.
29. Buchheit M, Manouvrier C, Cassirame J, Morin JB. Monitoring locomotor load in soccer: is metabolic power, powerful? Int J Sports Med. 2015; 36(14):1149-1155.
30. Hader K, Mendez-Villanueva A, Palazzi D, Ahmaidi S, Buchheit M. Metabolic power requirement of change of direction speed in young soccer players: not all is what it seems. PloS one. 2016;11(3):e0149839.
31. Rampinini E, Alberti G, Fiorenza M, Riggio M, Sassi R, Borges T, Coutts A. Accuracy of GPS devices for measuring high-intensity running in field-based team sports. Int J Sports Med. 2015; 36(1):49-53.
32. Casamichana D, Castellano J. Time-motion, heart rate, perceptual and motor behaviour demands in small-sided soccer games: Effects of pitch size. J Sport Sci. 2010;28(14):1615-1623.
33. Batterham AM, Hopkins WG. Making meaningful inferences about magnitudes. Int J Sports Physiol Perform. 2006;1(1):50-57.
34. Castellano J, Casamichana D. Differences in the number of accelerations between small-sided games and friendly matches in soccer. J Sports Sci Med. 2013;12(1): 209.
35. Castellano J, Casamichana D, Dellal A. Influence of game format and number of players on heart rate responses and physical demands in small-sided soccer games. J Strength Cond Res. 2013; 27(5):1295-1303.
36. Casamichana D, Castellano J, Castagna C. Comparing the physical demands of friendly matches and small-sided games in semiprofessional soccer players. J Strength Cond Res. 2012;26(3):837-43.
37. Delgado-Bordonau J, Mendez-Villanueva A. Tactical periodization: Mourinho's best kept secret. Soccer NSCAA J. 2012; 3:28-34.

Capítulo 6

Estudio IV: Physical demands of ball possession games in relation to the most demanding passage of the official match.

Martín-García, A., Castellano, J., Mendez-Villanueva, A., Díaz, A. G., Cos, F., & Casamichana, D. (2019). Physical demands of ball possession games in relation to the most demanding passage of the official match (En revision).

Physical demands of ball possession games in relation to the most demanding passage of the official match

Abstract

The main aim of the present study was to determine the physical demands of different small-sided ball possession games (SSBPGs) according to player field position, and compared these demands in relation to the most demanding passage (MDP) of the official matches. Global positioning system data were obtained from 25 football players (20.4 ± 2.1 y, 1.78 ± 0.66 m, 69.7 ± 6.1 kg) belonging to the reserve squad of a Spanish La Liga Club. Players were categorized based on positional groups; full-back (FB), central defender (CD), midfielder (MF), wide midfielder (WMF) and forwards (FW). The variables analyzed were relativized to meters per minute ($m \cdot min^{-1}$): total distance covered (TD), TD at high speed (HSR; >19.8 $km \cdot h^{-1}$), TD at sprint (SPR; >25.2 $km \cdot h^{-1}$), the number of accelerations (ACC) and decelerations (DEC) at high intensity (> +/-3 $m \cdot s^{-2}$), the average metabolic power (AMP; $W \cdot kg^{-1}$) and the high metabolic load distance (HMLD; >25.5 $W \cdot kg^{-1}$). The MDP was analyzed using a rolling average method, where maximal values were calculated for 3 and 5 minutes to compare with SSPGs using AMP as a criterion variable. The results were shown of the SSBPGs relative to the MDP (expressed in %) for each player position. FBs showed the greatest magnitude of overload in ACC/DEC according to the MDP in the two smaller SSBPGs formats (201-217%), while MF obtained minor magnitudes (105-140%). The load expressed in relation to the MDP can be different depending of the format of the SSBPGs and the characteristics of the position, being a factor to be considered by the coaches when planning the training.

Keywords: small-sided games, GPS, peak intensity, soccer.

Introduction

Small-sided games (SSGs) are extensively used in football training with the aim to concurrently stimulating a variety of technical and physical aspects of the sport. In this regard, the implementation of different SSGs has been shown to be effective in developing aerobic and anaerobic endurance, agility and strength in players of different levels (Hill-Haas et al., 2009; Los Arcos et al., 2015; Owen et al., 2012).

Among the vast array of football-specific task (e.g., SSGs, modified games, conditioned games, etc.) currently available, small-sided ball possession games (SSBPGs) are extensively used to develop combinative playing skills. In those drills, the generic target is to keep ball possession, with no goals or goalkeepers involved, but the four moments of the game (i.e., offensive organization, defensive organization and both, offensive and defensive transitions) are present. Moreover, the spatial structure and tactical tasks associated with the different playing positions, although simplified in comparison to an 11vs11 game, can be maintained.

While physical fitness training in football can typically target different objectives, improving game-related physical performance is the main focus. The physical demands of the competition present certain inter-player and intra-player variability (Carling 2013; Di Salvo et al., 2007). One of the variables that can greatly influence player's physical activity during the competition match is the position occupied by the player on the pitch (Castellano et al., 2014; Di Salvo et al., 2007). Thus, it would appear desirable that training drills aiming to improve game-related physical performance effectively addressed those positional-specific demands observed during matches. However, the scientific literature available to date on the demands of SSGs in football has typically reported mixed-positions values (Castellano and Casamichana, 2013; Hill-Haas et al., 2011; Randers et al., 2017). In this regard, SSGs typically present lower demands on high-speed running (HSR) and sprint actions, and greater acceleration-deceleration demands than competition matches (Beenham et al., 2017; Casamichana, Castellano and Castagna, 2012; Dellal et al., 2012; Giménez et al., 2017), being the magnitude of these differences increased when the number of players and/or pith dimensions are reduced (Casamichana and Castellano, 2010; Hill-Haas et al., 2009).

Recently, Lacome et al. (2017) compared official matches (OM) demand with those imposed by different SSGs and modified games, considering the position occupied by the players in the competition. The main findings revealed that, when compared with the most demanding passage (MDP) of the OM, substantial differences depending on the position occupied by the players during the competition, with central defenders and midfielders being the most over-stimulated and under-stimulated during the SSGs with respect to the competition, respectively. However, the possible differences that SSGs might impose on the different playing positions remain largely unexplored.

To date, a comprehensive evaluation of the physical demands of SSBPGs, in comparison with game demands, specific to each playing position has not yet been conducted. Therefore, the aim of the present study was to quantify the external training load that the different positions are exposed to during different SSBPGs when compared with the MDP of the OM.

Methods

Study design

Global Positioning System (GPS) data were collected during the 2015-2016 competitive season, to establish the position-specific demands of the OM and the different SSBPGs, expressing their demands in values relative to practice time ($m \cdot min^{-1}$ for example), and values relative to the most demanding passage of a match play (% of the MDP) of the soccer match competition of similar duration (3 or 5 minutes).

Participants

Data were collected in 25 football players (20.4 ± 2.1 y, 1.78 ± 0.66 m, 69.7 ± 6.1 kg) belonging to the reserve squad of a Spanish La Liga Club. In the last 10 seasons, the first team squad has been ranked among the top six, being three seasons ranked as the top team, in the official UEFA ranking. Players were grouped according to their playing position, as central defenders (CD, n=4), full backs (FB, n=6), midfielders (MF, n=3), wide midfielders (WMF, n=5) and forwards (FW, n=7). Data arose as a condition of the players' employment whereby they were assessed daily, thus no authorization was required from an institutional ethics committee (Carling et al., 2016; Lacome et al., 2017, Winter and Maughan, 2017). Nevertheless, this study conformed to the Declaration of Helsinki and players provided informed consent before participating.

Official matches

Thirty-seven OM of the 2015-2016 competitive season were included in the analysis (13 wins, 15 losses, 9 draw, final position 11th). The team systematically played in a 1-4-3-3 formation, with a goalkeeper, four defences (two FB and two CD), three midfielders (a MF and two WMF) and three FW. Goalkeepeers and players with less than six records were not included in the analysis. Only data from players who completed the full match were analysed in order to limit the effect of pacing strategies (Carling and Dupont, 2011). A total of 227 individual GPS files from match data of a professional male soccer team were collected, with this distribution per position: CD = 42, FB = 60, MF= 40, WMF = 34, and FW =51 GPS files.

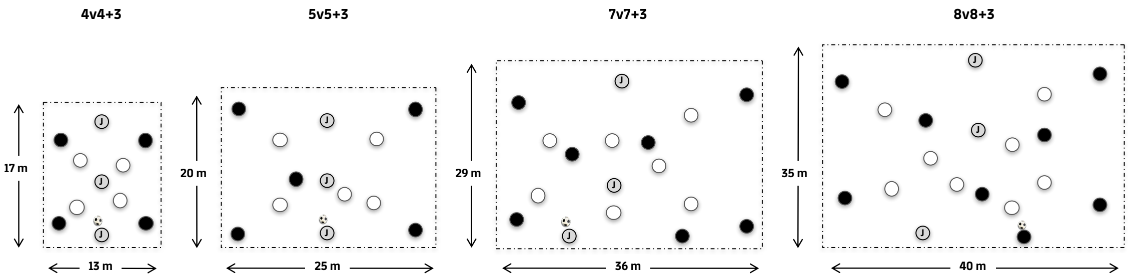
Small-Sided Ball Possession Games

The SSBPG were structured according to the position of the player in the game system (wide players occupied the positions closest to the narrow side line and MF and WMF occupied the inner positions). The main offensive objective of the positional games was to maintain possession of the ball in superiority, with three jokers (Jk), being the quick pressure after losing ball possession the main defensive tactical concept. The characteristics of each of the SSBPGs analyzed in the current study were as follows (Figure 1):

1. 4v4+3 is four against four players plus three Jk. Duration: 02:48±00:37 min. Dimensions: 13 x 17 m, surface area per player: 21.0 m^2; one of the Jk is located inside and the other two Jk on the sides of the playing area, which creates an overload of 7 vs. 4 in the possession phase.

2. 5v5+3 is five against five plus three Jk. Duration: 03:48±00:43 min. Dimensions: 25 x 20 m, surface area per player: 38.5 m^2; one of the Jk is located inside and the other two Jk on the sides of the playing area, which creates an overload of 8 vs. 5 in the possession phase.
3. 7v7+3 is seven against seven plus three Jk. Duration: 05:18±00:40 min. Dimensions: 29 x 36 m, surface area per player: 61.4 m^2; one of the Jk (always a MF) is located inside and the other two Jk (always a CD and FW) on the sides of the playing area, which creates an overload of 10 vs. 7 in the possession phase.
4. 8v8+3 in eight against eight plus three Jk. Duration: 05:23±00:37 min. Dimensions: 40 x 35 m, surface area per player: 73.7 m^2; one of the Jk is located inside and the other two Jk on the sides in the extremes of the playing area, which creates an overload of 11 vs. 8 in the possession phase.

Figure 1. Dimensions and format of each the small-sided ball possession games analyzed.



Note: 4v4+3 is four against four players plus three jokers; 5v5+3 is five against five players plus three jokers; 7v7+3 is seven against seven players plus three jokers; 8v8+3 is eight against eight players plus three jokers.

Variables and MDP of the games

The variables recorded were relativized to meters per minute ($m \cdot min^{-1}$): the distance covered (TD), distance covered at high speed running (HSR: >19.8 $km \cdot h^{-1}$, $m \cdot min^{-1}$), distance covered at sprinting (SPR: >25.2 $km \cdot h^{-1}$, $m \cdot min^{-1}$), the number of high intensity accelerations and decelerations (ACC/DEC: > 3 m·s^{-2}, n·min^{-1}), the high metabolic load distance (HMLD; >25.5 W·kg^{-1}, m·min^{-1}), and the average metabolic power (AMP: W·kg^{-1}). The intensity thresholds used have been established based on previous studies (Osgnach et al., 2010; Owen et al., 2017; Stevens, et al., 2017; Tierney, et al., 2016).

The AMP variable was used as variable criteria to estimate MDP of the four training game formats and OM. AMP is calculated from an estimation of the energy expenditure by players associated with the constant and intermittent activity (di Pampero et al., 2005; Osgnach et al., 2010) then although there are some deficiencies when there is no activity after a player effort, the inclusion of both dimensions, velocities and acc/dec, is considered a valid reference to estimate the load supported by the player in a given period.

