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EVALUACIÓN Y DESARROLLO DE LA CONDICIÓN FÍSICA EN NIÑOS PREESCOLARES

PRESENTADA POR:
DAVID JOSÉ MORA LÓPEZ

DIRIGIDA POR:
DR. D. PEDRO ÁNGEL LATORRE ROMÁN
DR. D. FELIPE GARCÍA PINILLOS

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Dedicatoria

A Mario y Elena,
por enseñarme los más simples y esenciales valores de la vida:
jugar, reír, trabajar, esforzarse, respetar, compartir.

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EVALUACIÓN Y DESARROLLO DE LA CONDICIÓN FÍSICA EN NIÑOS PREESCOLARES

EVALUATION AND DEVELOPMENT OF PHYSICAL FITNESS IN PRESCHOOL CHILDREN

David José Mora López

DIRECTORES DE TESIS

DR. Pedro Ángel Latorre Román
PhD
Profesor de la Universidad de Jaén

DR. Felipe García Pinillos
PhD
Profesor de la Universidad de Jaén

El **Doctor D. Pedro Ángel Latorre Román**, profesor Contratado Doctor, del Departamento de Didáctica de la Expresión Musical, Plástica y Corporal, de la Universidad de Jaén.

CERTIFICA:

Que la Tesis Doctoral presentada por Don David José Mora López**,** con el título: ***EVALUACIÓN Y DESARROLLO DE LA CONDICIÓN FÍSICA EN NIÑOS PREESCOLARES*** ha sido realizada bajo mi dirección. Considero que el trabajo reúne las condiciones científicas necesarias, siendo expresión de la capacidad investigadora e interpretativa de su autor en condiciones que le hace merecedor del título de Doctor, siempre y cuando así lo estime oportuno el tribunal.

En Jaén a 16 de Mayo de 2017

Fdo. Prof. Dr. D. Pedro Ángel Latorre Román

El **Doctor D. Felipe García Pinillos**, profesor sustituto interino, del Departamento de Didáctica de la Expresión Musical, Plástica y Corporal, de la Universidad de Jaén.

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Fdo. Felipe García Pinillos

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LISTA DE PUBLICACIONES

La presente memoria de Tesis Doctoral está compuesta por los siguientes artículos científicos:

I. Mora López, D.J., García Pinillos, F., Latorre Román, P.A. (2017). Actividad física, condición física y salud en niños preescolares. Estudio de revisión narrativa. *EmásF: Revista Digital de Educación Física* (45), 105-123

II. Latorre-Román, P. Á., Mora-López, D.J., Fernández-Sánchez, M., Salas-Sánchez, J., Moriana-Coronas, F. & García-Pinillos, F. (2015). Test-retest reliability of a field-based physical fitness assessment for children aged 3-6 years. *Nutricion hospitalaria*, *32*(n04), 1683-1688.

III. Latorre-Román, P. Á., García-Pinillos, F. & Mora-López, D.J. (2016). Reference Values of Standing Long Jump in Preschool Children: A Population-Based Study. *Pediatric exercise science*, 1-15.

IV. Latorre-Román, P. Á., Mora-López, D.J., Martínez-Redondo, M. & García-Pinillos, F. (2016). Reference values for running sprint field tests in preschool children: A population-based study. *Gait & Posture*.

V. Latorre, P.A., Mora, D.J., Berrios, B., Robles, A., García, F., Martínez, M. (2017). Handgrip strength is associated with anthropometric variables and sex in preschool children: A cross-sectional study providing reference values. *Physical Therapy in Sport. In press.*

VI. Latorre-Román, P. Á., Mora-López, D.J., Robles Fuentes, A. & García-Pinillos, F. (2017). Reference Values of Static Balance in Preschool Children: A Population-based Study. *Perceptual and Motor Skill*.

VII. Latorre Román, P. Á., Moreno del Castillo, R., Lucena Zurita, M., Salas Sánchez, J., García-Pinillos, F., & Mora López, D.J. (2016). Physical fitness in preschool children: association with sex, age and weight status. *Child: care, health and development*. (43*)* 267–273

VIII. Latorre-Román, P. Á., Mora-López, D.J., & García-Pinillos, F. (2016). Feeding practices, physical activity, and fitness in Spanish preschoolers. Influence of sociodemographic outcome measures. *Arch Argent Pediatr*, *114*(5), 441-447.

IX. Latorre-Román, P. Á., Mora-López, D., & García-Pinillos, F. (2016). Intellectual maturity and physical fitness in preschool children. *Pediatrics International*, *58*(6), 450-455.

X. Latorre-Román, P. Á., Mora-López, D.J., & García-Pinillos, F. Effects of a physical activity programme in the school setting on physical fitness and intellectual maturity in preschool children. *Child: care, health and development*. *Submitted.*

RESUMEN

La edad preescolar es un momento idóneo para establecer hábitos de nutrición y de actividad física (AF) adecuados que podrán persistir en la edad adulta, siendo un periodo crítico para la prevención de la obesidad, la cual se asocia con consecuencias para la salud. Según el currículum de esta etapa, está contemplado que se realicen sesiones o partes de la misma dedicadas al ejercicio físico y al juego. En la realidad, no es suficiente el tiempo que se le está dedicando a la AF por lo que se pueden estar perdiendo importantes efectos beneficiosos para los niños.

El objetivo de esta Tesis Doctoral es desarrollar un protocolo de evaluación de la condición física (CF) en niños preescolares, estableciendo las referencias normativas al respecto, analizar el nivel de CF en edad infantil, así como los factores que la determinan y estudiar el efecto de la incorporación de un programa de AF en las sesiones ordinarias de Educación Infantil.

Para poder alcanzar estos objetivos, hemos desarrollado diez estudios que dan dado lugar a otros tantos artículos, y han ayudado a justificar y fundamentar esta Tesis y sus resultados. Los artículos citados son los que siguen a continuación: i) Actividad física, CF y salud en niños preescolares. Estudio de revisión narrativa (paper I); ii) La fiabilidad test-retest de una evaluación de la CF en niños de 3-6 años (paper II); iii) Valores de referencia del salto horizontal en niños en edad preescolar: un estudio de base poblacional (paper III); iv) Valores de referencia para la ejecución de pruebas de campo de sprint en niños en edad preescolar: Un estudio poblacional (paper IV); v) La fuerza de prensión la mano asociada con variables antropométricas y sexo en niños en edad preescolar: Un estudio transversal que proporciona valores de referencia (paper V); vi) Valores de referencia del equilibrio estático en niños en edad preescolar: estudio basado en una población (paper VI); vii) Condición Física en niños preescolares: asociación con sexo, edad y estado ponderal (paper VII) ; viii) Prácticas de alimentación, AF y CF en niños españoles en edad preescolar. Influencia de las medidas sociodemográficas (paper VIII); ix) Madurez intelectual y CF en niños en edad preescolar (paper IX); x) Efectos de un programa de actividad física en el entorno

escolar sobre el estado físico y la madurez intelectual en los niños en edad preescolar (paper X).

De todos estos estudios que fundamentan la Tesis, podemos extraer los siguientes resultados:

A) La prevalencia de AF en preescolares es baja y no cumplen las recomendaciones internacionales, lo cual se asocia a una creciente prevalencia de sobrepeso y obesidad.
   - los niños de esta etapa tienen niveles bajos de actividad física, por debajo de las recomendaciones internacionales, lo cual afecta a su CF y su salud actual, y previsiblemente en su etapa de adolescencia y de adultos.
   - La escuela es un espacio esencial para la promoción de la actividad física y mejora de la CF y la salud.
   - Serían recomendables proyectos educativos para los niños, dirigidos a fomentar hábitos de actividad física y nutrición adecuados, así como el uso de baterías de test que se han validado para esta población, para conocer su nivel de CF y poder intervenir adecuadamente.

B) La batería de CF diseñada para esta tesis en niños preescolares ha obtenido parámetros de adecuados de fiabilidad, fácil utilización y comprensión por los niños. Las pruebas utilizadas fueron seguras, fáciles de realizar, muy aceptables y comprensibles para los niños.

C) En la prueba de salto horizontal, los niños mostraron un mayor rendimiento que las niñas de 3 a 5 años de edad, pero no se encontraron diferencias significativas a los 6 años de edad. En todo el grupo, el rendimiento fue mayor con el aumento de la edad. Sin embargo, no se encontraron diferencias significativas entre los niños de 5 y 6 años.

D) Los niños son más rápidos que las niñas de 3 a 5 años de edad, pero no se encontraron diferencias significativas a los 6 años de edad. En relación con la edad, el tiempo de sprint fue más corto cuando los niños son mayores.

E) Los niños mostraron una mayor fuerza de prensión manual que las niñas en los grupos de 4 y 5 años, pero no se encontraron diferencias significativas a los 3 y 6 años.

F) Las niñas exhibieron una puntuación más alta que los varones, en la prueba del equilibrio, con su pierna derecha, mientras que no se encontraron diferencias sexuales significativas para la pierna izquierda. En relación con la edad, las niñas exhibieron un mayor rendimiento que los niños a los cuatro años y un peor rendimiento a los seis años.

G) Los niños mostraron una mayor resistencia cardiorrespiratoria, tiempo de reacción, fuerza y velocidad de marcha. Encontramos diferencias por sexo en los diferentes grupos de edad (3, 4, 5 y 6 años).
Las diferencias sexuales en la CF son evidentes a una edad temprana. La relación entre la CF y el índice de masa corporal (IMC) es inconsistente en los niños en edad preescolar. La mejora del rendimiento de la CF y su asociación con la AF, es determinante para la salud de los niños, particularmente en la prevención de la obesidad.

H) Los niños preescolares de este estudio presentaron valores elevados de sobrepeso y obesidad y bajo nivel de AF, teniendo en cuenta las referencias internacionales. Las niñas mostraron una CF inferior a la de los varones. Los niños cuyos padres presentaron un nivel socioeconómico bajo y sin estudios, mostraron un nivel nutricional precario.

I) Desde una edad temprana, el rendimiento físico-motor y la madurez intelectual están vinculados. La CF es capaz de predecir la madurez intelectual. Aumentar la cantidad de tiempo dedicado a la educación física puede promover beneficios cognitivos en niños preescolares.

J) No hubo diferencias significativas en ninguna variable en el pretest entre los grupos, en las distintas pruebas del estudio: prueba de dibujo (GHDT), salto horizontal, equilibrio, sprint y resistencia (10x20 m) En el postest, el EG logró mejores resultados en salto horizontal y sprint. En relación con las diferencias entre el pretest y postest, el EG mostró un mayor incremento en salto horizontal, sprint, resistencia, y madurez intelectual

Conclusión final

La prevalencia de actividad física en preescolares es baja y no cumplen las recomendaciones internacionales, lo cual se asocia a una creciente prevalencia de sobrepeso y obesidad. Dentro de los correlatos que determinan la práctica de AF en preescolares destacamos la AF de los padres. La CF puede ser un biomarcador de salud en edades tempranas, por lo que su análisis es esencial en niños preescolares. En este estudio se han aportado datos de fiabilidad de una batería de pruebas para analizar la CF en estas edades. Existen diferencias significativas entre sexos en CF ya en una corta edad y las referencias normativas en relación con los diferentes componentes de la CF son necesarias. Destacar la influencia de las variables sociodemográficas en la CF y la relación de ésta con la madurez intelectual. En esta tesis, un programa de intervención de AF en las clases de Educación Infantil mejora la CF y la madurez intelectual.

ABREVIATURAS

6MWT	6-minute walk test
AF	Physical activity
ANCOVA	Analysis of covariance
ANOVA	Analysis of variance
CEIP	Centro de Ed. Infantil y Primaria.
CF	Physical condition
CG	Control group
CI	Confidence interval
CI	Correlation index
TD	Typical deviation
EG	Experimental group
FMS	Fundamental motor skills
GHDT	Goodenough Harris drawing test
HS	Handgrip strength
ICC	Intraclass correlation coefficients
IMC	Índice de masa corporal
IPAQ	International Physical Activity Questionnaire
IPAQ-SF	International Physical Activity Questionnaire - Short Form
MVPA	Moderate-to vigorous physical activity
PA	Physical Activity
RDT	Ruler Drop Test
RFEA	Spanish Athletics Federation
RT	Reaction time
SBST	Stork Balance Stand *Test*
SD	Standard deviation
SLJ	Standing Long Jump

INTRODUCCIÓN

Actividad física en niños preescolares

Los hábitos asociados con la AF y con un estilo de vida activo representan un factor significativo que afecta favorablemente a la salud de un individuo (Kvintová y Sigmund, 2016). Edwy (2015) afirma que la mayor conciencia de las relaciones entre la AF y la salud puede influir en el estilo de vida de los sujetos, y al mismo tiempo, aumentar positivamente su motivación. Esta relación entre AF y salud, se ha señalado en estudios previos (Fagaras, Radu y Vanvu, 2015; Pedišić, Rakovac, Titze, Jurakić, & Oja, 2014).

Identificar las maneras de promover la AF y disminuir el tiempo sedentario durante la infancia es un problema clave de salud pública, sin embargo, la investigación sobre las influencias de la AF de los niños en edad preescolar y el comportamiento sedentario es limitada y ha producido resultados inconsistentes (Schmutz et al. 2017).

La infancia es un momento esencial para la promoción de hábitos de vida saludables como la AF y la evitación de comportamientos sedentarios (Jones, Hinkley, Okely y Salmon, 2013). Sin embargo, varios estudios han demostrado que la AF de los niños en edad preescolar es moderadamente baja (Grzywacz et al. 2014; IP et al. 2016; Tucker, 2008) no cumpliendo con las recomendaciones de AF (Palmer et al 2016). En este sentido, el estilo de vida sedentaria a esta edad es elevado (De Bock, Genser, Raat, Fischer y Renz-Polster, 2013). Según O'Dwyer et al. (2014), los niños manifiestan mayores niveles de moderada y vigorosa AF que las niñas, aunque todos los niños no acumulan suficiente AF para obtener beneficios para la salud. Además, los niños con sobrepeso son significativamente menos activos que sus pares sin exceso de peso durante el día preescolar, aunque no se observan diferencias significativas en las niñas (Trost, Sirard, Dowda, Pfeiffer y Pate, 2003). Por otro lado, Grøntved, et al. (2009) destacan que los niños invierten una proporción significativamente mayor del tiempo en la AF moderada y vigorosa, y presentan un nivel total más alto de AF en comparación con las niñas; además, los niños de 3-4 años de edad emplean menos tiempo en AF moderada y vigorosa, y manifiestan un nivel total menor de AF en comparación con los niños de 4-5 años y los niños de 5-6 años. Por tanto, el sexo y la edad son fuertes predictores de la AF en niños preescolares. Tucker's (2008) en una revisión sistemática sobre los niveles de AF de los niños en edad preescolar (2-6 años) señala a treinta y nueve estudios primarios (publicados 1986-2007) que representan un total de 10.316 participantes (5.236 varones y 5.080 mujeres), procedentes de siete países y donde se describen si las conductas de AF de esta población se consideran de acuerdo con la pautas de AF para los niños preescolares (NASPE). Las recomendaciones actuales sugieren un mínimo de 60 minutos de AF por día y sólo el 54% de los participantes logró este nivel de práctica. Se desprende de esta revisión, que casi la mitad de los niños estudiados no cumplen con las pautas recomendadas para la AF. Por lo tanto, las intervenciones efectivas que promuevan y fomenten la AF en los niños, son necesarias. Sin embargo, una pauta más objetiva de la AF para los niños en edad preescolar es importante, por lo que la medición de la AF tiene que ser más unificada para comparar y seguir la actividad de forma más efectiva. En este sentido, uno de los inconvenientes para analizar el nivel de AF de los niños preescolares se centra en el tipo de registro realizado. La acelerometría es una tecnología que permite registrar de manera precisa los niveles de AF diaria y ha sido ya empelada en preescolares (Beets, Bornstein, Dowda y Pate, 2011; Burgi et al 2011; Puder et al., 2011) pero los resultados señalan una gran variabilidad e interpretaciones confusas entre estudios (Bornstein, Beets, Byun y McIver, 2011), además de las dificultades añadidas para el uso de este instrumental en niños de esta edad.

Existen limitados estudios que analicen los posibles correlatos de la AF asociada con el crecimiento y la madurez (con la excepción del índice de masa corporal, IMC), la CF y el dominio de las habilidades de movimiento (Malina y Katzmarzyk, 2006), especialmente en los niños en edad preescolar. Algunos factores no modificables como el sexo y la edad, y otros modificables como los ingresos familiares y el tiempo de los niños al aire libre, se correlacionan con la AF moderada y vigorosa, y con los niveles de sobrepeso y obesidad. Así, el conocimiento de estos factores puede ser útil en el diseño y la orientación de las intervenciones para disminuir la cantidad de tiempo sedentario y aumentar la cantidad de AF moderada y vigorosa en los niños pequeños (Dolinsky et al. 2011).

Hay otros factores más o menos susceptibles de modificación, que se han asociado al sobrepeso y la obesidad en niños preescolares: el IMC materno y paterno afecta al IMC en la primera infancia, pero el efecto general del IMC materno era más fuerte que el paterno, una mayor ganancia de peso durante la gestación en madres sin sobrepeso y obesidad se relaciona con el riesgo de sobrepeso en la infancia temprana (Gaillard et al. 2013); además, la duración del sueño diario de menos de 12 horas durante la infancia parece ser un factor de riesgo para el sobrepeso y la obesidad en los niños en edad preescolar (Taveras, Rifas-Shiman, Oken, Gunderson, y Gillman, 2008). Según Van Stralen et al. (2012), existe una asociación positiva entre el comportamiento sedentario (principalmente el tiempo de uso de pantallas, televisión, ordenadores, móviles, etc.) con el IMC y la circunferencia de la cintura. Según Hinkley et al. (2008), los niños con padres activos tendían a ser más activos. En este sentido, recientemente Abbott et al. (2016) muestran que los hábitos de AF y uso de la televisión de los padres se asocian a estos mismos comportamientos en sus hijos en edad preescolar, aspecto confirmado en el reciente estudio de Barkin et al. (2017) que asocia el nivel de AF de los padres con el de sus hijos. A su vez, los factores personales tienen la mayor influencia en la AF, mientras que los factores ambientales presentan la mayor influencia en el comportamiento sedentario (Schmutz et al. 2017)

Bürgi et al. (2011) indican que en los niños en edad preescolar, el nivel de AF se asocia con mejoras en la capacidad del corazón y la capacidad aeróbica, siendo un factor determinante del riesgo cardiovascular. Del mismo modo, los altos niveles de rendimiento aeróbico y la coordinación motora son fuertes predictores de la AF durante la infancia (Lopes, Rodrigues, Maia, y Malina, 2011). Puder et al. (2011) muestran que en niños preescolares el nivel de AF está asociado a la mejora de las habilidades motoras y la capacidad aeróbica, siendo un determinante del riesgo cardiovascular. El nivel de AF se ha relacionado igualmente como un factor temprano de riesgo de obesidad en niños preescolares (Reilly et al., 2005). Te Velde et al. (2012) muestran que la AF se asocia de manera inversa con el sobrepeso. A su vez, Okely, Booth y Chey (2004) destacan que el IMC y la circunferencia de la cintura fueron predictores significativos de las habilidades motrices fundamentales en niños y adolescentes. Niederer et al., (2013) por su parte señalan además la asociación entre el IMC y el nivel de CF en niños preescolares. Metallinos et al. (2007), en su estudio sobre la asociación entre la AF y el IMC en preescolares, indican que los niños con sobrepeso presentaban menores minutos diarios activos y muy activos que los niños que no tenían sobrepeso. El estudio concluyó que la actividad vigorosa y muy vigorosa se asocia con menores probabilidades de sobrepeso. En este sentido y en relación con el tipo de AF, recientemente Leppänen et al. (2016) destacan la asociación entre la AF vigorosa y el mayor índice de masa libre de grasa, lo cual se asocia a su vez con mejor CF, por lo que, la promoción de AF vigorosa puede ser importante para mejorar la composición corporal y la CF ya a una edad temprana. A su vez, en niños preescolares, la masa grasa y la masa libre de grasa parecen tener asociaciones conjuntas pero opuestas con la CF, un marcador importante para la salud actual y futura de los niños (Henriksson et al. 2016).

Sánchez, Jiménez, Fernández & Sánchez (2013), añaden, que en relación al sobrepeso y la obesidad, no existe un criterio común para establecer su identificación mediante el IMC. En España, es habitual el empleo de las curvas y tablas de crecimiento de la Fundación Orbegozo y que corresponde al percentil 85 el estado sobrepeso y al percentil 95 el de obesidad, específicos por edad y sexo (Sobradillo et al. 2004). De Onis et al. (2007), elaboran unas nuevas curvas de crecimiento, que vienen a complementar la falta de acuerdo para la población de 5 a 19 años.

Por lo tanto, la inactividad física se considera actualmente el cuarto factor de riesgo en lo que respecta a la mortalidad mundial. La obesidad infantil ocasiona varias complicaciones del tipo psicológicas, cardiovasculares, ortopédicas, respiratorias, y endocrinas (Córdoba y Paola, 2013). Moreno (2012), en su estudio sobre el problema de la obesidad infantil en países desarrollados como España, expone que ha aumentado alarmantemente el número de casos en los últimos años. Teniendo en cuenta los valores de prevalencia de sobrepeso y obesidad, De Onis, Blossner y Borghi (2010) analizaron un total de 450 encuestas transversales representativas a nivel nacional de 144 países, mostrando que en 2010, 43 millones de niños (35 millones en los países en desarrollo) se ubicaron en el sobrepeso y la obesidad y 92 millones estaban en riesgo de sobrepeso. La prevalencia mundial de sobrepeso y obesidad infantil aumentó del 4.2% en 1990 al 6.7% en 2010. Con esta tendencia se espera llegar al 9.1% ó ≈60 millones en 2020. El aumento observado en la prevalencia del sobrepeso y la obesidad entre los años 1990 y 2010 en la primera infancia, es una consecuencia probable de un cambio en los patrones de nutrición y AF. En el contexto europeo, la prevalencia de sobrepeso incluyendo la obesidad, oscila entre el 8% en niñas alemanas al 30% en las niñas españolas y la obesidad del 1% en las niñas belgas al 13% en los varones españoles, utilizando los criterios de la OMS. En general, las niñas preescolares tienen una mayor prevalencia de sobrepeso y obesidad que los varones (Van Stralen et al. 2012). Estos resultados confirman la necesidad de intervenciones eficaces que comienzan en la infancia para revertir las tendencias. A su vez, debido a la prevalencia de obesidad observada en niños y jóvenes, muchas investigaciones y profesionales se han interesado en promocionar la AF en niños preescolares (Boyle et al., 2010).

A pesar del hecho de que una vida sedentaria a esta edad es muy común, pocos estudios sobre programas de intervención con AF se han centrado en el tiempo de estancia escolar (Howie y Pate, 2012). La aplicación de programas de intervención en AF en niños de 3 a 6 años, requiere además de medidas de evaluación y seguimiento de la CF relacionada con la salud, válida y fiable para esta población. Monsalves et al. (2015), afirman que una intervención con actividades más intensas en pequeños recreos puede incrementar los patrones motores básicos en niños preescolares, y esta mejora en los patrones motores es el primer paso para el incremento de los niveles de AF. Para Delgado y Montes, (2015), sería interesante mejorar los programas de actividad físico-deportiva desde edades tempranas. Por otra parte, O'Neill, Pfeiffer, Dowda & Pate,(2016), estudiaron la relación entre la AF de los niños de preescolar, en la escuela y fuera de la escuela, y concluyeron que no hay diferencia significativa en la cantidad de AF que hacen fuera del contexto escolar, entre los niños que hacen más AF en la escuela, y los que hacen menos.

Finalmente, el propio currículum de Educación Infantil (RD1630/2006, de 9 de diciembre, por el que se establecen las enseñanzas mínimas del segundo ciclo de Educación infantil) pone de manifiesto mediante las áreas de conocimiento y los bloques de contenido, la importancia de la motricidad y la salud en esta etapa educativa, lo cual requiere instrumentos que permitan objetivar de manera precisa y especifica las adquisiciones en el ámbito de la AF y la salud en estas edades. A su vez, la presencia en el currículo universitario de un Grado de Educación Infantil y de materias específicas como Didáctica de la Educación Física en Educación Infantil o Motricidad y Salud, hacen necesaria la incorporación de líneas de investigación de esta naturaleza, que presenten un alto grado de innovación e interés educativo y social. Teniendo en cuenta que la etapa preescolar (3 a 6 años) es especialmente sensible a la adquisición de los primeros aprendizajes y conductas saludables que sin lugar a dudas posteriormente tienen proyección en la infancia, adolescencia e incluso vida adulta, sería interesante establecer los niveles de referencia que tipifiquen un estado físico saludable asociado al nivel de AF, CF, estado ponderal y nutricional, como marco de referencia para establecer programas de intervención específicos de AF saludable. A su vez, habría que acordar, después de los estudios pertinentes, los criterios de prescripción de ejercicio saludable en esta población, en lo que se refiere a los componentes de la carga como por ejemplo la frecuencia y duración. Finalmente, como señalan Palmer et al. (2016) los centros escolares de Educación Infantil, deberían proporcionar AF estructurada dentro de su jornada escolar.

Condición física y salud en niños de etapa preescolar

La CF es la capacidad que permite al individuo llevar a cabo sus actividades diarias sin fatiga indebida y con reserva adecuada para disfrutar actividades de ocio activo (Malina & Katzmarzyk, 2006). Para Ruiz et al. (2011), la CF se define como la capacidad que tiene una persona para realizar AF y/o ejercicio, y constituye una medida integrada de todas las funciones y estructuras que intervienen en la realización de AF o ejercicio.

Los componentes de la CF, son: la fuerza, la resistencia cardiorrespiratoria, la velocidad, equilibrio, fuerza y flexibilidad (Council of Europe Committee for the Development of Sport (1998). Según Molnar y Livingstone (2000), se pueden agrupar los componentes en dos grandes categorías: los aspectos relacionados con la salud (capacidad aeróbica, fuerza muscular, resistencia muscular y flexibilidad) y los aspectos relacionados con la habilidad (agilidad, equilibrio, coordinación, potencia, tiempo de reacción y velocidad). En este sentido, Stodden et al. (2008) señalan que el desarrollo de la competencia de habilidades motoras es un mecanismo subyacente primario que promueve la participación en la AF. Los niños con peor rendimiento de habilidades motoras, son menos activos que los niños con habilidades motoras más desarrolladas. Esta relación entre el rendimiento de las habilidades motoras y la AF podría ser importante para la salud de los niños, en particular en la prevención de la obesidad (Williams et al. 2008). El desarrollo tanto de la salud (fuerza muscular y aptitud aeróbica) como de la habilidad relacionada con la agilidad y la velocidad pueden facilitar el compromiso y acercamiento hacia la AF para los niños en edad preescolar (Tanaka et al. 2012). En este sentido, Sigmundsson y Haga (2016), destacan la vinculación entre las habilidades motrices, el nivel de CF y AF en niños de 4 a 6 años. Según Cliff, Okely, Smith y Mckeen (2009), altos niveles de rendimiento aeróbico y coordinación motora son fuertes predictores de la AF en niños durante la infancia.

El nivel de CF es un potente biomarcador de la salud desde una edad temprana (Ortega, Ruiz, Castillo y Sjöström, 2008). Además, la AF y la CF están muy relacionadas con la salud y con el sobrepeso (Fogelholm, Stigman, Huisman, Metsämuuronen, & Metsamuuronen, 2008; Rauner, Mess, & Woll, 2013). En este sentido, la obesidad actúa como mediador entre la aptitud cardiorrespiratoria y la presión arterial en niños preescolares (Pozuelo et al. 2017). Gómez et al. (2012) y Casajús et al. (2012) señalan que la CF, adiposidad y distribución grasa observadas en la infancia, han mostrado tener relación con la salud cardiovascular en la edad adulta.

El nivel de CF se puede evaluar objetivamente mediante test de laboratorio y test de campo (Ruiz et al., 2011). Existen diversas baterías de evaluación de la CF en niños y adultos (Batería Eurofit y Seniors Test) pero el problema está en adaptarla y validarla a la población infantil de 3 a 6 años. Fulton et al. (2001), destacan la necesidad de desarrollar métodos válidos para la medición de la AF y el comportamiento sedentario, lo cual se considera el primer paso necesario para llevar a cabo la vigilancia significativa de la CF y la investigación de intervenciones para niños de 2-5 años.

Pérez (2013) señala que a pesar de que existen diferentes pruebas para cada uno de los componentes de la CF son escasos los test que cumplen todos los requisitos de medir y valorar con fiabilidad la CF en edad infantil. Para Ayón et al. (2015) las pruebas de Course-Navette y Mini-Cooper son medidas confiables de aptitud cardiorrespiratoria que pueden usarse para evaluar la CF relacionada con la salud en niños en edad preescolar. Ortega et al. (2015), proponen la batería de pruebas (PREFIT) como una herramienta útil para evaluar la CF en niños de 3 a 5 años de edad.

Teniendo en cuenta los estudios previos sobre el análisis de la CF en niños preescolares destacamos las escasas investigaciones llevadas a cabo. Zhou, Ren, Yin, Wang y Wang (2014), no encontraron diferencias significativas entre el sexo en equilibrio, salto de longitud y velocidad, aunque los niños llevan a cabo un mejor rendimiento con el tiro de pelota de tenis, 20m de gateo y flexibilidad que las niñas. A su vez, Bürgi et al. (2011) no encontraron diferencias significativas entre niños y niñas preescolares en la capacidad aeróbica o pruebas de equilibrio. Por su parte, Tanaka, Hikihara, Ohkawara y Tanaka (2012), señalan que los niños (varones) muestran un mayor rendimiento en salto horizontal y velocidad de carrera, unido a un peor equilibrio, respecto a las niñas.

Estos resultados controvertidos podrían ser debidos a la relativa idoneidad y validez de las pruebas de evaluación de la CF a estas edades, así pues, más estudios debieran realizarse con pruebas adaptadas a estas edades que precisen realmente el nivel de CF en niños en edad preescolar.

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OBJETIVOS

- **Objetivos principales:**

  - Establecer la validación y fiabilidad de un protocolo de evaluación de la CF relacionada con la salud en niños de 3 a 6 años.
  - Analizar la asociación entre CF, madurez intelectual, niveles de actividad física y estado ponderal y nutricional en niños de 3 a 6 años.
  - Analizar el efecto de un programa de ejercicio físico en la CF estado ponderal y desarrollo cognitivo de niños de 3 a 6 años.

- **Objetivos específicos:**

  - Revisar la AF y CF en niños preescolares y su relación con la salud (Paper I).
  - Determinar la fiabilidad de una batería de pruebas para medir la CF en niños de 3 a 6 años (Paper II).
  - Examinar las diferencias de edad y sexo en el salto horizontal y determinar los valores referenciados por norma para los niños preescolares españoles (Paper III).
  - Determinar los valores de referencia en el test de sprint de 20 m para los niños preescolares españoles y examinar la influencia de la edad, el sexo y las características antropométricas en el rendimiento del sprint (Paper IV).
  - Examinar la influencia de la edad, el sexo y las variables antropométricas en la fuerza de la mano y determinar los valores referenciados por normas para los niños en edad preescolar (Paper V).
  - Examinar las diferencias de edad y sexo en el equilibrio estático y determinar valores normalizados para los niños preescolares españoles (Paper VI).

