UNIVERSIDAD SAN JORGE
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ANÁLISIS MULTIFACTORIAL DE LA CARGA DE ENTRENAMIENTO INDIVIDUAL EN JUGADORES DE FÚTBOL PROFESIONAL.

IMPORTANCIA DEL USO DE LA TECNOLOGÍA GPS EN EL FÚTBOL PROFESIONAL.

Adrián Díez Camín

TESIS DOCTORAL

Villanueva de Gállego, 2025

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entregada por

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Villanueva de Gállego, 5 de diciembre de 2025

"Camina hacia el futuro, abriendo nuevas puertas y probando cosas nuevas, sé curioso... porque nuestra curiosidad siempre nos conduce por nuevos caminos"
Walt Disney

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Quiero expresar mi más profundo agradecimiento a mi familia, directores, autores y entidades involucradas en la presente Tesis Doctoral.

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ABREVIATURAS

ACC: Aceleraciones >3 m/s²
Acc 2-4: Aceleraciones entre 2 y 4 m/s²
Acc +4: Aceleraciones superiores a 4 m/s²
AD: Duelos aéreos
ADW: Duelos aéreos ganados
AZP: Pases en zona de ataque
BMI: Índice de masa corporal
CD: Defensas centrales
CL: Despejes
CR: Centros
CRS: Centros exitosos
DEC: Deceleraciones <-3 m/s²
Dec -2-4: Deceleraciones entre -2 y -4 m/s²
Dec -4: Deceleraciones superiores a -4 m/s²
DIST +21: Distancia recorrida a más de 21 km/h
DIST +24: Distancia recorrida a más de 24 km/h
DR: Regates
DV: Volumen defensivo
EPTS: Sistemas Electrónicos de Seguimiento del Rendimiento
ES: Tamaño del efecto
FP: Pases hacia adelante
FPS: Pases hacia adelante exitosos
FW: Delanteros
GI: Indicadores generales
GNSS: Sistema Global de Navegación por Satélite
GPS: Sistema de Posicionamiento Global
GS: Tiros a portería
GST: Tiros a portería entre los tres palos
GV: Volumen de juego
HMLD: Distancia recorrida en acciones de alta carga metabólica
HSR: Carrera a alta velocidad, >19,8 km/h
IN: Intercepciones
KPIs: Indicadores Clave de Rendimiento
LPS: Sistema de Posicionamiento Local
LSG: Juegos en espacio grande
MD: Día de partido
MD-1, MD-2, MD-3, MD-4, MD-5: Días previos al partido
MEMS: Sistemas Microelectromecánicos
MID: Centrocampistas
MSG: Juegos en espacio medio
MSR: Carrera a velocidad moderada, >14,4 km/h
OI: Indicadores ofensivos
OMF: Centrocampistas ofensivos
OPIN: Intercepciones en campo contrario
OV: Volumen ofensivo
RPE: Percepción Subjetiva del Esfuerzo
SPR: Carrera a velocidad >25 km/h
SSG: Juegos en espacio reducido
TD: Distancia total
TIPO: Tipo de tarea de entrenamiento
TO: Pérdidas de balón
TP: Pases totales
TPS: Pases totales exitosos
VTS: Sistema de Seguimiento por Vídeo
WD: Defensas laterales
WP: Jugadores de banda
WCS: Escenarios de máxima exigencia

PREÁMBULO

La Tesis doctoral que se va a desarrollar a continuación está estructurada por los siguientes nueve apartados:

En primer lugar, se incluye un PREÁMBULO en el que se explica el contenido de cada uno de los apartados que conforman la presente memoria. Además, se presenta el listado de artículos que integran el compendio. En el apartado 1. INTRODUCCIÓN se presenta una revisión sobre la evolución del fútbol a lo largo de la historia, las demandas condicionales que surgen durante su práctica, la relevancia de la monitorización de la carga de entrenamiento y, finalmente, la importancia del uso de la tecnología GPS en el fútbol actual para optimizar el rendimiento de los deportistas. El apartado 2. JUSTIFICACIÓN, OBJETIVOS E HIPÓTESIS presenta el objetivo principal de la tesis, así como los objetivos secundarios, los cuales se muestran asociados a su correspondiente artículo. En el apartado 3. MATERIAL Y MÉTODOS describe los recursos utilizados y las metodologías aplicadas en los estudios realizados. El apartado 4. RESULTADOS presenta, en primer lugar, los artículos de investigación íntegros, respetando el formato original con el que fueron publicados en las revistas científicas. Posteriormente, se incluye una tabla que sintetiza los hallazgos principales de cada uno de los artículos que conforman la tesis. El apartado 5. DISCUSIÓN compara los resultados obtenidos sobre las demandas condicionales y analiza su relación con la monitorización de la carga de entrenamiento. En el apartado 6. LIMITACIONES, se presentan las dificultades encontradas durante la realización de los distintos estudios de nuestro compendio de artículos. El apartado 7. CONCLUSIONES destaca las principales conclusiones obtenidas en los estudios presentados. En el apartado 8. APLICACIONES PRÁCTICAS se presentan posibles aplicaciones prácticas para ayudar a los profesionales de fútbol en su día a día. En el apartado 9. IDEAS DE FUTURO se marcan algunas líneas de estudio por las que podría continuar esta investigación. Las referencias bibliográficas utilizadas para la redacción de la presente Tesis Doctoral aparecen en el apartado 10. REFERENCIAS. En el último apartado, 11. ANEXOS, se adjunta información correspondiente a la presenta memoria de Tesis Doctoral como los informes del dictamen favorable del Comité de Ética de la Investigación de la Comunidad Autónoma de Aragón: CEICA o los consentimientos informados para los participantes.

RESUMEN

En las últimas décadas, el fútbol ha experimentado una transformación significativa tanto en el ámbito condicional como en el técnico-táctico, impulsada, entre otros factores, por avances tecnológicos, científicos y metodológicos. La incorporación de sistemas de análisis de datos y herramientas de seguimiento como los sistemas GPS ha permitido una comprensión más precisa de las demandas condicionales y técnico-tácticas del juego, lo que ha derivado en entrenamientos más individualizados y orientados al rendimiento específico. La globalización del deporte y la profesionalización de las estructuras de formación han favorecido la homogenización de estilos de juego, aunque persisten adaptaciones culturales y estratégicas según las ligas y contextos. Además, el incremento en la velocidad del juego y la intensidad de las acciones ha exigido una preparación física más específica, así como protocolos avanzados de recuperación para reducir el riesgo de lesiones. En este sentido, la evolución del fútbol no solo se refleja en la dinámica competitiva, sino también en la integración de la ciencia aplicada al deporte, consolidando un modelo que prioriza la optimización del rendimiento y la sostenibilidad física del jugador.

El objetivo principal de esta investigación doctoral fue analizar la relación entre las variables de carga externa mediante la monitorización multifactorial y las demandas fisiológicas en fútbol en entrenamiento y en competición, considerando la influencia de las dimensiones o el espacio de la tarea, la demarcación específica del jugador y el grado de uniformidad de las cargas a lo largo de la temporada.

Para alcanzar dicho objetivo se realizaron tres estudios plasmados en los artículos de la presente tesis doctoral:

I. Influencia de los factores contextuales en las demandas físicas y las acciones técnico-tácticas en relación con la demarcación de juego en futbolistas profesionales (**Artículo 1**);
II. Comparación de los escenarios de máxima exigencia entre las semanas de entrenamiento y las de competición para cada demarcación en una temporada de fútbol de élite (**Artículo 2**);
III. Tareas de entrenamiento vs demandas del partido: ¿Replican las tareas de entrenamiento en fútbol los escenarios de máxima exigencia? (**Artículo 3**).

Los principales hallazgos de la presente tesis doctoral son:

I. Las demandas físicas y las acciones técnico-tácticas en competición varían cuando se consideran factores contextuales del juego, en este caso, la localización del partido y el resultado final.
    a. Así, una mayor distancia total recorrida y un mayor número de acciones de aceleración y desaceleración podrían estar relacionadas con jugar como local y perder, tanto para todos los jugadores como específicamente para centrocampistas y delanteros.
    b. Además, se observa un mayor número de sprints cuando el equipo juega como local y gana, en todas las demarcaciones
    c. Asimismo, se registran mayores valores de volumen de juego, volumen defensivo y nº de intervenciones, cuando el equipo juega como local y gana, tanto para todos los jugadores como, de manera específica, para centrocampistas y delanteros.
    d. Finalmente, se registran mayores valores de pases hacia delante y nº total de pases en zona de ataque cuando el equipo juega como visitante y pierde.

II. Durante el microciclo, los escenarios de alta exigencia suelen ocurrir en el día de partido.
    a. A lo largo del microciclo, no se encontraron diferencias significativas en ninguna de las demarcaciones analizadas en la variable de distancia total.
    b. Sin embargo, en todas las demarcaciones, excepto en defensas centrales, se hallaron diferencias significativas en los días de entrenamiento en las variables de distancia recorrida a velocidad > 21 km/h y distancia recorrida a velocidad > 24 km/h respecto al partido.
    c. En la demarcación de centrocampistas, el cuarto entrenamiento previo al partido presentó valores más altos que el día de partido en aceleraciones > 3 m/s². Además, en desaceleraciones < -3 m/s², el día pre-partido mostró valores superiores al día de partido en la demarcación de centrocampistas y delanteros.

d. Finalmente, para la variable distancia con alta carga metabólica, los valores del día pre-partido fueron significativamente menores en comparación con el día de partido en todas las demarcaciones.

III. Las tareas de entrenamiento realizadas no replican completamente los escenarios de máxima exigencia observados durante la competición. No obstante, algunas tareas muestran una mayor aproximación a estas demandas, especialmente en términos de aceleraciones y desaceleraciones. Además, las exigencias condicionales relacionadas con la carrera a alta velocidad y el sprint fueron, en la mayoría de las tareas, inferiores al 60% de los valores registrados en competición.

Palabras clave: monitorización, GPS, demandas condicionales, escenarios de máxima exigencia, demarcación.

ABSTRACT

In recent decades, football has undergone a significant transformation both in the physical and tactical domains, driven by technological, scientific, and methodological advances. The incorporation of data analysis systems and GPS tracking tools has enabled a more precise understanding of the conditional and technical-tactical demands of the game, leading to more individualized and performance-oriented training. The globalization of the sport and the professionalization of development structures have promoted the homogenization of playing styles, although cultural and strategic adaptations persist across leagues and contexts. Furthermore, the increase in game speed and action intensity has required more specific physical preparation, as well as advanced recovery protocols to reduce injury risk. In this regard, the evolution of football is reflected not only in competitive dynamics but also in the integration of applied sports science, consolidating a model that prioritizes performance optimization and the physical sustainability of players.

The main objective of this doctoral thesis was to analyse the relationship between the multifactorial monitoring of external training load and physiological demands in football, considering the influence of task dimensions, the player's specific position, and the uniformity of loads throughout the season.

To achieve this objective, three studies were carried out and presented in the articles of this doctoral thesis:

I. Influence of contextual factors on physical demands and technical-tactical actions in relation to playing position in professional football players (**Article 1**);
II. Comparison of peak demand scenarios between training weeks and competition weeks for each position during an elite football season (**Article 2**);
III. Training tasks vs match demands: Do football training tasks replicate peak demand scenarios? **(Article 3)**.

The main findings of this doctoral thesis are:

I. Physical demands and technical-tactical actions in competition vary when considering contextual factors of the game, in this case match location and final result.
    a. Thus, a greater total distance covered, and a higher number of acceleration and deceleration actions could be related to playing at home and losing, both for all players and specifically for midfielders and forwards.
    b. In addition, a higher number of sprints is observed when the team plays at home and wins, across all positions.
    c. Likewise, higher values of game volume, defensive volume, and number of interventions are recorded when the team plays at home and wins, both for all players and specifically for midfielders and forwards.
    d. Finally, higher values of forward passes and total number of passes in the attacking zone are recorded when the team plays away and loses.

II. During the microcycle, high-demand scenarios usually occur on match day.
    a. Throughout the microcycle, no significant differences were found in any of the positions analysed for the variable of total distance.
    b. However, in all positions except central defenders, significant differences were found on training days in the variables of distance covered at speeds > 21 km/h and distance covered at speeds > 24 km/h compared to match day.
    c. In the midfielder position, the fourth training session prior to the match showed higher values than match day in accelerations > 3 m/s^2. Furthermore, in decelerations < -3 m/s^2, the day before the match showed higher values than match day for midfielders and forwards.
    d. Finally, for the variable distance with high metabolic load, the values on the day before the match were significantly lower compared to match day across all positions.

III. The training tasks performed do not fully replicate the peak demand scenarios observed during competition. However, some tasks show a closer approximation to these demands, especially in terms of accelerations and decelerations. In addition, conditional demands related to high-speed running

and sprinting were, in most tasks, below 60% of the values recorded in competition.

Keywords: monitoring, GPS, physical demands, worst-case scenarios, playing position

1 INTRODUCCIÓN

1.1 El fútbol

Desde su perspectiva más simple, el éxito en el fútbol se basa en la capacidad de marcar un mayor número de goles que el equipo contrario durante un partido [1,2]. En particular, el primer gol en un encuentro [3–5] y un número reducido de goles encajados, especialmente durante la segunda mitad de la temporada, se han asociado con el éxito en el fútbol [5].

El fútbol moderno se caracteriza, en el componente condicional, por sus demandas físicas intermitentes y de alta intensidad, que requieren que los jugadores realicen repetidas series de sprints, cambios de dirección, saltos y contactos físicos, intercalados con actividades de menor intensidad. Estos esfuerzos obedecen a la ejecución de acciones tácticas y técnicas dictadas por las demandas cambiantes del juego tanto en las fases ofensivas como defensivas [6].

1.1.1 La tecnología en el fútbol

En los últimos años, los avances tecnológicos han permitido el desarrollo de herramientas que facilitan el trabajo en el ámbito deportivo [7]. En el deporte, estas herramientas permiten un control de la carga de trabajo de los atletas. Esto brinda la posibilidad de diferenciarlas en dos grupos principales: 1) tecnologías para el control de la carga externa del atleta y 2) tecnologías para el control de la carga interna del atleta [8–13]. La carga externa se define como las medidas objetivas de la actividad realizada por el atleta durante el entrenamiento y la competición, por ejemplo, velocidad, aceleración, fuerza, potencia... entre otras [14]. La carga interna se define como las respuestas psicofisiológicas de los atletas ante el ejercicio físico. La carga interna incluye medidas psicológicas como las obtenidas a partir de la percepción subjetiva del esfuerzo (RPE), y medidas fisiológicas como la frecuencia cardíaca, el lactato sanguíneo o el consumo de oxígeno [11,15]. Aunque pueden estar estrechamente relacionadas, las cargas externas se evalúan de manera independiente de las cargas internas [14]. Gracias a las tecnologías de control de carga, podemos individualizar y optimizar el entrenamiento, y reducir el riesgo de posibles lesiones [16–19].

Una de las tecnologías más utilizadas para monitorizar la carga externa en deportes de equipo son los dispositivos con sistemas electrónicos de seguimiento del rendimiento (EPTS) [20]. Estos se dividen a su vez en 3 grupos principales: 1) Sistemas de Posicionamiento Global (GPS), 2) Sistemas de Posicionamiento Local (LPS) y 3) Sistemas de Seguimiento por Vídeo (VTS) [19,21]. Estas tecnologías también pueden combinarse actualmente con sistemas de medición microelectromecánicos (MEMS), haciendo uso de sensores inerciales [22], que suelen consistir en acelerómetros que hacen que los dispositivos sean mucho más avanzados y puedan proporcionarnos muchas más medidas para el análisis del ejercicio. Estos dispositivos ofrecen métricas que complementan los sistemas de seguimiento, como aceleraciones, deceleraciones, giros, cambios de dirección, saltos, impactos o carga del jugador (definida como la acumulación de aceleraciones en los tres ejes del espacio) [23,24].

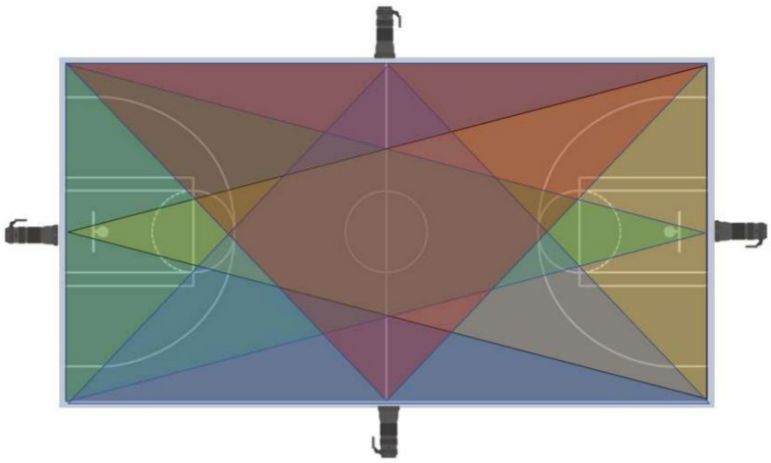

Ilustración 1. Registro del posicionamiento con VTS. Extraída de Rico-González et al. (2019)[25]

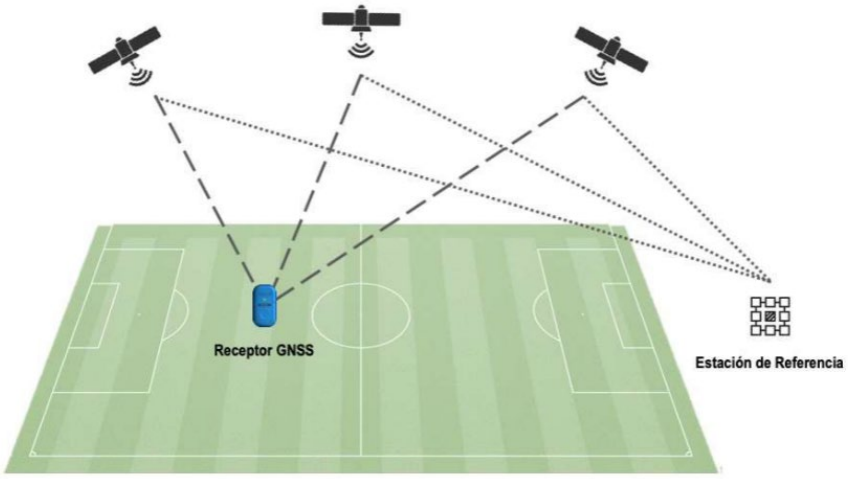

Ilustración 2. Registro del posicionamiento con GPS/GNSS. Extraída de Rico-González et al. (2019)[25]

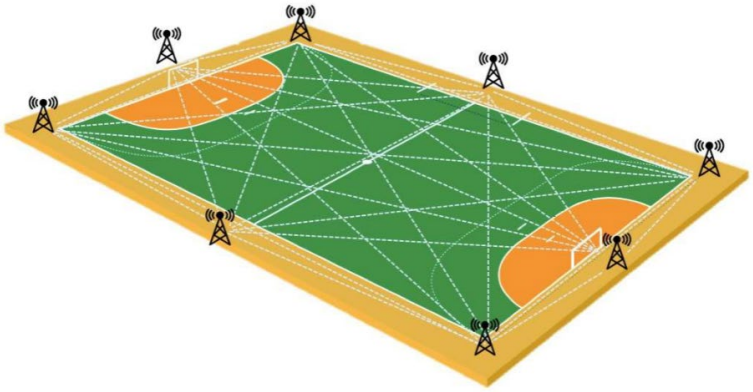

Ilustración 3. Registro del posicionamiento con LPS. Extraída de Rico-González et al. (2019)[25]

Gracias a esta aparición de tecnologías de seguimiento por GPS y el análisis de vídeo ha sido posible la cuantificación de las demandas físicas durante partidos de élite. Dichos análisis han identificado métricas clave de rendimiento que subrayan la naturaleza explosiva y metabólicamente exigente de la competición, proporcionando valores de referencia esenciales para alinear las tareas de entrenamiento con las demandas del partido [26].

1.1.2 La monitorización de la carga de entrenamiento

Explicar la relación entre las cargas físicas o condicionales inducidas por el entrenamiento y las demandas físicas máximas experimentadas por los jugadores durante la competición se ha convertido en un requisito crítico para el desarrollo de programas de entrenamiento optimizados para el rendimiento y basados en la evidencia [27].

Desde hace varios años, en el fútbol se han cuantificado las demandas físicas durante los entrenamientos y los partidos para organizar el entrenamiento en función de las demandas proporcionadas por los datos extraídos de las competiciones [22,28–43].

Como es obvio, la distribución de la carga a lo largo de la semana de competición puede producir una variación en la carga de entrenamiento. Esta variación puede estar influenciada por el tipo de programa semanal, el estado inicial del jugador, las demarcaciones de juego, el grupo de edad, el modo de entrenamiento y los factores contextuales [44], entro otros factores. También puede estar influenciada por el tipo de tareas utilizadas durante el entrenamiento, ya que normalmente el día con mayor carga corresponde al día con mayor número de tareas o la mayor duración de algunas tareas de

carácter competitivo realizadas, las cuales deberían realizarse 72 horas antes del día de partido [45] para no influir negativamente en el rendimiento en competición.

La individualización del entrenamiento es un principio clave para maximizar la adaptación y minimizar el riesgo de sobreentrenamiento [46] . Un factor crítico en este proceso de optimización es la consideración de las demandas físicas específicas asociadas a cada demarcación en el campo. Las responsabilidades tácticas y los patrones de movimiento inherentes a las diferentes demarcaciones resultan en perfiles diferenciados de demanda física [47,48]. Además, incluso dentro de la misma demarcación, los jugadores, de acuerdo con sus características individuales pueden presentar perfiles de rendimiento variables. Ignorar estas variaciones posicionales o no proporcionar estímulos de entrenamiento adecuados para aspectos clave de la preparación física al diseñar las tareas de entrenamiento puede conducir a una preparación insuficiente para las demandas específicas del partido, aumentando así el riesgo de sobreentrenamiento o lesión [46].

1.1.3 Los indicadores clave de rendimiento

Entrenadores e investigadores han intentado identificar estrategias para mejorar la efectividad táctica tanto en el área rival (es decir, para marcar goles) como en la propia área (es decir, para evitar encajar goles) [49] mediante el empleo de indicadores clave de rendimiento (KPIs) [50–53]. Los KPIs facilitan el análisis objetivo del rendimiento durante un partido y se definen como las variables que determinan los aspectos físicos y técnico-tácticos que contribuyen al éxito [54]. Por lo tanto, uno de los principales objetivos cuando se trabaja en fútbol de élite debería ser la correcta identificación de los KPIs que aumentan la probabilidad de ganar un partido, ya que ello contribuiría a optimizar el entrenamiento y la competición en fútbol [1].

En el fútbol de élite, la precisión al intentar el gol, seguida del número de intentos, el porcentaje de tiempo de posesión del balón y la precisión en el pase, se identifican como acciones clave al analizar el rendimiento [55]. Se ha identificado que los equipos exitosos utilizan la posesión del balón para atacar la portería rival, mientras que los equipos no exitosos intentan mantener la posesión para evitar ser atacados [56]. Una mayor posesión global del balón cerca del área rival se ha identificado como un buen indicador de éxito, ya que existen mayores posibilidades de marcar y, por tanto, de ganar [52].

1.1.4 Los factores contextuales

El hecho de afrontar el partido como equipo local o visitante también puede influir en el marcador final. Por ejemplo, existen estudios que afirman que jugar como local ayuda a obtener valores superiores en distancias a baja intensidad (<14,1 km/h) respecto a jugador visitante [57]. En un análisis más profundo se sugiere que la identificación de las acciones de juego que predicen el rendimiento en fútbol debería contextualizarse en función del rol que desempeña el equipo (esto es, local vs visitante), ya que quizás jugar como local incrementa sus posibilidades de ganar [50]. Sin embargo, la localización del partido parece no tener influencia en las zonas de velocidad del rendimiento físico (0–11 y 11,1–14 km/h) considerando tanto el tiempo total como el tiempo efectivo de juego [58]. Dada la controversia existente en torno a la influencia de la localización del partido sobre las demandas físicas y técnico-tácticas, parece apropiado analizar ambas en jugadores de fútbol de élite para ayudar a los entrenadores a diseñar y estructurar adecuadamente sus rutinas semanales [59].

Parece ser que, para intentar aclarar la interacción entre las variables físicas, conductuales, técnicas y tácticas del rendimiento en fútbol considerando el contexto del partido [29], podría ser necesaria una investigación holística.

1.1.5 Los factores condicionales

La relación existente entre los esfuerzos físicos realizados en un partido y su vinculación con el éxito ha sido ampliamente examinada en las principales ligas europeas de fútbol [60–63] y en los campeonatos de la Copa del Mundo [64,65]. Aparentemente, las demandas físicas son un pobre indicador para determinar el éxito de un equipo a lo largo de una temporada o campeonato. En este sentido, trabajos previos concluyeron que los equipos situados en el top 5 de la Serie A italiana y la Premier League inglesa recorrieron menos distancia total a menor intensidad que el resto de los equipos [61,62].

Hallazgos similares se encontraron en la Bundesliga alemana y en LaLiga española, donde no existe correlación entre la posición final en la clasificación, la distancia total recorrida y la intensidad de los esfuerzos [60,63]. Para determinar el éxito en los equipos, podría ser necesaria una perspectiva holística que incluya las habilidades técnico-tácticas, ya que se consideran esenciales dentro del rendimiento en fútbol [61].

El fútbol, en términos de capacidades condicionales, se considera un deporte de equipo en el cual las acciones explosivas pueden ser determinantes durante el juego. Además, está caracterizado por la repetición de períodos intermitentes de esfuerzos anaeróbicos, intercalados con largos períodos de recuperación [66–68]. Estos períodos intermitentes de esfuerzo anaeróbico incluirían sprints repetidos, aceleraciones y deceleraciones rápidas, cambios de dirección, saltos, lanzamientos y acciones posteriores a los saltos [69]. Todas estas demandas son únicas en cada contexto e impredecibles tanto en intensidad como en duración [70].

Las demandas físicas solicitadas por los futbolistas durante los partidos son muy conocidas [28], aunque también se sabe que, en función de la demarcación de juego y las características del jugador, estas demandas pueden variar, bien por las diferentes demandas físicas que tiene cada demarcación dentro del campo [70,71] o bien por los diferentes sistemas de juego que pueden ser utilizados por los entrenadores durante la temporada [72]. Estos hallazgos nos muestran la importancia de tener que individualizar tanto por deportista como por demarcación [28,68]. y por modelo de juego.

Las métricas que se encuentran principalmente en los estudios científicos en fútbol son las demandas de:

- Distancia total [17,30,35–39,41,42,66,68,73–76], definida como la suma de todos los metros recorridos por el jugador durante el partido o la sesión de entrenamiento, independientemente de la intensidad o velocidad.
- Distancia recorrida a alta velocidad [17,28,35–39,41,42,66–68,73–77], definida como la distancia cubierta por el jugador a velocidades superiores a un umbral específico (habitualmente >19,8 km/h o >21 km/h, según el dispositivo).
- Distancia de sprint [28,35–39,41,42,68,74–76], definida como la distancia recorrida a velocidades superiores al umbral de sprint (normalmente >24 km/h o >25 km/h, según el dispositivo).
- Número de sprints [67], definida como la cantidad de acciones en las que el jugador supera el umbral de velocidad definido para sprint.
- Número de aceleraciones y deceleraciones [17,28,35,36,74,75], definidas como el total de acciones en las que el jugador incrementa (>2 o >3 m/s^2) o reduce (<−2 o <−3 m/s^2) su velocidad de forma brusca.

- Distancia de aceleración y deceleración [19,41,42], definidas como los metros recorridos durante las fases de aceleración o desaceleración.
- Potencia metabólica [30,35,36,74,76], definida como la estimación del coste energético del movimiento, calculada a partir de la velocidad y la aceleración, expresada en vatios por kilogramo ($W \cdot kg^{-1}$).
- Distancia de alta carga metabólica (HMLD) [17,30,35,36,74,76], definida como los metros recorridos cuando la potencia metabólica supera un umbral de 25,5 $W \cdot kg^{-1}$.
- PlayerLoad^{TM} o Body-Load [16,67,68], definida como la métrica derivada de acelerómetros triaxiales que cuantifica la carga mecánica acumulada en los tres ejes del movimiento (vertical, lateral y anteroposterior).
- Velocidad máxima [67], definida como el valor más alto de velocidad alcanzado por el jugador durante el partido o entrenamiento.

1.1.6 Los escenarios de máxima exigencia (WCS)

Para cuantificar la carga de trabajo y programar las sesiones de entrenamiento semanales de manera individualizada y optimizada, el cuerpo técnico ha utilizado tradicionalmente datos promedio derivados de las demandas físicas obtenidas en los partidos de las variables condicionales seleccionadas. Por lo tanto, es importante considerar las demandas máximas al planificar las sesiones de entrenamiento. Sin embargo, el uso de estos promedios subestima las demandas máximas producidas en competición [41]. Para abordar esta subestimación, se empleó otro método que considera los momentos durante el partido en los que ocurren las mayores demandas físicas de cada variable. Este método se conoce como escenarios de máxima exigencia o worst case scenarios (WCS) [22,35,36,38,39,75]. Inicialmente, se comenzaron a analizar estos WCS con el método Fixed Length, método que consiste en dividir el total del partido en periodos fijos desde el inicio hasta el final del encuentro, por ejemplo, períodos de 1 minuto (0.00''-0.59'', 1.00''-1.59'', continuando de esta manera hasta el final del partido). Sin embargo, actualmente se utiliza el método Rolling Average o ventana móvil, que consiste en fijar los períodos cuando el WCS alcanza su intensidad máxima. Por ejemplo, la distancia máxima ocurre en el período entre 15.25'' y 16.25'' o el sprint máximo ocurre entre 24.49'' y 25.49'', y así sucesivamente con las variables a analizar [30,75].

Al identificar estos escenarios de máxima exigencia y replicarlos adecuadamente durante la semana de entrenamiento, se podría ayudar en la recuperación del jugador y reducir el riesgo de lesión [73]. Asimismo, utilizar el promedio del partido para analizar la carga de trabajo del jugador durante el encuentro y tener en cuenta la demarcación específica del jugador en el campo, también podría ayudar a la hora de analizar los WCS y prevenir lesiones [36,46].

Los WCS analizados comúnmente en fútbol pueden ser de 1 min, 3 min, 5 min o 10 min [22,39], pero reproducir el WCS de 1 min durante la sesión de entrenamiento podría servir para preparar a nuestros jugadores para las demandas máximas de la competición [42]). Existe una correlación muy elevada entre el tiempo del WCS y cada una de las variables condicionales aplicadas en el presente estudio (por ejemplo, variables relacionadas con distancias o aceleraciones, entre otras): cuanto más corto es el tiempo analizado, mayor es el WCS producido [22,30,32,34,35,38,41,73,75,77]. Por lo tanto, el WCS es mayor cuando se analizan tiempos de 1 min en comparación con 3 min, 5 min o 10 min. Finalmente, estos WCS podrían estar influenciados por factores contextuales inherentes al partido, como la demarcación del jugador, el desarrollo del encuentro en la primera o segunda parte, jugar el partido como local o visitante, o encontrarse en una situación de victoria, empate o derrota durante el partido [38,67,75].