The moving average duration method was used with the AMP variable using two different durations, 3 and 5 min, only in OM. As a result, for each individual match the period with the highest AMP values was selected and analyzed together with the rest of the variables. After that, the intensity of the SSBPGs was expressed both in absolute values (m·min^{-1} for example), and values relative (%) to MDP of the soccer match competition. The 4v4+3 and 5v5+3 were relativized to the values obtained in the MDP of the OM with the time-window of 3 min, while the 7v7+3 and 8v8+3 were relativized through comparison with the time-window of 5 min. Unlike previous studies (Lacome et al., 2017), it was used to determine the MDP in competition, while the values of the SSBPG were the average load values of all the training tasks studied.

Procedure

The activity profile of players was monitored during each training game format and official match using a portable 10 Hz GPS unit (Viper Pod,50 gr, 88 x 33 mm, Statsports Viper, Northern Ireland) as used in previous studies (Bowen et al. 2016; Fox et al., 2017). The accuracy of these devices has been studied recently, with 2.53 ± 6.03% estimation error in distance covered, with accuracy (%) improving as the distance covered increases and the speed of movement decreases (Beato et al., 2016). The GPS model used in this study was worn in a purpose designed vest, inside a mini pocket positioned in the center area of the upper back, just above the shoulder blades, and thus, not affecting mobility of the upper limbs and torso. Upon completion of each training session and OM, GPS data were extracted using the appropriate proprietary software (Viper, Statsports, Northern Ireland).

The number of records for each SSBPG and positions is shown in Table 1. SSPBGs were performed on a natural grass surface. During SSBPGs, the ball was always available by prompt replacement when out with the aim of maximizing effective playing time (Casamichana and Castellano, 2010). The demands of the SSBPGs were studied according to the position of the players during the competition. Data from Jk and Gk were not included in the analysis. In the SSBPG analysis pauses between repetitions were excluded, in order to compare them with the more intense periods of the match, MDP of the soccer OM.

Table 1. Number of records for each of the small-sided ball possession games and playing positions.

Player position	4v4+3	5v5+3	7v7+3	8v8+3	Total files
CD	28	22	44	34	128
FB	58	49	50	52	209
MF	21	17	29	20	87
WMF	39	37	37	46	159
FW	49	39	48	36	172
Total files	195	164	208	189	756

Note: CD = central defender; FB = full back; MF = midfielder; WMF = wide midfielder; FW = forward. 4v4+3 is four against four players plus three jokers; 5v5+3 is five against five players plus three jokers; 7v7+3 is seven against seven players plus three jokers; 8v8+3 is eight against eight players plus three jokers.

Statsports software (version 1.2) was then used for the computation of a moving average over the AMP variable for OM using two different time-windows of 3 and 5 min. As a result, for each official match, maximum values using AMP variable were calculated for each of the two moving average durations. These two different durations were analysed because they correspond to the usual duration of the SSBPGs in the team studied. Descriptive statistics and analysis were then calculated based on positions of play. These data were then averaged across all observations per position for between-group analysis.

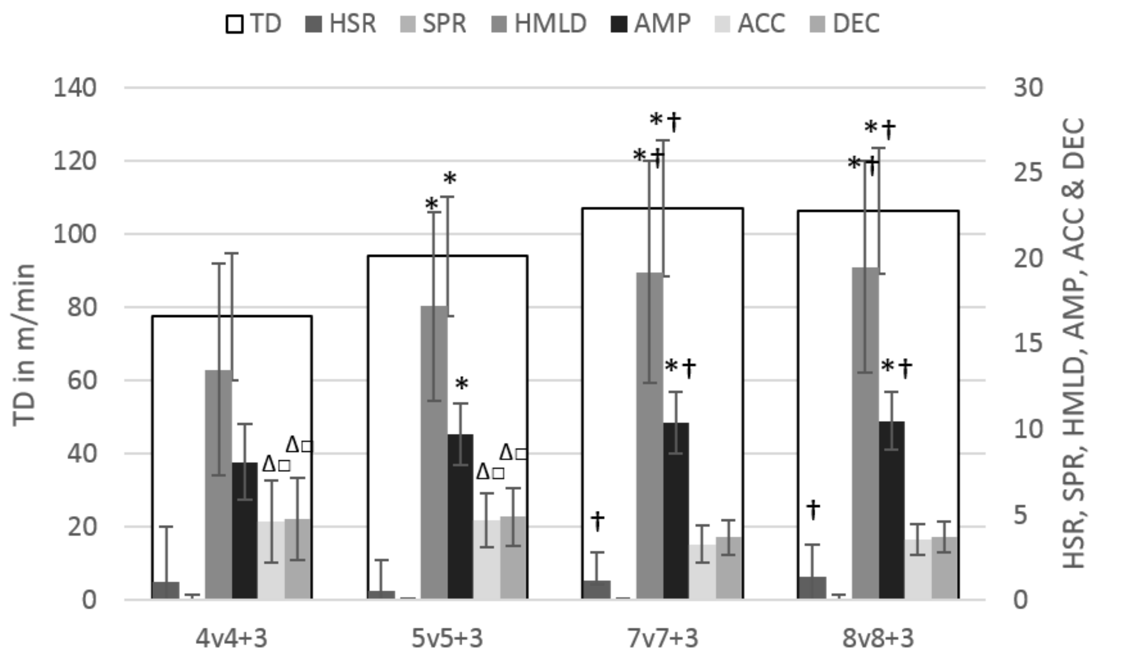
Statistical analysis

The data are presented as means and standard deviations (mean ± SD). The homogeneity of variances was examined by means of the Levene's test. The presence of significant differences was determined by means of a 2-tailed repeated-measures analysis of variance, applied to each of the dependent variables in relation to the position (CD, FB, MF, WMF and FW). Whenever a significant difference was found, a post hoc Bonferroni's test was used, whereas a Dunnett's T3 post hoc test was applied when the variances were not homogeneous. All the statistical analysis was performed using SPSS 16.0 (SPSS Inc., Illinois, USA) for Windows, with significance being set at $p<0.05$. Effect sizes (ES) were also calculated to determine meaningful differences with magnitudes classified as (Batterham and Hopkins, 2006): trivial (<0.2), small (>0.2-0.6), moderate (>0.6-1.2), large (>1.2-2.0) and very large (>2.0-4.0).

Results

Figure 2 shows the average (all positions pooled) SSBPGs intensity relative values per minute. As the SSBPGs dimensions get larger, TD (ES: 0.0–1.6), HMLD (ES: 0.1–1.0) and AMP (ES: 0.1–1.2) increased significantly while ACC (ES: 0.1–1.1) and DEC (ES: 0.1–0.9) were significantly reduced.

Figure 2. SSBPGs intensity variables in relative values (m/min) according to the MDP.



Note: * > 4v4+3; † > 5v5+3; Δ > 7v7+3; □ > 8v8+3; TD = total distance ($m{\cdot}min^{-1}$); HSR = high speed running (m > 19.8 $km{\cdot}h^{-1}$, $m{\cdot}min^{-1}$); SPR = sprint (m > 25.2 $km{\cdot}h^{-1}$, $m{\cdot}min^{-1}$); HMLD = high metabolic load distance; AMP = average metabolic power; ACC = accelerations (> 3 $m{\cdot}s^{-2}$, $n{\cdot}min^{-1}$); DEC = decelerations (< -3 $m{\cdot}s^{-2}$, $n{\cdot}min^{-1}$); 4v4+3 is four against four players plus three jokers; 5v5+3 is five against five players plus three jokers; 7v7+3 is seven against seven players plus three jokers; 8v8+3 is eight against eight players plus three jokers.

Table 2 displays the relative values per minute obtained for the four SSBPGs, differentiating the player positions on the field (CD, FW, MF, WMF, and FW).

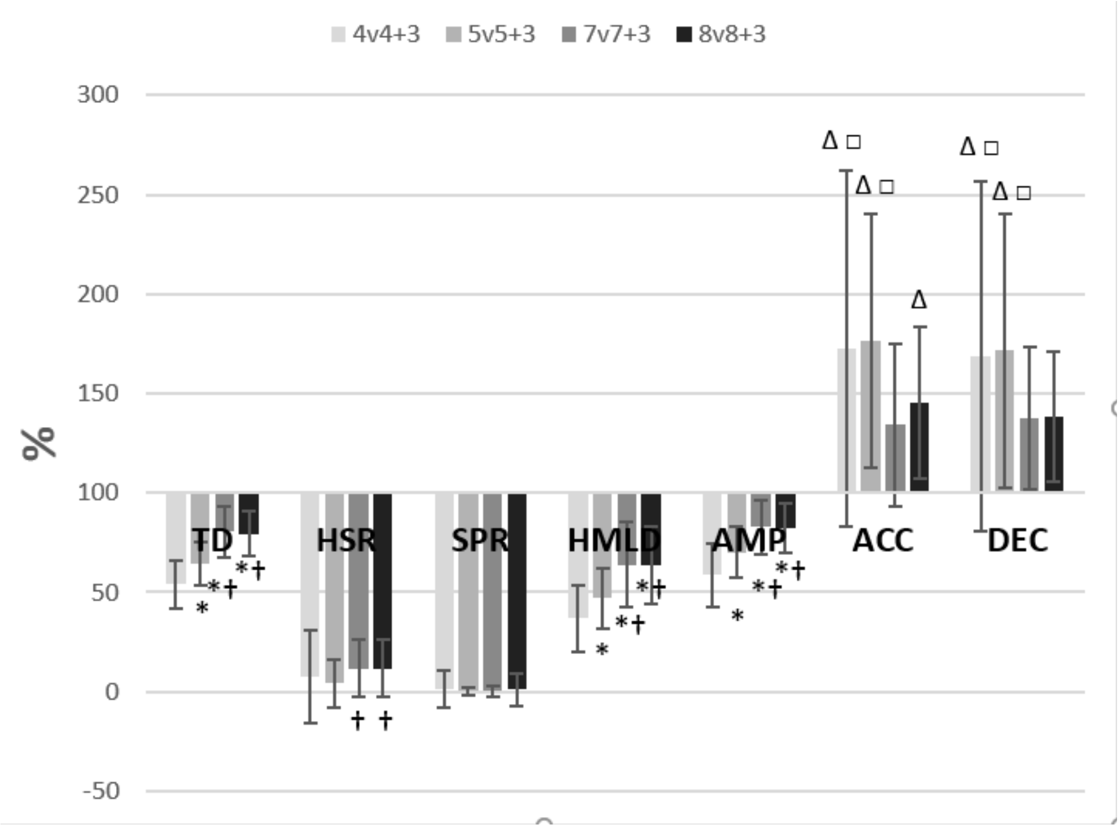
Table 2. Relative values per minute ($\cdot min^{-1}$) for different variables in SSBPGs according to the players' position.