- Determinar la CF en niños de 3 a 6 años de edad. Discriminación por sexo, edad e IMC (Paper VII).
- Analizar el estado nutricional, el nivel de AF y la CF de niños preescolares en relación con el sexo y con las variables sociodemográficas de los padres (Paper VIII).
- Analizar la asociación entre madurez intelectual y CF en niños en edad preescolar (Paper IX).
- Examinar los efectos de un programa de 10 semanas de juegos aeróbicos sobre la CF y la madurez intelectual en niños en edad preescolar (Paper X).

MATERIAL Y MÉTODOS

La sección de material y métodos de la presente memoria de Tesis se resume en la siguiente tabla que incluye la información metodológica más relevante de los artículos que componen la memoria de Tesis (Tabla 1):

TABLA1. TABLA RESUMEN DE MATERIAL Y MÉTODOS

Artículo	Diseño del estudio	Participantes	Protocolo ejecutado	Variable medida
I: Actividad física, condición física y salud en niños preescolares. Estudio de revisión narrativa	Estudio de revisión narrativa	- La búsqueda se efectuó desde Septiembre de 2016 a Febrero de 2017, en las bases de datos: Pubmed, Sportdiscus, ERIC, Web of Science, Scopus, ERIC y Dialnet. - Palabras clave usadas para la búsqueda: Actividad física, condición física, salud, educación infantil, etapa preescolar.		
II. La fiabilidad test-retest de una evaluación de la condición física basada en el campo de niños de 3-6 años	Estudio transversal	n= 553 niños de 3 a 6 años 274 niños 279 niñas	Dos sesiones separadas, 48 horas. Primera sesión de pruebas, RDT, salto horizontal (dos repeticiones) y equilibrio (dos ensayos con cada pierna) Dos días después, las pruebas del sprint de 20 m (dos ensayos) y la prueba de 10x20m (un ensayo). Los niños realizaron un calentamiento. Durante las pruebas, los niños fueron motivados y animados en todo momento.	- Fuerza de prensión manual - Tiempo de reacción - Salto horizontal. - Equilibrio - Sprint de 20 m. - Resistencia,10 x 20 - Sexo - Edad (3- 6 años)
III. Los valores de referencia de salto horizontal en niños en edad preescolar: un estudio de base poblacional	Estudio transversal	n=3555 niños de 3 a 6 años 1809 niños 1746 niñas	Antes de la prueba, los niños realizaron un calentamiento. La prueba SLJ, se realizó sobre una superficie dura (dos ensayos, el mejor ensayo fue registrado). Los niños realizaron algunos ensayos de familiarización para el SLJ. El equipo de investigación realizó una demostración. Durante las pruebas, los niños fueron motivados y animados en todo momento. Una semana después, realizaron la misma prueba.	- Fuerza en el tren inferior (salto) - Sexo - Edad (3-6 años)

Artículo	Diseño del estudio	Participantes	Protocolo ejecutado	Variable medida
IV. Valores de referencia para la ejecución de la prueba de sprint de 20 mts. en niños en edad preescolar: Un estudio poblacional	Estudio transversal	n: 3076 niños de 3 a 6 años 1537 niños 1539 niñas.	Antes de la prueba, los niños realizaron un calentamiento de cinco minutos de baja intensidad. Posteriormente, se realizó el ensayo de 20 m de sprint (dos ensayos con 120 segundos de recuperación entre los ensayos, se registró el mejor ensayo) en una superficie plana, dura y antideslizante, con la línea de inicio y la línea de llegada marcadas. Dos evaluadores realizaron en cronometraje. El equipo de investigación realizó una demostración. Los niños estaban motivados para correr lo más rápido posible. La prueba se midió con un cronómetro y se resgistraba con una precisión de 0,1 segundos. Una semana después, realizaron la misma prueba.	- Velocidad - Sexo - Edad (3- 6 años).
V. La fuerza de prensión la mano asociada con variables antropométricas y sexo en niños en edad preescolar: Un estudio transversal que proporciona valores de referencia	Estudio transversal	n: 1215 niños de 3 a 6 años 625 niños 590 niñas	Los participantes de pie con el brazo completamente extendido, formando un ángulo de 30 ° con respecto al tronco. Cada participante realizó dos intentos con cada mano. Durante la medición, le pedimos al sujeto que agarre el dinamómetro usando la fuerza máxima y que sostenga la empuñadura durante tres segundos. Los niños fueron motivados y animados a alcanzar la mejor puntuación posible El equipo de investigación realizó una demostración y los niños realizaron algunos ensayos de familiarización. La puntuación máxima en kilogramos para cada mano fue registrada y la puntuación media de ambas manos se utilizó en los análisis. Una semana después, realizaron la misma prueba .	- Fuerza de prensión de las manos - Sexo - Edad (3 - 6 años).
VI. Valores de referencia del equilibrio estático en niños en edad preescolar: estudio basado en una población	Estudio transversal	n: 3575 niños, de 3 a 6 años 1816 niños 1759 niñas	Los participantes se quitan el calzado, colocan sus manos en las caderas, y hacen contactar la planta de un pie, contra el interior de la rodilla de la pierna de apoyo. A la señal, el niño intentará mantener su equilibrio en la postura antes señalada, durante el mayor tiempo posible (máximo un minuto). La prueba terminaba cuando el niño movía sus manos de las caderas, el pie se movía de su posición original, o cuando el pie que estaba en el aire contactaba con el suelo. Se usó un cronómetro, que inició su conteo cuando el talón se elevó desde el suelo. Se registró el tiempo total en segundos. Se hicieron dos intentos con ambas piernas y se registró el mejor de los resultados de cada una.	- Equilibrio con una pierna (derecha e izquierda) - Sexo - Edad (3 - 6 años).

Artículo	Diseño del estudio	Participantes	Protocolo ejecutado	Variable medida
VII. Condición física en niños preescolares: asociación con sexo, edad y peso corporal (estado ponderal)	Estudio transversal	n= 3868 niños de 3 a 6 años 1961 niños 1907 niñas	En dos sesiones diferentes. Durante la primera sesión se realizó la prueba del RDT (dos ensayos con cada mano), la prueba de salto horizontal (dos ensayos) y la prueba de equilibrio (dos ensayos con cada pierna). En la siguiente sesión (dos días después), las pruebas del sprint de 20 m (dos ensayos) y 10 × 20m (un ensayo. En las pruebas que se realizaron dos repeticiones, se registró el mejor de los intentos. Antes de las sesiones los niños realizaban un calentamiento Además, los niños realizaron algunos ensayos de familiarización.	- RT - Equilibrio - Salto horizontal - Sprint de 20 m. - Resistencia,10 x 20 - Sexo - Edad (3- 6 años).
VIII. Prácticas de alimentación, actividad física y condición física en niños españoles en edad preescolar. Influencia de las medidas sociodemográficas	Estudio transversal	n= 1287 niños de 3 a 6 años 643 niños 644 niñas 1267 padres 918 H. y 349 M.	Mediante un cuestionario sociodemográfico realizado *ad hoc*, se recogió información de los padres. Como parámetros antropométricos, se analizaron la altura, el peso y el índice de masa corporal (IMC). Además, se registró el contorno del abdomen a nivel de la cicatriz umbilical. Para el análisis de la CF, se empleó una batería de pruebas que midió: fuerza de prensión manual, equilibrio, salto horizontal, sprint de 20 m y 10 x 20 m. El análisis del estado nutricional, tiempo de uso de pantallas y AF se realizó mediante el cuestionario Krece Plus.	- Estado nutricional - Fuerza de prensión manual - Equilibrio - Salto horizontal - Sprint de 20 m. - Resistencia,10 x 20 - Antropometría - Datos sociodemográficos de los padres - Sexo - Edad (3 - 6 años).

Artículo	Diseño del estudio	Participantes	Protocolo ejecutado	Variable medida
IX. Madurez intelectual y condición física en niños de preescolar.	Estudio transversal	n= 1012 niños de 3 a 6 años 502 niños 510 niñas	La prueba del dibujo, GHDT, se evaluó durante la primera sesión. En la segunda sesión, RDT, prueba de salto horizontal y la de equilibrio. Dos días después, durante la tercera sesión, se realizaron la de 20m. sprint y 10 × 20 m. Antes de las sesiones de prueba, los niños realizaron un calentamiento. Además, los niños realizaron algunos ensayos de las pruebas. Los niños fueron motivados y animados durante las pruebas.	- Fuerza de prensión manual - Equilibrio - Salto horizontal - Sprint de 20 m. - Resistencia,10 x 20 - Sexo - Edad (3- 6 años).
X. Efectos de un programa de actividad física en el entorno escolar sobre la CF y la madurez intelectual en los niños en edad preescolar	Estudio longitudinal	N= 111 niños, de 3 a 6 años de edad. 60 niños 51 niñas. EG, n = 56 CG, n = 55 Asignados aleatoriamente	Los niños fueron evaluados en tres sesiones en un pretest, y en otras tantas en el postest. Entre el pretest y postest, pasaron 10 semanas. Durante la primera sesión, se realizó la prueba del dibujo GHDT. En una segunda sesión, RDT, prueba de salto horizontal y la de equilibrio. En una tercera sesión, la de sprint de 20 m. y 10 × 20 m. Antes de las sesiones de las pruebas, los niños realizaron un calentamiento, además de algunos ensayos de las pruebas. Los niños fueron motivados y animados durante las pruebas.	- Fuerza de prensión manual - Tiempo de reacción - Salto horizontal. - Equilibrio - Sprint de 20 m. - Resistencia,10 x 20 - Madurez intelectual - Sexo - Edad (3- 6 años).

RESULTADOS

Los resultados se presentan en la forma en que han sido previamente sometidos y publicados en revistas científicas. Adicionalmente, se ofrece una tabla resumen de los principales resultados obtenidos en cada uno de los estudios (Tabla 2):

TABLA 2. TABLA DE RESULTADOS

Artículo	RESULTADOS
I. Actividad física, condición física y salud en niños preescolares. Estudio de revisión narrativa	La prevalencia de AF en preescolares es baja y no cumplen recomendaciones internacionales, lo cual se asocia a una creciente prevalencia de sobrepeso y obesidad. Dentro de los correlatos que determinan la práctica de AF en preescolares destacamos la AF de los padres. La CF puedes ser un biomarcador de salud en edades tempranas. Existen diferencias significativas entre sexos en CF ya en una corta edad
II. La fiabilidad test-retest de una evaluación de la condición física basada en el campo de niños de 3-6 años	Participaron un total de 553 niños, de entre 3 y 6 años de edad (279 niñas y 274 niños). Los resultados obtenidos en este estudio indican que la batería de CF para preescolares ha obtenido parámetros de fiabilidad test-retest adecuados y es capaz de discriminar según la edad entre las diferentes pruebas en niños sanos de 3 a 6 años.
III. Los valores de referencia del salto de longitud en niños de edad preescolar: un estudio de base poblacional	Participaron un total de 3555 niños, de 3 a 6 años de edad (1746 niñas y 1809 niños). En el análisis de la fiabilidad de la prueba de salto horizontal con 86 niños (48% varones, edad = 56,22 ± 10,34 meses), se obtuvieron los siguientes resultados descriptivos (media, desviación estándar): en el pre-test = 76,53 ± 20,20 cm, postest = 74,56 ± 21,12 cm (p = 0,124), y un coeficiente de correlación intraclase = 0,913 (intervalo de confianza del 95% = 0,866-0,943). Los niños mostraron un mayor rendimiento que las niñas de 3 a 5 años de edad, pero no se encontraron diferencias significativas a los 6 años de edad. En todo el grupo, el rendimiento de SLJ fue mayor con el aumento de la edad. Sin embargo, no se encontraron diferencias significativas entre los niños de 5 y 6 años.
IV. Valores de referencia para la ejecución de pruebas de campo de sprint en niños en edad preescolar: Un estudio poblacional	Participaron un total de 3076 niños, de 3 a 6 años de edad (1539 niñas y 1537 niños). Para medir el sprint, se utilizó la prueba de velocidad de 20 m. En el análisis de la fiabilidad, utilizando test-retest con 89 niños (48% varones). Se obtuvieron los siguientes resultados descriptivos (media, desviación estándar): en pretest = 5,72 ± 0,98 s, en postest= 5,71 ± 0,87 s (p = 0,819), y un coeficiente de correlación intraclase = 0,929 (intervalo de confianza del 95%: 0,891 - 0,954). Los niños son más rápidos que las niñas de 3 a 5 años de edad, pero no se encontraron diferencias significativas a los 6 años. En relación con la edad, el tiempo de sprint fue más corto a medida que los niños crecieron.

Artículo	RESULTADOS
V. La fuerza de prensión manual asociada con variables antropométricas y sexo en niños en edad preescolar: Un estudio transversal que proporciona valores de referencia	Participaron un total de 1215 niños, de 3 a 6 años de edad (590 niñas y 625 niños). Los niños mostraron un mayor rendimiento que las niñas en los grupos de 4 y 5 años, pero no se encontraron diferencias significativas a los 3 y 6 años. En relación con el crecimiento, el desempeño del HS fue mayor con el aumento de la edad. El análisis de correlación de Pearson muestra correlaciones significativas entre HS y masa corporal (r = 0,354, p <0,001), altura corporal (r = 0,352, p <0,001), índice de masa corporal (r = 0,164, p <0,001) y circunferencia de cintura = 0,118, p & lt; 0,001).
VI. Valores de referencia del equilibrio estático en niños en edad preescolar: estudio basado en una población	Participaron un total de 3575 niños, de 3 a 6 años de edad (1759 niñas y 1816 niños). Las niñas exhibieron una puntuación más alta en su pierna derecha que los varones (media, SD = 8,63 ± 9,35 s frente a 7,88 ± 8,70 s respectivamente, p = 0,014), mientras que no se encontraron diferencias sexuales significativas para la pierna izquierda. Las niñas exhibieron un mayor rendimiento que los niños a los cuatro años (p <0,001) y un peor rendimiento a los seis años (p = 0,002). El análisis de correlación de Pearson mostró correlaciones significativas entre la SB y la masa corporal (r = 0,106, p <0,001), altura corporal (r = 0,175, p <0,01) y WC (r = 0,044, p <0,01).
VII. Condición física en niños preescolares: asociación con sexo, edad y peso corporal (estado ponderal)	Participaron un total de 3868 niños, de 3 a 6 años de edad (1907 niñas y 1961 niños) . Se encontraron diferencias significativas entre los sexos y los diferentes grupos de edad. La CF aumentó con la edad. En los 10 × 20m, las diferencias de sexo se encontraron en 5-6 años, los niños muestran un mayor rendimiento. En el salto horizontal, las diferencias sexuales fueron encontradas en 3 y 4-5 años, los niños mostraron un mayor rendimiento. En el equilibrio, las niñas exhibieron un mayor rendimiento que los niños a los cuatro años y un peor rendimiento a los seis años. En la velocidad de carrera, las diferencias de sexo se encontraron a los 3 y 4-5 años, los niños mostraron un mayor rendimiento. En relación con el estado ponderal, la prevalencia de sobrepeso fue del 8,1% y la obesidad 8,9%. Según el análisis de correlación de Pearson, destacar que el IMC no correlacionó con la CF, excepto con el equilibrio, con el que muestra una baja correlación.

Artículo	RESULTADOS
VIII. Prácticas de alimentación, actividad física y condición física en niños españoles en edad preescolar. Influencia de las medidas sociodemográficas	Participaron un total de 1287 niños de entre 3 y 6 años de edad (644 niñas y 643 niños), y 1267 padres (el 72,4% eran madres y el 27,6%, padres). Las niñas presentaron niveles más bajos de sobrepeso y obesidad que los niños. Existieron diferencias significativas por sexos en el consumo de determinados alimentos: mayor consumo de lácteos en el desayuno y aceite de oliva en niñas y mayor consumo de comidas rápidas y pastas o arroz en los varones. Los varones presentaron una mejor CF. Los niños del estrato socioeconómico más bajo mostraron mayor índice de masa corporal, peor estado nutricional y más bajo nivel de AF. Los niños de padres con estudios universitarios presentaron menor índice de masa corporal y mejor estado nutricional.
IX. Madurez intelectual y condición física en niños de preescolar.	Participaron un total de 1012 niños, de entre 3 y 6 años de edad (502 niñas y 510 niños). Con respecto a la edad, las diferencias fueron significativas entre todos los grupos en todas las pruebas de CF. Los niños tuvieron mejores resultados en las pruebas de salto horizontal y pruebas de sprint de 20 m ($p<0,001$). Las niñas obtuvieron mejores resultados en el GHDT ($p= 0,001$). El subgrupo de menor puntuación en GHDT, también tuvieron menor rendimiento en la CF. Hubo una correlación significativa entre el GHDT y la CF.
X. Efectos de un programa de actividad física en el entorno escolar sobre el estado físico y la madurez intelectual en los niños en edad preescolar	Participaron un total de 111 niños, de 3 a 6 años de edad (51 niñas y 60 niños). Asignados aleatroriamente a un grupo experimenta (EG) = 56 y otro grupo control (CG) = 55. No hubo diferencias significativas en ninguna variable en el pretest entre los grupos. En el postest, el EG logró mejores resultados en salto horizontal y sprint. En relación con las diferencias entre el pretest y el postest, el EG mostró un mayor incremento en salto horizontal, sprint, resistencia, y madurez intelectual. Es importante destacar que se encontró una correlación significativa entre el incremento de la madurez intelectual y el incremento de la altura corporal ($r = 0.297$, $p <0.05$), el equilibrio ($r = 0.238$, $p <0.05$) y el sprint ($r = -0.275$, $p <0.01$).

CONCLUSIONES

- La prevalencia de AF en niños preescolares es baja y no cumplen con las recomendaciones internacionales, lo cual se asocia a una creciente prevalencia de sobrepeso y obesidad. Dentro de los correlatos que determinan la práctica de AF en preescolares destacamos la AF de los padres. La CF puedes ser un biomarcador de salud en edades tempranas. Existen diferencias significativas entre sexos en CF ya en una corta edad y las referencias normativas en relación con los diferentes componentes de la CF son necesarias. Por último, es importante incorporar programas de AF estructurada para niños de 3 a 6 años dentro y fuera del colegio.

- La batería de pruebas de CF desarrollada en esta Tesis ha obtenido parámetros adecuados de fiabilidad test-retest, y fue capaz de discriminar, utilizando la edad, entre las diferentes pruebas en niños sanos de 3 y 6 años. Las pruebas utilizadas fueron seguras, fáciles de realizar, muy aceptables y comprensibles para los niños. En consecuencia, los profesores, entrenadores y demás personal que trabaja con niños de estas edades pueden usar esta batería de pruebas a pesar de no tener una gran variedad de materiales y recursos tecnológicos.

- En esta Tesis se establecen los valores normativos para el salto horizontal, el sprint de 20 metros, el equilibrio estático y la dinamometría manual en niños sanos de 3 a 6 años.

- Las diferencias sexuales en la CF son evidentes a una edad temprana, además, la relación entre la CF y el IMC es inconsistente en los niños en edad preescolar. Las mejoras en el rendimiento físico y su asociación con la actividad física podrían ser importantes para la salud de los niños, particularmente en la prevención de la obesidad.

- Los niños preescolares de este estudio presentaron valores elevados de sobrepeso y obesidad y bajo nivel de AF, teniendo en cuenta las referencias internacionales. Las niñas mostraron una CF inferior a la de los varones. Los niños cuyos padres presentaron un nivel socioeconómico bajo y sin estudios mostraron un nivel nutricional precario.

- A partir de una edad temprana, el rendimiento físico-motor y la madurez intelectual están vinculados. La CF es capaz de predecir la madurez intelectual. Aumentar la cantidad de tiempo dedicado a la educación física puede promover beneficios cognitivos en niños preescolares.

- Un programa de juegos aeróbicos en el ambiente escolar mejoró la CF y la madurez intelectual en los niños preescolares. Estos datos indican que los niños en edad preescolar exhiben una capacidad de entrenabilidad física y mejora, considerables. Además, en este estudio se encontraron correlaciones entre madurez intelectual y altura corporal, equilibrio y sprint. Al mismo tiempo, el equilibrio y el sprint son predictores de la madurez intelectual.

PROSPECTIVAS FUTURAS DE ESTUDIO

La información sobre la conveniencia de AF en todas las edades para la mejora de la salud tiene que hacer recapacitar a la comunidad educativa sobre la importancia de incluirla de manera más programada en los currículum escolares, así como ampliar el tiempo dedicado a la AF, ya que aún no hay horario asignado a la misma en Educación Infantil de manera reglada.

Analizar en posteriores investigaciones, si el aumento del tiempo diario y de las horas semanales en general, dedicadas a actividades y juegos físicos, mejora la actitud y comportamiento de los niños, así como su capacidad e interés por adquirir nuevos aprendizajes.

También sería interesante analizar en otras investigaciones, la repercusión que pudiera tener, ampliar el período de actividades y juegos funcionales en los niños de preescolar, para su participación en tareas de la casa, y el desarrollo de su autonomía personal, rendimiento académico y otros parámetros de salud.

Por último, sería interesante analizar la relación entre el desarrollo de las habilidades motrices básicas (locomotrices y manipulativas) y la CF o niveles de AF en estas edades.

CURRICULUM VITAE RESUMIDO [SHORT CV]

Datos personales

- Apellidos y nombre: Mora López, David José
- Fecha nacimiento: 19 de Noviembre de 1971
- E-mail: davidjmora7@gmail.com

Actividad académica

- Licenciado en Ciencias de la Actividad Física y del Deporte (1990-1995). Universidad de Granada (Granada, España).
- Programa de Doctorado de "Nuevas perspectivas en la investigación de las ciencias de la actividad física y el deporte", en el campus de Melilla, de la Universidad de Granada.
- Trabajo tutelado de iniciación a la investigación, por la Universidad de Jaén.
- B2 de Inglés.

Datos personales

- Profesor de Educación Física en el IES Valle del Guadalimar, Puente de Génave

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Mora López, D.J., García Pinillos, F., Latorre Román, P.A. (2017)

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Actividad física, condición física y salud en niños preescolares. Estudio de revisión narrativa.

David José Mora López

Profesor de Educación Física. I.E.S. Castillo de la Yedra, Cazorla. España
Alumno de doctorado de la Universidad de Jaén
davidjmora7@gmail.com

Felipe García Pinillos

Profesor Dr. Universidad de Jaén
fegarpi@gmail.com

Pedro Ángel Latorre Román

Profesor Dr. Universidad de Jaén
platorre@ujaen.es

RESUMEN

El propósito de este trabajo es revisar y analizar los resultados de las investigaciones más recientes sobre la actividad física en niños de la etapa de Educación Infantil, y la repercusión que ésta tiene sobre algunos problemas para la salud, como el sobrepeso y la obesidad. Igualmente pretendemos analizar los programas y protocolos que se hayan realizado para analizar la condición física de los niños preescolares. A partir de esta revisión, podemos destacar que los niños de esta etapa tienen niveles bajos de actividad física, por debajo de las recomendaciones internacionales, lo cual afecta a su condición física y su salud actual, y previsiblemente en su etapa de adolescencia y de adultos. La escuela es un espacio esencial para la promoción de la actividad física y mejora de la condición física y la salud. Serían recomendables proyectos educativos para los niños, dirigidos a fomentar hábitos de actividad física y nutrición adecuados, así como el uso de baterías de test que se han validado para esta población, para conocer su nivel de condición física y poder intervenir adecuadamente.

PALABRAS CLAVE:

Actividad física; condición física; salud; educación infantil; etapa preescolar.

1. INTRODUCCIÓN

La edad preescolar es un momento idóneo para establecer hábitos de actividad física (AF) y nutrición adecuados, que mejorarán el nivel de condición física (CF) esencial para la prevención de algunas enfermedades, como la obesidad, la cual se asocia con consecuencias para la salud que pueden persistir en la adolescencia y edad adulta (Kondric, Trajkovski, Strbad, Foretić y Zenić 2013; Reilly, et al. 2005; Singh, Mulder, Twisk, Van Mechelen y Chinapaw, 2008; Latorre, Mora y García, 2016). La importancia de la CF para la salud es bien conocida y las investigaciones han demostrado que hay beneficios físicos y psicológicos cuando los niños participan en la AF (Ahn & Fedewa, 2011; - Janssen & Leblanc, 2010). A su vez, la AF sobre todo de carácter moderada a intensa favorece el crecimiento normal en niños preescolares (Butte et al. 2016).

La escuela representa un espacio esencial para la promoción de AF y mejora de la CF y la salud, sin embargo, actualmente en España, a pesar de que la Educación Física y la AF forman parte de manera relevante del currículo de Educación Infantil (REAL DECRETO 1630/2006, de 29 de diciembre) y su reconocimiento es importante en la Comunidad Educativa (Jordán, Navarro, Suárez y Madrona, 2006; Latorre, 2007) , la escasez de espacios y recursos materiales adecuados y seguros, y posiblemente una deficiente asignación horaria de las clases de Educación Física en Educación Infantil, provocan que gran parte (aproximadamente un 60%) del profesorado de Educación Infantil señale que la Educación Física no se trabaja suficientemente (Latorre, 2007). Por tanto, la promoción de la AF desde el entorno escolar, en el tiempo de ocio y en el hogar, así como el compromiso de los padres en la sensibilización sobre los beneficios que presenta la práctica precoz de la AF en niños preescolares, es esencial para la creación de este hábito saludable, para la prevención del sobrepeso y obesidad y para ayudar a establecer una óptima calidad de vida.

- Objetivo

Realizar una revisión de carácter narrativo de la AF y CF en niños preescolares y su relación con la salud.

- Metodología

La presente revisión narrativa pretende resumir los hallazgos bibliográficos con respecto a los factores asociados con la AF y CF en niños de 3 a 6 años de edad. En una revisión narrativa, la selección de artículos no tiene que ajustarse a un análisis sistemático (Granth & Booth, 2009). Sin embargo, para precisar la selección de las investigaciones a analizar en este estudio, en diciembre del 2016, se realizó una búsqueda exploratoria en siete base de datos: Pubmed, Sportdiscus, ERIC, Web of Science, Scopus, ERIC y Dialnet. Los términos de búsqueda utilizados fueron los siguientes: AF, ejercicio físico, CF, estado ponderal, sobrepeso, salud, preescolares, revisión y sedentarismo. Cada estudio incluido en esta revisión narrativa tuvo que cumplir con los siguientes criterios: (1) ser una revisión sistemática o meta-análisis de estudios (diseño transversal o longitudinal) o revisión sistemática de revisiones; (2) estudios originales que pretenden analizar factores asociados a la AF y CF en niños preescolares (3) publicado en inglés o español; (4) entre 2000 y 2017; (5) Incluyen niños sanos (excepto con sobrepeso y obesidad) (de 3 a 6 años).

1.1. ACLARACIÓN TERMINOLÓGICA

A.- infancia o niñez

Los conceptos de infancia y niñez presentan una gran complejidad no sólo a nivel social, sino desde la propia etimología de estas palabras. Según la RAE, Real Academia de la Lengua Española, (2014), "Infancia" proviene del latín infanta, cuyo significado primario alude a la incapacidad de hablar y define a los înfâns o înfantis como aquéllos que no tienen voz. Para la RAE, la infancia es delimitada como: i) el período de la vida humana desde que se nace hasta la pubertad; ii) el conjunto de los niños de tal edad; iii) el primer estado de una cosa después de su nacimiento o fundación. Por otro lado, la RAE define al infante en su primera acepción, como: i) el niño que aún no ha llegado a la edad de siete años. Wasserman (2001) resalta que la etimología de la palabra infancia proviene del latín in-fandus, que significa "no habla o que no es legítimo para tener la palabra".

Según Newman y Newman (1983) podríamos hablar de una primera infancia (desde al nacimiento a los 2 años); 2) segunda infancia (desde los 2 a los 4 años); 3) primera niñez (desde los 5 a los 7 años); 4) segunda niñez (desde los 8 a los 12 años). Para Kaplan, Sadock, y Grebb (1997), la infancia, se entenderá como el período que va desde el nacimiento hasta los tres años, y la niñez, el que abarca de los tres a los doce años, etapa en la que se produce un importante desarrollo físico, emocional y de ingreso al grupo social más amplio.

B.- etapa de educación infantil o etapa preescolar

Encontramos en la literatura dos términos diferentes para definir la etapa a la que nos referimos en el presente trabajo de revisión. Por una parte, en el marco legislativo estatal y autonómico, se cita como Etapa de "Educación Infantil". Esa etapa se divide en dos ciclos: el primero que comprende a los niños con edades entre 0 y 3 años, y un segundo ciclo, de los 3 a 6 años (REAL DECRETO 1630/2006). Muchos de los artículos y trabajos revisados sobre esta etapa, por autores de índole estatal, utilizan este término de "Etapa de Educación Infantil", (Jordán, et al. 2006; Lirio-Díaz, 2014; Luque, 2015). Por otro lado, en gran parte de la literatura científica, los autores consultados, emplean el término "etapa, edad o población preescolar", para referirse a los niños de la etapa de Educación Infantil (Ai-Wen Hwang et al. 2014; Aliño, Navarro, López y Pérez, 2007; Bouldin y Pratt, 1999 (3 a 9,5 años); Bürgi, 2011 (4 a 6 años); Latorre et al. ,2016; Niederer et al. 2013; Tango, 2010 (3-7); Tucker, 2008 (2 – 6 años); Tucker et al., 2016 & Schmutz, 2017).

2. ACTIVIDAD FÍSICA EN NIÑOS PRESCOLARES

Los hábitos asociados con la AF y con un estilo de vida activo representan un factor significativo que afecta favorablemente a la salud de un individuo, (Kvintová y Sigmund, 2016). Edwy (2015) afirma que la mayor conciencia de las relaciones entre la AF y la salud puede influir en el estilo de vida de los sujetos, y al mismo tiempo, aumentar positivamente su motivación. Esta relación entre AF y salud, se ha señalado en estudios previos (Fagaras, Radu y Vanvu, 2015; Pedišić, Rakovac, Titze, Jurakić, & Oja, 2014).

Identificar las maneras de promover la AF y disminuir el tiempo sedentario durante la infancia es un problema clave de salud pública, sin embargo, la investigación sobre las influencias de la AF de los niños en edad preescolar y el comportamiento sedentario es limitada y ha producido resultados inconsistentes (Schmutz et al. 2017).