1.1.7 Las tareas de entrenamiento

Dentro del contexto específico de las tareas de entrenamiento, es esencial evaluar su contribución al desarrollo de la capacidad para afrontar las demandas condicionales máximas del juego [78,79]. La manipulación de variables clave, como las dimensiones del campo, el número de jugadores implicados o el área relativa de juego por jugador (m^2 por jugador), influye significativamente en las demandas físicas generadas [80]. Cada tarea de entrenamiento provoca respuestas fisiológicas y neuromusculares distintas, con implicaciones variables para el desarrollo de las capacidades físicas de los jugadores [81]. Además, utilizar la estrategia de acumular volumen de entrenamiento por sí solo, no garantiza una preparación óptima para las fases más exigentes de la competición, es decir, para provocar respuestas fisiológicas y musculares a nuestros jugadores debemos de perseguir un objetivo concreto de entrenamiento. La selección de escenarios específicos de entrenamiento que repliquen las demandas físicas máximas del juego es, por tanto, un aspecto fundamental en el diseño de programas de entrenamiento verdaderamente

efectivos [46,82]. Esto requiere exponer a los jugadores a escenarios capaces de reproducir las intensidades observadas durante los momentos más exigentes físicamente de la competición [48]. La evidencia sugiere que los atletas adaptados a cargas de entrenamiento comparables a las demandas máximas de la competición pueden experimentar una menor incidencia de lesiones en comparación con aquellos expuestos a cargas de entrenamiento más bajas [27]. La progresión y periodización de las cargas de entrenamiento representan otro componente crítico para garantizar que los jugadores estén adecuadamente preparados para las fases más exigentes físicamente del juego [83]. Identificar estos WCS en las tareas permite optimizar e individualizar las cargas de entrenamiento, apoyando una planificación más precisa y específica para el rendimiento competitivo [73,84].

Los entrenadores emplean una amplia gama de tareas de entrenamiento, incluyendo juegos reducidos (SSG) y ejercicios de posesión específicos por posición, así como juegos de tamaño medio (MSG), juegos de tamaño grande (LSG), entrenamiento interválico de alta intensidad (HIIT), circuitos integrados físico-técnicos y entrenamiento específico de fuerza [78,81], además de tareas con un enfoque principalmente táctico o técnico. Los SSG, por ejemplo, se utilizan ampliamente debido a su capacidad para integrar componentes físicos, técnicos y tácticos dentro de un formato de alta intensidad [78,85,86]. Los LSG, que implican un mayor número de jugadores y dimensiones de campo más grandes, tienden a provocar mayores distancias totales recorridas [81]. El HIIT está diseñado para mejorar la capacidad de los jugadores para realizar y repetir esfuerzos de alta intensidad [78]. Aunque principalmente orientados al desarrollo de habilidades, los escenarios de entrenamiento técnico y táctico también contribuyen a la carga física total [81].

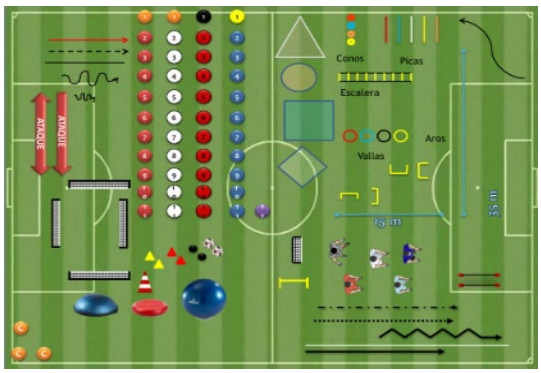

Ilustración 4. Plantilla para tarea de entrenamiento. Extraída de EntrenadorFutbol.com

2 JUSTIFACIÓN, OBJETIVOS E HIPÓTESIS

2.1 Justificación

En el ámbito del fútbol profesional, la optimización del rendimiento es un objetivo prioritario para entrenadores, preparadores físicos y demás profesionales implicados en la planificación y control del entrenamiento. Sin embargo, existe una carencia significativa de información científica sobre la relación entre la monitorización multifactorial de la carga externa y las demandas fisiológicas reales del juego, especialmente considerando variables como las dimensiones de la tarea, la demarcación específica del jugador y la uniformidad de las cargas a lo largo de la temporada.

Esta falta de evidencia limita la capacidad de diseñar entrenamientos que reproduzcan de manera precisa las exigencias competitivas, lo que puede derivar en sobrecargas o desajustes en la preparación física del jugador y del equipo. Además, comprender cómo influyen factores contextuales (localización del partido, resultado) y cómo se comparan los escenarios de máxima exigencia entre entrenamientos y competición permitirá a los profesionales ajustar las cargas de forma individualizada y optimizar el rendimiento.

Por tanto, esta investigación aporta un conocimiento esencial para mejorar la toma de decisiones en la planificación del entrenamiento, ofreciendo herramientas basadas en datos que permitan replicar las demandas más exigentes del juego en las tareas de entrenamiento. De este modo, se contribuye a cerrar una brecha existente en la literatura científica y a proporcionar información práctica y aplicable para el fútbol de élite.

2.2 Hipótesis

La carga externa de entrenamiento, medida mediante variables condicionales como distancias recorridas a altas velocidades, aceleraciones y desaceleraciones, se relaciona significativamente con las demandas físicas del partido en jugadores profesionales de fútbol, variando según la demarcación y las características de las tareas de entrenamiento.

2.3 Objetivos

2.3.1 Objetivo general

Analizar la relación entre las variables de la carga externa de entrenamiento obtenidas mediante la monitorización multifactorial y las demandas físicas en fútbol, considerando la influencia de las dimensiones de la tarea, la demarcación específica del jugador y la distribución de las cargas a lo largo de la temporada.

2.3.2 Objetivos específicos

- Analizar las demandas físicas y las acciones técnico-tácticas correspondientes a cada demarcación de juego, considerando la influencia de la localización del partido (jugar como local frente a como visitante) y el resultado final (victoria o derrota) en futbolistas profesionales.

- Analizar los escenarios de máxima demanda producidos durante el periodo competitivo a lo largo de la semana en diferentes sesiones de entrenamiento y compararlos con las demandas físicas de los partidos.

- Determinar qué tipos de tareas de entrenamiento replican mejor las demandas físicas de los escenarios de máxima demanda observados en partidos oficiales dentro de una ventana temporal de un minuto

3 MATERIAL Y MÉTODOS

El presente apartado muestra los principales materiales y métodos seguidos en los tres estudios que conforman la presente Tesis Doctoral.

En primer lugar, se desarrolló un estudio descriptivo aplicando una metodología observacional, realizada y reportada según los criterios STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) [87]. Respecto a los otros dos estudios que forman la presente Tesis Doctoral, también se utilizó la metodología observacional y descriptiva, la cual estuvo basada en la recogida de datos directamente de los participantes en los entrenamientos y en la competición [88] para posteriormente extraer conclusiones de ellos.

Todos los estudios de la Tesis Doctoral se realizaron gracias al convenio de investigación existente entre la Universidad San Jorge y el Real Zaragoza SAD.

El Comité de Ética de la Investigación de la Comunidad de Aragón, España (CEICA), aprobó la realización de los estudios pertenecientes a la presente memoria de Tesis Doctoral en el acta nº 04/2021 con licencia PI21/060. La investigación se realizó de acuerdo con la Declaración de Helsinki [89] y en cumplimiento de las normas éticas para la investigación en Ciencias del Deporte y el Ejercicio [90].

3.1 Participantes

La muestra de estos estudios estuvo formada por jugadores de élite de un club perteneciente a la 2ª división española de fútbol (Liga Hypermotion). Estos participantes, según el Participant Classification Framework [91], se clasifican como pertenecientes al tercer nivel competitivo, que corresponde a atletas altamente entrenados o de nivel nacional. La muestra de cada estudio se encuentra detallada en la Tabla 1 del presente documento.

Los participantes de estudio 1 fueron los pertenecientes a la plantilla de la temporada 2017/2018, los participantes de estudio 2 fueron los pertenecientes a la plantilla de la temporada 2020/2021 y, por último, los participantes de estudio 3 fueron los pertenecientes a la plantilla de la temporada 2021/2022.

Tabla 1. Muestra de todos los estudios

Estudio	Participantes
1. Influence of contextual factors on physical demands and technical-tactical actions regarding playing position in professional soccer players.	n = 21 (hombres) Nivel: Profesional edad: 25.1 ± 3.6 años altura: 170.3 ± 5.4 cm peso: 75.6 ± 6.4 kg BMI: 23.2 ± 1.2 kg/m^2 Entto: 9-10 horas/semana + partido
2. Comparison of the worst-case scenarios between training and competition weeks for each playing position in an elite football season.	n = 24 (hombres) Nivel: Profesional edad: 25.2 ± 4.5 años altura: 179.1 ± 5.9 cm peso: 75.0 ± 6.4 kg BMI: 23.3 ± 1.2 kg/m^2 Entto: 9-10 horas/semana + partido
3. Training tasks vs. match demands: Do football drills replicate Worst-Case Scenarios?	n = 23 (hombres) Nivel: Profesional edad: 26.6 ± 4.7 años altura: 179.3 ± 5.9 cm peso: 75.4 ± 5.4 kg BMI: 23.4 ± 0.9 kg/m^2 Ennto: 9-10 horas/semana + partido

BMI: índice de masa corporal; Entto: Entrenamiento

3.2 Instrumentos

En el estudio 1 las demandas físicas de los jugadores fueron monitorizadas durante cada partido de competición utilizando una unidad portátil de GPS de 18 Hz y un acelerómetro triaxial de 600 Hz (acelerómetro APEX pod, tecnología MAPPS y Bluetooth LE; STATSports; Irlanda del Norte). Estos dispositivos GPS tienen demostrada la validez, reproducibilidad y fiabilidad [92]. En cambio, las variables táctico-técnicas se obtuvieron de la herramienta de análisis Wyscout® (Chiavari, Italia). Este es un sistema informatizado de seguimiento con múltiples cámaras basado en la herramienta OPTA® (España) [1]. Las cámaras de los estadios, posicionadas en el nivel del techo, capturan las

acciones de los jugadores y estas son analizadas utilizando el software de OPTA® (España) [93]. La fiabilidad de OPTA® (España) se identificó con niveles aceptables, mostrando un coeficiente de correlación intraclase que varió de 0,88 a 1,00 [94]. Además, estas variables técnico-tácticas de Wyscout® han sido utilizadas y analizadas en estudios previos [1,95].

Ilustración 5. Dispositivo Apex Pro Series StatSports. Extraída de StatSports.com

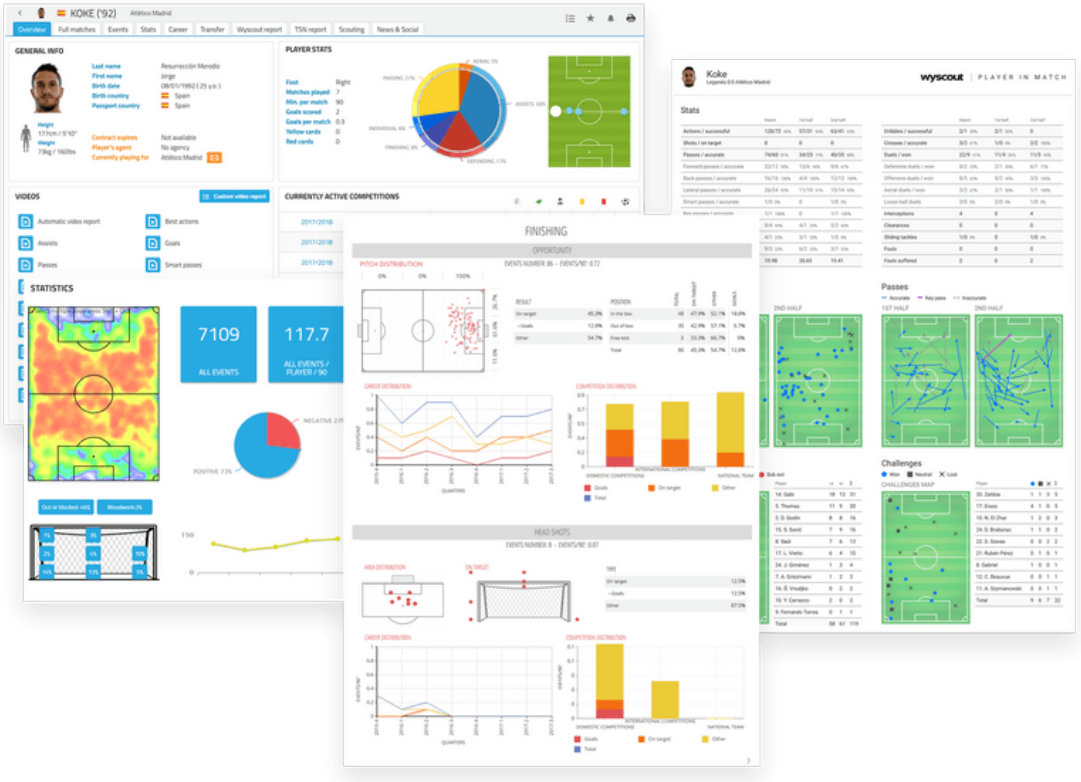

Ilustración 6. Herramienta de análisis Wyscout®. Extraída de Extraída de Hudl.com

En cambio, para el estudio 2 y el estudio 3 se recopilaron los datos con dispositivos de seguimiento GPS WIMU PRO™ (RealTrack Systems S.L., Almería, España), que cuentan con un GPS de 10 Hz y un acelerómetro triaxial con una frecuencia de 100 Hz. Los dispositivos WIMU PRO™ se consideran válidos y fiables para obtener métricas de posicionamiento derivadas de señales GPS en fútbol [96].

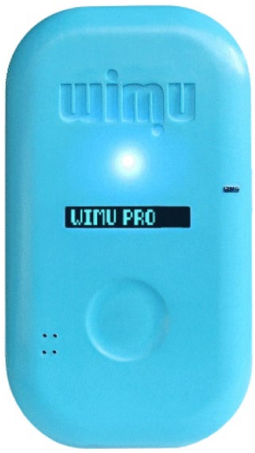

Ilustración 7. Dispositivo WIMUPRO™. Extraída de Hudl.com

Los instrumentos de cada estudio se encuentran detallada en la Tabla 2 del presente documento.

Tabla 2. Instrumentos de todos los estudios

Estudio	Instrumentos
1. Influence of contextual factors on physical demands and technical-tactical actions regarding playing position in professional soccer players.	Dispositivos Apex Pro Series StatSports WyScout®
2. Comparison of the worst-case scenarios between training and competition weeks for each playing position in an elite football season.	Dispositivos WIMU PRO™
3. Training tasks vs. match demands: Do football drills replicate Worst-Case Scenarios?	Dispositivos WIMU PRO™

3.3 Procedimientos

Dentro de los protocolos a seguir en los tres estudios, podemos destacar que todas las sesiones de entrenamiento se llevaron a cabo en el mismo campo de entrenamiento de césped natural; los atletas usaron calzado adecuado para la superficie y no utilizaron espinilleras; las sesiones se realizaron por la mañana, a la misma hora cada día; se realizó la misma rutina de calentamiento diariamente como introducción a la parte principal de la sesión, la cual se adaptó al contenido específico que se estaba trabajando; durante toda la temporada, el mismo cuerpo técnico dirigió todas las sesiones de entrenamiento; durante las pausas entre tareas, se aconsejó a los jugadores beber agua o bebidas isotónicas; y, por último, un nutricionista supervisó la dieta (desayuno y almuerzo) y la hidratación de todos los jugadores durante las semanas de entrenamiento, asegurando una recuperación óptima para los atletas en preparación para las siguientes sesiones.

Las demandas físicas seleccionadas para el análisis del estudio 1 fueron recogidas con dispositivos Apex Pro Series StatSports y WyScout®. Estas variables fueron las siguientes: distancia total (TD), distancia recorrida a velocidad moderada (MSR; metros recorridos a una velocidad superior a 14,4km/h), distancia recorrida a alta velocidad (HSR; metros recorridos a una velocidad superior a 19,8 km/h), distancia de sprint (SPR; metros recorridos a una velocidad superior a 25,0 km/h), número de aceleraciones entre 2 y 4 m/s² (Acc2-4) y por encima de 4 m/s² (Acc+4), número de deceleraciones entre 2 y 4 m/s² (Dec2-4) y por encima de 4 m/s² (Dec>4). Además, se seleccionaron también 19 variables técnico-tácticas que fueron consideradas clave para poder analizar el desempeño del equipo en el partido. Estas variables escogidas fueron clasificadas en tres categorías: (1) Indicadores generales (GI), (2) indicadores defensivos (DI) y (3) indicadores ofensivos (OI). (1) Los GI seleccionados fueron: Volumen de juego (suma de DI y OI) (GV); (2) Los DI analizados fueron: Volumen defensivo (suma de todos los DI) (DV), nº de interceptaciones (IN), nº de interceptaciones en campo contrario (OPIN), despejes (CL), duelos aéreos (AD), duelos aéreos ganados (ADW); (3) Los OI utilizados fueron: Volumen ofensivo (suma de todos los OI) (OV), pases totales (TP), pases totales exitosos (TPS), pases hacia adelante (FP), pases hacia adelante exitosos (FPS), pases en zona de ataque (AZP), pérdidas de balón (TO), tiros a portería (GS), tiros a portería a puerta (GST), centros (CR), centros exitosos (CRS) y regates (DR). Después del partido, los datos se descargaron y analizaron utilizando un paquete de software personalizado para

las variables condicionales (Apex, Statsports, Irlanda, Versión 1.2) y las variables técnico-tácticas (Wyscout®, Chiavari, Versión Web).

En cambio, para el Estudio 2 y el Estudio 3 se seleccionaron variables condicionales diferentes y fueron recogidas con dispositivos WIMUPRO^{TM}. Debido a que los dispositivos GPS utilizados en estos estudios eran de distintos proveedores y los parámetros de medición de las variables seleccionadas variaban. Por ejemplo, en los dispositivos Apex Pro Series Statsports empleados en el estudio anterior, el HSR se registra a partir de 19,8 km/h, mientras que en los dispositivos WIMU PRO™ utilizados en estos dos estudios, el HSR se recoge a partir de 21 km/h. Las variables elegidas fueron las siguientes: distancia total (DIST TOTAL), distancia total recorrida a una velocidad superior al umbral absoluto de carrera de alta velocidad (por defecto 21 km/h) (DIST 21), distancia total recorrida a una velocidad superior al umbral absoluto de sprint (por defecto 24 km/h) (DIST 24), número de aceleraciones de alta intensidad (> 3 m/s²) (ACC), número de deceleraciones de alta intensidad (< -3 m/s²) (DEC), y distancia cubierta en acciones de alta carga metabólica (por defecto, por encima del umbral de 25,5 W·kg^{-1}) (HMLD) [97]. El software utilizado para el análisis y procesamiento de los datos extraídos de las variables seleccionadas fue SPRO 960 (RealTrack Systems S.L., Almería, España, Versión 730).

En todos los estudios, los dispositivos fueron colocados en un chaleco específicamente diseñado para estos (Rasan, Valencia, Spain), el cual disponía de un bolsillo en la zona dorsal para introducirlos. Los dispositivos siempre fueron calibrados al inicio de la temporada por la empresa propietaria (RealTrack Systems, Almeria, Spain).

Ilustración 8. Colocación de dispositivo GNSS/GPS. Extraída de Reforma.com

Las variables de cada estudio se encuentran detallada en la Tabla 3 del presente documento.

Tabla 3. Variables de todos los estudios

Estudio	Variables
1. Influence of contextual factors on physical demands and technical-tactical actions regarding playing position in professional soccer players.	DIST TOTAL / Dist +14.4 / Dist +19.8 / Dist +25 Acc 2-4 / Acc +4 / Dec -2-4 / Dec -4 GV / DV / IN / OPIN CL / AD / ADW / OV TP / TPS / FP / FPS AZP / TO / GS / GTS CR / CRS / DR
2. Comparison of the worst-case scenarios between training and competition weeks for each playing position in an elite football season.	DIST TOTAL DIST +21 DIST +24 ACC DEC HMLD
3. Training tasks vs. match demands: Do football drills replicate Worst-Case Scenarios?	DIST TOTAL DIST +21 DIST +24 ACC DEC HMLD

DIST TOTAL: Distancia total; Dist +14.4: Distancia a más de 14.4 km/h; Dist +19.8: Distancia a más de 19.8 km/h; Dist +25: Distancia a más de 25 km/h; Acc 2-4: Aceleraciones entre 2 y 4 m/s^2 ; Acc +4: Aceleraciones superiores a 4 m/s^2; Dec -2-4: Deceleraciones entre -2 y -4 m/s^2 ; Dec -4: Deceleraciones superiores a -4 m/s^2; GV: volumen de juego; DV: volumen defensivo; IN: nº de interceptaciones; OPIN: nº de interceptaciones en campo contrario; CL: despejes; AD: duelos aéreos; ADW: duelos aéreos ganados; OV: volumen ofensivo; TP: pases totales; TPS: total pases exitosos; FP: pases hacia adelante; FPS: pases hacia adelante exitosos; AZP: pases en zona de ataque; TO: pérdidas de balón; GS: tiros a portería; GTS: tiros a portería entre los tres palos; CR: centros; CRS: centros exitosos; DR: regates; DIST +21: Distancia a más de 21 km/h; DIST +21: Distancia a más de 21 km/h; ACC +3: Aceleraciones superiores a 3 m/s^2; DEC -3: Deceleraciones superiores a -3 m/s^2; HMLD: distancia recorrida en acciones de alta carga metabólica.

3.4 Análisis estadístico

El análisis estadístico del artículo 1 fue realizado con IBM SPSS Statistics para Windows (versión 25.0; SPSS Inc., Chicago, IL, EE. UU.). En cambio, el análisis estadístico para el artículo 2 y el artículo 3 se realizaron con IBM SPSS Statistics para Windows (versión 29; IBM Corp., Armonk, NY, EE. UU.).

En el artículo 1 se examinó la distribución normal y la homogeneidad de las varianzas mediante las pruebas de Shapiro-Wilk y Levene. Se empleó un ANOVA de dos vías con la prueba post hoc de Tukey para evaluar el impacto de la interacción de los factores: la localización del partido (local/visitante) y el resultado final (victoria/derrota) sobre las respuestas de carga externa encontradas en los jugadores de fútbol. La significación estadística se estableció en $p<0,05$. Se utilizó el tamaño del efecto (ES) de Cohen para evaluar las diferencias prácticas entre grupos [98]. Los umbrales para el tamaño del efecto ES fueron: trivial = 0 a 0,19; pequeño = 0,2 a 0,59; moderado = 0,6 a 1,19; grande = 1,2 a 1,99; muy grande = 2,0 a 3,99; y casi perfecto ≥ 4,0 [99].

En el estudio 2 se utilizó la prueba de Kolmogorov-Smirnov para confirmar la normalidad de la distribución de los datos y la prueba de Levene para la igualdad de varianzas. Se empleó un análisis de varianza de medidas repetidas (ANOVA) para identificar diferencias en la demanda entre los días de entrenamiento y los días de partido. Posteriormente, se realizaron análisis post-hoc de Bonferroni cuando fue necesario para determinar diferencias significativas entre el día de entrenamiento y el día de partido para cada demarcación de juego. Finalmente, se calcularon los tamaños del efecto para todas las comparaciones por pares utilizando el g de Hedges, con intervalos de confianza del 95%. La interpretación de g fue la siguiente: trivial = 0 a 0,19; pequeño = 0,2 a 0,59; moderado = 0,6 a 1,19; grande = 1,2 a 1,99; muy grande = 2,0 a 3,99; y casi perfecto ≥ 4,0 [99].

En el estudio 3 la normalidad de los datos se evaluó mediante la prueba de Kolmogorov–Smirnov, y la homogeneidad de las varianzas se verificó mediante la prueba de Levene. Dado que el objetivo del estudio era determinar qué tareas de entrenamiento replican mejor las demandas físicas de las WCS basadas en partidos, se realizó un ANOVA de un factor para detectar diferencias significativas entre cada tipo de tarea y los valores de referencia de WCS. Incluir todos los tipos de tareas y las demandas del partido

dentro del mismo modelo permitió un marco de comparación robusto e integrado, posibilitando pruebas post hoc directas para evaluar qué tareas específicas diferían significativamente de las condiciones del partido. Cuando se cumplió el supuesto de homogeneidad de varianzas, se utilizaron pruebas post hoc ajustadas por Bonferroni para comparar cada tarea de entrenamiento con los valores del partido. Cuando este supuesto se violó, se aplicó la corrección de Games–Howell. Estas comparaciones por pares permitieron identificar qué tareas de entrenamiento fueron significativamente diferentes de las demandas del partido. Para complementar el análisis inferencial, se calcularon tamaños del efecto (d de Cohen) para todas las comparaciones por pares con el fin de cuantificar la magnitud de las diferencias entre cada tarea de entrenamiento y la condición del partido. La interpretación de d fue la siguiente: trivial = 0 a 0,19; pequeño = 0,2 a 0,59; moderado = 0,6 a 1,19; grande = 1,2 a 1,99; muy grande = 2,0 a 3,99; y casi perfecto ≥ 4,0 [99]. Además, se calculó el porcentaje de cumplimiento relativo a las demandas del partido para cada tarea utilizando la siguiente fórmula: % relativo al partido = (Media de la tarea / Media del partido) × 100.

El análisis estadístico realizado en cada estudio se encuentra detallado en la Tabla 4 del presente documento.

Tabla 4. Análisis estadístico de todos los estudios

Estudio	Instrumentos
1. Influence of contextual factors on physical demands and technical-tactical actions regarding playing position in professional soccer players.	Normalidad (Shapiro-Wilk) Varianzas (Levene test) ANOVA de dos factores (Tukey post hoc test) Tamaño del efecto d de Cohen
2. Comparison of the worst-case scenarios between training and competition weeks for each playing position in an elite football season.	Normalidad (Kolmogorov-Smirnov) Varianzas (Levene test) ANOVA de un factor (Bonferroni post hoc test) Tamaño del efecto h de Hedges
3. Training tasks vs. match demands: Do football drills replicate Worst-Case Scenarios?	Normalidad (Kolmogorov-Smirnov) Varianzas (Levene test) ANOVA de un factor (Bonferroni post hoc test) Tamaño del efecto d de Cohen

4 RESULTADOS

A continuación, se presentan, en primer lugar, los artículos que conforman el compendio. Posteriormente, se muestran tal como fueron publicados en sus respectivas revistas, siguiendo un orden cronológico. En ellos se detallan los resultados obtenidos. Asimismo, más adelante se incluye una tabla resumen (Tabla 4) que recoge los hallazgos más relevantes de cada uno de los artículos.

Los artículos pertenecientes a dicho compendio son los siguientes:

Estudio 1. Díez, A., Lozano, D., Arjol-Serrano, J.L., Mainer-Pardos, E., Castillo, D., Torrontegui-Duarte, M., Nobari, H., Jaén-Carrillo, D. & Lampre, M. (2021). Influence of contextual factors on physical demands and technical-tactical actions regarding playing position in professional soccer players. BMC Sports Science, Medicine and Rehabilitation, 13, 157-70. Doi: https://doi.org/10.1186/s13102-021-00386-x

Estudio 2. Díez, A., Bataller-Cervero, A.V., Mainer-Pardos, E., Roso-Moliner, A., Arjol-Serrano, J.L. & Lozano, D. (2025). Comparison of the worst-case scenarios between training and competition weeks for each playing position in an elite football season. Biology of Sport, 42(4), 135–44. Doi: https://doi.org/10.5114/biolsport.2025.148538

Estudio 3. Díez, A., Lozano, D., Arjol-Serrano, J.L., Bataller-Cervero, A.V., Roso-Moliner, A. & Mainer-Pardos, E. (2025). Training Tasks vs. Match Demands: Do Football Drills ReplicateWorst-Case Scenarios? Applied Sciences, 15, 8172-89. Doi: https://doi.org/10.3390/app15158172

Estudio 1. Influence of contextual factors on physical demands and technical-tactical actions regarding playing position in professional soccer players.

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RESEARCH Open Access

Influence of contextual factors on physical demands and technical-tactical actions regarding playing position in professional soccer players

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Abstract

Background: The aim of this study was to analyse the physical demands and technical-tactical actions for each playing position according to game location and final outcome in professional soccer players.

Methods: A convenience sample was obtained from twenty-one professional male soccer players, belonged to same soccer team of the Spanish Second Division. Players' physical demands were monitored during each match using a portable 18 Hz GPS unit and 600 Hz triaxial accelerometer. These analysed demands were total distance, moderate speed running distance (>14.4 km·h^{-1}), high-speed running distance (>19.8. km·h-1), sprint distance (>25.0 km·h^{-1}), number of accelerations between 2 and 4 m·s^{-2} and above 4 m·s^{-2}, and number of decelerations between 2 and 4 m·s^{-2} and above 4 m·s^{-2}. The data related to technical-tactical actions were obtained from WyScout®, a computerized multiple-camera tracking system based on the OPTA® track analysis tool. The obtained indicators were general, defensive and offensive.

Results: For all players, higher total distance ($p = 0.045$; effect size [ES] = 0.24, small effect) was covered and greater deceleration 2-4 m·ss^{-2} ($p = 0.001$; ES = 0.68, medium effect) was performed when the team plays at home and lose and for all players, playing at home and winning demanded higher defensive volume ($p = 0.014$; ES = − 1.49, large effect) and nº interceptions ($p = 0.031$; ES = − 1.40, large effect) in comparison to playing at home and losing.

Conclusions: The physical demands and technical-tactical actions vary when contextual game factors (i.e., match location and final outcome) are considered. We can confirm that, although the training of physical demands does not influence the final result of the match, the training of technical tactical actions could help to achieve an optimal performance of the team to win matches.

Keywords: Soccer, Performance, External training load, Contextual game factors, GPS

Background

On the one hand, success in soccer is based on the ability of scoring a higher number of goals than the other team over a game [1, 2]. On the other hand, the first goal in a game [3–5] and a reduced number of goals conceded, especially during the second half of a season, have been associated with success in soccer [5]. Coaches

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and researchers have attempted to identify strategies to improve effectivity in both the opponent box (i.e., to score goals) and their own box (i.e., to avoid conceding goals) [6] by employing key performance indicators (KPIs) [7–10]. KPIs facilitate the objective analysis of performance over a game and are referred as the variables that define physical and technical-tactical performance aspects which contribute to success [11]. In addition, it would be interesting to identify KPIs in professional soccer so increase the likelihood of winning a game and to optimise soccer training and competition [1], understanding optimization as the proper adjustment of workloads.

The existing connection between physical efforts carried out in a game and their relation with success have been widely examined in the main European soccer leagues [12–15] and World Cup championships [16, 17]. Seemingly, physical demands are a poor indicator to determine team success over a season or championship. Regarding this, previous works concluded that the teams in the top 5 of Italian Serie A and English Premier League covered less total distance at a lower intensity than the rest of the teams [13, 14]. Similar findings were found in German Bundesliga and Spanish LaLiga where there is no correlation between final ranking position, total distance covered and intensity of efforts [12, 15]. However, to determine success in teams, it would be necessary a holistic perspective might be needed including technical-tactical skills as they are considered essential within soccer performance [13].

In professional soccer, accuracy when attempting the opponent goal followed by number of attempts, ball possession percentage time, and pass accuracy are identified as key actions when analysing performance [18]. It has been identified that in successful team's possession time is influenced by type of start- up, intention and field zone. While, possession time of unsuccessful teams is determined fundamentally by intention and match status [19]. Greater overall ball possession near the opponent box has been identified as a good indicator of success since there are greater possibilities to score and thus to win [9].

Either facing the game as home or away team may also influence the final score. It has been found that local teams covered longer distances at low intensity (<14.1 $km.h^{-1}$) what may suggest that this condition could jeopardise team performance [20]. In a deeper analysis it was suggested that the identification of game actions which predict soccer performance should be contextualised in terms of the role the team plays (i.e., home vs. away) since perhaps the local team might have increased their possibilities to win [7]. On the other hand, game location seems to have no influence on speed zones physical performance [21]. Given the existing controversy around the influence of game location on physical and technical-tactical demands, it seems appropriate to analyse both in professional soccer players to help coaches design and structure their weekly routines properly, identifying the strong and weak indicators of the team, maintaining the workload of the strong indicators and increasing the workload of the weak indicators.