Variable	Position	4v4+3	5v5+3	7v7+3	8v8+3	ES; p:
TD ($m \cdot min^{-1}$)	CD	79.2 ± 17.2	95.7 ± 7.4*	108.6 ± 12.5^{b,*,†}	104.4 ± 17.8^{b,*}	ES: 0.3-2.0; p<0.001
	FB	81.1 ± 16.6^{b}	96.2 ± 11.3*	105.3 ± 13.6^{b,*,†}	108.7 ± 11.4^{b,*,†}	ES: 0.3-1.9; p<0.001
	MF	69.3 ± 12.5	89.1 ± 26.4	113.7 ± 17.6^{b,*,†}	104.2 ± 23.5*	ES: 0.5-2.8; p<0.001
	WMF	84.1 ± 18.9^{c,b}	97.9 ± 17.4^{b,*}	119.2 ± 25.5^{b,e,*,†}	118.2 ± 12.6^{a,b,c,e,*,†}	ES: 0.1-1.6; p<0.001
	FW	70.8 ± 16.2	88.5 ± 16.6*	93.6 ± 12.9*	90.8 ± 11.8*	ES: 0.2-1.5; p<0.001
	ES; p:	ES: 0.2-1.0; p<0.001	ES: 0.1-0.5; p=0.050	ES: 0.5-1.3; p<0.001	ES: 0.8-2.2; p<0.001	
HSR ($m \cdot min^{-1}$)	CD	0.5 ± 1.9	0.3 ± 0.7	1.7 ± 1.5*,†	1.2 ± 1.4	ES: 0.3-1.1; p=0.002
	FB	0.7 ± 2.4	0.9 ± 2.5	1.4 ± 1.8	2.9 ± 2.6$^{a,b,c,d,*,\dagger,\Delta}$	ES: 0.7-0.9; p<0.001
	MF	2.8 ± 5.3	0.9 ± 2.7	0.8 ± 1.0	0.6 ± 1.0	ES: 0.4-0.6; p=0.068
	WMF	0.4 ± 1.6	0.2 ± 0.5	1.3 ± 1.6†	0.7 ± 0.9†	ES: 0.4-0.8; p=0.003
	FW	1.8 ± 4.2	0.6 ± 1.6	1.1 ± 1.6	0.9 ± 1.2	ES: 0.2-0.4; p=0.208
	ES; p:	ES: 0.2-0.7; p=0.030	ES: 0.0-0.4; p=0.410	ES: 0.2-0.7; p=0.160	ES: 0.7-1.0; p<0.001	
SPR ($m \cdot min^{-1}$)	CD	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	ES: 0.0; p=0.687
	FB	0.0 ± 0.1	0.0 ± 0.1	0.0 ± 0.0	0.1 ± 0.3	ES: 0.4-0.5; p=0.041
	MF	0.0 ± 0.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	ES: 0.0; p=0.104
	WMF	0.0 ± 0.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	ES: 0.0; p=0.383
	FW	0.1 ± 0.6	0.0 ± 0.2	0.0 ± 0.2	0.1 ± 0.4	ES: 0.0-0.2; p=0.675
	ES; p:	ES: 0.0-0.2; p=0.570	ES: 0.0-0.2; p=0.650	ES: 0.0-0.2; p=0.620	ES: 0.0-0.3; p=0.230	
HMLD ($m \cdot min^{-1}$)	CD	14.0 ± 5.3	16.8 ± 3.4^{c}	20.1 ± 4.7^{c,*}	18.4 ± 6.1*	ES: 0.3-1.2; p<0.001
	FB	14.8 ± 6.8^{c}	18.4 ± 6.5^{c,*}	18.4 ± 7.6*	22.3 ± 6.3$^{b,c,*,\dagger,\Delta}$	ES: 0.6-1.4; p<0.001
	MF	9.3 ± 3.8	13.2 ± 3.5	16.6 ± 4.9*	15.9 ± 6.6*	ES: 0.1-1.6; p<0.001
	WMF	15.5 ± 6.0^{c}	17.8 ± 5.2^{c}	24.1 ± 0.5^{a,b,c,e,*,†}	21.3 ± 5.5^{b,c,*}	ES: 0.7-2.0; p<0.001
	FW	12.0 ± 6.0	17.3 ± 5.7*	17.2 ± 5.4*	16.6 ± 4.2*	ES: 0.0-0.9; p<0.001
	ES; p:	ES: 0.1-1.2; p<0.001	ES: 0.1-0.9; p=0.020	ES: 1.1-2.3; p<0.001	ES: 0.2-1.0; p<0.001	
AMP ($W \cdot kg^{-1}$)	CD	8.4 ± 1.9	9.8 ± 0.9*	10.5 ± 1.2^{b,*}	10.1 ± 1.7*	ES: 0.3-1.4; p<0.001
	FB	8.6 ± 2.2^{c,b}	10.2 ± 1.4^{b,*}	10.4 ± 1.6*	10.9 ± 1.3^{b,*,†}	ES: 0.3-1.3; p<0.001
	MF	6.7 ± 1.6	8.8 ± 2.6*	10.7 ± 1.6*,†	10.0 ± 2.2*	ES: 0.4-2.5; p<0.001
	WMF	8.9 ± 2.3^{c,b}	10.1 ± 1.9	11.7 ± 2.4^{b,*,†}	11.5 ± 1.3^{a,b,c,*,†}	ES: 0.1-1.2; p<0.001
	FW	7.2 ± 2.1	9.1 ± 1.9*	9.3 ± 1.3*	9.1 ± 1.2*	ES: 0.1-1.2; p<0.001
	ES; p:	ES: 0.1-1.1; p<0.001	ES: 0.1-0.8; p=0.010	ES: 0.5-1.3; p<0.001	ES: 0.5-1.9; p<0.001	
ACC ($n \cdot min^{-1}$)	CD	4.8 ± 1.7$^{\Delta,\square}$	4.6 ± 0.8$^{\Delta,\square}$	3.2 ± 0.8	3.1 ± 0.5	ES: 0.1-1.4; p<0.001
	FB	5.2 ± 2.5$^{b,\Delta,\square}$	5.6 ± 1.5$^{b,\Delta,\square}$	3.3 ± 1.2	3.8 ± 0.9^{a}	ES: 0.2-1.7; p<0.001
	MF	3.6 ± 2.2	4.3 ± 1.9	3.1 ± 0.7	3.7 ± 0.8$^{a,\Delta}$	ES: 0.4-0.9; p=0.089
	WMF	5.4 ± 2.3$^{b,\Delta,\square}$	4.5 ± 1.6	4.2 ± 1.1^{a,b,c,e}	4.1 ± 0.9^{a,b}	ES: 0.4-0.8; p<0.001
	FW	3.7 ± 2.4	4.1 ± 1.7$^{\Delta,\square}$	2.8 ± 0.8	3.2 ± 0.9	ES: 0.2-1.0; p=0.002
	ES; p:	ES: 0.1-0.8; p<0.001	ES: 0.8-0.9; p<0.001	ES: 0.8-1.5; p<0.001	ES: 0.3-1.3; p<0.001	
DEC ($n \cdot min^{-1}$)	CD	4.9 ± 2.1$^{\Delta,\square}$	4.9 ± 1.2$^{\Delta,\square}$	3.6 ± 0.8	3.2 ± 0.8	ES: 0.0-1.1; p<0.001
	FB	5.7 ± 2.5$^{c,b,\Delta,\square}$	5.6 ± 1.5$^{b,\Delta,\square}$	3.9 ± 1.1^{b}	4.1 ± 0.8^{a,b}	ES: 0.1-0.9; p<0.001
	MF	3.5 ± 2.3	4.6 ± 2.0	3.7 ± 0.9	3.7 ± 0.8	ES: 0.5-0.6; p=0.137
	WMF	5.4 ± 2.1$^{b,\Delta,\square}$	4.9 ± 1.9	4.2 ± 0.9^{a,b}	4.1 ± 1.1^{a,b}	ES: 0.2-0.8; p<0.001
	FW	3.8 ± 2.3	4.3 ± 1.7$^{\Delta,\square}$	3.1 ± 0.9	3.3 ± 0.8	ES: 0.2-0.9; p=0.006
	ES; p:	ES: 0.1-0.9; p<0.001	ES: 0.4-0.6; p<0.001	ES: 0.3-1.2; p<0.001	ES: 0.0-0.9; p<0.001	

Note: CD = central defender; FB = full back; MF = midfielder; WMF = wide midfielder; FW = forward; a > CD; b > FW; c > MF; d > OMF; e > FB; * > 4v4+3; † > 5v5+3; $^{\Delta}$ > 7v7+3; $^{\square}$ > 8v8+3; TD = total distance ($m \cdot min^{-1}$); HSR = high speed running (m > 19.8 $km \cdot h^{-1}$, $m \cdot min^{-1}$); SPR = sprint (m > 25.2 $km \cdot h^{-1}$, $m \cdot min^{-1}$); HMLD = high metabolic load distance; AMP = average metabolic power; ACC = accelerations (> 3 $m \cdot s^{-2}$, $n \cdot min^{-1}$); DEC = decelerations (< -3 $m \cdot s^{-2}$, $n \cdot min^{-1}$); 4v4+3 is four against four players plus three jokers; 5v5+3 is five against five players plus three jokers; 7v7+3 is seven against seven players plus three jokers; 8v8+3 is eight against eight players plus three jokers.

Figure 3 shows the average (all positions pooled) SSBPGs intensity relative to the MDP of the match-play expressed in percentage (%).

Figure 3. SSBPGs intensity variables (%) according to the MDP



Note: * > 4v4+3; † > 5v5+3; ∆ > 7v7 + 3; □ > 8v8+3; TD = total distance (m·min^{-1}); HSR = high speed running (m > 19.8 km·h^{-1}, m·min^{-1}); SPR = sprint (m > 25.2 km·h^{-1}, m·min^{-1}); HMLD = high metabolic load distance; AMP = average metabolic power; ACC = accelerations (> 3 m·s^{-2}, n·min^{-1}); DEC = decelerations (< -3 m·s^{-2}, n·min^{-1}); 4v4+3 is four against four players plus three jokers; 5v5+3 is five against five players plus three jokers; 7v7+3 is seven against seven players plus three jokers; 8v8+3 is eight against eight players plus three jokers.

Table 3 displays the results of the SSBPGs relative to the MDP (expressed in %) for each player position. The variables ACC and DEC showed significantly greater values (i.e., >100% of MDP) in any of the SSBPGs format 4v4+3 (AVG: 172/168%) and 8v8+3 (AVG: 145/138%). Among the different playing positions, FBs showed the greatest magnitude of overload according to the MDP in the two smaller SSBPGs formats in ACC variable during 4v4+3 (201.6 %), 5v5+3 (217.5%) and DEC variable during 4v4+3 (213.5%) and 5v5+3 (208.2%), while MF presented the lowest overload in the mechanical variables during 4v4+3 (115.2 %), 5v5+3 (138.3%) and DEC variable during 4v4+3 (105.3%) and 5v5+3 (140.4%). HSR and SPR showed the lowest magnitude of demand in comparison with the MDP during 5v5+3 (4.1%) and 7v7+3 (11.6%).

Table 3. Relative values in % (mean and standard deviation) of different variables according to the position in SSBPGs to MDP.