La infancia es un momento esencial para la promoción de hábitos de vida saludables como la AF y la evitación de comportamientos sedentarios (Jones, Hinkley, Okely y Salmon, 2013). Sin embargo, varios estudios han demostrado que la AF de los niños en edad preescolar es moderadamente baja (Grzywacz et al. 2014; IP et al. 2016; Tucker, 2008) no cumpliendo con las recomendaciones de AF (Palmer et al 2016). En este sentido, el estilo de vida sedentaria a esta edad es elevado (De Bock, Genser, Raat, Fischer y Renz-Polster, 2013). Según O'Dwyer et al. (2014), los niños manifiestan mayores niveles de moderada y vigorosa AF que las niñas, aunque todos los niños no acumulan suficiente AF para obtener beneficios para la salud. Además, los niños con sobrepeso son significativamente menos activos que sus pares sin exceso de peso durante el día preescolar, aunque no se observan diferencias significativas en las niñas (Trost, Sirard, Dowda, Pfeiffer y Pate, 2003). Por otro lado, Grøntved, et al.(2009) destacan que los niños invierten una proporción significativamente mayor del tiempo en la AF moderada y vigorosa, y presentan un nivel total más alto de AF en comparación con las niñas; además, los niños de 3-4 años de edad emplean menos tiempo en AF moderada y vigorosa, y manifiestan un nivel total menor de AF en comparación con los niños de 4-5 años y los niños de 5-6 años. Por tanto, el sexo y la edad son fuertes predictores de la AF en niños preescolares. Tucker's (2008) en una revisión sistemática sobre los niveles de AF de los niños en edad preescolar (2-6 años) señala a treinta y nueve estudios primarios (publicados 1986-2007) que representan un total de 10.316 participantes (5.236 varones y 5.080 mujeres), procedentes de siete países donde se describen si las conductas de AF de esta población se consideran de acuerdo con la pautas de AF para los niños preescolares (NASPE). Las recomendaciones actuales sugieren un mínimo de 60 minutos de AF por día y sólo el 54% de los participantes logró este nivel de práctica. Se desprende de esta revisión, que casi la mitad de los niños estudiados no cumplen con las pautas recomendadas para la AF. Por lo tanto, las intervenciones efectivas que promuevan y fomenten la AF en los niños, son necesarias. Sin embargo, una pauta más objetiva de la AF para los niños en edad preescolar es importante, por lo que la medición de la AF tiene que ser más unificada para comparar y seguir la actividad de forma más efectiva. En este sentido, uno de los inconvenientes para analizar el nivel de AF de los niños preescolares se centra en el tipo de registro realizado. La acelerometría es una tecnología que permite registrar de manera precisa los niveles de AF diaria y ha sido ya empelada en preescolares (Beets, Bornstein, Dowda y Pate, 2011; Burgi et al 2011; Puder et al., 2011) pero los resultados señalan una gran variabilidad e interpretaciones confusas entre estudios (Bornstein, Beets, Byun y McIver, 2011), además de las dificultades añadidas para el uso de este instrumental en niños de esta edad.

Existen limitados estudios que analicen los posibles correlatos de la AF asociada con el crecimiento y la madurez (con la excepción del índice de masa corporal, IMC), la CF y el dominio de las habilidades de movimiento (Malina y Katzmarzyk, 2006), especialmente en los niños en edad preescolar. Algunos factores no modificables como el sexo y la edad, y otros modificables como los

ingresos familiares y el tiempo de los niños al aire libre, se correlacionan con la AF moderada y vigorosa, y con los niveles de sobrepeso y obesidad. Así, el conocimiento de estos factores puede ser útil en el diseño y la orientación de las intervenciones para disminuir la cantidad de tiempo sedentario y aumentar la cantidad de AF moderada y vigorosa en los niños pequeños (Dolinsky et al. 2011).

Hay otros factores más o menos susceptibles de modificación, que se han asociado al sobrepeso y la obesidad en niños preescolares: el IMC materno y paterno afecta al IMC en la primera infancia, pero el efecto general del IMC materno era más fuerte que el paterno, una mayor ganancia de peso durante la gestación en madres sin sobrepeso y obesidad se relaciona con el riesgo de sobrepeso en la infancia temprana (Gaillard et al. 2013); la duración del sueño diario de menos de 12 horas durante la infancia parece ser un factor de riesgo para el sobrepeso y la obesidad en los niños en edad preescolar (Taveras, Rifas-Shiman, Oken, Gunderson, y Gillman, 2008). Latorre, Mora y García (2016), señalan que los niños con padres de nivel socioeconómico alto presentaron mejor estado nutricional, mayor tiempo de AF y menor uso de pantallas. Los niños de padres con estudios universitarios presentaron también mejor estado nutricional, además de un menor IMC y mayor salto horizontal. Según Van Stralen et al. (2012), existe una asociación positiva entre el comportamiento sedentario (principalmente el tiempo de uso de pantallas, televisión, ordenadores, móviles, etc.) con el IMC y la circunferencia de la cintura. Según Hinkley et al.,(2008), los niños con padres activos tendían a ser más activos. En este sentido, recientemente Abbott et al. (2016) muestran que los hábitos de AF y uso de la televisión de los padres se asocian a estos mismos comportamientos en sus hijos en edad preescolar, aspecto confirmado en el reciente estudio de Barkin et al. (2017) que asocia el nivel de AF de los padres con el de sus hijos. A su vez, los factores personales tienen la mayor influencia en la AF, mientras que los factores ambientales presentan la mayor influencia en el comportamiento sedentario (Schmutz et al. 2017)

Bürgi et al. (2011) indican que en los niños en edad preescolar, el nivel de AF se asocia con mejoras en la capacidad del corazón y la capacidad aeróbica, siendo un factor determinante del riesgo cardiovascular. Del mismo modo, los altos niveles de rendimiento aeróbico y la coordinación motora son fuertes predictores de la AF durante la infancia (Lopes, Rodrigues, Maia, y Malina, 2011). Puder et al. (2011) indican que en niños preescolares el nivel de AF está asociado a la mejora de las habilidades motoras y la capacidad aeróbica, siendo un determinante del riesgo cardiovascular. El nivel de AF se ha relacionado igualmente como un factor temprano de riesgo de obesidad en niños preescolares (Reilly et al., 2005). Te Velde et al. (2012) muestran que la AF se asocia de manera inversa con el sobrepeso. A su vez, Okely, Booth y Chey (2004) destacan que el IMC y la circunferencia de la cintura fueron predictores significativos de las habilidades motrices fundamentales en niños y adolescentes. Niederer et al., (2013) señalan además la asociación entre el IMC y el nivel de CF en niños preescolares. Metallinos et al. (2007), en su estudio sobre la asociación entre la AF y el IMC en preescolares, indican que los niños con sobrepeso presentaban menores minutos diarios activos y muy activos que los niños que no tenían sobrepeso. El estudio concluyó que la actividad vigorosa y muy vigorosa se asocia con menores probabilidades de sobrepeso. En este sentido y en relación con el tipo de AF, recientemente Leppänen et al. (2016) destacan la asociación entre la AF vigorosa y el mayor índice de masa libre de grasa, lo cual se asocia a su vez con mejor CF, por lo que, la promoción de AF vigorosa puede ser

importante para mejorar la composición corporal y la CF ya a una edad temprana. A su vez, en niños preescolares, la masa grasa y la masa libre de grasa parecen tener asociaciones conjuntas pero opuestas con la CF, un marcador importante para la salud actual y futura de los niños (Henriksson et al. 2016).

Sánchez, Jiménez, Fernández & Sánchez (2013), añaden, que en relación al sobrepeso y la obesidad, no existe un criterio común para establecer su identificación mediante el IMC. En España, es habitual el empleo de las curvas y tablas de crecimiento de la Fundación Orbegozo y que corresponde al percentil 85 el estado sobrepeso y al percentil 95 el de obesidad, específicos por edad y sexo (Sobradillo et al. 2004). De Onis et al. (2007), elaboran unas nuevas curvas de crecimiento, que vienen a complementar la falta de acuerdo para la población de 5 a 19 años.

Por lo tanto, la inactividad física se considera actualmente el cuarto factor de riesgo en lo que respecta a la mortalidad mundial. La obesidad infantil ocasiona varias complicaciones del tipo psicológicas, cardiovasculares, ortopédicas, respiratorias, y endocrinas, (Córdoba y Paola, 2013). Moreno (2012), en su estudio sobre el problema de la obesidad infantil en países desarrollados como España, expone que ha aumentado alarmantemente el número de casos en los últimos años. Teniendo en cuenta los valores de prevalencia de sobrepeso y obesidad, De Onis, Blossner y Borghi (2010) analizaron un total de 450 encuestas transversales representativas a nivel nacional de 144 países, mostrando que en 2010, 43 millones de niños (35 millones en los países en desarrollo) se ubicaron en el sobrepeso y la obesidad y 92 millones estaban en riesgo de sobrepeso. La prevalencia mundial de sobrepeso y obesidad infantil aumentó del 4.2% en 1990 al 6.7% en 2010. Con esta tendencia se espera llegar al 9.1% ó ≈60 millones en 2020. El aumento observado en la prevalencia del sobrepeso y la obesidad entre los años 1990 y 2010 en la primera infancia, es una consecuencia probable de un cambio en los patrones de nutrición y AF. En el contexto europeo, la prevalencia de sobrepeso incluyendo la obesidad, oscila entre el 8% en niñas alemanas al 30% en las niñas españolas y la obesidad del 1% en las niñas belgas al 13% en los varones españoles, utilizando los criterios de la OMS. En general, las niñas preescolares tienen una mayor prevalencia de sobrepeso y obesidad que los varones (Van Stralen et al. 2012). Estos resultados confirman la necesidad de intervenciones eficaces que comienzan en la infancia para revertir las tendencias. A su vez, debido a la prevalencia de obesidad observada en niños y jóvenes, muchas investigaciones y profesionales se han interesado en promocionar la AF en niños preescolares (Boyle et al., 2010).

A pesar del hecho de que una vida sedentaria a esta edad es muy común, pocos estudios sobre programas de intervención con AF se han centrado en el tiempo de estancia escolar (Howie y Pate, 2012). La aplicación de programas de intervención en AF en niños de 3 a 6 años, requiere además de medidas de evaluación y seguimiento de la CF relacionada con la salud, válida y fiable para esta población. Monsalves et al. (2015), afirman que una intervención con actividades más intensas en pequeños recreos puede incrementar los patrones motores básicos en niños preescolares, y esta mejora en los patrones motores es el primer paso para el incremento de los niveles de AF. Para Delgado y Montes, (2015), sería interesante mejorar los programas de actividad físico-deportiva, desde edades tempranas. Por otra parte, O'Neill, Pfeiffer, Dowda & Pate,(2016), estudiaron la relación entre la AF de los niños de preescolar, en la escuela y fuera de la

escuela, y concluyeron que no hay diferencia significativa en la cantidad de AF que hacen fuera del contexto escolar, entre los niños que hacen más AF en la escuela, y los que hacen menos.

Finalmente, el propio currículum de Educación Infantil (RD1630/2006, de 9 de diciembre, por el que se establecen las enseñanzas mínimas del segundo ciclo de Educación infantil) pone de manifiesto mediante las áreas de conocimiento y bloques de contenido, la importancia de la motricidad y la salud en esta etapa educativa, lo cual requiere instrumentos que permitan objetivar de manera precisa y especifica las adquisiciones en el ámbito de la AF y la salud en estas edades. A su vez, la presencia en el currículo universitario de un Grado de Educación Infantil y de materias específicas como Didáctica de la Educación Física en Educación Infantil o Motricidad y Salud, hacen necesaria la incorporación de líneas de investigación de esta naturaleza, que presenten un alto grado de innovación e interés educativo y social. Teniendo en cuenta que la etapa preescolar (3 a 6 años) es especialmente sensible a la adquisición de los primeros aprendizajes y conductas saludables que sin lugar a dudas posteriormente tienen proyección en la infancia, adolescencia e incluso vida adulta, sería interesante establecer los niveles de referencia que tipifiquen un estado físico saludable asociado al nivel de AF, CF, estado ponderal y nutricional, como marco de referencia para establecer programas de intervención específicos de AF saludable. A su vez, habría que acordar, después de los estudios pertinentes, los criterios de prescripción de ejercicio saludable en esta población, en lo que se refiere a los componentes de la carga como por ejemplo la frecuencia y duración. Finalmente, como señalan Palmer et al. (2016) los centros escolares de Educación Infantil, deberían proporcionar AF estructurada dentro de su jornada escolar.

3. CONDICIÓN FÍSICA Y SALUD EN NIÑOS DE ETAPA PREESCOLAR

La CF es la capacidad que permite al individuo llevar a cabo sus actividades diarias sin fatiga indebida y con reserva adecuada para disfrutar actividades de ocio activo (Malina & Katzmarzyk, 2006). Para Ruiz et al. (2011), la CF se define como la capacidad que tiene una persona para realizar AF y/o ejercicio, y constituye una medida integrada de todas las funciones y estructuras que intervienen en la realización de AF o ejercicio.

Los componentes de la CF, son: la fuerza, la resistencia cardiorrespiratoria, la velocidad, equilibrio, fuerza y flexibilidad (Hardman, 2002). Según Molnar y Livingstone (2000), se pueden agrupar los componentes en dos grandes categorías: los aspectos relacionados con la salud (capacidad aeróbica, fuerza muscular, resistencia muscular y flexibilidad) y los aspectos relacionados con la habilidad (agilidad, equilibrio, coordinación, potencia, tiempo de reacción y velocidad). En este sentido, Stodden et al. (2008) señalan que el desarrollo de la competencia de habilidades motoras es un mecanismo subyacente primario que promueve la participación en la AF. Los niños con peor rendimiento de habilidades motoras, son menos activos que los niños con habilidades motoras más desarrolladas. Esta relación entre el rendimiento de las habilidades motoras y la AF podría ser importante para la salud de los niños, en particular en la prevención de la obesidad (Williams et al. 2008). El desarrollo tanto de la salud (fuerza muscular y aptitud aeróbica) como de la habilidad relacionada con la agilidad y la velocidad pueden

facilitar el compromiso y acercamiento hacia la AF para los niños en edad preescolar (Tanaka et al. 2012). En este sentido, Sigmundsson y Haga (2016), destacan la vinculación entre las habilidades motrices, el nivel de CF y AF en niños de 4 a 6 años. Según Cliff, Okely, Smith y Mckeen (2009), altos niveles de rendimiento aeróbico y coordinación motora son fuertes predictores de la AF en niños durante la infancia.

El nivel de CF es un potente biomarcador de la salud desde una edad temprana (Ortega, Ruiz, Castillo y Sjöström, 2008). Además, la AF y la CF están muy relacionadas con la salud y con el sobrepeso (Fogelholm, Stigman, Huisman, Metsämuuronen, & Metsamuuronen, 2008; Rauner, Mess, & Woll, 2013). En este sentido, la obesidad actúa como mediador entre la aptitud cardiorrespiratoria y la presión arterial en niños preescolares (Pozuelo et al. 2016). Gómez et al. (2012) y Casajús et al. (2016) señalan que la CF, adiposidad y distribución grasa observadas en la infancia, han mostrado tener relación con la salud cardiovascular en la edad adulta.

El nivel de CF se puede evaluar objetivamente mediante test de laboratorio y test de campo (Ruiz et al., 2011). Existen diversas baterías de evaluación de la CF en niños y adultos (Batería Eurofit y Seniors Test) pero el problema está en adaptarla y validarla a la población infantil de 3 a 6 años. Fulton et al. (2001), destacan la necesidad de desarrollar métodos válidos para la medición de la AF y el comportamiento sedentario, lo cual se considera el primer paso necesario para llevar a cabo la vigilancia significativa de la CF y la investigación de intervenciones para niños de 2-5 años. Para Latorre et al. (2015), el poder analizar la CF en niños preescolares es un objetivo esencial y su consecución nos podrá permitir establecer percentiles y referencias normativas que podrían ayudar a ilustrar el nivel de AF de esta población así como su asociación con otros aspectos epidemiológicos como el sobrepeso, estado nutricional y otros factores socio demográficos como las condiciones sociales, económicas y culturales de los progenitores e incluso con aspectos cognitivos.

Pérez (2013), señala que a pesar de que existen diferentes pruebas para cada uno de los componentes de la CF son escasos los test que cumplen todos los requisitos de medir y valorar con fiabilidad la CF en edad infantil. Para Ayón et al. (2015) las pruebas de Course-Navette y Mini-Cooper son medidas confiables de aptitud cardiorrespiratoria que pueden usarse para evaluar la aptitud física relacionada con la salud en niños en edad preescolar. Ortega et al. (2015), proponen la batería de pruebas (PREFIT) como una herramienta útil para evaluar la aptitud física en niños de 3 a 5 años de edad. A su vez, Latorre et al. (2015) aplican una batería de test para medir los componentes básicos del CF-motora, la resistencia, la fuerza, la velocidad, el tiempo de reacción y el equilibrio en preescolares. Esta batería ha obtenido parámetros de fiabilidad adecuados, ha resultado ser válida y fácil de realizar, además de no requerir gran variedad de materiales ni equipo técnico complejo para evaluar la CF en niños de preescolar. Sería muy apropiado su uso por profesores, entrenadores, instructores y otro personal que trabaje con niños de estas edades.

Recientemente, Latorre et al. (2016 a,b) han publicado las referencias normativas del sprint de 20 metros y salto horizontal en niños preescolares. En Latorre, Mora, Martínez & García (2016), los niños son más rápidos que las niñas de 3

a 5 años de edad, en la prueba de 20 metros, pero no se encontraron diferencias significativas a los 6 años de edad. En relación con la edad, el tiempo de sprint fue más corto cuando aumentaba la edad de los niños de edad preescolar. Para Latorre, García, & Mora (2016), los chicos mostraron mayor rendimiento que las niñas de 3 a 5 años de edad, pero no se encontraron diferencias significativas a los 6 años de edad, en la prueba de salto horizontal. Además, se encuentran diferencias significativas entre los sexos: los varones muestran una mayor resistencia cardiorrespiratoria, mayor rendimiento en el sprint, en el salto horizontal, y en el tiempo de reacción. Igualmente se apreciaron diferencias por sexo en los diferentes grupos de edad (3, 4, 5 y 6 años). Además, la relación entre la CF y el IMC es inconsistente en los niños en edad preescolar (Latorre et al. 2016). Sin embargo, Zhou, Ren, Yin, Wang y Wang (2014), no encontraron diferencias significativas entre el sexo en equilibrio, salto de longitud y velocidad, aunque los niños llevan a cabo un mejor rendimiento con el tiro de pelota de tenis, 20m de gateo y flexibilidad que las niñas. A su vez, Bürgi et al. (2011) no encontraron diferencias significativas entre niños y niñas preescolares en la capacidad aeróbica o pruebas de equilibrio. Por su parte, Tanaka, Hikihara, Ohkawara y Tanaka (2012), señalan que los niños (varones) muestran un mayor rendimiento en salto horizontal y velocidad de carrera, unido a un peor equilibrio, respecto a las niñas.

Estos resultados controvertidos podrían ser debidos a la relativa idoneidad y validez de las pruebas de evaluación de la CF a estas edades, por los pocos estudios realizados aún, así pues, más estudios debieran realizarse con pruebas adaptadas a estas edades que precisen realmente el nivel de CF en niños en edad preescolar.

4. CONCLUSIONES

La prevalencia de AF en preescolares es baja y no cumplen recomendaciones internacionales, lo cual se asocia a una creciente prevalencia de sobrepeso y obesidad. Dentro de los correlatos que determinan la práctica de AF en preescolares destacamos la AF de los padres. La CF puedes ser un biomarcador de salud en edades tempranas. Existen diferencias significativas entre sexos en CF ya en una corta edad y las referencias normativas en relación con los diferentes componentes de la CF son necesarias. Por último, es importante incorporar programas de AF estructurada para niños de 3 a 6 años dentro y fuera del colegio.

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II. Test-retest reliability of a field-based physical fitness assessment for children aged 3-6 years.

(PAPER II)

II

Test-retest reliability of a field-based physical fitness assessment for children aged 3-6 years.

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Test-retest reliability of a field-based physical fitness assessment for children aged 3-6 years

Pedro Ángel Latorre Román[1], David Mora López[2], Marta Fernández Sánchez[1], Jesús Salas Sánchez[3], Francisco Moriana Coronas[1] and Felipe García-Pinillos[1]

[1]Department of Didactics of Corporal Expression, University of Jaen (Jaén). Spain. [2]Consejería de Educación, Junta de Andalucía. Spain. [3]Universidad Autónoma de Chile. Chile.

Abstract

Objective: **the present study aims to determine the test-retest reliability of the Fitness Test Battery in children aged 3-6 years.**

Methods: **a total of 553 children voluntarily participated in the current study; all children were aged 3 to 6 years. Demographic characteristics reveal that 274 children were male (age: 4.63 ± 0.94 years old, Body max index [BMI] = 16.30 ± 2.07 kg/m²), and 279 were female (age 4.70 ± 0.97 years old, BMI = 16.28 ± 2.09 kg/m²), and they were selected from 8 schools in southern Spain. All selected tests for the Fitness Test Battery, except the 10 x 20 metres (m) test that was designed ad hoc for this study, have been used in previous studies and are focused on testing basic components of physical condition and motor development such as endurance, strength, speed, reaction time and balance (10 x 20 m, Standing Broad Jump, 20 m running speed, Ruler drop test and Balance).**

Results: **the results obtained in this study indicate that the Fitness Test Battery has obtained adequate reliability parameters, and is able to discriminate with age among the different tests in healthy children between 3 and 6 years old. The tests used were safe, easy to perform, very acceptable and understandable by children.**

Conclusion: **the Fitness Test Battery is a valid, reliable and easy to assess the physical fitness of pre-schoolers children.**

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Key words: *Physical fitness. Children. Preschool. Validation. Test.*

FIABILIDAD TEST-RETEST DE UNA BATERÍA DE EVALUACIÓN DE LA CONDICIÓN FÍSICO-MOTORA EN NIÑOS DE 3 A 6 AÑOS

Resumen

Objetivo: **el presente estudio tiene como objetivo determinar la fiabilidad test-retest de una batería de evaluación de la condición física en niños de 3-6 años.**

Método: **un total de 553 niños participaron voluntariamente en el estudio; todos los niños tenían entre 3 a 6 años. Las características demográficas revelan que 274 eran niños (edad: 4.63 ± 0.94 años, índice de masa corporal [IMC]= 16.30 ± 2.07 kg/m²), y 279 eran niñas (edad 4.70 ± 0.97 años, IMC = 16.28 ± 2.09 kg/m²), que fueron seleccionados de entre 8 escuelas en el sur de España. Todas las pruebas incluidas en la batería, con excepción de la prueba de 10 x 20 metros (m), que fue diseñada *ad hoc* para este estudio, se han utilizado en estudios anteriores y se centraron en los componentes básicos de la condición físico-motora, como la resistencia, la fuerza, la velocidad, el tiempo de reacción y el equilibrio.**

Resultados: **los resultados obtenidos en este estudio indican que la batería de condición física para preescolares ha obtenido parámetros de fiabilidad test-retest adecuados y es capaz de discriminar según la edad entre las diferentes pruebas en niños sanos de 3 a 6 años.**

Conclusión: **la batería de condición física para preescolares diseñada en este estudio es un instrumento válido, fiable y fácil de emplear para evaluar la condición física de los niños en edad preescolar. Las pruebas utilizadas eran seguras, fáciles de realizar, muy aceptables y comprensibles para los niños.**

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Palabras clave: *Condición física. Niños. Preescolar. Validación. Test.*

Correspondence: Jesús Salas Sánchez.
Plaza de la Coronación N.º 4
C.P. 23480 Quesada (Jaén).
E-mail: Salas644@hotmail.com

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Introduction

The importance of physical activity for health is well known and research has noted both physical and psychological benefits when children participate in physical activity[1,2]. Fitness, adiposity and body fat distribution during childhood have shown a high correlation with cardiovascular health in adulthood[3]. Additionally, fitness level is a potent biomarker of health from an early age[4]. Furthermore, the relationship between physical activity practice and fitness has been widely studied, even at early ages. Bürgi et al. (2011)[5] indicate that in preschool children, the level of physical activity is associated with improvements in heart abilities and aerobic capacity, being a determinant of cardiovascular risk. Likewise, high levels of aerobic performance and motor coordination are strong predictors of physical activity during childhood[6]. Therefore, early childhood should be targeted as a critical time to promote healthy lifestyle behaviours, especially, sedentary behaviours[7].

Different test batteries have been designed and validated in order to assess the fitness level in young and older people (e.g., ALPHA, EUROFIT, FITNESSGRAM,)[8,9,10] However, these are usually inadequate to determine fitness in children 3-6 years old because of the difficulty participants at this age have with following strict instructions. Furthermore, the physical fitness test typically analyses only physiological components, such as muscle strength or endurance capacity, that are tested with more or less advanced technological equipment in controlled laboratory settings. In addition, laboratory tests are expensive and require highly trained experimenters; thus, they are not feasible for use with large groups of participants[11]. At the moment, there is insufficient information about reliability and validity of fitness tests in pre-schoolers children[12]. Valid and reliable measures of physical fitness of preschool children are necessary to investigate the relationship between physical fitness and health in this population[12,13,14]. To date, just a few studies[5,15] have focused on analysing the physical abilities and fitness level of children aged 3-6 years.

Taking into account the above information, a reliable test battery that leads to testing the fitness level of preschool children in a large population is needed. Therefore, the aims of this study are: i) to determine the test-retest reliability of the Fitness Test Battery and ii) to determine the feasibility of this battery in children 3-6 years in discriminating performance with age.

Method

Participants

In this study, a total of 553 children aged 3 to 6 years voluntarily participated. Demographic characteristics reveal that 274 children were male (age: 4.63 ± 0.94 years old, Body max index [BMI] = 16.30 ± 2.07 kg/m^2), and 279 were female (age 4.70 ± 0.97 years old, BMI = 16.28 ± 2.09 kg/m^2), and they were selected from 8 schools in southern Spain. Inclusion criteria included schooling in early childhood and being free from physical and/or intellectual disabilities. Parents voluntarily signed an informed consent form for the participation of their children in this study. The study was completed in accordance with the norms of The Declaration of Helsinki (2013 version) and following the directives of the European Union on Good Clinical Practice (111/3976/88 of July, 1990), as specified in the Spanish legal framework for human clinical research (Royal Decree 561/1993 on clinical essays). The study was approved by the Ethics Committee of the University of Jaen (Jaen, Spain).

Materials and testing

All selected tests for the Fitness Test Battery, except the 10x20 metres (m) test that was designed ad hoc for this study, have been used in previous studies[8,9,10,11,16,17] and are focused on testing basic components of physical condition and motor development such as endurance, strength, speed, reaction time and balance. The test battery is designed to reduce the cognitive component of the tests and more easily sustains children's motivation to participate.

Cardiorespiratory endurance was assessed using the 10x20m test, inspired by the spatial structure of the Léger test[18] and based on the guidelines of the Spanish Athletics Federation (RFEA) for participants at this age in endurance efforts. The test design took into account that the rules were very simple and the test had a playful motivation. Materials required include a tape measure to mark the distances of the runway (20m), 2 boxes, 5 balloons, and a stopwatch. It is a 20-m shuttle test, in which participants have to move five balloons from a box –A, located in an extreme- to other box –B, located in the opposite extreme-. The total distance covered is 200m, timed to the signal "Go" until the participant deposits the last balloon. It does not matter if the balloon does not enter into the box. If during the moving the balloon is dropped, the participants must take it and carry on moving. Supervisors should indicate to the participants that the balloon must be caught with both hands. The test allows running and walking. Only one attempt is allowed. The result is recorded in seconds with one decimal. The test score was the running time, a longer time indicating a poorer performance. As a test for convergent validity with 10x20m, the 6-minute walk test (6MWT) has been used (as gold standard). The 6MWT originally designed for adults, measures aerobic endurance evaluated by the maximum distance covered on flat ground for 6 minutes following a standard protocol. In healthy children and adolescents, this test has been validated and standardised in international studies[19,20]. To analyze the reaction time (RT) the Ruler Drop Test (RDT)[16], which aims to measure the RT and eye-hand coordination, was used. A rule of 50-60 centimetres (cm) long was used. The RDT was repeated three times with each hand, it taking the average score of each hand. The average of each hand and the average of both hands were used for the subsequent statistical analysis. The RT conversion (in seconds) is performed using the formula for a body in free fall under the influence of gravity ($d = ½gt2$). The test score was the running time, a longer time indicating a poorer performance. As for the balance assessment, the Stork Balance Stand Test[21] was used. Two attempts were made with both legs and the best results (s) were scored, averaging the results of both legs. The test score was the runtime, a longer time indicating a better performance. To measure explosive lower body strength, the standing broad jump test was used[8]. The test was performed twice and the best score was recorded in centimetres. The test score was the distance reached, a lower distance indicating a poorer performance. The sprint test was performed using a distance of 20m on a flat, hard, non-slip surface[11]. Two attempts were made for the test and the best time was recorded (in seconds). The test score was the running time, a longer time indicating a poorer performance.

Procedure

After obtaining the appropriate permits in schools and informed parental consent, we proceeded to the application of the test battery. In two separate sessions, 48 hours apart, a team of researchers previously trained in conducting the different test evaluated the children. During the first testing session, RDT, the standing broad jump test, the balance test and 6MWT were performed. Two-days later, during the second testing session, the 20m and 10x20m test were performed. Prior to conducting the tests, children performed a typical warm-up, consisting of five minutes of low-intensity running, and five minutes of general exercises (i.e., high skipping, leg flexions, lateral running, front and behind arm rotation, and sprints) and the research team conducted a demonstration. The children also performed some executions of the familiarization in RT, balance and horizontal jump. Each child was assessed individually. A week later a retest in every single fitness test was conducted with a sample of 90 children. The children were motivated and encouraged at all times to execute the tests.

Statistical Analysis

Data were analysed using SPSS, v.19.0 for Windows (SPSS Inc, Chicago, USA) and the significance level was set at $p<0.05$. The data are shown in descriptive statistics for mean and standard deviation (SD). Reliability analysis was performed using intraclass correlation coefficients (ICC) in the pretest-posttest and Bland-Altman graphs study. The convergent validity was performed by Pearson's correlation. Differences between genders and age groups were analysed using analysis of variance (ANOVA). Moreover, in the sprint test inter-observer reliability was calculated using ICC. Finally, a Pearson correlation analysis was performed between the different tests in this battery.

Results

Table I shows the descriptive statistics and ICC tests for all pre- and post-tests. In the 10x20m test, an ICC equal to 0.969 (95% confidence interval (CI)= 0.953-0.979) was achieved. The Bland-Altman graphic showed limits of agreement (2 SD) of 10.9 and -11.4s with the mean of the differences= -0.21 ± 5.60 s (Figure 1). Regarding the convergent validity between the 10x20m test and 6MWT, a Pearson correlation coefficient of $r = -0.657$, ($p <0.001$) was obtained. As for the RDT, an ICC equal to 0.744 (95% CI= 0.836-0.602) was obtained, the Bland-Altman graphic showed limits of agreement (2 SD) of 13.8 and -13.6cm, and the mean of the differences was equal to 0.10 ± 6.87cm. Regarding the balance test, an ICC equal to 0.995 (95% CI = 0.997-0.992) was achieved; the Bland-Alt-

Table I
Descriptive statistics and ICC of Fitness Test Battery.

	Test Mean (SD) n=90	*Retest Mean (SD) n=90*	*ICC*	*95% Confidence Interval*
10x20m (s)	83.11 (16.64)	83.31 (15.48)	0.969	0.953-0.979
Ruler drop test (cm)	37.98 (7.75)	37.87 (7.49)	0.744	0.602-0.836
Balance (s)	9.67 (8.65)	10.15 (8.45)	0.995	0.992-0.997
Standing broad jump (cm)	76.53 (20.20)	74.56 (21.12)	0.913	0.866-0.943
20m running speed (s)	5.77 (1.12)	5.78 (1.17)	0.942	0.911-0.962

SD (standard deviation).