It seems that when attempting to clarify the interaction between physical, behavioural, technical and tactical variables of soccer performance considering game context [22], a holistic research may be needed. To the best of the authors' knowledge, no research has focused on team success over an entire season considering playing positions and considering the analysis of technical-tactical and physical KPIs. Therefore, the aim of this study was to analyse the physical demands and technical-tactical actions for each playing position according to game location (i.e., playing at home vs. away) and final outcome (i.e., win or lose) in professional soccer players.

Materials and methods

Experimental design

The current investigation was descriptive and based on an observational methodology applied to the acquired data and was performed and reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) criteria (http://www.strobe-statement.org) (von Elm et al., 2007), which were obtained from global positioning system (GPS) devices (i.e., APEX pod) and Wyscout®, instrument validated [23], a multiple-camera tracking system so as to analyse the physical demands and the technical-tactical actions encountered by professional soccer players attending to contextual factors: location (play at home or away) and final outcome (win or lose) in which the same soccer team played a total of 30 official matches during the season 2017/2018. Also, the players were classified by their playing position. Two UEFA qualified coaches observed each of the games to verify that formation was consistent throughout the game [24]. Data for those players who did not play the entire match were excluded for further analysis.

Participants

A convenience sample was obtained from twenty-one professional male soccer players (age: 25.10 ± 3.56 years; height: 180.25 ± 5.38 cm; body mass: 75.56 ± 6.40 kg; body mass index [BMI]: 23.15 ± 1.20 kg/m^2), belonged to same soccer team of the Spanish Second Division (Table 1). All the players trained around 10 h per week and played an official match during the weekend (5-6 conditioned sessions + 1 game per week). Subjects were assigned one playing position by the head coach.

Table 1 Participants

Position [1]	n	Match	Age (years)	Height (cm)	Weight (kg)	BMI
CD	5	44	26.8 ± 3.49	187.6 ± 2.73	83.3 ± 2.68	23.39 ± 0.89
WD	4	44	24 ± 1.83	177.75 ± 5.68	70.52 ± 4.82	22.31 ± 0.70
MID	8	65	24.25 ± 3.85	177.75 ± 4.06	72.55 ± 6.24	22.94 ± 1.43
F	4	33	25.75 ± 4.19	180.25 ± 5.38	78.22 ± 1.97	24.10 ± 0.85

[1] CD: Central defender; WD: Wide defender; MID: Midfielder; F: Foward

Playing positions were: central defenders (CD, n=5), wide defenders (WD, n=4), midfielders (MID, n=8) and forwards (F, n=4) [25][26].

Moreover, for further statistical analysis players were divided into four groups: (1) played at home and won (PHW), (2) played at home and lose (PHL), (3) play away and won (PAW) and (4) play away and lose (PAL), tied matches were eliminated. Goalkeepers were not included in the analysis due to their specific role during match-play [27]. Informed consent was obtained from all participants before the start of the study. Data was obtained from the daily monitoring of players, so that the professional club authorized researchers to use the data collection and no ethics committee was required [28, 29]. Otherwise, this study was conformed to the Declaration of Helsinki (2016) and was approved by a Local Ethics Committee of Universidad San Jorge, Spain, nº 08-20/21.

Physical demands

Players' physical demands were monitored during each match using a portable 18 Hz GPS unit and 600 Hz triaxial accelerometer (APEX pod accelerometer, MAPPS Technology and Bluetooth LE; STATSports; North Ireland). Randers et al. (2010) shown the validity, reproducibility and reliability of GPS devices. Each unit was introduced into an adjustable neoprene vest, inside a back pocket, positioned on the upper part of their backs, between the scapulaes. The physical demands selected for analysis were previously used in soccer players [30–32]: total distance (TD), moderate speed running distance (MSR; m >14.4 km·h^{-1}), high-speed running distance (HSR; m >19.8. km·h^{-1}), sprint distance (SPR; m >25.0 km·h^{-1}), number of accelerations between 2 and 4 m·s^{-2} (Acc2-4) and above 4 m·s^{-2} (Acc>4), number of decelerations between 2 and 4 m·s^{-2} (Dec2-4) and above 4 m·s^{-2} (Dec>4). Post-match, data were downloaded and analysed using a customized software package (Apex, Statsports, Irlanda, Versión 1.2). Dwell time or minimum effort duration (MED) used in our variables were of 0,5 s in accelerations (Acc) and decelerations (Dec), and 1 s in sprint distance (SPR), high-speed running distance (HSR) and moderate speed running distance (MSR).

Technical-tactical actions

Data related to technical-tactical actions were obtained from Wyscout® (Chiavari, Italy), a computerized multiple-camera tracking system based on the OPTA® (Spain) track analysis tool [1]. Stadiums' cameras positioned at roof level captured players' actions and were analysed using proprietary software [24]. The OPTA® (Spain) reliability was identified with acceptable levels, showed an intra-class correlation coefficient varied from 0.88 to 1.00 [33]. Moreover, this technical-tactical Wyscout® variables have been used and analysed in previous studies [1, 34]. For this investigation, were selected 19 variables, which were classified into three categories: (1) General indicators (GI), (2) defensive indicators (DI) and (3) offensive indicators (OI). (1) GI selected: Game volume (add DI and OI) (GV); (2) DI analysed: Defensive volume (add all of DI) (DV), nº interceptions (IN), nº opposing pitch interceptions (OPIN), clearances (CL), aerial duels (AD), aerial duels won (ADW); (3) OI used: Offensive volume (add all of OI) (OV), total pass (TP), total pass success (TPS), forward pass (FP), forward pass success (FPS), attack zone pass (AZP), turnover (TO), goal shot (GS), goal shot on target (GST), crosses (CR) crosses success (CRS) and dribbles (DR).

Statistical analysis

Standard statistical methods were used for the calculation of the means and standard deviations (SD). Normal distribution and homogeneity of variances was examined by Shapiro-Wilk and Levene tests. The two-way ANOVA with the Tukey post hoc test was used to assess the impact of the interaction of both factors (i.e., match location and final outcome) on the external load responses encountered by soccer players. Statistical analyses were conducted using SPSS for Windows version 25.0 (SPSS Inc., Chicago, IL, USA). Statistical significance was set at $p<0.05$. Cohen's effect size (ES) was used to evaluate practical differences between groups [35]. Thresholds for ES statistics were 0.2, trivial; 0.6, small; 1.2, moderate; 2.0, large; 2.0, very large; and >4.0, extremely large [36]. A threshold value of 0.2 between-subject standard deviations was set as the smallest worthwhile change (SWC), and unclear effect was then based on the disposition of

Table 2 Descriptive of the physical demands (mean ± SD) encountered by soccer players for each playing position and for all players when play at home or away, and their team win or lose

	CD				WD				MID			
	Home		Away		Home		Away		Home		Away	
	Win	Lose	Win	Lose	Win	Lose	Win	Lose	Win	Lose	Win	Lose
TD	10,311 ± 276	10,645 ± 713	10,262 ± 664	10,124 ± 480	10,820 ± 206	10,851 ± 997	10,784 ± 603	10,686 ± 498	11,987 ± 722	11,735 ± 607	11,647 ± 641	11,355 ± 861
MSR	1549 ± 262	1677 ± 397	1577 ± 285	1590 ± 351	2231 ± 237	2217 ± 840	2147 ± 288	2290 ± 315	2693 ± 5429	2555 ± 469	2560 ± 446	2559 ± 516
HSR	431 ± 97	402 ± 175	353 ± 83	387 ± 113	766 ± 123	742 ± 452	662 ± 123	770 ± 210	732 ± 272	596 ± 144	673 ± 214	620 ± 202
SPR	71 ± 35	53 ± 40	54 ± 11	73 ± 45	193 ± 87	189 ± 179	106 ± 44	174 ± 74	136 ± 85	62,97 ± 46,03	112 ± 68	94 ± 54
Acc2-4	151 ± 33	174 ± 63	136 ± 68	158 ± 29	173 ± 17	186 ± 24	144 ± 67	160 ± 36	166 ± 41	185 ± 25	163 ± 65	163 ± 38
Acc>4	11 ± 5	15 ± 10	13 ± 7	13 ± 8	19 ± 8	20 ± 5	20 ± 6	16 ± 10	12 ± 6	11 ± 4	16 ± 5	13 ± 7
Dec2-4	122 ± 30	162 ± 44	132 ± 58	136 ± 24	149 ± 12	162 ± 17	128 ± 55	151 ± 17	161 ± 34	190 ± 29	161 ± 59	162 ± 35
Dec>4	21 ± 9	22 ± 12	20 ± 8	22 ± 12	38 ± 8	37 ± 11	35 ± 13	30 ± 17	30 ± 14	28 ± 8	33 ± 10	28 ± 17

	FW				All			
	Home		Away		Home		Away	
	Win	Lose	Win	Lose	Win	Lose	Win	Lose
TD	10,827 ± 715	11,032 ± 320	11,049 ± 669	11,056 ± 733	10,992 ± 791	11,240 ± 909	11,009 ± 827	10,847 ± 824
MSR	2149 ± 437	2126 ± 190	2360 ± 238	2258 ± 309	2202 ± 577	2237 ± 548	2189 ± 514	2219 ± 550
HSR	808 ± 231	681 ± 142	850 ± 120	769 ± 283	685 ± 243	604 ± 241	620 ± 226	626 ± 246
SPR	233 ± 101	144 ± 72	266 ± 92	266 ± 201	152 ± 96	103 ± 96	122 ± 89	130 ± 105
Acc2-4	146 ± 24	170 ± 11	168 ± 30	150 ± 34	160 ± 32	178 ± 31	153 ± 61	160 ± 34
Acc>4	20 ± 8	22 ± 2	19 ± 10	15 ± 9	15 ± 8	15 ± 6	16 ± 7	14 ± 9
Dec2-4	125 ± 18	149 ± 10	136 ± 20	127 ± 27	142 ± 30	169 ± 32	142 ± 53	148 ± 30
Dec>4	27 ± 9	36 ± 11	25 ± 13	23 ± 13	30 ± 12	31 ± 10	29 ± 12	26 ± 15

CD: central defenders; WD: wide defenders; MID: Midfielders; FW: forwards; TD: total distance; MSR: distance covered above 14.4 $km \cdot h^{-1}$; HSR: distance covered above 19.8. $km \cdot h^{-1}$; SPR: distance covered above 25.0 $km \cdot h^{-1}$; Acc2-4: number of accelerations between 2-4 $m \cdot s^{-2}$; Acc>4: number of accelerations above 4 $m \cdot s^{-2}$; Dec2-4: number of decelerations between 2-4 $m \cdot s^{-2}$; Dec>4: number of decelerations above 4 $m \cdot s^{-2}$

the confidence interval for the mean difference to this smallest worthwhile effect.

Results

The physical demands that soccer players face for each playing position and for all players when they play home or away and their team win or lose are compared and shown in Tables 2 and 3. For all players, higher TD ($p = 0.045$; ES = 0.24, S) was covered and greater Dec2-4 ($p = 0.001$; ES = 0.68, M) was performed when the team plays at home and lose. In addition, players performed more SPR when the team plays at home and wins ($p = 0.009$; ES = −0.81, M) in comparison to the team playing at home and lose. Otherwise, MID ($p = 0.012$; ES = 0.79, M) and FW ($p = 0.027$; ES = 1.52, L) performed higher Dec2-4 when the team play at home and lose in comparison to the team playing at home and win. In addition, WD covered higher SPR ($p = 0.026$; ES = 1.01, L), when the team play at home and lose in comparison to when the team playing at home and win.

The technical-tactical actions encountered by soccer players for each playing position and for all players when play at home or away and their team win or lose are compared and shown in Tables 4 and 5. For all players, playing at home and winning demanded higher DV ($p = 0.014$; ES = −1.49, L) and IN ($p = 0.031$; ES = −1.40, L) in comparison to playing at home and losing. Regarding playing position, MID performed greater GV, DV, IN and TPS ($p = 0.011$–0.043; ES = −0.89–1.09, M) and FW obtained higher GV, DV and IN ($p = 0.011$–0.048; ES = −0.64–0.89, M) when the team plays at home and wins compared to playing at home and losing. In addition, CD recorded higher GV and TPS ($p = 0.044$–0.047; ES = 0.17–0.88, S to M) when the team plays at home and loses in comparison to playing at home and winning. On the other side, FW registered higher FP and AZP ($p = 0.028$–0.029; ES = 0.99–1.16, M) when playing away and losing in comparison to playing away and winning. However, FW performed higher GST ($p = 0.036$; ES = −1.21, L) when the team plays away and wins compared to playing away and losing.

Discussion

The aim of this study was to analyse the physical demands and technical-tactical actions for each playing position according to game location (i.e., local vs. visitor) and final outcome (i.e., win vs. lose) in elite professional players. The current study is ground-breaking due to the attempt to determine success in Spanish professional soccer games including physical and technical-tactical KPIs for each playing position in different context game to achieve a holistic approach. The main findings were as follows: (i) physical demands and the technical-tactical actions vary when two contextual game factors (i.e., game location and final outcome) are considered, (ii) higher TD covered and Dec 2-4 performed could be related when the team plays at home and loses for all players, MID and FW, (iii) greater number of SPR are exhibited by players when the team plays at home and wins, (iv) greater GV, DV and IN is recorded when the team plays at home and win for all players, MID and FW, (v) higher GV and TPS are performed by CD when the team plays at home and losing, and (vi) greater FP and AZP are recorded by players when the team plays away and loses.

There exists lack of scientific evidence regarding the KPIs influencing the final outcome of a game considering its location (i.e., home vs. away) since most of the studies assess team success across the seasons [12–15]. From a general overview, the analysis of physical KPIs showed that when a team played at home and won, their players covered greater SPR, whereas when the team was defeated, greater TD and Dec2-4 were identified. It is well known that sprints are the most repeated actions in goal situations [37]. This allows to suggest that greater SPR might be associated with success when playing at home as a high number of goal attempts would be created and, thus, greater probability to achieve victory would be increased. Despite both studies consider the same competitive standards, such discrepancies might be explained in relation with temporal factors given that there is a span of period of 11 seasons between the aforementioned study and the current work. It is well known that today soccer is more physically demanding than before and, therefore, a higher number of sprints in each game is shown [38, 39].

As score changes, the team which is behind needs to do greater physical efforts to reduce that difference and overcome the other [21]. This statement is supported by our findings since greater TD and Dec2-4 values were found as the home team loses. On the contrary, two previous studies reported increased values for total distance covered, and low (11-14 km/h) and moderate intensity running (14-19 $km.h^{-1}$) on the side of the home team when they achieved victory in Brazilian third division championship [41]. However, it is widely accepted that low-intensity activities are not crucial in professional soccer performance [14]. A greater physical effort (i.e., higher total distance covered) does not guarantee success [42] as, shown in the current work, it might be associated with other cognitive, emotional or tactical factors than a lower physical performance [39]. Moreover, no significant differences were observed between won or lost matches when teams play away. In that context, it seems that KPIs such as technical-tactical efficacy might have a greater influence on success than physical KPIs [12, 22].

Table 3 Mean differences (MD, %) and effect sizes (ES; ±CL) of the physical demands (mean ± SD) encountered by soccer players for each playing position and for all players when play at home or away, and their team win or lose

	CD				WD				MID			
	Home		Away		Home		Away		Home		Away	
	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL
TD	3.1	0.43; ±1.19 S	−1.3	−0.21; ±0.72 S	0.0	0.00; ±1.21	−0.9	−0.16; ±0.74	2.2	0.37; ±0.66 S	2.2	0.37; ±0.66 S
MSR	7.5	0.27; ±1.15 S	0.0	0.00; ±0.67	−6.4	−0.15; ±1.20	6.5	0.46; ±0.71 S	−4.7	−0.23; ±0.66 S	−4.7	−0.23; ±0.66 S
HSR	−11.3	−0.25; ±1.17 S	8.2	0.31; ±0.67 S	−18.8	−0.27; ±1.21 S	14.0	0.55; ±0.67 S	−14.2	−0.40; ±0.61 S	−14.2	−0.40; ±0.61 S
SPR	−33.8	−0.40; ±1.15 S	12.2	0.21; ±0.59 S	−38.2	−0.34; ±1.20S	63.1	1.01; ±1.01 M*	−52.8	−0.89; ±0.89 M	−12.6	−0.15; ±0.59
Acc 2-4	13.9	0.32; ±1.03 S	46.5	0.53; ±0.79 S	7.4	0.48; ±1.03 S	31.1	0.41; ±0.83 S	15.5	0.55; ±0.58 S	17.9	0.25; ±0.64 S
Acc >4	68.5	1.44; ±1.43 L	−9.8	−0.13; ±0.64	10.3	0.25; ±0.87 S	−34.1	−0.60; ±0.62 S	−22.4	−0.30; ±0.71 S	−39.5	−0.62; ±0.62 M
Dec 2-4	34.3	0.80; ±0.89 M	17.5	0.30; ±0.79 S	8.7	0.68; ±1.03 M	−34.9	0.58; ±0.84 S	19.6	0.79; ±0.80 M*	13.0	0.23; ±0.64 S
Dec >4	8.3	0.08; ±0.93	−6.3	−0.09; ±0.64	−6.5	−0.16; ±1.16	−31.8	−0.50; ±0.63 S	18.6	0.21; ±0.57 S	−27.8	−0.43; ±0.52 S

	FW				All			
	Home		Away		Home		Away	
	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL
TD	2.1	0.37; ±0.78 S	0.0	0.00; ±0.87	1.8	0.24; ±0.50 S*	−3.2	−0.43; ±0.47 S
MSR	0.8	0.04; ±0.78	−4.7	−0.38; ±0.86 S	−2.8	−0.11; ±0.51	−6.4	−0.26; ±0.44 S
HSR	−13.0	−0.44; ±0.86 S	−13.2	−0.54; ±0.83 S	−16.4	−0.42; ±0.51 S	−12.5	−0.32; ±0.44 S
SPR	−34.9	−0.59; ±0.99 S	−26.2	−0.61; ±0.84 M	−49.9	−0.81; ±0.81 M**	−16.0	−0.23; ±0.44 S
Acc 2-4	18.0	1.17; ±1.17 M	−11.8	−0.49; ±0.85 S	5.9	0.39; ±0.50 S	65.2	0.68; ±0.68 M
Acc >4	34.3	0.42; ±0.70 S	−10.7	−0.10; ±0.90	−17.0	−0.36; ±0.51 S	−6.3	−0.08; ±0.45
Dec 2-4	20.3	1.52; ±1.52 L*	−8.1	−0.38; ±0.84 S	12.2	0.68; ±0.69 M**	50.7	0.73; ±0.73 M
Dec >4	46.7	0.59; ±0.78 S	−33.9	−0.37; ±0.82 S	−11.8	−0.30; ±0.51 S	3.8	0.05; ±0.44

CD: central defenders; WD: wide defenders; MID: Midfielders; FW: forwards; TD: total distance; MSR: distance covered above 14.4 km·h^{-1}; HSR: distance covered above 19.8. km·h^{-1}; SPR: distance covered above 25.0 km·h^{-1}; Acc2-4: number of accelerations between 2-4 m·s^{-2}; Acc>4: number of accelerations above 4 m·s^{-2}; Dec2-4: number of decelerations between 2-4 m·s^{-2}; Dec>4: number of decelerations above 4 m·s^{-2}

Standardized effect size thresholds: S. small; M. moderate; L. large; VL. very large; EL. extremely large

*Significant level set at $p<0.05$; ** Significant level set at $p<0.01$

Table 4 Descriptive of the technical-tactical actions (mean ± SD) encountered by soccer players for each playing position and for all players when play at home or away, and their team win or lose

	CD				WD				MID				FW				All			
	Home		Away		Home		Away		Home		Away		Home		Away		Home		Away	
	Win	Lose	Win	Lose	Win	Lose	Win	Lose	Win	Lose	Win	Lose	Win	Lose	Win	Lose	Win	Lose	Win	Lose
GV	56.7± 14.1	62.7± 16.5	51.6± 15.0	64.2± 14.8	60.3± 12.6	54.3± 15.7	65.4± 10.2	61.5± 14.8	68.7± 15.9	55.3± 12.5	59.5± 15.2	62.4± 15.9	33.9± 8.4	24.8± 8.2	31.4± 1.4	32.1 ± 9.6	569.1± 85.9	516.8± 98.1	537.2± 65.7	541.7 ±71.8
OV	41.2± 12.8	48.7± 15.8	37.5± 14.4	48.1± 15.5	50.3± 12.1	44.5± 14.3	51.3± 11.0	49.9± 13.4	55.0± 14.5	45.1± 12.5	45.7± 12.6	50.2± 15.1	27.7± 6.2	22.7± 8.7	25.3± 2.9	26.5 ± 6.6	457.3± 84.9	426.4± 99.5	414.3± 76.3	434 ±80.5
DV	15.5± 5.3	14.0± 2.9	14.1± 5.0	16.1± 4.5	10.0± 3.4	9.8± 3.0	14.1± 4.1	11.6± 4.3	13.7± 5.0	10.2± 4.4	13.8± 5.4	12.2± 3.9	6.2± 3.0	2.2± 2.0	6.1± 2.4	5.6± 3.7	111.8± 14.2	90.4± 11.8	122.8± 11.7	107.6 ±17.9
IN	6.0± 2.6	5.9± 2.6	4.6± 2.8	6.0± 2.6	4.4± 1.9	4.7± 2.0	7.2±2.4	6.1± 2.9	9.1± 3.7	5.6± 2.4	8.1± 4.1	8.3± 3.0	2.9± 1.7	1.2± 1.2	3.3± 1.7	3.0± 2.4	59.1± 11.0	46.4± 4.1	62.7±7.6	58.2 ±10.1
OPIN	0.5± 0.7	0.7± 0.8	0.5± 0.6	0.6± 0.6	0.5± 0.9	0.3± 0.5	0.8± 1.1	0.9± 1.3	1.9± 1.4	1.8± 1.3	1.8 ± 1.9	2.3 ± 1.1	0.9± 1.4	0.7 ± 0.8	1.6 ± 0.9	1.0 ± 0.6	11.5 ± 4.2	11.2 ± 1.5	11.8 ± 3.7	13.1 ± 3.1
CL	6.0± 3.3	5.4 ± 2.7	6.7 ± 2.4	6.3 ± 3.0	2.8 ± 1.6	2.4 ± 1.3	4.1 ± 2.1	2.8 ± 2.1	2.2 ± 2.0	1.9 ± 2.9	2.4 ± 2.5	2.1 ± 1.7	1.2 ± 1.3	0.2 ± 0.4	1.6 ± 1.8	1.2 ± 0.9	28.9 ± 10.3	21.0 ± 10.3	36.3 ± 8.9	27.4 ± 8.0
AD	4.4 ± 2.3	4.1 ± 2.0	4.3 ± 2.9	4.2 ± 2.0	1.6 ± 1.8	1.9 ± 1.9	2.4 ± 1.9	2.3 ± 1.3	2.4 ± 1.6	1.7 ± 1.5	3.1 ± 2.2	2.3 ± 1.9	3.9 ± 2.7	3.0± 1.9	3.6 ± 2.9	3.5 ± 2.8	28.9 ± 8.6	25.4 ± 6.1	34.5 ± 13.9	29.1 ± 7.8
ADW	3.1 ± 2.3	2.9 ± 1.6	2.8 ± 2.1	2.6 ± 1.7	0.9 ± 1.3	0.9 ± 0.9	1.5 ± 1.7	1.0 ± 1.1	1.2 ± 1.5	0.9 ± 1.4	1.5 ± 2.1	1.3 ± 1.2	2.0 ± 1.7	0.5± 1.2	1.6± 1.3	1.6±1.7	15.6 ± 5.3	12.4 ± 3.5	18.3 ± 9.6	13.1 ± 3.8
TP	40.4 ± 12.3	48.0 ± 15.8	37.0 ± 14.4	47.0 ± 15.7	48.3 ± 11.8	42.9 ± 14.5	49.1 ± 10.5	48.1 ± 13.2	52.7 ± 14.7	42.7 ± 12.0	42.0 ± 12.8	48.7 ± 15.4	22.7± 6.6	18.5± 6.9	20.4± 2.4	22.9± 6.7	427.8± 82.1	396.8± 98.7	383.5± 76.5	409.8± 78.3
TPS	32.9± 12.5	41.2± 13.4	30.8± 9.2	35.0± 14.1	35.6 ± 9.8	34.0± 13.5	37.1± 8.3	37.2± 10.9	42.5± 12.6	32.8± 10.8	33.1± 10.4	38.9± 13.2	15.4± 5.6	13.2± 5.3	14.6± 3.2	16.0± 7.3	336.3± 84.4	310.0 ± 80.4	294.3 ± 61.6	319.7± 73.9
FP	30.8 ± 9.2	35.0 ± 14.1	28.2± 10.0	35.9± 12.0	30.2± 7.3	24.5± 7.1	30.4± 8.6	27.9± 8.7	33.1± 11.3	28.6± 9.3	26.1± 10.1	32.1± 11.9	10.2± 4.6	8.8± 5.2	8.0± 3.0	12.2± 3.9	265.3± 47.3	248.8± 67.2	242.2± 42.4	260.8± 47.1
FPS	23.3± 9.5	28.4± 11.9	20.5± 9.3	27.9 ± 12.1	18.8 ± 4.9	16.7 ± 5.4	19.1 ± 5.8	18.5 ± 6.3	24.7 ± 9.8	20.1 ± 7.5	17.8 ± 8.1	23.6± 10.3	4.8 ± 3.1	4.3 ± 3.3	4.1 ± 1.8	6.7 ± 3.3	187.4 ± 48.7	173.2 ± 51.2	160.5± 26.0	184.3± 43.4
TO	4.4 ± 2.9	4.6 ± 2.3	3.6 ± 2.0	4.3 ± 2.3	6.1 ± 3.0	7.5 ± 3.8	6.4 ± 1.9	6.7 ± 2.1	6.7 ± 3.3	6.1 ± 3.3	7.3 ± 3.9	6.9 ± 2.9	9.0 ± 2.6	5.8 ± 3.9	9.0 ± 3.6	9.0± 4.2	68.4± 8.9	67.6± 5.1	69.5± 9.0	71.1± 11.3
GS	0.3± 0.6	0.4± 0.5	0.3± 0.5	0.6± 0.8	0.3± 0.6	0.2± 0.7	0.0± 0.0	0.1± 0.3	1.1 ± 0.9	1.7± 1.3	1.2± 0.9	0.7 ± 0.9	3.0 ± 1.9	1.3± 1.6	3.0 ± 2.0	1.8 ± 1.3	12.8 ± 4.2	10.8 ± 4.8	10.3 ± 2.6	10.3 ± 2.9
GST	0.2 ± 0.4	0.1 ± 0.3	0.3 ± 0.5	0.5 ± 0.7	0.1 ± 0.3	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.3	0.5 ± 0.6	0.9 ± 0.9	0.6 ± 0.6	0.4 ± 0.6	2.2 ± 1.8	0.8 ± 0.9	2.4 ± 1.4	1.0 ± 1.2	8.3 ± 2.5	5.8 ± 2.2	7.2 ± 1.5	6.0 ± 2.9
AZP	0.4 ± 0.7	0.7 ± 1.2	0.2 ± 0.4	0.9 ± 1.2	10.6 ± 5.2	11.5 ± 7.8	8.4 ± 5.0	10.1 ± 5.5	8.2 ± 4.8	8.3 ± 7.5	6.1 ± 4.9	6.3 ± 4.8	9.4 ± 2.9	8.2 ± 4.3	5.7 ± 2.9	9.4 ± 3.4	79.0 ± 22.2	77.6 ± 37.3	58.0± 17.8	74.4 ± 20.7
CR	0.1 ± 0.2	0.0 ± 0.0	0.0 ±0.0	0.1 ± 0.3	2.0 ± 1.5	3.1 ± 2.8	1.3 ± 1.3	2.0 ± 1.8	1.9 ± 2.9	2.3 ± 2.5	1.2 ± 1.6	1.0 ± 1.3	0.3 ± 0.5	0.2 ± 0.4	0.3 ± 0.5	0.9 ± 1.0	11.1 ± 4.9	15.4 ± 8.2	8.2 ± 4.4	11.1 ± 4.5
CRS	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0± 0.0	0.2 ± 0.5	0.7 ± 0.7	0.5 ± 0.7	0.2 ± 0.4	0.5 ± 0.7	0.5± 0.7	0.5 ± 0.8	0.3 ± 0.6	0.0 ± 0.0	0.0 ± 0.0	0.0± 0.0	0.2 ± 0.3	2.7 ± 2.1	2.8 ± 1.5	3.0 ± 1.9	1.9 ± 0.8

Table 4 (continued)

	CD				WD				MID				FW				All			
	Home		Away		Home		Away		Home		Away		Home		Away		Home		Away	
	Win	Lose	Win	Lose	Win	Lose	Win	Lose	Win	Lose	Win	Lose	Win	Lose	Win	Lose	Win	Lose	Win	Lose
DR	0.4 ± 0.9	0.4 ± 0.7	0.3 ± 0.5	0.5 ± 0.8	1.6 ± 1.7	1.4 ± 1.2	2.4 ± 1.7	1.7 ± 1.3	1.2 ± 1.7	0.7 ± 1.1	1.9 ± 2.1	0.8 ± 0.8	2.0 ± 1.3	2.8 ± 1.8	1.8 ± 1.7	1.7± 1.2	18.1 ± 6.8	18.8 ± 3.1	17.5 ± 2.7	14.0 ± 4.9

CD: central defenders; WD: wide defenders; MID: Midfielders; FW: forwards; GV: game volume; OV: offensive volume; DV: defensive volume; IN: interceptions; OPIN: opposing pitch interceptions; CL: clearances; AD: aerial duels; ARW: aerial duels won; TP: total pass; TPS: Total pass success; FP: forward. pass; FPS: forward pass success; TO: turnover; GS: goal shot; GST: goal shot on target; AZP: attack zone pass; CR: crosses; CRS: crosses success; DR: dribbles

Table 5 Mean differences (%) and effect sizes (ES; ±CL) of the technical-tactical actions encountered by soccer players for each playing position and for all players when play at home or away, and their team win or lose