Variable	Position	4v4+3	5v5+3	7v7+3	8v8+3	ES; p:
	CD	57.8 ± 12.5	$69.8 \pm 5.4^{c,*}$	$85.8 \pm 9.9^{b,e,*,\dagger}$	$82.5 \pm 14.1^{b,*,\dagger}$	ES: 0.3-2.5; p<0.001
	FB	56.3 ± 11.5^{c}	$66.8 \pm 7.8^{*}$	$79.1 \pm 10.3^{*,\dagger}$	$81.7 \pm 8.6^{b,*,\dagger}$	ES: 0.3-2.5; p<0.001
TD	MF	45.9 ± 8.3	58.9 ± 17.4	$80.7 \pm 12.5^{*,\dagger}$	$74.0 \pm 16.7^{*}$	ES: 0.5-3.2; p<0.001
	WMF	54.8 ± 12.3	$63.8 \pm 11.4^{*}$	$83.2 \pm 17.8^{*,\dagger}$	$82.5 \pm 8.8^{b,*,\dagger}$	ES: 0.1-1.9; p<0.001
	FW	52.4 ± 12	$65.4 \pm 12.3^{*}$	$74.9 \pm 10.4^{*,\dagger}$	$72.7 \pm 9.5^{*,\dagger}$	ES: 0.2-2.0; p<0.001
	ES; p:	ES: 0.1-1.1; p<0.001	ES: 0.4-0.9; p=0.03	ES: 0.2-1.1; p<0.001	ES: 0.0-0.8; p<0.001	
	CD	4.3 ± 15.9	2.6 ± 6.1	$18.5 \pm 17.1^{b,e,*,\dagger}$	$13.1 \pm 15^{\dagger}$	ES: 0.3-1.1; p<0.001
	FB	4.0 ± 13.5	5.1 ± 13.7	10.1 ± 12.9	$20.5 \pm 18.1^{b,c,d,*,\dagger,\Delta}$	ES: 0.7-1.0; p<0.001
HSR	MF	25.1 ± 17.4	8.3 ± 24.3	10.0 ± 12.5	8.4 ± 12.4	ES: 0.4-0.5; p=0.145
	WMF	2.9 ± 10.2	1.6 ± 3.1	$11.6 \pm 14.8^{*,\dagger}$	$6.4 \pm 8.9^{\dagger}$	ES: 0.4-0.9; p<0.001
	FW	10.4 ± 24.7	3.9 ± 9.3	8.0 ± 11.8	6.7 ± 9.1	ES: 0.1-0.3; p=0.292
	ES; p:	ES: 0.4-0.8; p<0.001	ES: 0.2-0.5; p=0.360	ES: 0.4-0.7; p<0.001	ES: 0.4-1.0; p<0.001	
	CD	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.6	0.1 ± 0.9	ES: 0.0-0.1; p=0.687
	FB	0.5 ± 2.7	0.4 ± 1.72	0.1 ± 1.0	2.6 ± 8.6	ES: 0.3-0.4; p=0.024
SPR	MF	3.4 ± 11.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	ES: 0.4-0.5; p=0.104
	WMF	0.8 ± 5.4	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	ES: 0.2-0.3; p=0.383
	FW	2.9 ± 16.5	0.6 ± 4.1	0.9 ± 6.2	2.6 ± 15.5	ES: 0.0-0.2; p=0.750
	ES; p:	ES: 0.0-0.5; p=0.480	ES: 0.1-0.2; p=0.650	ES: 0.2-0.3; p=0.600	ES: 0.0-0.4; p=0.340	
	CD	44.2 ± 16.7^{c}	53.2 ± 10.6^{c}	$77.6 \pm 18.3^{b,c,e,*,\dagger}$	$70.9 \pm 23.4^{b,c,*,\dagger}$	ES: 0.3-1.9; p<0.001
	FB	38.6 ± 17.8^{c}	$48.1 \pm 17.1^{*}$	$57.4 \pm 23.6^{*}$	$69.5 \pm 19.7^{b,*,\dagger,\Delta}$	ES: 0.6-1.6; p<0.001
HMLD	MF	26.7 ± 10.8	$38.1 \pm 10.1^{*}$	$56.8 \pm 16.7^{*,\dagger}$	$54.6 \pm 22.5^{*,\dagger}$	ES: 0.1-2.1; p<0.001
	WMF	38.4 ± 14.8^{c}	44.2 ± 12.8	$69.6 \pm 20.4^{*,\dagger}$	$61.5 \pm 15.9^{*,\dagger}$	ES: 0.4-1.8; p<0.001
	FW	33.4 ± 16.7	$48.1 \pm 15.9^{*}$	$57.8 \pm 18.2^{*,\dagger}$	$55.8 \pm 14.1^{*}$	ES: 0.1-1.4; p<0.001
	ES; p:	ES: 0.3-1.2; p<0.001	ES: 0.4-1.4; p=0.020	ES: 0.4-1.2; p<0.001	ES: 0.1-0.7; p<0.001	
	CD	63.9 ± 14.7	$75.1 \pm 7.1^{c,*}$	$87.7 \pm 10.2^{b,*,\dagger}$	$84.1 \pm 14.7^{*,\dagger}$	ES: 0.3-2.0; p<0.001
	FB	61.6 ± 15.7^{c}	$72.7 \pm 10.0^{*}$	$81.1 \pm 12.8^{*,\dagger}$	$85.5 \pm 10.2^{b,*,\dagger}$	ES: 0.4-1.8; p<0.001
AMP	MF	47.4 ± 11.4	$62.4 \pm 18.6^{*}$	$81.8 \pm 12.5^{*,\dagger}$	$76.4 \pm 17.1^{*,\dagger}$	ES: 0.4-2.8; p<0.001
	WMF	61.1 ± 15.6^{c}	68.5 ± 12.9	$87.0 \pm 17.7^{b,*,\dagger}$	$85.3 \pm 9.6^{b,*,\dagger}$	ES: 0.1-1.6; p<0.001
	FW	55.0 ± 16.0	$69.3 \pm 14.3^{*}$	$77.6 \pm 11.4^{*,\dagger}$	$76.0 \pm 10.5^{*}$	ES: 0.1-1.6; p<0.001
	ES; p:	ES: 0.1-1.2; p<0.001	ES: 0.3-0.9; p=0.020	ES: 0.1-0.9; p<0.001	ES: 0.0-0.9; p<0.001	
	CD	$173.7 \pm 62.7^{\Delta,\square}$	$165.1 \pm 29.9^{\Delta,\square}$	126.7 ± 31.6	124.0 ± 22.2	ES: 0.2-1.1; p<0.001
	FB	$201.6 \pm 94.8^{c,\Delta,\square}$	$217.5 \pm 56.5^{b,c,d,\Delta,\square}$	139.7 ± 50.9^{c}	159.3 ± 41.3^{a}	ES: 0.2-1.5; p<0.001
ACC	MF	115.2 ± 70.1	138.3 ± 61.0	112.6 ± 23.9	$134.2 \pm 27.7^{\Delta}$	ES: 0.1-0.9; p=0.197
	WMF	$181.4 \pm 76.8^{\square}$	152.4 ± 53.4	$151.5 \pm 40.2^{a,c}$	144.6 ± 33.8^{a}	ES: 0.4-0.6; p=0.011
	FW	155.9 ± 100.8	$171.4 \pm 72.2^{\Delta}$	135.6 ± 39.8^{c}	151.2 ± 45.4^{a}	ES: 0.2-0.6; p=0.132
	ES; p:	ES: 0.2-1.0; p<0.001	ES: 0.7-1.4; p<0.001	ES: 0.2-1.1; p<0.001	ES: 0.2-1.1; p<0.001	
	CD	159.9 ± 66.4	$158.1 \pm 39.3^{\square}$	142.9 ± 33.9	128.6 ± 31.7	ES: 0.0-0.6; p=0.019
	FB	$213.5 \pm 95.1^{a,b,c,\Delta,\square}$	$208.2 \pm 57.6^{b,c,d,\Delta,\square}$	138.9 ± 38.9	144.8 ± 29.1	ES: 0.1-1.0; p<0.001
DEC	MF	105.3 ± 71.6	140.4 ± 61.1	128.1 ± 30.3	126.9 ± 28.1	ES: 0.3-0.5; p=0.172
	WMF	$174.6 \pm 66.6^{c,\square}$	160.3 ± 61	146.1 ± 34.2	141.0 ± 36.6	ES: 0.2-0.6; p=0.016
	FW	142.9 ± 86.7	158.2 ± 64.9	130.3 ± 37.1	139.6 ± 33.7	ES: 0.2-0.5; p=0.209
	ES; p:	ES: 0.5-1.2; p<0.001	ES: 0.8-1.2; p<0.001	ES: 0.1-0.6; p= 0.130	ES: 0.1-0.6; p= 0.100	

Note: CD = central defender; FB = full back; MF = midfielder; WMF = wide midfielder; FW = forward; a > CD; b > FW; c > MF; d > OMF; e > FB; * >4v4+3; † > 5v5+3; $^{\Delta}$ > 7v7+3; $^{\square}$ > 8v8+3; TD = total distance (% of the MDP); HSR = high speed running distance (m > 19.8 $km{\cdot}h^{-1}$, % of the MDP); SPR = sprint distance (m > 25.2 $km{\cdot}h^{-1}$, % of the MDP); HMLD = high metabolic load distance; % of the MDP; AMP = average metabolic power (% of the MDP); ACC = number of accelerations (> 3 $m{\cdot}s^{-2}$, % of the MDP); DEC = number of decelerations (< -3 $m{\cdot}s^{-2}$, % of the MDP); 4v4+3 is four against four players plus three jokers; 5v5+3 is five against five players plus three jokers; 7v7+3 is seven against seven players plus three jokers; 8v8+3 is eight against eight players plus three jokers.

Discussion

SSBPGs are training games frequently used in academies and also high-performance teams. To our knowledge this is the first study that makes an analysis of the locomotor (e.g., TD, HSR and SPR) and mechanical (e.g., ACC and DEC) intensity of the SSPBGs, comparing the different positional player demands and establishing the comparison of these positional demands in relation to the MDP of the match-play. The main findings were: 1) regardless of the game format (i.e., size and number of players) and window-time (3 or 5 min), the density of ACC and DEC were the two mechanical variables showing the greatest degree of overload (>100% of the MDP); 2) on the contrary, HSR metrics showed the lowest degree of demand (<12% of the MDP), not being practically demanded SPR in any SSBPG; 3) taking into account that playing position was, at least partially, considered during the practice of the current SSBPGs, mechanical and locomotor dimensions were overload and underload, respectively, in relation to match demands differed among the different playing positions in different way; and 4) intensity and load global metrics (e.g., AMP and HMLD) were neither overloaded in relation to game demands regardless of playing position, being for MF less demanding than the rest of the players position in relation to match demands.

Playing position during the competition has been shown to impact the overall physical demands (Di Salvo et al., 2007) and also the MDP of the match-play (Delaney et al., 2017b). In the present study, and despite playing position was considered during training drills, every game format resulted in marked between-position differences in relative overload in most locomotor performance, with the exception of HSR and SPR (see Table 3 and Figure 3). Worth mentioning that sprint distance in these drills are almost non-existent for all the playing positions and all the formats of position games studied. Similar to previous studies investigation non-position dependent training responses to SSG (Castellano and Casamichana 2013; Hill-Haas et al., 2009; Lacome et al., 2017), in the present study there was an increase in the variables of TD and HSR, as the size of SSPBGs drills increased, in both relative (m^2 per player) and absolute (e.g., pitch dimensions) values. This was repercussion in HMLD and AMP. In this regard, it seems obvious that to allow players to achieve the high-speed or sprint thresholds, space and time is need it to accelerate (Delaney et al., 2017). On the contrary, the density of accelerations and decelerations were greater in the smaller game formats compared with the drills including more players (7v7+3 and 8v8+3).

Regarding players' positions, there were greater significant differences between them. Especially the FW position that with this type of format games there was low stimulation. As the playing space became larger and with more players these differences increase. It could be that the WMF is the most demanded position with this type of playing situations.

On the other side, training drills that take into account playing position should, in theory, better mimic individual match demands and therefore, result in more specific training stimuli. Comparing training drill demands with the MDP of the OM, in addition to average values, in competition can be useful to understand the magnitude of overload at near-maximal intensities a player is subjected to during football-specific training drills. That is, when drill data is expressed as % of the MDP during the match and values obtained exceed 100% it means that match demands have been exceed (overload). This training aspect (i.e., magnitude of the overload) is pivotal to the management of training load since systematic repetition over time could lead to an over- or under-stimulation with implications for performance (Jaspers et al., 2017) and for the player's health, where both situations can increase the athlete's risk of injury (Malone et al., 2017).

In this regard, in the present study, players' demands expressed as % of the MDP remain position-dependent (see Table 3). Our results when we compare the demand of the different SSPBGs studied according to the % of the MDP indicate that there is an under-solicitation in the variables of TD, AMP, HMLD and especially in the HSR and SPR. As mentioned above, in the present study we find how all the variables approach the value of 100% of the MDP, a value that corresponds to the MDP in competition, as the SSPGs increases in his size and numbers. Thus, the differences below in TD, HSD and SPR and above in ACC and DEC are lower in the larger formats (7v7+3 and 8v8+3) while increasing the differences in the smaller formats (4v4+3 and 5v5+3). Lacome et al. (2017) also found that as the reduced game format increased, players' demands were more similar to the MDP demands in the game.

CDs and FB have significantly higher values of ACC and FB also in DEC in small SSPBGs (4v4+3 and 5v5+3) than in the other two game formats (7v7+3 and 8v8+3). MDP for CDs are significantly lower compared to other demarcations, which means that, although they do not cover further distance (in meters), they have greater load than other players positions, such as example FW. Distance covered at HSR and sprint does not present significant differences in most of the formats studied. MF present a significantly lower value of HMLD than the CD in all the SSPBGs studied, with reduced values in AMP, especially in the SSPGs with less players. Regarding the accelerations and decelerations, it should be noted that FB have significantly higher values than MF and FW in the small SSPBGs.

Unfortunately, few studies have expressed soccer demands based on the % of the MDP found in match, and also differences in the game system used by the team, and therefore, players position make comparison with other studies more difficult (Lacome et al., 2017).