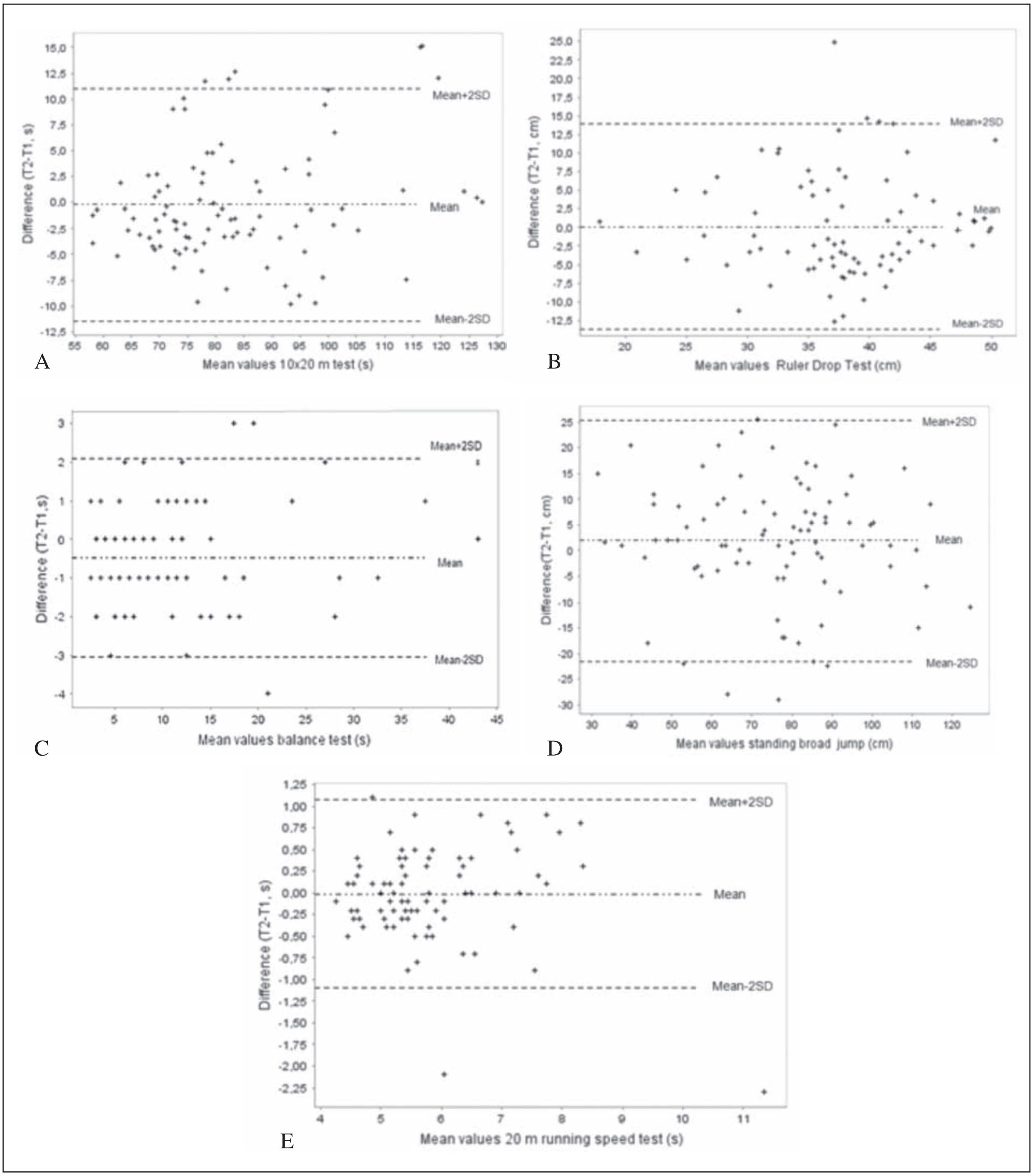

Fig. 1.—Bland-Altman graph 10x20m (A), RDT (B), balance test (C), standing broad jump (D) 20m running speed (E) pre-test/post-test.

man graphic showed limits of agreement (2 SD) of 2.09 and -3.03s, and the average of the differences was -0.47±1.28s. Concerning the standing broad jump test, an ICC= 0.913 (95% CI= 0.943-0.866) was obtained; the Bland-Altman graphic showed limits of agreement (2 SD) of 25.4 and -21.4cm, the mean differences were ± 1.96±11.72cm. Finally, as for the 20m sprint test, an ICC = 0.942 (95% CI= 0.962-0.911) was achieved and the Bland-Altman graphic showed limits of agreement (2 SD) of 1.06 and -1.09s; the average differences were -0.01±0.54s. The inter-observer agreement in the sprint test shows an ICC equal to 0.991 (95% CI= 0.987-0.994).

Table II shows the results of the battery Fitness Test Battery considering gender and age. The boys show higher scores on the standing broad jump than girls ($p=0.019$). Taking age group into account, a significant improvement ($p<0.001$) was observed in all tests with growth. Table III shows the results of the Pearson correlation analysis between the test battery and age; significant correlations between all tests with each other, and between each test with age, were found.

Discussion

In this study, the main goal was to describe a new test battery aimed at quantifying fitness level and motor development in children ages 3 to 6 years. The Fitness Test Battery has obtained adequate reliability parameters in the different tests performed. All tests were conducted without any incident and were appropriate for pre-schoolers children.

Moreover, a primary purpose of this study was that the test battery should be easy to perform and should not require complex technical equipment. In this regard, this test battery is designed to let us test large groups of children, and monitoring fitness levels and motor development of children over time. The evaluation of the acute response to physical activity is an important clinical tool as it provides an examination of the respiratory, cardiac and metabolic systems[20].

Originally, the 10x20m test was created to analyse cardiorespiratory fitness, which has obtained a high temporal reliability (test-retest), thus this test has been shown to be safe, easy to perform and highly acceptable for use with children. At the same time, the 10x20m test significantly correlates with age and it can be a test for monitoring the development of cardiorespiratory fitness in children of this age as the time taken is reduced with age, with no significant differences between genders, thus similar to the increase in 6 minute walk test (6MWT) in preschool children[22].

The results obtained in this study showed that RT decreases with age of the children; a previous study reported similar findings[23]. Similarly, the RDT shows adequate reliability; other studies have also shown reliability and validity of the RDT test in young adults[24,25]. Ruiz, Mata and Jimenez (2005)[26] and Raynor (1998)[27] indicate that the RT is a very interesting measure as it shows the ability of the neuromuscular system to respond quickly to the demands of the envi-

Table II
Results the Fitness Test Battery considering gender and age.

	Total Mean (SD)	*Boy Mean (SD) n=274*	*Girl Mean (SD) n=279*	*p-value*	*3 years n=173 Mean (SD)*	*4 years n=148 Mean (SD)*	*5 years n=149 Mean (SD)*	*6 years n=83 Mean (SD)*	*p-value*
10x20m (s)	94.35 (20.61)	94.53 (20.72)	94.18 (20.54)	0.842	109.18 (21.58)^{a}	93.53 (15.90)^{b}	87.19 (16.41)^{c}	78.73 (12.44)^{d}	<0.001
Ruler drop test (s)	0.27 (0.03)	0.27 (0.03)	0.27 (0.03)	0.083	0.28 (0.03)^{a}	0.27 (0.03)$^{b.}$	0.26 (0.02)^{c}	0.26 (0.03)^{c}	<0.001
Balance (s)	7.09 (7.18)	7.37 (7.78)	6.82 (6.55)	0.377	3.99 (3.06)^{a}	6.06 (5.51)^{b}	9.47 (8.88)^{c}	11.03 (9.05)^{c}	<0.001
Standing broad jump (cm)	70.01 (25.11)	72.54 (26.25)	67.51 (23.72)	0.019	51.90 (19.18)^{a}	66.39 (20.58)^{b}	81.93 (21.11)^{c}	91.36 (21.78)^{d}	<0.001
20m running speed (s)	6.30 (1.08)	6.23 (1.08)	6.37 (1.08)	0.122	7.14 (1.00)^{a}	6.32 (0.97)^{b}	5.73 (0.69)^{c}	5.59 (0.84)^{c}	<0.001

SD (standard deviation). Post-hoc analysis (Bonferroni): Different letter subscript indicates significant differences (p<0.05) between age groups.

Table III
Pearson correlation between the tests.

	Age	*10x20 m*	*Ruler drop test*	*Balance*	*Standing broad jump*	*20m running speed*
Age	1	-0.510**	-0.307**	0.391**	0.594**	-0.566**
10x20m		1	0.164**	-0.343**	-0.443**	0.523**
Ruler drop test			1	-0.241**	-0.307**	0.257**
Balance				1	0.381**	-0.313**
Standing broad jump					1	-0.508**
20m running speed						1

**p<0.01.

ronment and thus indicates increases in RT in people with developmental problems in motor coordination. Regarding balance, standing broad jump and sprint, equally suitable reliability values were obtained and association with the age of participants; results are consistent with Zhou et al. (2014)[28] in pre-schoolers children.

All tests correlated significantly with age suggesting that the Fitness Test Battery can be used with children aged 3-6 years. According to gender differences, only the standing broad jump test shows significant differences in children with higher values.

The most important limitation of this study was that it is limited to samples of 3- to 6-year-old Spanish children. Larger samples in each age group are essential for establishing age and gender specific norms. Nevertheless, to the best researchers´ knowledge, this is the first study that provides the reliability of a fitness test battery for preschool children.

Conclusions

The results obtained in this study indicate that the Fitness Test Battery has obtained adequate test-retest reliability parameters, and was able to discriminate, using age, among the different tests in healthy children between 3 and 6 years old. The tests used were safe, easy to perform, very acceptable and understandable by children. From a practical standpoint, the Fitness Test Battery is a valid, reliable and easy to assess the physical fitness of pre-schoolers children. Consequently, teachers, coaches, trainers and other staff working with children of these ages can use this test battery despite not having a large variety of materials and technological resources.

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III Reference Values of Standing Long Jump in Preschool Children: A Population-Based Study.

(PAPER III)

III

Reference Values of Standing Long Jump in Preschool Children: A Population-Based Study.

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Reference Values of Standing Long Jump in Preschool Children: A Population-Based Study

Pedro Ángel Latorre-Román and Felipe García-Pinillos
University of Jaen

David Mora-López[AUQ1]

Purpose: The purpose of this study was to examine age and sex differences in standing long jump (SLJ) and to determine norm-referenced values for Spanish preschool children. ***Method***: A total of 3555 children, aged 3–6 years, participated in this study (1746 girls and 1809 boys). To measure explosive leg power, the SLJ was used. ***Results***: In the analysis of reliability using test-retest with 86 children (48% boys, age = 56.22 ± 10.34 months), the following descriptive results were obtained (mean, *SD*): at pretest = 76.53 ± 20.20 cm, at retest = 74.56 ± 21.12 cm (p = .124), and an intraclass correlation coefficient = 0.913 (95% confidence interval = 0.866–0.943). Boys exhibited a greater performance than girls at 3- to 5-years old, but no significant differences were found at 6 years old. In whole group, the SLJ performance was higher with increased age. However, no significant differences were found between boys aged 5 and 6 years. ***Conclusion***: This study provides references values for muscle strength assessment through SLJ test carried out on a large sample of Spanish preschoolers.

Keywords: pediatrics, fitness, health, strength

The preschool age is characterized by significant changes in the acquisition of locomotors skills and nervous system maturation (23). Previous research has showed both physical and psychological benefits when children participate in physical activity (1,14). However, some previous studies have noted that preschool children spend insufficient time in physical activity (19,24). The relationship between motor performance, muscular strength and cardiovascular fitness with physical activity level has been widely studied and established in children (16). The development of muscular strength in children and adolescent causes health benefits (22). In line with this, Ortega et al. (2008) (21) showed that physical fitness level is a potent biomarker of health from an early age. Easy-to-perform test are clearly needed to assess physical fitness in early ages—schools and sports clubs. There is limited information about reliability and validity of fitness tests in preschool children (20). Reliable measures of fitness test in preschool children are necessary to investigate the relationship between physical fitness and health in this population (17,20), specially on leg strength.

There are limited studies to analyze correlates of physical fitness associated to growth and maturity (18), particularly in leg strength in preschool children. The standing long jump (SLJ) is a valid tool for assessing lower body muscular strength in youth (2,7). Moreover, SLJ is constituent part of several international batteries of physical fitness (9,10,12). The SLJ test is practical, time efficient, and does not require any additional equipment.

Moreover, to the best authors´ knowledge, there is no information available about reference values for SLJ in preschool children. The purpose of this study was to examine age and sex differences in SLJ and to determine reference values for Spanish preschool children.

Method

Participants

A total of 3555 children, aged 3–6 years, participated in this study (Age = 55.93 ± 11.14 months, Body mass index [BMI] =15.94 ± 1.91 kg/m^2, 1746 girls and 1809 boys), and they were selected from 51 schools in southern Spain. The sample has been selected by convenience in a large geographic area of Andalusia in both urban and rural areas. Inclusion criteria considered schooling in early childhood and being free from physical and/or intellectual disabilities.

Latorre-Román and García-Pinillos are with the Dept. of Didactics of Corporal Expression, University of Jaen, Jaén, Spain. Address author correspondence to Pedro Ángel Latorre-Román at platorre@ujaen.es.

Parents voluntarily signed an informed consent form for the participation of their children in this study. Parent's demographic characteristics are showed in the results. The study was completed in accordance to the norms of The Declaration of Helsinki (2013 version) and following the directives of the European Union on Good Clinical Practice (111/3976/88 of July 1990), as specified in the Spanish legal framework for human clinical research (Royal Decree 561/1993 on clinical essays). The study was approved by the Ethics Committee of the University of Jaen (Spain).

Materials and testing

Height (cm) was measured with a stadiometer (Seca 222, Hamburg, Germany) and body mass (kg) with a bascule (Seca 899, Hamburg, Germany). Body mass index (BMI) was calculated by dividing weight (in kilograms) by height^2 (in meters). Waist circumference (WC) was measured by using a SECA Ergonomic Circumference Measuring Tape SE201 (SECA, Germany). To measure explosive leg power, the SLJ was used (10). The test was performed twice and the best score was recorded in centimeters (between takeoff and the heel of the nearest foot at landing). The test score was the distance reached, a lower distance indicating a poorer performance.

Procedure

Before the testing sessions, children performed a typical warm-up consisting of 5 min of low-intensity running and five minutes of general exercise (i.e., skipping, leg lifts, lateral running, and front to behind arm rotations). Subsequently, the SLJ test (two trials, the best trial was registered) were performed on a hard surface. The children also performed some familiarization trials for the SLJ. The research team conducted a demonstration. The children were motivated and encouraged to reach the best distance possible. A week later, 86 children (included in the previous data collection) selected by a random process, performed the same test (retest).

Statistical Analysis

Data were analyzed using SPSS, v.19.0 for Windows (SPSS Inc, Chicago, USA) and the significance level was set at $p < .05$. The data are shown in descriptive statistics for mean, standard deviation (*SD*) and percentile. Tests of normal distribution and homogeneity (Kolmogorov-Smirnov and Levene's) were conducted on all data before analysis. Differences between sex and age groups were analyzed using analysis of variance (ANOVA) adjusting by Bonferroni test, using BMI as covariate. A Pearson correlation analysis and a multiple linear regression analysis were performed between SLJ test with age, sex and anthropometrics variables. The reliability of SLJ was analyzed by prepost-test through the intraclass correlation coefficient (ICC). For the analysis of heteroscedasticity, mean differences in relation to the individual values they were computed. We calculated the correlation coefficient to examine the presence of heteroscedasticity (3).

Results

In relation to parent's demographic characteristics: 9% are single, 80.8 married, 8.9% divorced, 1.3 widowed; 20.7% showed low socioeconomic status, 71.2% medium and 8.1 high, finally, 7.2% are uneducated, 19.8% primary, 38.7% secondary and 34.3% showed university studies.

In the analysis of reliability using test-retest, the following descriptive results are obtained in the pretest (mean, *SD*) = 76.53 ± 20.20 cm, retest (mean, *SD*) = 74.56 ± 21.12 cm, $p = .124$ and an ICC = 0.913 (95% confidence interval (CI) = 0.866–0.943) was found. Pearson correlation analysis of differences in absolute value with individual values showed not association ($r = .003$; $p = .978$).

Table 1 shows anthropometric characteristics and SLJ performance, boys exhibited a greater score than girls.

\\<<<Insert Table 1 here>>>>\

Table 2 showed SLJ performance by age groups and sex. Boys exhibited a greater performance than girls 3–5 years old, but no significant differences were found at 6 years old. In relation with age in whole group, the SLJ performance was higher with increased age.

\\<<<<Insert Table 2 here>>>>\

Pearson correlation analysis showed significant correlation between SLJ and age ($r = .474$, $p < .001$), height ($r = .454$, $p < .001$), weight ($r = .314$, $p < .001$) and WC ($r = .084$, $p < .001$). No significant correlation ($p \geq .05$) was found between SLJ and BMI. A multiple linear regression analysis between SLJ with age, sex and anthropometrics variables was conducted (Table 3). Age, height, body mass and sex are predictor's variables for SLJ. Table 4 and 5 exhibit percentiles of SLJ by sex. Finally, the greatest improvement in SLJ occurs 3–4 years in boys and girls.

\\<<<<<<Insert Table 3,4,5 here>>>>\\

Discussion

This study provides reference values for SLJ by age and sex in Spanish preschool children. Adequate reliability parameters were found in SLJ for children 3–6 years old. Using a cross-sectional study design, the results obtained showed that SLJ performance differs between boys and girls. Boys exhibited a greater performance than girls at 3–5 years old, but no significant differences were found at 6 years old. These findings are consistent with previous studies that supports sex differences in SLJ (5,15,23). However Zhou Ren, Yin, Wang and Wang (25) found no significant differences between boys and girls in SLJ.

The sex differences observed in this study might be caused by differences in the level of moderate-to vigorous physical activity (MVPA) found in a previous study, higher in boys (19). In this regard, higher distances in SLJ were associated with lower sedentary time, greater MVPA and increased physical activity level (23). Moreover, these results could indicate differences in neuromuscular maturation among girls and boys preschoolers.

In relation to age, in whole group, SLJ is higher 3- to 6-years old. However, SLJ performance in boys was higher

3–5 years old, with no significant differences between 5–6 years old.

Moreover, in preschool children, the body weight and body height should be considered as significant predictors of the physical fitness (15). The current study shows the influence of body weight and body height on muscular strength levels across age groups. In this sense, our findings showed that body height and body weight are predictors to SLJ performance. These results are consistent with previous studies in children, showing an inverse relationship between body weight and physical fitness (4,6,8).

Muscle strength contributes to skeletal development, while sedentary behavior negatively affects bone health in preschoolers (13). Therefore, fitness test provides an important information about the health of children, although its use is not usually taken into account in school context (6). Accordingly, schools are the setting which to identify, at an early stage, children with low fitness levels and establish programs to promote healthy behaviors (6) such as physical activity. The interpretation of physical fitness assessment requires comparing the individual score obtained with reference values for the general population in relation to sex and age (11). Therefore, this research provides reference values, presented for age and sex, for SLJ test in Spanish preschoolers.

The main limitation in this study is its cross-sectional design (i.e., level of muscular strength in growing children must be measured in longitudinal research). However, the strengths of this study include a large population sample of children analyzed and the reliability of SLJ in preschool children.

To sum up, this study provides the references values for muscle strength assessment through SLJ test carried out on a large sample of Spanish preschoolers. SLJ is a reliable test to assess lower limb strength in preschoolers. In addition, some differences in SLJ performance were found according to sex despite the early age of participants, and references values were established considering that variable.

Eventually, from a practical point of view and considering the lack of reference values for assessing physical fitness of preschool children, the percentiles values obtained in this study might play a key role for teachers and coaches who work with children aged 3–6 years.

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Table 1 Anthropometric Characteristics and Standing Long Jump (SLJ) Performance According to Sex

Characteristics	Whole group (*n* = 3555)	Boys (*n* = 1809)	Girls (*n* = 1746)	*p*-value	95% Confidence Interval
	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)		
Age (months)	55.93 (11.14)	55.71 (11.11)	56.16 (11.16)	.211	
Body mass(kg)	19.39 (4.27)	19.63 (4.37)	19.14 (4.16)	<.001	0.225/0.765
Height (cm)	109.18 (8.36)	109.48 (8.41)	108.87 (8.29)	.023	0.086/1.143
Body mass index (kg/m^2)	15.94 (1.91)	16.03 (1.93)	15.85 (1.89)	.002	0.061/0.310
Waist circumference (cm)	56.72 (7.90)	56.86 (7.68)	56.57 (8.11)	.243	-0.202/0.795
Standing long jump (cm) *	69.85 (25.21)	72.74 (25.91)	66.85 (24.11)	<.001	4.291/7.590

Note. SD = Standard deviation. *ANOVA with BMI as covariate. 95% CI values are the ranges for the difference scores between groups.

Table 2 SLJ Performance by Age Groups and Sex

Age (years)	Whole-group		Boys		Girls		*p*-value	95% Confidence Interval
	n	Mean (*SD*)	*n*	Mean (*SD*)	*n*	Mean (*SD*)		
3	876	52.34 (20.68)[a]	452	54.32 (21.10)a	424	50.22 (20.05)[a]	.006	1.182/7.060
4	1107	67.96 (23.03)[b]	583	71.28 (23.13)b	524	64.26 (22.38)[b]	<.001	4.475/9.711
5	1250	79.56 (23.20)[c]	628	83.61 (24.23)c	622	75.48 (21.38)[c]	<.001	5.785/10.708
6	322	86.39 (21.64)[d]	146	88.96 (21.75)c	176	84.27 (21.38)[d]	.059	-0.187/9.627
p-value (intra group)		<0.001		<0.001		<0.001		

SD. Standard deviation. Values with different subscript letters indicate significant differences ($p< 0.05$) in Post hoc analysis Bonferroni. 95% CI values are the ranges for the difference scores between groups.

Table 3 Multiple Linear Regression Analyses Between SLJ and Age, Anthropometric Variables, and Sex

Variables	B	t	*p*-value	95% confidence Interval to B	
				Lower Limit	Higher Limit
Constant	-66.052	-11.092	<.001	-77.728	-54.377
Age	0.725	17.030	<.001	0.641	0.808
Height	0.905	11.378	<.001	0.749	1.061
Weight	-0.358	-2.368	.018	-0.654	-0.062
Sex	6.061	8.408	<.001	4.648	7.475
R^2			0.282		

Sex. 1 = boys

Table 4 Percentiles of SLJ in Girls

Age (years)	5	25	50	75	95
3	22.77	33.00	47.00	63.00	90.00
4	26.00	48.95	64.85	80.00	103.00
5	32.85	63.00	76.70	90.00	110.00
6	49.00	70.25	85.00	96.00	122.00

Table 5 Percentiles of SLJ in Boys

Age (years)	5	25	50	75	95
3	23.00	39.00	52.00	68.00	97.00
4	28.00	56.00	73.50	88.00	107.00
5	40.40	67.00	84.50	100.00	120.00
6	54.40	72.00	89.00	103.00	125.00

Author Queries

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IV. Reference values for running sprint field tests in preschool children: A population-based study

(PAPER IV)

IV

Reference values for running sprint field tests in preschool children: A population-based study.

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Reference values for running sprint field tests in preschool children: A population-based study

Pedro Ángel Latorre-Román[a,*], David Mora-López[b], Melchor Martínez-Redondo[c], Felipe García-Pinillos[b]

[a] University of Jaen, Calle Chiclana de la Frontera 53, Úbeda, Jaén 23400, Spain
[b] University of Jaen, Paraje de las Lagunillas s/n, Jaén, 23071, Spain
[c] Government of Andalusia, C.E.I.P Doctor Fleming. Avda. San Sebastian, s/n, Jodar, 23400, Spain

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ABSTRACT

The purpose of this study was to determine reference values in the 20 m sprint test for Spanish preschool children and to examine the influence of age, sex and anthropometrics characteristics in sprint performance. A cross-sectional study was used. A total of 3076 children, aged 3 to 6 years, participated in this study (1539 girls and 1537 boys). To measure running speed, the 20 m sprint test was used. In the analysis of reliability, using test–retest with 89 children (48% boys), the following descriptive results were obtained (mean, SD): at pretest = 5.72 ± 0.98 s, at retest = 5.71 ± 0.87 s (p = 0.819), and an intraclass correlation coefficient = 0.929 (95% confidence interval 0.891–0.954). Boys are faster than girls at 3 to 5 years old, but no significant differences were found at 6 years old. In relation to age, the sprint time was shorter as kids got older. This study provides reference values for running speed assessment through a 20 m sprint test carried out on a large sample of Spanish preschoolers.

1. Introduction

The preschool age is characterized by significant changes in the acquisition of locomotor skills and nervous system maturation [1]. In the early childhood years, children develop fundamental motor skills (FMS), composed of locomotor skills and object control skills [2]; children who do not master FMS may participate little in sport and games during childhood and adolescence [3]. The mastery of FMS contributes to children's physical, cognitive and social development and is essential for an active lifestyle [4]. The relationship between motor performance, fundamental movement skills, muscular strength and cardiovascular fitness with physical activity levels and health status has been widely studied and established in children [5–7]. Previous research has shown both physical and psychological benefits when children participate in physical activity [8,9]. In a recent review, Catuzzo et al. [7] showed that the development of motor competence is inversely associated with body mass status and positively associated with cardio-respiratory fitness and musculoskeletal fitness across childhood and adolescence. In line with this, Ortega et al. [10] showed that physical fitness level is a potent biomarker of health from an early age. However, some previous studies have noted that preschoolers spend insufficient time in physical activity [11,12].

Current literature in physical activity in preschool children has not focused on the developmental nature of motor skill competence and physical fitness. Running is an essential locomotor skill to promote physical activity and fitness; in particular, running speed can provide consistency as a gross motor skill and probably reflect anaerobic fitness [13]. There are a number of limited studies analysing the correlates of physical fitness associated to growth and maturity [14], particularly in the 20 m sprint in preschool children. Easy-to-perform tests are clearly needed to assess physical fitness in early ages – at schools and at sports clubs.

Moreover, to the best of the authors' knowledge, there is no information available about reference values for the 20 m sprint test in preschool children. The purpose of this study was to determine reference values in the 20 m sprint test for Spanish preschool children and to examine the influence of age, sex and anthropometrics characteristics in sprint performance.

* Corresponding author.
E-mail addresses: platorre@ujaen.es (P.Á. Latorre-Román), davidjmora7@gmail.com (D. Mora-López), melchor_mr@hotmail.com (M. Martínez-Redondo), fegarpi@ujaen.es (F. García-Pinillos).

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2. Methods

A total of 3076 children, aged 3 to 6 years, participated in this study (Age = 4.31 ± 0.94 years, body mass index [BMI] = 15.34 ± 4.18 kg/m^2, 1539 girls and 1537 boys), and they were selected from 51 schools in southern Spain. The sample has been selected by convenience in a large geographic area of Andalusia in both urban and rural areas. Inclusion criteria included schooling in early childhood and being free from physical and/or intellectual disabilities. Parents voluntarily signed an informed consent form for the participation of their children in this study. The study was completed in accordance with the norms of the Declaration of Helsinki (2013 version) and following the directives of the European Union on Good Clinical Practice (111/3976/88 of July, 1990), as specified in the Spanish legal framework for human clinical research (Royal Decree 561/1993 on clinical essays). The study was approved by the Ethics Committee of the University of Jaen (Spain).

Body height (cm) was measured with a stadiometer (Seca 222, Hamburg, Germany, precision = 1 mm) and body mass with a bascule (Seca 899, Hamburg, Germany, precision = 100 g). Body mass index (BMI) was calculated by dividing weight (in kilograms) by height^2 (in meters). Waist circumference (WC) was measured using a Seca Ergonomic Circumference Measuring Tape SE201 (Seca, Germany, precision = 1 mm). To measure sprint, the 20 m sprint test was used [15]. The reliability of the sprint test in preschool children has been previously reported [13,15].

Prior to the testing sessions, children performed a typical warm-up consisting of five minutes of low-intensity running and five minutes of general exercise (i.e. skipping, leg lifts, lateral running, and front to behind arm rotations). Subsequently, the 20 m sprint test (two trials with 120 s of recovery between trials, the best trial was registered) were performed on a flat, hard, non-slip surface, with the start line and finish line marked. Two raters recorded all the start and stop times with a stopwatch at least twice. The research team conducted a demonstration. The children were motivated to run as fast as possible. The test was measured with a stopwatch to the nearest of 0.1 s. A lower score indicates a greater performance. A week later, 89 children (48% boys, included in the previous data collection) selected by a random process, performed the same test (retest). To ensure the measurements accuracy, the raters were familiarized with the evaluation protocol.

Data were analysed using SPSS, v.19.0 for Windows (SPSS Inc, Chicago, USA) and the significance level was set at $p < 0.05$. The data are shown in descriptive statistics for mean, standard deviation (SD) and percentile. Tests of normal distribution and homogeneity (Kolmogorov–Smirnov and Levene's, respectively) were conducted on all data before analysis. Differences between sex and age groups were analysed using analysis of variance (ANOVA: 2(sex) × 4(age) adjusting by Bonferroni test, using anthropometrics factors as covariates. A Pearson correlation analysis was performed between the 20 m sprint and anthropometrics variables age-adjusted. To test the pre-post reliability and the inter-observer reliability of the 20 m sprint test the intraclass correlation coefficient (ICC) was used [16] and paired *t*-test for intra-observer and independent *t*-test for interobserver.

3. Results

In the analysis of reliability using pre-post, performed on 89 participants, the following descriptive results are obtained in the pretest (mean, SD) = 5.72 ± 0.98 s, retest (mean, SD) = 5.71 ± 0.87 s, p = 0.819, and an ICC = 0.929 (95% confidence interval (CI) = 0.891–0.954) was found. In the inter-observer reliability, the following descriptive results are obtained (mean, SD): The rater 1 = 5.84 ± 1.02 s, the rater 2 = 5.88 ± 1.06 s, p = 0.774 and the agreement in the sprint test shows an ICC equal to 0.991 (95% CI = 0.987–0.994).

Table 1 shows anthropometric characteristics. Boys exhibited a higher score than girls in body height, body mass and BMI.

Table 2 shows 20 m sprint performance by age groups and sex. Boys are faster than girls at 3 to 5 years old, but no significant differences were found at 6 years old. In relation to age, the sprint time was shorter as kids got older. In the whole group and in the girls group the 20 m sprint test performance is better 3 to 6 years old; however, in boys was better 3 to 5 years old, with no significant differences between 5 and 6 years old.

Pearson correlation analysis showed significant correlation between 20 m sprint with age (r = −0.416, p < 0.001), body height (r = −0.162, p < 0.001) and body mass (r = −0.103, p < 0.001). No significant correlation (p ≥ 0.05) was found between 20 m sprint with BMI (r = −0.009, p = 0.646) and 20 m sprint with WC (r = 0.000, p = 0.999). Tables 3 and 4 exhibit percentiles of 20 m sprint by sex.

