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Universidad del País Vasco
Euskal Herriko Unibertsitatea

Facultad de Educación y Deporte

Departamento de Educación Física y Deportiva

TÍTULO

Análisis de la condición física, nivel de práctica de actividad física y hábitos nutricionales de jugadores jóvenes de baloncesto: descripción, comparación en función de edad y sexo y efectos de diferentes programas de intervención.

TESIS DOCTORAL

DÑA. SILVIA SÁNCHEZ DÍAZ

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PROGRAMA DE DOCTORADO

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A mis padres, por su esfuerzo y dedicación, porque gracias a ellos me he convertido en la persona que soy.

A mi hermana, porque en lo bueno y en lo malo siempre está para escucharme, apoyarme y darme consejo.

Y a ti, Dani, por estar siempre a mi lado, por tu amor incondicional y tu ayuda sin límite.

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Hace cuatro años era impensable para mi estar escribiendo los agradecimientos de lo que en este momento es mi tesis doctoral. A lo largo de estos años y durante la realización de esta investigación he contado con el apoyo incondicional de muchas personas que directa o indirectamente se han visto involucradas en la culminación de este proyecto y a las cuales me gustaría dedicar unas palabras.

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De la Universidad Isabel I me llevo también tres grandes tesoros, a mis tres compañeras y amigas de batalla, Marta, Raquel y Tara, que desde el minuto uno, me acogieron como una burgalesa más. Nos hemos reído, hemos llorado y hemos disfrutado de muchos momentos juntas, entre ellos destacaré las charlas interminables y los almuerzos de los viernes, benditos viernes, nos daba igual dulce que salado, la cuestión era comer. Os estaré eternamente agradecida.

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hemos conseguido crear un vínculo muy especial, nunca olvidaré los veranos y semanas santas vividos a vuestro lado.

Y finalmente siempre estaré en deuda con mi familia, mis padres Andrés y Teodora, mi hermana Isa y mi primo Vale, que, aunque primo y mejor padrino para mí siempre ha sido como un hermano y tanto a él como el resto, tengo que agradecerles que siempre han estado ahí, dándome ánimos y apoyándome en cada una de mis decisiones. A mi sobrina Martina, por su alegría y a mi marido y mejor amigo, Dani, por hacer que todos mis sueños se cumplan y por darme el mayor regalo, nuestra Jimena.

“Lograr aquello que has soñado te hace feliz, pero, sobre todo, te hace feliz recordar el esfuerzo empleado para lograrlo”. Rafael Nadal.

DECLARACIÓN

Yo, Silvia Sánchez Díaz soy la autora de esta tesis doctoral, que junto con la ayuda de mis dos directores Javier Yanci Irigoyen y Javier Raya González, he participado desde el minucioso trabajo del diseño de la investigación hasta la redacción del documento final. He abordado cada paso del plan de trabajo de forma exhaustiva y sistemática. Para ello, y como parte del presente proyecto, he asistido a gran parte de los entrenamientos de dos equipos de baloncesto de categoría cadete, donde he recogido todos los datos con seriedad, rigurosidad y profesionalidad. La toma de datos me ha requerido, a mi entender, de una alta capacidad de concentración, atención y, sobre todo, de la habilidad para responder de forma rápida y resolutiva a situaciones imprevistas generadas durante las pruebas físicas y el desarrollo de las estrategias de educación nutricional. Durante la toma de datos he sido la responsable de solicitar el material necesario a la Universidad, así como de la realización de los informes individualizados para los cuerpos técnicos y jugadores/as implicadas en la investigación. Posterior a cada toma de datos he realizado el análisis e interpretación de los mismos. Estas tareas las he realizado a la vez que llevaba a cabo una exhaustiva lectura de todas las publicaciones indexadas en el Journal Citation Report (JCR) sobre condición física y hábitos alimentarios en los deportes de equipo y, más concretamente en el baloncesto.

En una fase posterior he contrastado los resultados obtenidos en la presente investigación con los resultados publicados en la literatura científica. De esta forma, he ido elaborando y redactando los estudios que conforman esta tesis doctoral. Nada de esto hubiera sido posible sin la guía de mis directores. A ellos les debo mi formación durante este periodo; ellos se han involucrado en orientarme desde el diseño del estudio hasta su publicación en revistas científicas. Durante este proceso he colaborado con investigadores nacionales e internacionales, expertos en el área de estudio que, desde diferentes enfoques, han ayudado a mejorar la calidad del trabajo.

Las investigaciones llevadas a cabo han sido financiadas por la Fundación Obra Social La Caixa y la Fundación de la Universidad Isabel I. Esta tesis doctoral, así como cada uno de los artículos publicados que la conforman no presentan conflicto de intereses por parte de los autores ni familiares.

ABREVIATURAS

Castellano

FI = Factor de impacto

UPV/EHU = Universidad del País Vasco / Euskal Herriko Unibertsitatea

FECYT = Fundación Española para la Ciencia y la Tecnología

ACB = Asociación de Clubes de Baloncesto

FIBA = Federación Internacional de Baloncesto

FEB = Federación Española de Baloncesto

LEB = Liga Española de Baloncesto

EBA = Liga Española de Baloncesto Aficionado

LF-1 = Liga Femenina de Baloncesto

LF Endesa = Liga Femenina Endesa

LF-2 = Liga Femenina 2

LF- 1B = Liga Femenina C*hallenge*

FCBQ = Federación Catalana de Baloncesto

FC = Frecuencia cardíaca

FIFA = Federación Internacional de Fútbol Asociado

GPS = Sistema de Posicionamiento Global

CMJ = Salto con contra movimiento

Inglés

ISSN = International Standard Serial Number

JCR = Journal Citation Reports

NBA = National Basketball Association

RSA = Repeated Sprint Ability

DJ = Drop Jump

UWB= Ultrawideband

ÍNDICE

ÍNDICE

SECCIÓN 1

1.1. INTRODUCCIÓN

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Uno de los principales objetivos de los técnicos deportivos es la mejora del rendimiento individual y grupal de sus deportistas. Además, cuando se trata de deportistas jóvenes, la labor de los técnicos también debe abordar la formación y la mejora de su calidad de vida. El comportamiento y la práctica alimentaria es un aspecto fundamental para conseguir un estilo de vida saludable. Esta conducta alimentaria está vinculada con la aparición, cada vez más predominante, de enfermedades crónicas no transmisibles entre la población juvenil, como puede ser la obesidad infantil. Por ello, además de mejorar el nivel de condición física, los programas de educación nutricional que se apliquen con esta población joven deberían incidir en una mejora de la salud de los deportistas. En este sentido, las estrategias de educación nutricional parecen obtener resultados prometedores, principalmente en el aumento del conocimiento nutricional, en la mejora de las elecciones dietéticas y en la modificación de los hábitos de consumo. Sin embargo, estas estrategias han sido poco estudiadas en jugadores de baloncesto, y menos aún en jugadores jóvenes y combinadas con algún programa de entrenamiento físico adicional al entrenamiento regular de baloncesto. Por todo esto, surge la necesidad de realizar esta Tesis Doctoral, la cual pretende conocer y comparar los hábitos de consumo y conocimiento nutricional, además del nivel de actividad física y condición física, entre jugadores de baloncesto jóvenes masculinos y femeninos. Asimismo, también se pretende estudiar los efectos de un programa combinado de estrategias educativas y entrenamiento físico sobre los hábitos de consumo, el conocimiento nutricional, el nivel de actividad física y la condición física en jugadores de baloncesto jóvenes. A nivel profesional, cuento con experiencia en la implementación de estrategias de educación nutricional, así como en la participación en proyectos de investigación en deporte formativo, por lo que es una temática que me produce gran motivación. Finalmente, destacar que se trata de una Tesis Doctoral con un gran alcance a nivel de investigación, ya que actualmente, las investigaciones de este tipo en deportistas jóvenes son escasas en comparación con deportistas adultos. Los resultados obtenidos en la presente investigación pueden favorecer la labor de los técnicos deportivos que trabajen con jugadores jóvenes de baloncesto a la hora de instruir de forma voluntaria las conductas relacionadas con la alimentación y el entrenamiento. Se trata de una Tesis Doctoral por compendio de publicaciones, las cuales se muestran en la siguiente tabla:

Tabla 1. Artículos incluidos en la Tesis Doctoral.

Revista	Abreviatura	ISSN	Rama de conocimiento	Categoría	Base de datos (año para FI)	FI o Puntuación	C
Nutrients	Nutrients	2072-6643	Ciencias de la Salud	Nutrition & Dietetics	JCR (2020)	5,719	1
Frontiers in Psychology	Front Psychol	1664-1078	Ciencias Sociales y Jurídicas	Psychology, Multidisciplinary	JCR (2020)	2,988	2
European Journal of Human Movement	Eur J Hum Mov	2386-4095	Ciencias Sociales y Jurídicas	Ciencias de la Educación	FECYT (2020)	23,37	3

ISSN = International Standard Serial Number; FI = Factor de impacto; C = Cuartil, JCR = Journal Citation Reports, FECYT = Fundación Española para la Ciencia y la Tecnología

Tal como dicta la normativa de la UPV/EHU (UPV/EHU, 2022) para optar a la presentación de una tesis doctoral en la modalidad de compendio de publicaciones es necesario tener publicados o aceptados al menos tres contribuciones, estando esta tesis doctoral compuesta por tres artículos, los cuales se encuentran ya publicados en revistas de primer, segundo y tercer cuartil de su categoría. Las revistas en las cuales han sido publicados estos estudios están indexadas en las bases de datos JCR y del FECYT, perteneciendo a las de conocimiento de Ciencias Sociales y Jurídicas (e.g., *Frontiers in Psychology*, y *European Journal of Human Movement)* y a Ciencias de la Salud. (e.g., *Nutrients*).

De acuerdo con la normativa vigente (UPV/EHU, 2022), esta tesis doctoral está dividida en tres secciones. La primera de ellas está compuesta por la introducción, donde se realiza una presentación de la tesis y se justifica la unidad temática; el marco teórico, en el que se describe el tema de la tesis, el conocimiento científico más relevante sobre la temática y las herramientas metodológicas utilizadas; los objetivos y las hipótesis, en los que se plantean los objetivos y las hipótesis tanto generales como específicos de la tesis doctoral; un resumen de los resultados y discusión, donde se resumen los resultados obtenidos en la investigación llevada a cabo y se resume la discusión de estos resultados; y por último las referencias bibliográficas, donde están enumeradas todas las referencias

de la primera sección. La segunda sección está compuesta por las conclusiones. En este apartado se redactan las conclusiones extraídas del análisis de los resultados obtenidos en esta tesis doctoral; las aplicaciones prácticas, donde se muestran las aplicaciones reales que se puedan derivar de esta tesis doctoral; las limitaciones, donde se enumeran las principales limitaciones; y las futuras líneas de investigación, donde se plantean futuros temas que podrían ser susceptibles de investigar o herramientas que se podrían utilizar derivados de esta tesis doctoral. Finalmente, la tercera sección está compuesta por los artículos que componen esta tesis doctoral, donde se incluyen los artículos publicados en su formato original.

Iniciar dentro del ámbito deportivo y desde etapas bien tempranas el abordaje del comportamiento y la práctica alimentaria combinado con la práctica deportiva planificada, está en boga de los responsables de la preparación física para conseguir afianzar un estilo de vida saludable en jugadores jóvenes. Es por ello que, en esta tesis doctoral, se pretende conocer y comparar los hábitos de consumo y conocimiento nutricional de estos jugadores, tanto de sexo masculino como femenino, además de su nivel de actividad física y condición física, aplicando un programa que combine diferentes estrategias nutricionales y deportivas. Así pues, gracias a estos estudios se pretende optimizar el proceso de formación de los jugadores jóvenes de baloncesto desde un enfoque multidisciplinar.

1.2. MARCO TEÓRICO

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1.2.1 Contexto del baloncesto

El baloncesto, más conocido en inglés bajo el término *basketball* (basket, canasta y *ball*, pelota) fue creado por James Naismith, profesor de educación física de la International YMCA Training School de Springfield (Massachusetts), en 1891 (Rains, 2009). La motivación principal de Naismith por crear este deporte nació como respuesta a la necesidad de practicar actividades deportivas durante el invierno, ya que la dureza de los inviernos del norte de Estados Unidos dificultaba la práctica de actividad física al aire libre (Rains, 2009). En un primer momento, este deporte comenzó practicándose bajo techo, derivando más tarde en la práctica de este deporte en las dos modalidades de juego que actualmente se conocen, en pista cubierta y pista descubierta.

En los primeros años tras la implementación de este deporte, había algunos aspectos que estaban sin definir, como el número de jugadores implicados y el tamaño de la cancha de juego. Fue en 1898 cuando se estableció el número de participantes, quedando fijado en dos equipos de cinco jugadores cada uno y que competían entre sí. El objetivo era anotar más puntos que el contrario lanzando un balón a un aro colocado a 3,05 metros del suelo, vestido con una red que le daba un aspecto de cesta o canasta. Más adelante, en 1904 fue cuando se concretó el tamaño de la cancha de juego.

En el año 1892 se desarrolló el primer reglamento, el cual estaba compuesto por 13 reglas, que se basaban en el antiguo juego *pok-ta-pok* o *tlachtlli* azteca (Lorenzo Calvo, 2000). Este reglamento determinaba que los jugadores no podían desplazarse con el balón en la mano, sino que tenían que lanzarlo desde la posición en la que se encontraban a otros jugadores. Para realizar los lanzamientos, debían emplear una o ambas manos y/o palmear el balón, pero nunca golpearlo con el puño. En caso de hacerlo, se consideraba falta (Comas M, 1991). Además, golpear, zancadillear o empujar al adversario era considerado una infracción que se castigaba con una falta y se traducía en la expulsión del jugador del terreno de juego hasta que su equipo consiguiera anotar una canasta. En este sentido, cada vez que se anotaba una canasta, se efectuaba un salto entre dos jugadores en el centro del campo (Comas M, 1991). En cuanto a la duración del partido,

este constaba de dos partes de 15 minutos, separadas por un descanso de cinco minutos. En caso de empate, y si los capitanes de ambos equipos estaban de acuerdo, se continuaba jugando hasta que uno de los dos equipos lograra encestar una canasta (FEB, 2016). Con el paso del tiempo, estas reglas fueron adaptándose a las necesidades de los espacios cerrados de los que se disponían, hasta llegar a la reglamentación actual, formada por ocho reglas compuestas por diferentes subapartados: el juego, el terreno de juego y el equipamiento, los equipos, la reglamentación, violaciones, infracciones, disposiciones generales y árbitros. En la actualidad, un partido consta de cuatro cuartos de 10 minutos cada uno atendiendo al reglamento de la ACB o de 12 minutos según el reglamento de la NBA, con un tiempo adicional de cinco minutos en caso de empate. El partido comienza con un salto entre un jugador de cada equipo en el centro de la cancha y las canastas tienen diferente puntuación dependiendo del lugar de lanzamiento y el tipo de tiro. Cuando el lanzamiento se realiza desde la línea de tiro libre, la canasta vale un punto. En cambio, si la canasta se consigue por delante de la línea de tres puntos vale dos puntos, mientras que aquellas que se encestan por detrás de la línea de tres puntos, valen tres puntos. El jugador puede avanzar driblando con la pelota, es decir, botando el balón. Sin embargo, nunca podrá parar de driblar, agarrar el balón y volver a driblar, ya que esa acción se considera infracción por dobles. Del mismo modo, un jugador que recibe el balón mientras progresa y realiza un *dribling*, solo puede dar dos pasos para intentar un tiro o pasar el balón. Si el jugador da más de dos pasos, se considera infracción por pasos. En el caso de las infracciones que derivan en falta por agresión al jugador contrario, denominadas faltas personales, pueden ser ofensivas o defensivas en función de si el jugador que la comente se encuentra atacando o defendiendo (FEB, 2018).

Según Lorenzo (2000), el baloncesto se define como un deporte de equipo que puede ser considerado como una situación social, dinámica, cambiante y, por tanto, sociomotor, donde los jugadores siempre van a estar interaccionando, bien con los compañeros o bien con los adversarios. Se caracteriza principalmente por ser un deporte de cooperación-oposición constituido por habilidades perceptivas, abiertas y de regulación externa (Ruiz Pérez, 1995) que se llevan a cabo en un espacio común y de acción simultánea sobre el móvil (Hernández Moreno, 1994). Si bien, ese espacio de juego se desenvuelve en un entorno cambiante, variable e incierto, que exige anticiparse y adaptarse a las cambiantes circunstancias de juego (Hernández Moreno, 1994)

El baloncesto cuenta con un alto número de practicantes a nivel mundial, tanto de forma recreativa como federada, siendo Estados Unidos el país con mayor participación, aunque esta se puede considerar elevada en todo el mundo (Labonté, 2015). A nivel internacional, la entidad que rige las competiciones en el baloncesto es la Federación Internacional de Baloncesto, más conocida como FIBA (FIBA.basketball, n.d.) que fue fundada en 1932 en Suiza. En cambio, a nivel nacional, el organismo encargado de gestionar el baloncesto en España es la FEB.

En cuanto a las categorías en las que se estructura el baloncesto, hay que tener en cuenta dos aspectos importantes. Por un lado, las categorías en las competiciones que organiza la FEB y las categorías en las competiciones que dependen de las distintas federaciones territoriales. En estas últimas se incluyen las competiciones senior, junior e inferiores que se disputan a nivel autonómico (Consejo Superior de Deportes, n.d.; Federación Española de Baloncesto, 2021).

A nivel profesional, el baloncesto es disputado tanto en categoría masculina como femenina, estructurándose las competiciones de manera distinta. La ACB es la primera categoría, seguida de la LEB Oro y Plata. Los equipos mejor clasificados de esta última categoría ascenderán a LEB Oro y los de LEB Oro a ACB. Mientras que los peor clasificados de LEB Plata descenderán a la liga EBA, última categoría dentro de las ligas profesionales organizadas por la FEB. Por otro lado, la máxima competición de clubes femeninos de baloncesto que se disputa en España es la LF-1, también conocida como LF Endesa por cuestiones de patrocinio, cuya organización corresponde a la FEB (FEB, 2021). Está formada por 16 equipos, de los cuales 14 pertenecen a la LF Endesa de la temporada anterior y los dos equipos ascendidos de la LF-2 la temporada anterior. Los dos últimos clasificados, descienden a la LF-1B.

A nivel amateur, aunque su nombre parezca indicar lo contrario, la Primera División de Baloncesto es la primera categoría del baloncesto autonómico, es decir, la primera en ser organizada por cada una de las federaciones autonómicas. Existen excepciones en la denominación y organización en algunas de las federaciones, como es el caso de la FCBQ, cuya primera división pasa a denominarse Copa Cataluña. Y las comunidades de País

Vasco, Navarra y La Rioja que compiten entre ellas y, por tanto, comparten un mismo grupo.

Además, las categorías inferiores en las que los jugadores van aprendiendo los fundamentos de este deporte, se estructuran en función de los siguientes criterios: sexo y edad. De esta manera se establecen las categorías expuestas en la tabla 2.

Tabla 2. Categorías de baloncesto según la edad de los participantes.
Fuente: (Federación Española de Baloncesto, 2021)

Categoría		**Año de nacimiento**	**Edad**	
Senior		2003 y anteriores	22 años o más	Absoluta
Senior sub-22		2000-2003	18-21 años	Sub-22
Junior		2004-2005	16-17 años	Sub-17 y sub-18
Cadete		2006-2007	14-15 años	Sub-15 y sub-16
Infantil		2008-2009	12-13 años	Sub-13 y sub-14
Preinfantil		2009	12 años	Sub-13
Minibasket	*Alevín*	2010-2011	10-11 años	Sub-11 y sub-12
	Benjamín	2012-2013	6-7 años	Sub-10 y sub-11

1.2.2 Demandas físicas y fisiológicas del baloncesto

Cuantificar la carga externa (i.e. demandas físicas) y la carga interna (i.e. demandas fisiológicas y percepción subjetiva del esfuerzo) en el baloncesto puede ayudar a los preparadores físicos a optimizar el rendimiento de los jugadores a través del desarrollo de estrategias de entrenamiento específicas (Fox et al., 2017; Stojanović et al., 2018). Así mismo, este conocimiento de la carga externa e interna que suponen los partidos a los jugadores de baloncesto, permite controlar los estímulos y respuestas, prescribir estrategias de recuperación tras la competición y, consecuentemente reducir el riesgo lesivo (Mujika, 2013).

En este sentido, se ha demostrado que el baloncesto es un deporte de equipo en el cual el rendimiento de los jugadores está influenciado de manera multifactorial, ya que este deporte presenta una alta exigencia a nivel técnico, táctico, psicológico y condicional (Fox et al., 2017). Desde el año 2000, el reglamento del baloncesto ha sufrido modificaciones que están directamente relacionadas con las demandas físicas y

fisiológicas de los jugadores (Ben Abdelkrim et al., 2010; Ferioli et al., 2019): cuatro periodos de 10 minutos, un tiempo de ataque de 24 segundos y ocho segundos de tiempo para cruzar la línea media del campo, entre otros. Desde un enfoque condicional, los jugadores están expuestos a una gran cantidad de acciones de alta intensidad, como saltos, esprints y cambios de dirección, combinadas con periodos de baja intensidad (i.e., descansos activos y pasivos) durante los partidos, las cuales son determinantes para tener mayores probabilidades de éxito deportivo (Ben Abdelkrim et al., 2007).

El baloncesto es un deporte que implica constantes transiciones ofensivas y defensivas con la intención de organizar las situaciones de ataque para meter canasta y de impedir que el rival consiga este mismo objetivo (McInnes et al., 1995). Los jugadores de baloncesto recorren un total de aproximadamente 5-6 km por partido (Stojanović et al., 2018), alcanzando velocidades máximas de 18-23 km/h (Castillo et al., 2021; Vazquez-Guerrero et al., 2020). Así mismo, el baloncesto se caracteriza por ser un deporte intermitente en el que destacan las frecuentes acciones de alta intensidad y largos periodos de descanso coincidiendo con el juego parado (e.g., tiempos muertos, tiros libres, infracciones, etc.) o las sustituciones. Concretamente, los jugadores realizan aproximadamente 33 acciones de alta intensidad por minuto en las que se incluyen aceleraciones y desaceleraciones (Torres-Ronda et al., 2016; Vazquez-Guerrero et al., 2020). Además, se ha demostrado que, a diferencia de algunos otros deportes de equipo, en el baloncesto predominan los saltos durante el juego, y que se realizan alrededor de un salto por minuto (Svilar et al., 2019).