Comparison between different SSGs has been studied extensively (Castellano et al., 2013; Dellal, et al., 2012; Hill-Haas et al., 2009; Rampinini, et al., 2007). However, there are few studies where this comparison has been made based on the players position during the OM (Lacome et al., 2017).

As described by Lacome et al. (2017), the results obtained suggest the need to incorporate training drills that replicate and perhaps exceed the demands of the MDP of the match-play. Based on the results obtained, the high-speed and sprint displacement actions are the most under stimulated with the studied SSPBGs. Therefore, inside training dynamics, other drills should be included to avoid underestimating HSR and SPR players actions. Perhaps including some type of work such as HIIT could be interesting to exceed the values, obtained in the MDP in match-play, in variables referring to TD or especially HSR (Lacome et al., 2017), since in our study SSPBGs do not manage to replicate these demands.

Some of study limitations refers to the fact that only physical and external load demand has been registered by GPS. It would be interesting to have information about the internal load that the athlete assumes performing this type of drills. In future studies, it would be interesting to apply the same SSPBGs with superior playing surfaces for the same number of players, to enforce game rules that favor or limit the number of contacts with the ball or use a different game space than rectangular pitch in order to confirm the hypothesis of the present study.

Implications for soccer training

- The small SSBPGs, 4v4+3 and 5v5+3, can be used to moderately overload mechanical variables (ACC and DEC), while 7v7+3 and 8v8+3 formats can be used to increase the values in variables TD and HMLD. In addition, none of the SSBPGs that were designed with relative dimensions per player of less than 75 m^2, did not stimulate HSR and SPR variables. It is necessary to plan specific intervention strategies (e.g. increase the relative dimensions per player while maintaining a high number of players per team) or complementary exercises to balance the load in relation to the demands of the game.
- The values relative to min of practice showed differences between the positions, increasing when the SSBPGs were larger. However, when values were considered in relative terms to % of the MDP, these differences decreased, especially in the larger formats.

- The playing positions had different requests depending on the type of task. For the MF these types of tasks were less demanding than for the rest of positions. In addition, in the 4v4+3 and 5v5+3 game formats, the FB was the position with highest demand compared to the MDP in the mechanical variables (>200%), while the MF did not exceed the 50% load compared to its MDP.

Key Points

- It is necessary to plan specific intervention strategies (e.g. increase the relative dimensions per player while maintaining a high number of players per team) or complementary exercises to balance the load in relation to the demands of the game.
- The values relative to min of practice showed differences between the positions, increasing when the SSBPGs were larger.
- The playing positions had different requests depending on the type of task.

References

Akenhead, R, Harley, JA, and Tweddle, SP. (2016) Examining the external training load of an English Premier League football team with special reference to acceleration. The Journal of Strength & Conditioning Research 30, 2424–2432.

Batterham, A. M. Hopkins, W. G. (2006). Making meaningful inferences about magnitudes. International journal of sports physiology and performance 1, 50-57.

Beato, M., Bartolini, D., Ghia, G. and Zamparo, P. (2016) Accuracy of a 10 Hz GPS Unit in Measuring Shuttle Velocity Performed at Different Speeds and Distances (5–20 M). The Journal of Human Kinetics 54, 15-22.

Beenham, M., Barron, D.J., Fry, J., Hurst, H.H., Figueirdo, A., and Atkins, S. (2017) A Comparison of GPS Workload Demands in Match Play and Small-Sided Games by the Positional Role in Youth Soccer. The Journal of Human Kinetics 22, 129-137.

Bowen, L., Gross, A.S., Gimpel, M. and Li, F.X. (2017) Accumulated workloads and the acute: chronic workload ratio relate to injury risk in elite youth football players. British Journal of Sports Medicine 51, 452-459.

Bradley, P. S. and Noakes, T. D. (2013) Match running performance fluctuations in elite soccer: indicative of fatigue, pacing or situational influences?. Journal of sports sciences 31, 1627-1638.

Brandes, M, Heitmann, A, and Muller, L. (2012) Physical responses of different small-sided games formats in elite youth soccer players. The Journal of Strength & Conditioning Research 26, 1353–1363.

Brown, D. M., Dwyer, D. B., Robertson, S. J., and Gastin, P. B. (2016) Metabolic power method: Underestimation of energy expenditure in field-sport movements using a global positioning system tracking system. International journal of sports physiology and performance 11, 1067-1073.

Buchheit, M., Manouvrier, C., Cassirame, J., and Morin, J. B. (2015) Monitoring locomotor load in soccer: is metabolic power, powerful. International Journal of Sports Medicine 36, 1149-1155.

Casamichana, D. and Castellano, J. (2010) Time-motion, heart rate, perceptual and motor behaviour demands in small-sides soccer games: Effects of pitch size. Journal of Sports Sciences 28, 1615-1623.

Casamichana, D., Castellano, J. and Castagna, C. (2012) Comparing the physical demands of friendly matches and small-sided games in semiprofessional soccer players. The Journal of Strength & Conditioning Research 26, 837-843.

Castellano, J., Alvarez-Pastor, D. and Bradley, P.S. (2014) Evaluation of research using computerised tracking systems (Amisco® and Prozone®) to analyse physical performance in elite soccer: A systematic review. Sports Medicine 44, 701-712.

Castellano, J. and Casamichana, D. (2013) Differences in the number of accelerations between small-sided games and friendly matches in soccer. Journal of sports science & medicine 12, 209.

Castellano, J., Casamichana, D., and Dellal, A. (2013) Influence of game format and number of players on heart rate responses and physical demands in small-sided soccer games. The Journal of Strength & Conditioning Research 27, 1295-1303.

Carling, C. (2013). Interpreting physical performance in professional soccer match-play: should we be more pragmatic in our approach?. Sports Medicine 43, 655-663.

Carling, C., Bradley, P., McCall, A., and Dupont, G. (2016) Match-to-match variability in high-speed running activity in a professional soccer team. Journal of sports sciences 34, 2215-2223.

Delaney, J. A., Cummins, C. J., Thornton, H. R., and Duthie, G. M. (2018) Importance, Reliability, and Usefulness of Acceleration Measures in Team Sports. The Journal of Strength & Conditioning Research 32, 3485-3493.

Delaney, J.A., Thornton, H.R., Rowell, A.E., Dascombe, B.J., Aughey, R.J. and Duthie, G.M. (2017b) Modelling the decrement in running intensity within professional soccer players. Science and Medicine in Football 2, 86-92.

Dellal, A., Owen, A., Wong, D.P., Krustrup, P., van Exsel, M. and Mallo, J. (2012) Technical and physical demands of small vs. large sided games in relation to playing position in elite soccer. Human Movement Science 31, 957-969.

di Prampero, P.E., Fusi, S., Sepulcri, L., Morin, J.B., Belli, A. and Antonutto, G. (2005) Sprint running: a new energetic approach. Journal of Experimental Biology 208, 2809-2816.

Di Salvo, V., Baron, R., Tschan, H., Montero, F.C., Bachl, N. and Pigozzi, F. (2007) Performance characteristics according to playing position in elite soccer. International Journal of Sports Medicine 28, 222-227.

Fox, R., Patterson, S.D. and Waldron, M. (2017) The relationship between heart rate recovery and temporary fatigue of kinematic and energetic indices among soccer players. Science and Medicine in Football 1, 132-138.

Giménez, J.V., Del-Coso, J., Leicht, A.S. and Gomez, M.A. (2017) Comparison of the movement patterns between small-and large-side games training and competition in professional soccer players. The Journal of Sports Medicine and Physical Fitness, Epub ahead of print.

Hader, K., Mendez-Villanueva, A., Palazzi, D., Ahmaidi, S., and Buchheit, M. (2016) Metabolic power requirement of change of direction speed in young soccer players: not all is what it seems. PloS one 11, e0149839.

Halouani, J., Chtourou, H., Gabbett, T., Chaouachi, A., and Chamari, K. (2014) Small-sided games in team sports training: A brief review. The Journal of Strength & Conditioning Research 28, 3594-3618.

Hill-Haas, S. V., Coutts, A. J., Rowsell, G. J., and Dawson, B. T. (2009). Generic versus small-sided game training in soccer. International journal of sports medicine 30, 636-642.

Hill-Haas, S., Dawson, B., Coutts, A., and Rowsell, G. (2009) Physiological responses and time-motion characteristics of various small-sided soccer games in youth players. Journal of Sports Sciences 27, 1-8.

Hill-Haas, S. V., Dawson, B., Impellizzeri, F. M., and Coutts, A. J. (2011). Physiology of small-sided games training in football. Sports medicine 41, 199-220.

Jaspers, A., Brink, M. S., Probst, S. G., Frencken, W. G., and Helsen, W. F. (2017) Relationships between training load indicators and training outcomes in professional soccer. Sports Medicine 47, 533-544.

Lacome, M., Simpson, B.M., Cholley, Y., Lambert, P. and Buchheit, M. (2017) Small-Sided Games in Elite Soccer: Does One Size Fits All? International Journal of Sports Physiology and Performance 13, 1-24.

Los Arcos, A., Vázquez, J. S., Martín, J., Lerga, J., Sánchez, F., Villagra, F., and Zulueta, J. J. (2015) Effects of small-sided games vs. interval training in aerobic fitness and physical enjoyment in young elite soccer players. PloS one 10, e0137224.

Martín-García, A., Díaz, A. G., Bradley, P. S., Morera, F., and Casamichana, D. (2018) Quantification of a Professional Football Team's External Load Using a Microcycle Structure. The Journal of Strength & Conditioning Research 32, 3511-3518.

Malone, S., Roe, M., Doran, D.A., Gabbett, T.J. and Collins, K. (2017) High chronic training loads and exposure to bouts of maximal velocity running reduce injury risk in elite Gaelic football. Journal of Sports Science and Medicine 20, 250-254.

Osgnach, C., Poser, S., Bernardini, R., Rinaldo, R. and Di Prampero, P.E. (2010) Energy cost and metabolic power in elite soccer: a new match analysis approach. Medicine and Science in Sports and Exercise 42, 170-178.

Owen, A.L., Djaoui, L., Newton, M., Malone, S. and Mendes, B. (2017) A contemporary multi-modal mechanical approach to training monitoring in elite professional soccer. Science and Medicine in Football 1, 216-221.

Owen, A. L., Wong, D. P., Paul, D., and Dellal, A. (2012) Effects of a periodized small-sided game training intervention on physical performance in elite professional soccer. The Journal of Strength & Conditioning Research 26, 2748-2754.

Rampinini, E., Alberti, G., Fiorenza, M., Riggio, M., Sassi, R., Borges, T. O., and Coutts, A. J. (2015) Accuracy of GPS devices for measuring high-intensity running in field-based team sports. International journal of sports medicine 36, 49-53.

Rampinini, E., Impellizzeri, F. M., Castagna, C., Abt, G., Chamari, K., Sassi, A., and Marcora, S. M. (2007) Factors influencing physiological responses to small-sided soccer games. Journal of sports sciences 25, 659-666.

Randers, M. B., Ørntoft, C., Hagman, M., Nielsen, J. J., and Krustrup, P. (2018) Movement pattern and physiological response in recreational small-sided football–effect of number of players with a fixed pitch size. Journal of sports sciences 36, 1549-1556.

Stevens, T.G., de Ruiter, C.J., Twisk, J.W., Savelsbergh, G.J. and Beek, P.J. (2017) Quantification of in-season training load relative to match load in professional Dutch Eredivisie football players. Science and Medicine in Football 1, 117-125.

Tierney, PJ, Young, A, Clarke, ND, and Duncan, MJ. (2016) Match play demands of 11 versus 11 professional football using Global Positioning System tracking: Variations across common playing formations. Human Movement Science 49, 1-8.

Winter, EM and Maughan, RJ. Requirements for ethics approvals. (2009) Journal of sports sciences 27, 985.