4. Discussion

This study provides reference values for the 20 m sprint test by age and sex in Spanish preschool children. Adequate reliability parameters[16] were found in the 20 m sprint test for children aged 3 to 6 years old. Similar results in the pre-post reliability in the sprint test were obtained by Nguyen et al. [13] Using a cross-sectional study design, the results obtained show that the 20 m sprint test performance differs between boys and girls. Boys are faster than girls at 3 to 5 years old, but no significant differences were found at 6 years old, further, the sprint time was shorter as kids got older. These findings are consistent with previous studies that support sex differences in a sprint test [1,17].

The sex differences observed in this study might be caused by differences in the level of moderate-to vigorous physical activity (MVPA) found in a previous study, which was higher in boys [11]. Moreover, these results could indicate differences in neuromuscular maturation among preschool girls and boys. Previous studies have found lower neuromuscular performance in preschool girls [18,19].In relation to age, in the whole group and in the girls group the 20 m sprint test performance is better 3 to 6 years old. However, the 20 m sprint test performance in boys was better 3 to

Table 1
Anthropometric characteristics and 20 m sprint performance according to sex.

	Whole group (n = 3076) Mean (SD)	Boys (n = 1537) Mean (SD)	Girls (n = 1539) Mean (SD)	p-value	95% Confidence Interval
Age (years)	4.27 (0.93)	4.24 (0.92)	4.29 (0.94)	0.072	−0.005/0.113
Body mass (kg)	19.34 (4.18)	19.53 (4.21)	19.15 (4.15)	0.013	0.080/0.672
Body height (cm)	109.55 (8.04)	109.88 (8.01)	109.22 (8.07)	0.023	0.093/1.231
Body mass index (kg/m^2)	15.84 (1.86)	15.91 (1.87)	15.76 (1.84)	0.035	0.010/0.281
Waist circumference (cm)	56.79 (7.91)	56.97 (7.79)	56.60(8.03)	0.198	−0.192/0.927

SD. Standard deviation. 95% CI values are the ranges for the difference scores between groups.

Table 2
20 m sprint performance by age groups and sex.

Age (years)	Whole-group		Boys		Girls		p-value	95% Confidence Interval
	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)		
3	721	6.93 (1.18)a	366	6.76 (1.12)a	335	7.11 (1.21)a	0.001	−436/−0.119
4	976	6.23 (1.12)b	500	6.13 (1.10)b	476	6.33 (1.14)b	0.014	−0.308/−0.034
5	1075	5.80 (0.98)c	527	5.70 (1.03)c	548	5.89 (0.92)c	0.018	−0.286/−0.027
6	304	5.49 (0.86)d	144	5.43 (1.01)c	160	5.55 (0.70)d	0.452	−0.339/0.151
p-value (intra group)		<0.001		<0.001		<0.001		

SD. Standard deviation. Values with different subscript letters indicate significant differences ($p < 0.05$) in Post hoc analysis Bonferroni. 95% CI values are the ranges for the difference scores between groups.

Table 3
Percentiles of 20 m sprint in girls.

	5	25	50	75	95
3	5.10	6.32	7.06	8.03	9.10
4	4.80	5.51	6.16	6.89	8.82
5	4.64	5.29	5.81	6.30	7.64
6	4.57	5.02	5.50	6.01	6.60

Table 4
Percentiles of 20 m sprint in boys.

Age (years)	5	25	50	75	95
3	4.90	6.03	6.81	7.41	8.76
4	4.58	5.32	6.00	6.83	8.29
5	4.34	5.02	5.54	6.10	7.85
6	4.40	4.78	5.19	5.78	7.45

5 years old, with no significant differences between 5 and 6 years old.

On the other hand, in preschoolers, the body height and body mass should be considered as significant predictors of physical fitness [19]. In this regard, our findings show that there are moderate correlations between 20 m sprint with body height and body mass. These results are not consistent with previous studies in children, showing an inverse relationship between body mass and physical fitness [20–22].

Fitness tests provide important information about the health of children, although their use is not usually taken into account in a school context [20]. Accordingly, schools are the setting in which to identify, at an early stage, children with low fitness levels and to establish programs to promote healthy behaviors [20], such as physical activity. The interpretation of physical fitness assessment requires comparing the individual score obtained with reference values for the general population in relation to sex and age [23]. Therefore, this research provides reference values, presented for age and sex, for the 20 m sprint test in Spanish preschoolers.

The main limitation in this study is its cross-sectional design (i.e. level of running speed in growing children must be measured in longitudinal research). However, the strengths of this study include a large population sample of children analyzed and the reliability of the 20 m sprint test in preschool children.

Finally, from a practical point of view and considering the lack of reference values for assessing the physical fitness of preschool children, the percentile values obtained in this study might play a key role for teachers and coaches who work with children aged 3–6 years. Moreover, these results are a reference for the analysis of child motor development, therefore the lowest percentile – for example, the 5th and 10th percentiles as indicated by Ortega et al. [24] in an adolescent population – can be used as a 'warning signal' and it would be necessary to conduct an additional test in order to identify possible motor delays or low physical activity.

To sum up, this study provides the reference values for running speed assessment through a 20 m sprint test carried out on a large sample of Spanish preschoolers. The 20 m sprint test is a reliable test to assess running speed and locomotor skills in preschoolers. Additionally, some differences in the 20 m sprint test performance were found according to sex despite the early age of participants, and references values were established considering that variable.

Conflict of interest statement

All authors agree with the content of the article and approve of its submission to the Journal. There are not relevant financial interests related to the research. No conflict of interest.

The contribution of each author

Pedro Ángel Latorre Román: Concept and design; Statistic analysis; Written document; Significant manuscript reviewer/reviser.

David Mora López and Melchor Martínez Redondo: Concept and design; Datalogging; Significant manuscript reviewer/reviser.

Felipe García Pinillos: Concept and design; Datalogging; Significant manuscript reviewer/reviser.

Name of department(s) and institution(s)

Department of Corporal Expression, University of Jaén (Spain).

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V. Handgrip strength is associated with anthropometric variables and sex in preschool children: a cross-sectional study providing reference values.

(PAPER V)

V

Handgrip strength is associated with anthropometric variables and sex in preschool children: A cross-sectional study providing reference values.

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Original Research

Handgrip strength is associated with anthropometrics variables and sex in preschool children: A cross sectional study providing reference values

Pedro Ángel Latorre Román [a,*], David Mora López [a], Beatriz Berrios Aguayo [a], Alejandro Robles Fuentes [a], Felipe García-Pinillos [a], Melchor Martínez Redondo [b]

[a] University of Jaen, Department of Corporal Expression, Paraje de las Lagunillas s/n, Jaén, España, 23071, Spain
[b] Government of Andalusia, C.E.I.P Doctor Fleming. Avda. San Sebastián s/n, Jódar (Jaén), 23500, Spain

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ABSTRACT

Objective: The purpose of this study was to examine the influence of age, sex and anthropometric variables in handgrip strength and to determine norm-referenced values for preschool children.
Design: Cross-sectional study.
Setting: Schools.
Participants: A total of 1215 children, aged 3–6 years (590 girls and 625 boys).
Intervention: Not applicable.
Main outcome measures: Handgrip strength (HS), measured by the CAMRY hydraulic hand dynamometer (EH101; Camry, Guangdong Province, China).
Results: Boys exhibited a greater performance than girls in the 4 and 5 years age groups, but no significant differences were found at 3 and 6 years. In relation to growth, HS performance was greater with increased age. The Pearson correlation analysis showed significant correlations between HS and body mass ($r = 0.354$, $p < 0.001$), body height ($r = 0.352$, $p < 0.001$), body mass index ($r = 0.164$, $p < 0.001$) and waist circumference ($r = 0.118$, $p < 0.001$).
Conclusion: This study provides references values for muscular strength assessment by an HS test carried out on a large sample of preschoolers in relation to age and sex. Additionally, some differences in HS performance were found according to sex.

1. Introduction

The preschool age is characterised by significant changes in the acquisition of locomotor skills and nervous system maturation (Tanaka, Hikihara, Ohkawara, & Tanaka, 2012). The development of muscular strength in children and adolescents brings health benefits (Smith et al., 2014). In line with this, Ortega, Ruiz, Castillo, and Sjöström (2008) showed that physical fitness level is a potent biomarker of health from an early age. Therefore, a fitness test provides important information on children's health, although is not often used in schools (Castro-Piñero et al., 2009). Specifically, in preschoolers muscular strength contributes to skeletal development, while sedentary behaviour negatively affects bone health (Herrmann et al., 2015). In adolescents, muscular fitness is negatively associated with a clustered metabolic risk independent of cardiorespiratory fitness (Artero et al., 2011). Furthermore, muscular strength has been identified for the first time as an independent and powerful predictor of better insulin sensitivity in children (Benson, Torode, & Fiatarone Singh, 2006). A low level of muscular strength in adolescence, as measured by knee extension and handgrip strength (HS), is associated with all-cause premature mortality; other risk factors include abnormal body mass index (BMI) and blood pressure (Ortega, Silventoinen, Tynelius, & Rasmussen, 2012).

Handgrip strength is outstanding as a measure of general health and is often estimated in screenings of normal motor function (Häger-Ross & Rösblad, 2002). In particular, HS is an indicator of nutritional level (Schlüssel, Anjos, & Kac, 2008), which correlates to

* Corresponding author.
E-mail addresses: platorre@ujaen.es (P.Á. Latorre Román), davidjmora7@gmail.com (D.M. López), bba00005@red.ujaen.es (B.B. Aguayo), saltodemanos@yahoo.es (A.R. Fuentes), fegarpi@ujaen.es (F. García-Pinillos), melchor_mr@hotmail.com (M.M. Redondo).

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Abbreviations

ANOVA	analysis of variance
BMI	Body mass index
CI	confidence interval
HS	Handgrip strength
ICC	Intraclass correlation coefficient
SD	Standard deviation

morbidity and mortality in the young (Montalcini et al., 2016). Several studies have shown the importance of the use of HS tests in clinical practice and fitness control in children (Latorre-Román, Navarro-Martínez, Mañas-Bastidas, & García-Pinillos, 2014; Marrodán Serrano et al., 2009; Martinez-Tellez et al., 2015; Rauch, Neu, Wassmer, & Beck, 2002).

Handgrip strength is a simple, inexpensive, reliable, and valid indicator of upper-body muscular strength. The handgrip test seems to be the most practicable way of assessing upper-body strength in children; moreover, handgrip scores can be used to analyse age- and sex-related variation in muscular strength (Saint-Maurice, Laurson, Karsai, Kaj, & Csanyi, 2015). However, it is not often used in preschool children (Cohen et al., 2010; Ploegmakers, Hepping, Geertzen, Bulstra, & Stevens, 2013). There are currently limited studies that have analysed correlates of physical fitness associated with growth and maturity (Malina & Katzmarzyk, 2006), particularly regarding HS in preschool children, although a recent study showed an association of HS with BMI in preschool children (Martinez-Tellez et al., 2015).

Currently, different authors propose reference values for HS in different populations (Budziareck, Pureza Duarte, & Barbosa-Silva, 2008; Cohen et al., 2010; Hogrel, 2015; Ploegmakers et al., 2013); however, to our knowledge, there are no reference values for preschool children. Low values of HS in childhood may have negative health implications for later life (Cohen et al., 2010; Ortega et al., 2012). From a public health perspective, population-specific normative data may be useful to identify those with low HS. At present, there is no normative reference available regarding HS for preschool-age Spanish children. Therefore, the main purpose of this study was to examine the influence of age, sex and anthropometric variables in HS and to determine norm-referenced values for preschool children. A second objective was to evaluate the reliability of the HS test in preschool children.

2. Method

2.1. Study design

This cross-sectional study analysed HS in a cohort of healthy preschool children to generate normative values.

2.2. Participants

A total of 1215 children, aged 3–6 years, participated in this study (mean age = 4.32 ± 1.05 years, BMI = 19.59 ± 4.56 kg/m^2, 590 girls and 625 boys), recruited from 30 schools located in southern Spain (Andalusia) from the Jaen, Cordoba and Granada provinces. The sample is therefore one of convenience, taken from urban and rural areas. Inclusion criteria comprised schooling in early childhood and being free from physical and/or intellectual disabilities. Parents voluntarily signed an informed consent form for the participation of their children in this study. The study was completed in accordance with the norms of the Declaration of Helsinki (2013 version) and followed the directives of the European Union on Good Clinical Practice (111/3976/88 of July, 1990), as specified in the Spanish legal framework for human clinical research (Royal Decree 561/1993 on clinical essays). The study was approved by the Ethics Committee of the University of Jaen (Spain).

3. Materials and testing

Body mass (kg) was measured using a weighing scale (Seca 899, Hamburg, Germany) and body height (cm) was measured with a stadiometer (Seca 222, Hamburg, Germany). The body mass index was calculated by dividing body mass (kg) by body height^2 (in metres). Waist circumference was measured at the umbilical location by using a non-elastic Ergonomic Circumference Measuring Tape (Seca 201, Germany; range 0–150 cm; accuracy: 1 mm). All measures were taken twice, and the average was used for analysis. Handgrip strength was assessed using the CAMRY hydraulic hand dynamometer (EH101; Camry, Guangdong Province, China) (range 0–90 kg; accuracy 0.1 kg), which has an adjustable grip to account for varying hand sizes.

3.1. Procedure

The following standardised testing position for measuring HS was used: participants stood with the arm fully extended, forming an angle of 30° to the trunk. The research team conducted a demonstration and the children performed some familiarisation trials. During HS measurement, we asked the subject to grip the dynamometer using maximum strength and to hold the grip for three seconds. The children were motivated and encouraged to reach the best score possible. Each participant performed two attempts with each hand using the same grip span (4.0 cm), with one minute's rest between attempts. We used a grip span of 4.0 cm because this was reported to be the grip span at which the children performed the highest HS (Sanchez-Delgado et al., 2015). The order of testing of each hand was randomised. The maximum score in kilograms for each hand was recorded and the mean score of both hands was used in the analyses. A week later, 132 children (included in the previous data collection) performed the same test (retest).

3.2. Statistical analysis

Data were analysed using SPSS, v.19.0 for Windows (SPSS Inc, Chicago, USA) and the R statistical program (R Development Core Team, 2016) with the GAMLSS (Generalized Additive Model for Location, Scale and Shape) package (Rigby & Stasinopoulos, 2006). The significance level was set at $p < 0.05$. Descriptive data are reported in terms of means and standard deviations (SD). Tests of normal distribution and homogeneity (Kolmogorov-Smirnov and Levene's tests respectively) were conducted on all data before analysis. Differences between sex and age groups were analysed using analysis of variance (ANOVA) adjusted by the Bonferroni test. The magnitude of the differences between values was also interpreted using the partial eta squared measure. A Pearson correlation analysis was performed between the HS and anthropometric variables, adjusting for age and sex. A reliability pretest-posttest analysis was performed using intraclass correlation coefficients (ICC) and Bland-Altman graphs. According to the classifications proposed by Shrout and Fleiss (1979), a very good ICC is obtained when ICC>90; a good correlation lies between 0.71 < ICC<0.90; a moderate ICC lies between 0.51 < ICC<0.70; and a poor ICC lies between 0.31 < ICC<0.50. The percentile curves were calculated as a function of age stratified by sex using the LMSP (mbda, mu, sigma, power exponential) method, assuming a Box-Cox power exponential distribution, a generalized model of the LMS (lambda, mu, sigma) method. This method has been implemented in the GAMLSS package in R software (Stasinopoulos & Rigby, 2007).

4. Results

In the test-retest analysis, the following descriptive results were obtained in the pretest (mean, SD) = 6.46 ± 2.09 kg, retest (mean, SD) = 6.29 ± 1.97 kg, $p \geq 0.05$, and an ICC = 0.969 (95% confidence interval (CI) = 0.950–0.980) was found. The Bland-Altman graph showed limits of agreement (2 SD) of 1.49 and −1.26 kg, and the mean of the differences was equal to 0.11 ± 0.69 kg (Fig. 1).

Table 1 shows the anthropometric characteristics and HS performance in relation to sex. Boys exhibited a greater score in HS than girls. Table 2 shows HS performance average by age groups and sex. Boys exhibited a greater performance than girls at 4 and 5 years old. In relation to age, HS performance became greater with increased age. The Pearson correlation analysis showed some significant correlations: HS and body mass ($r = 0.354$, $p < 0.001$), HS and body height ($r = 0.352$, $p < 0.001$), BMI ($r = 0.164$, $p < 0.001$) and waist circumference ($r = 0.118$, $p < 0.001$). The multiple linear regression analysis between HS and age, anthropometric variables and sex is shown in Table 3. Age, BMI and sex are predictor variables for HS performance. The 0.4th, 2nd, 10th, 25th, 50th, 75th, 90th, 98th and 99.6th percentile curves were computed for handgrip, averaging the results of both hands according to sex and age (Table 4, Fig. 2).

5. Discussion

The main purpose of this study was to examine the influence of age, sex and anthropometric variables in HS and to determine norm-referenced values for preschool children. A second objective was to evaluate the reliability of the HS test in preschool children.

To our knowledge, this is the first study to provide reference values of HS in southern Spanish preschool children. The main findings of this study show that HS, as expected, increased with age, that boys are generally stronger than girls and that anthropometric measures correlated positively with HS. These findings are in consonance with those of Häger-Ross and Rösblad (2002) in children aged 4–16 years. Different devices have been used in previous studies (Häger-Ross & Rösblad, 2002; Molenaar et al., 2010) to establish reference values of HS; therefore, comparison with the results of these studies is not possible. Cadenas-Sanchez et al. (2016) demonstrated the reliability of HS test in preschool children; likewise, in this study, HS was shown to be a feasible and highly reliable test in preschool children. Reliable interpretation of physical fitness assessment requires the individual score obtained to be compared with reference values for the general population in relation to sex and age.

The results of this study showed a significant increase in HS in relation to age; this is consistent with previous studies (De Miguel-Etayo et al., 2014; Omar, Alghadir, & Baker, 2015; Ortega et al., 2011; Ploegmakers et al., 2013), and boys tended to be stronger than girls in age groups between 4 and 5 years. The information available on HS performance at early ages is not consistent with a previous study reporting no significant differences in HS performance with increased age (4–7 years old) (Häger-Ross & Rösblad, 2002). In addition, a significant sex dimorphism from the age of 4–5 years was observed. These results are in agreement with those obtained by Molenaar et al. (2010) which showed that, in children of 4–6 years, the boys were 24%–34% stronger in HS. Likewise, regarding the effect of sex on HS performance in children, some previous studies have reported significant differences according to sex (Cohen et al., 2010; Montalcini et al., 2016; Omar et al., 2015; Ploegmakers et al., 2013). However, Marrodán Serrano et al. (2009) in a study of children and teenagers aged from 6 to 18 years, found sex dimorphism only from the age of 12 years. The authors of this current work suggest that differences might be due to the higher level found in boys of moderate-to vigorous physical activity (O'Dwyer et al., 2014). Moreover, these results could indicate differences in neuromuscular maturation among preschool girls and boys. In addition, boys showed higher body mass and body height than girls, which are positively associated with HS.

We demonstrated significant correlations between HS and body mass, body height, BMI and waist circumference. These associations between HS with BMI and waist circumference in preschool children concur with those reported by Martinez-Tellez et al. (2015). All of these associations may be explained by the observation that high body mass is an extra load to be moved in any movement; moreover, neurological factors, such as motor unit recruitment and synchronisation, may explain the higher HS observed in preschool children with a higher BMI and waist circumference (Martinez-Tellez et al., 2015). Furthermore, multiple linear regression analysis between HS and age, anthropometric variables and sex shows that age, BMI and sex are predictor

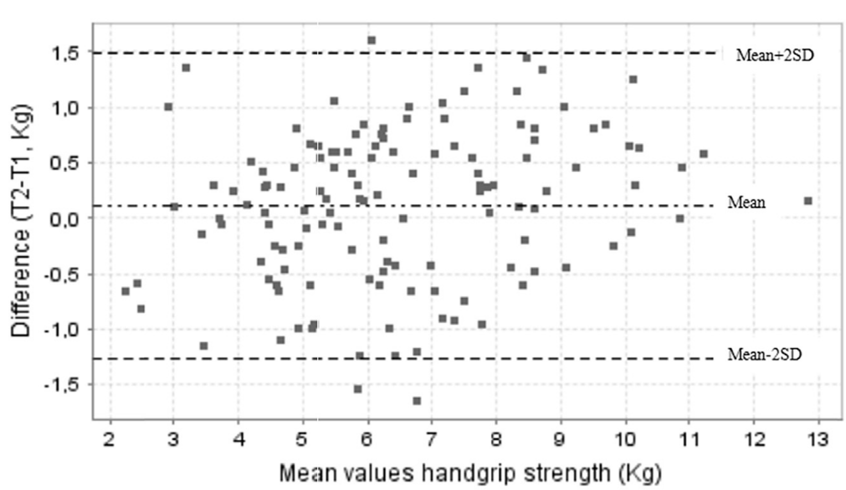

Fig. 1. Bland-Altman graph handgrip strength; the x axis shows mean values of handgrip strength and the y axis the difference values of posttest-pretest of handgrip strength. The graph shows limits of agreement (2 SD) of 1.49 and −1.26 kg; the mean of the differences was equal to 0.11 ± 0.69 kg.

Table 1
Anthropometric characteristics and handgrip strength performance according to sex.

	All (n = 1215) Mean (SD)	Boys (n = 625) Mean (SD)	Girls (n = 590) Mean (SD)	p-value	95% Confidence Interval	Partial Eta Squared
Age (years)	4.32 (1.05)	4.35 (1.06)	4.28 (1.03)	0.232	−0.046/0.190	0.001
Body mass (kg)	19.59 (4.56)	19.94 (4.77)	19.22 (4.29)	0.007	0.200/1.235	0.006
Body height (cm)	109.95 (9.13)	110.51 (9.23)	109.36 (9.00)	0.031	0.106/2.199	0.004
Body mass index (kg/m^2)	16.10 (2.14)	16.21 (2.20)	15.98 (2.07)	0.068	−0.017/0.478	0.003
Waist circumference (cm)	55.61 (6.05)	55.48 (6.22)	55.74 (5.86)	0.478	−1.001/0.470	<0.001
Handgrip strength. Right hand (Kg)	6.24 (2.48)	6.46 (2.55)	6.01 (2.39)	0.002	0.174/0.735	0.008
Handgrip strength. Left hand (Kg)	5.81 (2.41)	6.06 (2.47)	5.54 (2.32)	<0.001	0.248/0.793	0.012
Handgrip strength. Average (Kg)	6.02 (2.33)	6.25 (2.39)	5.77 (2.25)	<0.001	0.226/0.750	0.011

SD (Standard deviation).

Table 2
Handgrip strength performance average by age groups and sex.

Age (years)	All		Boys		Girls		p-value	95% Confidence Interval	Partial Eta Squared
	n	Mean (D)	n	Mean (D)	n	Mean (D)			
3	327	4.44 (1.43)a	452	4.57 (1.50)a	424	4.31 (1.36)a	0.216	−0.148/0.655	0.001
4	355	5.34 (1.69)b	583	5.58 (1.70)b	524	5.09 (1.63)b	0.013	0.103/0.876	0.005
5	313	6.97 (1.91)c	628	7.23 (1.91)c	622	6.73 (1.90)c	0.017	0.091/0.919	0.005
6	202	8.32 (2.62)d	143	8.45 (2.66)d	174	8.14 (2.57)d	0.243	−0.211/0.832	0.001
p-value (intra group)		<0.001		<0.001		<0.001			

SD (standard deviation). Values with different subscript letters indicate significant differences ($p < 0.05$) in Post hoc analysis Bonferroni.

Table 3
Multiple linear regression analyses between handgrip strength with age, anthropometric variables and sex.

	B	t	p-value	95% confidence interval to B	
				Lower limit	Higher limit
Constant	−1.749	−3.819	<0.001	−2.648	−0.851
Age	1.292	24.911	<0.001	1.190	1.394
BMI	0.125	4.924	<0.001	0.075	0.175
Sex	0.355	3.261	0.001	0.141	0.569
R^2	0.370				

variables for HS; these results are in agreement with those of Montalcini et al. (2016) in elementary school children. In this study, body height did not predict HS; this finding is in contrast to that of Jürimäe, Hurbo, and Jürimäe (2009). Nevertheless, specifically in preschoolers, body height and body weight should be considered as significant predictors of physical fitness (Kondric et al., 2013); Ploegmakers et al. (2013) showed that body height and body weight have a strong association with HS in children.

The availability of reference values of HS is relevant from different points of view: (i) HS is an important test to evaluate physical fitness and nutritional status in children (Marrodán Serrano et al., 2009; Martinez-Tellez et al., 2015); (ii) HS determination provides information about an important aspect of physical development, particularly of skeletal muscle development (Rauch et al., 2002); (iii) HS is positively associated with lung capacity and quality of life in children (Latorre-Román et al., 2014); (iv) HS is an emerging risk factor for major causes of death in young adulthood (Ortega et al., 2012); (v) there is a relationship between HS and fasting insulin levels (Lazarus, Sparrow, & Weiss, 1997); (vi) in primary school students, a poorer HS was associated with metabolic risk. Therefore, the addition of handgrip dynamometry to non-invasive youth health surveillance programmes would improve the accuracy of the assessment of cardio-metabolic health (Cohen et al., 2014) and, thereby, the availability of normative data for HS could help to identify children with possible health problems.

Table 4
Percentiles of handgrip strength (Kg) average in boys and girls.

Age (months)	Percentile	0.4	2	10	25	50	75	90	98	99.6
36	Boys	1.60	1.98	2.63	3.35	4.46	5.72	6.76	7.92	8.73
	Girls	1.58	2.01	2.66	3.27	4.07	4.95	5.74	6.76	7.55
42	Boys	1.29	1.81	2.61	3.38	4.40	5.50	6.44	7.58	8.42
	Girls	1.36	1.92	2.72	3.43	4.29	5.21	6.04	7.12	7.97
48	Boys	1.15	2.04	3.28	4.30	5.47	6.67	7.76	9.15	10.24
	Girls	1.19	2.02	3.16	4.09	5.13	6.20	7.19	8.48	9.50
54	Boys	0.83	1.84	3.21	4.23	5.29	6.33	7.31	8.58	9.59
	Girls	0.73	1.61	2.81	3.71	4.65	5.58	6.45	7.61	8.53
60	Boys	0.97	2.28	4.11	5.42	6.71	7.93	9.06	10.52	11.66
	Girls	0.81	2.03	3.84	5.13	6.38	7.58	8.74	10.28	11.52
66	Boys	1.16	2.61	4.70	6.18	7.66	9.02	10.18	11.59	12.63
	Girls	0.84	2.12	4.12	5.51	6.77	7.96	9.14	10.73	12.02
72	Boys	1.34	2.86	5.04	6.63	8.28	9.73	10.84	12.08	12.94
	Girls	1.04	2.49	4.80	6.36	7.69	8.95	10.23	11.99	13.43
78	Boys	1.62	3.28	5.66	7.45	9.36	10.98	12.10	13.23	13.96
	Girls	1.40	3.16	5.95	7.78	9.26	10.67	12.14	14.20	15.91

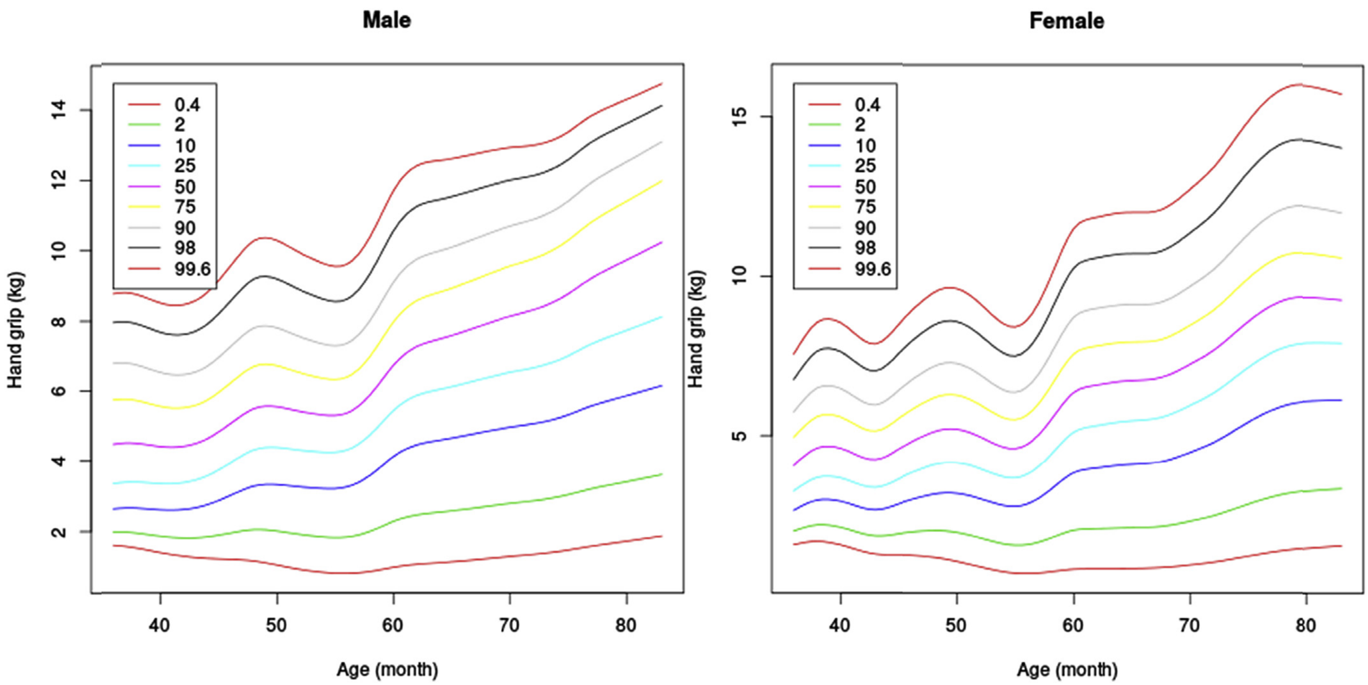

Fig. 2. Percentile curves for handgrip strength for boys and girls preschool children aged 3–6 years.

According to Ortega et al. (2011), HS under the 10th, can be used as a "warning signal," and further testing should be conducted investigate the presence of morbidity. Although it is rarely used at present in schools, the HS test provides important information on children's health. Schools provide appropriate settings in which to identify, at an early stage, children with low fitness levels and to establish programmes to promote healthy behaviours (Castro-Piñero et al., 2009), such as physical activity.

The main limitation in this study is its cross-sectional design; the level of muscular strength in growing children should be measured in a longitudinal study. In addition, the sample comprised children in southern Spain and generalisation to a wider population should be done with caution, which was another limitation. Moreover, the range of the grip span of the CAMRY dynamometer was calculated with the TKK dynamometer references (its analogue version), which is another limitation. However, the strengths of this study are that a large number of children were studied throughout a large geographical area, and both rural and urban schools were included.

Eventually, from a practical point of view and considering the lack of reference values for assessing the HS of Spanish preschool children of southern Spain, the percentile values obtained in this study might play a key role for teachers and physicians who work with children aged 3–6 years. Assessing HS costs little and its easy use allows the test to be employed in both sports and clinical practice.

In conclusion, as expected, HS increased with age, boys were generally stronger than girls and various anthropometric measures correlated positively with HS. This study has provided references values for muscular strength assessment by an HS test carried out in a large sample of preschoolers. Finally, this study reports that HS is a feasible and highly reliable test in preschool children.