La mayoría de las investigaciones que se han centrado en analizar las demandas físicas de los jugadores de deportes de equipo los cuales se juegan a cubierto (*indoor)*, y especialmente el baloncesto, han utilizado sistemas de seguimiento (*tracking*) basados en vídeo o microtecnología como son los acelerómetros (Ben Abdelkrim et al., 2007; Schelling & Torres, 2016; Svilar et al., 2019). Los sistemas de *tracking* son una tecnología no invasiva, ya que los jugadores no tienen que llevar puesto ningún dispositivo electrónico, aunque tienen unos altos costes e implican una alta dedicación para procesar los datos, ya que en ocasiones se requiere de correcciones manuales. Por otro lado, los acelerómetros han facilitado el proceso de monitorización de las demandas físicas soportadas por los jugadores de baloncesto, utilizando diferentes variables tales como las

aceleraciones, cambios de dirección, saltos, choques y la variable de *player load* entre otros (Scanlan et al., 2019; Schelling & Torres, 2016). Sin embargo, el inconveniente de estos dispositivos es que no posibilita la cuantificación de los perfiles de actividad en términos de distancias totales recorridas, así como a diferentes rangos de velocidad. Por ello, como alternativa a las limitaciones indicadas anteriormente, surge la tecnología UWB, la cual es utilizada para identificar el posicionamiento de los jugadores en instalaciones cubiertas. Dado que el baloncesto se juega a cubierto, se necesita de esta tecnología para conocer la actividad que realizan los jugadores, no pudiéndose utilizar los GPS ya que no podrían conectarse a la señal del satélite (Rico-González et al., 2020). En resumen, la tecnología que posibilita el registro de las demandas físicas de los jugadores de baloncesto son los sistemas de *tracking*, los acelerómetros y la tecnología UWB. En función de las posibilidades de los cuerpos técnicos se empleará tal tecnología siendo conocedores de sus fortalezas y sus limitaciones.

Además de los requisitos a nivel físico ya mencionados que demanda el baloncesto, es importante conocer las respuestas fisiológicas para comprender el estrés general impuesto a los jugadores de baloncesto durante el partido, es decir, las respuestas originadas en el organismo ante los estímulos propuestos (Fox et al., 2017; Impellizzeri et al., 2018; Mujika, 2013). La concentración de lactato en sangre y la FC se han medido con frecuencia como respuestas fisiológicas en jugadores de baloncesto durante el partido (Ben Abdelkrim, Castagna, Jabri, et al., 2010; Ben Abdelkrim et al., 2007; McInnes et al., 1995; Rodríguez-Alonso et al., 2004; Scanlan et al., 2012). Las concentraciones elevadas de lactato en sangre sugieren que la glucólisis rápida hace una contribución importante a las necesidades energéticas del jugador, mientras que las respuestas de la frecuencia cardíaca proporcionan una indicación indirecta de la utilización de fuentes de energía predominantemente aeróbica (McInnes et al., 1995). En este contexto, se ha reportado que los jugadores de baloncesto registran concentraciones de lactato de 4-7 $mmol.L^{-1}$ a nivel nacional e internacional (Ben Abdelkrim et al., 2007; McInnes et al., 1995; Scanlan et al., 2012). Además, los estudios han mostrado que la FC relativa media registrada se estableció en un rango de 66,7 y 89,1% de la FC máxima registrada durante el tiempo total de juego y entre el 81,8 y el 94,6% de la FC máxima durante el tiempo de juego efectivo, lo que refleja las exigentes demandas impuestas al sistema cardiovascular de los jugadores de baloncesto (Ben Abdelkrim et al., 2007; Klusemann et al., 2013;

McInnes et al., 1995; Vaquera Jiménez et al., 2008). Es importante mencionar la cantidad de tiempo en que los jugadores transcurren por encima de ciertos valores de FC relativa, ya que son valores indicativos de esfuerzos de alta intensidad. La mayoría de los estudios (en Abdelkrim, Castagna, el Fazaa, et al., 2010; Vencúrik & Nykodým, 2015) reportaron que aproximadamente durante el 75% del tiempo de juego efectivo, los jugadores de baloncesto registraban un porcentaje de FC mayor al 85% de la FC máxima.

La mayor parte de las investigaciones que cuantifican las demandas físicas y fisiológicas han sido llevadas a cabo con jugadores senior (profesionales o amateurs) y con universitarios (Russell et al., 2021). Sin embargo, también sería interesante conocer las demandas en el baloncesto formativo (i.e., iniciación deportiva). Considerando las altas exigencias tanto de carga externa como de carga interna a las que están expuestos los jugadores durante la competición a nivel profesional y amateur, sería de gran interés para los preparadores físicos conocer las demandas del juego en baloncesto formativo de cara a prescribir estrategias de entrenamiento que ayuden a optimizar el proceso entrenamiento en estas poblaciones.

1.2.3 Condición física en baloncesto

Considerando las altas demandas físicas y fisiológicas a las cuales están sometidos los jugadores durante los partidos, se necesita un óptimo nivel de condición física para afrontar los partidos con garantías, es decir, ser competente en el juego retrasando la aparición de fatiga neuromuscular, así como reducir el riesgo de sufrir una lesión (Mancha-Triguero et al., 2019). Con el objetivo de conocer la influencia de la condición física en el rendimiento físico de los jugadores de baloncesto durante los partidos, Rodríguez-Fernández et al. (2021) realizaron un estudio con jugadores senior jóvenes y profesionales. Estos autores relacionaron diferentes test específicos de condición física (i.e., *lane agility drill*, esprint de 20 m, CMJ, DJ y test de esprint repetidos) con la carga externa registrada por estos jugadores durante dos partidos simulados (4 series de 7 min). Los resultados de este estudio mostraron que el tiempo en cubrir los 20 m a esprint y el salto con contra movimiento eran los test que más se asociaban de manera positiva con el rendimiento físico en partido, principalmente en variables como deceleraciones, máxima velocidad o distancia recorrida a esprint. Aunque serían necesarios más estudios, pero con diferentes poblaciones, Rodríguez-Fernández et al. (2021) extraen de sus resultados

la necesidad de llevar a cabo un entrenamiento de la condición física en baloncesto controlado, periodizado y planificado durante la temporada, para optimizar el rendimiento físico de los deportistas.

Por otro lado, el nivel de condición física parece influir en el nivel de los jugadores de baloncesto, mostrando un mejor rendimiento en las capacidades físicas básicas aquellos jugadores de mayor nivel competitivo (Ferioli et al., 2018). Además, estos autores concluyen que el nivel de condición física parece ser útil para la determinación del puesto específico de los jugadores y como herramienta para la identificación del talento, teniendo esto gran relevancia en el baloncesto formativo (i.e., iniciación deportiva). En este sentido, autores como Mancha-Triguero et al. (2021) han mostrado que los jugadores de baloncesto masculino de mayor edad (sub-18) presentaron unos niveles de condición física mejores respecto a sus compañeros de menor edad (sub-16 y sub-14) en un test de esprints repetidos, en el test de salto *Abalakov* y en el test de multisaltos. Similares resultados se pueden observar en las jugadoras femeninas en los test de salto, siendo las jugadoras más jóvenes (sub-14) las que mostraron un mejor rendimiento en la capacidad de repetir esprint. Estos mismos autores observaron, atendiendo a las diferencias en función del sexo relativas a la condición física, que los jugadores masculinos obtuvieron mejores resultados en el test de salto simple (masculino: 32,6 ± 2,6 cm; femenino: 25,5 ± 4,0 cm) y repetido (masculino: 26,4 ± 5,8 cm; femenino: 20,7 ± 4,3 cm), mientras que las jugadoras femeninas presentaron un mejor rendimiento en la capacidad de repetir esprints (masculino: 14,1 ± 1,1 s; femenino: 13,8 ± 0,6 s) en relación a sus compañeros masculinos.

Por todo lo expuesto, parece fundamental que los jugadores jóvenes de baloncesto desarrollen un nivel de condición física óptimo durante su proceso formativo, siendo especialmente importante en los jugadores de baloncesto durante la adolescencia temprana (es decir, de 12 a 14 años de edad) los cuales experimentan cambios corporales drásticos, como aumentos repentinos de la estatura y masa corporal, así como alteraciones en el control motor (Faigenbaum et al., 2009). No obstante, y dada la evidencia limitada respecto a esta temática en jugadores de baloncesto, estudios futuros sobre este tema parecen necesarios para facilitar el proceso de entrenamiento en los jugadores de

baloncesto durante la adolescencia temprana para una progresión óptima dentro y fuera de las academias de baloncesto de élite.

1.2.4 Entrenamiento invisible

Con el objetivo de que los jugadores de baloncesto lleguen a la competición en óptimas condiciones para exhibir su máximo nivel, ya se ha comentado previamente que los deportistas requieren de una adecuada condición física (Mancha-Triguero et al., 2019). Sin embargo, esto no parece ser suficiente para alcanzar la excelencia, siendo necesario la aplicación y control del entrenamiento invisible. Este tiene como objetivo optimizar a corto y largo plazo el rendimiento del jugador (Mujika et al., 2018) a través de la aplicación de estrategias distintas al entrenamiento condicional, tales como la actividad física realizada durante el tiempo libre y los hábitos nutricionales, así como el nivel de descanso/recuperación (cuantificado, por ejemplo, a través de los niveles de estrés, fatiga, sueño y dolor muscular reportados por cada deportista antes del inicio de una sesión de entrenamiento o competición).

Una estrategia clave dentro de las que componen el entrenamiento invisible es la actividad física realizada fuera del entrenamiento y la competición deportiva regulada, respecto a la que conviene destacar que su principal beneficio probado es que puede desarrollar hábitos de vida saludables en los jugadores jóvenes de baloncesto (López Villalba et al., 2016). Atendiendo a los datos de actividad física registrados en adolescentes alemanes (n: 3505, edad: 12,0 ± 3,3 años) diferenciados en función del sexo, se puede observar que una mayor proporción de chicos realizaban actividad física durante su tiempo libre de diferente tipología y fuera del contexto de los clubes deportivos respecto a sus homólogas femeninas (52,6 vs 46,9%, p = 0,010) (Reimers et al., 2019). Del mismo modo, Barja-Fernández et al. (2020) observaron que los chicos realizaban significativamente más actividad física en el tiempo libre (por ejemplo, ejercicio aeróbico, ciclismo o balonmano) que las chicas (3,01 ± 0,84 vs 2,79 ± 0,75, p = 0,04) al estudiar a un amplio grupo de jóvenes adolescentes españoles (n: 662, edad: 12,4 ± 0,9 años). A pesar de estas tendencias en los hábitos de actividad física reportadas en los adolescentes europeos, no existen datos que demuestren diferencias en el nivel de práctica de actividad física entre sexos específicamente en jugadores jóvenes de baloncesto. Por lo tanto, es necesaria una investigación futura que compare los niveles de práctica de

actividad física durante el tiempo libre en función del sexo en jugadores de baloncesto para comprender mejor los comportamientos y el estilo de vida fuera del entrenamiento en estas poblaciones, con el objetivo de poder individualizar aún más los planes de entrenamiento durante el entrenamiento deportivo regulado.

Otra estrategia fundamental del entrenamiento invisible es la nutrición, la cual no solo es vital para un adecuado crecimiento y desarrollo de los niños y jóvenes, sino que también contribuye a conseguir una óptima recuperación tras el esfuerzo físico, a mejorar rendimiento deportivo y a reducir el riesgo de lesiones en los jóvenes deportistas (Jeukendrup & Cronin, 2010). Además, se ha observado que unos hábitos nutricionales adecuados también pueden incidir positivamente en aspectos psicológicos como el autoconcepto y la autoeficacia en deportistas jóvenes (Balsalobre et al., 2014; Zaccagni et al., 2020). Esto se debe principalmente a que unos hábitos de consumo adecuados se relacionan con una mejor composición corporal, la cual, a su vez, influye en las variables psicológicas previamente indicadas (Balsalobre et al., 2014). Por ello, conocer los hábitos nutricionales de los jugadores de baloncesto durante la adolescencia temprana, así como las diferencias en función del sexo en estos comportamientos, parece fundamental para la aplicación de estrategias de educación nutricional específicas y efectivas en jugadores jóvenes de baloncesto masculino y femenino. En este sentido, son varios los factores que pueden contribuir a los malos hábitos nutricionales en los deportistas jóvenes, incluida la falta de conocimiento nutricional. De hecho, Trakman et al. (2016) identificaron el conocimiento nutricional como un factor modificable clave de los hábitos alimentarios. En consecuencia, es importante comprender también el conocimiento nutricional y cualquier diferencia subyacente en el conocimiento basado en el sexo, para poder influir sobre los hábitos nutricionales en los jóvenes jugadores de baloncesto y desarrollar de manera satisfactoria las estrategias de educación nutricional específicas y adecuadas para optimizar sus hábitos nutricionales. Sin embargo, hasta la fecha ningún estudio ha explorado los hábitos nutricionales y el conocimiento nutricional diferenciando entre sexos en jóvenes jugadores de baloncesto.

La mayoría de estudios que tratan sobre la importancia de la nutrición de los deportistas de equipo están centradas en los efectos que la instauración de unas pautas dietéticas y el empleo de suplementos deportivos tienen sobre la salud y el rendimiento

de los deportistas (Castillo et al., 2019; Kondo et al., 2018; Paoli et al., 2015; Raya-González et al., 2020). Sin embargo, investigaciones actuales han mostrado datos prometedores con respecto a la eficacia de las estrategias de educación nutricional en los deportes de equipo (Tam et al., 2019). Las estrategias de educación nutricional son programas específicos diseñados para ayudar a las poblaciones objeto de estudio a modificar sus hábitos alimentarios y/o mejorar sus conocimientos sobre nutrición (Murimi et al., 2017). Estos efectos son particularmente relevantes para los atletas de deportes de equipo, ya que un mayor conocimiento sobre nutrición puede producir cambios positivos sustanciales en sus hábitos alimentarios (Tam et al., 2019), al mismo tiempo que, la mejora de los hábitos alimentarios, puede incidir en un mejor rendimiento deportivo (Bentley et al., 2020). Por lo tanto, las estrategias de educación nutricional parecen ser un elemento clave para optimizar el rendimiento de los atletas que practican estas modalidades. La mayoría de las investigaciones presentes en la literatura que examinan la efectividad de las estrategias de educación nutricional se han realizado teniendo en cuenta a atletas de deportes individuales, las cuales han mostrado resultados positivos tanto en la adherencia a la dieta como en su conocimiento nutricional (Philippou et al., 2017). Sin embargo, las investigaciones centradas en la aplicación de estrategias de educación nutricional en los deportes de equipo son más limitadas, ya que, en los deportes de equipo, con plantillas de entre 15 a 22 jugadores, cada jugador presenta unas necesidades nutricionales específicas (Martín-García et al., 2018). Aun así, las estrategias de educación nutricional se están aplicando cada vez más entre los deportistas de modalidades de equipo, ya que éstas se pueden implementar utilizando una amplia gama de recursos y herramientas (e.g., clases magistrales, aplicaciones informáticas o juegos) que permiten trabajar de manera individual sobre los requerimientos nutricionales de los atletas (Anderson, 2010; Simpson et al., 2017; Wenzel et al., 2012). Entre las diferentes herramientas utilizadas se incluyen entrevistas personales y registros alimentarios (Valliant et al., 2012), actividades grupales y talleres interactivos (Patton-Lopez et al., 2018), empleo de libros ilustrados (Zeng et al., 2020), actividades impartidas por un equipo multidisciplinar formado por psicólogos y nutricionistas (Daniel et al., 2016) y el uso de plataformas tecnológicas (Abood et al., 2004). Sin embargo, es necesario analizar específicamente la efectividad de cada herramienta empleada en las estrategias de educación nutricional para identificar el enfoque más apropiado para cada colectivo o grupo diana.

Particularmente, Valliant et al. (2012) en su intervención aplicaron una estrategia de educación nutricional basada en sesiones presenciales individualizadas que mejoraron tanto el conocimiento nutricional y los hábitos alimentarios de las jugadoras de voleibol participantes en el estudio, así como el porcentaje de masa libre de grasa y de grasa corporal. Por otro lado, Zeng et al. (2020) consiguieron una mejora del conocimiento nutricional de los jugadores de voleibol participantes a través del empleo de libros ilustrados. En la misma línea, Shoemaker et al. (2019) lograron mejoras significativas en el rendimiento físico (i.e., salto vertical, salto horizontal, prueba de agilidad y fuerza del tren superior) de los jugadores de deportes de equipo participantes, después de la aplicación de un programa de educación de nutrición deportiva en línea. A pesar de los probados beneficios que aporta la aplicación de este tipo de programas en los deportes de equipo, hasta la fecha, solo se ha realizado un estudio con jugadores de baloncesto, aunque en este estudio también participaron jugadores de voleibol (Kavouras et al., 2012). Todos estos aspectos hacen que sea necesario la realización de futuras investigaciones en este ámbito, ya que, este tipo de programas y/o intervenciones podrían aportar información relevante a los cuerpos técnicos de los equipos sobre las necesidades de la población objeto de estudio, para optimizar el proceso de formación y mejorar su rendimiento deportivo.

Dado que las estrategias de educación nutricional en los deportes de equipo pueden beneficiar el conocimiento nutricional y los hábitos alimentarios de los atletas y, a su vez, el rendimiento deportivo (Elias et al., 2018), parece esencial recopilar la literatura existente sobre este tema para comprender la eficacia que las diferentes estrategias tienen en la mejora de los hábitos alimentarios de los atletas de los deportes de equipo. En este sentido, una revisión sistemática previa (Bentley et al., 2020) analizó la influencia de las estrategias de educación nutricional en los hábitos alimentarios de los participantes, y la mayoría de los estudios que se incluyeron (13 de 16 estudios) mostraron cambios positivos en el comportamiento dietético de los atletas pertenecientes a los veinticinco deportes individuales y de equipo analizados. Además, la evidencia meta-analítica (Tam et al., 2019) mostró que la mayoría de las estrategias de educación nutricional (85,7%) aumentaron significativamente el conocimiento nutricional que los deportistas presentaban antes de llevar a cabo la intervención, y más concretamente que, aquellas

sesiones que se llevaron a cabo de manera presencial, fueron las que tuvieron una mayor efectividad tanto en la instauración de nuevos patrones alimentarios como en la mejora del conocimiento nutricional inicial de los participantes (28 de 36 estudios). Por ello, debido a las grandes relaciones que los comportamientos dietéticos y el conocimiento sobre nutrición tienen sobre la composición corporal y el rendimiento físico (Beck et al., 2015; Burke et al., 2019; Esco et al., 2018), muchos estudios han examinado los efectos de las estrategias de educación nutricional sobre la composición corporal (Anderson, 2010; Valliant et al., 2012; Wenzel et al., 2012) y los indicadores de rendimiento (Kavouras et al., 2012; Rossi et al., 2017; Shoemaker et al., 2019). En cuanto a la composición corporal, Nascimento et al. (2016) indicaron que, dentro de la estrategia nutricional aplicada, el consejo dietético ofrecido por los nutricionistas a los participantes del estudio, en este caso atletas adolescentes y adultos de deportes individuales, resultaron eficaces, obteniendo un aumento de la masa corporal magra en ambos grupos después de la intervención (pre-intervención = 48,0 1,2 kg vs. intervención = 49,2 1,6 kg; $p < 0,05$). En cuanto al rendimiento físico, Rossi et al. (2017) informaron una mejora en la velocidad en el cambio de dirección (cambio = 0,15 - 0,13 s; $p < 0,001$) y altura del salto vertical (cambio = 6,6 - 9,4 cm; $p < 0,001$) en jugadores de béisbol universitarios después de la aplicación de una estrategia de educación nutricional que incluyó sesiones informativas de 90 min centradas en la comida, su preparación, composición nutricional y hábitos alimentarios saludables, durante 12 semanas. Aunque varias revisiones sistemáticas han explorado la efectividad de las intervenciones educativas sobre los comportamientos dietéticos y el conocimiento nutricional (Bentley et al., 2020; Tam et al., 2019), ninguna revisión sistemática se ha centrado explícitamente en los atletas de deportes de equipo en esta área, ni ha examinado la efectividad de las intervenciones de educación nutricional en los indicadores de rendimiento en dicha población.

1.2.5 Programas de entrenamiento

Estudios previos han mostrado la eficacia de diferentes programas complementarios al entrenamiento diario sobre la condición física de los jóvenes jugadores de baloncesto, principalmente aquellos basados en el entrenamiento interválico de alta intensidad, en el entrenamiento sobre la capacidad de repetir esprint o programas de entrenamiento de fuerza/potencia (Gonzalo-Skok et al., 2016; Padulo et al., 2016; Zeng et al., 2021). En este sentido, Gonzalo-Skok et al. (2019) aplicaron dos programas diferentes de

entrenamiento pliométrico en jugadores jóvenes de baloncesto durante 6 semanas (2 veces a la semana). Estos autores observaron que ambos programas eran efectivos en la mejora del tiempo de esprint y la agilidad. Del mismo modo, Zeng et al. (2021) mostraron mejoras en la resistencia específica, en la capacidad de repetir esprint y en la agilidad de jugadoras jóvenes de baloncesto tras la aplicación de un protocolo basado en un entrenamiento interválico de alta intensidad (4 semanas; 3 veces a la semana). Finalmente, Gonzalo-Skok et al. (2016) obtuvieron mejoras en la capacidad de repetir esprint y en el cambio de dirección de jugadores jóvenes de baloncesto tras la realización de un programa de entrenamiento de fuerza (habilidad para repetir potencia; 6 semanas; 2 veces a la semana). A pesar de los prometedores resultados observados en estudios previos, al diseñar o seleccionar dichos programas se deben considerar las características específicas de los deportes de equipo (e.g., calendario congestionado o alto número de partidos oficiales) (Wing, 2018).