	CD				WD				MID				FW				All			
	Home		Away		Home		Away		Home		Away		Home		Away		Home		Away	
	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL
GV	10.2	0.32; ±0.74 S	26.0	0.88; ±0.88 M*	− 11.1	− 0.43; ±0.75 S	− 7.5	− 0.36; ±0.65 S	− 21.9	− 1.09; ±1.09 M*	5.3	0.19; ±0.56	− 29.0	− 0.89; ±0.91 M*	− 2.1	− 0.09; ±0.69	− 9.5	− 0.53; ±0.97 S	0.7	0.05; ±0.88
OV	17.0	0.40; ±0.74 S	30.1	0.77; ±0.77 M	− 12.7	− 0.45; ±0.76 S	− 4.0	− 0.16; ±0.66	− 19.9	− 0.83; ±0.83 M	9.3	0.29; ±0.56 S	− 22.8	− 0.60; ±0.94 M	− 2.1	0.10; ±0.72	− 7.3	− 0.33; ±0.97 S	4.7	0.22; ±0.89 S
DV	− 6.5	− 0.23; ±0.64 S	18.1	0.44; ±0.68 S	− 2.0	− 0.06; ±0.72	− 20.6	− 0.65; ±0.66 M	− 30.9	− 0.99; ±0.99 M*	− 7.9	− 0.20; ±0.57 S	− 42.1	− 0.81; ±0.89 M*	− 20.5	− 0.38; ±0.75 S	− 19.0	− 1.49; ±1.49 L*	− 13.2	− 0.96; ±0.96 M
IN	1.5	0.03; ±0.67	35.6	0.43; ±0.67 S	5.9	0.13; ±0.76	− 20.3	− 0.51; ±0.65 S	− 39.6	− 1.05; ±1.05 M*	− 2.1	− 0.04; ±0.57	− 35.5	− 0.64; ±0.95 M*	− 19.7	− 0.30; ±0.77 S	− 20.4	− 1.40; ±1.40 L*	− 7.8	− 0.53; ±0.85 S
OPIN	18.9	0.40; ±1.08 S	− 6.0	− 0.20; ±0.99 S	− 39.2	− 1.16; ±1.17 L	− 4.2	− 0.07; ±0.97	− 2.0	− 0.04; ±0.72	− 0.5	− 0.01; ±0.67	− 43.1	− 0.93; ±1.33 M	− 32.4	− 0.94; ±0.94 M	2.8	0.08; ±0.83	13.2	0.37; ±0.92 S
CL	0.9	0.02; ±0.63	− 13.3	-0.24; ±0.65 S	− 29.7	− 0.66; ±0.76 M	− 22.7	− 0.36; ±0.70 S	− 33.0	− 0.52; ±0.82 S	− 23.5	− 0.41; ±0.68 S	− 48.6	–	− 38.9	− 0.95; ±1.05 M	− 29.6	− 0.84; ±1.00 M	− 25.8	− 0.94; ±0.94 M
AD	− 12.0	− 0 0.21; ±0.77 S	7.1	0.11; ±0.68	25.1	0.42; ±0.90 S	24.0	0.33; ±0.70 S	0.5	0.01; ±0.73	− 13.2	− 0.25; ±0.62 S	− 29.4	− 0.43; ±0.87 S	− 7.2	− 0.10; ±0.89	− 11.2	− 0.41; ±0.94 S	− 13.3	− 0.42; ±0.92 S
ADW	− 6.0	− 0.09; ±0.73	2.5	0.04; ±0.71	0.8	0.01; ±0.99	− 31.3	− 0.57; ±0.87 S	21.4	0.24; ±1.06 S	− 24.4	− 0.44; ±0.81 S	51.1	–	− 3.1	− 0.05; ±0.92	− 19.2	− 0.58; ±0.94 S	− 24.3	− 0.67; ±0.94 M
TP	17.2	0.41; ±0.74 S	29.1	0.73; ±0.73 M	− 13-0	− 0.43; ±0.76 S	− 3.3	− 0.13; ±0.66	− 20.8	− 0.82; ±0.82 M	15.9	0.44; ±0.56 S	− 21.1	− 0.55; ±0.91 S	0.0	0.30; ±0.71 S	− 7.9	− 0.34; ±0.99 S	6.9	0.30; ±0.89 S
TPS	27.5	0.59; ±0.70 S	8.1	0.17; ±0.78*	− 7.9	− 0.22; ±0.77 S	− 1.5	− 0.05; ±0.66	− 24.5	− 0.89; ±0.89 M*	17.1	0.45; ±0.56 S	− 15.6	− 0.34; ±0.89 S	2.2	0.06; ±0.73	− 7.6	− 0.29; ±0.94 S	7.7	0.30;±0.87 S
FP	8.1	0.17; ±0.78	28.0	0.73; ±0.73 M	− 19.6	− 0.72; ±0.72 M	− 8.6	− 0.31; ±0.67 S	− 16.5	− 0.53; ±0.66 S	21.8	0.48; ±0.56 S	− 20.8	− 0.34; ±0.91 S	54.7	0.99; ±0.99 M*	− 7.6	− 0.31; ±1.00 S	7.5	0.36; ±0.88 S
FPS	20.7	0.38; ±0.73 S	34.4	0.70; ±0.70 M	− 12.0	− 0.41; ±0.75 S	− 3.3	− 0.10; ±0.67	− 20.9	− 0.60; ±0.65 M	30.9	0.55; ±0.56 S	24.0	0.28; ±0.84 S	63.3	0.78; ±0.81 M	− 8.1	− 0.28; ±0.97 S	13.1	0.55; ±0.85 S
TO	2.7	0.04; ±0.73 S	36.4	0.48; ±0.68 S	21.6	0.32; ±0.74 S	1.5	0.04; ±0.66	− 15.6	− 0.30; ±0.67 S	− 9.4	− 0.17; ±0.56	− 43.0	− 1.01; ±1.01 M	− 1.3	− 0.02; ±0.80	− 0.7	− 0.06; ±0.87	1.9	0.13; ±0.87
GS	− 12.9	− 0.51; ±1.08 S	41.4	1.09; ±1.09 M	68.2	–	–	–	33.0	0.55; ±0.78 S	− 17.6	− 0.41; ±0.75 S	− 13.8	− 0.26; ±1.06 S	− 38.6	− 0.93; ±0.94 M	− 18.1	− 0.42; ±1.00 S	− 0.6	− 0.02; ±0.88
GST	0.0	–	26.0	0.77; ±0.99 M	–	–	–	–	24.8	0.52; ±0.96 S	3.9	0.14; ±0.91	28.4	− 0.53; ±0.99 S	− 44.9	− 1.21; ±1.21 L*	− 31-1	− 1.00; ±1.00 M	− 22.3	− 0.67; ±0.83 M
AZP	44.2	0.56; ±1.57 S	54.2	1.06; ±1.06 M	− 1.3	− 0.02; ±0.77	38.6	0.38; ±0.69 S	− 26.5	− 0.31; ±0.70 S	2.4	0.03; ±0.57	− 20.6	− 0.42; ±0.94 S	72.4	1.16; ±1.17 L*	− 6.2	− 0.15;±1.00	29.8	0.79; ±0.91 M
CR	–	–	–	–	12.8	0.16; ±0.80	21.8	0.37; ±0.80 S	31.3	0.30; ±0.82 S	− 19.7	− 0.36; ±0.81 S	0.0	–	42.6	0.94; ±0.95 M	34.1	0.45; ±0.97 S	37.4	0.69; ±0.89 M

Table 5 (continued)

	CD				WD				MID				FW				All			
	Home		Away		Home		Away		Home		Away		Home		Away		Home		Away	
	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL	MD (%)	ES; ±CL
CRS	–	–	–	–	− 18.8	−0.16; ±1.78	− 12.9	−0.51; ±1.08 S	0.0	0.00; ±1.08	− 24.2	−0.72; ±1.08 M	–	–	–	–	19.8	0.24; ±0.91 S	−49.6	−1.66; ±1.67 L
DR	−29.3	–	68.2	1.54; ±1.54 L	− 13.3	−0.23; ±0.84 S	−9.6	−0.17; ±0.73	−5.8	−0.09; ±0.95	−35.7	−0.81; ±0.82 M	0.7	0.01; ±0.93	8.4	−0.12; ±0.92	10.8	0.29; ±0.83 S	−23.4	−0.91; ±0.91 L

CD: central defenders; WD: wide defenders; MID: Midfielders; FW: forwards; GV: game volume; OV: offensive volume; DV: defensive volume; IN: interceptions; OPIN: opposing pitch interceptions; CL: clearances; AD: aerial duels; ARW: aerial duels won; TP: total pass; TPS: Total pass success; FP: forward pass; FPS: forward pass success; TO: turnover; GS: goal shot; GST: goal shot on target; AZP: attack zone pass; CR: crosses; CRS: crosses success; DR: dribbles

Standardized effect size thresholds: S. small; M. moderate; L. large; VL. very large; EL. extremely large

*Significant level set at $p<0.05$

On the one hand, one of the most robust findings derived from time motion analysis are the different physical demands regarding playing positions [43]. Activity profiles and tactical demands are considered positional dependent in soccer, therefore, the analysis based on playing positions might be useful to know whether physical performance influences success. Analysis of playing positional data on physical performance showed differences between MID and FW as the game was played at home and when the team lost in Dec2-4. Such differences might be explained due to the fact that MID need to escape from an opponent and find a free space in order to receive a pass resulting in technical-tactical demands which implied an increased number of changes of direction. Accordingly, deaccelerations are essential within these changes of direction not only when attacking, but also as the team defends [44]. A higher number of Dec2-4 identified as the team loses at home might be an indicator of the presence of more changes of direction carried out associated to the difficulty in taking the ball away from the opponent and, thus, associated to less success. Moreover, it seems that a greater number of curvilinear runs has been observed for MID before taking possession of the ball [43], resulting in a higher number of Dec2-4. This can negatively contribute to take the ball from the opponent as MIDs need to brake making this issue especially hard. It is worth highlighting that ball possession has been identified as an indicator of success in soccer [18]. Similarly, an increased amount of Dec2-4 has been shown for FW when the team plays at home and loses. However, most of the studies reported that distance covered sprinting during attacks in FW seems to be essential in order to succeed [45]. These actions facilitate the attack actions requiring slips [46] to look for positive situations or to break into the opponent box [43].

On the other hand, WD show a high number of SPR when playing at home and losing the game in comparison with playing away and winning [45]. This might be attributed to the repeated efforts derived from attack-defend transitions needed to recover defensive positions [45]. These findings seem to be supported by ours as an acceleration is needed prior to decelerate [44]. Finally, no physical demand when analysing by playing position showed differences between playing at home or away when team wins. These findings may suggest that a greater physical effort could have no relation with achieving victory. Although a proper physical capacity may be favourable in order to deal with soccer conditional demands, there exist concerns regarding the connection between physical performance and competitive success [22]. Given this existing controversy, it seems noteworthy the clarification of the degree of technical-tactical participation associated with playing positions as it has been considered as an indicator of soccer performance to determine its influence on success [13, 47]. In these regards, the present study observed more significant GV, DV and IN when the team won playing at home.

A previous study concluded that defensive actions were more related with the accumulation of points in evenly-matched championships (i.e., Spanish soccer second league) [48]. Accordingly, those teams carrying out more interceptions, tackles [49] and winning aerial duels [50] were more likely to win the game. In addition, it seems that better teams are more efficient when applying defensive pressure near the opponent box [49] leading the opponent team to make mistakes and hindering their progression. This contributes to a greater amount of DV and IN to win games as home team. Of note, these differences between DV and IN are not found when team plays away as the contextual factor influences these types of actions when a team wins at home.

The analysis in relationship with technical-tactical actions across playing position showed some differences in CD, MID and FW. Playing at home and victory demanded higher values of GV, DV, IN and TPS for MID; GV, DV and IN for FW. Likewise, a previous study reported that when playing home, UEFA Champions League teams recovered the ball more frequently than when playing away [49]. The atmosphere when playing at home, having all the fans encouraging the players, is associated with increased aggressiveness and intentionality in players causing successful defensive actions [51]. Moreover, recovering the possession of the ball close to the opponent box has been identified as an influencing factor on success in soccer [7, 49], supporting, therefore, the findings reported in the current work for MID and FW in GV, DV and IN. Likewise, our study also Support previous findings [52] where a higher number of passes by MID contributed to increased chances to score a goal. Although passes accuracy is related to ball possession [53], this might occurred near the opponent box in order to be effective and contribute to win the game [19]. Regarding this, the MID might be decisive to succeed when playing at home.

Then, our findings showed that winning playing at home required more GST for FW, whereas losing playing away is more related to greater GV and TPS for CD, and AZP and FP for FW. Hence, a greater number of GV and TPS was associated to lose a game away in CD. In fact, ball possession far from the opponent box and with no intention to make a progress resulted ineffective [9]. Therefore, the accumulation of a greater number of GV and TPS in CD not only seems to influence victory, but also it is associated with losing games away. Likewise, a high number of attempts ot goal has been identified as a key KPI to win games [54] as well

as to succeed at the end of a championship [1, 4, 51, 54–56]. The findings shown in the current work support the aforementioned discussed studies, but it determines a very novel aspect as FW is the only position that establishes GST as KPI to win games away. This may suggest that key role of FW should be to score goals and to focus on doing GST instead of trying to participate excessively in game creation as it has been observed that a great number of AZP and FP carried out by FW in a game are associated to lose games away.

Despite the findings shown in the present study, there are some limitations to be considered. First, either score dynamics or games ended in a tie were not considered. Then, tactics and game model used in each game were also not considered, remaining unknown physical demands under different models and strategies. Second, the wide midfielders have not been described because they were substituted in practically all the matches, which is why they were excluded from the present study since the sample was not significant. The third limitation comes from the sample size of the players who participated in the study. It would be interesting to have access to a greater number of players in order to obtain more representative results.

Practical applications.

The findings here provided might help sports practitioners understand that greater physical expenditure (i.e., greater amount of distance covered in different speed zones) during games seems to have no relationship with achieving victory. Therefore, it seems that fitness development should be aimed at dealing with the game physical demands derived from the coach's proposal and minimising injury risk. Additionally, context variables are strongly influenced by playing position and not by final score [43], thus, the adoption of a position-specific approach for player conditioning would be potentially needed.

The main practical approach for coaches is the knowledge of the implications of the technical-tactical KPIs to win games. This could determine the strategical behaviour of the team and guide a successful model of play. During practices, coaches and practitioners would put special emphasis on that technical-tactical KPIs that have shown to be essential to achieve victory based on the context of the next game (i.e., home or away). This would help select players and thus enhance team performance linked to the individual characteristics. Therefore, further research is needed to clarify which physical demands and technical-tactical KPIs are key in defend-attack and attack-defend transitions given their outstanding importance in soccer games.

Conclusions

The findings here reported support that physical demands and technical-tactical actions vary when contextual game factors (i.e., match location and final outcome) are considered. As such, higher TD covered and Dec 2-4 performed could be related when the team plays at home and loses for all players, MID and FW. In addition, greater number of SPR are exhibited when the team plays at home and wins. Moreover, greater GV, DV and IN are recorded when the team plays at home and win for all players, MID and FW. Otherwise, higher GV and TPS are performed by CD when the team plays at home and loses. Finally, greater FP and AZP are recorded when the team plays away and loses. Overall, greater physical performance was not associated with winning soccer games, therefore, the recognition of the implications of technical-tactical KPIs to win could improve the selection of training goals, model play and selection of players to achieve optimal team performance that could help win games.

Abbreviations

CD: Central defenders; WD: wide defenders; MID: midfielders; F: forwards; PHW: played at home and won; PHL: played at home and lose; PAW: play away and won; PAL: play away and lose; KPIs: key performance indicators; GPS: global positioning system; BMI: body mass index; TD: total distance; MSR: moderate speed running distance; HSR: high-speed running distance; SPR: sprint distance; Acc2-4: number of accelerations between 2-4 $m \cdot s^{-2}$; Acc>4: above 4 $m \cdot s^{-2}$; Dec2-4: above 4 $m \cdot s^{-2}$; MED: minimum effort duration; Acc: accelerations; Dec: decelerations; SPR: 1 s in sprint distance; HSR: high-speed running distance; MSR: moderate speed running distance; GI: General indicators; DI: defensive indicators; OI: offensive indicators; GV: Game volume; DV: Defensive volume; IN: no interceptions; OPIN: no opposing pitch interceptions; CL: clearances; AD: aerial duels; ADW: aerial duels won; OV: offensive volume; TP: total pass; TPS: total pass success; FP: forward pass; FPS: forward pass success; AZP: attack zone pass; TO: turnover; GS: goal shot; GST: goal shot on target; CR: crosses; CRS: crosses success; DR: dribbles; SD: standard deviations; ES: effect size; SWC: smallest worthwhile change.

Authors' contributions

Conceptualization, D.L., M.L., and J.L.A.; methodology, D.L., E.M.P and J.L.A.; validation, A. D., D.L., and D.J-C.; formal analysis, D.L., H.N. and D. C.; investigation, D.L. and M.L.; data curation, D.L. and M.T.; writing—original draft preparation, D.L., M.T., H.N. and D.C.; writing—review and editing, D.L., M.L, A.D, D.C, D.J_C., M.T. and J.L.A.; project administration, D.L., E.M.P. and J.L.A. All authors have read and agreed to the published version of the manuscript.

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Availability of data and materials

The datasets generated and analysed during the current study are not publicly available due to ethical restrictions, however, they are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Informed consent was obtained from all participants before the start of the study. Data was obtained from the daily monitoring of players, so that the professional club authorized researchers to use the data collection and no ethics committee was required [28, 29]. Otherwise, this study was conformed to the

Declaration of Helsinki (2016) and was approved by a Local Ethics Committee of Universidad San Jorge, Spain, nº 08-20/21.

Consent for publication
No individual or indemnifiable data is being published as part of this manuscript.

Competing interests
The authors declare no competing interests.

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Publisher's Note

Estudio 2. Comparison of the worst-case scenarios between training and competition weeks for each playing position in an elite football season.

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Comparison of the worst-case scenarios between training and competition weeks for each playing position in an elite football season

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ABSTRACT: The aim of this study was to examine the worst-case scenarios (WCS) produced during the week in training sessions and compare them with the physical demands of the matches. A total of 194 training sessions and 42 matches were analysed during the 2020/2021 season in the Second Spanish Football League. Data were collected using Global Positioning System devices. Players were grouped according to their playing positions into central defenders, wide players, midfielders (MID), and forwards. The variables analysed were distance, HSR distance, sprint distance, high acceleration, high deceleration, and high metabolic load distance. The most demanding passages were analysed in 1-minute periods using the rolling average method. The most significant differences were found in the HSR distance ($p < 0.001$; $\eta p^2 = 0.854$), sprint distance ($p < 0.001$; $\eta p^2 = 0.882$) and high metabolic load distance ($p < 0.001$; $\eta p^2 = 0.899$) variables on the day furthest from the match day. No significant differences were found in the data analysed for MID in any training session of the week compared with the match, nor in the variables of high acceleration and high deceleration. Knowledge about the worst-case scenario during a competitive microcycle can help understand the physical level and individual requirements that our players need to perform at a high level on the match day, as well as preventing possible injuries or fatigue.

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INTRODUCTION

Football, in terms of conditional capacities, is considered an explosive team sport characterised by the repetition of intermittent periods of anaerobic efforts, interspersed with long recovery periods [1]. These intermittent periods of anaerobic effort include repeated sprints, rapid accelerations and decelerations, changes in direction, jumps, throws, and post-jump activities [2]. All these demands are unique to each context and are unpredictable in terms of both intensity and duration [2].

In recent years, technological advances have enabled the development of tools that facilitate sports activities [3]. In sports, these tools allow for control of the athletes' workload, which can be divided into two main groups: 1) technologies for controlling the athlete's external workload and 2) technologies for controlling the athlete's internal workload [4–9]. External workload is defined as the objective measures of activity performed by the athlete during training and competition, for instance, speed, acceleration, strength and power [10]. The measures that are mainly found in studies are the demands of total distance, high sprint running distance, sprint distance [11], the number of sprints, the number of accelerations and decelerations [12], the acceleration and deceleration distance, the metabolic power, high metabolic load distance (HMLD), player load and maximum speed [13]. Internal workload is defined as the psychophysiological response of athletes with physical exercise. Internal workload includes psychological measures such as subjective perception of effort (rate of perceived exertion – RPE), and physiological measures, such as heart rate, blood lactate or oxygen consumption [9]. Although they may be closely related, external workloads are assessed independently from internal workloads [10]. Due to workload control technologies, training can be individualised and optimised, reducing the risk of potential injuries [14].

One of the most commonly used technologies for monitoring the external workload in team sports is electronic performance tracking devices (EPTS) [15]. These are further divided into 3 main groups: 1) Global Positioning System (GPS) devices, 2) local positioning systems (LPS), and 3) video tracking systems (VTS) [14]. These technologies can also currently be combined with micro-electromechanical measurement systems (MEMS), making use of inertial sensors [16], which usually consist of accelerometers that

make the devices much more beneficial and can provide us with many more measures for exercise analysis. These devices offer metrics that complement tracking systems, such as accelerations, decelerations, turns, changes of direction, jumps, impacts, or player load (defined as the accumulation of movement in the three axes of motion) [17].

For several years in football, physical demands have been quantified during training and matches to organise training based on the demands provided by data extracted from competitions [11]. These demands can be analysed weekly, monthly, or across different seasonal phases [18]. Thus, it is appropriate to quantify the workload because continuous workload following is important to quantify aspects such as individual responses to training, accumulative fatigue, preparation, and recovery status [6].

The physical demands of football players during matches are widely recognised [2]. However, these demands may vary depending on the player's position on the field or the playing systems used by coaches during the season [19]. These findings demonstrate the significance of individualising both by athlete and position [2].

To quantify workload and programme weekly training sessions in an individualised and optimised manner, coaching staff have traditionally used average data derived from physical demands obtained in matches of chosen conditional variables. Therefore, it is important to consider the maximum demands when planning training sessions. However, using these averages underestimates the maximum demands produced in competition [20]. To address this underestimation, another method was employed, which considers the moments during the match when the highest physical demands of each variable occur. This method is known as the worst-case scenarios (WCS) or most demanding passages (MDP) [16]. The analysis of these WCS initially involved using fixed-length periods, which divide the total match into fixed periods from the beginning to the end of the match, for instance, periods of 1 minute (0.00"-0.59", 1.00"-1.59", continuing in this manner until the end of the match). However, currently, the rolling average is used, which involves fixing the periods when the WCS reaches its peak intensity. For example, the peak distance occurs in the period between 15.25" and 16.25", the peak sprint occurs between 24.49" and 25.49", and similar patterns continue [21].

It is common to think that identifying scenarios of maximum demand and replicating them during the week could aid in a player's recovery and reduce the risk of injury [22]. However, there is no research that indicates a clear relationship between replicating the WCS and reducing the risk of injury [6].

The commonly analysed WCS may be of 1 min, 3 min, 5 min, or 10 min [23], but recreating the 1 min WCS during the session could serve to prepare our players for the maximum demands of competition [11]. There is a correlation between the WCS time and the conditional variable analysed (for example, variables relating to distances or accelerations, among others); the shorter the time analysed is, the higher is the WCS produced [2]. Therefore, the WCS is higher when analysing times of 1 min compared to 3 min, 5 min, or 10 min. Finally, these WCS could be influenced by contextual factors inherent to the match, such as the player's position, the development of the match in the first or second half, playing the match at home or away, or being in a winning, drawing, or losing position during the match [2].

Due to the novelty of the present research topic, few studies have compared the WCS of training sessions with those of matches

TABLE 1. Goals and contents of the training sessions.

Session	Goals	Contents
MD-5	Physical Tactical Technical	Strength Small-sided games / Small-sided possession Ball control / Passing
MD-4	Physical Tactical Technical	Endurance Small-sided games / Large-sided possession Ball control / Shotting / Dribbling
MD-3	Physical Tactical Technical	Strength / Endurance Full-pitch match / Large-sided possession Ball control / Passing / Dribbling
MD-2	Physical Tactical Technical	Speed Full-pitch match / Small-sided possession Crossing & Finishing
MD-1	Physical Tactical Technical	Neuromuscular Small-sided games / Set pieces Shotting
MD	Physical Tactical Technical	All All All

throughout an entire season in a professional team. Therefore, we considered it novel and interesting to conduct a detailed analysis of the conditional variables recorded throughout an entire season according to the positions of our players and compare them with the matches. This approach is novel because it not only examines weekly variations in WCS and provides practical information to optimise training. By identifying the specific WCS for each playing position during the week, coaches can ensure that training adequately prepares players to meet the demands of matches. In addition, this information enables targeted interventions, allowing coaches to identify the most appropriate days to train specific positional demands, thus improving both performance and recovery strategies.

Therefore, the main objective of this study was to analyse the worst-case scenarios (WCS) produced during the competition period throughout the week in various training sessions and to compare them with the physical demands of the matches. This comparison determines on which day of the week these maximum scenarios most closely resemble those experienced during a match over the season.

MATERIALS AND METHODS

This longitudinal study was conducted on a professional football team over 40 weekly microcycles, excluding pre-season. The study included a total of 194 training sessions and 42 matches in the Spanish Second Division (Smartbank League) during the 2020/2021 season. Matches mainly occurred during uncongested competition periods, with one match per week. However, there were occasional matches during the congested competition periods, with two matches per week [24]. The training week was structured according to the competition schedule.

The training sessions were classified based on their proximity to the match day, as described in some previous studies [25]. The study analysed training sessions conducted on MD-5, MD-4, MD-3, MD-2, MD-1 (training held days before the match day) and MD (match day). Sessions conducted on MD-7, MD-6, and MD+1 were excluded from the study due to an insufficient and insignificant sample size.

Table 1 presents the general objectives and contents of each training session depending on the day it was conducted with respect to the MD.

MD-5 (training held five days before the match day), MD-4 (training held four days before the match day), MD-3 (training held three days before the match day), MD-2 (training held two days before the match day), MD-1 (training held one day before the match day) y MD (match day).

The Ethical Committee of Clinical Research of Aragón, Spain (CEICA), approved the present study under act nº 04/2021, with license PI21/060. The research was conducted in accordance with the Declaration of Helsinki. All participants were informed of the study objective and signed an informed consent form.

Participants

Twenty-four male professional football players (age: 25.2 ± 4.5 years, height: 179.1 ± 5.9 cm, body mass: 75.0 ± 6.4 kg, body mass index (BMI): 23.3 ± 1.2 kg/m^2) belonging to the Spanish Second Division (Liga Smartbank) were selected for the present study, as shown in Table 2. According to the Participant Classification Framework [26], the players are classified as belonging to the third level of competition, which is reserved for highly trained or national level athletes. However, for the analysis of each microcycle, only players who completed the full match MD match were included. Goalkeepers were excluded from the study because the physical demands of goalkeepers are totally different from those of outfield players. Participants trained for 9–10 hours per week (1.5–2 hours per day) and played one match during uncongested weeks. During the congested weeks, they trained for 7–8 hours per week (1.5–2 hours per day) and played two matches. The study analysed participants individually and by field demarcation, including central defenders (CD) (n = 5), wide players (WP) (n = 8), midfielders (MID) (n = 7), and forwards (FW) (n = 4). A total of 5053 observations were carried out, taking into account players, training sessions and, matches.

Instruments

The data for this study were obtained from GPS tracking devices, specifically the WIMU PROTM (RealTrack Systems S.L., Almeria, Spain), which have a 10 Hz GPS and a triaxial accelerometer with a frequency of 100 m0 Hz. The WIMU PROTM devices are considered valid and reliable for obtaining positioning metrics derived from GPS signals in football [27]. The software of this company was used

TABLE 2. Players by position

Position	n	Age (years)	Height (cm)	Weight (kg)	BMI
CD	5	27.6 ± 5.41	183.6 ± 4.34	77.20 ± 5.40	22.92 ± 1.72
WP	8	23.59 ± 1.55	176.29 ± 4.98	73.21 ± 5.61	23.53 ± 0.78
MID	7	26.25 ± 6.02	176.88 ± 5.25	73.00 ± 7.87	23.28 ± 1.55
FW	4	24.50 ± 5.07	185.50 ± 3.32	80.85 ± 2.22	23.47 ± 0.51

CD: Central defenders; WP: Wide Players; MID: Midfielders; FW: Forwards; BMI: Body Mass Index

to calculate the WCS. The devices were placed in a specially designed vest (Rasan, Valencia, Spain) with a pocket on the back for insertion. RealTrack Systems S.L. (Almeria, Spain), the owning company, calibrated the devices at the beginning of the season.

Procedures

All sessions were conducted on the same natural grass training field. The athletes wore appropriate footwear for the surface and did not use shin guards. Sessions were held in the morning at the same time each day. The same warm-up routine was performed daily as an introduction to the main part of the session, which was tailored to the specific content being worked on. Throughout the season, the same coaching staff led all training sessions. During breaks between tasks, players were advised to drink water or isotonic drinks. A nutritionist supervised the diet (breakfast and lunch) and hydration of all players throughout the training weeks, ensuring optimal recovery for the athletes in preparation for the following sessions.

The software used for the analysis and processing of the data extracted from the selected variables was SPRO 960 (RealTrack Systems S.L., Almería, Spain). The variables chosen are as follows:

- Distance (metres) (DIST TOTAL): total distance travelled.
- Distance HSR (metres) (DIST 21): total distance run at a speed above the absolute high sprint running (HSR) threshold (default 21 km/h).
- Distance sprint (metres) (DIST 24): total distance run at a speed above the absolute sprint threshold (default 24 km/h).
- High accelerations (counts) (ACC): number of high-intensity accelerations (> 3 m/s^2).
- High decelerations (counts) (DEC): number of high-intensity decelerations (< -3 m/s^2).
- HMLD (metres) (HMLD): distance covered in high metabolic load actions (by default, above the threshold of 25.5 $W \cdot kg^{-1}$). Includes all high-speed running (speed greater than 21 km/h) and accelerations and decelerations exceeding 2 m/s^2 [28].

Absolute thresholds were used for all variables in this study. This approach was chosen because although studies have suggested that relative thresholds may better individualise athlete workloads, the use of absolute thresholds ensures consistency and comparability across different athletes and studies [29]. Other studies have shown that the choice of analysing absolute or relative thresholds does not influence the planning and programming of training loads in athletes [30].

Statistical analysis

The Kolmogorov-Smirnov test was used to confirm the normality of the data distribution and Levene's test for equality of variances. A repeated measures analysis of variance (ANOVA) was used to identify differences in demand for training and match days. Bonferroni post-hoc analyses were then conducted when necessary to determine significant differences between training and match day for each playing position. Finally, effect sizes were calculated for all pairwise comparisons using Hedges' g, with 95% confidence intervals. The interpretation of g was as follows: trivial = 0 to 0.19, small = 0.2 to 0.59, moderate = 0.6 to 1.19, large = 1.2 to 1.99, very large = 2.0 to 3.99, and near perfect ≥ 4.0 [31].

RESULTS

Figures 1, 2 and 3 display the micro-cycle and comparisons between every training day and the MD in terms of the total distance covered, high-velocity running (above 21 km/h and 24 km/h), accelerations

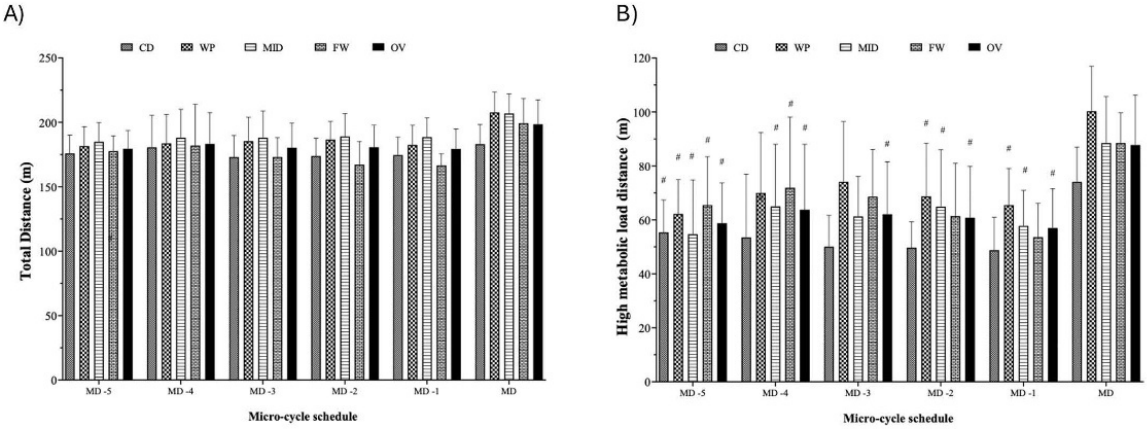

FIG. 1. Micro-cycle patterns and comparative analyses of daily training workloads throughout a competition season, taking into account the field position and overall team in A) distance total and B) high metabolic load distance.
#Significant differences with $p < 0.05$ between MD and training days. CD: Central defenders; WP: Wide players; MID: Midfielders; FW: Forwards; OV: overall; MD: match day; MD-5: five days before the match day; MD-4: four days before the match day; MD-3: three days before the match day; MD-2: two days before the match day; MD-1: one day before the match day

and decelerations exceeding 3 m/s^2, and high metabolic load distance considering the playing position. The repeated-measures ANOVA revealed no significant differences in the total distance covered within weekdays when comparing playing positions, as shown in Figure 1A. However, the total distance covered on MD represented 118.5% of the average training values (MD-5 to MD-1). High metabolic load distance was significantly lower on MD-1 compared to MD ($p < 0.05$), with no significant differences observed between MD and MD-4 for all playing positions (Figure 1B). The high metabolic load distance on MD represented 151.4% of the average training values.