Capítulo 7

Discusión, conclusiones y aplicaciones prácticas

7.1 Discusión

El objetivo principal de esta tesis fue describir la demanda cinemática que definen el ME, analizando tanto el proceso de entrenamiento como la competición. Para ello se realizó un estudio en profundidad de los EME de la competición, de las sesiones de entrenamiento caracterizadas en función de la distancia con el partido anterior y/o siguiente, y de las SSP más representativas de esta metodología de entrenamiento (Partidos y JP) aplicando la tecnología GPS como herramienta de recogida de datos. Según nuestro conocimiento, este es el primer estudio que analiza la carga externa de la metodología impulsada por Seirul·lo (2017), con la monitorización de la demanda cinemática de los diferentes patrones metodológicos, atendiendo al rol posicional.

El entrenamiento en los deportes de equipo y en concreto en el fútbol, ha sido analizado profundamente (Casamichana et al., 2012; Di Salvo et al., 2007; Mohr et al., 2008). Modelos de planificación contemporáneos como la Periodización Táctica de Vitor Frade (Acero et al., 2013) y el ME de Seirul·lo (2017), han intentado adaptarse a la evolución constante de la competición, el aumento del número de partidos, incremento de la exigencia condicional o la acentuada especificidad profesional de los cuerpos técnicos (Ryan, Lewin, Forsythe y McCall, 2018), otorgando mayor protagonismo a estos modelos de planificación. Los enfoques contemporáneos examinan la naturaleza integradora del juego, en el que se sintetizan una serie de factores, proporcionando una mayor comprensión de la dinámica de cargas de un jugador en relación con los requisitos posicionales y del juego (Ade, Fitzpatrick y Bradley, 2016; Bradley y Ade, 2018).

El uso de la tecnología del sistema de GPS tanto en el entrenamiento como en los partidos oficiales es una herramienta eficaz para monitorear la carga de entrenamiento y competición de los jugadores (Casamichana et al., 2012). A pesar de que esta tecnología se utiliza ampliamente en el fútbol para cuantificar las demandas del entrenamiento, su uso en los partidos oficiales es menos común (Akenhead et al., 2016). El rol táctico de un jugador parece ser un determinante poderoso de su desarrollo condicional en el partido (Bush, Archer, Hogg y Bradley, 2015), por lo que es imperativo que el estímulo condicional tenga un elemento posicional (Bradley y Ade, 2018). Para definir la competición y poder comparar estos valores con lo acontecido en las SSP propuestas en los entrenamientos, se analizaron los EME, utilizando PM, DAPM y DT como variables criterio, aplicando el método "*rolling average*" en ventanas de tiempo de 1, 3, 5 y 10 minutos. Las diferencias posicionales en los episodios de juego más exigentes se han analizado en trabajos previos en el fútbol (Dalen et al., 2019; Lacome et al., 2018). Del mismo modo que sucede en anteriores trabajos realizados sobre la temática, a medida que las ventanas de tiempo aumentan, la intensidad de las variables analizadas ($m \cdot min^{-1}$ o $n \cdot min^{-1}$) se reducen. Nuestros hallazgos muestran que las demandas, relacionados con las exigencias de esfuerzo máximo en la competición, varían según la posición de los jugadores en el campo. Estos resultados son similares a los obtenidos por Delaney et al. (2016) en jugadores profesionales australianos y superiores a los registrados por Lacome et al. (2018) en los futbolistas profesionales franceses. Los equipos estudiados en este trabajo (Lacome et al., 2018, Delaney et al., 2017) utilizaron el mismo sistema de juego (1-4-3-3), pero la clasificación de las posiciones fue diferente ya que nuestro estudio no diferenció entre los delanteros y extremos (Lacome et al., 2018), o diferenciando entre centrocampistas y centrocampistas de carácter ofensivo (Delaney et al., 2017). A pesar de estas diferencias, los estudios previos también encontraron que los jugadores de mediocampo son los que cubren la mayor distancia, y el DC tiene los valores más bajos (Lacome et al., 2018; Delaney et al., 2017). Uno de los principales hallazgos originales de este trabajo es que los EME de los valores de juego se definen en función de la variable criterio (PM, DAPM y DT) de las que derivan otras variables (DT, DAV, SPR, PM, DAPM, ACC y DEC), que pueden ayudar a comprender las demandas de los momentos más críticos del partido y adaptar las tareas de entrenamiento para replicar estos EME.

El análisis del ME se centró en el comportamiento condicional de las sesiones de entrenamiento a lo largo del microciclo competitivo, describiendo las sesiones posteriores a la competición (+1 y +2) y las previas al siguiente partido (-4,-3,-2 y -1), contextualizando los contenidos llevados a cabo en cada una de ellas, diferenciando entre las posiciones habituales en el sistema de juego utilizado por el equipo analizado (1-4-3-3). Un hallazgo importante de este estudio fue que las cargas de entrenamiento fueron mayores 4 días antes de la competición (Sesión -4), valores que se aproximan a las demandas que exige el partido. Curiosamente, el tiempo de entrenamiento en la sesión MD-4 fue 12 minutos menor que lo reportado en la literatura (Stevens et al., 2017). Por otra parte, las métricas tales como DT, DAV, SPR y ACC también diferían sustancialmente de lo reportado por otros autores a través de varias fases de la semana de entrenamiento (Owen et al., 2017). Estas diferencias pudieran deberse a variaciones en los estándares competitivos de los jugadores y las metodologías de entrenamiento utilizadas (Carling, 2013). En este estudio aún se encuentra que las sesiones de entrenamiento ubicadas en la zona central del microciclo produjeron la mayor carga, lo que resulta una marcada diferencia respecto a las sesiones -2 y -1, un hallazgo apoyado por una gran cantidad de literatura (Akenhead et al., 2016; Owen et al, 2017; Stevens et al., 2017);

La propuesta de planificación presentada en el Estudio II, muestra el comportamiento de la dinámica de cargas a lo largo del ME. Uno de los aspectos diferenciadores del artículo es la contextualización de los datos dentro de la planificación del entrenamiento (Bradley y Ade, 2018). Sirva como ejemplo la propuesta en la sesión -4 destinada a desarrollar las capacidades de fuerza y potencia de los jugadores. Esta sesión, consistió en un entrenamiento de gimnasio, seguido de JP y PEM (área: 25–50 m^{-2} por jugador), o la sesión -3, donde el entrenamiento se basó en preparar tácticamente a los jugadores para el próximo partido. La estructura consistía en JP (área: 70–100 m^{-2}) y concluía con un PEM 11v11 (72 x 65 m). Como se puede comprobar, las SSP con mayor peso dentro del entrenamiento bajo la influencia del ME fueron los JP y PEM. En el Estudio III y IV, se analizaron estos tipos de tareas, comparándolas con el EME analizado en el Estudio II, atendiendo al rol posicional, relativizando los resultados a los minutos de juego (m·min^{-1} o n·min^{-1}) y en relación con el porcentaje (%) del EME en competición, utilizando la PM como variable criterio. Tanto en los JP como en los formatos más pequeños de los PEM (5V5 +2 porteros – 6v6 +1 comodín + 2 porteros – 9v9 + 2 porteros) se sobre estimularon las variables mecánicas ACC/DEC, aspecto que apoya la literatura actual (Castellano, Casamichana y Dellal, 2013; Randers, Ørntoft, Hagman, Nielsen y Krustrup, 2018), teniendo unos valores menores en las variables DT, DAV y SPR. La literatura reciente ha profundizado en este ámbito, destacando que un bajo rendimiento en el entrenamiento de las variables locomotoras podría suponer un riesgo de lesión (Gabbett et al., 2016; Malone et al., 2018). Uno de los principales hallazgos metodológicos es la capacidad del PEM 10v10 + 2 porteros de desarrollar la variable sprint un 125% del EME, aproximando el resto de variables al 100% del momento más crítico en la competición. Con estos resultados la investigación ofrece un recurso a los entrenadores para igualar o incluso superar el EME y asegurar que el jugador conviva con los elementos del juego.

Atendiendo a las características posicionales, los resultados muestran que las exigencias impuestas en las diferentes SSP, los formatos difieren según la posición ocupada por los jugadores en el partido cuando las demandas se expresan en valores absolutos (Abbott, Brickley y Smeeton, 2018), también en valores relativos (% del EME). Las exigencias físicas tienen un efecto opuesto en su interpretación dependiendo si son considerados como valores relativos o absolutos. Por ejemplo, mientras que en formatos expuestos las demandas son similares en valores absolutos entre grupos posicionales, emergen diferencias cuando se relativizan a un porcentaje con respecto al EME. Sirva como ejemplo lo sucedido en la SSP 5v5 + 2 porteros en la variable DEC, donde los valores absolutos (n·min^{-1}) posicionales fueron: DC: 3.6; DL: 4.2; PIV: 4.2; INT: 4.2; DEL: 4.4; mientras que los valores relativos (% EME) fueron: DC: 144%; DL: 152%; PIV: 142%; INT: 143%; DEL: 180%.

En esta tesis se ha analizado la gestión de cargas (planificación), estudiando la competición (EME) y las SSP utilizadas en los entrenamientos, atendiendo al rol posicional. Las necesidades de los jugadores no solo tienen que ajustarse a la demanda media del equipo, si no que deben adecuarse a las exigencias posicionales y aproximar el requerimiento de la carga externa según la intensidad competitiva. La información aportada podría ser útil para los cuerpos técnicos y científicos del deporte cuando intentan gestionar sistemáticamente la carga de entrenamiento.

7.2 Conclusiones

En este capítulo mostramos las conclusiones que se han obtenido de los diferentes estudios realizados, así como las posibles aplicaciones prácticas sugeridas de los hallazgos encontrados.

Las actividades que realiza un jugador de fútbol son estocásticas y multidimensionales, por lo tanto, es necesario considerar las actividades individuales y posicionales que definen el proceso de entrenamiento. Los hallazgos de esta tesis ofrecen herramientas para diseñar sesiones y tareas de entrenamiento que imiten e incluso superen los periodos más exigentes del partido, atendiendo a los requisitos posicionales y adaptando estas fases a la duración de los ejercicios de entrenamiento. Del mismo modo, ofrece recursos para gestionar la carga de entrenamiento y ajustar las necesidades posicionales en un deporte multifactorial como el fútbol.

Las conclusiones de esta investigación son las siguientes:

- Durante el periodo más exigente de la competición, las demandas condicionales son dependientes de la posición.

- En los EME, a medida que las ventanas de tiempo aumentan, la intensidad de las variables analizadas ($m \cdot min^{-1}$ o $n \cdot min^{-1}$) se reduce.

- Hay diferentes demandas para los jugadores en función de su posición en el campo en los formatos de juego de entrenamiento y competición.

- La sesión compensatoria (MD + 1C) fue más intensa que la sesión de recuperación (MD + 1R) el día después de la competición.

- Las cargas fueron mayores en la sesión que se realizó 4 días antes de los partidos.

- La carga externa del microciclo varió sustancialmente según el rol táctico de los jugadores en el equipo.

- Los formatos de juego de entrenamiento presentan diferentes demandas para los jugadores, incrementándolos a medida que aumenta el número de jugadores en el formato de juego de entrenamiento, excepto para las variables ACC y DEC, donde los valores se reducen.

- El partido 11v11 de entrenamiento replicó la mayoría de las demandas del EME, mientras que los formatos de juego de entrenamiento con el número más bajo de jugadores sobre estimulan las ACC y DEC.

- Las demandas de las SSP relacionadas con el EME también varían dependiendo de la posición del jugador.

Como conclusión final podríamos indicar que la competición exige de forma diferenciada según la posición ocupada en el campo. Estas diferencias se ven acentuadas por las SSP propuestas que estimulan de forma diferente al jugador según el rol posicional, siendo necesario el análisis y ajuste de carga para ofrecer a los jugadores las herramientas necesarias para el desempeño óptimo en las sesiones de entrenamiento y en la competición. La tecnología GPS ha permitido evaluar tanto situaciones de partidos como situaciones de entrenamiento de una manera sencilla, válida y fiable, perfectamente aplicable a la evaluación del entrenamiento y la competición en el ámbito del fútbol, siendo una herramienta de gran utilidad para gestionar de forma precisa las necesidades condicionales de los jugadores y llevar acabo la planificación del entrenamiento lo más individualizada y ajustada posible.

7.3 Aplicaciones prácticas

En este apartado detallaremos las aplicaciones prácticas que derivan de los diferentes artículos que conforman la tesis. Mediante las conclusiones y discusiones aportadas por los diferentes estudios llevados a cabo, podemos definir aportaciones prácticas al campo de la ciencia aplicada y el entrenamiento deportivo.