Una opción viable para solventar los problemas previamente detectados podría ser el programa FIFA 11+, el cual ha mostrado una gran aplicabilidad en contextos específicos de deportistas de deportes de equipo (al Attar & Alshehri, 2019; Lopes et al., 2020). Específicamente, FIFA 11+ es un programa multi-ejercicio desarrollado inicialmente por el Centro de Investigación y Evaluación Médica (F-MARC) de la Federación Internacional de Fútbol Asociado (FIFA) para hacer más accesibles los programas de prevención de lesiones y rendimiento a los deportistas de diferentes niveles, principalmente futbolistas (Dvorak, 2005). Investigaciones anteriores han mostrado efectos positivos tras la aplicación de este programa tanto en el rendimiento como en la prevención de lesiones en poblaciones de deportes de equipo (Nawed et al., 2018; Nuhu et al., 2021), tales como fútbol y baloncesto (Longo et al., 2012). Específicamente, Nawed et al. (2018) aplicaron el programa FIFA 11+ en futbolistas amateur durante 12 semanas obteniendo mejoras en su capacidad de salto vertical y esprint. Por otro lado, Junge et al. (2002) aplicaron durante dos temporadas los ejercicios del programa FIFA 11+ en jugadores de fútbol amateurs y observaron un descenso del número de lesiones en un 20% así como una disminución del porcentaje de lesión/jugador del 36% tras el periodo de intervención. A pesar de esto, las referencias relativas a jugadores de baloncesto son escasas. Al respecto, solo se ha realizado un estudio (Longo et al., 2012) con jóvenes jugadores de baloncesto, que demuestra que el programa FIFA 11+ es eficaz para reducir

la incidencia lesional de esta población. Dado que los estudios previos basados en este programa han mostrado resultados prometedores y permite su aplicación como calentamiento previo a cualquier sesión de entrenamiento sin interferir con el contenido posterior, parece oportuno analizar sus efectos en los jugadores jóvenes de baloncesto.

1.3. OBJETIVOS E HIPÓTESIS

1.3. OBJETIVOS E HIPÓTESIS

Los principales objetivos de esta tesis doctoral fueron:

- Objetivo 1: Conocer y comparar el rendimiento físico, la actividad física realizada fuera del ámbito deportivo, los hábitos nutricionales y el conocimiento nutricional atendiendo al sexo en jugadores de baloncesto jóvenes.
    - Hipótesis 1: En base a los hallazgos de estudios previos que examinaron a jugadores de baloncesto sub-14 (Mancha-Triguero et al., 2021) y estudiantes durante la adolescencia temprana (Reimers et al., 2019), se plantea la hipótesis de que los jugadores masculinos sub-14 poseerán una mejor condición física y realizarían más actividad física fuera del entrenamiento regular que sus compañeras femeninas, las cuales tendrían mejores hábitos y mayor conocimiento nutricional que los jugadores de baloncesto masculinos.

Objetivo 1 abordado en: Sánchez-Díaz, S., Yanci, J., Raya-González, J., Scanlan, A.T., & Castillo, D. (2021). A comparison in physical fitness attributes, physical activity behaviors, nutritional habits, and nutritional knowledge between elite male and female youth basketball players. Frontiers in Psychology, 12. https://doi.org/10.3389/fpsyg.2021.685203

- Objetivo 2: Conocer y analizar los efectos de las estrategias de educación nutricional sobre los hábitos de consumo alimentario, el conocimiento nutricional, los parámetros relativos a la composición corporal (i.e., % de grasa corporal y % de masa muscular) y el rendimiento físico en deportistas de deportes de equipo.
    - Hipótesis 2: Atendiendo a la literatura encontrada y la heterogeneidad de los estudios incluidos con respecto a la modalidad deportiva, el nivel competitivo, la edad y el sexo de los deportistas implicados en las investigaciones, así como el tipo de intervención adoptado (es decir, en línea o presencial), no se prevé un claro consenso que permita establecer intervenciones de educación nutricional óptimas para cada variable analizada.

Objetivo 2 abordado en: Sánchez-Díaz, S., Yanci, J., Castillo, D., Scanlan, A.T., & Raya-González, J. (2020). Effects of nutrition education interventions in team sport players. a systematic review. *Nutrients, 12*(12), 3664. https://doi.org/10.3390/nu12123664

- Objetivo 3: Analizar los efectos del programa de entrenamiento FIFA 11+ combinado con un programa de educación nutricional sobre los hábitos de consumo alimentario, el conocimiento nutricional y el rendimiento físico en jugadores jóvenes de baloncesto.
    - Hipótesis 3: Tras lo observado en estudios previos (Nawed et al., 2018; Rossi et al., 2017), planteamos la hipótesis de que, tras la aplicación de este programa, los jugadores de baloncesto mejorarán sus hábitos alimentarios, conocimientos nutricionales y rendimiento deportivo.

Objetivo 3 abordado en: Sánchez-Díaz, S., Raya-González, J., Yanci, J., & Castillo, D. *(In press).* The influence of nutrition education intervention combined with FIFA 11+ program on physical fitness attributes, physical activity behaviours, eating habits and nutritional knowledge in young basketball players. *European Journal of Human Movement*.

1.4. RESULTADOS Y DISCUSIÓN

1.4. RESUMEN DE RESULTADOS Y DISCUSIÓN

Primera investigación

Sánchez-Díaz, S., Yanci, J., Raya-González, J., Scanlan, A.T., & Castillo, D. (2021). A comparison in physical fitness attributes, physical activity behaviors, nutritional habits, and nutritional knowledge between elite male and female youth basketball players. Frontiers in Psychology, 12. https://doi.org/10.3389/fpsyg.2021.685203

Los resultados obtenidos en este estudio indican que, de entre los participantes, los jugadores de baloncesto sub-14 masculinos presentan mejores resultados en las diferentes pruebas físicas realizadas al compararlos con los resultados obtenidos por las jugadoras sub-14 del equipo femenino, es decir, presentan una condición física mejor que las jugadoras de baloncesto femenino (test de salto vertical [CMJ y DJ], test de esprint en línea recta, test de cambio de dirección y test de esprint repetidos con cambio de dirección). Por otro lado, existen diferencias significativas en los resultados del cuestionario sobre el nivel de actividad física realizada fuera del entrenamiento regular en función del sexo. Las respuestas de los jugadores del equipo masculino indicaron que realizaban una mayor práctica de actividad física que las jugadoras del equipo femenino ($p = 0.036$). En cambio, los resultados referentes al cuestionario dietético, donde se planteaban cuestiones sobre el conocimiento nutricional y la frecuencia de consumo de los distintos grupos de alimentos, no mostraron diferencias significativas entre los jugadores masculinos y femeninos. Si bien, cabe destacar que, en las respuestas dadas sobre la frecuencia de consumo de frutas y verduras, una alta proporción de jugadores y jugadoras indicaban no incluir nunca o solo a veces este tipo de alimentos en su dieta diaria. Finalmente, en las cuestiones referentes a conceptos nutricionales donde se valoraba el conocimiento que los participantes tenían sobre alimentación, más de la mitad de la muestra no seleccionó la respuesta correcta.

Los resultados obtenidos en este estudio parecen apoyar lo que otros estudios han mostrado previamente. Los jugadores de sexo masculino sub-14 presentaron una mejor aptitud física en pruebas de rendimiento físico. Esto parece que es debido a que esta franja de edad coincide con la etapa puberal, donde el reparto de masa libre de grasa difiere entre las jugadoras femeninas y los jugadores masculinos, lo que influye de manera directa en el rendimiento físico. Por ello, conocer este aspecto puede ayudar a optimizar

los entrenamientos con el fin de mejorar el rendimiento deportivo de los jugadores y jugadoras de esta edad.

En cuanto a la frecuencia de realización de actividad física en el tiempo libre, hubo diferencias significativas en cuanto a la frecuencia con la que se realizaba, siendo los jugadores masculinos sub-14, los que destinaban mayor parte de su tiempo libre a la práctica deportiva. Sin embargo, el pertenecer a un club deportivo, podría ayudar en gran medida a equiparar esa frecuencia por parte de las jugadoras femeninas sub-14.

Por último, destacar que este es el primer estudio que analiza el patrón alimentario de adolescentes deportistas en etapa puberal temprana. Aunque no se han observado diferencias significativas entre sexos en sus hábitos alimentarios, cabe destacar que el 30% de la muestra indicó que nunca o solo a veces come fruta y el 57% de la muestra que nunca o solo a veces come verdura. Teniendo en cuenta que la Organización Mundial de la Salud (OMS) recomienda el consumo de frutas y verduras 5 veces al día para tener un estilo de vida saludable y evitar la aparición de enfermedades crónicas como la diabetes, el sobrepeso o la obesidad entre otras, resulta preocupante, desde el punto de vista de la salud, un consumo prácticamente nulo de estos dos grupos de alimentos. En cuanto al rendimiento deportivo, el incluir frutas y verduras de manera diaria en la alimentación ayuda a la mejora de la composición corporal de los jugadores y jugadoras de baloncesto, ya que disminuye el consumo de otros alimentos de un peor valor nutricional, como, por ejemplo, los alimentos ricos en azúcares y grasas. Esto, además, tiene influencia directa en la disminución de la aparición, a la larga, de enfermedades crónicas asociadas como son el sobrepeso o la diabetes ya mencionadas. Por todo ello, se hace necesaria la aplicación de estrategias de educación nutricional.

Las limitaciones encontradas en este estudio están relacionadas con un tamaño muestral reducido, la participación de jugadores sub-14 de un solo club deportivo, así como la valoración en un solo momento de la temporada. Estos aspectos, impidieron conocer la evolución de la condición física y de los hábitos alimentarios de los participantes en diferentes etapas de la misma.

Segunda investigación

Sánchez-Díaz, S., Yanci, J., Castillo, D., Scanlan, A.T., & Raya-González, J. (2020). Effects of nutrition education interventions in team sport players. a systematic review. *Nutrients, 12*(12), 3664. https://doi.org/10.3390/nu12123664

En la revisión sistemática llevada a cabo se analizó el impacto que las intervenciones de educación nutricional tienen sobre los hábitos alimentarios, el conocimiento nutricional, la composición corporal y rendimiento deportivo en atletas de diferentes deportes de equipo (voleibol, balonmano, fútbol, hockey, baloncesto, etc.). Pese a la disparidad de la población diana, estrategias nutricionales y deportes sobre los que se llevaron a cabo, en la mayoría de los estudios incluidos en la revisión sistemática se concluyó que la implementación de estrategias de educación nutricional dentro de la planificación deportiva de los atletas tuvo efectos positivos en alguna de las variables mencionadas.

Con respecto a los hábitos alimentarios, conviene destacar que se vieron modificadas algunas conductas o comportamientos erróneos por parte de los participantes, lo que dio lugar a una mejora de sus hábitos alimentarios, así como un aumento de interés por conocer los alimentos que deberían incluir en la dieta para mejorar el rendimiento deportivo. También se corroboró que las estrategias educativas implementadas aumentaron el conocimiento sobre nutrición, lo que derivó en una mejora tanto del patrón alimentario como de la composición corporal de los atletas participantes. Esto último, resulta beneficioso ya que puede incidir en una disminución del riesgo lesivo de los deportistas además de mantener una buena condición física en las diferentes fases o etapas de la temporada competitiva. Y en cuanto al rendimiento, destacar que, dentro de la preparación para la competición, las estrategias de educación nutricional pueden optimizar la preparación física de los atletas y mitigar la fatiga y posibles lesiones derivadas. Aunque la disparidad de deportistas incluidos en cada estudio hizo que los resultados obtenidos fueran bastante heterogéneos y pese a haberse encontrado mejoras en cada uno de ellos, se necesita una mayor evidencia para verificar la eficacia que los hábitos alimentarios tendrían sobre la mejora del rendimiento físico de los atletas de deportes de equipo.

Tercera investigación

Sánchez-Díaz, S., Raya-González, J., Yanci, J., & Castillo, D. (In press). The influence of nutrition education intervention combined with FIFA 11+ program on physical fitness attributes, physical activity behaviours, eating habits and nutritional knowledge in young basketball players. *European Journal of Human Movement*. https://www.eurjhm.com/index.php/eurjhm/article/view/708

La implementación de estrategias de educación nutricional combinadas con el programa FIFA 11+ mejoraron la condición física de los jugadores masculinos y femeninos de baloncesto sub-14 y mantuvieron constantes los hábitos alimentarios de los participantes. Si bien, otros estudios previos analizaron la combinación de estas estrategias y los resultados obtenidos no fueron concluyentes. Las puntuaciones finales del cuestionario de actividad física realizada en el tiempo libre mejoraron con respecto al inicio de la intervención, siendo esto un indicador de que los conocimientos aportados durante las diferentes sesiones podrían influir en los comportamientos de los participantes, es decir, en llevar a cabo unos hábitos de vida saludables.

En cuanto a los hábitos alimentarios, los resultados no mostraron cambios significativos al finalizar la intervención si bien se evidenció que los resultados referentes a los hábitos de consumo alimentario y nutricional declarados por los jugadores y jugadoras no empeoraron. Del mismo modo, estos resultados coinciden con aquellos encontrados en otros estudios previos, algo que se puede atribuir a la duración, modalidad y frecuencia de las intervenciones llevadas a cabo. Por ello, sería interesante, teniendo en cuenta la edad del grupo de intervención, hacer partícipe a los padres/tutores de los participantes ya que son ellos los encargados de llevar a cabo todas las tareas relacionadas con la elección y preparación de las distintas ingestas. Una mejora del conocimiento nutricional podría traducirse en una dieta sana, variada y equilibrada.

Las principales limitaciones estarían enfocadas al tamaño de la muestra, ya que solamente participaron en la intervención los jugadores sub-14 pertenecientes a un único club. Además, este estudio fue realizado con un solo grupo de intervención, por ello, sería interesante replicarlo mediante un diseño que implique dos grupos de intervención (grupo experimental y grupo control). Por último, sería adecuado analizar el efecto de las

estrategias de educación nutricional y el FIFA 11+ sobre el rendimiento en partidos simulados, y no solo sobre el rendimiento en test de condición física.

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SECCIÓN 2

2.1. CONCLUSIONES

2.1. CONCLUSIONES

Las investigaciones incluidas en la presente Tesis Doctoral proporcionan información de interés para la mejora de la calidad de vida y el rendimiento de los jugadores y jugadoras jóvenes de baloncesto. En primer lugar, en términos de estado nutricional y rendimiento, este trabajo ha permitido constatar diferencias en el nivel de condición física y actividad física realizada en el tiempo de ocio por parte de los jugadores del equipo masculino respecto a sus compañeras del equipo femenino, aunque sin diferencias significativas al analizar el conocimiento nutricional y los hábitos de consumo.

Por otro lado, se ha observado que, a pesar de que la gran mayoría de las estrategias de educación nutricional aplicadas en deportistas de equipos han obtenido resultados positivos en alguna de las variables analizadas (i.e., hábitos de consumo, conocimiento nutricional, composición corporal y condición física), no es posible extraer conclusiones sólidas sobre su efectividad. Esto se debe a que los estudios incluidos en la literatura presentan una gran heterogeneidad en cuanto a muestra, modalidad deportiva, variables analizadas y tipo de estrategia nutricional aplicada. Esto, además, dificulta la elección de un método como el más efectivo, por lo que se recomienda la individualización en función de los objetivos perseguidos.

Por último, se ha demostrado que la combinación de estrategias de educación nutricional basadas en talleres y juegos, aplicadas en combinación con el programa FIFA 11+ son efectivas para la mejora de la condición física y el nivel de actividad física en el tiempo de ocio. Además, parece ser una estrategia adecuada para mantener unos niveles adecuados de consumo alimentario.

Con los resultados obtenidos en la primera investigación se pueden extraer las siguientes conclusiones, derivadas de los resultados obtenidos:

1. Los jugadores de baloncesto masculino sub-14 de élite tenían una mayor condición física y realizaban más actividad física durante el tiempo libre en comparación con las jugadoras femeninas sub-14.
2. Mientras que los hábitos nutricionales y el conocimiento nutricional fueron similares entre sexos, los jugadores de ambos sexos exhibieron un bajo

consumo de frutas y verduras, así como un conocimiento nutricional relativamente bajo.

3. Se recomienda la aplicación de estrategias de educación nutricional para mejorar los conocimientos nutricionales de los jugadores de baloncesto de élite en la adolescencia temprana.

De la segunda investigación se desprenden las siguientes conclusiones por los resultados obtenidos:

1. Las estrategias de educación nutricional son efectivas para la mejora y mantenimiento de los hábitos de consumo, el conocimiento nutricional y la composición corporal de los deportistas que participan en modalidades de equipo cuando se aplican de manera regular en sus rutinas de entrenamiento.
2. Aunque se han observado mejoras en el rendimiento físico, el hecho de que haya escasos estudios sobre la temática sugiere la necesidad de seguir investigando sobre ello.
3. Considerando la heterogeneidad observada entre los estudios incluidos en esta investigación con respecto a las características de la muestra (e.g., modalidad deportiva, nivel, edad y sexo) y estrategias de intervención aplicadas (e.g., modalidad, frecuencia y duración) es difícil establecer una estrategia de educación nutricional óptima. Más bien, se recomienda la individualización en función de los objetivos perseguidos.

Las conclusiones alcanzadas con los resultados obtenidos en la tercera investigación son las siguientes:

1. La aplicación de un programa de educación nutricional combinado con el programa FIFA 11+ durante 5 meses es efectivo para la mejora de la condición física y el nivel de actividad física realizada en el tiempo libre en jugadores de baloncesto jóvenes.
2. Además, esta estrategia mostró que durante el tiempo que duró la intervención no empeoraron los hábitos alimentarios y nutricionales en esta población, consiguiendo que se mantuvieran estables.

2.2. APLICACIONES PRÁCTICAS

2.2. APLICACIONES PRÁCTICAS

El objetivo general de las tres investigaciones que componen esta Tesis Doctoral es aportar información útil para la mejora del rendimiento y la calidad de vida en jugadores de baloncesto jóvenes. Las conclusiones previamente presentadas sobre los hechos observados y estudiados tienen como fin la aplicación al propio proceso de entrenamiento, para así poder obtener mejores resultados en la competición. En este sentido, un logro fundamental de los investigadores de las Ciencias del Deporte es identificar las deficiencias en la práctica y solventarlas a través del método científico.

Gracias a las conclusiones obtenidas en el presente trabajo las aplicaciones prácticas son numerosas y entre ellas destacan las siguientes:

1. Dado que existen diferencias entre sexos en cuanto a condición física y actividad física realizada en lo que a tiempo libre se refiere, se sugiere la individualización de los estímulos de entrenamiento aplicados en jugadores jóvenes de baloncesto para optimizar la preparación de cada grupo (e.g., masculino o femenino).
2. De manera general, se recomienda incluir diferentes estrategias de educación nutricional dentro del proceso de entrenamiento de los deportistas que participan en las diferentes modalidades de deportes de equipo.
3. Estas estrategias de educación nutricional se deben aplicar de manera individualizada y específica a la modalidad deportiva con la que se va a trabajar y atendiendo a las variables sobre las que se quiere intervenir.
4. Dado que el consumo reportado de frutas y verduras es muy bajo entre jóvenes jugadores de baloncesto, se recomienda la aplicación temprana de estrategias de educación nutricional con el fin de mejorar los hábitos de consumo en esta población.
5. Se debe implementar la inclusión de estrategias de educación nutricional combinadas con el programa FIFA 11+ en las academias de baloncesto, no solo para mejorar el rendimiento de los jugadores, sino también para mejorar su calidad de vida en términos de conductas de actividad física realizada durante el tiempo libre.
6. También se recomienda aplicar las estrategias de educación nutricional combinadas con el programa FIFA 11+ en las academias de baloncesto para

mantener los hábitos de consumo alimentario identificados previamente como saludables.

2.3. LIMITACIONES

2.3. LIMITACIONES

Las investigaciones científicas desarrolladas en esta Tesis Doctoral, aunque cumplen con el protocolo de investigación científica, no están exentas de limitaciones. El hecho de que los estudios sean diferentes metodológicamente hablando, hace que cada uno presente unas limitaciones específicas.

En la primera investigación, conviene destacar como limitación principal que se reclutaron únicamente a jugadores pertenecientes a una academia de baloncesto de élite, y se utilizó un tamaño de muestra relativamente pequeño en cada grupo (hombres y mujeres). Por otro lado, los datos se obtuvieron en un solo momento de la temporada por lo que no permitió conocer los cambios en la condición física, los comportamientos de actividad física o los patrones alimentarios de los jugadores a lo largo de la temporada. Finalmente, conviene destacar que el análisis de los hábitos alimentarios se limitó a patrones amplios de conductas dietéticas, mientras que una mayor comprensión del gasto energético diario y la ingesta de macronutrientes permitiría una visión más detallada para desarrollar estrategias integrales en la intervención de educación nutricional que promuevan hábitos nutricionales saludables en jugadores de baloncesto adolescentes.

En consonancia con la segunda investigación, se muestra la dificultad para establecer un consenso definitivo con respecto a las estrategias específicas de educación nutricional que son más efectivas para mejorar los hábitos alimentarios, el conocimiento nutricional, la composición corporal y el rendimiento físico, considerando el amplio rango de deportistas examinados a través de los estudios incluidos, los cuales abarcan diferentes deportes, edades, niveles de competencia y culturas. Otra limitación de esta investigación es la reducida muestra de deportistas reclutados en algunos de los estudios incluidos en la revisión realizada, algo que debe tenerse en cuenta al interpretar los hallazgos que indican la efectividad de las estrategias de educación nutricional en atletas de deportes de equipo en la literatura. Para finalizar, el número de actividades, talleres y/o herramientas incluidos en las estrategias de educación nutricional con intención de mejorar el rendimiento deportivo son muy escasos.

Por último, en la tercera investigación se observa como limitación principal el tamaño de la muestra reclutada en el estudio, ya que solo los jugadores de baloncesto sub-14

participaron en el estudio. Además, el estudio se realizó con un solo grupo experimental (diseño con un solo grupo de intervención), por lo que la inclusión de diseños experimentales que incluyan dos grupos de intervención (un grupo experimental y un grupo control) habría sido de gran interés para comparar los resultados obtenidos. Finalmente, y dado que la condición física ha sido evaluada únicamente a través de pruebas específicas, sería adecuado analizar el rendimiento en el juego durante partidos de baloncesto controlando los factores contextuales.