When examining the differences between days, a significant difference was observed in running distance above 21 km/h and 24 km/h compared with MD across almost all playing positions ($p < 0.05$), except for CD, for which no significant differences were found when comparing MD with MD-3 and MD-1 in both variables (Figure 2). Notably, running distance above 21 km/h on MD represented 218.7% of the average training values, whereas the running distances above 24 km/h represented 289.3%.

Figure 3 highlights a significantly lower number of accelerations on MD-1 compared with MD for MID ($p < 0.05$). On the other hand, deceleration was significantly higher on MD-4 compared with MD

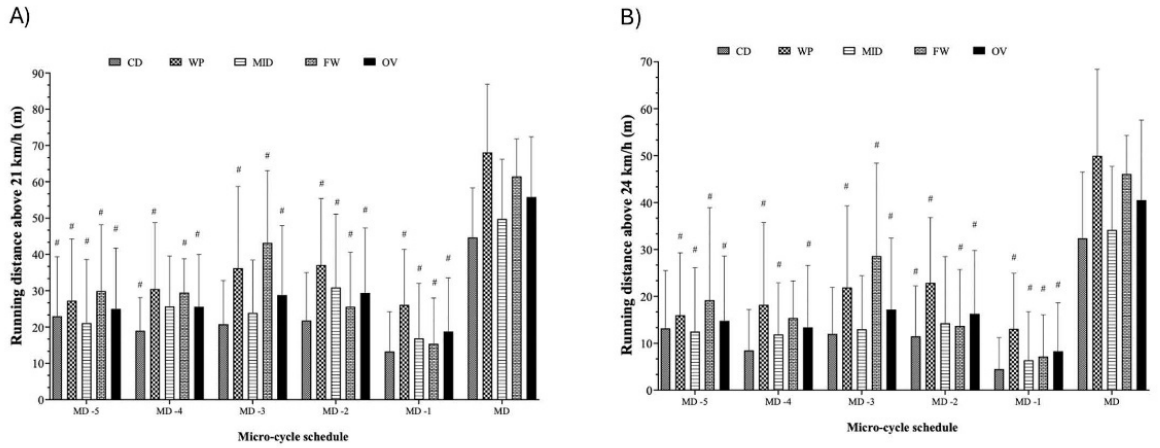

FIG. 2. Micro-cycle patterns and comparative analyses of daily training workloads throughout a competition season, taking into account the field position and overall team in A) running distance above 21 km/h and B) 24 km/h.
#Significant differences with $p < 0.05$ between MD and training days. CD: Central defenders; WP: Wide players; MID: Midfielders; FW: Forwards; OV: overall; MD: match day; MD-5: five days before the match day; MD-4: four days before the match day; MD-3: three days before the match day; MD-2: two days before the match day; MD-1: one day before the match day

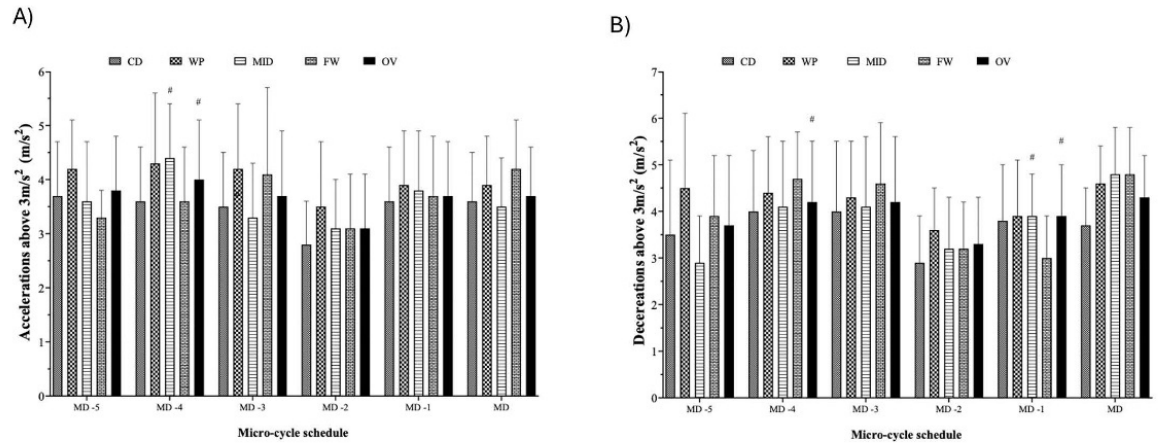

FIG. 3. Micro-cycle patterns and comparative analyses of daily training workloads throughout a competition season, taking into account the field position and overall team in A) accelerations and B) decelerations exceeding 3 m/s^2.
#Significant differences with $p < 0.05$ between MD and training days. CD: Central defenders; WP: Wide players; MID: Midfielders; FW: Forwards; OV: overall; MD: match day; MD-5: five days before the match day; MD-4: four days before the match day; MD-3: three days before the match day; MD-2: two days before the match day; MD-1: one day before the match day

for the same position ($p < 0.05$). Acceleration exceeding 3 m/s² on MD represented 101.1% of the average training values. Deceleration exceeding -3 m/s² on MD represented 111.4% of the average training values.

Table 3 presents the pairwise comparisons between each training day and MD in terms of total distance covered, high-velocity running (above 21 km/h and 24 km/h), accelerations and decelerations exceeding 3 m/s², and high metabolic load distance. The results

TABLE 3. Comparisons over competition season micro-cycles in terms of worst-case scenarios in Mean ± Standard Deviation.

	Microcycle period		Comparative	Mean difference (95% CI)	p	Hedge's g (95% CI)
Total distance (m)	MD-5	138.9 ± 16.5	MD vs MD-5	11.3 (-26.4; 48.9)	0.295	-1.12 (-1.53; -0.71)
	MD-4	157.2 ± 13.8	MD vs MD-4	17.3 (-27.1; 61.6)	0.987	-1.06 (-1.50; -0.63)
	MD-3	159.4 ± 14.1	MD vs MD-3	33.1 (-28.5; 94.6)	0.999	-0.88 (-1.13; -0.62)
	MD-2	175.2 ± 9.05	MD vs MD-2	35.3 (-25.4;96.1)	0.965	-1.13 (-1.54; -0.72)
	MD-1	181.2 ± 3.03	MD vs MD-1	53.5 (-16.6; 123.7)	0.923	-1.40 (-1.83; -0.98)
	MD	192.5 ± 9.73				
Running distance above 21 km/h (m)	MD-5	25.0 ± 16.7	MD vs MD-5	36.2 (22.6; 49.7)	< 0.001	-3.17 (-4.21; -2.13)
	MD-4	25.6 ± 14.4	MD vs MD-4	26.9 (16.9; 36.8)	< 0.001	-3.24 (-3.90; -2.58)
	MD-3	28.8 ± 19.1	MD vs MD-3	29.3 (15.4; 43.1)	< 0.001	-2.34 (-2.89; -1.80)
	MD-2	29.4 ± 17.9	MD vs MD-2	34.4 (22.1; 46.8)	< 0.001	-2.89 (-3.64; -2.02)
	MD-1	18.8 ± 14.7	MD vs MD-1	38.2 (22.7; 53.5)	< 0.001	-4.52 (-5.42; -3.62)
	MD	55.8 ± 18.8				
Running distance above 24 km/h (m)	MD-5	14.8 ± 13.8	MD vs MD-5	29.3 (19.3; 39.4)	< 0.001	-2.30 (-3.00; -1.60)
	MD-4	13.4 ± 13.2	MD vs MD-4	23.4 (15.5; 31.3)	< 0.001	-3.54 (-4.27; -2.81)
	MD-3	17.2 ± 15.2	MD vs MD-3	22.4 (11.7; 33.1)	< 0.001	-2.01 (-2.47; -1.56)
	MD-2	16.3 ± 13.5	MD vs MD-2	27.8 (18.7; 36.9)	< 0.001	-3.37 (-4.30; -2.43)
	MD-1	8.3 ± 10.3	MD vs MD-1	28.7 (17.1; 40.4)	< 0.001	-4.05 (-4.93; -3.17)
	MD	40.5 ± 17.1				
Accelerations above 3 m/s² (m/s²)	MD-5	3.8 ± 1.0	MD vs MD-5	-0.03 (-0.65; 0.59)	0.986	0.22 (-0.44; 0.89)
	MD-4	4.0 ± 1.1	MD vs MD-4	0.82 (0.17; 1.45)	0.006	0.06 (-0.77; 0.89)
	MD-3	3.7 ± 1.2	MD vs MD-3	0.59 (-0.47; 1.66)	0.921	-0.10 (-0.44; 0.25)
	MD-2	3.1 ± 1.0	MD vs MD-2	0.45 (-0.77; 1.67)	0.953	-1.85 (-2.58; -1.13)
	MD-1	3.7 ± 1.0	MD vs MD-1	1.06 (-0.42; 2.53)	0.421	-0.12 (-0.83; 0.60)
	MD	3.7 ± 0.9				
Decelerations above -3 m/s² (m/s²)	MD-5	3.7 ± 1.5	MD vs MD-5	0.30 (-0.26; 0.85)	0.975	-1.20 (-2.25; .0.16)
	MD-4	4.2 ± 1.3	MD vs MD-4	1.28 (0.57; 1.98)	< 0.001	-0.05 (-0.62; 0.52)
	MD-3	4.2 ± 1.4	MD vs MD-3	0.69 (-0.68; 2.07)	0.923	-0.02 (-0.37; 0.32)
	MD-2	3.3 ± 1.0	MD vs MD-2	0.65 (-0.77; 2.08)	0.961	-1.78 (-2.28; -1.29)
	MD-1	3.9 ± 1.1	MD vs MD-1	1.78 (0.19; 3.37)	0.020	-0.37 (-0.84; 0.09)
	MD	4.3 ± 0.9				
High metabolic load distance (m)	MD-5	58.8 ± 14.9	MD vs MD-5	30.7 (21.7; 39.6)	< 0.001	2.38 (-3.34; -1.42)
	MD-4	63.8 ± 24.2	MD vs MD-4	28.9 (14.2; 43.6)	< 0.001	-1.89 (-2.46; -1.32)
	MD-3	62.1 ± 19.5	MD vs MD-3	32.3 (9.02; 55.5)	0.002	-1.61 (-2.18; -1.04)
	MD-2	60.8 ± 19.0	MD vs MD-2	35.1 (13.3; 57.1)	< 0.001	-2.06 (-2.71; -1.40)
	MD-1	57.0 ± 14.6	MD vs MD-1	48.4 (21.5; 75.4)	< 0.001	-2.39 (-2.79; -1.99)
	MD	87.8 ± 18.5				

MD-5, training held five days before the match day; MD-4, training held four days before the match day; MD-3, training held three days before the match day; MD-2, training held two days before the match day; MD-1, training held one day before the match day; MD, match day.

revealed no significant differences in total distance between pre-match days (MD-5 to MD-1) and MD ($p > 0.05$; $\eta p^2 = 0.342$). However, significant increases in the distance covered at speeds above 21 km/h and 24 km/h were observed on match days ($p < 0.001$; $\eta p^2 = 0.854$ and 882, respectively). Similarly, significant results were observed for accelerations and decelerations over 3 m/s² compared to MD. In particular, accelerations on MD-4 demonstrated a significant difference ($p = 0.006$; $\eta p^2 = 0.677$). The high metabolic load distance also increased significantly on MD ($p < 0.001$; $\eta p^2 = 0.899$).

DISCUSSION

The main aim of the study was to analyse the scenarios of maximum physical demand (WCS) produced during the week in the different training sessions and compare them with the physical demands of the match to determine which day of the week these maximum scenarios most closely resemble, in one season. Additionally, physical demands were compared between playing positions in relation to the training performed with respect to MD. There are studies suggesting that comparing training demands with match demands can help determine necessary modifications to training to meet match demands [3]. That is, understanding the demands of the match or training allows the selection of the most optimal training strategies to achieve the desired objectives within the microcycle.

The main findings were as follows: (i) MD showed the highest levels of training load compared to other days of the competition season, such as MD-5, MD-2 and MD-1. (ii) No significant differences were observed in the total distance covered in the different playing positions within the weekdays. (iii) Statistically significant greater distances covered above 21 km/h and 24 km/h were observed on MD compared to other days for most playing positions, except for central defenders (CD), among whom no significant differences were found on MD-3 and MD-1. (iv) A statistically significant lower number of accelerations was observed on MD-4 compared to MD for midfielders (MID), while a statistically significant greater number of decelerations was recorded on MD-1 for MID. (v) High metabolic load distance was statistically significantly lower on MD-1 compared to MD, while no significant differences were observed between MD and MD-4 across all playing positions. Therefore, pairwise comparisons revealed no significant differences in total distance between pre-match days and MD, but a notable increase in distances covered at higher speeds and accelerations/decelerations on MD, along with an increase in high metabolic load distance, indicating that match days are characterised by heightened physical demands and intensity, demonstrated by increased high-speed distances and metabolic loads.

An interesting study [32] analysed the physical demands by position in matches using variables similar to those used in the present study. In terms of total distance, the players with the highest WCS values are the midfielders (MID); in accelerations (> 3 m/s²) and decelerations (< -3 m/s²), they are the offensive midfielders (OMF); and in high metabolic load distance (HMLD), they are the MID. The data obtained in our study are not similar, as the players with the highest WCS values in total distance are the wide players (WP); in accelerations and decelerations greater than 3 m/s², they are the forwards (FW); and in HMLD, they are the WP. These differences could be due to the different demands of each position when playing with one system of play or another [19].

In another, similar study [20], it was observed that on match days, players in wide positions (WP) had higher peaks in total distance, distance > 21 km/h, distance > 24 km/h, and HMLD compared to players in central positions. These data are in line with the values obtained in our study, in which the WPs had the highest peaks among the previously mentioned variables. Although only home matches were analysed in that study, the number of participants was similar, and the level of the athletes was equivalent to that in our research. Another recent study [16] showed that the players who reproduce the most WCS in total distance, high-intensity distance, or sprint distance on match day are the midfielders (MID). These studies do not match ours, because the players with the highest total distance and high-intensity distance are the WP. These differences could also be explained by the different demands of each position, depending on the playing system employed by each team [33].

Some studies have asserted that the dimensions of the tasks directly influence the physical demands obtained during the training week [34]. Based on their dimensions, these tasks can be classified as large sided games (LSG), medium sided games (MSG), or small sided games (SSG). An interesting study [35] showed that, during the week, the scenarios with the highest maximum demand correspond to training days that primarily include large sided games (LSG). Midfielders (MID) are the players who reach the highest peak of metres covered in one minute during training days and during the match. In all positions, the peaks reached during the week never exceed those reached on the match day. According to that study, the training days on which the highest WCS of the total distance covered should occur are MD-3 and MD-4. Our study found that the MID players had the highest WCS of total distance on MD-3 and MD-4. However, this was not the case on the match day, because the players with the greatest distance in the WCS were the WP instead of the MID. This difference could be due to the playing style used by the team during the season, in which the WP were important players in the team's play, especially regarding play on the wings.

Previous research [36] indicated that the day of training with the highest volume and intensity relative to variables such as high-intensity metres covered or total distance would correspond to MD-3 in all positions. These findings are in line with our study regarding the high-intensity distance variable over 24 km/h, where the highest WCS values corresponded to MD-3 in nearly all positions. However, they do not align in total distance and distance over +21 km/h, as in our study, and the highest weekly values for total distance occurred on MD-4 and for distance over +21 km/h on MD-2. Nevertheless, other research [7] found that MD-4 and MD-5 were the days when

the highest training demands in terms of volume and intensity typically occurred in the team, in all positions.

Also, in another study [37], the day of highest demand during the training week corresponded to MD-4, both in total distance and in the number of accelerations (> 3 m/s^2) and decelerations (< -3 m/s^2), which is in line with our study.

Not only are there studies analysing WCS in 1 min periods, but we can also find others [38, 39] analysing them in 5 min periods during competition. In the matches analysed in the first study [38], the players with the highest WCS peaks in acceleration, deceleration, and high-intensity distances were the WP. In the present study, based on 1 min durations, the highest WCS values for high-intensity distance variables were also observed in the WP. However, the FW exhibited higher acceleration and deceleration values. Both studies consistently indicated that players positioned on the wings tended to exhibit higher WCS values for total distance and high-intensity distances compared to those positioned centrally. Furthermore, in the second study [39], players who reproduced the most WCS in high-intensity distances in 5-minute periods were also the WP. Therefore, we can confirm that, generally, wide players require higher physical demands during competition.

When comparing the WCS produced in 1 min intervals with those produced in 3 min intervals, as demonstrated by some authors [40], divergent results were found. This study observed that MID players covered the greatest total distances during 3 min periods. However, our results, obtained by analysing WCS in 1 min intervals, showed that WP players covered the greatest distances. This discrepancy suggests that the player movement dynamics may vary significantly depending on the duration of the analysis interval. It is important to bear in mind that these differences may also reflect variations in the methodologies or contextual factors of the studies, such as differences in playing styles, tactical strategies, or physical conditioning across teams.

An interesting study [41] analysed similar conditional variables in the same demarcation as in our study in the WCS at 1 min, 3 min, 5 min, and 10 min in MD. Focusing on the WCS analysis of the 1 min period, we observed that the players who covered the most distance were the MID. In contrast, the players who covered the most distance at high intensity, accelerated and decelerated more times, and covered the most HMLD were the wing players. In our study, we found that, in 1 min periods, the players who covered the most total distance, the most distance at high intensity, accelerated and decelerated more times, and covered the most HMLD were the WP. Compared with our study, it only differed between the players who covered the most total distance during 1 min periods in the match. Without being able to precisely know the team's playing model and tactical disposition in the study we are making a comparison to, these differences could arise because in the team we analysed in our study, the WP players had a significant role in the team's gameplay development both in attack and defence. Therefore, comparing the results without knowing all the data raises a concern in this context.

Recently, a study [42] analysed the differences in WCS between the first and second halves of matches, without specifying whether only starting players, players who completed the entire match, or all players who participated in the match were included. In 1 min WCS, the players who covered the most distance in both the first and second halves were MID players. The players who had higher values of HMLD in both halves were also MID players. Although our study specifically analysed complete matches, the players who had higher values of total distance and HMLD were WP players. We cannot infer conclusions from this comparison because the difference between the analyses of the two halves individually and globally can be significant.

In recent years, research on the physical demands in women's football has grown [43], allowing for comparisons with the physical demands of men's football. When comparing the WCS without splitting into playing positions, the values found in the 1 min WCS were higher in men's football for all variables. This difference is mainly attributed to the physical and morphological characteristics that distinguish men and women. [44].

Due to the novelty of the investigated topic, few studies in the scientific literature have compared WCS from training sessions with those from matches over an entire season in a professional team. Therefore, we considered it novel and interesting to conduct a detailed analysis of the conditioning variables recorded throughout a season based on our players' positions and to compare them with match data.

However, we also identified a series of limitations in the development of this study. The first limitation was that MD+1 was not included in the study because players who completed the match, having performed recovery-oriented training, did not wear GPS devices. The second limitation was the decision to group both fullbacks and wide midfielders into a single group called 'wide players', since including only players who completed the entire match resulted in a very small sample size of wide midfielders throughout the season. Typically, substitutions in matches involve attacking players, which affects wide midfielders. The final limitation of the study was the sample size, as a professional football squad usually consists of 20–25 players distributed over several positions. Therefore, while analysing the data by playing positions can provide valuable information, the small sample size for each position limits the representativeness and generalisability of the results.

CONCLUSIONS

It can be confirmed that, during the microcycle, high-demand scenarios typically occur during the MD. During the microcycle, no significant differences were found in any of the analysed playing positions in the total distance variable. However, significant differences were found in the variables of distance > 21 km/h and distance > 24 km/h in all positions except for the CD. In the MID position, MD-4 produced higher values than MD at acceleration > 3 m/s^2. In addition, in decelerations < -3 m/s^2, MD-1 produced higher values than MD. Finally, for the HMLD variable, MD-1 values were significantly lower compared to MD in all playing positions. Therefore,

the reproduction of maximum demand scenarios during the week suggests a low injury rate. Future studies should examine the relationship between high-demand scenarios and injury rates or cumulative fatigue during the season. Investigating why physical demands vary between positions based on MD could help refine positional training strategies and improve recovery protocols. Finally, this study could help coaches or sport scientists to identify the most appropriate days to train specific positional demands, thus improving both performance and recovery strategies.

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Conflict of interest disclosure

The authors report no conflict of interest.

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Estudio 3. Training Tasks vs. Match Demands: Do Football Drills Replicate Worst-Case Scenarios?

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Training Tasks vs. Match Demands: Do Football Drills Replicate Worst-Case Scenarios?

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Abstract

This study analyses the physical performance variables involved in different training tasks aimed at replicating the worst-case scenarios (WCSs) observed during official matches in professional football, with a focus on playing positions and occurrences within a 1 min period. Data were collected from 188 training sessions and 42 matches of a Spanish Second Division team during the 2021/2022 season. All data were reported on a per-player basis. GPS tracking devices were used to record physical variables such as total distance, high-speed running (HSR), sprints, accelerations, decelerations, and high metabolic load distance (HMLD). Players were grouped according to their match positions: central defenders, wide players, midfielders and forwards. The results showed that none of the training tasks fully replicated the physical demands of match play. However, task TYPEs 11 (Large-Sided Games) and 9 (small-sided games with orientation and transition) were the closest to match demands, particularly in terms of accelerations and decelerations. Although differences were observed across all variables, the most pronounced discrepancies were observed in sprint and HSR variables, where training tasksfailed to reach 60% of match demands. These findings highlight the need to design more specific drills that simulate the intensity of WCS, allowing for more accurate weekly training load planning. This study offers valuable contributions for optimising performance and reducing injury risk in professional footballers during the competitive period.

Keywords: football; worst-case scenario; physical performance; football drills; playing position; GPS tracking

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1. Introduction

Elucidating the relationship between training-induced physical or conditional workloads and the peak physical demands experienced by players during competitive match play has become a critical prerequisite for the development of evidence-based, performance-optimised training programmes [1].

Modern football is characterised by its intermittent and high-intensity physical demands, requiring players to perform repeated bouts of sprinting, changes in direction, jumping, and physical contact, interspersed with lower-intensity activities. These efforts support the execution of tactical and technical actions dictated by the evolving demands of the game across both attacking and defensive phases [2]. The advent of GPS tracking technologies and video analysis has enabled the quantification of physical demands during

elite-level matches. Such analyses have identified key performance metrics, including total distance covered, high-speed running (HSR) distance, the frequency and intensity of accelerations and decelerations, peak velocity, and PlayerLoad™ [1,3]. These metrics underscore the explosive and metabolically demanding nature of competition, providing reference values essential for aligning training tasks with match demands [4].

The individualisation of training is a key principle for maximising adaptation and minimising the risk of overtraining [5]. A critical factor in this optimisation process is the consideration of the specific physical demands associated with each playing position on the pitch. Distinct tactical responsibilities and movement patterns inherent to different positions result in differentiated physical demand profiles [6,7]. Furthermore, even within the same position, individual players may perform successfully with varying performance profiles. Neglecting these positional variations or failing to provide adequate training stimuli for key aspects of physical preparation when designing training tasks may lead to insufficient readiness for the specific demands of match play, thereby increasing the risk of fatigue or injury [5].

Within the specific context of training tasks, it is essential to evaluate their contribution to developing the capacity to meet the peak demands of match play [8]. The manipulation of key variables, such as pitch dimensions and the number of players involved, significantly influences the physical demands elicited [9]. Each training task elicits distinct physiological and neuromuscular responses, with varying implications for the development of players' physical capacities [3]. However, accumulating training volume alone does not ensure optimal preparation for the most demanding phases of competition. The selection of specific training scenarios that replicate the peak physical demands of match play is therefore a fundamental aspect of designing truly effective training programmes [5,10]. This necessitates exposing players to scenarios capable of reproducing the intensities observed during the most physically demanding moments of competition [7]. Evidence suggests that athletes who are adapted to training loads comparable to the peak demands of competition may experience a lower incidence of injury compared to those exposed to lower training loads [1]. The progression and periodisation of training loads represent another critical component in ensuring that players are adequately prepared for the most physically demanding phases of match play [11]. Therefore, it is essential to consider peak physical demands when designing training sessions. Nonetheless, research has shown that relying solely on average values tends to lead to underestimation of the maximum demands encountered during competition. To overcome this limitation, an alternative approach has been adopted that focuses on identifying the periods within a match when the highest physical demands for each variable occur. This approach is commonly referred to as "worst-case scenarios" (WCSs) [12]. Identifying these WCSs enables the optimisation and individualisation of training loads, supporting more precise and demand-specific planning for competitive performance [13,14]. Initial analyses of worst-case scenarios (WCSs) relied on fixed-length time windows, segmenting the match into uniform intervals from start to finish—for example, one-minute periods such as 0:00–0:59, 1:00–1:59, and so forth until the end of the match. However, contemporary approaches have shifted toward the use of rolling averages, which identify the specific time frames during which peak intensities occur. For instance, the highest distance covered may be observed between 15:25 and 16:25, while the peak sprinting effort might occur between 24:49 and 25:49, with similar patterns emerging across other performance variables [15]. While WCS are commonly analysed over durations of 1, 3, 5, or 10 min [16], focusing on the 1 min WCSs during training sessions may be particularly useful for preparing players to meet the peak physical demands encountered in competitive match play [17].

The primary aim of this comparative and longitudinal study is to determine which types of training tasks best replicate the physical demands of WCSs observed in official matches within a one-minute time window. Specifically, the study analyses and compares six external load variables—total distance (DIST TOTAL), high-speed running distance (>21 km/h; DIST 21), sprint distance (>24 km/h; DIST 24), high-intensity accelerations (ACCs), high-intensity decelerations (DECs), and high metabolic load distance (HMLD)—across different training tasks and playing positions. We hypothesise that certain training tasks, particularly those with reduced pitch size and specific constraints (e.g., small-sided games), will replicate worst-case scenario demands more accurately than others, especially in terms of DIST 21, DIST 24, and HMLD. Moreover, we expect that the degree of replication will differ significantly between playing positions, reflecting the positional specificity of physical demands.

2. Materials and Methods

This comparative and longitudinal study was conducted within the context of a professional football team over the course of 42 consecutive weekly microcycles, excluding the pre-season period. The analysed sample comprised a total of 188 training sessions and 42 official matches played in the Spanish Second Division (Smartbank League) during the 2021/2022 season. It is worth noting that the majority of matches took place during non-congested weeks, with a typical frequency of one match per week [18–22]. Weekly training load planning was structured according to the competitive calendar, adapting to the scheduling of official fixtures.

The Ethical Committee of Clinical Research of Aragon, Spain (CEICA) approved the present study in act nº04/2021 with licence PI21/060. The research was conducted in accordance with the Declaration of Helsinki [23] and in compliance with the ethical standards for Sport and Exercise Science Research [24].

2.1. Task Classification

Coaches employ a wide range of training tasks, including small-sided games (SSGs) and position-specific possession drills, as well as medium-sided games (MSGs), large-sided games (LSGs), high-intensity interval training (HIIT), integrated physical–technical circuits, and specific strength training [3,8], in addition to tasks with a primarily tactical or technical focus. SSGs, for instance, are widely used due to their capacity to integrate physical, technical, and tactical components within a high-intensity format [8,25,26]. LSGs, which involve a greater number of players and larger pitch dimensions, tend to elicit coverage of higher total distances [3]. HIIT is designed to enhance players' ability to perform and repeat high-intensity efforts [8]. Although primarily aimed at skill development, technical and tactical training scenarios also contribute to the overall physical load [3].

To differentiate the training tasks performed during the season under investigation, task characteristics were considered in relation to their level of specificity; namely, their degree of similarity to actual match play. These included the presence or absence of opposition, directional play, transitional phases, goals, the number of players involved [27], and the size of the playing area [28]. All tasks analysed in the present study were based on regular training methods and were not specifically designed for the purposes of this study. These types of tasks are detailed in Table 1.

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Table 1. Task classification.

Type of Task	Characteristics	Approximate Playing Area	Examples
TYPE 0	Without opposition Non-directional	-	Warm-up
TYPE 1	Without opposition Directional	-	Finishing drills Set pieces Tactical automatisms Tactical work
TYPE 2	Without opposition Non-directional Without transition	80–120 m^2	Rondo
TYPE 3	With opposition Non-directional With transition ≤6 players in possession team	80–728 m2	4v2 possession game 4v3 possession game 4v4 possession game 5v2 possession game 6v3 possession game 6v6 possession game
TYPE 4	With opposition Non-directional With transition 7–8 players in possession team	240–1260 m^2	7v7 possession game 8v4 possession game 8v8 possession game
TYPE 5	With opposition Non-directional With transition ≥9 players in possession team	1400–3000 m^2	9v9 possession game 10v10 possession game 11v11 possession game 12v12 possession game
TYPE 6	With opposition Directional Without transition ≤6 players in possession team	500–750 m^2	4v2 attack vs. defence 5v3 attack vs. defence 5v4 attack vs. defence
TYPE 7	With opposition Directional Without transition 7–8 players in possession team	1000–1500 m^2	7v5 attack vs. defence 8v5 attack vs. defence 8v6 attack vs. defence
TYPE 8	With opposition Directional Without transition ≥9 players in possession team	2000–3000 m^2	10v4 attack vs. defence 10v8 attack vs. defence 11v8 attack vs. defence
TYPE 9	With opposition Directional With transition ≤6 players in possession team	460–900 m^2	5v5 SSG 6v6 SSG
TYPE 10	With opposition Directional With transition 7–8 players in possession team	728–2080 m^2	7v7 MSG 8v8 MSG
TYPE 11	With opposition Directional With transition ≥9 players in possession team	5100–6400 m^2	9v9 LSG 10v10 LSG 11v11 LSG
TYPE 12 (Official match)	Official match	6000 m^2	Official match

TYPE 0 tasks are characterised by the absence of both opposition and spatial orientation towards a specific objective. These are low-tactical-complexity situations typically used in the initial phases of a training session, such as warm-ups, with the primary aim of physically activating the player.

TYPE 1 tasks are defined as non-oppositional but directionally oriented towards a specific game objective. These drills allow for the development of technical and tactical aspects in a controlled environment, facilitating the automation of playing patterns and improving execution without the pressure of an opponent.

TYPE 2 tasks involve opposition between players but lack directional orientation and transitions. They focus on technical interactions under pressure and on improving decision-making in reduced spaces.

TYPE 3 tasks include both opposition and transitions, but without a specific orientation towards a goal. These are typically possession-based drills with role changes between attackers and defenders, introducing greater tactical and cognitive complexity than previous types. They usually involve six or fewer players in the possession team.

TYPE 4 tasks involve seven to eight players in the possession team and are conducted in non-directional contexts with active opposition and transitions. Although there is no defined spatial objective, the inclusion of transitions requires players to reorganise tactically at high speed.

TYPE 5 tasks are designed for high player-density contexts, involving nine or more players in the possession team. These drills simulate collective structures closer to real match play. Despite the absence of directional goals, the presence of opposition and constant transitions demands sustained organisation, communication, and decision-making under pressure.

TYPE 6 tasks focus on positional attacks with six or fewer attacking players against an organised defence, including goals and goalkeepers. Tactical lines emerge in both attack and defence. As there are no role changes, the emphasis is on ball circulation, spatial occupation, and finishing.

TYPE 7 tasks involve seven to eight attacking players and expand the structure of positional attacks, allowing for the development of more complex collective behaviours than TYPE 6.

TYPE 8 tasks include nine or more attacking players and, like TYPE 6 and TYPE 7, simulate structured attacking scenarios on a full or half pitch, with clearly defined offensive and defensive tactical lines.

TYPE 9 tasks correspond to small-sided games (SSGs). These are played with goals and rules similar to official matches, including constant transitions between attack and defence in small spaces, often without defined tactical lines or only in a rudimentary form.

TYPE 10 tasks are known as medium-sided games (MSGs), involving 7 to 8 players per team. Played in medium-sized spaces, they allow for greater tactical breadth than TYPE 9, maintaining goal orientation, transitions, and well-defined tactical lines.