Ethical statement

The study was completed in accordance with the norms of the Declaration of Helsinki (2013 version) and following the directives of the European Union on Good Clinical Practice (111/3976/88 of July, 1990), as specified in the Spanish legal framework for human clinical research (Royal Decree 561/1993 on clinical essays). The study was approved by the Ethics Committee of the University of Jaen (Spain) (Reference: CEIH 120215-1).

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VI. Reference Values of Static Balance in Preschool Children: A Population-based Study

(Paper VI)

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Reference Values of Static Balance in Spanish Preschool Children

Pedro Ángel Latorre Román[1], David Mora López[1], Alejandro Robles Fuentes[1], and Felipe García Pinillos[1]

Abstract

The purpose of this study was to examine age and sex differences in static balance (SB) and to determine norm-referenced values for Spanish preschool children. A total of 3,575 children, aged 3 to 6 years (age $= 56.08 \pm 11.11$ months; body mass index $= 15.94 \pm 1.91$ kg/m^2; 1,759 girls and 1,816 boys) were selected from 51 schools in southern Spain. To measure SB, we used the Stork Balance Stand Test, averaging both right and left foot data for determining SB normative values, expressed in percentiles. Girls exhibited a better performance than boys at 4 years of age ($p = .010$, Cohen's $d = -0.165$), but a poorer performance at 6 years ($p = .002$, Cohen's $d = 0.247$). SB performance of the entire sample was higher with increased age, except for 5 to 6 years.

Keywords

pediatrics, fitness, health, balance

Introduction

Preschool development is characterized by significant changes in the acquisition of fundamental motor skills (FMS) and nervous system maturation (Tanaka,

[1]Department of Corporal Expression, University of Jaén, Spain

Corresponding Author:

Pedro Ángel Latorre Román, University of Jaén, Chiclana de la Frontera 53, Úbeda, Jaén 23400, Spain.
Email: platorre@ujaen.es

Hikihara, Ohkawara, & Tanaka, 2012). Motor competence during infancy and childhood is influenced by the child's individual growth and morphological, physiological, and neuromuscular characteristics (Venetsanou & Kambas, 2009). The mastery of FMS contributes to children's physical, cognitive, and social development and is essential for an active lifestyle and sport and game participation in childhood and adolescence (Hardy, King, Farrell, Macniven & Howlett, 2010; Lubans, Morgan, Cliff, Barnett, & Okely, 2010; Williams et al., 2008). The relationship between children's motor performance, FMS, muscular strength, and cardiovascular fitness with physical activity level and health status has been widely studied and established (Cattuzzo et al., 2014; Larsen, Kristensen, Junge, Rexen, & Wedderkopp, 2014; Schott & Holfelder, 2015). On the other hand, compromised stability may hinder a child's ability to master FMS (Mickle, Munro, & Steele, 2011). Balance control includes both static and dynamic balance and is essential in the development of locomotion and manipulation skills; specifically, the development of static balance (SB), a basic characteristic of normal motor development (Geuze, 2005). The control of SB is defined as the ability to maintain the center of gravity within the limits of the base of support (Rogers, Page, & Takeshima, 2013). Children with developmental disabilities may have poor control of either compensatory postural reactions, or anticipatory postural control, which may contribute to their delayed or deviated motor development (Liao, Mao, & Hwang, 2001). Balance deficits have been well demonstrated in children with autism (Fournier et al., 2010), Down's syndrome (Galli et al., 2008), cerebral palsy (Pavao, dos Santos, de Oliveira, & Rocha, 2014), children with developmental coordination disorders (Geuze, 2005), children with developmental dyslexia (Pozzo et al., 2006), and children with attention deficit hyperactivity disorder (Shum & Pang, 2009).

Most SB studies have been carried out in children over 6 years (Geldhof et al., 2006; Rival, Ceyte, & Olivier, 2005). One recent study examined the neuromotor development of 3- to 5-year-old children and provides normative data of SB, but its sample size was small (Kakebeeke et al., 2013). Although there are limited studies analyzing correlates of physical and motor fitness associated with growth and maturity (Malina & Katzmarzyk, 2006), particularly on SB in preschool children, research is limited regarding the reliability and validity of fitness and motor tests in preschool children (Ortega et al., 2015), despite the need for reliable measures for investigating the relationship between physical fitness and health (Latorre et al., 2015; Ortega et al., 2015). To the best of the authors' knowledge, there is no available information regarding reference values for SB tests in Spanish preschool children. We hypothesized that there are no significant differences in SB between children of different sexes, but we suspected that such variables as age and body mass index (BMI) could influence SB. Therefore, the main purpose of this study was to examine age and sex differences in Spanish preschool children on SB tests, analyze the influence of anthropometrics variables on SB and provide SB reference values for Spanish preschool children.

Method

Participants

A total of 3,575 children participated in this study (age = 56.08 ± 11.11 months; BMI = 15.94 ± 1.91 kg/m^2; 1,759 girls and 1,816 boys), selected from 51 schools in southern Spain. This convenience sample was selected within a large geographic area of Andalusia (Spain) containing both urban and rural areas. Inclusion criteria for participant selection included early childhood school enrolment and being free from physical or intellectual disabilities or any pathological disorder associated with the visual or vestibular system. Parents voluntarily signed an informed consent form permitting their children to participate in this study. The study was completed in accordance with the norms of The Declaration of Helsinki (2013 version) and followed the directives of the European Union on Good Clinical Practice (111/3976/88 of July 1990), as specified in the Spanish legal framework for human clinical research (Royal Decree 561/1993 on clinical essays). The study was approved by the Ethics Committee of the University of Jaen (Spain).

Materials and Testing

Body height (cm) was measured with a stadiometer (Seca 222, Hamburg, Germany) and body mass (kg) with a weighing scale (Seca 899, Hamburg, Germany). BMI was calculated by dividing body mass (in kilograms) by height^2 (in meters). Waist circumference (WC) was measured by using a Seca Ergonomic Circumference Measuring Tape SE201 (Seca, Germany). To measure SB, the Stork Balance Stand Test (SBST) was used (Johnson & Nelson, 1968). The reliability of SB in preschool children has previously been reported using test–retest in the pretest (mean, SD) = 13.14 ± 10.16 s and retest (mean, SD) = 13.32 ± 9.70 s ($p \geq .05$), and an intraclass correlation coefficient (ICC) = 0.995 (95% CI, [0.992, 0.997]) (Latorre et al., 2015).

Procedure

To standardize the testing procedure for SBST participants stood without shoes on one foot and placed their hands on their hips with their opposite foot placed against the inside of the supporting knee. On a signal, the child raised the heel of one foot from the floor and attempted to maintain balance for as long as possible during one minute. The trial ended if the child either moved his/her hands from the hips, the kickstand moved from its original position, or if the non-supporting foot lost contact with the knee. The test was timed using a stopwatch. The stopwatch was started as the heel was raised from the floor. The total time in seconds was recorded for one minute. Two attempts were made with both legs and the best results were scored. Right and left foot data were both collected, and the average was used to determine the normative values of SB. The test score was the runtime, a longer time indicating a better performance. The research team conducted a demonstration, and the children performed some familiarization trials to reach the best score possible.

Statistical Analysis

Data were analyzed using SPSS, v.19.0 for Windows (SPSS Inc, Chicago, USA) and the R statistical program (R Core Team, 2016) with the GAMLSS (Generalized Additive Model for Location, Scale and Shape) package (Rigby & Stasinopoulos, 2006) and the significance level was set at $\alpha < .05$. The data are shown in descriptive statistics for means, standard deviations, and percentiles. Tests of normal distribution and homogeneity (Kolmogorov–Smirnov and Levene's, respectively) were conducted on all data before analyses. Differences between sex and age-groups were analyzed using analysis of variance (ANOVA) and Bonferroni test, using BMI as a covariate. The magnitudes of the differences between values were also interpreted using the Cohen's *d* effect size statistic (Cohen, 1988). Effect sizes of less than 0.4 represented a small magnitude of change while 0.41 to 0.7 and greater than 0.7 represented moderate and large magnitudes of change, respectively (Thomas, Silverman, & Nelson, 2015). A Pearson correlation analysis was performed between the SBST and various age-adjusted anthropometric variables. A reliability pretest–posttest analysis was performed using ICCs. The percentile curves were calculated as a function of age stratified by sex using the LMSP (Lambda, mu, sigma, power exponential) method, assuming a Box-Cox power exponential distribution, a generalized model of the LMS (lambda, mu, sigma) method. This method has been implemented in the GAMLSS package in R software (Stasinopoulos & Rigby, 2007).

Results

Table 1 shows anthropometric characteristics and SB performance in relation to sex. Girls exhibited a higher right leg SB score than boys (mean, $SD = 8.63 \pm 9.35$ s vs. 7.88 ± 8.70 s, respectively, $p = .014$) while no significant sex differences were found for the left leg or average SB performances. Table 2 shows SB performance for the left leg by both age and sex groupings. There were no significant SB differences between boys and girls in any age-group. Table 3 shows SB performance in the right leg by age-group and sex. Girls exhibited a greater performance than boys at 4 years ($p < .001$) and a poorer performance at 6 years old ($p = .002$). Table 4 shows the average SB performance by age-group and sex. Girls exhibited a better performance than boys at four years ($p = .010$) and a poorer performance at six years old ($p = .002$). In relation to age, for the whole group, the SB performance was higher with increased age, except for 5 to 6 years. Reference values for SB

Table 1. Anthropometric Characteristics and Static Balance Performance According to Sex.

	All ($n = 3,575$) Mean (*SD*)	Boys ($n = 1,816$) Mean (*SD*)	Girls ($n = 1,759$) Mean (*SD*)	*p*	95% CI	Cohen's *d*
Age (years)	56.08 (11.11)	55.85 (11.10)	56.31 (11.12)	0.206	−1.162/0.251	−0.041
Body mass (kg)	19.42 (4.27)	19.66 (4.36)	19.17 (4.17)	<0.001	0.218/0.762	0.114
Body height (cm)	109.27 (8.33)	109.57 (8.37)	108.96 (8.28)	0.026	0.072/1.134	0.073
Body mass index (kg/m^2)	15.94 (1.91)	16.03 (1.92)	15.84 (1.89)	0.003	0.063/0.314	0.099
Waist circumference (cm)	56.73 (7.91)	56.88 (7.65)	56.58 (8.16)	0.248	−0.207/0.799	0.037
Static balance: Right leg (s)[a]	8.25 (9.03)	7.88 (8.70)	8.63 (9.35)	0.014	−1.339/−0.148	−0.083
Static balance: Left leg (s)[a]	8.11 (11.91)	8.06 (8.79)	8.17 (8.96)	0.677	−0.712/0.463	−0.012
Static balance: Average (s)[a]	8.13 (7.81)	7.92 (7.63)	8.34 (7.98)	0.111	−0.930/0.096	−0.053

[a]ANOVA with BMI as covariate.

Table 2. Static Balance by Age-Groups and Sex in Left Leg.

	All		Boys		Girls				
Age (years)	*n*	Mean (*SD*)	*n*	Mean (*SD*)	*n*	Mean (*SD*)	*p*	95% CI	Cohen's *d*
3	849	4.55 (4.83)$_a$	441	4.62 (4.45)$_a$	408	4.49 (5.21)$_a$	.826	−1.023/1.281	0.026
4	1.109	7.38 (8.06)$_b$	581	7.23 (7.83)$_b$	528	7.55 (8.31)$_b$	.536	−1.327/0.690	−0.039
5	1.248	10.42 (10.23)$_c$	627	10.38 (10.23)$_c$	621	10.45 (10.23)$_c$	.873	−1.028/0.873	−0.006
6	317	11.19 (10.46)$_c$	144	11.83 (11.15)$_c$	173	10.65 (9.84)$_c$	.220	−0.708/3.075	0.112
p (intragroup)		<.001		<.001		<.001			

Values with different subscript letters indicate significant differences ($p < .05$) in post hoc analysis Bonferroni. The data are displayed in seconds.

Table 3. Static Balance by Age-Groups and Sex in Right Leg.

Age (years)	All		Boys		Girls				
	n	Mean (*SD*)	*n*	Mean (*SD*)	*n*	Mean (*SD*)	*p*	95% CI	Cohen's *d*
3	864	$4.59\ (4.72)_a$	447	$4.49\ (4.19)_a$	417	$4.71\ (5.23)_a$	.709	−1.375/0.936	−0.046
4	1.111	$7.52\ (8.01)_b$	581	$6.55\ (6.69)_b$	530	$8.57\ (9.14)_b$	<.001	−3.019/−0.979	−0.252
5	1.246	$10.65\ (10.53)_c$	622	$10.34\ (10.42)_c$	624	$10.95\ (10.64)_c$	.243	−1.536/0.389	−0.057
6	319	$11.37\ (10.91)_c$	146	$13.03\ (12.01)_d$	173	$9.98\ (9.71)_{bc}$	.002	1.162/4.977	0.279
p (intragroup)		<.001		<.001		<.001			

Values with different subscript letters indicate significant differences ($p < .05$) in post hoc analysis Bonferroni. The data are displayed in seconds.

Table 4. Static Balance Average by Age-Groups and Sex.

	All		Boys		Girls				
Age (years)	*n*	Mean (*SD*)	*n*	Mean (*SD*)	*n*	Mean (*SD*)	*p*	95% CI	Cohen's *d*
3	875	4.51 (4.26)$_a$	452	4.50 (3.75)$_a$	423	4.52 (4.76)$_a$	0.973	−0.998/0.965	−0.004
4	1.120	7.40 (6.99)$_b$	586	6.85(6.28)$_b$	534	8.01(7.65)$_b$	0.010	−2.015/−0.279	−0.165
5	1.255	10.51(8.84)$_c$	629	10.34 (8.81)$_c$	626	10.68 (8.88)$_c$	0.243	−0.494/1.146	−0.038
6	320	11.25(9.19)$_c$	146	12.39 (8.81)$_d$	174	10.28 (8.21)$_c$	0.002	0.489/3.746	0.247
p (intragroup)		<.001		<.001		<.001			

Values with different subscript letters indicate significant differences ($p < .05$) in post hoc analysis Bonferroni. The data are displayed in seconds.

Table 5. Percentiles Values of Static Balance (in Seconds) Average in Boys and Girls.

Age (months)	Percentile	10	25	50	75	90
36	Boys	1.75	2.48	3.82	6.30	10.70
	Girls	1.60	2.23	3.41	5.62	9.68
42	Boys	1.35	1.96	3.11	5.22	8.86
	Girls	1.21	1.73	2.72	4.57	7.84
48	Boys	1.47	2.22	3.63	6.21	10.54
	Girls	1.76	2.63	4.28	7.36	12.65
54	Boys	1.88	2.94	4.96	8.58	14.43
	Girls	2.23	3.47	5.83	10.14	17.24
60	Boys	2.62	4.23	7.27	12.55	20.66
	Girls	2.44	3.94	6.75	11.69	19.34
66	Boys	2.89	4.79	8.26	14.04	22.38
	Girls	2.87	4.69	8.01	13.48	21.32
72	Boys	3.70	6.22	10.68	17.74	27.30
	Girls	3.17	5.23	8.78	14.27	21.58
78	Boys	1.71	2.92	4.97	8.06	12.01
	Girls	3.50	5.99	9.99	15.84	23.54

performance in Spanish preschool children according to sex and age are shown in Table 5 and are expressed in percentiles (also see Figures 1 and 2). The Pearson correlation analysis showed significant correlations between SB and body mass ($r = .106$, $p < .001$), body height ($r = .175$, $p < .01$), and WC ($r = .044$, $p < .01$).

Discussion

As hypothesized, there were no significant overall sex differences in average SB scores, but variables such as age and BMI influenced SB, even to the point that SB performance differed between boys and girls at different ages, with girls exhibiting a better performance than boys at four years old but a poorer performance at six years old and with no significant sex differences at three and five years of age. Our findings refine findings of past research which showed significant sex differences for balance among preschoolers, with girls outperforming boys in SB (Iivonen et al., 2013). Franjoine, Darr, Held, Kott, and Young (2010), using the Paediatric Balance Scale (PBS), found that girls had significantly higher scores across age-groups, with this effect most pronounced in children younger than five years old and the greatest sex differences in the two years, two years six months, three years, and four years age-groups. However,

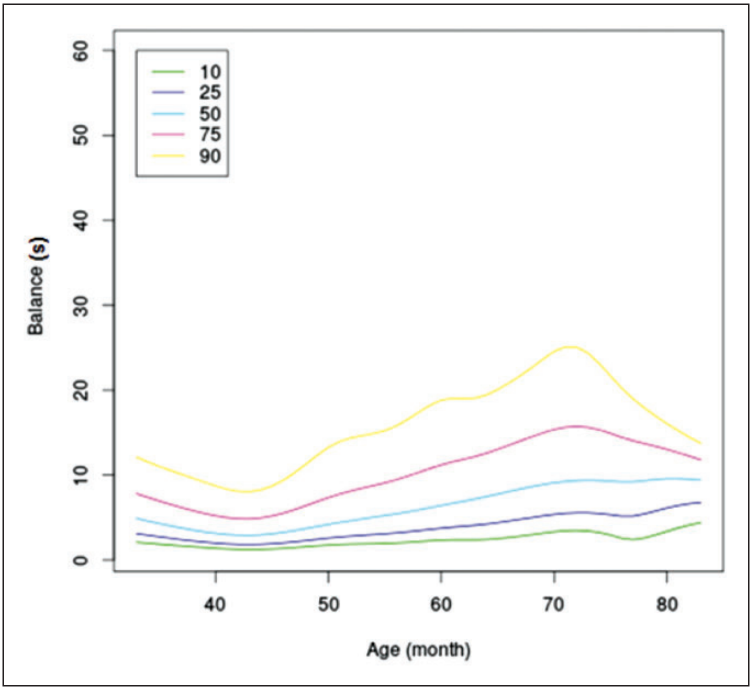

Figure 1. Percentile curves for static balance for boys.

Kaur et al. (2015), with a greatly reduced sample of 49 preschool children showed no significant sex differences in balance. In relation to age, balance control improves as a result of maturation (Cumberworth, Patel, Rogers, & Kenyon, 2007; Steindl, Kunz, Schrott-Fischer, & Scholtz, 2006), and these data support that impression and further suggest that both age and sex significantly affect SB performance in preschoolers, as suggested by Franjoine et al. (2010).

The influences of anthropometric characteristics such as body mass, body height, BMI, and WC on SB in preschool children have been less well understood. Several studies showed that obesity and being overweight reduced static and dynamic balance and postural skills (Boucher, Handrigan, Mackrous, & Hue, 2015; Deforche et al., 2009). However, in preschoolers, motor skill abilities such as balancing are generally of the same level in both obese and normal weight children of 4 to 6 years of age (Castetbon & Andreyeva, 2012). The present study found that SB skills in healthy preschool children aged three to six years old correlated with parameters of physical growth, such as body mass

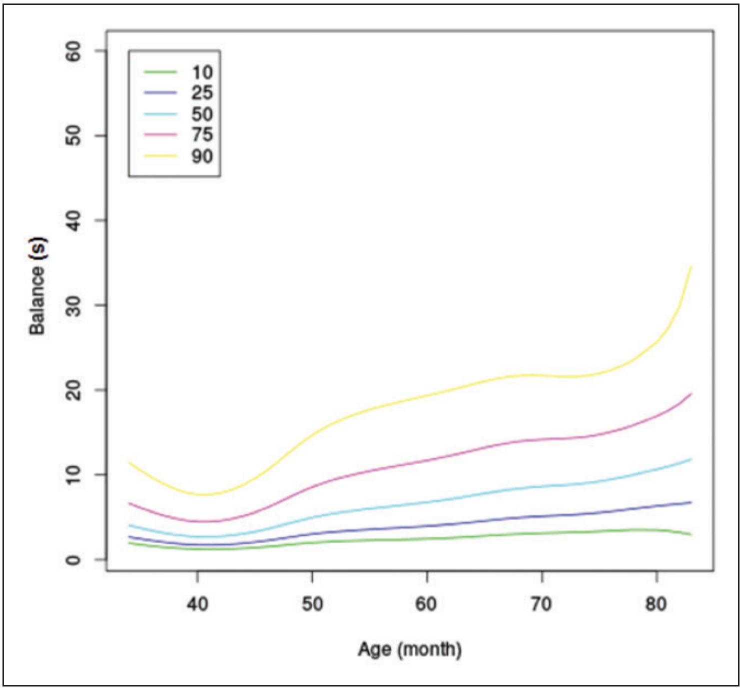

Figure 2. Percentile curves for static balance for girls.

and body height, although Pearson values were very low. Similar results were reported by Franjoine et al. (2010), who found moderately strong correlations between body height and pediatric balance scale (PBS) score ($r = .650$), body mass and PBS score ($r = .642$), and a weak correlation between BMI and PBS scores ($r = .182$). Other authors concluded that preschoolers with lower BMI scored better in the balance test, showing significant correlations between balance skills with body height ($r = .45$, $p = .001$) and BMI ($r = .47$, $p = .001$) (Kaur et al., 2015), but, in this study, no correlations between BMI and SB were found.

Finally, this study provides reference values for SB adjusted by age and sex for a large sample of Spanish preschool children. The main limitation in this study was its cross-sectional versus longitudinal design for measuring SB in growing children. However, a strength of this study included its large population sample size. Practically, reference percentile values from this study provide needed comparative data for teachers and coaches who wish to use the simple, low-cost SBST to monitor static balance development in preschool children they see. Moreover, the lowest percentile can be used as a "warning signal" to conduct additional tests in order to identify possible motor delays.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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VII. Physical condition in preschool children: association with gender, age and body weight status

(PAPER VII)

VII

Physical fitness in preschool children: association with sex, age and weight status.

Latorre Román, P. Á., Moreno del Castillo, R., Lucena Zurita, M., Salas Sánchez, J., García-Pinillos, F., & Mora López, D.J. (2016).

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Physical fitness in preschool children: association with sex, age and weight status

P. Á. Latorre Román,* R. Moreno del Castillo,* M. Lucena Zurita,* J. Salas Sánchez,† F. García-Pinillos* and D. Mora López*

*Department of Corporal Expression, University of Jaén, Jaén, Spain, and
†Universidad Autónoma de Chile, Chile

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Correspondence: Pedro Ángel Latorre Román, Department of Corporal Expression, University of Jaén, Campus Las Lagunillas, s/n, 23071 Jaén, Spain.
E-mail: platorre@ujaen.es

Abstract

Background Because fitness level is a potent biomarker of health from an early age, the improvements of physical fitness performance through the promotion of physical activity could be important for the health of preschool children, particularly in obesity prevention.

Objective The purpose of this study is to determine the physical fitness in children aged 3–6 years, discriminating performance by sex, age and body mass index (BMI).

Method A total of 3868 children from 3 to 6 years agreed voluntarily to participate. Demographic characteristics revealed that 1961 children were male (age: 55.71 ± 11.11 months old, BMI = 16.03 ± 1.93 kg/m^2), and 1907 were female (age 56.16 ± 0.97 months old, BMI = 15.85 ± 1.89 kg/m^2), and they were selected from 51 schools in southern Spain.

Results Significant differences were found between sexes: boys showed a greater performance on cardio respiratory endurance, reaction time, strength and running speed. We found significant differences by sex in the different age groups (3, 4, 5 and 6 years old).

Conclusions Sex differences in physical fitness are evident at an early age; in addition, the relationship between physical fitness and BMI is inconsistent in preschool children. The improvements of physical fitness performance and its association with physical activity could be important for the health of children, particularly in obesity prevention.

Introduction

Preschool age is characterized by significant changes in the acquisition of locomotors skills and nervous system maturation (Tanaka, Hikihara, Ohkawara, & Tanaka, 2012). Physical fitness is a condition that permits the individual to carry out his or her daily activities without undue fatigue and with adequate reserve to enjoy active leisure pursuits (Malina & Katzmarzyk, 2006). Components of physical fitness have included strength, cardio respiratory endurance, speed, balance, strength and flexibility (Council of Europe Committee for the Development of Sport, 1998). Fitness level is a potent biomarker of health from an early age and physical exercise being one of the main determinants of physical fitness (Ortega, Ruiz, Castillo, & Sjöström, 2008). The importance of physical activity for health is well known, and research has noted both physical and psychological benefits when children participate in physical activity (Ahn & Fedewa, 2011;¯ Janssen & Leblanc, 2010). Several studies have shown that the physical activity of preschool children is moderately low (Grzywacz *et al.* 2014; Tucker, 2008). Physical activity and physical fitness have similar influence on health outcomes, including overweight (Rauner, Mess, & Woll, 2013), although the association between physical activity and physical fitness has been stronger than that between overweight and physical fitness (Fogelholm, Stigman, Huisman, Metsämuuronen, & Metsamuuronen,

Table 1. Results in the physical fitness considering sex and age group

	Total mean (SD) $n = 3868$	Boys mean (SD) $n = 1961$	Girls mean (SD) $n = 1907$	*P*-value	95% confidence interval	3 years $n = 978$ Mean (SD)	4 years $n = 1205$ Mean (SD)
10 × 20 m (s)	88.19 (19.31)	87.41 (19.58)	88.96 (19.02)	0.026	−3.034/−0.196	98.98 (20.66)	89.62 (18.38)
Ruler drop test (cm)	32.49 (10.65)	31.88 (10.40)	33.13 (10.87)	0.001	−1.906/−0.477	32.57 (11.13)	33.36 (11.03)
Balance (s)	8.51 (7.91)	8.37 (7.81)	8.65 (8.01)	0.276	−0.228/0.801	4.96 (4.44)	7.79 (7.25)
Standing long jump (cm)	69.92 (25.21)	72.80 (25.93)	66.93 (24.08)	<0.001	4.225/7.611	52.17 (20.58)	67.99 (22.94)
20-m running speed (s)	6.15(1.16)	6.05 (1.15)	6.25 (1.16)	<0.001	−0.282/−0.110	6.93 (1.18)	6.24 (1.12)

SD (standard deviation). Post-hoc analysis (Bonferroni).
***$P < 0.001$.

2008). In addition, physical fitness, adiposity and the distribution of body fat during childhood have shown a high correlation with cardiovascular health in adulthood (Casajús *et al.* 2012).

Bürgi *et al.* (2011) indicate that in preschool children, the level of physical activity is associated to improvements in heart abilities and aerobic capacity, consequently being a determinant of cardiovascular risk. Likewise, high levels of aerobic performance and motor coordination are strong predictors of physical activity during childhood (Lopes, Rodrigues, Maia, & Malina, 2011). Krombholz's (2006) study with 1194 preschool children indicates positively significant correlations between measures of physical growth and physical performance and between motor and cognitive performance, physical fitness, body coordination and manual dexterity, which improved across age groups.

Therefore, early childhood should be targeted as a critical time to promote healthy lifestyle behaviours (Jones, Hinkley, Okely, & Salmon, 2013). However, despite the fact that a sedentary lifestyle at this age is quite common (De Bock, Genser, Raat, Fischer, & Renz-Polster, 2013), few studies have analysed the physical fitness of children age 3–6 years old (Bürgi *et al.* 2011; Niederer *et al.* 2012). Considering the facts and information mentioned above, the aim of this study is to determine the physical fitness in children aged 3–6 years, discriminating performance by sex, age and BMI.

Methods

Participants

Initially 4459 children aged 3 to 6 years were selected to participate in the current study. Of these, 3868 returned signed parental consent to participate. Demographic characteristics revealed that 1961 children were male (age: 55.71 ± 11.11 months old, body mass index [BMI] = 16.03 ± 1.93 kg/m^2), and 1907 were female (age 56.16 ± 0.97 months old, BMI = 15.85 ± 1.89 kg/m ^{2}), and they were selected from 51 schools in southern Spain. The sample has been selected by convenience in a large geographic area of Andalusia in both urban and rural areas. Inclusion criteria considered schooling in early childhood and being free from physical and/or intellectual disabilities. Parents voluntarily signed an informed consent form for the participation of their children in this study. The study was completed in accordance to the norms of The Declaration of Helsinki (2013 version) and following the directives of the European Union on Good Clinical Practice (111/3976/88 of July, 1990), as specified in the Spanish legal framework for human clinical research (Royal Decree 561/1993 on clinical essays). The study was approved by the Ethics Committee of the University of Jaen (Spain).

Materials and testing

Height (cm) was measured with a stadiometer (Seca 222, Hamburg, Germany) and weight with a bascule (Seca 899, Hamburg, Germany). BMI was calculated by dividing weight (in kilograms) by height^2 (in metres). The 85th and 95th percentiles of the study by Sobradillo *et al.* (2004) were considered in classifying children as overweight or obese, respectively, in relation to BMI.

The fitness test battery by Latorre *et al.* (2015) was used in the current study, which is focused on testing basic components of physical condition and motor development, such as endurance (10 × 20 m), strength (standing long jump), speed (20 m), reaction time (RT) (ruler drop test) and balance (flamingo). Latorre *et al.* (2015) show test–retest reliability, by intra-class correlation coefficient, between 0.774 and 0.995. In

Table 1. Continued

	5 years $n = 1345$ Mean (SD)	6 years $n = 340$ Mean (SD)	*P*-value	Post-hoc analysis	Normal weight $n = 2983$ Mean (SD)	Overweight $n = 294$ Mean (SD)	Obesity $n = 324$ Mean (SD)	*P*-value
10 × 20 m (s)	82.92 (16.34)	76.15 (14.35)	<0.001	3 > 4,5,6***. 4 > 5,6***, 5 > 6***	88.03 (19.07)	88.02 (19.07)	90.66 (22.96)	0.304
Ruler drop test (cm)	32.38 (10.07)	29.66 (9.59)	<0.001	3 > 6***, 4 > 6***, 5 > 6***	32.68 (10.65)	32.18 (10.19)	31.12 (10.69)	0.094
Balance (s)	10.66 (8.82)	11.47 (9.24)	<0.001	3 < 4,5,6***, 4 < 5,6***,	8.45 (7.83)	7.96 (7.52)	8.53 (7.95)	0.090
Standing long jump (cm)	79.71 (23.11)	86.90 (21.38)	<0.001	3 < 4,5,6***. 4 < 5,6***, 5 < 6***	70.07 (24.98)	70.52 (24.99)	68.41 (27.56)	0.427
20-m running speed (s)	5.80 (0.98)	5.49 (0.86)	<0.001	3 > 4,5,6***. 4 > 5,6***, 5 > 6***	6.17 (1.16)	6.07 (1.21)	6.09 (1.16)	0.672

SD (standard deviation). Post-hoc analysis (Bonferroni).
***$P < 0.001$.

the 10 × 20 m and sprint test, the test score was the running time, so that a longer time indicates a poorer performance. In the RT, the test score was the distance reached, so a greater distance indicates a poorer performance. In the balance test, the test score was the runtime, so a longer time indicates a greater performance. In the standing long jump, the test score was the distance reached, a greater distance indicating a greater performance.