2.4. FUTURAS LÍNEAS DE INVESTIGACIÓN

2.4. FUTURAS LÍNEAS DE INVESTIGACIÓN

Las investigaciones desarrolladas en esta tesis doctoral van encaminadas a optimizar el rendimiento y la calidad de vida de jugadores jóvenes de baloncesto, con el firme propósito de perfeccionar el proceso de entrenamiento en este deporte, mejorando los resultados en la competición y preservando la salud de los jugadores de baloncesto.

Por ello, el trabajo desempeñado hasta el momento no debe detenerse aquí. Los resultados obtenidos en las distintas investigaciones abren las puertas a posteriores trabajos en torno a la implementación de estrategias de educación nutricional en el deporte formativo. Por tanto, se proponen las siguientes líneas de investigación:

1. La investigación futura debería ampliar las variables de composición corporal disponibles y explorar los efectos de las estrategias de educación nutricional en otras variables, como, por ejemplo, el contenido mineral óseo.
2. Se recomienda analizar las variables nutricionales (e.g., conocimiento nutricional y hábitos alimentarios) en muestras mayores que un solo club, incluyendo jugadores de baloncesto de diferentes niveles.
3. Futuras investigaciones deben contemplar la valoración de la condición física y las evaluaciones a través de cuestionarios en diferentes momentos de la temporada para comprender los cambios temporales en la condición física, los comportamientos de actividad física en el tiempo de ocio y los hábitos nutricionales, con el objetivo de implementar estrategias específicas en diferentes fases a lo largo de la temporada competitiva.
4. Se recomienda realizar futuros estudios que analicen las posibles diferencias entre sexos en relación a los efectos de las estrategias de educación nutricional combinadas con el programa de entrenamiento de FIFA 11+.
5. También sería interesante conocer los efectos de las estrategias de educación nutricional combinadas con el programa de entrenamiento de FIFA 11+ a través de diseños experimentales que incluyan dos grupos de intervención, para comparar los resultados obtenidos con un grupo control.
6. Por último, sería adecuado realizar un estudio futuro donde se busquen las relaciones entre la condición física valorada a través de test físicos y el rendimiento en partidos de competición, en diferentes momentos de la temporada.

SECCIÓN 3

3.1. TRABAJOS PUBLICADOS

3.1. TRABAJOS PUBLICADOS

3.1.1 Primera investigación

frontiers in Psychology

ORIGINAL RESEARCH
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A Comparison in Physical Fitness Attributes, Physical Activity Behaviors, Nutritional Habits, and Nutritional Knowledge Between Elite Male and Female Youth Basketball Players

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Background: Limited evidence exists comprehensively assessing physical fitness attributes, physical activity behaviors, nutritional habits, and nutritional knowledge according to sex in basketball players during early adolescence. Insight of this nature could be used to optimize the training process and lifestyles in young basketball players.

Objective: To compare physical fitness attributes, physical activity levels, nutritional habits, and nutritional knowledge between elite male and female basketball players under 14 years of age (U-14).

Methods: Twenty-three U-14 basketball players (male, $n = 13$ and female, $n = 10$) from the same elite basketball academy (Spanish Asociación de Clubes de Baloncesto [ACB] League) participated in this study. Physical fitness attributes were assessed using a basketball-specific test battery (countermovement jump, drop jump, linear sprint, Lane Agility Drill, 505 change-of-direction, and repeated-change-of-direction tests), while physical activity levels (Physical Activity Questionnaire for Adolescents, PAQ-A), nutritional habits (Turconi questionnaire), and nutritional knowledge (Turconi questionnaire) were assessed using questionnaires.

Results: Male players exhibited better physical fitness in all tests ($p < 0.001$ to 0.036, effect size = −0.44 to −0.76, intermediate to strong) compared to female players. Male players also performed more physical activity in their leisure time ($p = 0.036$) than females. No significant differences in nutritional habits and nutritional knowledge were evident between sexes ($p > 0.05$). Of note, a high proportion of players declared never or only sometimes eating fruit (males: 23%; females: 40%) and vegetables (males: 46%; females: 70%). In addition, relatively poor nutritional knowledge was evident in all players with the group correctly answering <50% of nutritional questions overall (4.57 ± 1.88 out of 11 points, 42%) and according to sex (males: 4.07 ± 2.10, 37%; females: 5.20 ± 1.40, 47%).

Conclusion: These findings emphasize the necessity to perform individualized prescription of training stimuli across sexes to optimize the physical preparedness and development of youth basketball players. Additionally, strategies such as nutrition-focused education interventions may be necessary in this population given the low consumption of fruits and vegetables, as well as the poor nutritional knowledge observed in players.

Keywords: team sports, eating, diet, performance, health, adolescent, gender

INTRODUCTION

Basketball is a highly demanding team sport, requiring players to adequately develop various physical fitness attributes for successful on-court performance (Castillo et al., 2021). In this sense, quantifying physical fitness attributes is important in the training process to detect deficits in players and consequently prescribe appropriate training strategies (Mancha-Triguero et al., 2019). Quantifying physical fitness attributes is especially important in basketball players during early adolescence (i.e., 12–14 years of age) who undergo dramatic body changes, such as sudden increases in height and body mass as well as alterations in motor control (Faigenbaum et al., 2009). Nevertheless, only one study has compared physical fitness attributes in basketball players under 14 years of age (U-14) according to sex. Specifically, Mancha-Triguero et al. (2021) observed that U-14 male basketball players who participated in the Spanish national championship performed better in single (male: 32.6 ± 2.6 cm; female: 25.5 ± 4.0 cm) and repeated (male: 26.4 ± 5.8 cm; female: 20.7 ± 4.3 cm) jumping tests while their U-14 female counterparts had better repeated-sprint ability (male: 14.1 ± 1.1 s; female: 13.8 ± 0.6 s). Given the limited evidence base to draw from, future studies on this topic seem necessary to facilitate the training process in basketball players during early adolescence for optimal progression into and across elite basketball academies.

Despite the known effect of training strategies on improving physical fitness in young basketball players (Schelling and Torres-Ronda, 2016), the importance of "invisible" training to optimize short- and long-term sports performance has also been highlighted (Mujika et al., 2018). "Invisible" training involves the application of strategies other than physical training, such as the physical activity performed during leisure time and nutritional habits (Mujika et al., 2018). In this sense, the physical activity performed outside of regulated sports training and competition can develop healthy lifestyle habits in young basketball players (López Villalba et al., 2016). Considering physical activity data recorded in German adolescents (*n*: 3,505, age: 12.0 ± 3.3 years) according to sex, a greater proportion of males have been shown to engage in self-reported physical activity in different domains outside the context of sports clubs (leisure-time physical activity outside of sports clubs, extracurricular physical activity and outdoor play) than females (52.6 vs. 46.9%, $p = 0.010$) (Reimers et al., 2019). Similarly, Barja-Fernández et al. (2020) observed males undertake significantly more leisure-time physical activity (e.g., aerobic, cycling, handball) than females (3.01 ± 0.84 vs. 2.79 ± 0.75, $p = 0.04$) among young Spanish adolescents (*n*: 662, age: 12.4 ± 0.9 years). Despite these trends in physical activity behaviors reported in European adolescents, no data exist demonstrating variations in physical activity between sexes specifically in young basketball players. Therefore, future research comparing physical activity levels during leisure time between sexes in U-14 basketball players are necessary to better understand lifestyle behaviors and further individualize training plans in this population.

Another fundamental aspect comprising "invisible" training is nutrition, which is not only vital for adequate growth and development, but also contributes to optimal recovery, performance, and injury risk in young athletes (Jeukendrup and Cronin, 2010). In addition, suitable nutritional habits can also positively affect psychological aspects such as self-concept and self-efficacy in young athletes (Balsalobre et al., 2014; Zaccagni et al., 2020). Thus, understanding the nutritional habits of basketball players during early adolescence, as well as sex-based differences in these behaviors, seems essential for the application of specific and effective nutritional strategies in young male and female basketball players. In this sense, several factors may contribute to poor nutritional habits in young athletes, including a lack of nutritional knowledge. In fact, Trakman et al. (2016) identified nutritional knowledge as a key modifiable determinant of dietary behaviors. Consequently, it is important to also understand the nutritional knowledge, and any underlying sex-based differences in knowledge, to explain nutritional habits in young basketball players and best inform specific intervention strategies to optimize their nutritional habits (e.g., nutrition education programs). However, no studies have explored nutritional habits and nutritional knowledge according to sex in young basketball players.

Given the importance of developing suitable fitness attributes and adopting appropriate activity and nutritional habits outside of training and competition in youth sports, it is essential to examine these aspects and quantify differences between males and females in young basketball players to best develop sex-specific training and lifestyle interventions in this population. Consequently, to address the gaps on this topic in youth basketball, this study aimed to quantify and compare physical fitness attributes, physical activity levels, nutritional habits, and nutritional knowledge between elite U-14 male and female basketball players. Based on findings in previous studies examining U-14 basketball players (Mancha-Triguero et al., 2021) and students during early adolescence (Reimers et al., 2019), we hypothesized that male U-14 players would possess

better physical fitness and perform more physical activity outside of regular training and competition than females, and that U-14 females would have better nutritional habits and knowledge than males.

METHODS

Study Design

A cross-sectional, observational study design was followed. In a single testing session, players had anthropometric measurements taken and completed a basketball-specific fitness test battery including jumping tests [countermovement jump (CMJ) and drop jump (DJ)], linear sprint tests, Lane Agility Drill test, 505 change-of-direction (COD) test, and repeated change-of-direction (RCOD) sprint test on an indoor basketball court (15–18°C, 60–70% relative humidity), with 5 min of passive, standing recovery applied between tests. Prior to testing, all players performed a standardized warm-up consisting of running at a moderate intensity for 5 min, followed by 5 min of jumps performed at progressively increasing intensities, 5 min of dynamic stretching exercises, and 3 min of 20-m running bouts performed at increasing intensities. Passive, standing recoveries were administered between efforts during the different warm-up tasks. All tests were carried out 3 days following official competition in the afternoon between 16:00 h and 19:00 h. Players were advised not to perform any physical exercise in the 2 days prior to testing and were given advice to ensure adequate hydration and nutritional status upon arrival for testing. Physical testing was conducted in groups of 3–4 players to ensure consistent recovery times could be administered between tasks across players during testing. Also, before physical testing, players completed questionnaires regarding physical activity behaviors, nutritional habits, and nutritional knowledge on their own and not in the presence of peers. Players were familiarized with the study protocol during training sessions across the month before the start of the study, including all physical fitness tests and questionnaires. Completion of the physical fitness testing and questionnaires took place during the same session during the in-season phase (October) of the 2020–2021 competitive season.

Participants

Twenty-three U-14 basketball players (male, $n = 13$, age: 13.5 ± 0.3 yr, height: 168.1 ± 6.7 cm, body mass: 56.6 ± 12.5 kg, body fat composition: 14.6 ± 5.2%, muscle composition: 37.4 ± 7.7%, training experience: 6.0 ± 3.1 yr; and female, $n = 10$, age: 12.7 ± 0.5 yr, height: 161.1 ± 4.7 cm, body mass: 52.1 ± 7.2 kg, body fat composition: 24.1 ± 5.5%, muscle composition: 33.9 ± 1.7%, training experience: 5.0 ± 2.1 yr) participated in this study. All players belonged to the same elite basketball academy (i.e., Spanish Asociación de Clubes de Baloncesto [ACB] League) being members of teams competing at the highest competitive level in Spain for the U-14 age category. Players were included in the study if they completed all fitness assessments and questionnaires and had not missed ≥4 weeks of participation continuously in training during the 2 months prior to testing. All players were not consuming any medications or ergogenic supplements that may have altered performance. All players were undertaking on-court team training consisting of games-based and conditioning drills three times per week with each session typically lasting 75–90 min, as well as participating in one official match per week when testing took place. All players and their legal guardians were informed of the procedures, potential risks, and benefits of participation in the study before giving written informed assent (players) and consent (guardians). The study was performed in accordance with the Declaration of Helsinki (World Medical Association Declaration of Helsinki, 2013) and approved by the Ethics Committee of the University (Code: FUi1-P007).

Physical Fitness Tests

Jumping Tests

Players performed two trials each of the CMJ and DJ to assess lower-limb power (Marshall and Moran, 2013). Each jump trial was separated by 45 s of passive, standing recovery. During CMJ trials, players were instructed to perform a downward movement followed by a complete, explosive extension of the lower-limbs, maintaining their hands on their hips while jumping as high as possible (Heishman et al., 2020). For DJ trials, players were instructed to step from a wooden box (30 cm high) and immediately following ground contact, jump for maximal height as quickly as possible (Marshall and Moran, 2013). A photocell system (Optojump, Microgate™, Bolzano, Italy) was used to measure jump height (cm) for each CMJ and DJ trial with the highest jump used for subsequent analysis in each test. The between-trial intraclass correlation coefficients (ICCs) for jump height attained during both tests was 0.97 in the current sample of players.

Linear Sprint Test

Players completed two trials of 20-m linear sprints at maximal effort to assess linear speed. Each sprint trial was separated by 120 s of passive, standing rest. Four pairs of photoelectric cells (Microgate™ Polifemo, Bolzano, Italy) were used to record sprint split times at 5, 10, and 20 m. The starting position was placed 0.5 m behind the first timing gate to avoid inadvertent triggering of timing, with players commencing each sprint on their own volition. The fastest time (s) for each split (irrespective of the trial) was used for subsequent analysis. The between-trial ICCs were 0.70, 0.67, and 0.75 for 5, 10, and 20-m sprint times in the current sample of players.

Change-Of-Direction (COD) Speed Tests

The Lane Agility Drill test and the 505 COD test were used to assess COD speed in players. In the Lane Agility Drill test, players started at the top left corner of the key, 0.2 m behind the free-throw line to avoid inadvertent triggering of timing, with players commencing each sprint on their own volition. Players faced the baseline throughout the entirety of the test. Initially, players ran 5.8 m to the baseline from the starting point. Players then side-shuffled 4.9 m to the right across the baseline before running backward to the top right corner of the free-throw line. Players then side-shuffled 4.9 m to the left where they touched the floor with their foot at the corner of the key (starting point), and then immediately completed the same circuit in the

opposite direction (Raya-González et al., 2021). In the 505 COD test, players ran 15 m linearly from the starting position and performed a 180° turn, self-selecting the preferred lower-limb to initiate the change in direction. After changing direction, players ran as quickly as possible for a further 5 m back toward the starting position (Castillo et al., 2021). A photocell timing gate (Microgate™ Polifemo, Bolzano, Italy) was positioned 10 m from the starting position to capture performance time (s) across the 5 m immediately prior to and the 5 m immediately following the change in direction. Players completed two trials of each test with 90 s of passive, standing rest applied between trials. The fastest trial was used for subsequent analysis in each test. The ICCs were 0.90 for the Lane Agility Drill test and 0.74 for the 505 COD test in the current sample of players.

Repeated Change-Of-Direction (RCOD) Sprint Test

A single trial of the RCOD sprint test was administered consisting of 5 × 30-m shuttle sprints (15 + 15 m) interspersed with 30 s of passive, standing recovery between each sprint. Players started 0.5 m before the first timing gate and sprinted for 15 m, before touching a line on the floor with their preferred foot and returning to the starting position as fast as possible (Castillo et al., 2021). A single pair of photoelectric cells (Microgate™ Polifemo, Bolzano, Italy) were placed at the start line to record performance time (s) during each shuttle. The sum of all shuttle sprint times (total performance time during the RCOD sprint test) was calculated and used for subsequent analysis.

Questionnaires

The questionnaires were conducted following a typical week in which players maintained their normal daily routines involving attendance at school on 5 days, three on-court training sessions, and participation in an official match during the weekend.

Physical Activity Questionnaire for Adolescents (PAQ-A)

The PAQ-A was applied to assess the physical activity behaviors of players outside of regular basketball training and competition across the entire week (Monday to Sunday) prior to testing. The PAQ-A consists of nine questions, each using 5-point Likert scales. The first six questions in the questionnaire assess the physical activity carried out in the last 7 days during leisure time, during physical education classes, during specific times on school days (lunch, afternoon, and night), and during the weekend. The last two questions of the questionnaire assess the level of physical activity carried out during the week and how often physical activity occurred on each day of the week. The final score attained in the PAQ-A is the average of the scores obtained in the first eight questions, while the final question is used to identify whether any circumstances that prevented usual physical activity occurred in the week that was analyzed. The PAQ-A was designed for and validated (ICC = 0.71 for total score) in males (n = 46) and females (n = 36) aged 13–18 years (Martínez-Gómez et al., 2009).

Dietary Questionnaire

The dietary questionnaire was applied to identify the nutritional habits and nutritional knowledge of players (Turconi et al., 2003). The dietary questionnaire was originally composed of 10 sections; however only three sections (i.e., B, C, and H) were deemed relevant for this study and thus used to assess player nutritional habits and nutritional knowledge. Furthermore, each section was slightly modified with the addition of a "non-reported" option for each item in each section for players to select if they did not feel compelled, were not comfortable, or did not know the precise amounts when answering a question. The three sections from the dietary questionnaire used in this study included:

- *Section B* is focused on the consumption frequency of common foods and beverages, consisting of 28 questions. The questions must be answered using categorical variables based on the perceived frequency of consumption by each player (i.e., always, often, sometimes, never).
- *Section C* is focused on nutritional habits related to breakfast contents, number of meals consumed in a day, daily consumption of fruit and vegetables, and daily consumption of soft drinks and alcoholic beverages. This section contains 14 questions with categorical variables based on the perceived frequency of consumption for 10 questions (i.e., always, often, sometimes, never) and open-ended responses able to be given for four questions. The maximum total score able to be attained in this section is 54.
- *Section H* is focused on nutritional knowledge, consisting of 11 questions. Each question is focused on important nutritional aspects including the function of specific macronutrients and micronutrients as well as the relevance of nutrition. Four answers are available for players to select in each question with only one answer being correct. A point is awarded for each correct answer, with no points awarded for incorrect answers. The maximum total score able to be attained in this section is 11.

Statistical Analysis

Data are presented as mean ± standard deviations (SD) for quantitative variables or frequencies and percentages for qualitative variables. Considering the non-normal distribution of data detected by the Shapiro-Wilk test, Mann Whitney tests were used to examine differences in each physical fitness attribute, questions 1, 8, and the total score in the PAQ-A, and total scores in sections C and H in the dietary questionnaire between male and female groups. Practical significance was assessed by calculating Cohen's r effect size (ES) (Cohen, 1988), which were interpreted in magnitude as: small, ≤0.1; trivial, 0.11–0.30; intermediate, 0.31–0.50; and strong, >0.50 (Hopkins et al., 2009). Also, chi squared goodness-of-fit tests were used to examine the distribution of players for each item in the PAQ-A (questions 2–7) as well as sections B, C (questions 1–14), and H (questions 1–11) in the dietary questionnaire. Data analysis was carried out using the Statistical Package for Social Science (SPSS Statistics for Windows, version 25.0, IBM Corp., Armonk, N.Y., USA), with statistical significance set at $p < 0.05$.

RESULTS

The mean ± SD physical fitness attributes in the entire sample, as well as separately for male and female U-14 basketball players are shown in **Table 1**. Male players demonstrated significantly better jump heights (CMJ: $p < 0.001$, strong; DJ: $p < 0.001$, strong), linear sprint times ($p < 0.001$, strong), COD speed (Lane Agility Drill: $p < 0.001$, strong; 505 COD test: $p = 0.001$, intermediate), and RCOD time ($p = 0.04$, intermediate) than female players.

Responses to the PAQ-A in the entire sample, as well as separately for male and female U-14 basketball players are presented in **Table 2**. While male players reported significantly higher physical activity during leisure time compared to female players ($p = 0.036$), no significant differences were evident between sexes in all other questionnaire items nor PAQ_{total}.

Results from the dietary questionnaire regarding the nutritional habits and nutritional knowledge of the entire sample as well as separately for male and female U-14 basketball players are shown in **Table 3** and **Table 4**, respectively. No significant differences ($p > 0.05$) were found between sexes in nutritional habits or nutritional knowledge. However, descriptive data showed a high proportion of players never or only sometimes eat fruit (males: 23%; females: 40%) and vegetables (males: 46%; females: 70%). Furthermore, players demonstrated relatively poor nutritional knowledge with <50% of questions being answered correctly across the entire sample (4.57 ± 1.88 out of 11 points, 42%) and in each sex (males: 4.07 ± 2.10, 37%; females: 5.20 ± 1.40, 47%).

DISCUSSION

A better understanding of the physical fitness attributes, physical activity behaviors, nutritional habits, and nutritional knowledge of elite male and female basketball players participating in a youth basketball academy is essential to optimize their health and development in prescribing specific and effective training and nutritional strategies. In this regard, elite U-14 male basketball players exhibited better physical fitness across all tests (i.e., a test battery consisting of jumping, linear sprint, and change-of-direction tests) and performed more physical activity in their leisure time compared to elite U-14 female basketball players. In contrast, no significant differences were observed between sexes in nutritional habits and nutritional knowledge; however, male and female players reported a low consumption of fruit and vegetables and demonstrated relatively poor nutritional knowledge across a range of nutritional concepts.

Regarding physical fitness, the results of this study showed that elite male U-14 basketball players had superior jump heights (i.e., CMJ and DJ), linear speed (i.e., 5, 10, and 20 m- sprint times), COD speed (i.e., Lane Agility Drill and 505 COD tests), and RCOD speed (i.e., RCODAtotal) than female players. These results coincide with those reported in U-14 Spanish national basketball players revealing that male players ($n = 33$) possess superior lower-body power (i.e., abalakov jump and multi-jump test) and repeated-sprint capacity (i.e., repeat sprint ability test) compared to U-14 female players ($n = 12$) (Mancha-Triguero et al., 2021). This finding is supported with previous literature since sex differences in athletic performances start to increase around the age associated with the onset of puberty in males (12–13 years) (Handelsman, 2017). Also, the superior physical fitness in U-14 male players across many of the fitness tests we examined may be attributed to them possessing greater absolute and relative fat-free mass than females in early adolescence as females have been shown to experience a decline in relative fat-free mass prior to puberty (McCarthy et al., 2014). Furthermore, physical fitness attributes (linear sprint time and RCOD ability) have been shown to be significantly associated ($p < 0.05$; $r = -0.60$ to -0.63) with external load variables (total distance, high-speed running distance, and number of jumps performed) during simulated matches in elite U-14 male basketball players (Castillo et al., 2021) and with performance index rating during matches in elite U-14 male (CMJ height, 20-m linear sprint time, and Agility T-test time, $r = -0.25$ to 0.23, $p < 0.01$) and female (CMJ power, $r = 0.16$, $p < 0.05$) basketball players (Ramos et al., 2019). Given this demonstrated importance of physical fitness attributes for in-match activity and performance, a thorough understanding of differences in physical fitness between male and female U-14 players may inform the development of training stimuli to optimize the physical preparedness of players across both sexes to meet the demands of competition.