TYPE 11 tasks represent large-sided games (LSGs), with nine or more players per team. These simulate real match conditions with full tactical structures and game dynamics.

TYPE 12 corresponds to the official match context, where all game variables are present and fully expressed.

Only TYPE 0 to TYPE 11 tasks were recorded during training sessions, while TYPE 12 was used to classify data from official matches.

Then, Table 2 presents the relationship, in minutes and percentages, between the time spent on each type of task (TSOETT) during the entire competitive period and the total accumulated minutes of physical activity (TAMOPA) performed throughout the season.

To determine the total minutes of physical activity throughout the season, both training sessions and official matches were considered.

Table 2. Task-specific time allocation during the competitive period.

Type of Task [1]	TSOETT (min)	TAPOMA (min)	TSOETT: TAMOPA (%)
TYPE 0	2833		13.7
TYPE 1	643		3.1
TYPE 2	765		3.69
TYPE 3	972		4.7
TYPE 4	958		4.62
TYPE 5	946		4.57
TYPE 6	1401	20,700	6.76
TYPE 7	1145		5.53
TYPE 8	1898		9.16
TYPE 9	1919		9.27
TYPE 10	1525		7.36
TYPE 11	1915		9.28
TYPE 12 (official match)	3780		18.26

[1] TSOETT: time spent on each type of task; TAMOPA: total accumulated minutes of physical activity.

2.2. *Participants*

The sample for this study consisted of 23 professional football players (age: 26.6 ± 4.7 years; height: 179.3 ± 5.9 cm; body mass: 75.4 ± 5.4 kg; body mass index (BMI): 23.4 ± 0.9 kg/m^2), all members of a team competing in the Spanish Second Division (Smartbank League), as detailed in Table 3. The team finished the competition in a mid-table position, far from both promotion and relegation zones. According to the Participant Classification Framework [29], these players are categorised as belonging to the third competitive level, which corresponds to highly trained or national-level athletes. However, for the specific analysis of each weekly microcycle, only those players who completed the full duration of the match day (MD) were included. Goalkeepers were excluded from the study due to the distinct physical demands associated with their role, which differ substantially from those of outfield players [30,31]. During non-congested weeks, participants engaged in 9–10 h of training per week (approximately 1.5 h per day) and played one official match. In contrast, during weeks with a higher competitive load, the total training volume was reduced to 7–8 h per week, while maintaining daily session duration, and players participated in two official matches. Players were analysed both individually and by positional role, including central defenders (CDs), wide players (WP), midfielders (MID), and forwards (FW) [32]. Full-backs and wide midfielders were grouped under the single category of "wide players" due to the limited number of wide midfielders who completed full matches throughout the season.

Table 3. Anthropometric characteristics of the participants.

Playing Position [1]	n	Age (years)	Height (cm)	Weight (kg)	BMI (kg/m^2)
CD	4	24.8 ± 5.4	183.5 ± 4.4	77.0 ± 4.7	22.9 ± 1.2
WP	6	24.3 ± 3.4	175.2 ± 3.7	72.8 ± 3.2	23.7 ± 0.6
MID	8	27.6 ± 5.5	180.3 ± 6.8	76.3 ± 7.2	23.4 ± 0.9
FW	5	26.8 ± 4.7	181.4 ± 4.3	77.8 ± 1.5	23.7 ± 1

[1] CD: central defenders; WP: wide players; MID: midfielders; FW: forwards; BMI: body mass index.

Due to the large volume of data collected, it was decided that the inclusion and exclusion criteria of the study would be reviewed on a microcycle-by-microcycle basis.

The inclusion criteria of the study were as follows:

- Participants were required to be part of the club's first-team squad during the 2021/2022 season.

- They were required to complete the training sessions in their entirety and the match within the microcycle.
- They were required to play in one of the following playing positions: central defender, wide player, midfielder, or forward.

The exclusion criteria of the study were as follows:

- Playing in the goalkeeper playing position.
- Undergoing a return-to-play process.
- Being injured.
- Failing to complete any of the training sessions or the match within the microcycle.

A total of 5750 observations were recorded, encompassing players, training sessions, and official matches, excluding the pre-season period. All participants were fully informed of the study's objectives and provided written informed consent, in accordance with ethical research principles.

All training sessions were conducted on the same natural grass pitch under standardised conditions. Players wore footwear specifically designed for this surface and did not use shin guards. With few exceptions, sessions were held in the morning, maintaining a consistent start time throughout the study period. Each session began with a standardised warm-up routine, designed to prepare players for the main part of the session, which was subsequently adjusted according to the planned technical and tactical content. All sessions were led by the same coaching staff throughout the season, ensuring methodological consistency. During breaks between drills, players were encouraged to consume water or isotonic beverages to maintain adequate hydration. Additionally, a sports nutritionist continuously monitored players' dietary intake (breakfast and lunch) and hydration practices with the aim of optimising recovery processes.

2.3. Intruments

Data collection was carried out using WIMU PRO™ devices (RealTrack Systems, Almería, Spain), equipped with 10 Hz GPS technology and a triaxial accelerometer with a sampling frequency of 1000 Hz. This configuration enabled precise recording of kinematic variables during both training sessions and competitive matches. WIMU PRO™ devices have been validated as reliable and accurate tools for obtaining GPS-based positioning metrics in professional football contexts [33]. The devices were placed in specially designed vests (Rasan, Valencia, Spain) featuring a rear pocket for secure placement. All units were calibrated by RealTrack Systems (Almería, Spain), the manufacturer, at the beginning of the season to ensure data accuracy and consistency.

2.4. Procedures

Data analysis and processing were conducted using SPRO Version 2.2.0 software (RealTrack Systems, Almería, Spain). The following variables were selected for inclusion in the study:

- Distance (m)—total distance (DIST TOTAL): the total distance covered during the session or match.
- High-Speed Running Distance (m)—DIST 21: the distance covered at speeds exceeding the absolute high-speed threshold of 21 km/h.
- Sprint distance (m)—DIST 24: the distance covered at speeds exceeding the absolute sprint threshold of 24 km/h.
- High accelerations (count)—ACC: the number of high-intensity accelerations (>3 m/s^2).
- High decelerations (count)—DEC: the number of high-intensity decelerations (<−3 m/s^2).

- High Metabolic Load Distance (m)—HMLD: the distance covered during actions involving high metabolic demand (≥25.5 W/kg), including metres covered at high speed (>21 km/h) and during intense accelerations and decelerations (>2 m/s^2) [34].

Absolute thresholds were applied for all variables analysed. This methodological choice was based on the premise that, although some studies suggest that relative thresholds allow for greater individualisation of workload, the use of absolute thresholds ensures greater consistency and facilitates comparisons across athletes and studies [35,36]. Moreover, it has been shown that the choice between absolute and relative thresholds does not significantly affect training load planning or programming [37,38].

The analysis window selected for identifying WCS was one minute. While WCS are commonly analysed over durations of 1, 3, 5, or 10 min [12,15], the 1-min period was chosen in this study, as it allows for the replication of peak-intensity scenarios during training sessions, which may serve as an effective strategy to prepare players for the most demanding physical moments of competitive match play [17]. Finally, the WCS analysed were based on the average of the most demanding one-minute windows in each task or match for each player.

2.5. Statistical Analysis

All statistical analyses were conducted using IBM SPSS Statistics (version 29; IBM Corp., Armonk, NY, USA). The normality of the data was assessed using the Kolmogorov–Smirnov test, and the homogeneity of variances was verified using Levene's test. Given that the aim of the study was to determine which training tasks best replicate the physical demands of match-based WCS, a one-way ANOVA was conducted to detect significant differences between each task type and the WCS reference values. Including all task types and match demands within the same model allowed for a robust and integrated comparison framework, enabling direct post hoc testing to assess which specific tasks significantly differed from match conditions. When the assumption of homogeneity of variances was met, Bonferroni-adjusted post hoc tests were used to compare each training task against match values. When this assumption was violated, the Games–Howell correction was applied. These pairwise comparisons enabled the identification of which training tasks were significantly different from match demands. To complement the inferential analysis, effect sizes (Cohen's d) were calculated for all pairwise comparisons to quantify the magnitude of the differences between each training task and the match condition. The interpretation of d was as follows: trivial = 0 to 0.19, small = 0.2 to 0.59, moderate = 0.6 to 1.19, large = 1.2 to 1.99, very large = 2.0 to 3.99, and near perfect ≥ 4.0 [39]. In addition, the percentage of fulfilment relative to match demands was calculated for each task using the following formula:

$$\% \text{ relative to match} = (\text{Mean of the task}/\text{Mean of the match}) \times 100$$

3. Results

Significant differences were found between most training tasks and match play for all physical variables across all playing positions ($p < 0.05$), with some exceptions. These differences and their effect sizes are shown in Table 4, and the percentage changes with respect to match play are detailed in Figures 1–6. For total distance, tasks represented 33.7–91.6% of match demands for central defenders, 52.0–86.1% for wide players, 32.8–87.7% for midfielders, and 36.6–88.0% for forwards. Effect sizes ranged from trivial to very large (ES = 0.08–2.61). For HSR distance, tasks covered 14.5–56.1% of match demands in central defenders, 15.1–44.6% in wide players, 18.6–58.1% in midfielders, and 22.6–69.2% in forwards, with large to very large effect sizes (ES = 1.10–3.74). Regarding HMLD, tasks reached

18.6–77.2% of match values for central defenders, 26.4–73.1% for wide players, 13.4–79.9% for midfielders, and 18.2–74.9% for forwards, showing moderate to very large effect sizes (ES = 0.97–5.20). For decelerations, most tasks showed significant differences, except for TYPE 6 (p = 0.182) and TYPE 9 (p = 0.091) in central defenders. Relative values were 64.1–90.4% for central defenders, 52.8–79.4% for wide players, 52.8–81.6% for midfielders, and 52.6–81.6% for forwards, with effect sizes ranging from trivial to large (ES = 0.08–1.78). Accelerations showed significant differences across most tasks, except for TYPE 6 (p = 0.003) in central defenders; TYPE 5 (p = 0.0697), TYPE 6 (p = 0.1432), TYPE 7 (p = 0.1608), and TYPE 9 (p = 0.0752) in midfielders; and TYPE 6 (p = 0.241), TYPE 7 (p = 0.089), and TYPE 9 (p = 0.141) in forwards. Tasks covered 52.9–74.0% of match accelerations in central defenders, 52.8–77.2% in wide players, 48.0–74.9% in midfielders, and 52.6–81.6% in forwards, with trivial to large effect sizes (ES = 0.04–1.43). Sprints showed significant differences across all tasks, except for TYPE 3 (p = 0.48), TYPE 4 (p = 0.094), and TYPE 8 (p = 0.137) in midfielders. Tasks achieved 7.9–51.1% of match sprints for central defenders, 8.4–54.5% for wide players, 8.5–57.2% for midfielders, and 15.9–55.2% for forwards, with large to very large effect sizes (ES = 0.88–4.20). No results were reported for TYPE 5 and TYPE 7 in forwards for the sprint variable due to an insufficient sample size.

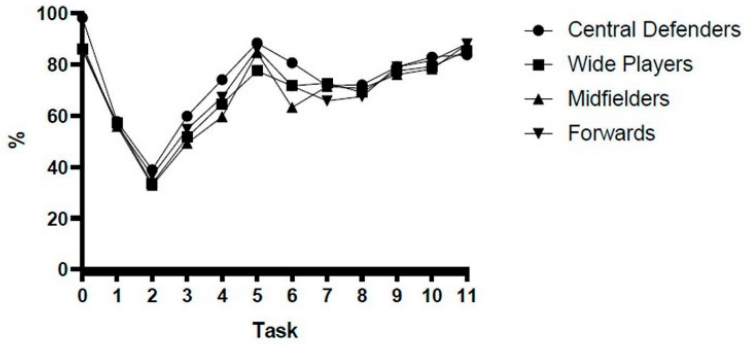

Figure 1. % Total distance with respect to task Type 12 (official match).

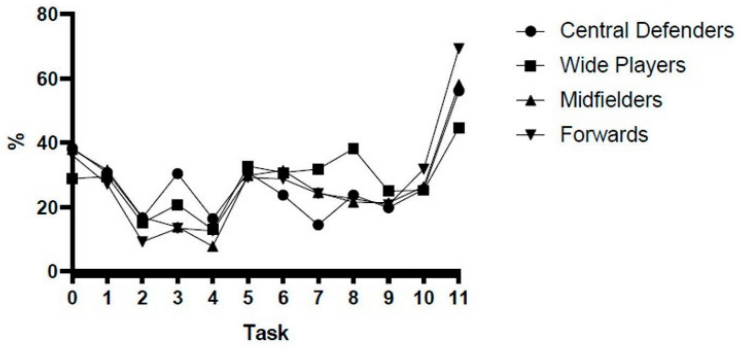

Figure 2. % High-sprint running with respect to task Type 12 (official match).

Table 4. Descriptive statistics of physical performance variables by playing position and task type.

Task	Playing Position	DIST TOTAL	ES	DIST 21	ES	DIST 24	ES	ACC	ES	DEC	ES	HMLD	ES
TYPE 0	CD	147.6 ± 29.1	0.08	15.3 ± 14.3	−1.71 *	13.2 ± 13.7	−1.42 *	1.3 ± 0.5	0.91 *	1.2 ± 0.4	0.74 *	21.5 ± 13.9	2.82 *
	WP	147.2 ± 29.9	0.88 *	15.9 ± 13.3	−2.70 *	11.2 ± 9.4	−2.02 *	1.2 ± 0.5	1.02 *	1.2 ± 0.4	0.94 *	20.9 ± 13.9	3.89 *
	MID	150.8 ± 31.1	−0.85 *	16.6 ± 15.5	−1.66 *	11.9 ± 13.0	−1.17 *	1.3 ± 0.6	1.10 *	1.2 ± 0.5	0.93 *	20.9 ± 15.1	3.03 *
	FW	142.0 ± 36.3	0.71 *	18.2 ± 14.2	−2.09 *	11.7 ± 9.9	−2.69 *	1.2 ± 0.5	1.16 *	1.2 ± 0.5	0.99 *	21.9 ± 16.0	3.59 *
	TEAM	147.4 ± 31.6	−0.68 *	16.5 ± 14.4	−2.02 *	11.9 ± 11.5	−1.73 *	1.3 ± 0.5	0.86 *	1.2 ± 0.5	0.98 *	21.2 ± 14.8	3.34 *
TYPE 1	CD	86.6 ± 25.2	−3.69 *	12.3 ± 11.3	−2.14 *	9.7 ± 8.9	0.80 *	1.4 ± 0.6	0.80 *	1.3 ± 0.6	0.70 *	22.4 ± 13.4	2.81 *
	WP	97.5 ± 27.3	−2.72 *	16.3 ± 12.6	−2.67 *	12.0 ± 10.0	0.82 *	1.4 ± 0.7	0.82 *	1.3 ± 0.6	0.88 *	27.7 ± 14.2	3.40 *
	MID	95.8 ± 25.3	−3.25 *	13.8 ± 12.5	−2.00 *	10.5 ± 9.4	0.94 *	1.6 ± 0.7	0.94 *	1.3 ± 0.6	0.80 *	25.0 ± 13.6	2.90 *
	FW	65.8 ± 14.5	−2.57 *	13.7 ± 16.2	−2.25 *	13.0 ± 15.6	0.81 *	1.4 ± 0.7	0.81 *	1.4 ± 0.7	0.81 *	27.0 ± 14.9	3.38 *
	TEAM	94.6 ± 26.3	−2.91 *	14.2 ± 13.1	−2.25 *	11.3 ± 10.8	−1.81 *	1.5 ± 0.7	0.63 *	1.3 ± 0.6	0.88	25.7 ± 14.0	3.12 *
TYPE 2	CD	58.5 ± 13.8	−5.97 *	6.7 ± 5.0	−3.08 *	2.5 ± 3.2	−2.13 *	1.4 ± 0.7	0.75 *	1.4 ± 0.7	0.67 *	8.0 ± 9.2	4.52 *
	WP	57.2 ± 18.5	−5.24 *	8.4 ± 6.6	−3.75 *	3.5 ± 2.2	−2.00 *	1.4 ± 0.7	0.80 *	1.4 ± 0.6	0.83 *	8.2 ± 10.8	5.20 *
	MID	56.4 ± 15.3	−6.42 *	7.4 ± 4.2	−2.92 *	2.6 ± 1.7	−2.08 *	1.4 ± 0.6	0.96 *	1.3 ± 0.6	0.79 *	6.8 ± 9.3	4.58 *
	FW	60.7 ± 18.3	−4.89 *	4.6 ± 5.3	−3.74 *	3.0 ± 2.8	−11.67 *	1.3 ± 0.6	1.01 *	1.3 ± 0.6	0.91 *	8.2 ± 9.9	5.58 *
	TEAM	57.9 ± 16.5	−5.69 *	6.9 ± 5.2	−3.36 *	2.9 ± 2.3	−3.02 *	1.4 ± 0.6	0.74 *	1.3 ± 0.6	0.88 *	7.7 ± 9.8	4.94 *
TYPE 3	CD	89.7 ± 21.1	−3.51 *	12.1 ± 12.3	−2.08 *	11.5 ± 5.0	−1.47 *	1.5 ± 0.7	0.73 *	1.4 ± 0.7	0.66 *	17.5 ± 8.2	3.83 *
	WP	88.1 ± 23.2	−3.07 *	10.5 ± 10.2	−3.27 *	9.5 ± 2.5	−1.70 *	1.4 ± 0.7	0.81 *	1.4 ± 0.6	0.8 *	16.5 ± 9.0	4.83 *
	MID	84.5 ± 25.5	−4.03 *	6.2 ± 7.5	−2.85 *	5.7 ± 2.5	−1.42	1.4 ± 0.6	0.78 *	1.3 ± 0.6	0.79 *	12.9 ± 9.6	4.11 *
	FW	90.7 ± 21.0	−2.62 *	6.8 ± 6.6	−3.47 *	4.3 ± 0.0	−1.39	1.4 ± 0.6	0.90 *	1.4 ± 0.7	0.87 *	16.5 ± 8.1	5.18 *
	TEAM	88.7 ± 23.2	−3.49 *	8.5 ± 8.8	−2.98 *	7.4 ± 2.4	−2.59 *	1.4 ± 0.6	0.74 *	1.4 ± 0.6	0.79 *	15.4 ± 8.9	4.46 *
TYPE4	CD	111.1 ± 32.2	−2.36 *	6.6 ± 6.6	−2.97 *	5.6 ± 9.1	−1.86 *	1.5 ± 0.7	0.71 *	1.4 ±0.7	0.39 *	34.1 ± 17.1	1.69 *
	WP	110.4 ± 29.1	−2.08 *	7.2 ± 7.7	−3.75 *	4.0 ± 3.3	−2.00 *	1.5 ± 0.8	0.71 *	1.5 ± 0.7	0.78 *	33.0 ± 13.9	3.08 *
	MID	102.3 ± 29.7	−3.22 *	3.4 ± 2.8	−3.30 *	2.5 ± 0.5	−2.09 *	1.6 ± 0.8	0.70 *	1.5 ± 0.7	0.72 *	26.5 ± 13.0	2.86 *
	FW	111.4 ± 35.5	−1.54 *	6.4 ± 6.1	−3.54 *	5.9 ± 4.7	−6.63 *	1.4 ± 0.5	0.88 *	1.5 ± 0.6	0.88 *	33.4 ± 18.6	2.58 *
	TEAM	107.8 ± 31.2	−2.38 *	5.6 ± 5.5	−3.44 *	4.2 ± 3.6	−2.85 *	1.5 ± 0.7	0.63 *	1.5 ± 0.7	0.68 *	31.0 ± 15.2	2.66 *

Table 4. *Cont.*

Task	Playing Position	DIST TOTAL	ES	DIST 21	ES	DIST 24	ES	ACC	ES	DEC	ES	HMLD	ES
TYPE 5	CD	132.5 ± 22.4	−0.83 *	12.3 ± 7.7	−2.39 *	6.5 ± 5.7	−1.91 *	1.6 ± 0.7	0.70 *	1.6 ± 0.9	0.47 *	43.2 ± 12.5	1.30 *
	WP	132.4 ± 25.4	−1.08 *	18.7 ± 12.4	−2.51 *	10.0 ± 9.0	−2.00 *	1.6 ± 0.9	0.60 *	1.6 ± 0.8	0.76 *	47.7 ± 14.9	2.04 *
	MID	145.5 ± 25.4	−1.25 *	13.0 ± 8.8	−2.26 *	6.0 ± 6.5	−1.72 *	1.4 ± 0.7	0.56 *	1.5 ± 0.7	0.64 *	45.7 ± 13.9	1.54 *
	FW	142.4 ± 28.3	−0.61 *	18.7 ± 9.3	−2.37 *	9.4 ± 7.6	−3.79 *	1.7 ± 0.9	0.53 *	1.4 ± 0.6	0.57 *	51.9 ± 17.2	1.52 *
	TEAM	139.1 ± 25.5	−1.14 *	15.6 ± 9.7	−2.38 *	7.9 ± 7.3	−2.31 *	1.6 ± 0.8	0.53 *	1.5 ± 0.7	0.68 *	47.1 ± 14.6	1.64 *
TYPE 6	CD	121.0 ± 19.0	−1.52 *	9.7 ± 6.5	−2.70 *	6.5 ± 6.1	−1.93 *	1.2 ± 0.4	1.15	1.8 ± 0.9	0.30 *	37.8 ± 9.6	1.90 *
	WP	122.5 ± 23.5	−1.40 *	17.2 ± 10.5	−2.76 *	11.4 ± 6.0	−2.07 *	1.7 ± 0.9	0.54 *	1.5 ± 0.6	1.09 *	42.3 ± 13.4	2.50 *
	MID	108.6 ± 16.7	−3.15 *	13.8 ± 8.4	−2.23 *	10.7 ± 8.1	−1.53 *	1.7 ± 0.9	0.44	1.4 ± 0.6	0.60 *	31.1 ± 8.0	2.90 *
	FW	118.6 ± 17.1	−1.00 *	14.5 ± 8.1	−2.77 *	8.8 ± 5.8	−5.14 *	1.6 ± 0.8	0.50	1.4 ± 0.7	0.63 *	38.7 ± 14.3	2.62 *
	TEAM	118 ± 21.1	−2.27 *	14.1 ± 8.6	−2.56 *	9.7 ± 6.7	−2.19 *	1.6 ± 0.8	0.53 *	1.5 ± 0.7	0.68 *	36.8 ± 11.1	2.60 *
TYPE 7	CD	107.6 ± 11.4	−2.57 *	5.8 ± 4.0	−3.21 *	2.0 ± 1.2	−2.27 *	1.6 ± 0.8	0.68 *	1.3 ± 0.5	0.83 *	26.2 ± 6.5	3.21 *
	WP	124.4 ± 16.0	−1.32 *	17.7 ± 10.6	−2.72 *	11.3 ± 8.9	−2.08 *	1.4 ± 0.6	0.84 *	1.6 ± 0.8	0.75 *	41.1 ± 11.8	2.71 *
	MID	122.5 ± 18.0	−2.46 *	10.8 ± 7.3	−2.51 *	7.2 ± 4.3	−1.66 *	1.2 ± 0.5	0.83 *	1.3 ± 0.5	0.80 *	30.7 ± 13.3	2.55 *
	FW	109.2 ± 20.0	−1.36 *	6.3 ± 6.2	−3.54 *	5.4 ± 0.0	−1.86 *	1.5 ± 0.7	0.55	1.4 ± 0.7	0.66 *	28.3 ± 9.9	3.92 *
	TEAM	119.2 ± 17.8	−2.40 *	10.8 ± 7.3	−2.91 *	7.0 ± 4.0	−2.57 *	1.4 ± 0.6	0.74 *	1.4 ± 0.6	0.79 *	32.1 ± 11.0	2.95 *
TYPE 8	CD	108.1 ± 14.3	−2.56 *	9.5 ± 7.6	−2.64 *	7.1 ± 7.8	−1.89 *	1.3 ± 0.4	0.91 *	1.4 ± 0.6	0.45 *	27.4 ± 8.0	2.95 *
	WP	118.2 ± 24.4	−1.49 *	17.4 ± 15.5	−2.37 *	12.9 ± 11.5	−1.95 *	1.4 ± 0.6	0.86 *	1.6 ± 0.8	0.94 *	37.3 ± 17.2	2.52 *
	MID	121.4 ± 29.8	−2.42 *	16.0 ± 18.5	−1.57 *	12.2 ± 15.4	−0.78	1.4 ± 0.6	0.88 *	1.4 ± 0.6	0.81 *	36.4 ± 19.2	1.83 *
	FW	111.8 ± 27.0	−1.32 *	16.9 ± 17.9	−1.95 *	11.0 ± 8.1	−3.33 *	1.4 ± 0.6	0.82 *	1.4 ± 0.6	0.81 *	36.2 ± 19.7	2.32 *
	TEAM	116.2 ± 25.1	−2.14 *	15.4 ± 15.7	−2.01 *	11.2 ± 11.5	−1.78 *	1.4 ± 0.6	0.74 *	1.5 ± 0.7	0.68 *	35.0 ± 16.8	2.28 *
TYPE 9	CD	118.6 ± 18.3	−1.72 *	7.9 ± 7.1	−2.82 *	4.9 ± 4.5	−2.05 *	1.9 ± 1.0	0.42 *	2.0 ± 1.1	0.20 *	37.0 ± 11.3	1.86 *
	WP	132.4 ± 16.8	−1.08 *	11.9 ± 6.7	−3.45 *	6.3 ± 5.2	−2.00 *	1.8 ± 0.9	0.49 *	1.8 ± 0.9	0.41 *	47.9 ± 10.2	2.33 *
	MID	130.6 ± 18.0	−2.08 *	9.4 ± 5.4	−2.71 *	4.3 ± 3.8	−1.93 *	1.8 ± 1.1	0.32	1.5 ± 0.7	0.52 *	41.6 ± 9.6	2.03 *
	FW	131.1 ± 20.4	−0.85 *	10.4 ± 6.4	−3.19 *	6.1 ± 4.8	−4.21 *	1.9 ± 1.4	0.17	1.7± 0.9	0.29 *	46.9 ± 10.8	2.31 *
	TEAM	129.1 ± 18.3	−1.86 *	10.0 ± 6.3	−3.03 *	5.3 ± 4.5	−2.70 *	1.8 ± 1.1	0.32	1.7 ± 0.9	0.49 *	43.6 ± 10.3	2.14 *

Table 4. *Cont.*

Task	Playing Position	DIST TOTAL	ES	DIST 21	ES	DIST 24	ES	ACC	ES	DEC	ES	HMLD	ES
TYPE 10	CD	124.3 ± 17.9	−1.39 *	10.1 ± 7.9	−2.57 *	5.7 ± 4.5	−2.01 *	1.8 ± 1.0	0.50 *	1.7 ± 0.9	0.31 *	40.0 ± 11.2	1.62 *
	WP	135.2 ± 18.4	−0.99 *	13.9 ± 6.6	−3.30 *	6.2 ± 5.5	−2.00 *	1.7 ± 0.9	0.56 *	1.7 ± 0.9	0.48 *	48.0 ± 10.8	2.29 *
	MID	134.5 ± 16.7	−1.91 *	11.5 ± 8.0	−2.42 *	5.9 ± 6.6	−1.77 *	1.7 ± 0.8	0.40 *	1.6 ± 0.9	0.61 *	43.3 ± 11.4	1.82 *
	FW	135.3 ± 19.9	−0.70 *	14.2 ± 7.6	−2.82 *	7.1 ± 4.3	−3.85 *	1.8 ± 1.1	0.23 *	1.8 ± 0.9	0.39 *	47.3 ± 10.9	2.27 *
	TEAM	133.1 ± 18.9	−1.64 *	12.5 ± 7.5	−2.76 *	6.2 ± 5.4	−2.57 *	1.7 ± 0.9	0.42 *	1.7 ± 0.9	0.49 *	44.8 ± 11.1	2.00 *
TYPE 11	CD	125.6 ± 17.2	−1.32 *	22.5 ± 12.8	−1.29 *	16.2 ± 11.2	−0.88 *	1.6 ± 0.9	0.65 *	1.6 ± 0.8	0.33 *	42.3 ± 12.8	1.35 *
	WP	145.8 ± 23.4	−0.46 *	32.6 ± 16.4	−1.38 *	22.2 ± 13.8	−2.27 *	1.7 ± 0.9	0.51 *	1.7 ± 0.9	0.71 *	57.9 ± 17.1	1.29 *
	MID	151.0 ± 22.5	−0.97 *	25.9 ± 15.3	−1.10 *	16.9 ± 11.8	−1.65 *	1.6 ± 0.9	0.38 *	1.6 ± 0.8	0.58 *	53.7 ± 15.7	0.97 *
	FW	145.9 ± 24.3	−0.46 *	31.5 ± 16.2	−1.15 *	21.1 ± 13.1	−1.31 *	1.8 ± 1.0	0.26 *	1.8 ± 1.1	0.42 *	56.4 ± 16.9	1.25 *
	TEAM	144.1 ± 22.2	−1.00 *	28.3 ± 15.3	−1.21 *	19.1 ± 12.5	−1.14 *	1.7 ± 0.9	0.42 *	1.7 ± 0.9	0.49 *	53.4 ± 15.8	1.18 *
TYPE 12 (official match)	CD	150.1 ± 16.6	-	40.0 ± 14.5	-	31.7 ± 13.1	-	2.4 ± 1.4	-	2.3 ± 1.4	-	60.0 ± 13.4	-
	WP	171.1 ± 19.1	-	55.2 ± 16.4	-	40.7 ± 15.0	-	2.3 ± 1.4	-	2.3 ± 1.4	-	79.2 ± 16.0	-
	MID	171.9 ± 20.2	-	43.8 ± 17.1	-	29.5 ± 15.5	-	2.0 ± 1.2	-	2.1 ± 1.3	-	69.6 ± 17.0	-
	FW	165.8 ± 18.7	-	50.4 ± 16.5	-	38.2 ± 14.4	-	2.4 ± 1.5	-	2.8 ± 2.0	-	75.8 ± 14.0	-
	TEAM	165.6 ± 20.8	-	47.5 ± 16.3	-	34.7 ± 14.7	-	2.2 ± 1.4	-	2.3 ± 1.5	-	71.8 ± 15.5	-

* CD: central defenders; WP: wide players, MID: midfielders; FW: forwards, DIST TOTAL: total distance (m); DIST 21: high-speed running distance (m); DIST 24: sprint distance (m); ACC: high accelerations (count); DEC: high decelerations (count), HMLD: high metabolic load distance (m), ES: effect size, which represents WCS 1 min in task vs. match day.

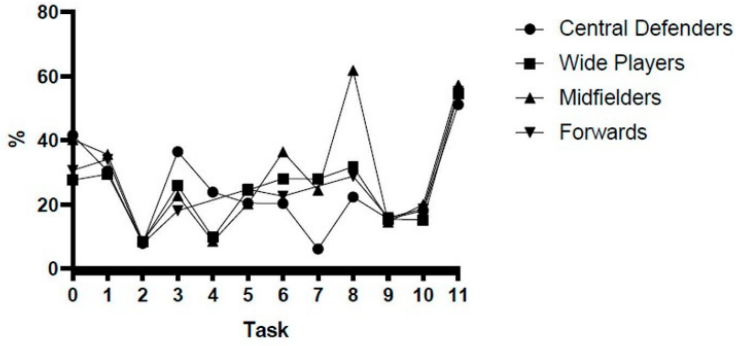

Figure 3. % Sprint with respect to task Type 12 (official match).