Procedure

After obtaining the appropriate permits in schools and informed parental consents, we proceeded to the application of the test battery. All tests were conducted in schools – sports facilities and classrooms – and were supervised by own researchers, with teachers present too, during playtime with each group of students. In two separate sessions, 48 h apart, a team of researchers previously trained in conducting the different tests evaluated participants. During the first testing session, RT (two trials with left and right hand; the average of both hands was recorded), the standing long jump test (two trials, the best trial was registered) and the balance test (two trials with left and right leg; the average of both legs was registered) were performed. Two days later, during the second testing session, the 20-m sprint (two trials, the best trial was registered) and 10 × 20 m tests (one trial) were performed. Prior to the testing sessions, children performed a typical warm-up consisting of five minutes of low-intensity running and 5 min of general exercise (i.e. skipping, leg lifts, lateral running and front-to-behind arm rotations). The children also performed some familiarization trials for the RT, balance assessment and the horizontal jumping. Each child was individually assessed. The research team conducted a demonstration. The children were motivated and encouraged to reach the best score possible in every test.

Statistical analysis

Data were analysed using SPSS, v.19.0 for Windows (SPSS Inc, Chicago, USA), and the significance level was set at $P < 0.05$. The data are shown in descriptive statistics for mean and standard deviation (SD). Tests of normal distribution and homogeneity (Kolmogorov–Smirnov and Levene's, respectively) were conducted on all data before analysis. Differences between sex and age groups were analysed using analysis of variance (ANOVA) adjusting by Bonferroni test; additionally, differences between weight status were analysed with ANOVA using as covariables: age and sex. Finally, a Pearson correlation analysis was performed between physical fitness tests with BMI adjusted for age.

Results

Table 1 shows results in physical fitness regarding sex, age and weight status. Significant differences were found between sexes: boys showed a greater performance on cardio respiratory endurance, RT, strength and running speed. Furthermore, an increase in physical fitness in correlation to age was found and significant differences by sex in the different age groups

(Figs1–4). In the 10 × 20 m, sex differences were found at 5–6 years, the boys showing a greater performance. In the standing long jump, the sex differences were found at 3 and 4–5 years, the boys showing a greater performance. In RT, the sex differences were found at 4–5 years, the boys showing a greater performance. Finally, in running speed, the sex differences were found at 3 and 4–5 years, the boys showing a greater performance. In relation to the weight status, the prevalence of overweight was 8.1% and obesity 8.9% and no significant differences were found in physical fitness. The Pearson correlation analysis is shown in Table 2; BMI does not correlate with the physical fitness, except for balance, which does show a low correlation.

Discussion

The aim of this study was to determine the physical fitness in children 3–6 years old, discriminating performance by sex, age and BMI. The main finding was that sex differences in physical fitness were evident at an early age. These differences could be explained because of the fact that preschool girls present a more sedentary lifestyle and lower levels of moderate to vigorous physical activity than boys (Tanaka *et al.* 2012). Likewise Malina, Bouchard and Bar-Or (2004) showed that there are large inter-individual differences in physical fitness in children. In this study, boys showed greater performance in strength, cardio respiratory capacity, RT and running speed than girls. Previous studies support sex differences in physical fitness and fundamental motor skills. Tanaka *et al.* (2012) showed a greater performance in standing long jump, running speed and lower balance in preschool boys than preschool girls. Kondric *et al.* (2013) found better scores for preschool boys in the standing long jump relative to preschool girls. Although, Bürgi *et al.* (2011) did not find significant differences between preschool boys and girls in BMI, or in aerobic fitness or balance tests. Moreover, Zhou, Ren, Yin, Wang and Wang (2014) did not

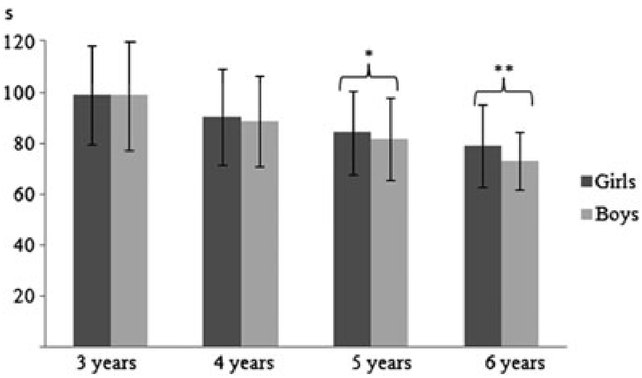

Figure 1. 10 × 20 m differences by sex in age groups $*P < 0.05$. $**P < 0.01$.

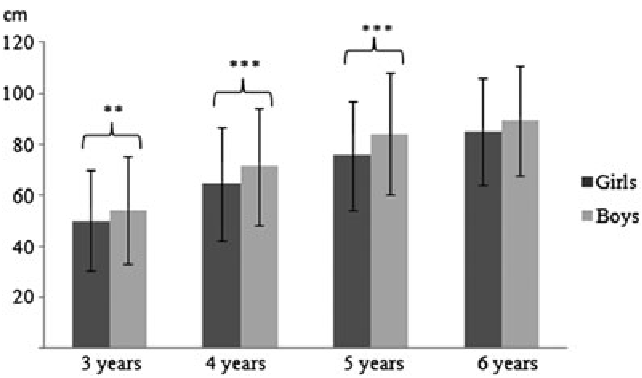

Figure 2. Standing long jump differences by sex in age groups. $**P < 0.01$. $***P < 0.001$.

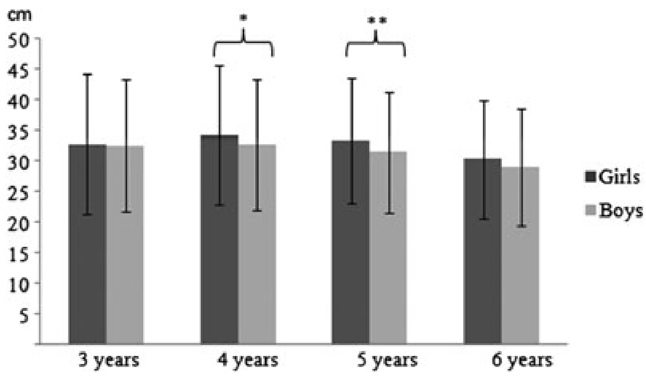

Figure 3. Ruler drop test differences by sex in age groups. $*P < 0.05$. $**P < 0.01$.

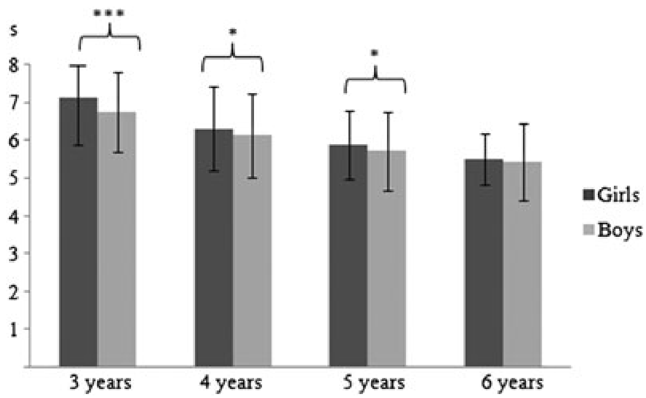

Figure 4. Running speed differences by sex in age groups. $*P < 0.05$. $***P < 0.001$.

Table 2. Correlation Pearson between BMI and physical fitness test adjusted for age

	BMI	10 × 20 m	Ruler drop test	Balance	Standing long jump	20-m running speed
BMI	1	0.028	−0.015	−0.052*	−0.012	−0.013
10 × 20 m		1	0.032	−0.176***	−0.157***	0.405***
Ruler drop test			1	−0.085***	−0.069**	0.018
Balance				1	0.129***	−0.108***
Standing long jump					1	−0.268***
20-m running speed	1					

*$P < 0.05$. **$P < 0.01$. ***$P < 0.001$.

find significant differences between sex in the balance beam walk, standing long jump and 30-m sprint; however, boys carried out better performances in the tennis ball throw, 30-m crawl and flexibility measures than girls. Similarly, Vameghi, Shams and Shamsipour Dehkordi (2013) showed, in both ages (4–5 years–5–6 years), that boys were better than girls in jumping and ladder-climbing skills, but girls were better in skipping and hopping skills.

In this study, the prevalence of obesity is higher than that detected in Europe in preschool children (Manios & Costarelli, 2011). Moreover, no significant differences were found between boys and girls in BMI. Similar results were obtained by Tomporowski, Davis, Miller and Naglieri (2008), Tanaka *et al.* (2012) and Vameghi *et al.* (2013). The negative impact of obesity on physical fitness has been documented in youth. There are inverse relationships between physical fitness and overweight (Rauner *et al.* 2013). However, in this study, BMI did not correlate with physical fitness. Hence, the data on the relationship between physical fitness and BMI are inconsistent in preschool children. However, other authors (Lopes *et al.* 2011) indicated that BMI-group-related differences in physical fitness can already be present in preschool-age children. Accordingly, Vameghi *et al.* (2013) suggested that both overweight and obese children have lower performance than normal children. Likewise, overweight children (ages 43 to 84 months) showed lower performance in gross motor skills (coordination and fitness), if compared with healthy-weight children (Krombholz, 2013). Therefore, the presence of conflicting results regarding the relationship between weight status and physical fitness in preschool children requires further studies to address this issue.

On the other hand, in this study, all physical fitness tests correlate and improve with age, which may be a healthy-growth indicator in preschool children. The results are consistent with Zhou *et al.* (2014) in preschoolers. Additionally, Vameghi *et al.* (2013) demonstrated that age had a significant effect on walking and running skills.

Physical fitness could be considered as a useful health marker in childhood; hence, it is necessary to include physical fitness testing in the health-monitoring system (Ortega *et al.* 2008). Nevertheless, it is worth noting that fitness testing in a school environment needs to be conducted in a manner that does not stigmatize child who is overweight or uncoordinated. Accordingly, the increased prevalence of obesity, physical inactivity, low physical fitness and the emergence of symptoms of metabolic and cardiovascular diseases during childhood and adolescence highlight the need to consider physical activity and physical fitness in the development of an International Growth Standard for Preadolescent and Adolescent Children (Malina & Katzmarzyk, 2006). The improvements in physical fitness performance through the promotion of physical activity could be important for the health of preschool children, particularly in obesity prevention. Additionally, opportunities to be physically active at school are limited by pressure on scholastic performance (Mahar *et al.* 2006); accordingly, little time for physical activity is incorporated into preschool classrooms (Latorre, 2007). Increasing the amount of time devoted to physical education can improve the physical fitness and health of preschool children.

Finally, a limitation of the present study is its cross-sectional design, so caution must be exercised when interpreting the observed associations. However, the strengths of our study include a relatively large population sample of children analysed across the first three school years and the reliability of physical fitness tests in preschool children.

In conclusion, sex differences in physical fitness are evident at an early age in addition; the relationship between physical fitness and BMI is inconsistent in preschool children. Moreover, there is a strong connection between growth and physical fitness. Therefore, measures of the physical fitness of preschool children are necessary to investigate the relationship between physical fitness and health in this population.

Key messages

- Sex differences in physical fitness are evident at an early age; in addition, the relationship between physical fitness and BMI is inconsistent in preschool children.
- Promoting physical activity in preschool children is of considerable importance from a health perspective.
- From a public health policy perspective, the evaluation of this aspect is crucial in order to design programmes for the prevention of cardiovascular risk factors and obesity.
- The involvement of those working in health care, education and politics is important to promoting physical activity in preschoolers.

Conflict of interests

No conflict of interest.

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VIII. Feeding practices, physical activity and fitness of Spanish preschoolers. Influence of sociodemographic outcome measures

(PAPER VIII)

VIII

Feeding practices, physical activity, and fitness in Spanish preschoolers. Influence of sociodemographic outcome measures.

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Prácticas de alimentación, actividad física y condición física de niños preescolares españoles. Influencia de variables sociodemográficas

Feeding practices, physical activity and fitness of Spanish preschoolers. Influence of sociodemographic variables

Dr. Pedro Á. Latorre Román[a], Lic. David Mora López[a] y Lic. Felipe García Pinillos[a]

a. Universidad de Jaén, Jaén, España.

Correspondencia:
Dr. Pedro Á. Latorre Román, platorre@ujaen.es

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RESUMEN

Introducción. La edad preescolar es un período esencial para establecer hábitos de nutrición y actividad física adecuados.

Objetivo. El propósito de este estudio fue analizar el estado nutricional, el nivel de actividad física (AF) y la condición física (CF) de niños preescolares en relación con el sexo y con las variables sociodemográficas de los padres.

Material y métodos. Se incluyeron niños preescolares seleccionados de 30 centros escolares del sur de España. Se registraron parámetros de CF, AF, antropometría, estado nutricional de los niños y variables sociodemográficas de los padres.

Resultados. Participaron 1287 niños de entre 3 y 6 años, 643 niños y 644 niñas, y 1267 padres (el 72,4% eran madres y el 27,6%, padres). Las niñas presentaron niveles más bajos de sobrepeso y obesidad que los niños. Existieron diferencias significativas por sexos en el consumo de determinados alimentos: mayor consumo de lácteos en el desayuno y aceite de oliva en niñas y mayor consumo de comidas rápidas y pastas o arroz en los varones. Los varones presentaron una mejor CF. Los niños del estrato socioeconómico más bajo mostraron mayor índice de masa corporal, peor estado nutricional y más bajo nivel de AF. Los niños de padres con estudios universitarios presentaron menor índice de masa corporal y mejor estado nutricional.

Conclusiones. Los niños preescolares de este estudio presentaron valores elevados de sobrepeso y obesidad y bajo nivel de AF, teniendo en cuenta las referencias internacionales. Las niñas mostraron una CF inferior a la de los varones. Los niños cuyos padres presentaron un nivel socioeconómico bajo y sin estudios mostraron un nivel nutricional precario.

Palabras clave: *preescolar, aptitud física, actividad física, obesidad, nutrición.*

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INTRODUCCIÓN

El incremento del sobrepeso y la obesidad en el mundo entero es una realidad y es uno de los mayores retos para la protección de la salud. La prevalencia mundial de sobrepeso y obesidad infantil aumentó del 4,2% en 1990 al 6,7% en 2010. Con esta tendencia, se espera llegar al 9,1% en 2020; todo ello como consecuencia de un probable cambio en los patrones de nutrición y de actividad física (AF).[1] Además, la adiposidad, la baja condición física (CF) aeróbica y los bajos niveles de AF están asociados con el riesgo de enfermedad cardiovascular en los niños y su alta prevalencia representa un importante problema de salud pública.[2]

Es necesario analizar determinados factores modificables (influencia de los padres, entorno social, colegios, tiempo de ocio, etc.) y no modificables (sexo y edad) para poder realizar un abordaje integral del sobrepeso y la obesidad en niños preescolares y su relación con la AF. Dentro de los factores modificables, se destaca la AF, la cual se asocia de manera inversa con el sobrepeso.[3] Varios estudios han demostrado que la AF de los niños en edad preescolar es moderadamente baja.[4-6] Además, la CF es un biomarcador importante de la salud desde una edad temprana.[7] El sobrepeso y la adiposidad influyen negativamente en la CF de los niños,[8] y existe una importante conexión entre el crecimiento del cuerpo y la CF.[9,10] Además del ejercicio físico, la alimentación es otro de los factores exógenos que más importancia tienen en el crecimiento infantil.

La edad preescolar es un momento idóneo para establecer hábitos de nutrición y AF adecuados; es un período crítico para la prevención de la obesidad, la cual se asocia con consecuencias para la salud que pueden persistir en la adolescencia y la edad adulta.[8,11,12] Por tanto, la evaluación del estado nutricional y el nivel de AF en niños preescolares debe ser un elemento esencial para el control y el seguimiento de la salud de esta población.

Teniendo en cuenta la información presentada anteriormente, se plantea como hipótesis que es posible que, a edades preescolares, las prácticas alimenticias y la AF puedan verse afectadas por el sexo de los niños y por determinadas características sociodemográficas de los padres. El objetivo de este estudio fue evaluar el estado nutricional, ponderal, el nivel de AF y CF de niños preescolares en relación con el sexo y otras variables sociodemográficas de los padres.

POBLACIÓN Y MÉTODOS

Se incluyeron niños preescolares pertenecientes a 30 centros escolares del sur de España seleccionados aleatoriamente. Como criterios de inclusión, se establecieron la escolarización en Educación Infantil y no padecer discapacidad física y/o intelectual. Los padres firmaron un consentimiento informado de participación voluntaria en esta investigación (determinante para la inclusión de los niños). El estudio se completó de acuerdo con las normas de la Declaración de Helsinki (versión 2013). El estudio fue aprobado por el Comité de Ética de la Universidad de Jaén.

Mediante un cuestionario sociodemográfico realizado *ad hoc*, se recogió información de los padres, como nivel de estudios, estado civil y nivel socioeconómico (sobre la base de su autopercepción socioeconómica). Como parámetros antropométricos, se analizaron la altura (cm), que se midió con un estadiómetro (Seca 222, Hamburgo, Alemania), el peso (kg), que se midió con una báscula (Seca 634, Hamburgo, Alemania), y el índice de masa corporal (IMC), que se obtuvo de la ecuación IMC= peso (kg)/talla (m)^2. Además, se registró el contorno del abdomen a nivel de la cicatriz umbilical mediante una cinta ergonómica Seca 201. En el análisis de la CF, se empleó la batería de pruebas de Latorre et al. (2015),[13] que representa componentes básicos de la condición físico-motriz, como la resistencia, la fuerza, la velocidad y el equilibrio. Además, se añadió la prueba de dinamometría manual para analizar la fuerza de prensión manual. El análisis del estado nutricional, tiempo de uso de pantallas (se refiere al uso de pantallas de video, como televisión, tabletas, consolas, móviles, computadoras, etc.) y AF se realizó mediante el cuestionario Krece Plus, el cual presenta 16 cuestiones referentes a la ingesta nutricional y dos cuestiones sobre uso de pantallas y AF extraescolar.[14] El registro del tiempo en sedestación de los padres se realizó mediante el análisis del ítem 7 del *International Physical Activity Questionnaire* (IPAQ)[15] en su versión corta.

Todas las pruebas se realizaron en los centros escolares, en sus instalaciones deportivas y aulas, por investigadores expertos y en presencia de los docentes de cada grupo de alumnos. Los padres cumplimentaron, de manera autoadministrada, los diferentes cuestionarios en su hogar. Posteriormente, en dos sesiones separadas por 48 horas, los niños fueron evaluados en la jornada escolar (de 9 a 14), con una duración aproximada de 40 minutos por sesión. En el primer día, se realizaron las pruebas de fuerza de prensión manual (dos intentos con cada mano), equilibrio (dos intentos con cada pierna) y salto horizontal (dos intentos). El segundo día, se registraron la prueba de 20 m (dos intentos) y 10 x 20 m (un intento). Previamente a la realización de las pruebas físicas, los niños efectuaron un calentamiento basado en carrera continua y movilidad articular; además, se realizaron, por parte del equipo investigador, pruebas de demostración y los niños ejecutaron ensayos de familiarización. Se seleccionaron los mejores intentos en cada prueba, excepto en la dinamometría manual y equilibrio, que se realizó un promedio de las dos manos y piernas, respectivamente, con el mejor intento. Todos los niños fueron motivados para desarrollar el máximo rendimiento físico mediante instrucciones verbales que los animaran a correr más rápido, saltar más lejos, etc.

El tamaño de la muestra para una población infinita con prevalencia desconocida en la que $p = q = 0,50$, con un nivel de confianza del 99% y un error del 5% fue de 645 sujetos. Para la selección de la muestra, se emplearon los datos de la Junta de Andalucía sobre Centros de Educación Infantil de Andalucía.

Los datos de este estudio se analizaron mediante el programa estadístico SPSS, v.19.0 para Windows (SPSS Inc., Chicago, USA). El nivel de significación se fijó en $p < 0,05$, a un nivel de confianza del 95%. Los datos se mostraron en estadísticos descriptivos de media, desviación típica y porcentajes. Se comprobó la distribución normal de los datos y la homogeneidad de varianzas mediante pruebas de Kolmogorov-

Smirnov y contraste de Levene, respectivamente. Las diferencias entre sexos, nivel de estudios y estado socioeconómico de los padres se analizaron mediante el análisis de varianza (*analysis of variance*; ANOVA, por sus siglas en inglés) con prueba *post hoc* mediante el ajuste de Bonferroni. El análisis del estado ponderal y del cuestionario Krece Plus por ítems en relación con el sexo se realizó mediante la prueba chi cuadrado. Por último, se realizó la correlación de Pearson entre las diferentes variables.

Tabla 1. *Características sociodemográficas de los padres*

Estado civil	n (%)
Soltero	53 (4,2)
Casado o en pareja	826 (65,2)
Divorciado/separado	372 (29,4)
Viudo	16 (1,2)
Total	*1267 (100)*
Nivel socioeconómico	
Bajo	107 (8,6)
Medio	814 (65,6)
Alto	319 (25,8)
Total	1240 (100)
Nivel de estudios	
Sin estudios	32 (2,5)
Primarios	316 (25)
Secundarios	483 (38,2)
Universitarios	433 (34,3)
Total	1264 (100)
Tiempo de sedestación diario en minutos	
Media (DT)	248,20 (168,31)

DT: desviación típica.

RESULTADOS

El estudio se realizó entre los meses de abril y mayo de 2015. Participaron un total de 1287 niños de entre 3 y 6 años (edad= 50,90 meses; IMC= 16,03 ± 2,13 kg/m^2), 643 niños y 644 niñas, y 1267 padres (el 72,4% eran madres y el 27,6%, padres).

En la *Figura 1*, se expone el diagrama de flujo de los participantes. En la *Tabla 1*, se presentan las variables sociodemográficas en relación con uno de los padres.

En cuanto al estado ponderal por sexos, las diferencias fueron significativas (p= 0,004); las niñas presentaron niveles más bajos de sobrepeso y obesidad que los niños, 7,0%-9,2% vs. 9,7%-13,9%, respectivamente, y la prevalencia total de sobrepeso y obesidad fue de 8,3% y 11,5%, respectivamente.

Figura 1. *Diagrama de flujo de los participantes*

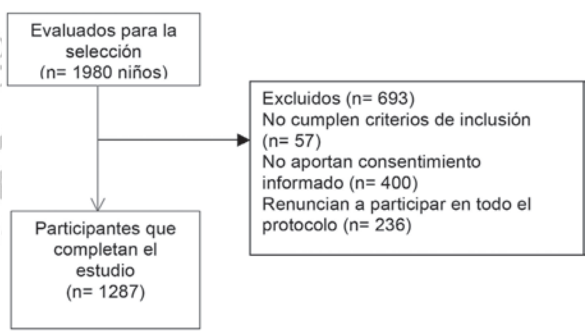

Tabla 2. *Resultados del cuestionario Krece Plus en porcentaje de respuesta de los padres por cada ítem en la muestra total y por sexos*

Ítems	n padres	Porcentaje total	Niña (%)	Niño (%)	*p*-valor
No desayuna.	1248	1,5	1,5	1,6	0,817
Desayuna un lácteo (leche o derivados).	1257	93,3	94,9	91,7	0,024
Desayuna un cereal o derivado.	1254	68	66,6	69,4	0,290
Desayuna bollos o dulces.	1243	27,8	26,9	28,8	0,442
Ingiere una fruta o jugo de fruta todos los días.	1263	79,2	78,4	79,9	0,516
Ingiere una segunda fruta todos los días.	1257	38,9	37,7	40,2	0,360
Ingiere un segundo lácteo durante el día.	1257	85,7	85,6	85,9	0,862
Ingiere regularmente verduras frescas o cocinadas una vez al día.	1265	62,9	63,9	61,8	0,439
Ingiere verduras frescas o cocinadas más de una vez al día.	1262	23	21,8	24,2	0,315
Ingiere pescado regularmente (más de 2 o 3 veces por semana).	1264	76,9	77,5	76,3	0,617
Come una o más veces a la semana hamburguesas, panchos *(hot dogs)* o pizza.	1266	29,7	25	34,3	< 0,001
Le gustan las legumbres (lentejas, judías, más de una vez a la semana).	1267	84,1	84,7	83,5	0,572
Ingiere varias veces al día dulces y golosinas.	1266	22,9	23	22,8	0,930
Ingiere pasta o arroz casi a diario (más de 5 veces por semana).	1267	31,6	28,3	34,9	0,012
Utiliza aceite de oliva en su casa.	1267	95,6	97,1	94,1	0,008
Toma bebidas alcohólicas (≥ 1/semana).	1266	0	0	0	--

En la *Tabla 2*, se muestran los resultados del cuestionario Krece Plus en porcentaje de respuesta por cada ítem. Existieron diferencias significativas por sexos en el consumo de determinados alimentos: mayor consumo de lácteos en el desayuno y aceite de oliva en las niñas y mayor consumo de comidas rápidas y pastas o arroz en los varones.

En la *Tabla 3*, se exponen los resultados de las diferentes variables teniendo en cuenta el sexo. Se encontraron diferencias significativas en el IMC, que fue mayor en los niños. A su vez, estos manifestaron mejor rendimiento en salto horizontal, velocidad, resistencia y fuerza de prensión manual.

En la *Tabla 4*, se presentan los resultados de las diferentes variables teniendo en cuenta el nivel socioeconómico de los padres. Los niños del estrato socioeconómico más bajo mostraron mayor IMC, peor estado nutricional y más bajo nivel de AF. El tiempo de uso de pantallas fue menor en el estrato socioeconómico más elevado, que, sin embargo, presentó menor rendimiento en pruebas físicas, como el salto horizontal y la velocidad.

En la *Tabla 5*, se exponen los resultados de las diferentes variables teniendo en cuenta el nivel de estudios de los padres. Los niños de padres con estudios universitarios presentaron menor IMC, mejor estado nutricional y mayor salto horizontal.

Tabla 3. *Edad, variables antropométricas, estado nutricional, nivel de actividad física, tiempo de uso de pantallas y condición física por sexos*

	Niño Media (DT) n= 643	**Niña Media (DT) n= 644**	***p*-valor**
Edad (meses)	51,13 (10,41)	50,68 (10,86)	0,493
IMC (kg/m²)	16,19 (2,17)	15,87 (2,08)	0,007
Circunferencia de cadera (cm)	55,01 (5,71)	55,46 (5,92)	0,228
Puntuación total Krece Plus (0-10)	6,52 (2,06)	6,56 (2,00)	0,716
Actividad física semanal (horas)	1,87 (1,63)	1,71 (1,55)	0,079
Tiempo de uso de pantallas diario (horas)	3,14 (6,64)	3,13 (6,63)	0,971
Salto horizontal (cm)	73,28 (25,83)	65,98 (25,55)	< 0,001
Velocidad, 20 m (s)	6,16 (1,21)	6,55 (1,26)	< 0,001
Resistencia (s)	83,04 (19,54)	85,75 (19,65)	0,016
Equilibrio (s)	8,85 (9,67)	9,30 (10,43)	0,435
Fuerza de prensión manual (kg)	5,80 (2,03)	5,33 (1,99)	< 0,001

DT: desviación típica. IMC: índice de masa corporal.

Tabla 4. *Edad, variables antropométricas, estado nutricional, nivel de actividad física, tiempo de uso de pantallas y condición física según el nivel socioeconómico de los padres*

	Bajo Media (DT)[a] n= 102	**Medio Media (DT)[b] n= 768**	**Alto Media (DT)[c] n= 293**	***p*-valor**	**Prueba *post hoc***
Edad (meses)	50,37 (10,32)	51,21 (10,65)	52,13 (10,85)	0,709	
IMC (kg/m²)	16,53 (2,53)	15,94 (1,99)	16,02 (2,36)	0,038	a > b*
Circunferencia de cadera (cm)	54,88 (6,86)	54,94 (5,62)	53,27 (5,81)	0,563	
Puntuación total Krece Plus (0-10)	5,91 (2,39)	6,53 (1,98)	7,21 (1,77)	< 0,001	a < b*, a < c***, b < c***
Actividad física semanal (horas)	1,42 (1,54)	1,83 (1,60)	2,02 (1,63)	0,006	a < c**
Tiempo de uso de pantallas diario (horas)	3,29 (6,15)	3,70 (8,01)	1,85 (0,93)	< 0,001	b > c***
Salto horizontal (cm)	70,32 (28,29)	72,13 (26,44)	61,50 (22,50)	< 0,001	a > c*, b > c***
Velocidad, 20 m (s)	6,30 (1,17)	6,26 (1,21)	6,66 (1,32)	< 0,001	b < c***
Resistencia (s)	87,02 (24,05)	84,15 (19,86)	81,99 (16,41)	0,092	
Equilibrio (s)	10,16 (11,84)	9,00 (9,61)	9,59 (11,03)	0,475	
Fuerza de prensión manual (kg)	5,69 (1,74)	5,57 (2,08)	6,33 (2,24)	0,359	

DT: desviación típica. IMC: índice de masa corporal.* $p < 0,05$; ** $p < 0,01$; *** $p < 0,001$.

El análisis de correlación de Pearson no reveló ninguna asociación significativa entre el tiempo de sedestación diario de los padres y el resto de las variables analizadas.

DISCUSIÓN Y CONCLUSIONES

El hallazgo más relevante de este estudio indica que, en la población estudiada, el sexo de los niños y el nivel socioeconómico y de estudios de los padres afectaron a diferentes aspectos del estado ponderal, nutricional, AF y CF de niños preescolares.

En relación con el sexo, las niñas presentaron menor prevalencia de sobrepeso y obesidad que los niños; sin embargo, estos manifestaron mejor nivel de CF, y no afectó el sexo al estado nutricional, nivel de AF y uso de pantallas. Además, no se encontró asociación entre el IMC y el nivel de AF, tiempo de uso de pantallas, estado nutricional y, excepto con la fuerza de prensión manual, el resto de las pruebas de CF.

En relación con el estado nutricional y tomando como referencia el baremo de Serra et al.,[14] los niños preescolares de este estudio mostraron un nivel nutricional medio, lo que requería mejoras en la alimentación y la visita al pediatra en seis meses. Sin embargo, los niños con padres de nivel socioeconómico bajo y sin estudios presentaron un nivel nutricional muy bajo, lo que requería corregir urgentemente los hábitos alimentarios y la consulta con el pediatra.