While the players in the present study underwent a rigorous training routine participating in an elite basketball academy, an understanding of their physical activity level outside the sports context is also of interest given its positive effects on athletic performance (Mujika et al., 2018). In this way, identifying discrepancies in physical activity performed during leisure time between sexes during early adolescence is needed to understand specific trends in lifestyle behaviors during this phase of life and for the development of specific training strategies. In this study, no significant differences were reported in most items contained in the PAQ-A. Only higher $PAQ1_{mean}$ activities, that is, how often players engaged in activities identified in the PAQ-A (skipping rope, cycling, jogging, racket sports, soccer, etc.) during their leisure time, were evident in male players compared to female players. Similar to these findings, higher participation in physical activity outside of sports clubs has been reported in males compared to females in German adolescents ($n = 2{,}117$, age: 12.0 ± 3.3 years, 52.6 vs. 46.9%, $p = 0.01$) (Reimers et al., 2019) and in Spanish adolescents ($n = 662$, age: 12.4 ± 0.9 years, 3.01 ± 0.84 AU vs. 2.79 ± 0.75 AU, $p = 0.04$) (Barja-Fernández et al., 2020). The greater leisure-time physical activity we observed in elite U-14 male basketball players compared to female players might be attributed to males experiencing greater encouragement from significant reference people (i.e., parental models) to engage in physical activity than females during early adolescence (Dixon et al., 2008). However, we observed no significant differences between sexes in physical activity behaviors during physical education classes, on school days, and during the weekend, suggesting

TABLE 1 | Comparisons in physical fitness attributes between elite, male and female under 14 basketball players.

Variable	Entire sample ($n = 23$)	Male players ($n = 13$)	Female players ($n = 10$)	Mean difference (%)	p-value	Effect size, magnitude
Jump tests						
Countermovement jump height (cm)	24.7 ± 5.6	27.6 ± 4.9	20.7 ± 3.8	25.1	**<0.001**	0.62, strong
Drop jump height (cm)	26.1 ± 6.4	30.0 ± 4.8	20.5 ± 3.6	31.7	**<0.001**	0.75, strong
Linear Sprint test						
5-m sprint time (s)	1.12 ± 0.08	1.07 ± 0.04	1.19 ± 0.06	−10.8	**<0.001**	−0.76, strong
10-m sprint time (s)	2.00 ± 0.14	1.92 ± 0.09	2.12 ± 0.12	−10.1	**<0.001**	−0.68, strong
20-m sprint time (s)	3.46 ± 0.40	3.23 ± 0.34	3.79 ± 0.23	−17.1	**<0.001**	−0.70, strong
Change-of-direction (COD) speed tests						
Lane Agility Drill time (s)	15.31 ± 1.00	14.76 ± 0.58	16.10 ± 0.97	−9.1	**<0.001**	−0.66, strong
505 COD test time (s)	2.68 ± 0.20	2.60 ± 0.15	2.80 ± 0.22	−7.7	**0.001**	−0.48, intermediate
Repeated change-of-direction (RCOD) sprint test						
RCOD sprint test time (s)	34.13 ± 2.06	33.36 ± 1.56	35.23 ± 2.27	−5.6	**0.036**	−0.44, intermediate

Bolded p-value indicates statistical significance at $p < 0.05$.

participation in an elite basketball academy may lessen the differences in leisure-time physical activity between males and females compared to the wider population as shown in European adolescents (Reimers et al., 2019; Barja-Fernández et al., 2020). As such, it seems that basketball practice in an elite academy may have had a positive influence on equating the practice of physical activity in wider social contexts across sexes in young players.

In addition to adequate physical fitness, a balanced and appropriate diet is essential to ensure optimal growth and performance are attained in adolescent basketball players (Iglesias-Gutiérrez et al., 2005, 2012). This is the first study to analyze differences in nutritional habits according to sex in basketball players during early adolescence, with no significant differences in nutritional habits observed between males and females. However, closer examination of the nutritional habits of the players examined in this study reveal some notable findings. Specifically, 30% of the entire sample (23% of males and 40% of females) never or sometimes eat fruit, while 57% of the entire sample (46% of males and 70% of females) never or sometimes eat vegetables. As such, considering the global recommendation of consuming 5 fruits and vegetables daily to prevent chronic diseases such as overweight, obesity, diabetes, or cardiovascular diseases (World Health Organization, 2003), the limited consumption of fruit and vegetables we observed in elite U-14 basketball players is concerning from a health perspective. From a performance perspective, consumption of fruits and vegetables has been shown to influence body composition (fat mass and fruit intake, $r = -0.21$, $p < 0.01$; fat free mass and vegetable intake, $r = 0.25$, $p < 0.01$) and physical fitness (progressive aerobic cardiovascular endurance run performance and vegetable intake, $r = 0.22$, $p < 0.01$) in University students (21.5 ± 1.5 years) (López-Sánchez et al., 2019). Research has indicated that the consumption of fruits and vegetables can delay or prevent the appearance of chronic non-communicable diseases, that is, diseases associated with unhealthy lifestyle habits (e.g., obesity, type II diabetes) (Lampe, 1999; Tian et al., 2018). These benefits are mainly related to the nutritional composition of foods, including vitamins, minerals (essential nutrients), and dietary fiber. By incorporating fruits and vegetables into the daily diet in adolescents, the intake of fats, sugars, and salt are typically reduced, which can help prevent weight gain and reduce the risk of developing overweight or obesity later in adulthood (World Health Organization/Food and Agriculture Organization, 2003).

Like our findings regarding player nutritional habits, no significant differences in nutritional knowledge were found between sexes in elite U-14 basketball players. These insights are novel for youth basketball players and are necessary to identify knowledge deficits regarding nutritional concepts that can be addressed in targeted educational interventions tailored to both sexes (Bird and Rushton, 2020). While these data are the first on this topic in basketball players, contradictory findings have been reported in other athletic populations. For instance, Ali et al. (2015) observed greater nutritional knowledge ($p < 0.05$) in female (19.3 ± 0.7 years) compared to male athletes (21.0 ± 1.8 years) who were involved in football, volleyball, cross-country, basketball, swimming, and other sports activities than males (21.0 ± 1.8 years) using a nutrition knowledge and dietary habits questionnaire. In contrast, Manore et al. (2017) reported no significant differences in nutritional knowledge ($p = 0.08$; females = 45%, males = 56% correct answers) between sexes in high school soccer players under 15 years of age using a nutritional knowledge questionnaire. Irrespective of sex, relatively poor nutritional knowledge was demonstrated across the entire sample of elite U-14 basketball players we examined (42% correct responses). Likewise, some relevant nutrition concepts such as fiber, fat, vitamins, minerals, balanced diet, and transgenic foods were poorly understood across players. Taking

TABLE 2 | Comparisons in Physical Activity Questionnaire for Adolescents (PAQ-A) results between elite, male and female, under 14 basketball players.

Question	Entire sample ($n = 23$)					Males ($n = 13$)					Females ($n = 10$)					p-value
$PAQ1_{mean}$ Activities	0.48 ± 0.27					0.59 ± 0.31					0.34 ± 0.14					**0.04**
PAQ2 Physical education	Never	Hardly ever	Sometimes	Often	Always	Never	Hardly ever	Sometimes	Often	Always	Never	Hardly ever	Sometimes	Often	Always	
	0	0	8.7	56.5	34.8	0	0	0	61.5	38.5	0	0	20	50	30	0.24
PAQ3 Lunch	Sit	Walk	Play little	Play a lot	Play intensely	Sit	Walk	Play little	Play a lot	Play intensely	Sit	Walk	Play little	Play a lot	Play intensely	
	69.6	21.7	4.3	4.3	0	76.9	15.4	7.7	0	0	60	30	0	10	0	0.41
	None	Once a week	2–3 a week	4 a week	>4 a week	None	Once a week	2–3 a week	4 a week	>4 a week	None	Once a week	2–3 a week	4 a week	>4 a week	
PAQ4 4–6 pm	21.7	13	30.4	21.7	13	23.1	0	30.8	38.5	7.7	20	30	30	0	20	0.08
PAQ5 6–10 pm	13	13	47.8	17.4	8.7	7.7	7.7	61.5	15.4	7.7	20	20	30	20	10	0.63
PAQ6 Weekend	8.7	22.7	43.5	17.4	8.7	7.7	15.4	38.5	23.1	15.4	10	30	50	10	0	0.58
PAQ7 Week intensity	Little	1–2 a week	3–4 a week	5–6 a week	>6 a week	Little	1–2 a week	3–4 a week	5–6 a week	>6 a week	Little	1–2 a week	3–4 a week	5–6 a week	>6 a week	
	21.7	39.1	34.8	4.3	0	23.1	30.8	38.5	7.7	0	20	50	30	0	0	0.70
$PAQ8_{mean}$ Diary frequency	1.80 ± 0.63					1.84 ± 0.69					1.74 ± 0.57					0.66
PAQ_{total}	1.63 ± 0.52					1.73 ± 0.60					1.50 ± 0.40					0.32

$PAQ1_{mean}$ Activities, Frequency of physical activities during leisure time across the last 7 days; PAQ2 Physical education, Frequency of being physically active during physical education sessions at school across the last 7 days; PAQ3 Lunch, Type of physical activity before and after lunch across the last 7 days; PAQ4 4–6 pm, Frequency of being physically active immediately after school during the last 7 days; PAQ5 6–10 pm, Frequency of being physically active between 6 and 10 pm across the last 7 days; PAQ6 Weekend, Frequency of being physically active during the last weekend; PAQ7 Week intensity, Weekly frequency of performing physical activity in leisure time; $PAQ8_{mean}$ Diary frequency, Frequency of daily physical activity for each day of the week; PAQ_{total}, Total score obtained across the first eight questions in the questionnaire; Mann-Whitney U-tests were applied to questions 1, 8, and total score, which contain data presented as mean ± standard deviation, while Chi-squared tests were applied to all other questions which contain data presented as percentages. Bold value indicates significance at $p < 0.05$.

TABLE 3 | Comparisons in nutritional habits between elite, male, and female, U-14 basketball players.

Question	Entire sample ($n = 23$)					Male players ($n = 13$)					Female players ($n = 10$)					*p*-value
C1 Breakfast	Never	Sometimes	Often	Always	NR	Never	Sometimes	Often	Always	NR	Never	Sometimes	Often	Always	NR	
	4.3	0	0	95.7	0	7.7	0	0	92.3	0	0	0	0	100	0	0.37
C2 Beverage breakfast	Tea	Juice	Chocolate	Milk	NR	Tea	Juice	Chocolate	Milk	NR	Tea	Juice	Chocolate	Milk	NR	
	0	0	0	95.7	4.3	0	0	0	92.3	7.7	0	0	0	100	0	0.37
C3 Eat breakfast	Cheese	Pizza	Bread	Fruit	NR	Cheese	Pizza	Bread	Fruit	NR	Cheese	Pizza	Bread	Fruit	NR	
	0	0	95.7	0	4.3	0	0	92.3	0	7.7	0	0	100	0	0	0.37
	Never	Sometimes	Often	Always	NR	Never	Sometimes	Often	Always	NR	Never	Sometimes	Often	Always	NR	
C4 Fruit	13	17.4	30.4	34.8	4.3	7.7	15.4	30.8	46.2	0	20	20	30	20	10	0.54
C5 Vegetables	8.7	47.8	26.1	13	4.3	15.4	30.8	23.1	23.1	7.7	0	70	30	0	0	0.16
C6 Cake	21.7	52.2	13	8.7	4.3	23.1	53.8	7.7	7.7	7.7	20	50	20	10	0	0.83
C7 Wine, beer	60.9	30.4	0	8.7	0	61.5	23.1	0	15.4	0	60	40	0	0	0	0.36
C8 Three meals	0	0	21.7	78.3	0	0	0	15.4	84.6	0	0	0	30	70	0	0.40
C9 Diet	Monotony	Different on weekend	Different sometimes	Different all days	NR	Monotony	Different on weekend	Different sometimes	Different all days	NR	Monotony	Different on weekend	Different sometimes	Different all days	NR	
	4.3	0	8.7	87.0	0	7.7	0	0	92.3	0	0	0	20	80	0	0.18
C10 Diet based on	Different all days	Carbohydrate	Lipids	Protein	NR	Different all days	Carbohydrate	Lipids	Protein	NR	Different all days	Carbohydrate	Lipids	Protein	NR	
	56.5	0	4.3	34.8	4.3	61.5	0	7.7	30.8	0	50	0	0	40	10	0.51
C11 Snacks	Sweets	Fried	Bread	Fruit	NR	Sweets	Fried	Bread	Fruit	NR	Sweets	Fried	Bread	Fruit	NR	
	8.7	21.7	26.1	30.4	13	7.7	23.1	30.8	15.4	23.1	10	20	20	50	0	0.30
C12 Beverages	Juice	Wine, beer	Refresh	Water	NR	Juice	Wine, beer	Refresh	Water	NR	Juice	Wine, beer	Refresh	Water	NR	
	0	0	8.7	91.3	0	0	0	15.4	84.6	0	0	0	0	100	0	0.19
	Never	Sometimes	Often	Always	NR	Never	Sometimes	Often	Always	NR	Never	Sometimes	Often	Always	NR	
C13 Milk	0	0	4.3	95.7	0	0	0	0	100	0	0	0	10	90	0	0.24
C14 Water	0	13	26.1	56.5	4.3	0	7.7	15.4	69.2	7.7	0	20	40	40	0	0.31
C Total	44.78 ± 3.70					45.39 ± 3.86					44.00 ± 3.53					0.45

All questions were obtained from section C in the Turconi questionnaire; NR, not reported; Chi-squared tests were applied to questions 1–14, while a Mann-Whitney U test was applied to the total score.

TABLE 4 | Comparisons in nutritional knowledge between elite, male and female, U-14 basketball players.

Question	Entire sample ($n = 23$)		Male players ($n = 13$)		Female players ($n = 10$)		p-value
	Correct (%)	*Incorrect (%)*	*Correct (%)*	*Incorrect (%)*	*Correct (%)*	*Incorrect (%)*	
H1 Carbohydrates	56.5	43.5	61.5	38.5	50.0	50.0	0.58
H2 Fiber	17.4	82.6	7.7	92.3	30.0	70.0	0.16
H3 Fat	8.7	91.3	7.7	92.3	10.0	90.0	0.85
H4 Protein	56.5	43.5	46.2	53.9	70.0	30.0	0.25
H5 Calories	56.5	43.5	61.5	38.5	50.0	50.0	0.58
H6 Energy	47.83	52.17	53.85	46.15	40.0	60.0	0.51
H7 Vitamins and minerals	4.3	95.7	0	100	10.0	90.0	0.24
H8 Balanced diet	21.74	78.26	76.9	23.1	80.0	20.0	0.86
H9 Daily energy expenditure	65.2	34.8	53.8	46.2	80.0	20.0	0.19
H10 Biological foods	56.5	43.5	46.2	53.8	70.0	30.0	0.25
H11 Transgenic foods	21.7	78.3	15.4	84.6	30.0	70.0	0.40
H Total	4.57 ± 1.88		4.07 ± 2.10		5.20 ± 1.40		0.24

All questions were obtained from section H in the Turconi questionnaire; total score is presented as mean ± standard deviation for the number of correctly answered questions.

into account that an adequate nutritional knowledge could promote better nutrional habits (Muderedzwa and Matsungo, 2020) and consequently better health and physical conditioning (Nikolaidis and Theodoropoulou, 2014), nutrition education interventions are likely needed in elite U-14 basketball players to enhance nutritional habits. Further research on this topic is encouraged to identify whether the poor nutritional knowledge we observed represents that of the wider elite adolescent basketball player population.

This study is not exempt from limitations, which should be acknowledged. First, given U-14 players from a single elite basketball academy were strictly recruited in this study, a relatively small sample size was used in each group (males and females). Accordingly, future studies should expand on this work examining larger samples of players and adolescent players from other age categories and levels of play (i.e., international). Secondly, endurance capacity was not measured in this study. Due to the documented importance of aerobic fitness in accomplishing high-intensity running distances during matches in elite, adolescent (18.2 ± 0.5 years) male basketball players (Ben Abdelkrim et al., 2010), further studies comparing fitness attributes between sexes in youth basketball players should include aerobic fitness testing protocols (e.g., Yo-Yo Intermittent Recovery Test, 30–15 Intermittent Fitness Test). Thirdly, data were acquired at a single timepoint in the season and does not capture changes in fitness, physical activity behaviors, or nutritional habits across the season. Consequently, future research should conduct fitness testing and questionnaire assessments at different timepoints throughout the season to understand temporal changes in fitness, physical activity behaviors, and nutritional habits to implement specific strategies at different phases across the competitive season. Fourthly, analysis of nutritional habits was limited to broad patterns of dietary behaviors, whereas further understanding of daily energy expenditure and macronutrient intake would allow for more detailed insight to develop comprehensive nutrition intervention strategies promoting healthy nutritional habits in adolescent basketball players. Finally, maturity status was not able to be measured in this study. Future research on this topic is encouraged to identify the maturity status of players where permissible to understand its role on the variables measured in this study.

CONCLUSIONS

Elite U-14 male basketball players had greater physical fitness and underwent more physical activity during leisure time compared to female players, suggesting individualized prescription of training stimuli across sexes should be adopted to optimize the physical preparedness and development of players. Additionally, while nutritional habits and nutritional knowledge were similar between sexes, players exhibited low consumption of fruits and vegetables as well as relatively poor nutritional knowledge. Consequently, strategies such as education interventions may be necessary to improve the nutritional knowledge of elite basketball players in early adolescence.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Universidad Isabel I. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

SS-D led the project and developed and revised the original manuscript. DC and JR-G analyzed and interpreted the data and developed and revised the original manuscript. AS revised the original manuscript. JY developed the statistical report and revised the original manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

3.1.2 Segunda investigación

nutrients

MDPI

Review

Effects of Nutrition Education Interventions in Team Sport Players. A Systematic Review

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Abstract: Considering nutrition education interventions have been frequently implemented in team sport athletes and have shown promising results, this study aimed to summarize the effects of nutrition education interventions on eating habits, nutrition knowledge, body composition, and physical performance in team sport athletes. A systematic review was conducted using the following databases: PubMed/MEDLINE, Web of Science and SPORTDiscus. A total of 14 studies met the inclusion criteria for the review. The methodological quality of included studies was evaluated, and each study was assessed according to the analyzed variables (i.e., eating habits, nutrition knowledge, body composition, and physical performance). Most studies showed improvements in or maintenance of variables used to indicate eating habits, nutrition knowledge, and body composition. However, limited studies examined the effect of nutrition education interventions on physical performance, with existing studies demonstrating disparate results. These findings suggest implementation of nutrition education interventions in team sport athletes could be an effective strategy to improve their eating habits, nutrition knowledge, and body composition. Due to the heterogeneity across the included studies regarding sport modality, competition level, age, and sex of the athletes investigated, as well as the intervention type adopted (i.e., online or face-to-face), it is difficult to establish optimal nutrition education interventions for each analyzed variable.

Keywords: nutrition knowledge; eating habits; sports performance; body composition; soccer; basketball

1. Introduction

Team sports are played around the world [1], accumulating large audiences [2] and generating high economic impact [3]. In recent decades, the application of sport science has become a staple in most team sports to improve the health and performance of athletes [4]. In this sense, sport science research has grown with most studies focusing on three predominant topic areas including: training and game load monitoring through physical, physiological, and perceptual variables [5]; optimization of athletes' anthropometric characteristics and physical fitness [6]; and evaluation of injury prevention and rehabilitation programs [7]. However, recent research has highlighted the relevance of invisible strategies (i.e., those other than training plans) in the pursuit of optimizing athlete health and performance [8]. Nutrition is considered a key invisible strategy, benefiting performance during competition and facilitating recovery [9].

Most team sport studies focusing on athlete nutrition have reported on the health- and performance-related effects of diets [10–12] and supplementation [13–15]. However, some promising data have emerged regarding the efficacy of nutrition education interventions in team sports [16]. Nutrition education interventions are specific programs designed to assist target populations in modifying their eating habits and/or enhancing their nutrition knowledge [17]. These outcomes are particularly relevant for team sport athletes given increasing nutrition knowledge can yield substantial positive changes in eating habits in team sport athletes [16]. In turn, improved eating habits can enhance performance in team sport athletes [18]. Therefore, nutrition education interventions appear to be a key strategy to optimize team sport athletes' performance. Most investigations examining the effectiveness of nutrition education interventions have recruited athletes from individual sports, showing beneficial results in compliance with Mediterranean diet quality index [19] and nutrition knowledge, perceived susceptibility to the Female Athlete Triad, and self-efficacy constructs in specific contexts for each athlete [20]. However, research exploring the application of nutrition education interventions in team sports is more limited than in individual sports, since teams are made up of 15–22 players who have different nutritional needs [21]. Nevertheless nutrition education interventions are being increasingly applied among team sport athletes since interventions can be implemented using a wide range of modalities, including personal interviews [22], group activities [23], comics [24], interactive workshops [23], or technological platforms [25]. However, the effectiveness of each specific modality in nutrition education interventions needs to be analyzed to identify the most appropriate approach relevant to the specific context applied.