Adquirir conocimiento de las cargas de entrenamiento externas relacionadas con el juego es importante para los profesionales del deporte, particularmente cuando se intenta optimizar cargas específicas por posición. Por ejemplo, la aplicación de una carga de DAV similar a DL y PIV podría potencialmente provocar una sobrecarga en la última posición y una carga insuficiente en la posición DL. Tales diferencias en la carga, podrían afectar al rendimiento y aumentar el riesgo de lesiones. Por lo tanto:

- Cuantificar las cargas en relación con las demandas de la competición podría ser una estrategia ventajosa que los entrenadores podrían usar dentro de sus modelos de periodización de entrenamiento.

Dado que el juego competitivo es un estímulo importante para desarrollar las capacidades fisiológicas de los jugadores que completan los partidos de forma regular, es imperativo que se implementen estrategias prácticas para compensar cualquier déficit en la carga condicional de los jugadores que obtienen un tiempo limitado de juego. Por lo tanto:

- La sesión posterior al partido podría ser un día ideal para compensar la carga reducida de la competición en jugadores con tiempo de juego limitado, además del estímulo elevado dentro de los días centrales del microciclo.

Además, el carácter de las tareas llevadas a cabo en las sesiones de entrenamiento condiciona el comportamiento cualitativo de las variables analizadas. Identificar el rendimiento condicional de forma cuantitativa según el tipo de sesión posibilita una gestión de las cargas de forma más precisa, detectando esfuerzos excesivos o de bajo rendimiento, pudiendo actuar en consecuencia. Las actividades que realiza un jugador de fútbol, en la competición y en las sesiones de entrenamiento, son aleatorias e inesperadas; por lo tanto, es necesario considerar las actividades individuales, y en especial los EME. De este modo:

- Nuestros datos pueden ayudar a los entrenadores a diseñar situaciones de entrenamiento que imiten e incluso superen los episodios más exigentes de la competición, atendiendo a los requisitos posicionales y adaptando estas fases a la duración de los ejercicios de entrenamiento.

La propuesta metodológica debe ofrecer a los jugadores las herramientas necesarias para poder afrontar los EME con garantías condicionales, cognitivas y coordinativas para ser lo más eficientes y efectivos, tomando las decisiones oportunas para adaptarse a los requisitos del modelo de juego pretendido por el entrenador. Según los resultados presentados, puede ser necesario:

- Incluir varios tipos de tareas en el proceso de entrenamiento para sobrecargar al jugador durante el proceso de entrenamiento.

Los datos presentados muestran que la DT, la DAV y SPR son variables que tienen el porcentaje de EME más bajo al realizar los formatos de juego estudiados, especialmente en los formatos más pequeños de los partidos de entrenamiento y JP. Por lo tanto:

- Puede ser necesario diseñar otro tipo de tareas donde estas variables se puedan estimular o complementar.
- Es necesario planificar estrategias de intervención específicas (por ejemplo, aumentar las dimensiones relativas por jugador mientras se mantiene un alto número de jugadores por equipo) o ejercicios complementarios para equilibrar la carga en relación con las demandas del juego en las variables relacionadas con la velocidad.

Capítulo 8

Referencias

1. Abbott, W., Brickley, G., & Smeeton, N. J. (2018). Positional differences in GPS outputs and perceived exertion during soccer training games and competition. *The Journal of Strength & Conditioning Research*, 32(11), 3222-3231. doi:10.1519/JSC.0000000000002387
2. Acero, R. M., Peñas, C. L., y Lalin, C. (2013). Causas Objetivas de Planificación en DSEQ (II): La Microestructura (Microciclos). *Revista de Entrenamiento Deportivo*, 27(2).
3. Ade, J., Fitzpatrick, J., & Bradley, P. S. (2016). High-intensity efforts in elite soccer matches and associated movement patterns, technical skills and tactical actions. Information for position-specific training drills. *Journal of sports sciences*, 34(24), 2205-2214. doi:10.1080/02640414.2016.1217343
4. Akenhead, R., Harley, J. A., & Tweddle, S. P. (2016). Examining the external training load of an English Premier League football team with special reference to acceleration. *Journal of strength and conditioning research*, 30(9), 2424-2432. doi:10.1519/JSC.0000000000001343
5. Akenhead, R., Hayes, P. R., Thompson, K. G., & French, D. (2013). Diminutions of acceleration and deceleration output during professional football match play. *Journal of Science and Medicine in Sport*, 16(6), 556-561. doi:10.1016/j.jsams.2012.12.005
6. Anderson, L., Orme, P., Di Michele, R., Close, G. L., Morgans, R., Drust, B., & Morton, J. P. (2016). Quantification of training load during one-, two-and three-game week schedules in professional soccer players from the English Premier League: implications for carbohydrate periodisation. *Journal of sports sciences*, 34(13), 1250-1259. doi:10.1080/02640414.2015.1106574
7. Arjol, J. L. (2012). La planificación actual del entrenamiento en fútbol.: Análisis comparado del enfoque estructurado y la periodización táctica. *Acciónmotriz*, (8), 27-37.
8. Barnes, C., Archer, D. T., Hogg, B., Bush, M., & Bradley, P. S. (2014). The evolution of physical and technical performance parameters in the English Premier

League. *International Journal of Sports Medicine*, 35(13), 1095-1100. doi:10.1055/s-0034-1375695

9. Beato, M., Bartolini, D., Ghia, G., & Zamparo, P. (2016). Accuracy of a 10 Hz GPS unit in measuring shuttle velocity performed at different speeds and distances (5–20 m). *Journal of human kinetics*, 54(1), 15-22. doi:10.1515/hukin-2016-0031
10. Beenham, M., Barron, D. J., Fry, J., Hurst, H. H., Figueirdo, A., & Atkins, S. (2017). A comparison of GPS workload demands in match play and small-sided games by the positional role in youth soccer. *Journal of human kinetics*, 57(1), 129-137. doi:10.1515%2Fhukin-2017-0054
11. Bompa. T (2003), *Periodización, Teoría y metodología del entrenamiento deportivo*. Barcelona: Paidotribo.
12. Bowen, L., Gross, A. S., Gimpel, M., & Li, F. X. (2017). Accumulated workloads and the acute: chronic workload ratio relate to injury risk in elite youth football players. British *Journal of Sports Medicine*, 51(5), 452-459. doi:10.1136/bjsports-2015-095820
13. Bradley, P. S., & Ade, J. D. (2018). Are current physical match performance metrics in elite soccer fit for purpose or is the adoption of an integrated approach needed?. *International journal of sports physiology and performance*, 13(5), 656-664. doi:10.1123/ijspp.2017-0433
14. Bradley, P. S., & Noakes, T. D. (2013). Match running performance fluctuations in elite soccer: indicative of fatigue, pacing or situational influences?. *Journal of sports sciences*, 31(15), 1627-1638. doi:10.1080/02640414.2013.796062
15. Brandes, M., Heitmann, A., & Müller, L. (2012). Physical responses of different small-sided game formats in elite youth soccer players. *The Journal of Strength & Conditioning Research*, 26(5), 1353-1360. doi: 10.1519/JSC.0b013e318231ab99
16. Buchheit, M., Haddad, H. A., Simpson, B. M., Palazzi, D., Bourdon, P. C., Salvo, V. D., & Mendez-Villanueva, A. (2014). Monitoring accelerations with GPS in football: time to slow down?. *International journal of sports physiology and performance*, 9(3), 442-445. doi:10.1123/ijspp.2013-0187

17. Buchheit, M., & Simpson, B. M. (2017). Player-tracking technology: half-full or half-empty glass?. *International journal of sports physiology and performance*, 12(Suppl 2), S2-35. doi:10.1123/ijspp.2016-0499
18. Bush, M. D., Archer, D. T., Hogg, R., & Bradley, P. S. (2015). Factors influencing physical and technical variability in the English Premier League. *International journal of sports physiology and performance*, 10(7), 865-872. doi:10.1123/ijspp.2014-0484
19. Bush, M., Barnes, C., Archer, D. T., Hogg, B., & Bradley, P. S. (2015). Evolution of match performance parameters for various playing positions in the English Premier League. Human movement science, 39, 1-11. doi:10.1016/j.humov.2014.10.003
20. Capra, F. (1998). *La Trama de la Vida; Una nueva visión de los sistemas vivos.* Barcelona: Editorial Anagrama.
21. Carling, C. (2013). Interpreting physical performance in professional soccer match-play: should we be more pragmatic in our approach?. *Sports Medicine*, 43(8), 655-663. doi:10.1007/s40279-013-0055-8
22. Carling, C., & Dupont, G. (2011). Are declines in physical performance associated with a reduction in skill-related performance during professional soccer match-play?. *Journal of sports sciences*, 29(1), 63-71. doi:10.1080/02640414.2010.521945
23. Carling, C., Bradley, P., McCall, A., & Dupont, G. (2016). Match-to-match variability in high-speed running activity in a professional soccer team. *Journal of sports sciences*, 34(24), 2215-2223. doi:10.1080/02640414.2016.1176228
24. Casamichana, D., & Castellano, J. (2010). Time–motion, heart rate, perceptual and motor behaviour demands in small-sides soccer games: Effects of pitch size. *Journal of sports sciences*, 28(14), 1615-1623. doi:10.1080/02640414.2010.521168
25. Casamichana, D., Castellano, J., & Castagna, C. (2012). Comparing the physical demands of friendly matches and small-sided games in semiprofessional soccer players. *The Journal of Strength & Conditioning Research*, 26(3), 837-843. doi:10.1519/JSC.0b013e31822a61cf

26. Castellano, J., Alvarez-Pastor, D., & Bradley, P. S. (2014). Evaluation of research using computerised tracking systems (Amisco® and Prozone®) to analyse physical performance in elite soccer: A systematic review. *Sports medicine*, 44(5), 701-712. doi:10.1007/s40279-014-0144-3
27. Castellano, J. y Casamichana, D. (2016). *El arte de planificar*. Barcelona: Futbol del libro.
28. Castellano, J., Casamichana, D., Calleja-González, J., San Román, J., & Ostojic, S. M. (2011). Reliability and accuracy of 10 Hz GPS devices for short-distance exercise. *Journal of sports science & medicine*, 10(1), 233.
29. Castellano, J., Casamichana, D., & Dellal, A. (2013). Influence of game format and number of players on heart rate responses and physical demands in small-sided soccer games. *The Journal of Strength & Conditioning Research*, 27(5), 1295-1303. doi:10.1519/JSC.0b013e318267a5d1
30. Clemente, F. M., Martins, F. M. L., & Mendes, R. S. (2014). Developing aerobic and anaerobic fitness using small-sided soccer games: Methodological proposals. *Strength & Conditioning Journal*, 36(3), 76-87. doi:10.1519/SSC.0000000000000063
31. Coutts, A., Reaburn, P., Piva, T. J., & Murphy, A. (2007). Changes in selected biochemical, muscular strength, power, and endurance measures during deliberate overreaching and tapering in rugby league players. *International journal of sports medicine*, 28(02), 116-124. doi:10.1055/s-2006-924145
32. Da Silva, N. P., Kirkendall, D. T., & Neto, T. L. D. B. (2007). Movement patterns in elite Brazilian youth soccer. *Journal of Sports Medicine and Physical Fitness*, 47(3), 270.
33. Dalen, T., Jørgen, I., Gertjan, E., Havard, H. G., & Ulrik, W. (2016). Player load, acceleration, and deceleration during forty-five competitive matches of elite soccer. *The Journal of Strength & Conditioning Research*, 30(2), 351-359. doi:10.1519/JSC.0000000000001063
34. Dalen, T., Sandmæl, S., Stevens, T. G., Hjelde, G. H., Kjøsnes, T. N., & Wisløff, U. (2019). Differences in Acceleration and High-Intensity Activities Between Small-Sided Games and Peak Periods of Official Matches in Elite Soccer

Players. *Journal of strength and conditioning research*. doi:10.1519/JSC.0000000000003081