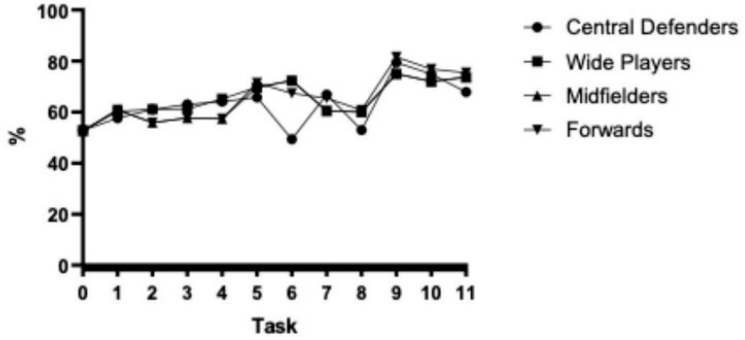

Figure 4. % Accelerations > +3 m/s^2 with respect to task Type 12 (official match).

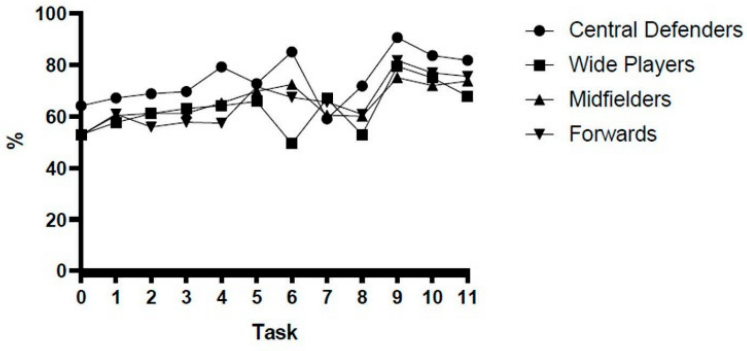

Figure 5. % Decelerations < −3 m/s^2 with respect to task Type 12 (official match).

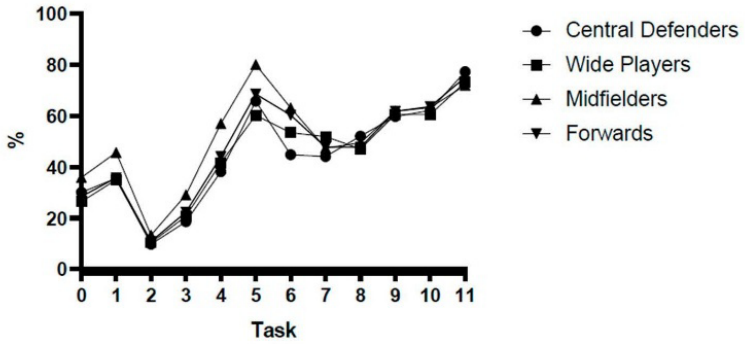

Figure 6. % HMLD with respect to task Type 12 (official match).

4. Discussion

The present study aimed to identify which training tasks best replicate the WCSs observed during match play, considering playing positions and occurrences within a 1 min period.

None of the training tasks fully replicated the peak demands observed during match play, although some approached them depending on the variable and playing position. Tasks TYPE 5 and TYPE 11 were the closest in terms of total distance covered, yet generally remained below 90% of match values, particularly for wide players and forwards. HSR and HMLD showed substantial demands, with TYPE 11 and TYPE 8 standing out for central defenders and midfielders. Accelerations and decelerations were the most accurately replicated variables, exceeding 80% in tasks such as TYPE 9, 10, and 11. However, sprint efforts exhibited the greatest discrepancies, with no task reaching 60% of match demands. TYPE 11 and TYPE 9 were generally the most representative in approximating the WCSs observed in matches, whereas HSR and sprint demands were largely underrepresented across all training scenarios.

When comparing playing positions with previous studies [40], it can be observed that wide players and forwards tend to cover the greatest total distance during large-pitch tasks. Additionally, in these tasks, central defenders and central midfielders are the ones who accumulate the highest volumes of HSR. These results contrast with those of the comparative study, in which, on the day large-sided games were performed, the players who generally covered the greatest total distance and HSR were the central defenders.

Numerous studies [41–44] support the notion that match demands are not fully replicated during the microcycle, a finding that aligns with the results of the present study.

Furthermore, a recent study [45] not only concluded that none of the training tasks performed during the microcycle replicated the WCSs observed on match day (MD), but also noted—consistent with the findings of the present study—that in certain tasks, acceleration and deceleration metrics may approximate the WCSs of MD.

To address the challenge of underestimating WCSs in training tasks, previous research [12] has suggested that, in order to replicate peak match demands, players should cover approximately 190 m/min in total distance and around 60 m/min in HSR during training. However, when compared to the WCSs observed in the present study, these thresholds appear excessively high. This discrepancy may be attributed to differences in physical and technical–tactical profiles between squads, the level of competition (Spanish Smartbank League vs. English Championship) [46], and the tracking technologies used for training monitoring and data collection (WIMU PRO vs. Catapult) [47]. These differences, along with the distinct training methodologies applied by coaching staff across different leagues, could have a direct impact on team performance, the optimisation of players' physical output, or injury prevention.

Other studies [48] excluded ball-out-of-play time and rest periods between sets in their analyses. They concluded that the peak physical demands to be replicated in training tasks with ball in play should be approximately 165 m/min for total distance, around 46 m/min for HSR, approximately 3.8 counts/min for accelerations >3 m/s^2, approximately 3.6 counts/min for decelerations <−3 m/s^2, and around 56 m/min for high metabolic load distance (HMLD). In comparison with the present study, which did not exclude ball-out-of-play data, these values are notably higher. This substantial difference may be explained by contextual variations between teams.

In contrast to our study and others [49], which employed objective variables to monitor training load, some investigations have utilised subjective measures to assess both training load and fatigue [50]. When considering training monitoring through both objective and

subjective variables, it becomes evident that the most demanding tasks of the week fall short of match demands, regardless of the monitoring approach used.

However, several limitations were identified during the development of the present study and should be acknowledged. The first limitation concerns the fact that data were collected from a single team, within a specific league, and under a particular playing style and training methodology defined by the coaching staff. As such, these findings may not be generalisable—even to other teams within the same division—due to potential differences in match play strategies and training task design.

Another limitation relates to the overall sample size, as a professional football squad typically comprises between 20 and 25 players distributed across various playing positions. Although positional analysis provides valuable insights, the limited number of players per position restricts the representativeness and generalisability of the findings with respect to playing position.

5. Conclusions

The results clearly demonstrate that none of the training tasks performed fully replicated the worst-case scenarios (WCSs) observed during competitive match play. However, certain tasks (TYPE 9 and TYPE 11) showed closer alignment with these demands, particularly in terms of accelerations and decelerations. Moreover, conditional demands related to HSR and sprinting were, in most tasks, below 60% of the values recorded in competition. These findings may encourage coaches and strength and conditioning staff to reconsider the design of training tasks within the microcycle, with the aim of optimising performance, preventing injuries, and developing position-specific drills that reflect match-day demands. In practical terms, coaches are advised to integrate tasks that more accurately replicate the physical and tactical demands observed in competition, particularly for those positions that appear to be underexposed during training. Although these tasks are closely related to performance in official competition, coaches should incorporate a variety of training tasks to enhance players' physical condition and decision-making. Therefore, all tasks are essential for the comprehensive development of a football player's performance. Finally, it is worth reflecting on the possibility that, if the conditional discrepancies between training and competition are substantial, the tactical objectives embedded within training tasks may also fall short of meeting the tactical requirements of competitive match play. Future research should explore the relationship between training-task design and tactical performance in competition, as well as investigate how different training methodologies applied across leagues and countries influence player development, injury rates, and team success.

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Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

WCS	Worst-case scenarios.
HSR	High-sprint running.
HMLD	High metabolic load distance.
SSGs	Small-sided games.
MSGs	Medium-sided games.
LSGs	Large-sided games.
HIIT	High-intensity interval training.
BMI	Body mass index.
CD	Central defenders.
WP	Wide players.
MID	Midfielders.
FW	Forwards.
TSOETT	Time spent on each type of task.
TAMOPA	Total accumulated minutes of physical activity.

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Tabla 5. Resumen de los principales resultados obtenidos en los estudios

Estudio	Resultados
Influence of contextual factors on physical demands and technical-tactical actions regarding playing position in professional soccer players.	Se comparan las demandas físicas y técnico-tácticas de los futbolistas en competición según la demarcación, si el equipo juega como local o visitante y según el resultado. Para el conjunto de jugadores, se observó mayor distancia total recorrida (TD) (p = 0,045; ES = 0,24, pequeña) y más deceleraciones moderadas (Dec2-4) (p = 0,001; ES = 0,68, moderada) cuando el equipo juega como local y pierde. Además, realizaron más sprints (SPR) cuando el equipo juega como local y gana (p = 0,009; ES = −0,81, moderada) frente a jugar como local y perder. Los centrocampistas (MID) (p = 0,012; ES = 0,79, moderada) y delanteros (FW) (p = 0,027; ES = 1,52, grande) ejecutaron más Dec2-4 en derrotas como local, y los jugadores laterales (WD) más SPR (p = 0,026; ES = 1,01, grande) en la misma condición. En acciones técnico-tácticas, jugar como local y ganar implicó mayor volumen defensivo (DV) (p = 0,014; ES = −1,49, grande) e intercepciones (IN) (p = 0,031; ES = −1,40, grande). Los MID realizaron más GV, DV, IN y TPS (p = 0,011–0,043; ES = −0,89–1,09, moderada), y los FW más GV, DV e IN (p = 0,011–0,048; ES = −0,64–0,89, moderada) en victorias como local. Los CD registraron más GV y TPS (p = 0,044–0,047; ES = 0,17–0,88) en derrotas como local. Como visitante, los FW hicieron más FP y AZP (p = 0,028–0,029; ES = 0,99–1,16) en derrotas, y más GST (p = 0,036; ES = −1,21, grande) en victorias.
Comparison of the worst-case scenarios between training and competition weeks for each playing position in an elite football season.	El ANOVA de medidas repetidas no mostró diferencias significativas en la distancia total recorrida entre los días de la semana al comparar demarcaciones (p > 0,05; ηp^2 = 0,342). Sin embargo, la distancia total en el día de partido (MD) representó el 118,5% del promedio de los valores de entrenamiento (MD-5 a MD-1). La distancia de alta carga metabólica fue significativamente menor en MD-1 frente a MD (p < 0,05), sin diferencias entre MD y MD-4, y en MD alcanzó el 151,4% del promedio semanal. Se observaron diferencias significativas en la distancia recorrida por encima de 21 km/h y 24 km/h en comparación con MD en casi todas las demarcaciones (p < 0,05), excepto en defensores centrales (CD) para MD-3 y MD-1. La distancia >21 km/h en MD representó el 218,7% del

promedio y la >24 km/h el 289,3%. Los centrocampistas (MID) realizaron menos aceleraciones en MD-1 frente a MD ($p < 0,05$), mientras que las deceleraciones fueron mayores en MD-4 ($p < 0,05$). Las aceleraciones >3 m/s² en MD representaron el 101,1% del promedio y las deceleraciones >-3 m/s² el 111,4%. Las comparaciones por pares confirmaron incrementos significativos en alta velocidad ($p < 0,001$; $\eta p^2 = 0,854–0,882$) y en distancia de alta carga metabólica ($p < 0,001$; $\eta p^2 = 0,899$) en MD, así como diferencias en aceleraciones en MD-4 ($p = 0,006$; $\eta p^2 = 0,677$).

Training Tasks vs. Match Demands: Do Football Drills Replicate Worst-Case Scenarios?

Se encontraron diferencias significativas entre la mayoría de las tareas de entrenamiento y el juego competitivo para todas las variables físicas en todas las demarcaciones ($p < 0,05$), con algunas excepciones. En la distancia total, las tareas representaron entre el 33,7% y el 91,6% de las demandas del partido para defensores centrales, 52,0%–86,1% para jugadores de banda, 32,8%–87,7% para centrocampistas y 36,6%–88,0% para delanteros (ES = 0,08–2,61). Para la distancia en alta velocidad (HSR), las tareas cubrieron entre el 14,5% y el 56,1% en defensores centrales, 15,1%–44,6% en jugadores de banda, 18,6%–58,1% en centrocampistas y 22,6%–69,2% en delanteros (ES = 1,10–3,74). Respecto a la carga metabólica de alta intensidad (HMLD), las tareas alcanzaron entre el 18,6% y el 77,2% en defensores centrales, 26,4%–73,1% en jugadores de banda, 13,4%–79,9% en centrocampistas y 18,2%–74,9% en delanteros (ES = 0,97–5,20). Las deceleraciones fueron del 64,1%–90,4% en defensores centrales, 52,8%–79,4% en jugadores de banda, 52,8%–81,6% en centrocampistas y 52,6%–81,6% en delanteros (ES = 0,08–1,78). Las aceleraciones cubrieron entre el 52,9% y el 74,0% en defensores centrales, 52,8%–77,2% en jugadores de banda, 48,0%–74,9% en centrocampistas y 52,6%–81,6% en delanteros (ES = 0,04–1,43). Los sprints alcanzaron entre el 7,9% y el 51,1% en defensores centrales, 8,4%–54,5% en jugadores de banda, 8,5%–57,2% en centrocampistas y 15,9%–55,2% en delanteros (ES = 0,88–4,20).

5 DISCUSIÓN

En conjunto, los resultados obtenidos en los tres estudios ponen de manifiesto la complejidad del control de las demandas condicionales y técnico-tácticas en el fútbol profesional y la necesidad de planificar los entrenamientos. El primer estudio confirma que factores contextuales como la localización del partido y el resultado influyen significativamente en las cargas externas y en las acciones técnico-tácticas. El segundo estudio revela que los WCS se concentran en el día de partido y que las cargas alcanzadas durante el microciclo no replican completamente estas demandas. Finalmente, el tercer estudio demuestra que, aunque algunas tareas de entrenamiento se aproximan a las exigencias del partido en aceleraciones y deceleraciones, ninguna reproduce íntegramente los WCS.

El primer artículo de la presente Tesis Doctoral en este compendio de artículos tuvo como objetivo analizar las demandas físicas y las acciones técnico-tácticas en competición para cada demarcación de juego según la localización del partido (local vs. visitante) y el resultado final (ganar vs. perder) en jugadores profesionales de élite. El estudio intentó determinar el éxito en partidos profesionales españoles incluyendo KPIs físicos y técnico-tácticos para cada demarcación de juego en diferentes contextos de partido para lograr un enfoque holístico. Los principales hallazgos fueron los siguientes:

(I) Las demandas físicas y las acciones técnico-tácticas varían cuando se consideran dos factores contextuales del juego: localización del partido y el resultado final.

(II) La mayor TD y desaceleraciones entre -2-4 m/s^2 (Dec -2-4) realizadas podrían estar relacionadas cuando el equipo juega como local y pierde para todo el equipo y concretamente diferenciando por demarcaciones, en centrocampistas (MID) y delanteros (FW).

(III) Se realiza un mayor número de SPR por parte de los jugadores cuando el equipo juega como local y gana.

(IV) Se registra mayor número de volumen de juego (GV), volumen defensivo (DV) e intercepciones (IN) cuando el equipo juega como local y gana para todas las demarcaciones, MID y FW.

(V) Mayor número de GV y TPS son realizados por los defensas centrales (CD) cuando el equipo juega como local y pierde.

(VI) Mayor número de pases hacia adelante (FP) y pases en zona de ataque (AZP) son registradas por los jugadores cuando el equipo juega como visitante y pierde.

Existe una falta de evidencia científica respecto a los KPIs que influyen en el resultado final de un partido considerando su localización (local vs. visitante) ya que la mayoría de los estudios evalúan el éxito del equipo a lo largo de las temporadas sin tener en cuenta los factores contextuales [60–63]. Desde una visión general, el análisis de los KPIs condicionales mostró que cuando un equipo jugó como local y ganó, sus jugadores cubrieron mayor número de SPR, mientras que cuando el equipo fue derrotado, se identificaron mayor TD y Dec -2-4. Además, es conocido que como los sprints son las acciones más repetidas en situaciones de gol [100], un mayor número de SPR podría estar asociado con el éxito cuando se juega como local, ya que se crearían un alto número de intentos de gol y, por lo tanto, se incrementaría la probabilidad de lograr la victoria. A pesar de que ambos estudios consideran los mismos estándares competitivos, tales discrepancias podrían explicarse en relación con factores temporales dado que existe un período de varias temporadas entre el estudio mencionado y el presente trabajo, ya que hoy en día el fútbol es más exigente físicamente que antes y, por lo tanto, se muestra un mayor número de sprints en cada partido [101,102].

Durante el partido, a medida que el marcador cambia, el equipo que va por detrás necesita realizar mayores esfuerzos físicos para reducir esa diferencia y superar al rival [58]. Esta afirmación está respaldada por nuestros hallazgos, ya que se encontraron mayores valores de TD y desaceleraciones -2-4 (Dec-2-4) cuando el equipo local pierde. Además, dos estudios previos informaron valores aumentados de distancia total cubierta, y carrera de baja (11-14 km/h) y moderada intensidad (14-19 km/h) por parte del equipo local cuando lograron la victoria en el campeonato de tercera división brasileña [103]. Además, cabe mencionar que se acepta ampliamente que las actividades de baja intensidad no son cruciales en el rendimiento del fútbol profesional [62]. Un mayor esfuerzo físico (es decir, mayor distancia total cubierta) no garantiza el éxito [104], como se muestra en el presente trabajo, ya que podría estar asociado con otros factores cognitivos, emocionales o tácticos más que con un menor rendimiento físico [102]. Además, no se observaron diferencias significativas entre partidos ganados o perdidos cuando los equipos juegan como visitante. En ese contexto, parece que los KPIs como la

eficacia técnico-táctica podrían tener una mayor influencia en el éxito que los KPIs físicos [29,60].

Las demandas tácticas se consideran dependientes de la demarcación en el fútbol, por lo tanto, el análisis basado en las demarcaciones de juego podría ser útil para saber si el rendimiento físico influye en el éxito. El análisis de datos posicionales sobre el rendimiento condicional mostró diferencias entre MID y FW en Dec -2-4 cuando el partido se jugó como local y el equipo perdió. Estas diferencias podrían explicarse por el hecho de que los MID necesitan escapar de un oponente y encontrar un espacio libre para recibir un pase, lo que en demandas técnico-tácticas implica un mayor número de cambios de dirección. En consecuencia, las desaceleraciones son esenciales dentro de estos cambios de dirección no solo cuando se ataca, sino también cuando el equipo defiende [105]. Si se dan un alto número de Dec-2-4 cuando el equipo pierde como local podría ser un indicador de la presencia de más cambios de dirección realizados, asociados a la dificultad para quitar el balón al oponente y, por lo tanto, a un menor éxito. Además, parece que se ha observado un mayor número de carreras curvilíneas para los MID antes de tomar posesión del balón [47], lo que resulta en un mayor número de Dec-2-4. Esto puede contribuir negativamente a quitar el balón al oponente, ya que los MID necesitan frenar, haciendo que este aspecto sea especialmente difícil. Cabe destacar que la posesión del balón se ha identificado como un indicador de éxito en el fútbol para conseguir resultados positivos [55]. De manera similar y en relación con los resultados obtenidos en nuestro estudio se ha mostrado una mayor cantidad de Dec-2-4 para los FW cuando el equipo juega como local y pierde. Además, también en consonancia con nuestro estudio la mayoría de los estudios informaron que la distancia cubierta en sprint durante los ataques en FW parece ser esencial para tener éxito [106].

Por otro lado, los defensas laterales (WD) muestran un alto número de SPR cuando juegan como local y pierden el partido en comparación con jugar como visitante y ganar. Esto podría atribuirse a los esfuerzos repetidos derivados de las transiciones ataque-defensa necesarias para recuperar posiciones defensivas [106]. Estos hallazgos parecen respaldas a los nuestros, ya que se necesita una aceleración antes de desacelerar [105]. Finalmente, ninguna demanda física al analizar por demarcación de juego mostró diferencias entre jugar como local o visitante cuando el equipo gana. Estos hallazgos pueden sugerir que un mayor esfuerzo físico podría no tener relación con lograr la victoria, ya que existen otros factores no condicionales que podrían influir en el éxito.

Aunque tener una alta capacidad física puede ser favorable para afrontar las demandas del partido, existen dudas sobre si estas buenas capacidades favorecen el éxito en el partido [29]. No obstante, existen estudios que afirman que la relación entre una buena condición física y la influencia en el éxito deportivo [61,107].

Siguiendo en la línea del presente estudio, en cuanto a las variables técnico-tácticos se observó más GV, DV e IN significativos cuando el equipo ganó jugando como local. Un estudio previo concluyó que el éxito en las acciones defensivas se relacionaba con la acumulación de puntos en campeonatos como la segunda división española [108]. En consecuencia, aquellos equipos que realizaron más intercepciones, entradas [109] y ganaron más duelos aéreos [110] tenían más probabilidades de ganar el partido. Además, parece que los mejores equipos son más eficientes al aplicar presión defensiva cerca del área rival [109], llevando al equipo contrario a cometer errores y dificultando su progresión. Esto contribuye a una mayor cantidad de DV e IN para ganar partidos como equipo local. Cabe destacar que estas diferencias entre DV e IN no se encuentran cuando el equipo juega como visitante, ya que el factor contextual, según nuestro estudio, influye en este tipo de acciones cuando se gana como local.

El análisis en relación con las acciones técnico-tácticas según la demarcación de juego mostró algunas diferencias en CD, MID y FW. Jugar como local y ganar exigió valores más altos de GV, DV, IN y TPS para MID; GV, DV e IN para FW. Asimismo, un estudio previo informó que cuando se juega como local, los equipos de la UEFA Champions League recuperaron el balón con más frecuencia que cuando juegan como visitante [109]. El ambiente al jugar como local, con todos los aficionados animando a los jugadores, se asocia con una mayor agresividad e intencionalidad en los jugadores, provocando acciones defensivas exitosas [111]. Además, recuperar la posesión del balón cerca del área rival se ha identificado como un factor influyente en el éxito en el fútbol [50,109], respaldando, por tanto, los hallazgos reportados en el presente trabajo para MID y FW en GV, DV e IN. Asimismo, nuestro estudio va en línea de hallazgos previos [112] donde un mayor número de pases por parte de MID contribuyó a aumentar las posibilidades de marcar un gol. Aunque la precisión en los pases está relacionada con la posesión del balón [113], esto podría ocurrir cerca del área rival para ser efectivo y contribuir a ganar el partido [56]. En relación con esto, el MID podría ser decisivo para tener éxito cuando se juega como local.

Entonces, nuestros hallazgos mostraron que ganar jugando como local requirió más GST para FW, mientras que perder jugando como visitante está más relacionado con un mayor número de GV y TPS para CD, y AZP y FP para FW. Por lo tanto, un mayor número de GV y TPS se asoció con perder un partido como visitante en CD. De hecho, la posesión del balón lejos del área rival y sin intención de progresar resultó ineficaz [52]. De esta forma, la acumulación de un mayor número de GV y TPS en CD no solo parece influir en la victoria, sino que también está asociada con perder partidos como visitante. Asimismo, se ha identificado que un alto número de intentos de gol es un KPI clave para ganar partidos [114–116]. Los hallazgos mostrados en el presente trabajo coinciden con los estudios mencionados anteriormente, pero determinan un aspecto muy novedoso, ya que FW es la única demarcación que establece GST como KPI para ganar partidos como visitante. Esto puede sugerir que el papel clave de FW debería ser marcar goles y centrarse en realizar GST en lugar de intentar participar excesivamente en la creación del juego, ya que se ha observado que un gran número de AZP y FP realizados por FW en un partido están asociados con perder partidos como visitante.

Tras analizar las demandas físicas que determinaron la victoria tanto de local como de visitante, se decidió profundizar en el aspecto condicional, al considerarse que podría ser determinante para el éxito en la competición.

El segundo artículo de la presente investigación tuvo como objetivo analizar los WCS producidos durante la semana en las diferentes sesiones de entrenamiento y compararlos con las demandas físicas del partido para determinar qué día de la semana estos escenarios máximos se asemejan más, en una temporada. Además, se compararon las demandas físicas entre las diferentes demarcaciones de juego en relación con el entrenamiento semanal realizado respecto al día de partido (MD). Existen estudios que sugieren que comparar las demandas del entrenamiento con las del partido puede ayudar a determinar las modificaciones necesarias en el entrenamiento para cumplir con las demandas del partido [7]. Comprender las demandas del partido o del entrenamiento permite seleccionar las estrategias de entrenamiento óptimas para lograr los objetivos deseados dentro del microciclo. Los principales hallazgos fueron los siguientes:

(I) MD mostró los niveles más altos de carga en comparación con otros días de entrenamiento de la temporada competitiva, como MD-5, MD-2 y MD-1.

(II) No se observaron diferencias significativas en la distancia total recorrida en las diferentes demarcaciones de juego dentro de los días de la semana.

(III) Se observaron distancias significativamente mayores por encima de 21 km/h y 24 km/h en MD en comparación con otros días para la mayoría de las demarcaciones, excepto en los defensas centrales (CD), entre los cuales no se encontraron diferencias significativas en MD-3 y MD-1.

(IV) Se observó un número significativamente menor de aceleraciones en MD-4 en comparación con MD para los MID, mientras que se registró un número significativamente mayor de deceleraciones en MD-1 para los MID.

(V) La distancia de alta carga metabólica fue significativamente menor en MD-1 en comparación con MD, mientras que no se observaron diferencias significativas entre MD y MD-4 en todas las demarcaciones. Por lo tanto, las comparaciones por pares revelaron que no hubo diferencias significativas en la distancia total entre los días previos al partido y MD, pero sí un aumento notable en las distancias recorridas a velocidades más altas y en aceleraciones/deceleraciones en MD, junto con un incremento en la distancia de alta carga metabólica, lo que indica que los días de partido se caracterizan por mayores demandas físicas e intensidad, demostradas por el aumento de las distancias a alta velocidad y las cargas metabólicas.

Un interesante estudio [36] analizó las demandas físicas por demarcación en los partidos utilizando variables similares a las empleadas en el presente trabajo. En cuanto a la distancia total, los jugadores con los valores más altos de WCS son los MID; en aceleraciones (> 3 m/s²) y deceleraciones (< -3 m/s²), son los centrocampistas ofensivos (OMF); y en distancia de alta carga metabólica (HMLD), son los MID. Los datos obtenidos en nuestro estudio no son similares, ya que los jugadores con los valores más altos de WCS en distancia total son los jugadores de banda (WP); en aceleraciones y deceleraciones mayores a -3 m/s², son los FW; y en HMLD, son los WP. Estas diferencias podrían deberse a las distintas demandas de cada demarcación al jugar con un sistema de juego u otro [72]. En otro estudio similar [41], se observó que, en los días de partido, los WP tenían picos más altos en distancia total, distancia > 21 km/h, distancia > 24 km/h y HMLD en comparación con los jugadores en posiciones centrales. Estos datos están en línea con los valores obtenidos en nuestro estudio, en el que los WP tuvieron los picos más altos entre las variables mencionadas. Aunque en ese estudio solo se analizaron

partidos como local, el número de participantes fue similar y el nivel de los atletas equivalente al de nuestra investigación.

Otro estudio reciente [22] mostró que los jugadores que reproducen más WCS en distancia total, distancia de alta intensidad o distancia de sprint en el día de partido son los MID. Estos estudios no coinciden con el nuestro, porque los jugadores con mayor distancia total y distancia de alta intensidad son los WP. Estas diferencias también podrían explicarse por las distintas demandas de cada demarcación, dependiendo del sistema de juego empleado por cada equipo [93].

Algunos estudios han afirmado que las dimensiones de las tareas relacionadas con el número de jugadores por equipo influyen directamente en las demandas físicas obtenidas durante la semana de entrenamiento [117]. Según sus dimensiones, estas tareas pueden clasificarse como juegos de espacio grande (LSG - 5100–6400 m2), juegos de espacio medio (MSG - 728–2080 m2) o juegos de espacio reducido (SSG - 460–900 m2). Una interesante investigación [46] mostró que, durante la semana, los escenarios con la mayor demanda máxima corresponden a los días de entrenamiento que incluyen principalmente juegos de espacio grande (LSG). En el presente estudio, los MID son los jugadores que alcanzan el mayor pico de metros recorridos en un minuto durante los días de entrenamiento y durante el partido. En todas las demarcaciones, los picos alcanzados durante la semana nunca superan los alcanzados en el día de partido. Según ese estudio, los días de entrenamiento en los que deberían ocurrir los mayores WCS de la distancia total recorrida son MD-3 y MD-4. Nuestro estudio encontró que los jugadores MID tuvieron los mayores WCS de distancia total en MD-3 y MD-4. Sin embargo, esto no ocurrió en el día de partido, porque los jugadores con la mayor distancia en el WCS fueron los WP en lugar de los MID. Esta diferencia podría deberse al estilo de juego utilizado por el equipo durante la temporada o a la no diferenciación en las tareas de entrenamiento, en el que los WP fueron jugadores importantes en el juego del equipo, especialmente en lo que respecta al juego por las bandas.

Investigaciones previas [118] indicaron que el día de entrenamiento con el mayor volumen e intensidad en relación con variables como metros recorridos a alta intensidad o distancia total correspondería a MD-3 en todas las demarcaciones. Nuestro estudio está en línea con hallazgos anteriores en lo que respecta a la variable de distancia de alta intensidad por encima de 24 km/h, donde los valores más altos de WCS correspondieron

a MD-3 en casi todas las demarcaciones. Sin embargo, no coinciden en la distancia total y en la distancia superior a +21 km/h, ya que en nuestro estudio los valores semanales más altos para la distancia total ocurrieron en MD-4 y para la distancia superior a +21 km/h en MD-2. No obstante, otras investigaciones [13] encontraron que MD-4 y MD-5 fueron los días en los que las mayores demandas de entrenamiento en términos de volumen e intensidad ocurrían típicamente en el equipo, en todas las demarcaciones. Asimismo, en otro estudio [24], el día de mayor demanda durante la semana de entrenamiento correspondió a MD-4, tanto en distancia total como en el número de aceleraciones (> 3 m/s^2) y deceleraciones (< -3 m/s^2), lo cual está en línea con nuestro estudio. Se entiende que estas diferencias entre carga en los días de entrenamiento estarían estrechamente relacionadas con las tareas realizadas en cada caso de acuerdo con cómo se programaron los contenidos.

En referencia a la selección de la duración de los WCS, no solo existen estudios que analizan WCS en períodos de 1 min, sino que también podemos encontrar otras investigaciones [28,66] que los analizan en períodos de 5 min durante la competición. En los partidos analizados en el primer estudio [28], los jugadores con los picos más altos de WCS en aceleración, deceleración y distancias de alta intensidad fueron los WP. En el presente estudio, basado en duraciones de 1 min, los valores más altos de WCS para variables de distancia de alta intensidad también se observaron en los WP. Sin embargo, los FW mostraron valores más altos de aceleración y deceleración. Ambos estudios indicaron de manera consistente que los jugadores posicionados en las bandas tendían a mostrar valores más altos de WCS para distancia total y distancias de alta intensidad en comparación con los posicionados en el centro. Además, en el segundo estudio [66], los jugadores que reprodujeron más WCS en distancias de alta intensidad en períodos de 5 minutos también fueron los WP. Por lo tanto, podemos confirmar que, en general, los jugadores de banda requieren mayores demandas físicas durante la competición.

Al comparar los WCS producidos en intervalos de 1 min con los producidos en intervalos de 3 min, como demostraron algunos autores [37], se encontraron resultados divergentes. Este estudio observó que los jugadores MID cubrieron las mayores distancias totales durante períodos de 3 min. Sin embargo, nuestros resultados, obtenidos al analizar WCS en intervalos de 1 min, mostraron que los jugadores WP cubrieron las mayores distancias. Esta discrepancia sugiere que la dinámica de movimiento de los jugadores puede variar significativamente dependiendo de la duración del intervalo de análisis. Es

importante tener en cuenta que estas diferencias también pueden reflejar variaciones en las metodologías o factores contextuales de los estudios, como diferencias en estilos de juego, estrategias tácticas o acondicionamiento físico entre equipos.