Since nutrition education interventions in team sports can benefit athlete nutrition knowledge and dietary behaviors, and in turn performance [26], collating the existing literature on this topic is essential to understand the efficacy of different interventions in improving eating habits in team sport athletes. In this regard, a previous systematic review [18] analyzed the influence of nutrition education interventions on eating habits, finding most studies (13 out of 16 studies) reported positive changes in dietary behavior post-intervention across athletes competing in twenty-five different individual and team sports. Furthermore, meta-analytic evidence [16] showed most nutrition education interventions (85.7%) significantly increased nutrition knowledge in athletes competing in individual and team sports following different nutrition education interventions with face-to-face strategies the most effective intervention modality (28 out of 36 studies). Due to the strong relationships that dietary behaviors and nutrition knowledge hold with body composition and physical performance [9,27,28], many studies have examined the effects of nutrition education interventions on body composition [22,29–33] and performance indicators [32,34,35]. Regarding body composition, Nascimento et al. [31] applied nutrition counselling consisting of four consultations separated by 45 to 60 days in adult and adolescent team and individual sport athletes, observing increased lean body mass in both groups after the intervention (pre-intervention = 48.0 ± 1.2 kg vs. post-intervention = 49.2 ± 1.6 kg; $p < 0.05$). Regarding physical performance, Rossi et al. [32] reported improved change-of-direction speed (change = −0.15 ± 0.13 s; $p < 0.001$) and vertical jump height (change = 6.6 ± 9.4 cm; $p < 0.001$) in collegiate baseball players following a nutrition education intervention involving 90-min information sessions focused on food preparation, nutrients, and healthy eating habits across 12 weeks. Although multiple systematic reviews have explore the effectiveness of education interventions on dietary behaviors and nutrition knowledge [16,18], no systematic reviews have focused explicitly on team sport athletes in this area nor examined the effectiveness of nutrition education interventions on performance indicators in any athlete groups.

Despite the strong interest in conducting nutrition education interventions in team sports, there is currently no scientific consensus for the most effective intervention to apply in practice. Therefore, a systematic review of the literature is essential to generate robust conclusions regarding the effects of different nutrition education interventions in team sport athletes and facilitate their application to practice in specific contexts. Consequently, the aim of this systematic review was to analyze the

effects of nutrition education interventions on eating habits, nutrition knowledge, body composition, and physical performance in team sport athletes.

2. Materials and Methods

This review was carried out following the recommendations and criteria established in the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement guidelines [36].

2.1. Search Strategy

To identify potential studies, a systematic search was performed in the following databases: PubMed/MEDLINE, Web of Science (including all Web of Science Core Collection: Citation Indexes) and SPORTDiscus. The search syntax included the following keywords with relevant Boolean operators inserted: ("education intervention" OR "nutritional intervention" OR "nutrition education") AND ("nutrition knowledge" OR "health knowledge" OR "food knowledge" OR "diet knowledge" OR "dietary behavior" OR "dietary behaviour" OR "dietary intake" OR "dietary assessment" OR "food habit" OR "body composition" OR "weight management" OR "performance" OR "physical performance" OR "athletic performance") AND ("team sport" OR "athlete"). A year restriction was applied for this search (i.e., studies published between 1980 and 2020). Furthermore, the reference lists of included studies were searched, and studies that cited the included studies were located using Google Scholar and checked for their relevance. Two authors (S.S-D. and D.C.) independently screened the title and abstract of each study. Full-text versions of studies that met the inclusion criteria were then screened. Discrepancies regarding inclusion of studies between authors were decided by consensus with a third author (J.R-G.). The search was performed on 21 November 2020.

2.2. Inclusion Criteria

Studies meeting the following criteria were included in our review: (1) sample in experimental group was composed solely of team sport athletes; (2) nutrition intervention implemented using educational strategies; (3) instrument(s) used produced quantitative scores pre- and post-intervention; (4) intervention impact was assessed on any of the following outcomes: eating habits, nutrition knowledge, body composition, and/or physical performance indicators; and (5) a full-text version of the study was published in a peer-reviewed journal. In addition, studies that were not written in English, as well as conference abstracts, letters to the editor, errata, narrative reviews, systematic reviews, meta-analyses, or invited commentaries were excluded from our review.

2.3. Study Coding and Data Extraction

The following data were extracted from the included studies: (a) authors, year of publication, and study design; (b) sample characteristics (including sample size, sex, age, country, sport modality, and competition level); (c) tool/questionnaire/parameter/test used for each analyzed variable; (d) intervention procedure (modality, frequency, and duration); and (e) major findings (i.e., positive/negative/unchanged effects on eating habits, nutrition knowledge, body composition, and/or physical performance).

2.4. Methodological Quality Assessment

To assess the methodological quality of the included studies, a modified version of the Downs and Black checklist was used [37]. In this regard, items 8, 13, and 17 were removed, and the tool was complemented with two additional items (i.e., 9 and 10) from the Academy of Nutrition and Dietetics (AND) quality criteria checklist [38] for greatest relevance to nutrition intervention studies [16]. In the checklist, each question is answered with "yes" if the criteria are satisfied or "no" if the criteria are not satisfied. The answer "yes" was awarded one point for all items (and the answer "no" given zero points) except items 5 and 18, which were scored with a maximum of two points. This approach

allowed reviewers to differentiate between studies providing two or less validity or reliability measures for the chosen nutrition knowledge instrument and studies that used three or more validity or reliability measures for the chosen nutrition knowledge instrument. Additionally, for studies using single-arm designs in our review, items 14, 15, 21, 22, 23, and 24 were not deemed relevant, so the maximum score for studies using this study design was 22 points with the following scoring criteria adopted: ≤11 points: poor quality; 12–15 points: fair quality; 16–19 points: good quality; 20–22 points: excellent quality). For studies using double-arm designs, the maximum score was 28 points with the following scoring criteria adopted: ≤14 points: poor quality; 15–19 points: fair quality; 20–25 points: good quality; 26–28 points: excellent quality) [16,39].

Data extraction and methodological quality assessment were performed by two authors (S.S-D. and J.R-G.) independently, and a third author was consulted (D.D.) to solve any discrepancies via consensus.

2.5. Search Results

Figure 1 shows the study retrieval process performed for our review. A total of 456 studies were identified in the initial search, while three additional studies were identified through other sources (i.e., ResearchGate). One hundred and thirty-one study duplicates were eliminated, and 325 studies were screened. Furthermore, 276 studies were excluded based on their titles and/or abstracts. Full-text versions of the remaining 49 studies were assessed for eligibility, with 14 studies meeting the inclusion criteria and being retained in our systematic review [22–26,29,30,32–35,40–42].

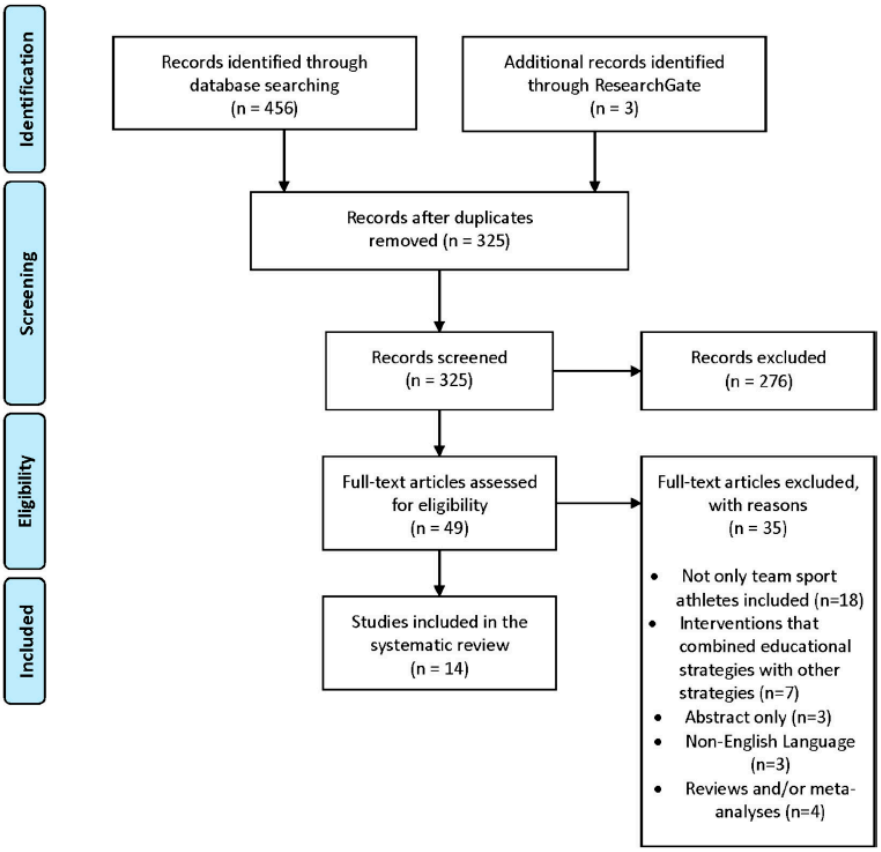

Figure 1. Flow diagram of the study retrieval process.

3. Results

3.1. Descriptive Characteristics of the Studies

Tables 1–4 summarize the characteristics of the 14 included studies according to the outcome variables analyzed. In this regard, 10 studies analyzed the impact of nutrition education interventions on eating habits [22–26,29,30,32,33,40], nine studies analyzed nutrition knowledge [22–26,32,40–42], five studies analyzed body composition [22,29,30,32,33], and three studies analyzed physical performance [32,34,35] in team sport athletes. Regarding the experimental design, seven studies used single-arm designs [22,30,32,34,40–42] and seven studies used double-arm designs [23–26,29,33,35]. Moreover, quasi-experimental pre-post and repeated measures designs were used. Included studies examined a total of 683 athletes with five studies examining only male athletes [24,26,30,41,43], six studies examining only female athletes [22,25,29,32,33,40], and three studies examining male and female athletes combined [23,34,35]. Four studies examined volleyball athletes [22,29,33,40], three studies examined soccer athletes [23–25], two studies examined field and ice hockey athletes [41,42], one study examined handball athletes [30], one study examined basketball athletes [32], and three studies examined athletes from different team sports [26,34,35]. Finally, interventions between ten days and two seasons were applied, including from 2 to 12 educational sessions and using several delivery modalities (i.e., face-to-face, game, technological platform, workshop, comic book, and sport nutrition lessons).

3.2. Methodological Quality Assessment

Tables 5 and 6 show the methodologic quality of the included studies. In single-arm studies, quality scores ranged from 6 to 16 points, with an average of 11.7 ± 3.4 points, while double-arm studies ranged from 13 to 21 points, with an average of 17.4 ± 2.8 points. Regarding quality assessment of each study, four studies were categorized as poor quality, seven studies were categorized as fair quality, and three studies were categorized as good quality.

Table 1. Characteristics and major findings of the studies analyzing the effect of nutrition education interventions on eating habits in team sport athletes.

Authors	Year	Sample Size (*n*)	Age (M ± SD Years)	Country	Sport	Competition Level	Tool	Intervention (Modality, Frequency and Duration)	Major Findings
Abood et al. [25]	2004	NEI (15 females) CG (15 females)	NEI (19.6 ± 1.0) CG (19.4 ± 1.2)	United States	NEI Soccer CG Swimming	College division I	3-day food record	Nutrition education intervention NEI (online, 8 sessions of 1 h, 8 weeks) CG (no treatment)	NEI athletes experienced a significant increase in self-efficacy compared to CG. CG recorded a decrease in carbohydrate intake (percentage of total calories) and fiber. There was a significant overall difference in the number of positive dietary changes favoring the NEI.
Anderson et al. [29]	2010	Feedback (8 females) Baseline (8 females)	Feedback (20.1 ± 0.5) Baseline (19.3 ± 0.5)	United States	Volleyball	NCAA division II	3-day food record	Feedback regarding dietary intake Feedback (F2F at beginning, peak during, and following each season for two full seasons). Baseline (no treatment)	No changes in total carbohydrate, protein, and fat intake between baseline and feedback across the two seasons; however, greater protein intake was recorded after feedback at beginning of the season.
Daniel et al. [40]	2016	10 females	17.2 ± 0.9	Brazil	Volleyball	Junior	Quesitonnaire of Associação Brasileira de Empresas de Pesquisa	Interdisciplinary Food, Nutrition and Health Education Program (F2F, 8 sessions, 8 months)	Athletes made dietary changes during the year increasing their daily intake of fruits and vegetables and decreasing high-energy, low-nutrient food intake.
Elias et al. [26]	2018	NEI (52 males) CG (53 males)	NEI (18.7 ± 0.9) CG (23.3 ± 3.8)	Malaysia	NEI Field hockey and soccer CG Cricket and rugby union	National	KAP questionnaire	Sport education intervention activities NEI (F2F and online, 7 × 1.5-h sessions, 9 weeks) CG (no treatment)	NEI athletes showed higher mean total energy intake than CG following the education intervention. NEI showed greater increases in total carbohydrate, protein, and fat intake than CG following the education intervention.

Table 1. *Cont.*

Authors	Year	Sample Size (*n*)	Age (M ± SD Years)	Country	Sport	Competition Level	Tool	Intervention (Modality, Frequency and Duration)	Major Findings
Molina-López et al. [30]	2013	14 males	22.9 ± 2.7	Spain	Handball	Professional	3-day food record	Nutrition education program (F2F, 3 phases, 5 months)	Significant increase in total energy and macronutrient intakes following the intervention.
Patton-Lopez et al. [23]	2018	NEI (153 males and females) CG (64 males and females)	NEI (14.9 ± 0.9) CG (14.9 ± 0.9)	United States	Soccer	High school	SNK questionnaire	WAVE education program NEI (F2F, 7 sport nutrition lessons and 3 team-building workshops, 1–1.5 h, 2 years) CG (no treatment)	NEI were three times more likely to report trying to eat for performance. Consumption of lunch (≥ 5-days per week) did not change in NEI, but significantly declined in the CG.
Rossi et al. [32]	2017	15 females	19.3 ± 1.0	United States	Baseball	College division I	3-day food record	Nutrition education intervention (F2F, every 3 weeks, 12 weeks)	NEI athletes significantly increased total energy intake, total carbohydrate intake, and total protein intake following the intervention.
Valliant et al. [22]	2012	NEI 11 females CG 11 females	NEI 19.8 ± 1.0 CG 19.5 ± 1.0	United States	Volleyball	College division 1	3-day food record	Nutrition education NEI (F2F, 4 individual sessions, 4 months) CG (no treatment)	NEI athletes significantly increased total energy, carbohydrate, and protein intake following the intervention.
Wenzel et al. [33]	2012	NEI 10 females CG 29 females	NEI 19.8 ± NR CG 19.8 ± NR	United States	Volleyball	College division 1	3-day food record	Nutrition counselling NEI (F2F, once a month, 4 months) CG (no treatment)	Athletes significantly increased total energy, carbohydrate, and protein intake following the intervention.
Zeng et al. [24]	2020	NEI 15 males CG 15 males	NEI 16.7 ± 1.8 CG 16.8 ± 1.7	China	Soccer	Youth top	3-day food record	Nutrition education intervention NEI (F2F and comic book, once a week during 30 min, 4 weeks) CG (comic book)	No changes were observed in total carbohydrate, protein, and fat intake in NEI and CG following the intervention.

n: number; M: mean; SD: standard deviation; NEI: nutrition education intervention; CG: control group; F2F: face to face; KAP: nutrition knowledge, attitude and practice; SNK: sport nutrition knowledge; NCAA: National Collegiate Athletic Association.

Table 2. Characteristics and major findings of the studies analyzing the effect of nutrition education interventions on nutrition knowledge in team sport athletes.

Authors	Year	Sample Size (*n*)	Age (M ± SD Years)	Country	Sport	Competition Level	Questionnaire	Intervention (Modality, Frequency, and Duration)	Major Findings
Abood et al. [25]	2004	NEI (15 females) CG (15 females)	NEI (19.6 ± 1.0) CG (19.4 ± 1.2)	United States	NEI Soccer CG Swimming	College division I	Flesch-Kincaid Grade Level Index	Nutrition education intervention NEI (online, 8 × 1-h sessions, 8 weeks) CG (no treatment)	NEI athletes experienced a significant increase in nutrition knowledge and self-efficacy compared to CG.
Daniel et al. [40]	2016	10 females	17.2 ± 0.9	Brazil	Volleyball	Junior	KAP questionnaire	Interdisciplinary Food, Nutrition and Health Education Program (F2F, 8 sessions, 8 months)	NE athletes improved their nutrition knowledge from 57.0 ± 9.9% at baseline to 63.0 ± 11.8% following the intervention.
Elias et al. [26]	2018	NEI (52 males) CG (53 males)	NEI (18.7 ± 0.9) CG (23.3 ± 3.8)	Malaysia	NEI Field hockey and soccer. CG Cricket and rugby union	National	Jürgensen questionnaire	Sport education intervention activities NEI (F2F and online, 7 × 1.5-h sessions, 9 weeks) CG (no treatment)	NEI athletes showed significant increases (−6.21 ± 2.95 points) in nutrition knowledge after the intervention. Significant decrease (−2.15 ± 1.45 points) in nutrition knowledge after the intervention in the CG.
Patton-Lopez et al. [23]	2018	NEI (153 males and females) CG (64 males and females)	NEI (14.9 ± 0.9) CG (14.9 ± 0.9)	United States	Soccer	High school	SNK questionnaire	WAVE education program NEI (F2F, 7 sport nutrition lessons and 3 team building workshops, 1–1.5 h, 2 years) CG (no treatment)	NEI athletes significantly increased their nutrition knowledge scores from 5.16 ± 1.80 points at baseline to 6.09 ± 1.59 points after the 1-year intervention, while there were no changes in the CG.
Reading et al. [41]	1999	33 males	14.3 ± 3.6	Canada	Ice hockey	Youth	Modified version of SNAC questionnaire	Sport Nutrition for the Athletes of Canada (SNAC) (F2F, online and lectures, 4 × 1-h sessions, 2 weeks)	No changes in nutrition knowledge following the intervention.
Rossi et al. [32]	2017	15 females	19.3 ± 1.0	United States	Baseball	College division 1	Reilly and Maughan sports nutrition questionnaire	Nutrition education intervention (F2F, 3 times per week, 12 weeks)	NEI athletes significantly improved their nutrition knowledge from 54.7 ± 14.3% at baseline to 70.0 ± 9.4% following the intervention.

Table 2. *Cont.*

Authors	Year	Sample Size (*n*)	Age (M ± SD Years)	Country	Sport	Competition Level	Questionnaire	Intervention (Modality, Frequency, and Duration)	Major Findings
Simpson et al. [42]	2017	17 males	19.0 ± 0.7	New Zealand	Hockey	International and national	Zin et al. questionnaire of nutritional knowledge	Nutrition education intervention (online, once a week, 6 weeks)	NEI athletes significantly improved their nutrition knowledge from 56.7 ± 11.4% at baseline to 61.1 ± 11.5% following the intervention.
Valliant et al. [22]	2012	NEI 11 females CG 11 females	NEI 19.8 ± 1.0 CG 19.5 ± 1.0	United States	Volleyball	College division 1	Reilly and Maughan sports nutrition questionnaire	Nutrition education intervention NEI (F2F, 4 individual sessions, 4 months) CG (no treatment)	NEI athletes significantly increased their nutrition knowledge scores from 24.7 ± 5.9 points at baseline to 31.5 ± 6.1 points following intervention.
Zeng et al. [24]	2020	NEI 15 males CG 15 males	NEI 16.7 ± 1.8 CG 16.8 ± 1.7	China	Soccer	Youth top	KAP questionnaire	Nutrition education intervention NEI (F2F and comic book, once a week during 30 min, 4 weeks) CG (comic book)	NEI improved general and sports nutrition knowledges following the intervention.

n: number; M: mean; SD: standard deviation; NEI: sport nutrition education intervention; CG: control group; F2F: face to face; KAP: nutrition knowledge, attitude and practice; SNK: sport nutrition knowledge.

Table 3. Characteristics and major findings of the studies analyzing the effect of nutrition education interventions on body composition in team sport athletes.

Authors	Year	Sample Size (*n*)	Age (Mean ± SD)	Country	Sport	Competition Level	Parameter	Intervention (Modality, Frequency, and Duration)	Major Findings
Anderson et al. [29]	2010	Feedback (8 females) Baseline (8 females)	Feedback (20.1 ± 0.5) Baseline (19.3 ± 0.5)	United States	Volleyball	NCAA division II	Body mass Body fat (%)	Feedback regarding dietary intakes Feedback (F2F, at beginning, peak during, and following each season for two full seasons) Baseline (no treatment)	No changes in body mass and body fat percentage at beginning, peak, and following the season between the first season (no information given) and the second season (feedback).
Molina-López et al. [30]	2013	14 males	22.9 ± 2.7	Spain	Handball	Professional	Body mass Body mass index Body fat (%)	Nutrition education program (F2F, 3 phases, 5 months)	NEI athletes showed no changes in body mass index and body fat percentage following the intervention.

Table 3. *Cont.*

Authors	Year	Sample Size (*n*)	Age (Mean ± SD)	Country	Sport	Competition Level	Parameter	Intervention (Modality, Frequency, and Duration)	Major Findings
Rossi et al. [32]	2017	NEI (15 females) CG (15 females)	NEI (19.3 ± 1.0) CG (19.8 ± 1.4)	United States	Baseball	College division I	Body mass Body fat (%) Fat free mass Fat mass	Nutrition education intervention NEI (F2F, every 3 weeks, 12 weeks) CG (no treatment)	NEI athletes significantly decreased body fat percentage (−1.4 ± 2.2%) following the intervention compared to the CG (0.5 ± 2.6%). NEI athletes significantly decreased fat mass (−1.0 ± 2.0%) following the intervention compared to the CG (0.6 ± 1.4%).
Valliant et al. [22]	2012	NEI 11 females CG 11 females	NEI 19.8 ± 1.0 CG 19.5 ± 1.0	United States	Volleyball	College division 1	Fat free mass (%) Fat mass (%)	Nutrition education NEI (F2F, 4 individual sessions, 4 months) CG (no treatment)	NEI athletes and CG significantly decreased body fat percentage (~2%) and significantly increased fat-free mass percentage (~2%).
Wenzel et al. [33]	2012	NEI 10 females CG 29 females	NEI 19.8 ± NR CG 19.8 ± NR	United States	Volleyball	College division 1	Body mass Body fat (%)	Nutrition counselling NEI (F2F, once a month, 4 months) CG (no treatment)	NEI athletes significantly decreased their body fat percentage (~2%), while CG did not change.

n: number; M: mean; SD: standard deviation; NEI: sport nutrition education intervention; CG: control group; F2F: face to face education; F2F: face to face; NCAA: National Collegiate Athletic Association.