35. Delaney, J. A., Duthie, G. M., Thornton, H. R., Scott, T. J., Gay, D., & Dascombe, B. J. (2016). Acceleration-based running intensities of professional rugby league match play. *International journal of sports physiology and performance*, 11(6), 802-809. doi:10.1123/ijspp.2015-0424
36. Delaney, J. A., Thornton, H. R., Burgess, D. J., Dascombe, B. J., & Duthie, G. M. (2017). Duration-specific running intensities of Australian Football match-play. *Journal of science and medicine in sport*, 20(7), 689-694. doi:10.1016/j.jsams.2016.11.009
37. Delaney, J. A., Thornton, H. R., Rowell, A. E., Dascombe, B. J., Aughey, R. J., and Duthie, G. M. (2017). Modelling the decrement in running intensity within professional soccer players. *Science and Medecine in Football*, 1-7. doi:10.1080/24733938.2017.1383623
38. Dellal, A., Owen, A., Wong, D. P., Krustrup, P., van Exsel, M., & Mallo, J. (2012). Technical and physical demands of small vs. large sided games in relation to playing position in elite soccer. *Human movement science*, 31(4), 957-969. doi:10.1016/j.humov.2011.08.013
39. Di Mascio, M., & Bradley, P. S. (2013). Evaluation of the most intense high-intensity running period in English FA premier league soccer matches. *The Journal of Strength & Conditioning Research*, 27(4), 909-915. doi:10.1519/JSC.0b013e31825ff099
40. Di Prampero, P. E., Fusi, S., Sepulcri, L., Morin, J. B., Belli, A., & Antonutto, G. (2005). Sprint running: a new energetic approach. *Journal of experimental Biology*, 208(14), 2809-2816. doi:10.1242/jeb.01700
41. Di Salvo, V., Baron, R., Tschan, H., Montero, F. C., Bachl, N., & Pigozzi, F. (2007). Performance characteristics according to playing position in elite soccer. *International journal of sports medicine*, 28(03), 222-227. doi:10.1055/s-2006-924294
42. Drew, M. K., & Finch, C. F. (2016). The relationship between training load and injury, illness and soreness: a systematic and literature review. *Sports medicine*, 46(6), 861-883. doi:10.1007/s40279-015-0459-8

43. Fessi, M. S., Zarrouk, N., Di Salvo, V., Filetti, C., Barker, A. R., & Moalla, W. (2016). Effects of tapering on physical match activities in professional soccer players. *Journal of sports sciences*, 34(24), 2189-2194. doi:10.1080/02640414.2016.1171891
44. Fox, R., Patterson, S. D., & Waldron, M. (2017). The relationship between heart rate recovery and temporary fatigue of kinematic and energetic indices among soccer players. *Science and Medicine in Football*, 1(2), 132-138. doi:10.1080/24733938.2017.1329590
45. Fransson, D., Nielsen, T. S., Olsson, K., Christensson, T., Bradley, P. S., Fatouros, I. G., ... & Mohr, M. (2018). Skeletal muscle and performance adaptations to high-intensity training in elite male soccer players: speed endurance runs versus small-sided game training. *European journal of applied physiology*, 118(1), 111-121. doi:10.1007/s00421-017-3751-5
46. Gabbett, T. J., & Whiteley, R. (2017). Two training-load paradoxes: can we work harder and smarter, can physical preparation and medical be teammates?. *International journal of sports physiology and performance*, 12(Suppl 2), S2-50. doi:10.1123/ijspp.2016-0321
47. Gabbett, T. J., Kennelly, S., Sheehan, J., Hawkins, R., Milsom, J., King, E., ... and Ekstrand, J. (2016). If overuse injury is a 'training load error', should undertraining be viewed the same way? *British Journal of Sports Medicine*, 50(17), 1017-8. doi:10.1136/bjsports-2016-096308
48. Gaudino, P., Iaia, F. M., Strudwick, A. J., Hawkins, R. D., Alberti, G., Atkinson, G., y Gregson, W. (2015). Factors influencing perception of effort (session rating of perceived exertion) during elite soccer training. *International journal of sports physiology and performance*, 10(7), 860-864. doi:10.1123/ijspp.2014-0518
49. Giménez, J. V., Del-Coso, J., Leicht, A. S., and Gómez, M. A. (2017). Comparison of the movement patterns between small-and large-side games training and competition in professional soccer players. *The Journal of Sports Medicine and Physical Fitness*. doi:10.23736/S0022-4707.17.07343-1
50. Halouani, J., Chtourou, H., Gabbett, T., Chaouachi, A., & Chamari, K. (2014). Small-sided games in team sports training: a brief review. *The journal of*

strength & conditioning research, 28(12), 3594-3618. doi:10.1519/JSC.0000000000000564

51. Hill-Haas, S. V., Coutts, A. J., Rowsell, G. J., & Dawson, B. T. (2009). Generic versus small-sided game training in soccer. *International journal of sports medicine,* 30(09), 636-642. doi:10.1055/s-0029-1220730
52. Issurin, V. B. (2010). New horizons for the methodology and physiology of training periodization. *Sports medicine*, 40(3), 189-206. doi:10.2165/11319770-000000000-00000
53. Katz J., & Katz L. (1999). Power laws and athletic performance. *Journal of Sports Sciences*, 17(6), 467-476.
54. Krustrup, P., Mohr, M., Ellingsgaard, H. E. L. G. A., & Bangsbo, J. (2005). Physical demands during an elite female soccer game: importance of training status. *Medicine and science in sports and exercise*, 37(7), 1242. doi:10.1249/01.mss.0000170062.73981.94
55. Lacome, M., Simpson, B. M., Cholley, Y., Lambert, P., & Buchheit, M. (2018). Small-Sided Games in Elite Soccer: Does One Size Fit All?. *International journal of sports physiology and performance*, 13(5), 568-576. doi:10.1123/ijspp.2017-0214
56. Mallo, J. (2015). *Complex Football*. Madrid: Topprosoccer.
57. Mallo, J., & Dellal, A. (2012). Injury risk in professional football players with special reference to the playing position and training periodization. *The Journal of sports medicine and physical fitness*, 52(6), 631-638.
58. Mallo, J., Mena, E., Nevado, F., & Paredes, V. (2015). Physical demands of top-class soccer friendly matches in relation to a playing position using global positioning system technology. *Journal of human kinetics*, 47(1), 179-188. doi:10.1515/hukin-2015-0073
59. Malone, J. J., Di Michele, R., Morgans, R., Burgess, D., Morton, J. P., y Drust, B. (2015). Seasonal training-load quantification in elite English premier league soccer players. *International journal of sports physiology and performance*, 10(4), 489-497. doi:10.1123/ijspp.2014-0352
60. Malone, S., Owen, A., Mendes, B., Hughes, B., Collins, K., & Gabbett, T. J. (2018). High-speed running and sprinting as an injury risk factor in soccer: Can well-

developed physical qualities reduce the risk?. *Journal of science and medicine in sport*, 21(3), 257-262. doi:10.1016/j.jsams.2017.05.016

61. Malone, S., Solan, B., Hughes, B., and Collins, K. (2017). Duration specific Running performance in Elite Gaelic Football. *The Journal of Strength & Conditioning Research*. doi:10.1519/JSC.0000000000001972
62. Matveev, L. P. (2001). *Teoría general del entrenamiento deportivo*. Barcelona: Editorial Paidotribo.
63. Mohr, M., Krustrup, P., Andersson, H., Kirkendal, D., & Bangsbo, J. (2008). Match activities of elite women soccer players at different performance levels. The *Journal of Strength & Conditioning Research*, 22(2), 341-349. doi:10.1519/JSC.0b013e318165fef6
64. Nedelec, M., McCall, A., Carling, C., Legall, F., Berthoin, S., & Dupont, G. (2014). The influence of soccer playing actions on the recovery kinetics after a soccer match. *The Journal of Strength & Conditioning Research*, 28(6), 1517-1523. doi:10.1519/JSC.0000000000000293
65. Osgnach, C., Poser, S., Bernardini, R., Rinaldo, R., & Di Prampero, P. E. (2010). Energy cost and metabolic power in elite soccer: a new match analysis approach. *Medicine & Science in Sports & Exercise*, 42(1), 170-178. doi:10.1249/MSS.0b013e3181ae5cfd
66. Owen, A. L., Djaoui, L., Newton, M., Malone, S., & Mendes, B. (2017). A contemporary multi-modal mechanical approach to training monitoring in elite professional soccer. *Science and Medicine in Football*, 1(3), 216-221. doi:10.1080/24733938.2017.1334958
67. Randers, M.B., Ørntoft, C., Hagman, M., Nielsen, J.J., & Krustrup, P. (2018). Movement pattern and physiological response in recreational small-sided football–effect of number of players with a fixed pitch size. *Journal of sports sciences*, 36(13), 1549-1556. doi:10.1080/02640414.2017.1402552
68. Ryan, D., Lewin, C., Forsythe, S., & McCall, A. (2018). Developing world-class soccer players: an example of the academy physical development program from an english premier league team. *Strength & Conditioning Journal*, 40(3), 2-11. doi:10.1519/SSC.0000000000000340

69. Roca, A. (2008). *El proceso de entrenamiento en el fútbol. Metodología de trabajo en un equipo profesional (FC Barcelona)*. Barcelona: Colección: Preparación futbolística. MC sports.
70. Seirul·lo, F. (1987). Opción de planificación en los deportes de equipo de largo período de competición. *Revista de Entrenamiento Deportivo*, 1, 3.
71. Seirul·lo, F. (1998). Planificación a largo plazo en los deportes colectivos. Curso sobre entrenamiento deportivo en la infancia y la adolescencia. Canarias: Escuela Canaria del Deporte. Dirección General de Deportes del Gobierno de Canarias.
72. Seirul·lo, F. (2002). La Preparación Física en Deportes de Equipo. Entrenamiento estructurado. Jornada sobre Rendimiento Deportivo. Dirección general del deporte. Valencia (Spain).
73. Seirul·lo, F. (2005). Master Profesional en Alto Rendimiento Deportivo Deportes de Equipo. Notas de clase del Módulo: *"Planificación del entrenamiento en los deportes de equipo"*. Barcelona: Byomedic y Fundación F. C. Barcelona.
74. Seirul·lo, F. (2011). Master Profesional en Alto Rendimiento Deportivo Deportes de Equipo. Notas de clase del Módulo: *"Planificación del entrenamiento en los deportes de equipo"*. Barcelona: Byomedic y Fundación F. C. Barcelona.
75. Seirul·lo, F. (2015). II Congreso Internacional en Optimización del Entrenamiento y Readaptación Físico Deportiva. Entrenamiento Estructurado. Sevilla: Dogesport.
76. Seirul·lo, F. (2012). Competencias: desde la Educación Física al Alto Rendimiento. *Revista de Educación Física*, 128, 5-8.
77. Seirul·lo, F. (2017). *El entrenamiento en los deportes de equipo*. Barcelona: Librería deportiva.
78. Seirul·lo, F. (2000). Una línea de trabajo distinta. I Jornadas de Actualización de Preparadores Físicos de futbol. Comité olímpico español.
79. Stevens, T. G., de Ruiter, C. J., Twisk, J. W., Savelsbergh, G. J., & Beek, P. J. (2017). Quantification of in-season training load relative to match load in professional Dutch Eredivisie football players. *Science and Medicine in Football*, 1(2), 117-125. doi:10.1080/24733938.2017.1282163

80. Tarragó, J. R., Massafred, M., Seirul·lo, F. y Cos, F. (2019). Metodologia d'entrenament en el Futbol Club Barcelona: L'Entrenament Estructurat. *Apunts. Educación física y deportes*. Ahead of print.
81. Varley, M. C., Elias, G. P., & Aughey, R. J. (2012). Current match-analysis techniques' underestimation of intense periods of high-velocity running. *International journal of sports physiology and performance*, 7(2), 183-185. doi:10.1123/ijspp.7.2.183
82. Verkhoshansky, Y. (2002) *Teoría y metodología del entrenamiento deportivo. Barcelona*. Editorial Paidotribo.
83. Winter, E. M., & Maughan, R. J. (2009). Requirements for ethics approvals. 27: 985. doi:10.1080/02640410903178344