Un interesante estudio [35] analizó variables condicionales similares en la misma demarcación que en nuestro estudio en los WCS de 1 min, 3 min, 5 min y 10 min en MD. Centrándonos en el análisis de WCS del período de 1 min, observamos que los jugadores que cubrieron la mayor distancia fueron los MID. En cambio, los jugadores que cubrieron la mayor distancia a alta intensidad aceleraron y desaceleraron más veces, y recorrieron la mayor HMLD fueron los jugadores de banda. En nuestro estudio, encontramos que, en períodos de 1 min, los jugadores que cubrieron la mayor distancia total, la mayor distancia a alta intensidad, aceleraron y desaceleraron más veces, y recorrieron la mayor HMLD fueron los WP. En comparación con nuestro estudio, solo difirió en los jugadores que cubrieron la mayor distancia total durante períodos de 1 min en el partido. Sin poder conocer con precisión el modelo de juego y la disposición táctica del equipo en el estudio con el que hacemos la comparación, estas diferencias podrían surgir porque en el equipo que analizamos en nuestro estudio, los jugadores WP tuvieron un papel significativo en el desarrollo del juego del equipo tanto en ataque como en defensa. Por lo tanto, comparar los resultados sin conocer todos los datos no permite extraer conclusiones claras al respecto.

Recientemente, un estudio [30] analizó las diferencias en WCS entre la primera y la segunda mitad de los partidos, sin especificar si se incluyeron solo los jugadores titulares, los que completaron el partido entero o todos los jugadores que participaron en el partido. En WCS de 1 min, los jugadores que cubrieron la mayor distancia tanto en la primera como en la segunda mitad fueron los MID. Los jugadores que tuvieron valores más altos de HMLD en ambas mitades también fueron los MID. Aunque nuestro estudio analizó específicamente partidos completos, los jugadores que tuvieron valores más altos de distancia total y HMLD fueron los WP. No podemos inferir conclusiones de esta comparación porque la diferencia entre los análisis de las dos mitades individual y globalmente puede ser significativa.

En los últimos años, la investigación sobre las demandas físicas en el fútbol femenino ha crecido [119], lo que permite comparaciones con las demandas físicas del fútbol masculino. Al comparar los WCS sin dividir por demarcaciones de juego, los valores

encontrados en los WCS de 1 min fueron más altos en el fútbol masculino para todas las variables. Esta diferencia se atribuye principalmente a las características físicas y morfológicas que distinguen a hombres y mujeres [120].

Viendo los resultados actuales, se planteó la hipótesis de si el tiempo de las tareas de entrenamiento utilizadas era adecuado para cumplir con las exigencias condicionales de la competición.

Por último, el tercer estudio tuvo como objetivo identificar qué tareas de entrenamiento replican mejor los WCS observados durante el juego en competición, considerando las demarcaciones de juego y las ocurrencias dentro de un período de 1 min. Los principales hallazgos fueron los siguientes:

(I) Ninguna de las tareas de entrenamiento replicó completamente las demandas máximas observadas durante el partido, aunque algunas se aproximaron dependiendo de la variable analizada y la demarcación de juego.

(II) las tareas TIPO 5 y TIPO 11 fueron las más cercanas en términos de distancia total recorrida, aunque generalmente se mantuvieron por debajo del 90% de los valores del partido, especialmente para los jugadores de banda y delanteros;

(III) las variables HSR y HMLD mostraron demandas sustanciales, destacando TIPO 11 y TIPO 8 para defensas centrales y centrocampistas

(IV) las aceleraciones y deceleraciones fueron las variables más fielmente replicadas, superando el 80% en tareas como TIPO 9, 10 y 11.

(V) los esfuerzos de sprint presentaron las mayores discrepancias, sin que ninguna tarea alcanzara el 60% de las demandas del partido. TIPO 11 y TIPO 9 fueron, en general, las más representativas en aproximar los WCS observados en los partidos, mientras que las demandas de HSR y sprint estuvieron ampliamente subrepresentadas en todos los escenarios de entrenamiento

Al comparar las demarcaciones de juego con estudios previos [121], se puede observar que los jugadores de banda y delanteros tienden a cubrir la mayor distancia total durante tareas en campos grandes. Además, en estas tareas, los defensas centrales y los centrocampistas centrales son quienes acumulan los mayores volúmenes de HSR. Estos resultados contrastan con los del estudio comparativo, en el que, en el día en que se

realizaron juegos en espacios grandes, los jugadores que generalmente cubrieron la mayor distancia total y HSR fueron los defensas centrales.

Numerosos estudios [13,67,122,123] respaldan la idea de que las demandas del partido no se replican completamente durante el microciclo, hallazgo que coincide con los resultados del presente estudio. Además, un estudio reciente [124] no solo concluyó que ninguna de las tareas de entrenamiento realizadas durante el microciclo replicó los WCS observados en el MD, sino que también señaló—en consonancia con los hallazgos del presente estudio—que, en ciertas tareas, las métricas de aceleración y deceleración pueden aproximarse a los WCS del MD.

Para abordar el desafío de subestimar los WCS en las tareas de entrenamiento, investigaciones previas [22] han sugerido que, para replicar las demandas máximas del partido, los jugadores deberían cubrir aproximadamente 190 m/min en distancia total y alrededor de 60 m/min en HSR durante el entrenamiento. Sin embargo, al compararlos con los WCS observados en el presente estudio, estos umbrales parecen excesivamente altos. Esta discrepancia puede atribuirse a diferencias en los perfiles físicos y técnico-tácticos entre plantillas, el nivel de competición (Liga Smartbank española vs. Championship inglesa) [125], y las tecnologías de seguimiento utilizadas para el control del entrenamiento y la recopilación de datos (WIMU PRO vs. Catapult) [126]. Estas diferencias, junto con las distintas metodologías de entrenamiento aplicadas por los cuerpos técnicos en diferentes ligas, podrían tener un impacto directo en el rendimiento del equipo, la optimización del esfuerzo físico de los jugadores o la prevención de lesiones.

Otros estudios [17] excluyeron el tiempo sin el balón en juego y los períodos de descanso entre series en sus análisis. Concluyeron que las demandas físicas máximas que deben replicarse en las tareas de entrenamiento con el balón en juego deberían ser aproximadamente 165 m/min para la distancia total, alrededor de 46 m/min para HSR, aproximadamente 3,8 acciones/min para aceleraciones >3 m/s^2, aproximadamente 3,6 acciones/min para deceleraciones <−3 m/s^2, y alrededor de 56 m/min para la distancia de alta carga metabólica (HMLD). En comparación con el presente estudio, que no excluyó los datos sin el balón en juego, estos valores son notablemente más altos. Esta diferencia sustancial puede explicarse por variaciones contextuales entre equipos.

En contraste con nuestro estudio y otros [37], que emplearon variables objetivas para monitorizar la carga de entrenamiento, algunas investigaciones han utilizado medidas subjetivas para evaluar tanto la carga de entrenamiento como la fatiga [45]. Al considerar la monitorización del entrenamiento mediante variables objetivas y subjetivas, se hace evidente que las tareas más exigentes de la semana no alcanzan las demandas del partido, independientemente del enfoque de monitorización utilizado.

6 LIMITACIONES

En este apartado se describen las limitaciones encontradas durante el desarrollo de los artículos que conforman la presente Tesis Doctoral.

En el artículo 1 se señalan varias limitaciones ocurridas durante la investigación. En primer lugar, no se incluyeron ni la dinámica del marcador ni los partidos que finalizaron en empate. En segundo lugar, tampoco se tuvieron en cuenta las tácticas y el modelo de juego empleado en cada encuentro, por lo que las demandas físicas bajo diferentes modelos y estrategias permanecen desconocidas. Otra limitación corresponde a los centrocampistas interiores, quienes fueron excluidos en el estudio debido a que fueron sustituidos en prácticamente todos los partidos; por esta razón, se excluyeron del estudio al no contar con una muestra significativa. Finalmente, la tercera limitación está relacionada con el tamaño de la muestra de jugadores participantes. Sería deseable disponer de un número mayor de jugadores para obtener resultados más representativos.

En el artículo 2 también se identifican varias limitaciones en el desarrollo del estudio. La primera limitación fue que MD+1 no se incluyó porque los jugadores que completaron el partido, al ser sesión de entrenamiento con objetivo de recuperación, no llevaban dispositivos GPS. La segunda limitación se refiere a la decisión de agrupar tanto a los laterales como a los centrocampistas exteriores en un único grupo denominado “jugadores de banda”, ya que como criterio de inclusión del estudio se tenía incluir únicamente a jugadores que completaron todo el partido resultó en un tamaño de muestra muy reducido de centrocampistas interiores a lo largo de la temporada. Esto se debe a que, normalmente, las sustituciones en los partidos afectan a jugadores ofensivos, lo que repercute en los centrocampistas interiores. Finalmente, la última limitación está relacionada con el tamaño de la muestra, dado que una plantilla profesional de fútbol suele estar compuesta por 20–25 jugadores distribuidos en varias demarcaciones. Por lo tanto, aunque el análisis por demarcaciones de juego puede aportar información valiosa, el reducido tamaño de la muestra para cada demarcación limita la representatividad y la generalización de los resultados.

Por último, en el artículo 3 se identificaron varias limitaciones. La primera limitación se refiere a que los datos fueron recopilados de un solo equipo, dentro de una liga específica y bajo un estilo de juego particular y una metodología de entrenamiento

definida por el cuerpo técnico. Por ello, estos hallazgos pueden no ser generalizables, incluso a otros equipos dentro de la misma división, debido a posibles diferencias en las estrategias de juego y en el diseño de las tareas de entrenamiento. Otra limitación está relacionada con el tamaño total de la muestra, ya que una plantilla profesional de fútbol normalmente comprende entre 20 y 25 jugadores distribuidos en varias demarcaciones de juego. Aunque el análisis por demarcación aporta información valiosa, el número limitado de jugadores por demarcación restringe la representatividad y la generalización de los hallazgos respecto a la demarcación de juego.

En resumen, las principales limitaciones que hemos tenido en el desarrollo de esta investigación han sido el tamaño total de la muestra (dado que una plantilla de fútbol está compuesta por 20-25 jugadores) y la imposibilidad de incluir la posición de centrocampistas interiores, lo que ha obligado a excluirlos del estudio o a integrarlos en otra posición con demandas similares, ya que estos jugadores normalmente suelen ser los sustituidos durante los partidos.

7 CONCLUSIONES

A partir de la investigación desarrollada en el marco de esta tesis doctoral, y de acuerdo con los objetivos planteados, se han podido establecer las siguientes conclusiones:

I. Las demandas físicas y las acciones técnico-tácticas varían cuando se consideran factores contextuales del juego (la localización del partido y el resultado final). Así, una mayor distancia total recorrida y un mayor número de acciones de Acc 2-4 y Dec -2-4 podrían estar relacionadas con jugar como local y perder, tanto para todos los jugadores como específicamente para MID y FW. Además, se observa un mayor número de SPR cuando el equipo juega como local y gana. Asimismo, se registran mayores valores de volumen de juego (GV), volumen defensivo (DV) y nº de intervenciones (IN) cuando el equipo juega como local y gana, tanto para todos los jugadores como para centrocampistas y delanteros. Por otro lado, los defensas centrales (CD) realizan mayores valores de GV y acciones de pase total (TPS) cuando el equipo juega como local y pierde. Finalmente, se registran mayores valores de pases hacia adelante (FP) y nº total de pases en zona de ataque (AZP) cuando el equipo juega como visitante y pierde.

II. Durante el microciclo, los escenarios de alta exigencia suelen ocurrir en el MD. A lo largo del microciclo, no se encontraron diferencias significativas en ninguna de las demarcaciones analizadas en la variable de distancia total. Sin embargo, se hallaron diferencias significativas, en todos los días de entrenamiento respecto al partido, en las variables de distancia > 21 km/h y distancia > 24 km/h en todas las demarcaciones, excepto en los defensas centrales (CD). En la demarcación de centrocampista (MID), el día MD-4 presentó valores más altos que el MD en aceleraciones > 3 m/s^2. Además, en desaceleraciones < -3 m/s^2, el día MD-1 mostró valores superiores al MD en centrocampistas y delanteros. Finalmente, para la variable HMLD, los valores de MD-1 fueron significativamente menores en comparación con el MD en todas las demarcaciones.

III. Las tareas de entrenamiento realizadas no replican completamente los WCS observados durante la competición. No obstante, ciertas tareas (TIPO 9 y TIPO 11) muestran una mayor aproximación a estas demandas, especialmente en términos de aceleraciones y desaceleraciones. Además, las exigencias condicionales relacionadas con la HSR y el sprint fueron, en la mayoría de las tareas, inferiores al 60% de los valores registrados en competición.

8 APLICACIONES PRÁCTICAS

A partir de las conclusiones extraídas de la presente Tesis Doctoral, se han propuesto las siguientes aplicaciones prácticas para que profesionales del ámbito del fútbol puedan llevarlas a cabo en su día a día:

I. Se sugiere que reconocer las implicaciones de los indicadores clave técnico-tácticos (KPIs) para la victoria, podría mejorar la selección de objetivos de entrenamiento, el modelo de juego y la elección de jugadores para alcanzar un rendimiento óptimo del equipo que contribuya a ganar partidos.

II. Se propone que identificar los días más adecuados para entrenar demandas específicas por demarcación, mejoraría tanto el rendimiento como las estrategias de recuperación. Investigar por qué las demandas físicas varían entre demarcaciones en función del MD podría ayudar a perfeccionar las estrategias de entrenamiento por demarcación y mejorar los protocolos de recuperación.

III. Se recomienda a integrar en las sesiones de entrenamiento tareas que reproduzcan con mayor precisión las exigencias físicas y tácticas observadas en competición, especialmente para aquellas demarcaciones que parecen estar subexpuestas durante el entrenamiento, así como, incorporar una variedad de tareas para potenciar la condición física.

IV. Se aconseja reflexionar sobre la posibilidad de que, si las discrepancias condicionales entre entrenamiento y competición son sustanciales, los objetivos tácticos integrados en las tareas de entrenamiento también puedan no cumplir con los requerimientos tácticos del juego competitivo.

9 IDEAS DE FUTURO

En el presente punto de la Tesis Doctoral se marcan algunas líneas de estudio por las que podría continuar esta investigación:

I. Aclarar qué demandas físicas y KPIs técnico-tácticos son clave en las transiciones defensa-ataque y ataque-defensa, dada su destacada importancia en los partidos de fútbol.

II. Examinar la relación entre los escenarios de alta exigencia y las tasas de lesión o la fatiga acumulada durante la temporada.

III. Identificar los días más adecuados para entrenar demandas específicas por demarcación, optimizando tanto el rendimiento como las estrategias de recuperación.

IV. Explorar la relación entre el diseño de las tareas de entrenamiento y el rendimiento táctico en competición.

V. Analizar cómo las diferentes metodologías de entrenamiento aplicadas en distintas ligas y países influyen en el desarrollo del jugador, las tasas de lesión y el éxito del equipo

VI. Interrelacionar los datos obtenidos en nuestro estudio sobre un equipo de fútbol profesional masculino con los datos procedentes de un equipo de fútbol profesional femenino u otros equipos de similar categoría y distinta posición final en la clasificación.

VII. Evaluar el estrés competitivo en las sesiones de entrenamiento y en las tareas programadas diariamente, en comparación con el partido, y factores hormonales como el cortisol.

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11 ANEXOS

11.1 ANEXO 1. FI-379. Aceptación de coautores de publicaciones en tesis doctorales por compendio de artículos

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Aceptación de Coautores de Publicaciones en Tesis Doctorales por Compendio de Artículos

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Aceptación de Coautores de Publicaciones en Tesis Doctorales por Compendio de Artículos
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Título de las publicaciones ***Title of the research publications affected***	- Influence of contextual factors on physical demands and technical-tactical actions regarding playing position in professional soccer players.
Apellidos, nombre del doctorando ***PhD student's surname, name***	Adrián Díez Camín

Acepto que la publicación mencionada sea presentada por el doctorando como trabajo que forma parte de su tesis doctoral / *Hereby I accept that the above mentioned research publication is presented by the PhD student as part of its PhD Thesis.*

En Zaragoza, a 21 de noviembre de 2025

Firma / *Signature*

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RENUNCIA DEL COAUTOR NO DOCTOR A PRESENTAR EL TRABAJO COMO PARTE DE OTRA TESIS DOCTORAL / *Resignation of the co-author to use the research publication as part of my PhD Thesis*

Renuncio a presentar las publicaciones mencionadas como parte de otra tesis doctoral / *I resign to use the mentioned publications as part of my PhD Thesis*

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Aceptación de Coautores de Publicaciones en Tesis Doctorales por Compendio de Artículos
Acceptance of research co-authors for PhD Thesis presented as publications compendium

ACEPTACIÓN ESCRITA DE LOS COAUTORES PARA QUE EL DOCTORANDO PRESENTE EL TRABAJO COMO TESIS DOCTORAL / *Written acceptance of the co-authors of a research publication for its presentation as part of a PhD Thesis*

Datos del coautor / *co-author data*

DNI/NIE/PASAPORTE *Identity number*	78747490K
Apellidos, nombre del coautor *Coauthor's surname, name*	Daniel Castillo Alvira
Institución, departamento, universidad de pertenencia *Affiliation, Department, University*	Universidad San Jorge, Autov A23 km 299, Villanueva de Gállego, 50830 Zaragoza, Spain
Categoría *Academic category*	Doctor
Doctor/a	○ Sí
Título de las publicaciones *Title of the research publications affected*	- Influence of contextual factors on physical demands and technical-tactical actions regarding playing position in professional soccer players.
Apellidos, nombre del doctorando *PhD student's surname, name*	Adrián Díez Camín

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En Zaragoza, a 21 de noviembre de 2025

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Firma / *Signature*

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ACEPTACIÓN ESCRITA DE LOS COAUTORES PARA QUE EL DOCTORANDO PRESENTE EL TRABAJO COMO TESIS DOCTORAL / *Written acceptance of the co-authors of a research publication for its presentation as part of a PhD Thesis*

Datos del coautor / *co-author data*

DNI/NIE/PASAPORTE ***Identity number***	Y7701389Z
Apellidos, nombre del coautor ***Coauthor's surname, name***	Hadi Nobari
Institución, departamento, universidad de pertenencia ***Affiliation, Department, University***	LFE Research Group, Department of Health and Human Performance, Faculty of Physical Activity and Sport Science (INEF), Universidad Politécnica de Madrid, Madrid, Spain
Categoría ***Academic category***	Doctor
Doctor/a	○ Sí
Título de las publicaciones ***Title of the research publications affected***	- Influence of contextual factors on physical demands and technical-tactical actions regarding playing position in professional soccer players.
Apellidos, nombre del doctorando ***PhD student's surname, name***	Adrián Díez Camín

Acepto que la publicación mencionada sea presentada por el doctorando como trabajo que forma parte de su tesis doctoral / *Hereby I accept that the above mentioned research publication is presented by the PhD student as part of its PhD Thesis.*

En Zaragoza, a 21 de noviembre de 2025

Firma / *Signature* NOBARI HADI - Y7701389Z

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Date: 2025.11.21 13:09:28 +01'00'

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Datos del coautor / *co-author data*

DNI/NIE/PASAPORTE *Identity number*	48500181-N
Apellidos, nombre del coautor *Coauthor's surname, name*	Diego Jaén-Carrillo
Institución, departamento, universidad de pertenencia *Affiliation, Department, University*	Department of Sport Science, University of Innsbruck, Innsbruck, Austria
Categoría *Academic category*	Doctor
Doctor/a	○ Sí
Título de las publicaciones *Title of the research publications affected*	- Influence of contextual factors on physical demands and technical-tactical actions regarding playing position in professional soccer players.
Apellidos, nombre del doctorando *PhD student's surname, name*	Adrián Díez Camín

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En Zaragoza, a 21 de noviembre de 2025

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Datos del coautor / *co-author data*

DNI/NIE/PASAPORTE ***Identity number***	73016591D
Apellidos, nombre del coautor ***Coauthor's surname, name***	Lampre Ezquerra, Miguel
Institución, departamento, universidad de pertenencia ***Affiliation, Department, University***	Universidad San Jorge
Categoría ***Academic category***	Categoría profesional: Experto en fútbol
Doctor/a	○ No
Título de las publicaciones ***Title of the research publications affected***	Influence of contextual factors on physical demands and technical-tactical actions regarding playing position in professional soccer players.
Apellidos, nombre del doctorando ***PhD student's surname, name***	Adrián Díez Camín

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Renuncio a presentar las publicaciones mencionadas como parte de otra tesis doctoral / *I resign to use the mentioned publications as part of my PhD Thesis*

Firma / *Signature*

11.2 ANEXO 2. Memoria económica

GOBIERNO DE ARAGON
Departamento de Sanidad

Ceica
Avda. San Juan Bosco, 13. 50009 Zaragoza

MEMORIA ECONÓMICA-UTILIZACIÓN DE RECURSOS EN INVESTIGACIÓN

El fin de este documento es disponer de la información necesaria para garantizar un uso adecuado y eficiente de los recursos tales como tiempo de los profesionales, aparataje y dispositivos, pruebas complementarias, que son necesarios para desarrollar el proyecto. ***Indique si forman parte de los que se utilizan en la práctica clínica habitual del servicio en que lo va a desarrollar o si precisa de recursos y pruebas diagnósticas adicionales.*** *Marque lo que proceda:*

TÍTULO DEL PROYECTO: Análisis multifactorial de la carga de entrenamiento individual en jugadores de fútbol profesional. Importancia del uso de la tecnología GPS en el fútbol profesional.

1. **Uso de recursos:**

	SI	NO
Dispone de financiación específica para el desarrollo del proyecto Especifique la fuente de financiación:		X
En caso afirmativo indique la cantidad y la procedencia de los fondos. En caso de convocatoria competitiva se debe adjuntar el presupuesto concedido desglosado		
¿Requiere colaboración de personal del Servicio para el desarrollo del Proyecto de Investigación?		X
En caso afirmativo indique el nombre y su función o actividad en el desarrollo del proyecto:		
¿Requiere participación del personal de otros Servicios para el desarrollo del Proyecto de Investigación?		X
En caso afirmativo indique el nombre y su función o actividad en el desarrollo del proyecto, y recoja la firma del Jefe de Servicio correspondiente:		
¿Requiere sólo pruebas diagnósticas utilizadas en la práctica clínica habitual para los pacientes incluidos en el estudio?		X
¿Requiere pruebas diagnósticas adicionales a las de la práctica clínica habitual realizadas en el propio servicio?		X
En caso afirmativo indique cuáles. Valore el coste de las pruebas en el apartado 2		
¿Requiere pruebas diagnósticas adicionales a las de la práctica clínica habitual realizadas en otros servicios?		X
En caso afirmativo indique cuáles y haga constar la **aceptación expresa del jefe del servicio** o unidad. Valore el coste de las pruebas en el apartado 2		

2. **Valoración coste pruebas diagnósticas adicionales a la práctica asistencial:**

Prueba	Coste unitario	Nº pruebas	Coste total
-	0	0	0
-	0	0	0

3. **Conformidad de los responsables de los servicios implicados (NECESARIA SIEMPRE):**

Firma
Nombre: DEMETRIO LOZANO JARQUE

4. **Conformidad de la Dirección/responsable del centro en que se desarrollará el proyecto (sólo es necesaria en caso de utilización de recursos adicionales):**

Firma
Nombre: DEMETRIO LOZANO JARQUE

Versión 13/01/2021 1

11.3 ANEXO 3. Información al participante

DOCUMENTO DE INFORMACIÓN PARA EL PARTICIPANTE

Título de la investigación: Análisis multifactorial de la carga de entrenamiento individual en jugadores de fútbol profesional. Importancia del uso de la tecnología GPS en el fútbol profesional.

Promotor: Adrián Díez Camín

Investigador Principal: Adrián Díez Camín Tfno: 655034681 adiezcamin@usj.es

Centro: Universidad San Jorge

1. Introducción:

Nos dirigimos a usted para solicitar su participación en un proyecto de investigación que estamos realizando en Universidad San Jorge. Su participación es voluntaria, pero es importante para obtener el conocimiento que necesitamos. Este proyecto ha sido aprobado por el Comité de Ética, pero antes de tomar una decisión es necesario que:

- lea este documento entero
- entienda la información que contiene el documento
- haga todas las preguntas que considere necesarias
- tome una decisión meditada
- firme el consentimiento informado, si finalmente desea participar.

Si decide participar se le entregará una copia de esta hoja y del documento de consentimiento firmado. Por favor, consérvelo por si lo necesitara en un futuro.

2. ¿Por qué se le pide participar?

Se le solicita su colaboración para participar en la Tesis Doctoral realizada por el investigador que se detalla en la parte superior de esta hoja.

En total en el estudio participarán 24 jugadores profesionales de fútbol pertenecientes a un equipo profesional.

3. ¿Cuál es el objeto de este estudio?

El objetivo del presente estudio en analizar variables físicas extraídas de dispositivos GPS para poder contribuir a la mejora de la planificación del entrenamiento deportivo, la mejora del rendimiento físico del futbolista y la prevención de lesiones.

4. ¿Qué tengo que hacer si decido participar?

Para poder participar usted en el presente estudio, únicamente tiene que vestirme con un chaleco especial para insertar el dispositivo durante los entrenamientos y dentro del chaleco insertar el dispositivo GPS.
No será una investigación que haya que utilizar ningún método invasivo para el participante.

5. ¿Qué riesgos o molestias supone?

El presente estudio no tiene riesgos ni supone molestias para sus participantes.

6. ¿Obtendré algún beneficio por mi participación?

Al tratarse de un estudio de investigación orientado a generar conocimiento no es probable que obtenga ningún beneficio por su participación si bien usted contribuirá al avance científico y al beneficio social.

ADVERTENCIA: LA OBTENCIÓN GRATUITA DE LOS PRODUCTOS DE ESTUDIO, LOS RESULTADOS DE LAS PRUEBAS, EL SEGUIMIENTO ESTRECHO, ETC NO DEBE SER CONSIDERADO COMO BENEFICIO DE LA PARTICIPACIÓN EN EL ESTUDIO

Usted no recibirá ninguna compensación económica por su participación.

7. ¿Cómo se van a tratar mis datos personales?

Información básica sobre protección de datos.
Responsable del tratamiento: Adrián Díez Camín
Finalidad: Sus datos personales serán tratados exclusivamente para el trabajo de investigación a los que hace referencia este documento.
Legitimación: El tratamiento de los datos de este estudio queda legitimado por su consentimiento a participar.
Destinatarios: No se cederán datos a terceros salvo obligación legal.
Derechos: Podrá ejercer sus derechos de acceso, rectificación, supresión y portabilidad de sus datos, de limitación y oposición a su tratamiento, de conformidad con lo dispuesto en el Reglamento General de Protección de Datos (RGPD 2016/679) ante el investigador principal del proyecto, pudiendo obtener información al respecto dirigiendo un correo electrónico a la dirección adiezcamin@usj.es
Podrá consultar información adicional y detallada en el Registro de Actividades de Tratamiento del Gobierno de Aragón, en el siguiente enlace: https://aplicaciones.aragon.es/notif_lopd_pub/details.action?fileId=731

Así mismo, en cumplimiento de los dispuesto en el RGPD, se informa que, si así lo desea, podrá acudir a la Agencia de Protección de Datos (https://www.aepd.es) para presentar una reclamación cuando considere que no se hayan atendido debidamente sus derechos.

El tratamiento de sus datos personales se realizará utilizando técnicas para mantener su anonimato mediante el uso de códigos aleatorios, con el fin de que su identidad personal quede completamente oculta durante el proceso de investigación.

A partir de los resultados del trabajo de investigación, se podrán elaborar comunicaciones científicas para ser presentadas en congresos o revistas científicas, pero se harán siempre con datos agrupados y nunca se divulgará nada que le pueda identificar.

8. ¿Cómo se van a tratar mis muestras biológicas?

Para el presente estudio no se van a utilizar muestras biológicas.

9. ¿Quién financia el estudio?

Este proyecto no tiene financiación.

10. ¿Se me informará de los resultados del estudio?

Usted tiene derecho a conocer los resultados del presente estudio, tanto los resultados generales como los derivados de sus datos específicos. También tiene derecho a no conocer dichos resultados si así lo desea. Por este motivo en el documento de consentimiento informado le preguntaremos qué opción prefiere. En caso de que desee conocer los resultados, el investigador le hará llegar los resultados.

¿Puedo cambiar de opinión?

Su participación es totalmente voluntaria, puede decidir no participar o retirarse del estudio en cualquier momento sin tener que dar explicaciones. Basta con que le manifieste su intención al investigador principal del estudio.

¿Qué pasa si me surge alguna duda durante mi participación?

En la primera página de este documento está recogido el nombre y el teléfono de contacto del investigador responsable del estudio. Puede dirigirse a él en caso de que le surja cualquier duda sobre su participación.

Muchas gracias por su atención, si finalmente desea participar le rogamos que firme el documento de consentimiento que se adjunta.

DOCUMENTO DE CONSENTIMIENTO INFORMADO

Título del PROYECTO: Análisis multifactorial de la carga de entrenamiento individual en jugadores de fútbol profesional. Importancia del uso de la tecnología GPS en el fútbol profesional.

Yo, ... (nombre y apellidos del participante)

He leído la hoja de información que se me ha entregado.

He podido hacer preguntas sobre el estudio y he recibido suficiente información sobre el mismo.

He hablado con: Adrián Díez Camín

Comprendo que mi participación es voluntaria.

Comprendo que puedo retirarme del estudio:

1) cuando quiera
2) sin tener que dar explicaciones
3) sin que esto repercuta en mis cuidados médicos

Presto libremente mi consentimiento para participar en este estudio y doy mi consentimiento para el acceso y utilización de mis datos conforme se estipula en la hoja de información que se me ha entregado

Deseo ser informado sobre los resultados del estudio: sí no (marque lo que proceda)

He recibido una copia firmada de este Consentimiento Informado.

Firma del participante: .....

Fecha: .....

He explicado la naturaleza y el propósito del estudio al paciente mencionado

Firma del Investigador: .....

Fecha:

11.4 ANEXO 4. Comité de ética de los estudios

GOBIERNO DE ARAGON
Departamento de Sanidad

Informe Dictamen Favorable
Trabajos académicos
C.P. - C.I. PI21/060
24 de febrero de 2021

Dña. María González Hinjos, Secretaria del CEIC Aragón (CEICA)

CERTIFICA

1º. Que el CEIC Aragón (CEICA) en su reunión del día 24/02/2021, Acta Nº 04/2021 ha evaluado la propuesta del Trabajo:

Título: Análisis multifactorial de la carga de entrenamiento individual en jugadores de fútbol profesional. Importancia del uso de la tecnología GPS en el fútbol profesional.

Alumno: Adrián Díez Camín
Directores: Demetrio Lozano Jarque y José Luis Arjol Serrano

Versión protocolo: v2, 15/02/2021
Versión documento de información y consentimiento: v2, 15/02/2021

2º. Considera que

- El proyecto se plantea siguiendo los requisitos de la Ley 14/2007, de 3 de julio, de Investigación Biomédica y los principios éticos aplicables.
- El Tutor/Director garantiza la confidencialidad de la información, la obtención de los consentimientos informados, el adecuado tratamiento de los datos en cumplimiento de la legislación vigente y la correcta utilización de los recursos materiales necesarios para su realización.

3º. Por lo que este CEIC emite **DICTAMEN FAVORABLE a la realización del proyecto**.

Lo que firmo en Zaragoza
GONZALEZ HINJOS MARIA - DNI 03857456B
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Fecha: 2021.02.26 11:08:25 +01'00'
María González Hinjos
Secretaria del CEIC Aragón (CEICA)

Tel. 976 71 5836 Fax. 976 71 55 54 Correo electrónico mgonzalezh.ceic@aragon.es

UNIVERSIDAD SAN JORGE

Facultad de Ciencias de la Salud