Table 4. Characteristics and major findings of the studies analyzing the effect of nutrition education interventions on physical performance in team sport athletes.

Authors	Year	Sample Size (*n*)	Age (M ± SD Years)	Country	Sport	Competition Level	Test	Intervention (Modality, Frequency and Duration)	Major Findings
Kavouras et al. [35]	2012	NEI (61 males and females) CG (31 males and females)	NEI (14.0 ± 4.8) CG (13.2 ± 2.3)	Greece	Volleyball and basketball	Youth	600-m run 30-m sprint Vertical jump Skill test	Hydration intervention plan NEI (F2F, 3 times per day, 10 days) CG (no treatment)	NEI athletes significantly decreased 600-m running time (−12.7 ± 1.5%) following the intervention.
Rossi et al. [32]	2017	NEI (15 females) CG (15 females)	NEI (19.3 ± 1.0) CG (19.8 ± 1.4)	United States	Baseball	College division I	5–10–5 shuttle run Vertical jump Broad jump Squat 1RM	Nutrition education intervention NEI (F2F, every 3 weeks, 12 weeks) CG (no treatment)	NEI athletes and CG significantly decreased 5-10-5 shuttle run time (−0.06 to −0.15 s), and significantly increased vertical jump height (5.1–6.6 cm) broad jump distance (9.9–12.0 cm), and 1 RM squat strength (20.0–27.7 kg). No significant ($p > 0.05$) interactions between NEI and CG for each performance variable.
Shoemaker et al. [34]	2019	Male (18) Female (25)	Male (16.6 ± 1.1) Female (16.1 ± 1.0)	United States	School-or club-sponsored sports	NR	Vertical jump Broad jump Agility test Push-up force	Sports nutrition curriculum (online, 7 sessions, 8 weeks)	Athletes increased vertical jump peak power (~13 $W \cdot kg^{-1}$), broad jump distance (~7 cm), and push-up force (~27 N) following the intervention.

n: number; M: mean; SD: standard deviation; NEI: sport nutrition education intervention; CG: control group; F2F: face to face education; RM: repetition maximum; NR: not reported.

Table 5. Methodologic quality of the included single-arm studies.

Study	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Score (/22)
Daniel et al. (2016) [40]	1	1	0	1	0	1	1	1	0	0	0	0			0	0	0	0	0					0	0	0	6
Molina-López (2013) [30]	1	1	1	1	1	1	1	1	0	0	0	0			1	1	0	1	1					0	1	0	12
Reading et al. (1999) [41]	1	1	1	1	1	1	1	1	1	0	1	1			1	1	1	1	0					0	1	0	16
Rossi et al. (2017) [32]	1	0	1	1	1	1	1	1	1	0	1	1			1	1	0	1	0					0	1	0	14
Shoemaker et al. (2019) [34]	1	1	1	1	1	1	0	1	1	0	0	1			1	1	0	1	1					0	1	0	14
Simpson et al. (2017) [42]	1	1	0	1	0	1	1	0	1	0	0	0			1	1	0	0	0					0	1	0	9
Valliant et al. (2012) [22]	1	1	1	0	0	1	1	1	1	1	0	0			1	1	0	0	0					0	1	0	11

1. Hypothesis stated (/1); 2. Outcome described (/1); 3. Characteristics described (/1); 4. Interventions described (/1); 5. Confounders described (/2); 6. Main findings described (/1); 7. Random variability described for main outcomes (/1); 8. Characteristics of athletes lost to follow-up reported (/1); 9. Actual probability reported (/1); 10. Biases and limitations considered (/1); 11. Representative of population (/1); 12. Participating subjects representative (/1); 13. Attempt to blind subjects (/1); 14. Attempt to blind main outcomes (/1); 15. Data dredging reported (/1); 16. Statistics used appropriate (/1); 17. Compliance with intervention reliable (/1); 18. Measurement tool accurate (/2); 19. Funding reported (/1); 20. Groups recruited from same population (/1); 21. Recruited over same time (/1); 22. Randomization (/1); 23. Intervention assignment concealed (/1); 24. Adjustment for confounding (/1); 25. Athletes lost to follow-up accounted for (/1); 26. Sufficient power (/1).

Table 6. Methodologic quality of the included double-arm studies.

Study	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Score (/28)
Abood et al. (2004) [25]	1	1	1	1	2	0	0	1	0	1	0	0	0	0	1	1	1	2	0	1	1	1	0	1	1	1	19
Anderson (2010) [29]	1	1	1	1	1	1	1	0	0	0	0	0	0	0	1	1	0	1	1	1	1	0	0	0	0	0	13
Elias et al. (2018) [26]	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	1	2	0	1	1	1	0	0	1	1	20
Kavouras et al. (2012) [35]	1	1	1	1	1	1	1	1	0	1	0	0	0	0	1	1	1	2	0	1	1	0	0	0	1	0	17
Patton-Lopez et al. (2018) [23]	1	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	0	1	1	1	1	0	0	0	0	1	17
Wenzel et al. (2012) [33]	1	1	1	1	1	1	1	0	0	1	0	1	0	0	1	1	1	2	1	0	0	0	0	0	0	0	15
Zeng et al. (2020) [24]	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1	1	1	2	1	1	1	1	0	0	1	0	21

1. Hypothesis stated (/1); 2. Outcome described (/1); 3. Characteristics described (/1); 4. Interventions described (/1); 5. Confounders described (/2); 6. Main findings described (/1); 7. Random variability described for main outcomes (/1); 8. Characteristics of athletes lost to follow-up reported (/1); 9. Actual probability reported (/1); 10. Biases and limitations considered (/1); 11. Representative of population (/1); 12. Participating subjects representative (/1); 13. Attempt to blind subjects (/1); 14. Attempt to blind main outcomes (/1); 15. Data dredging reported (/1); 16. Statistics used appropriate (/1); 17. Compliance with intervention reliable (/1); 18. Measurement tool accurate (/2); 19. Funding reported (/1); 20. Groups recruited from same population (/1); 21. Recruited over same time (/1); 22. Randomization (/1); 23. Intervention assignment concealed (/1); 24. Adjustment for confounding (/1); 25. Athletes lost to follow-up accounted for (/1); 26. Sufficient power (/1).

4. Discussion

The aim of our systematic review was to analyze the effects of nutrition education interventions on eating habits, nutrition knowledge, body composition, and physical performance in team sport athletes. The main results showed that implementation of nutrition education interventions consistently induced positive changes in eating habits and nutrition knowledge, as well as maintained or ameliorated body composition. Meanwhile the disparity of results across a limited number of studies exploring the effectiveness of education nutrition interventions implies further research is needed on this topic to draw definitive conclusions. These findings suggest the health and performance of team sport athletes from various backgrounds could benefit from nutrition education interventions as a complementary strategy to training routines.

4.1. Effects of Nutrition Education Interventions on Eating Habits

Balanced nutritional intakes combined with regular physical activity is advisable for optimal growth and health [44–46]. Additionally, balanced nutritional intakes are essential to ensure suitable nutrients are available to carry out essential systemic functions in the body, while nutrient deficiencies could influence growth and development as well as negatively affect physical performance in young athletes, and promote greater injury risk in all athletes [47]. Nutrient deficiencies can contribute to the development of certain health problems such as diabetes, obesity, sarcopenia, and osteoporosis [48,49]. In this regard, to improve eating habits by means of appropriate macronutrient and micronutrient intakes is convenient to optimize athlete performance during team sport competition, which could be assisted through nutrition education interventions. Our systematic review collated findings from 13 studies exploring the effects of nutrition education interventions on eating habits in team sport athletes, with ten studies showing total energy, carbohydrate, protein, and fat intakes and eating habits such as daily intake of fruits and vegetables as well as reporting trying to eat for performance were ameliorated in team sport athletes [22,25,26,29–33,40]. Additionally, nutrition education interventions provide team sport athletes with knowledge regarding the nutritional properties of food, which could lead to consumption of varied and balanced diets that provide essential nutrients to enhance performance and recovery. It should also be noted that some major limitations were apparent in one study observing nutrition education interventions to yield no changes in eating habits. In this sense, Patton-Lopez et al. [23] noted athletes in the control group declined the consumption of lunch (consuming lunch on less than five days per week) after the intervention, while athletes in the nutrition education intervention group did not change their consumption (consuming lunch on at least five days per week). NEI athletes were three times more likely to report trying to eat for performance, revealing that these athletes were motivated to learn and improve their diet behaviors and benefit from team-based nutrition interventions. Consequently, our review presents strong evidence demonstrating the effectiveness of using nutrition education interventions to improve eating habits in a diverse range of team sport athletes.

4.2. Effects of Nutrition Education Interventions on Nutrition Knowledge

Given greater nutrition knowledge is associated with better eating habits and physical conditioning status [50–52], it is relevant for nutrition specialists to ascertain whether nutrition education interventions enhance nutrition knowledge in team sport athletes. In turn, enhanced nutrition knowledge in team sport athletes may promote adoption of a more balanced diet, which could potentially optimize physical preparedness for competition [53]. In this sense, most studies (eight out of nine studies) in our systematic review demonstrated improvements in nutrition knowledge following nutrition education interventions in team sport athletes. Consequently, it appears that team sport athletes develop an understanding of key nutritional concepts following nutrition education interventions to make informed decisions regarding eating habits suited to their training and competition requirements. Contrarily, the study showing no changes in nutrition knowledge following a nutrition education intervention included the shortest intervention period among included studies

(i.e., 2 weeks), where 33 Canadian ice hockey athletes completed a sport nutrition workbook in a single-arm design [41]. Consequently, future studies should investigate whether longer nutrition education interventions using various modalities improve nutrition knowledge in ice hockey athletes. Considering the effectiveness of nutrition education interventions on nutrition knowledge across most studies, team sport coaching staff should prescribe additional educational strategies to optimize athlete understanding of nutrition to promote eating behaviors that optimize health and performance across the season.

4.3. Effects of Nutrition Education Interventions on Body Composition

Possessing optimal body composition is necessary to perform at a high standard during competition in team sports [28]. Given improved body composition can assist team sport athletes in obtaining better physical conditioning and, consequently, reduce injury risk [47,54], understanding whether nutrition education interventions can enhance body composition in team sport athletes is of interest to coaching staff, athletes, and nutrition specialists alike. All five studies examining the effects of nutrition education interventions on body composition in team sport athletes in our systematic review reported improvements in or maintenance of body composition following the intervention. Three studies showed fat mass to decrease [22,32,33] following nutrition education interventions lasting between 3 and 8 months. In contrast, two studies showed no variations in body composition variables (body mass, body mass index, fat mass, body fat percentage, and sum of skinfolds) following implementation of nutrition education interventions [29,30]. The lack of change in body composition detected in these studies may be attributed to the team sport athletes examined presenting with desired body composition variables at the time of baseline testing given athletes can be required to maintain appropriate physical condition across different seasonal phases to adequately cope with training and competition demands.

4.4. Effects of Nutrition Education Interventions on Physical Performance

Team sport athletes should undergo physical conditioning that enables them to meet the physical demands of competition [55] and mitigate the fatigue-related injury risk derived from poor conditions [56]. In this sense, a primary goal of team sport coaching staff is to optimize the physical preparedness of athletes for competition which could be ameliorated with appropriate nutritional intake. Thus, including nutrition education strategies during daily routines could be effective in assisting coaches and athletes in achieving this goal. Our systematic review only retrieved three studies analyzing the effects of nutrition education interventions on physical performance in team sport athletes, with disparity in the reported results due to variations in the characteristics of the athletes examined. In this sense, while some nutrition education strategies improved performance during specific fitness tests (i.e., 600-m running time), no change in performance was observed in other tests (i.e., vertical jump and strength tests). For example, Kavouras et al. [35] observed young volleyball and basketball players to improve 600-m running speed following a hydration intervention plan for 10 days, but no improvements were reported in 30-m linear sprint speed, vertical jump height, and skill performance. Similarly, another study assessing the efficacy of an online sports nutrition curriculum across 8 weeks showed improvements in change-of-direction speed and vertical jump height, with no variations in upper-body strength in male and female team sport athletes [34], while another study demonstrated improvements in change-of-direction speed and vertical jump height in female basketball athletes receiving face-to-face nutrition education for 12 weeks and controls [32]. Considering the mixed results regarding changes in physical performance following nutrition education interventions, further research is needed to build the evidence base for team sport athletes specific to sport modality, competition level, age, and sex to uncover the most appropriate nutrition education intervention to optimize physical performance in different contexts.

4.5. Limitations

This study contains some important limitations that should be considered when interpreting the reported effects of nutrition education interventions on eating habits, nutrition knowledge, body composition, and physical performance in team sport athletes. Firstly, it is difficult to establish a definitive consensus regarding specific nutrition education strategies that are most effective at enhancing eating habits, nutrition knowledge, body composition, and physical performance considering the wide range of athletes examined across studies encompassing different sports, ages, competition levels, and cultures. For these reasons, a meta-analysis was not permissible to undertake. Secondly, the small sample of athletes recruited in some studies should be considered when interpreting findings indicating the effectiveness of nutrition education strategies in team sport athletes across the literature. Thirdly, studies included in our review only analyzed physical performance using physical fitness testing, which does not represent actual in-game performance during team sport competition. Consequently, future studies are encouraged examining the effects of nutrition education interventions on in-game performance variables to provide evidence with greater ecological validity on this topic. Fourthly, 11 out of the 14 studies in our review had poor to fair methodological quality suggesting the methodological approaches of studies need to improve on this topic moving forward. Fifthly, the inclusion of athletes from different sports in the control group in some double-arm studies [25,26] should be considered when interpreting the associated results given the variations in physical attributes and nutritional needs that may exist between athletes from different sports [57]. Finally, body composition was measured with different approaches possessing varied validity and reliability across studies including anthropometry, air displacement plethysmography, and dual-energy x-ray absorptiometry, which should be considered when interpreting the findings presented. Future research should expand on the available body composition variables and explore the effects of nutrition education interventions on other variables such as bone mineral content.

5. Conclusions

Nutrition education interventions are an effective strategy to improve or maintain eating habits, nutrition knowledge, and body composition in team sport athletes when applied in addition to regular training routines. However, the effects of nutrition education interventions on physical performance in team sport athletes are not clear given the limited studies and mixed findings on this topic. Additionally, due to the heterogeneity across studies included in our review regarding the characteristics of the athletes examined (i.e., sport modality, competition level, age, and sex) and intervention strategies adopted (i.e., modality, frequency, and duration) it is difficult to establish optimal nutrition education interventions to adopt in specific contexts based on the existing literature.

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3.1.3 Tercera investigación

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Article

The influence of nutrition education intervention combined with FIFA11+ program on physical fitness attributes, physical activity behaviors, eating habits and nutritional knowledge in young basketball players

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Abstract:

The aim of this study was to analyze the effects of a nutritional education program combined with the FIFA 11+ program on physical fitness attributes, physical activity levels, food and nutritional habits and nutritional knowledge in young basketball players. Twenty-three under 14 elite basketball players (13 males and 10 females) belonging to a professional basketball academy participated in the study. Physical fitness attributes (countermovement jump [CMJ], drop jump [DJ], linear sprint, Lane Agility Drill, 505 change-of-direction, and repeated-change-of-direction [RCOD]), physical activity levels (Physical Activity Questionnaire for Adolescents, PAQ-A), eating and nutritional habits (Turconi questionnaire), and nutritional knowledge (modified version of the Turconi questionnaire) were assessed before and after the five months intervention period. Participants were involved in five nutrition education sessions and in a weekly session of the FIFA 11+ program. Pre-to-post differences revealed improvements in physical fitness attributes (i.e., CMJ, Lane Drill Test and RCOD time test [$p < 0.05$; effect size (ES) = 0.52 to -1.68]) and physical activity behaviors (PAQtotal and PAQ Lunch [$p < 0.001$; ES = 0.68-0.89]), as well as a maintenance of eating and nutritional habits and nutrition knowledge. In practical terms, the usual on-court and the implementation of nutrition education interventions combined with the FIFA 11+ improve physical fitness attributes and physical activity behaviors while favor the maintenance of eating and nutritional habits and nutrition knowledge in U14 elite basketball players.

Keywords: team sports; eating; diet; performance; health; adolescent.

1. Introduction

Basketball is a worldwide practiced team sport (Hulteen et al., 2017) which is highly demanding regarding technical, tactical, psychological and conditional variables (Montgomery et al., 2010) in all practice levels. In a conditional approach, a great amount of high intensity actions, such as jumps, sprints and change of directions, are required during a basketball match (Ziv & Lidor, 2009), which are determinant to achieve a great on-court competitive performance (ben Abdelkrim et al., 2007). In this sense, several factors such as a high rate of wellness state (i.e., sleep, stress, fatigue, muscle soreness…) as well as adequate eating habits are crucial to cope match demands in basketball players (Sánchez-Díaz et al., 2021). This could be a key factor for young players, since an inadequate physical condition together with nutritional deficits could affect both their sports career and their quality of life in adulthood (Mujika et al., 2018). For this reason, the application of strategies to optimize the physical condition and consumption habits of basketball players seems essential, favoring a holistic preparation of the athletes.

From a nutrition and dietetic point of view, nutrition education interventions are considered as a key factor for the team sport athletes' preparation (Sánchez-Díaz et al., 2020). These strategies could be defined as specific programs designed to assist targeted populations in acquiring relevant knowledge or adopting improved eating behaviors maintaining or improving health and enhancing athletic performance (Murimi et al., 2017). Among these strategies, there are some modalities, including personal interviews (Valliant et al., 2012), group activities (Patton-Lopez et al., 2018), comics (Zeng et al., 2020), interactive workshops (Patton-Lopez et al., 2018), or technological platforms (Abood et al., 2004). However, the effectiveness of each modality of nutrition education interventions needs to be analyzed to identify the most appropriate approach to each context. Specifically, Rossi et al. (2017) observed improvements in baseball players' eating habits and decrements in their body fat percentage using an educational intervention based on in face-to-face individual sessions. On the other hand, Zeng et al. (2020) applied a nutrition education intervention through comic books, increasing the nutrition knowledge in volleyball players. Finally, Shoemaker et al. (2019) achieved significant improvements in the physical performance (i.e., vertical jump, broad jump and push-up force) of team sport athletes after the application of an online sports nutrition curriculum. Despite this, to date, only one study (Kavouras et al., 2012) has been carried out with basketball players, although combined with volleyball players, so future studies on this topic are necessary, since this could provide value information to nutritionists to optimize the training process in this population.

Previous studies have shown the efficacy of different complementary

programs to daily training (e.g., high-intensity interval training, repeated sprint ability or power training programs) on the physical condition of young basketball players (Gonzalo-Skok et al., 2016; Padulo et al., 2015; Zeng et al., 2021). However, when designing or selecting such programs, the specific characteristics of team sports must be considered (e.g., congested schedule or high number of official matches) (Wing, 2018). In this sense, the FIFA 11+ program has shown great applicability in specific contexts of team sports athletes (al Attar & Alshehri, 2019; Lopes et al., 2020). Specifically, FIFA 11+ is a multi-exercises warm-up developed Medical Assessment and Research Center (F-MARC) in team sports to make injury-prevention and performance programs more accessible (Dvorak, 2005). Specifically, previous research has shown positive effects after the application of this program in team sport populations in both performance and injury prevention (Nawed et al., 2018; Nuhu et al., 2021), although references to basketball players are scarce. Regarding this, only one study (Longo et al., 2012) has been carried out with young basketball players, showing that the FIFA 11+ is effective in reducing the rates of injuries in this group. Given that the typology of this program has shown promising results and it allows its application as a warm-up prior to any training session without interfering with the subsequent content, it seems appropriate to analyze its effects on young basketball players.

Since the application of nutritional education strategies and the FIFA 11+ program isolated have shown benefits in different populations of team sports athletes but their application to basketball is scarce, it would be pertinent to apply a combined program consisting of both strategies in young basketball players. Therefore, the aim of this study was to analyze the effects of a nutritional education program combined with the FIFA 11+ program on physical fitness attributes, physical activity levels, food and nutritional habits and nutritional knowledge in young basketball players. Based on previous studies (Nawed et al., 2018; Rossi et al., 2017), we hypothesize that after the application of this combined program, basketball players will improve their physical performance, eating habits and nutritional knowledge.

2. Materials and Methods

Subjects — A convenience sample of twenty-three under 14 (U14) elite basketball players (13 males and 10 females, age: 13.1 ± 0.4 years, height: 164.6 ± 5.7 cm, body mass: 54.4 ± 9.9 kg, percentage of body fat: 19.4 ± 6.5%, percentage of muscle mass: 35.7 ± 4.7%, training experience: 5.5 ± 2.6 years) belonging to the same elite basketball academy (i.e., Spanish Asociación de Clubes de Baloncesto [ACB] League) were selected to participate in this study. All players were members of teams competing at the highest competitive level in Spain for the U14 age category and their on-court team training consisted on games-based and conditioning drills three times per week with each session typically lasting 75-90 min, as well as participating in one official match per week. Players were included in the study if they completed all fitness assessments, questionnaires, assisted to five nutrition education sessions and were free of injuries the two months prior to the experimental period. Additionally, players

who missed more than 20% of the sessions (i.e., on-court and additional sessions) over the five months intervention period were excluded from the final analysis. All participants and their legal guardians were informed about the procedures, potential risks, and benefits of the study before signing a written informed consent. The study was performed in accordance with the Declaration of Helsinki (2013) and approved by the Ethics Committee of the Universidad Isabel I (FUI1-007).

Design — A longitudinal study design was applied to analyze the effects of a nutritional education program combined with the FIFA 11+ program on eating habits, nutritional knowledge and physical fitness attributes in young basketball players. Before and after of the intervention period, players completed a basketball-specific fitness test battery including jumping tests [countermovement jump (CMJ) and drop jump (DJ)], linear sprint tests, Lane Agility Drill test, 505 change-of-direction (COD) test, and repeated change-of-direction (RCOD) sprint test. Prior to testing, all players performed a standardized warm-up consisting of running at a moderate intensity for five min, followed by five min of jumps performed at progressively increasing intensities, five min of dynamic stretching exercises, and three min of 20 m running bouts performed at increasing intensities. These tests were performed in a single session on an indoor basketball court (15–18 ◦C, 60–70% relative humidity), with five min of passive, standing recovery applied between tests. All tests were carried out three days following official competition in the afternoon between 16:00 h and 19:00 h. Also, before physical testing, players completed questionnaires regarding physical activity behaviors, nutritional habits, and nutritional knowledge on their own and not in the presence of peers. All of these questionnaires were be previously validated. During the five months intervention period, players completed five nutrition education sessions and performed one weekly session of the FIFA11+ program. Players were familiarized with the study protocol during training sessions across the month before the start of the study, including all physical fitness tests and questionnaires. Likewise, players were advised not to perform any physical exercise in the two days prior to testing and were given advice to ensure adequate hydration and nutritional status (avoiding the caffeine consumption or similar) upon arrival for testing. The experimental intervention took place during the in-season phase (October to February), in the afternoon (between 16:00 h and 19:00 h), of the 2020–2021 competitive season.

Physical fitness tests

Jumping tests — Players performed two trials each of the CMJ and DJ to assess the jump height (cm) through a photocell system (Optojump, Microgate™, Bolzano, Italy). Each jump trial was separated by 45 s of passive, standing recovery, and the highest jump was used for subsequent analysis in each test. During CMJ trials, players were instructed to perform a downward movement followed by a complete, rapid extension of the lower-limbs, maintaining their hands on their hips while jumping as high as possible (Heishman et al., 2020). For DJ trials, players were instructed to step from a wooden box (30 cm height) and immediately following ground contact, jump for maximal height as quickly as possible

(Marshall & Moran, 2013). In the current sample of players, the between-trial intraclass correlation coefficients (ICCs) for jump height attained during both tests was 0.97.

Linear sprint test — Players completed two trials of 20 m linear at maximal effort to assess linear speed, using four pairs of photoelectric cells (Polifemo, Microgate™, Bolzano, Italy) to record sprint split times sprints (i.e., at 5 m, 10 m, and 20 m). Each sprint trial was separated by 120 s of passive, standing rest. Players started each sprint 0.5 m before the first timing gate and upon their own volition. The fastest time (s) for each split (irrespective of the trial) was used for further analysis. In the current sample of players, the between-trial ICCs were 0.70, 0.67, and 0.75 for 5, 10 and 20 m sprint times.

Change-of-direction (COD) speed tests — The Lane Agility Drill test and the 505 COD test were used to assess COD time in players. For the first of them, basketball players followed the protocol previously used by (Raya-González et al., 2021), while in the second test, players completed the protocol described by (Castillo et al., 2021a). Two trials of each test with 90 s of passive were completed, and standing rest was applied between trials. A photocell timing gate (Polifemo, Microgate™, Bolzano, Italy) was used to determine the time employed to complete both tests, and the fastest trial was used for subsequent analysis in each test. The ICCs were 0.90 for the Lane Agility Drill test and 0.74 for the 505 COD test in the current sample of players.

Repeated change-of-direction (RCOD) sprint test — A single trial of the RCOD sprint test was administered. This test consisted in the repetition of 5 × 30 m shuttle sprints (15 m + 15 m) interspersed with 30 s of passive, standing recovery between each sprint. A single pair of photoelectric cells (Polifemo, Microgate™, Bolzano, Italy) were used to determine the time to cover each repetition. Players started 0.5 m before the first timing gate and sprinted for 15 m, before touching a line on the floor with their preferred foot and returning to the starting position as fast as possible (Castillo et al., 2021a). The sum of the 5 shuttle sprint times (total performance time during the RCOD sprint test) was calculated and used for subsequent analysis.

Questionnaires

The questionnaires were conducted following a typical week in which players maintained their normal daily routines involving attendance at school on five days, three on-court training sessions, and participation in an official match during the weekend.

Physical Activity Questionnaire for Adolescents (PAQ-A) — This questionnaire is composed by nine questions (5-point Likert scales) aiming to assess the physical activity behaviors of players outside of regular basketball training and competition across the entire week (i.e., Monday to Sunday) prior to testing. The first six questions in the questionnaire are related with the physical activity carried out in the last seven days during leisure time, during physical education classes, during specific times on school days (i.e., lunch, afternoon, and night), and during the weekend, while the last two questions are focused on the level of physical activity carried out during the week and how often physical activity occurred on each day of the week. The average of the scores obtained in the first eight questions is used as the PAQ-A final, being the last question used

to identify whether any circumstances that prevented usual physical activity occurred in the week analyzed. Transformation techniques were used to transform the raw data on a scale ranging from 0 to 100 (Müller et al., 2016). The PAQ-A was designed for and validated (ICC = 0.71 for total score) in males (n = 46) and females (n = 36) aged 13 to 18 years (Martínez-Gómez et al., 2009).

Dietary questionnaire. — A modified dietary questionnaire was applied to identify the nutritional habits and nutritional knowledge of players. This questionnaire was originally used by (Turconi et al., 2003), which was composed of 10 sections. However, we only used three sections (i.e., B, C, and H) following to (Sánchez-Díaz et al., 2021) in young basketball players. These sections were relevant for this study and thus used to assess player eating habits and nutritional knowledge. Transformation techniques were used to transform the raw data on a scale ranging from 0 to 100 (Müller et al., 2016).

Intervention

Nutrition education interventions — During the experimental period, five nutrition education sessions were applied (once per month). These sessions were conducted in a relaxed atmosphere by a nutrition and dietetics specialist, who designed all the nutrition education program. The sessions were performed face-to-face and online, combining theoretical information (i.e., slide show presentation and guided discussion) with several games. During these nutrition education sessions topics such as food groups (e.g., foods and nutrients), varied and balanced diet (e.g., recommended and usual portion), food typologies (e.g., fresh and processed) and nutritional labeling were discussed. The sessions had a mean duration of 60 min and were carried out prior to the basketball training session.

Physical activity intervention (FIFA 11+) — During the five months experimental period, a weekly session (i.e., 20 sessions) of FIFA11+ was performed by basketball players. Each FIFA11+ session lasted between 15 to 20 min and was conducted immediately after a general warm up and before the regular on-court basketball training sessions (60 min to 75 min). All FIFA11+ sessions were supervised by the strength and conditioning staff of the team, providing adequate feedback and cues for exercise and drill execution. During these sessions, players performed running, strength, plyometric and balance exercises, as proposed by (Dvorak, 2005). FIFA 11+ sessions were included within the basketball periodization as shown in Table 1 since this training program has improved the power performances (i.e., sprint and jumping) in basketball players (Nawed et al., 2018).

Table 1. In-season weekly program for the U-14 basketball teams.

	Day of the week						
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
		Duration: 70 min		*Duration: 80 - 90 min*	*Duration: 70 min*		
Training program	*Rest*	Warm-up: 15 min Free throw shooting: 10 min Technical training: 20 min Small sided games: 25 min	*Rest*	Warm-up: 15 min **FIFA 11+ session: 15 to 20 min** Tactical training: 20 min Simulated game: 30 min	Warm-up: 15 min Speed training: 10 min Small sided games: 15 min Tactical training: 20 min Shooting exercises: 10 min	*Match*	*Rest*

Note: Once a month on Tuesday nutrition education sessions topics were carried out during 60 min each.

Statistical Analysis — Data are presented as mean ± standard deviations (SD) for quantitative variables or frequencies and percentages for qualitative variables. Normal distribution of data was assessed by the Shapiro-Wilk test, and paired t-test or Wilcoxon rank sum test were used to examine differences in those quantitative variables regarding to physical fitness attributes, physical activity levels, eating habits and nutritional knowledge after the five months intervention period (Pre and Post). Also, McNemar test was applied to those dichotomous qualitative variables to examine the effect of the intervention program on the aforementioned variables. In addition, to analyze between-groups (i.e., male and females) differences after the intervention, an analysis of covariance (ANCOVA), assuming baseline values as covariates, was applied. Cohen's effect size (ES) was used for those quantitative variables which fulfilled the principle of normal distribution of data (Cohen, 1988), and eta square for those quantitative variables which did not fulfill the principle of normal distribution of data. The following scales was used to interpret magnitudes: <0.1, trivial; small, 0.11-0.30; intermediate, 0.31-0.50; and strong, >0.50 (Hopkins et al., 2009), and eta squared <0,25, 0,26–0,63 y >0,63, as small, intermediate and strong effects, respectively. Data analysis was carried out using the Statistical Package for Social Science (SPSS Statistics for Windows, version 25.0, IBM Corp., Armonk, N.Y., USA), with statistical significance set at $p < 0.05$.

3. Results

Changes in physical fitness attributes after 5-months period of nutrition education intervention and FIFA11+ training are shown in Table 2. Elite U14 basketball players improved significantly bilateral (CMJ: $p < 0.001$, strong) and unilateral (CMJRight: $p = 0.008$, strong; CMJLeft: $p = 0.040$, strong) jumps, COD (Lane Agility Drill test: $p < 0.001$, strong) and RCOD sprint test times ($p < 0.001 – 0.006$, strong). In addition, individual changes after 5-months period of nutrition education intervention and FIFA11+ training are presented in Figure 1 (A: CMJ; B: CMJRight; C: CMJLeft), Figure 2 (Lane Drill Test) and Figure 3 (A: RCOD sprint 1-5 tests; B: RCOD sum time test).

Table 2. Changes in physical fitness attributes after 5-month period of nutrition education intervention and FIFA11+ training in elite under 14 basketball players.

Variables	Before	After	p-value	Effect size, magnitude
Jump test				
CMJ (cm)	24.74 ± 5.62	27.70 ± 6.93	**<0.001**	0.89, strong
CMJ_{Right} (cm)	11.70 ± 3.03	13.62 ± 4.11	**0.008**	0.66, strong
CMJ_{Left} (cm)	12.66 ± 3.80	14.17 ± 4.29	**0.040**	0.52, strong
DJ (cm)	26.14 ± 6.39	26.97 ± 6.33	0.841	-0.06, trivial
Linear Sprint Test				
5 m sprint (s)	1.12 ± 0.08	1.19 ± 0.28	0.130	0.35, intermediate
10 m sprint (s)	2.00 ± 0.14	2.00 ± 0.14	0.908	0.03, small
20 m sprint (s)	3.46 ± 0.40	3.56 ± 0.26	0.159	0.37, intermediate
Change of Direction Ability (CODA) test				
Lane Agility Drill (s)	15.31 ± 1.00	14.29 ± 0.81	**<0.001**	-1.68, strong
505-COD (s)	2.68 ± 0.20	2.63 ± 0.17	0.166	-0.32, intermediate
Repeated change-of-direction (RCOD) sprint test				
RCOD sprint test time (s)	34.13 ± 2.06	33.23 ± 1.75	**<0.001**	-1.13, strong
RCOD-1	6.64 ± 0.40	6.58 ± 0.36	0.266	-0.26, small
RCOD-2	6.83 ± 0.42	6.63 ± 0.36	**0.006**	-0.67, strong
RCOD-3	6.88 ± 0.43	6.70 ± 0.38	**0.001**	-0.85, strong
RCOD-4	6.91 ± 0.46	6.67 ± 0.35	**<0.001**	-1.57, strong
RCOD-5	6.88 ± 0.42	6.66 ± 0.44	**<0.001**	-0.95, strong

Bolded p-value indicates statistical significance at $p < 0.05$.

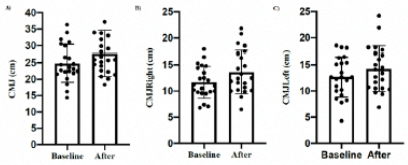

Figure 1. Individual changes after 5-months period in A) CMJ; B) CMJRight; C) CMJLeft.

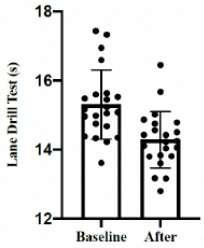

Figure 2. Individual changes after 5-months period in Lane Drill Test.

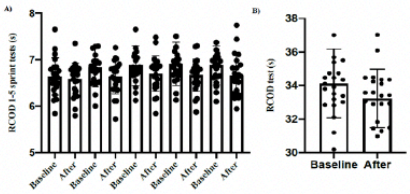

Figure 3. Individual changes after 5-months period in A) RCOD sprint 1-5 tests; B) RCOD sum time test.

Regarding to physical activity behaviours, PAQtotal and type of physical activity before and after lunch across the last 7 days (PAQ3 Lunch) was improved significantly after 5-months period of nutrition education intervention and FIFA11+ training in elite under 14 basketball players (Table 3).

Table 3. Changes in Physical Activity Questionnaire for Adolescents (PAQ-A) after 5-month period of nutrition education intervention and FIFA11+ training in elite under 14 basketball players.

	Baseline	After	p-value	Effect size, magnitude
$PAQ1_{mean}$ Activities	0.54 ± 0.35	0.63 ± 0.54	0.186	0.33, intermediate
PAQ2 Physical	81.53 ± 15.48	81.82 ± 23.38	1.000	0.03, trivial
Education PAQ3 Lunch	10.87 ± 19.69	27.27 ± 32.67	**0.009**	0.89, strong
PAQ4 4-6 pm	47.83 ± 33.64	53.41 ± 32.09	0.275	0.25, small
PAQ5 6-10 pm	48.91 ± 27.67	59.09 ± 25.05	0.189	0.30, small
PAQ6 Weekend	48.91 ± 26.63	48.86 ± 30.35	0.881	-0.03, trivial
PAQ7 Week intensity	30.44 ± 21.26	48.86 ± 27.25	0.055	0.46, intermediate
$PAQ8_{mean}$ Diary	2.04 ± 0.42	2.36 ± 0.62	0.085	0.43, intermediate
frequency PAQ_{total}	1.65 ± 0.48	1.97 ± 0.48	**0.009**	0.68, strong

$PAQ1_{mean}$ Activities, Frequency of physical activities during leisure time across the last 7 days; PAQ2 Physical education, Frequency of being physically active during physical education sessions at school across the last 7 days; PAQ3 Lunch, Type of physical activity before and after lunch across the last 7 days; PAQ4 4–6 pm, Frequency of being physically active immediately after school during the last 7 days; PAQ5 6–10 pm, Frequency of being physically active between 6 and 10 pm across the last 7 days; PAQ6 Weekend, Frequency of being physically active during the last weekend; PAQ7 Week intensity, Weekly frequency of performing physical activity in leisure time; $PAQ8_{mean}$ Diary frequency, Frequency of daily physical activity for each day of the week; PAQ_{total}, Total score obtained across the first eight questions in the questionnaire; Paired t-test was applied to total score and Wilcoxon rank sum test to questions 1 and 8, which contain data presented as mean ± standard deviation, while McNemar test were applied to all other questions which contain data presented as percentages. Bold value indicates significance at $p < 0.05$.

No significant changes ($p > 0.05$) were detected after 5-months period of nutrition education intervention and FIFA11+ training (Supplementary Tables) in elite under 14 basketball players in food habits (section B) and nutritional (section C) habits, and nutrition knowledge (section H) using the modified version of Turconi questionnaire (Sánchez-Díaz et al., 2021).

Additionally, no significant differences between gender groups after the intervention were observed ($p > 0.05$).

4. Discussion

Previous studies have shown the effectiveness of applying nutrition education programs and the FIFA 11+ program isolated in different populations of team sports athletes but scarce literature has focused in basketball players (Sánchez-Díaz et al., 2020) so it would be pertinent to analyze the influence of both strategies in a combined program. Therefore, the aim of this study was to analyze the effects of a nutritional education program combined with the FIFA 11+ program on physical fitness attributes, physical activity behaviors, eating habits and nutrition knowledge in elite U14 basketball players. The main results obtained have shown that the usual on-court training and the implementation of nutrition education interventions combined to the FIFA 11+ program consistently induced positive changes in physical fitness attributes (i.e., CMJ, Lane Drill Test and RCOD time test) and improved physical activity behaviors (PAQ_{total} and PAQ Lunch). Otherwise, a maintenance of eating and nutritional habits and nutrition knowledge was observed in elite U14 basketball players.

One of the main goals of strength and conditioning specialists of team sports athletes (e.g., basketball) is to ensure that players meet the physical requirements of competition (Castillo et al., 2021b) and to mitigate the fatigue-related injury risk in order to optimize the physical performance and increase players' availability (Mujika et al., 2018). So that, the inclusion prevention training routines as well as the improvement of nutritional intake behaviors could optimize the preparedness of basketball players for competition (Sánchez-Díaz et al., 2021). Our results indicated that elite U14 basketball players enhanced their physical fitness attributes in terms of bilateral and unilateral CMJ height, time spent in Lane Agility Drill test, and RCOD sprint test times after the 5-months in which the nutrition education interventions and FIFA11+ program were applied. This is the first investigation analyzing the effect of combined nutrition education interventions and physical conditioning program on physical fitness, although previous studies including these nutritional and training strategies in an isolated way showed controversial results attending to team sports athletes. In this sense, Kavouras et al. (2012) and Shoemaker et al. (2019) observed improvements in physical fitness in team sport players (i.e., endurance and jump abilities) after the application of several nutrition education interventions. Conversely, in the study conducted by Rossi et al. (2017) no significant differences were observed comparing the intervention group (i.e., nutrition education intervention) with their counterparts belonging to the control group. In addition, Nawed et al. (2018)

observed enhances in several attributes of physical performance in soccer players after the application of the FIFA11+ program. Attending to the aforementioned results, these findings suggest that the physical fitness attributes in young basketball players could be improved by the inclusion of a combined program based on nutrition education interventions and the FIFA11+ training to the usual on-court training. Nevertheless, future studies could investigate the effectiveness of these strategies adding a control group although it would be difficult to find high-level young basketball teams and the sample for each group would be low.

In addition to the effects on physical fitness, it is also of great interest to know the influence of the purposed intervention on the level of practice outside the sports context due to its positive effects on athletic performance (Mujika et al., 2018). As such, the results of our study showed that elite U14 basketball players ameliorated the sum of scores in PAQ_{total} questionnaire and the type of physical activity before and after lunch across the last seven days after 5-months period of nutrition education intervention and FIFA 11+ training. Since this is the first investigation carried out in young basketball players considering this specific variable (i.e., PAQ), our results are not comparable with those obtained in previous studies. However, we hypothesize that the improvements obtained could be due to the fact that with the knowledge contributed during nutrition education interventions they influence healthy lifestyle habits in a multifactorial way, including physical activity outside. In addition, the fact of including specific conditioning programs in training routines (i.e., the FIFA 11+ program) can favor the creation of sports habits in young athletes. Therefore, the inclusion of nutrition and prevention training interventions in daily routine of elite basketball academies could be justify due to the positive influence found on equating the practice of physical activity in wider social contexts.

Conversely, our results did not report significant changes in food habits (section B) nutritional habits (section C) and nutrition knowledge (section H) using the modified version of Turconi questionnaire (Sánchez-Díaz et al., 2021) after 5-months period of nutrition education intervention combined with the FIFA 11+ training program in elite U14 basketball players. A priori, these results could be surprising, however, previous studies have already reported the existing controversy, mainly attributed to the intervention's modality, frequency and duration (Sánchez-Díaz et al., 2020). Although some studies have showed modifications in carbohydrate, protein, fat and/or total energy intakes after nutrition education interventions in team sports athletes (Elias et al., 2018; Molina-López et al., 2013; Valliant et al., 2012; Wenzel et al., 2012), other studies reported no significant changes in nutritional intakes (Anderson, 2010; Patton-Lopez et al., 2018; Zeng et al., 2020) in experimental groups. Additionally, the participants of our study are minors and, normally, they depend on their parents/guardians. That is, the players do not buy the food, nor do they cook it, and probably some of them eat at high school. Consequently, it can be said that they do not have the ability to change if their parents /

guardians do not change. Perhaps, this fact may have influenced the results obtained and it could be interesting to design workshops aimed at parents / guardians on appropriate nutritional behaviors in young people. Attending to nutritional knowledge, no improvements in scores of section C of Turconi questionnaire could be explained by modality of interventions (i.e., online) as occurred in the study of Reading et al. (1999) in which no changes in nutrition knowledge were detected following the intervention applied in youth ice-hockey players using the modified version of SNAC questionnaire, or indeed by age of participants. Despite the reported results, it is suggested to include nutrition education interventions in daily routines because could provide relevant knowledge for team sport athletes, regarding the nutritional properties of food and nutritional knowledge, which could lead to consumption of varied and balanced diets that provide essential nutrients to enhance performance and recovery. However, it could more appropriate to include higher frequency and time-period as well as face-to-face modalities.

This study is not exempt of limitation being the main one the sample size recruited in the study, since only elite U14 basketball players were part of the sample. Accordingly, future studies should expand on this work examining larger samples of players from other age categories and competitive-levels of play (i.e., international). In addition, it would be interesting to analyze potential sex differences in the effects of combined nutrition education interventions and FIFA 11+ training. Also, although many studies imply only one experimental group (single-arm design), it would be interesting to know the effects on physical fitness attributes, physical activity behaviors, eating and nutritional habits and nutrition knowledge following a double-arm design. In addition, since the physical fitness has been assessed by the specific tests, it would be adequate to analyze the in-game performance during basketball competition. Consequently, future studies are encouraged examining the effects of combined nutrition education interventions and prevention strategies on in-game performance variables to provide evidence with greater ecological validity on this topic.

5. Practical Applications.

In practical terms, the inclusion of nutrition education interventions combined with the FIFA 11+ program must be implemented in basketball academies environment not only to improve the players performance, but also to improve their quality of life in terms of physical activity behaviors.

6. Conclusions

The results of this study have shown positive changes in physical fitness attributes (i.e., CMJ, Lane Drill Test and RCOD time test) and improved physical activity behaviors (PAQtotal and PAQ Lunch), as well as a maintenance of eating and nutritional habits and nutrition knowledge in elite U14 basketball players after a 5-months period based on the combined implementation of nutrition education interventions with the FIFA 11+ training program. However, no gender differences in response to the intervention were found.

Supplementary Materials: The following are available online at http://eurjhm.com/index.php/eurjhm, Table

S1: Changes in food habits after 5-month period of nutrition education intervention and FIFA11+ training in elite under 14 basketball players, Table S2: Changes in nutritional habits attributes after 5-month period of nutrition education intervention and FIFA11+ training in elite under 14 basketball players, Table S3: Changes in nutritional knowledge after 5-month period of nutrition education intervention and FIFA11+ training in elite under 14 basketball players.

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