En relación con los niveles de AF, los niños preescolares analizados en este estudio presentaron valores muy bajos de AF semanal, teniendo en cuenta las recomendaciones internacionales.[16] Además, el tiempo de uso diario de pantallas fue superior al tiempo semanal de AF, lo que, unido a la alta prevalencia de sobrepeso y obesidad en relación con los datos de referencia de De Onis et al.,[17] expuso una población muy sensible a problemas de salud relacionados con el sobrepeso y el sedentarismo. En este sentido, Van Stralen et al.,[18] destacaron una asociación positiva entre el comportamiento sedentario, principalmente, el tiempo de uso de pantallas, y el IMC y la circunferencia de la cintura. Hinkley et al.,[19] indicaron que la mayoría de los niños pequeños no participaban en las cantidades adecuadas de AF y sí en cantidades excesivas de uso de pantallas. En relación con el sexo, otros autores, en consonancia con este estudio, no encontraron diferencias entre niños y niñas preescolares en los niveles de AF tanto si la evaluación se hacía por medios objetivos (acelerometría) como por informes parentales.[20] Además, los niños con sobrepeso fueron significativamente menos activos, aunque no se observaron diferencias significativas en las niñas.[21]

Teniendo en cuenta la influencia de las características sociodemográficas de los padres en las diferentes variables, los niños con padres de nivel socioeconómico alto presentaron mejor estado nutricional, mayor tiempo de AF y menor uso de pantallas. Los niños de padres con estudios universitarios presentaron menor IMC, mejor estado nutricional y mayor salto horizontal. En

Tabla 5. *Edad, variables antropométricas, estado nutricional, nivel de actividad física, tiempo de uso de pantallas y condición física según el nivel de estudios de los padres*

	Sin estudios Media (DT)[a] n= 26	Primarios Media (DT)[b] n= 289	Secundarios Media (DT)[c] n= 446	Universitarios Media (DT)[d] n= 414	p-valor	Prueba *post hoc*
Edad (meses)	48,00 (8,72)	51,47 (10,65)	51,54 (11,07)	50,53 (10,29)	0,327	
IMC (kg/m²)	16,88 (3,21)	16,28 (2,28)	15,95 (2,17)	15,86 (1,90)	0,017	
Circunferencia de cadera (cm)	54,30 (5,79)	54,67 (5,48)	54,84 (6,34)	55,07 (5,22)	0,879	
Puntuación total Krece Plus (0-10)	5,92 (2,93)	6,55 (1,99)	6,66 (1,98)	6,85 (1,89)	0,042	
Actividad física semanal (horas)	1,75 (1,64)	1,74 (1,61)	1,77 (1,54)	1,98 (1,66)	0,163	
Tiempo de uso de pantallas diario (horas)	2,75 (1,43)	2,98 (6,15)	3,11 (6,87)	3,27 (7,09)	0,939	
Salto horizontal (cm)	64,41 (29,41)	65,28 (25,60)	69,75 (25,37)	71,97 (26,68)	0,009	b < d**
Velocidad, 20 m (s)	5,98 (1,11)	6,35 (1,30)	6,36 (1,25)	6,37 (1,20)	0,495	
Resistencia (s)	90,88 (23,96)	83,04 (18,20)	83,69 (19,75)	84,19 (19,73)	0,281	
Equilibrio (s)	11,69 (10,49)	10,07 (11,36)	9,36 (10,30)	8,72 (9,68)	0,255	
Fuerza de prensión manual (kg)	5,90 (1,55)	5,44 (2,07)	5,62 (1,93)	5,59 (2,13)	0,707	

DT: desviación típica. IMC: índice de masa corporal. ** p < 0,01.

este sentido, Sotos et al.,[22] destacaron que tanto el nivel educacional como el socioeconómico influían en el estado nutricional infantil.

Además, en este estudio, el nivel de sedentarismo de los padres no se asoció con ninguna variable analizada. Sin embargo, Hinkley et al.,[23] señalaron que los niños con padres activos tendían a ser más activos. Del mismo modo, Hesketh et al.,[24] indicaron que los niveles de AF diaria de la madre se asociaban con todas las intensidades de AF de los niños preescolares.

Por tanto, la AF es uno de los factores que influyen en el sano desarrollo de los niños, pero la mayoría de los niños en edad preescolar tienden a ser inactivos.[25] O'Dwyer et al.,[26] sugirieron que la escuela representaba un entorno propicio para el sedentarismo. En España, sucede la misma circunstancia que señalan otros autores[27] en relación con la AF en los colegios; así, aunque las escuelas pueden ofrecer oportunidades únicas para la AF estructurada, hay una tendencia a recortar las clases de Educación Física, debido a las presiones crecientes para mejorar los resultados académicos. Summerbell et al.,[28] recomendaron una serie de orientaciones para intervenir en el ámbito de la AF en niños preescolares, como fomentar el transporte activo para distancias cortas, visitar los lugares donde los niños pueden ser activos, desalentar la provisión de pantallas en el dormitorio, fomentar la participación no competitiva en la AF, mejorar todas las áreas de juego infantiles, dotar de ropa cómoda, proporcionar juegos durante las pausas de las clases, alentar a los niños a ser activos y disminuir el tiempo de sedentarismo total en el aula.

Una de las limitaciones de este estudio es su carácter transversal, lo que obliga a ser cautos en los resultados obtenidos y no permite realizar inferencias causales observadas. Otra es no haber considerado otros factores que pueden influir en las variables analizadas, por ejemplo, aspectos del entorno social y físico, tales como las instalaciones deportivas, la planificación urbana, los sistemas de transporte, parques y senderos, etc.

Sin embargo, una fortaleza de esta investigación es haber contado con una muestra amplia de sujetos y el registro de variables que escasamente se han abordado en estudios de esta naturaleza, como la CF.

Desde un punto de vista de aplicación práctica, intervenciones para mejorar el nivel de AF en niños preescolares, tanto en el colegio como fuera de este, son esenciales, todo ello acompañado con medidas de educación nutricional a los padres con menos recursos económicos y con escasa formación académica.

En conclusión, los niños preescolares de este estudio presentaron valores elevados de sobrepeso y obesidad y bajo nivel de AF, teniendo en cuenta las referencias internacionales. Las niñas mostraron una CF inferior a la de los niños. Por último, los niños cuyos padres tenían un nivel socioeconómico bajo y sin estudios mostraron un nivel nutricional precario. ■

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IX.Intellectual maturity and physical fitness in preschool children

(PAPER IX)

Intellectual maturity and physical fitness in preschool children.

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Original Article

Intellectual maturity and physical fitness in preschool children

Pedro Á Latorre-Román,[1] David Mora-López[2] and Felipe García-Pinillos[1]

[1]*Department of Corporal Expression, University of Jaén, and* [2]*Andalusian Regional Government, Department of Education, Jaén, Spain*

Abstract ***Background:*** There is an important connection between body growth, physical fitness and cognition. The association between physical fitness and cognitive function has been investigated in some studies, but little is known about the relationship between physical and motor performance and intellectual maturity in preschool children. The aim of this study was therefore to analyze the association between intellectual maturity and physical and motor fitness in preschool children.

Methods: A total of 1012 children aged 3–6 years participated voluntarily. A fitness test battery and the Goodenough–Harris drawing test (GHDT) were used.

Results: Boys did better in the standing broad jump and 20 m sprint ($P < 0.001$), and girls had a better crude GHDT score ($P = 0.001$). With regard to age group, there were significant differences ($P < 0.01$) between all groups in all fitness test variables and GHDT. Moreover, a significant correlation was found between crude GHDT score and the fitness test variables.

Conclusions: From an early age, physical–motor performance and intellectual maturity are linked. Fitness condition is able to predict intellectual maturity. Increasing the amount of time devoted to physical education can promote cognitive benefits in preschool children.

Key words children, cognitive, performance, physical fitness.

The importance of physical activity for health is well known and research has noted both physical and psychological benefits when children participate in physical activity.[1,2] In recent years, interest has grown in the benefits of physical activity for academic and cognitive performance.[3,4] There is an important connection between body growth, physical fitness[5,6] and cognition.[7] Fundamental motor skills affect children's physical, social, and cognitive development,[8] and there is a close association between motor development and cognitive development that takes place in the cerebellum and prefrontal cortex.[9] Cardiorespiratory fitness in childhood is related to cognition and differences in regional brain structure and function.[10,11] Cardiorespiratory fitness and motor skills play an important role in cognitive development during childhood and young adulthood.[12,13] The children who are physically fit have greater cortical activation and corresponding cognitive performance than less fit children.[14] Accordingly, in a recent review, Chang *et al.* showed that fitness was a significant moderator in the association between physical activity and cognitive performance.[15] In the same way, Chaddock-Heyman *et al.* noted a relationship between cardiorespiratory fitness and white matter microstructure during childhood.[16]

The physical fitness assessment of preschool children should be an essential for the control and monitoring of the quality of life related to health of this population, with all its health implications. It is also an important way to track healthy growth that other studies have associated with parallel cognitive development.[13]

When analyzing the drawings of young children, insights can be gained as to the social, emotional, physical, and intellectual development.[17] The progression of drawings that children make over a period of time can show a child's developmental level.[18,19] In several investigations children's drawing were used to analyze cognitive, motor, and intellectual development.[20–23] Lowenfeld and Brittain emphasized the importance of children's drawings for studying child development in a research setting.[19] Children 3–6 years go through two basic periods: period 1, doodle (18 months–4 years), a period characterized by reduced synthetic capacity and attention, thus, the drawing is done without intention; and period 2, pre-schematic phase (4–7 years), which is more realistic and shows the presence of the human figure.

The association between physical fitness and cognitive function has been investigated in some studies, but little is known about the relationship between physical and motor performance and maturity intellectual in preschool children. Taking the aforementioned information into account, the aim of this study was to analyze the association between intellectual maturity and physical and motor fitness in preschool children.

Methods

Participants

A total of 1012 children, aged 3–6 years, voluntarily participated in this study; 502 children were male (age, 57.05 ± 10.61 months; body mass index [BMI], 16.41 ± 2.16 kg/m^2), and 510 were female (age, 57.32 ± 16.67 months; BMI, 16.14 ± 2.18 kg/m^2). The

Correspondence: Pedro Ángel Latorre Román, PhD, Universidad de Jaén, Calle Chiclana de la Frontera 53, Úbeda (Jaén) 23400, España. Email: platorre@ujaen.es

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children were selected from 15 schools in southern Spain. Inclusion criteria included schooling in early childhood and being free from physical and intellectual disabilities. Parents voluntarily signed an informed consent form for the participation of their children in this study. The study was completed in accordance with the norms of The Declaration of Helsinki (2013 version) and following the directives of the European Union on Good Clinical Practice (111/3976/88 July 1990), as specified in the Spanish legal framework for human clinical research (Royal Decree 561/1993 on clinical essays). The study was approved by the Ethics Committee of the University of Jaen (Jaen, Spain).

Materials and testing

Physical and motor performance

The fitness test battery by Latorre *et al.*[24] was used in the current study. All selected tests for the fitness test battery have been used in previous studies[25–29] and test basic components of physical condition and motor development, such as endurance, strength, speed, reaction time (RT), and balance. The test battery is designed to reduce the cognitive component of the tests and to more easily sustain children's motivation to participate. This fitness test battery showed a proper reliability and, thereby, it is a good tool to determine the physical fitness of children aged 3-6 years.

Cardiorespiratory endurance was assessed using the 10 × 20 m test, inspired by the spatial structure of the Léger *et al.* test,[30] and based on the guidelines of the Spanish Athletics Federation (RFEA) for participants at this age. The rules of the test are very simple. Materials required include a tape measure to mark the distance of the runway (20 m), two boxes, five balloons, and a stopwatch. It is a 20 m shuttle test, in which participants move five balloons from one box (A, located at one end of the runway) to the other box (B, located at the other end). The total distance covered is 200 m, and timing starts from the signal "Go" and ends when the participant drops the last balloon into the box. It does not matter if the balloon does not enter the box. If the balloon is dropped at any time, the participants must pick it up and carry on moving. Supervisors should indicate to the participants that the balloon must be caught with both hands. The test allows running and walking. Only one attempt is allowed. The result is recorded in seconds, to one decimal place. The test score is the time recorded, with a longer time indicating poorer performance.

To measure RT, the ruler drop test (RDT)[28] was used to gauge eye–hand coordination. A ruler 50–60 cm long was used. The RDT was repeated three times with each hand. The final score was the average score of each hand. The average of each hand and the average of both hands were used for the subsequent statistical analysis. The test score was the distance that the ruler dropped before being caught, with a shorter distance indicating better performance.

In the balance assessment, the Johnson and Nelson test[31] was used. Two attempts were made with both legs and the best result (s) was accepted; the test score was the average result of both legs. The test score was the run time, with longer time indicating better performance.

To measure explosive lower body strength, the standing broad jump[22] was used. The test was performed twice and the best score was recorded in centimeters. The test score was the distance reached, with shorter distance indicating poorer performance.

The sprint test was performed using a distance of 20 m on a flat, hard, non-slip surface.[27] Two attempts were made for the test and the best time was recorded in seconds. The test score was the running time, with longer time indicating poorer performance.

Intellectual maturity

For the assessment of intellectual maturity, we used the Goodenough–Harris drawing test (GHDT), developed by Goodenough and revised by Harris.[32] The assessment focuses on details and the general body proportion of a drawn figure of a man (73 details) and a woman (71 details). The GHDT was designed to assess both children and adolescents up to 15 years of age. In the GHDT, children are asked to make three drawings: one of a man, one of a woman, and a self-portrait. Harris developed scoring systems only for the drawings of the man and woman. The GHDT, as it was used in this study, has good reliability and validity compared with other tests of intelligence in children aged 3–15.[33,34] We used the average crude score of the two drawings.

Procedure

After obtaining the appropriate permits in schools and informed parental consent, the test battery was carried out. In three separate sessions, a team of previously trained researchers performed the evaluation. The drawing test, GHDT, was assessed during the first testing session. In the second session, RDT, horizontal jump test and balance test were performed. Two days later, during the third testing session, the 20 m sprint and 10 × 20 m tests were performed. Prior to the testing sessions, children performed a typical warm-up consisting of 5 min of low-intensity running and 5 min of general exercise (i.e. skipping, leg lifts, lateral running, and front to behind arm rotations). The children also performed some familiarization trials for RT, the balance assessment, and the horizontal jump. Each child was individually assessed. The research team conducted a demonstration. Seven days later, a retest was performed; altogether, 92 children were assessed with the same protocol. The children were motivated and encouraged to reach the best score possible in every test.

Statistical analysis

Data were analyzed using SPSS, v.19.0 for Windows (SPSS, Chicago, IL, USA) and the significance level was set at $P < 0.05$. The data are given as mean ± SD. Reliability of the test battery was analyzed using intraclass correlation coefficients (ICC). Differences between sexes and age groups were analyzed using analysis of covariance (ANCOVA). The data for the ANCOVA analyses were adjusted for age, sex and BMI. A cluster k-means analysis was performed according to the physical and motor performance. Pearson correlation analysis was performed between the different physical fitness tests for crude GHDT score, age and BMI. Finally, multiple linear regression analysis between crude GHDT score and

Table 1 Test results vs sex and age

	Boys $n = 502$ Mean ± SD	Girls $n = 510$ Mean ± SD	P	$n = 230^a$ Mean ± SD	$n = 310^b$ Mean ± SD	$n = 359^c$ Mean ± SD	$n = 113^d$ Mean ± SD	P	Post-hoc analysis
Age (months)	57.05 ± 10.61	57.32 ± 16.67	0.687	42.95 ± 3.16	52.94 ± 3.62	64.90 ± 3.71	73.31 ± 1.51	<0.001	a < b,c,d,*** , b < c,d*** , c < d***
BMI (kg/m²)	16.41 ± 2.16	16.14 ± 2.18	0.053	16.20 ± 1.85	16.24 ± 2.36	16.28 ± 2.16	16.52 ± 2.28	0.624	
Standing broad jump (cm)	74.38 ± 25.75	68.53 ± 23.82	<0.001	54.15 ± 19.32	65.04 ± 22.97	82.37 ± 21.37	89.85 ± 22.18	<0.001	a < b,c,d,*** , b <9 c,d*** , c < d**
20 m sprint test (s)	6.03 ± 0.99	6.27 ± 1.05	<0.001	6.93 ± 1.01	6.35 ± 0.99	5.72 ± 0.72	5.46 ± 0.83	<0.001	a > b,c,d** , b > c,d***
10 × 20 m (s)	89.80 ± 20.00	90.67 ± 18.61	0.206	103.43 ± 21.41	92.32 ± 16.54	84.16 ± 16.47	76.93 ± 11.96	<0.001	a > b,c,d*** , b > c,d*** , c > d**
Balance (s)	7.64 ± 7.62	7.63 ± 7.30	0.690	4.03 ± 3.18	6.54 ± 6.41	9.84 ± 8.66	10.82 ± 8.43	<0.001	a < b,c,d,*** , b < c,d***
RDT (cm)	32.47 ± 9.75	33.56 ± 10.13	0.077	33.76 ± 11.65	34.33 ± 8.77	32.27 ± 9.51	30.32 ± 9.97	0.001	a > d*, b > c*, b > d**
Crude GHDT score (0–73)	13.27 ± 6.93	14.74 ± 7.56	0.001	9.82 ± 6.11	12.49 ± 6.10	16.68 ± 7.16	18.22 ± 7.30	<0.001	a < b,c,d,*** , b < c,d***

*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$. BMI, body mass index; GHDT, Goodenough–Harris drawing test; RDT, ruler drop test., $_a$3 years, $_b$4 years, $_c$5 years, $_d$6 years

physical and motor test variables was performed: age, sex and parental education were forced into the linear regression models and the measures of physical and motor performance were entered stepwise into the models.

Results

Intraclass correlation coefficients were as follows: 10 × 20 m test, ICC, 0.969 (95%CI: 0.953–0.979); RDT, ICC, 0.744 (95%CI, 0.836–0.602); balance test, ICC, 0.995 (95%CI: 0.997–0.992); horizontal jump test, ICC, 0.913 (95%CI: 0.943–0.866); finally, 20 m sprint test, ICC, 0.942 (95%CI: 0.962–0.911).

Table 1 lists BMI, fitness test battery results, and GHDT score according to sex and age. Boys did better in the standing broad jump and 20 m sprint tests ($P < 0.001$); nevertheless, girls had better crude GHDT score ($P = 0.001$). With regard to age, there were significant differences between all groups on all fitness test variables and for the GHDT ($P < 0.01$). Figure 1 shows the drawings by a, 3-year-old girl and 6-year-old girl, and crude GHDT score. Figure 2 shows the associations of measures of physical and motor performance with GHDT score in physical and motor performance groups 3–6 years; the lower performance subgroup had lower GHDT score in all physical and motor tests 3–6 years.

Pearson correlation analysis between age, BMI, crude GHDT score and fitness test variables was performed (Table 2). There was significant correlation between crude GHDT score and fitness test variables. Table 3 lists the linear regression between crude GHDT score and fitness test variables adjusted for age and sex.

Discussion

The main finding is that intellectual maturity in preschool children is associated with physical fitness; also, intellectual maturity

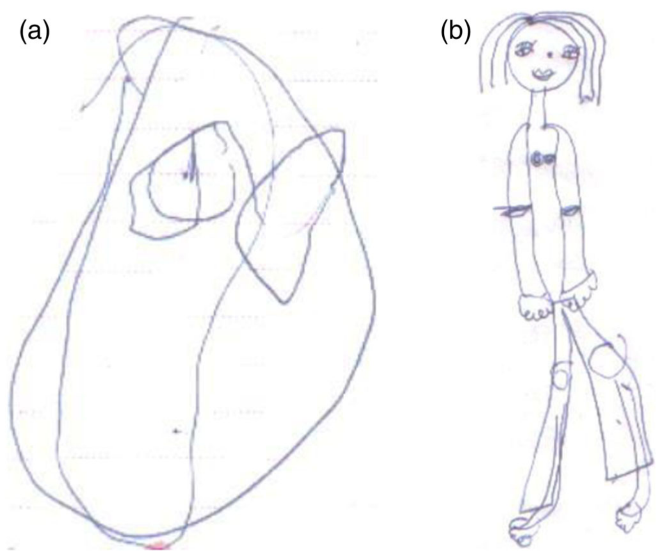

Fig. 1 Drawing by (a) a 3-year-old girl (crude Goodenough–Harris drawing test score = 4) and (b) a 6-year-old girl (crude Goodenough–Harris drawing test score = 39).

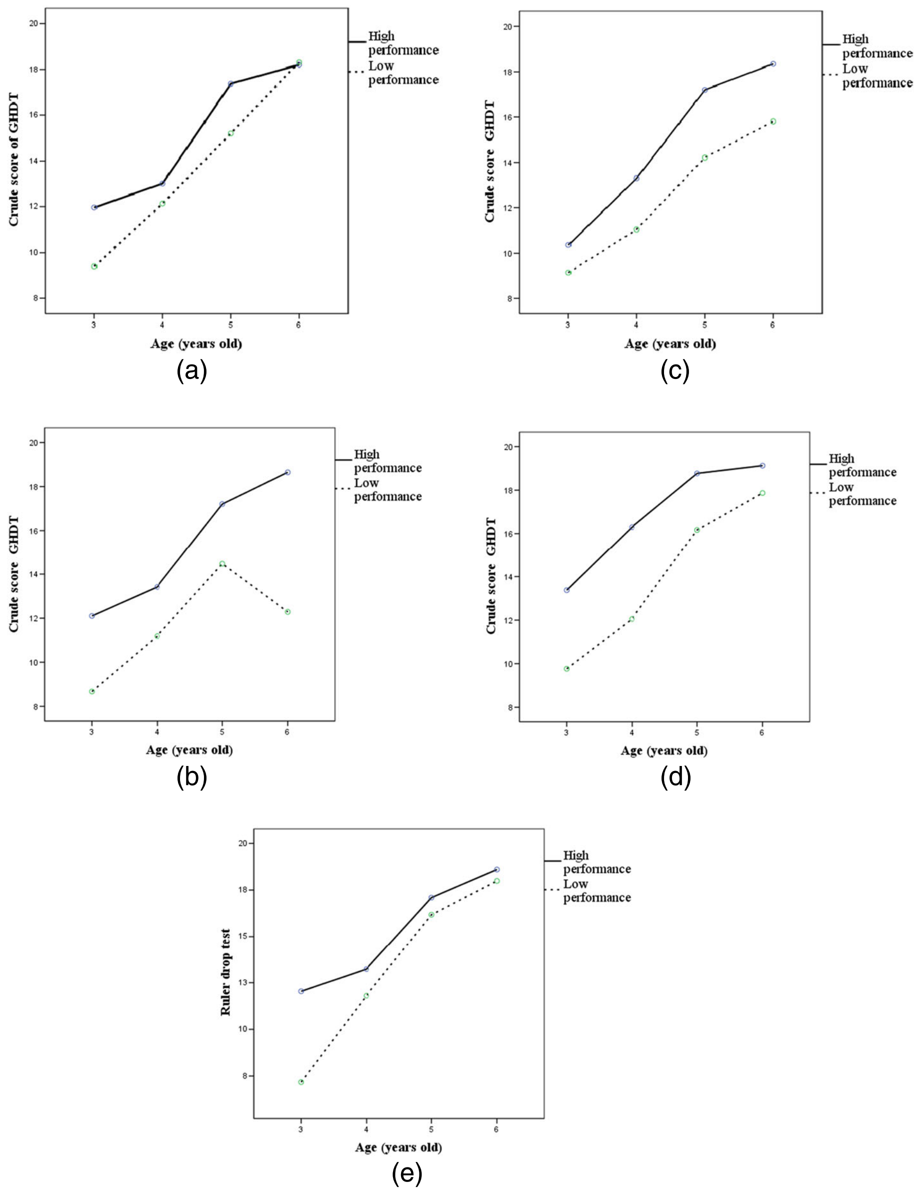

Fig. 2 Goodenough–Harris drawing test (GHDT) score vs (a) standing broad jump ($P = 0.012$), (b) 20 m sprint test ($P < 0.001$), (c) 10 × 20 m test ($P = 0.001$), (d) balance test ($P = 0.003$), and (e) ruler drop test ($P < 0.001$) according to age and performance (— high; ···, low).

Table 2 Pearson correlation analysis

	A	B	C	D	E	F	G	H
Crude GHDT score (A)	1	0.378**	0.012	0.316**	−0.372**	−0.348**	0.305**	−0.206**
Age (B)		1	0.054	0.526**	−0.517**	−0.421**	0.355**	−0.074*
BMI (C)			1	0.012	−0.030	0.027	−0.059	−0.011
Standing broad jump (D)				1	−0.472**	−0.307**	0.280**	−0.104**
20 m sprint test (E)					1	0.478**	−0.278**	0.144**
10 × 20 m (F)						1	−0.327**	0.147**
Balance (G)							1	−0.095**
RDT (H)								1

*$P < 0.05$; **$P < 0.01$. BMI, body mass index; GHDT, Goodenough–Harris drawing test; RDT, ruler drop test.

evolves with growth, as does physical fitness. The children with lower performance in the test battery had lower GHDT score. These results have important implications for clinical, educational, and experimental practice. This fitness test battery showed a proper reliability and, thereby, it is a good tool to determine the physical fitness of children aged 3-6 years.

Table 3 Multiple linear regression analysis: Crude GHDT score and physical fitness test variables

	B	t	*P*-value	95%CI for B Lower limit	Higher limit
Constant	17.825	6.626	<0.001	12.545	23.104
20 m sprint test	−1.134	−4.532	<0.001	−1.625	−0.643
Balance	0.117	3.962	<0.001	0.059	0.175
RDT	−0.090	−4.370	<0.001	−0.131	−0.050
10 × 20 m	−0.037	−2.846	0.005	−0.062	−0.011
Standing broad jump	0.023	2.333	0.020	0.004	0.042
			R^2=0.286		

Several studies have indicated an association between cognitive and motor development in children aged 5–11 years.[35,36] It is difficult to establish the nature of this relationship; it may be direct or it may be affected by some factor, such as parental influence. Wassenberg *et al.* noted the parallel development of specific cognitive and motor performance in children during normal or delayed development: specific brain structures, such as the basal ganglia or frontal cortex, and dopamine transmission are involved in both cognitive and motor performance.[36] In a recent study, children and youth with intellectual disabilities were found to have poor physical fitness compared with typically developing children.[37] Niederer *et al.* found that higher baseline cardiorespiratory fitness and motor skills corresponded to better spatial working memory or attention in preschool children.[38] Likewise, Krombholz noted positively significant correlations between measures of physical growth and physical performance and between motor and cognitive performance, physical fitness, body coordination, and manual dexterity, in preschool children, which improved with age group.[39,40] Moreover, significant sex differences were found; boys scored highest on some measures and girls on others.[39,40]

In the present study, no significant differences were found between boys and girls in BMI. Similar results were obtained by Tomporowski *et al.*[14] Moreover, BMI did not correlate with GHDT or the fitness test. In contrast, boys consistently scored higher than girls on the standing broad jump and 20 m sprint test. Likewise, Kondric *et al.* found better scores for preschool boys on the standing broad jump relative to preschool girls.[41] Burgi *et al.* did not find significant differences between preschools boys and girls in BMI, or cardiorespiratory fitness or balance tests.[42]

Opportunities to be physically active at school are limited because of pressure to perform well scholastically.[43] Exercise training programs may prove to be important methods of enhancing aspects of children's mental functioning that are central to cognitive and social development.[14] In this sense, the literature suggests that academic achievement, physical fitness, and health of children will not be improved by limiting the time allocated to physical exercise and physical activity.[44] Chaddock *et al.* showed the importance of physical activity and cardiorespiratory fitness for maximizing brain health and cognitive function during development.[10]

A limitation of the present study is its cross-sectional design, therefore caution must be exercised when interpreting the observed associations. More studies are needed to provide adequate evidence of causality. The strengths of the study, however, include the relatively large sample of children analyzed across the first 3 school years.

In conclusion, from an early age, physical fitness and intellectual maturity are linked. The present study helps to highlight the association between cognitive and physical functioning in preschool children, as well as facilitate a better understanding of the association between mental maturity and physical fitness in preschool children.

Implications for school health

There is a very important connection between body growth, physical fitness and cognition. Increasing the amount of time devoted to physical education can promote cognitive benefits and improve the health of preschool children.

Disclosure

The authors declare no conflicts of interest.

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X. Effects of a physical activity programme in the school setting on physical fitness and intellectual maturity in preschool children

(X)

Submitted

X

Effects of a physical activity programme in the school setting on physical fitness and intellectual maturity in preschool children.

Latorre-Román, P. Á., Mora-López, D.J., & García-Pinillos, F.

Child: care, health and development. *Submitted.*

Effects of a physical activity programme in the school setting on physical fitness and intellectual maturity in preschool children

Abstract

Aim: The purpose of this study was to examine the effects of a 10-week aerobic games programme on physical fitness and intellectual maturity in preschool children. **Methods:** A total of 111 children, aged 3 to 6 years, participated in this study; 60 children were male (age: 4.28± 0.61 years old), and 51 were female (age 4.59 ± 0.49 years old). Participants were randomly assigned to an experimental group (EG, n = 56) and a control group (CG, n = 55). The fitness test battery of Latorre, Mora, Fernández, Salas, and Moriana (2015) and the Goodenough–Harris drawing test were used. The children in the EG performed three weekly training sessions of physical activity in a classroom during a 10-week period. Every EG session lasted about 30 min. **Results:** There were no significant differences in any variable in the pretest between groups. In the posttest, the EG achieved better results in horizontal jump and sprint. In relation to posttest–pretest differences, the EG showed a greater increase in horizontal jump, sprint, endurance, and intellectual maturity. Importantly, a significant correlation was found between Δ intellectual maturity and Δ body height ($r=0.297$, $p<0.05$), Δbalance ($r=0.238$, $p<0.05$), and Δsprint ($r=-0.275$, $p<0.01$). **Conclusion:** An aerobic games programme in the school setting improved physical fitness and intellectual maturity in preschool children.

Key words: fitness, cognitive, performance, preschoolers, physical activity.

Introduction

The worldwide prevalence of childhood overweight and obesity increased from 4.2% in 1990 to 6.7% in 2010, and this trend is expected to reach 9.1% in 2020, this is a likely consequence of a change in nutrition and physical activity (PA) patterns over time(de Onis, Blössner, & Borghi, 2010). Alarming trends in childhood obesity even among preschool children show the importance of PA in this population(Timmons, Naylor, & Pfeiffer, 2007). In this regard, overweight and obesity in preschoolers are associated with greater intake of sugar-sweetened beverages, watching more television, having a television in the child's bedroom, getting inadequate sleep, and low rates of PA (especially higher-intensity activities) (Kuhl, Clifford, & Stark, 2012). Higher levels of habitual PA are preventive against child and adolescent obesity (Jiménez-Pavón, Kelly, & Reilly, 2010).

Early childhood is a critical time for promoting PA (M V O'Dwyer et al., 2013).The importance of PA for health is well known, and research has noted both physical and psychological benefits when children participate in PA (Ahn & Fedewa, 2011; Janssen & Leblanc, 2010). Bürgi et al. (2011) indicate that in preschool children, the level of PA is associated with improvements in heart abilities and aerobic capacity, which are determinants of cardiovascular risk. Furthermore, children who are physically fit exhibit greater cortical activation and corresponding cognitive performance than less fit children

(Tomporowski, Davis, Miller, & Naglieri, 2008). Accordingly, in a recent review, Chang, Labban, Gapin, & Etnier (2012) showed that fitness is a significant moderator in the association between PA and cognitive performance.

Preschoolers should accumulate at least 60 minutes of structured physical activity each day (National Association for Sport and Physical Education, 2009); however, O'Dwyer et al., (2014) suggest that school accounted for an environment that promoted a sedentary lifestyle. In this regard,Barbosa, Coledam, Stabelini Neto, Elias, & de Oliveira (2016) showed that children attending preschool spend most of the day in sedentary behaviour. PA is one of the factors that have an impact on the healthy development of children, but most preschoolers tend to have a sedentary lifestyle (Dolinsky, Brouwer, Evenson, Siega-Riz, & Østbye, 2011). Several studies have shown that the PA of preschool children is moderately low (Grzywacz et al., 2014; Tucker, 2008). Additionally, opportunities to be physically active at school are limited by pressure from scholastic performance (Mahar et al., 2006); accordingly, little time for PA is incorporated into preschool classrooms (Latorre, 2007). Accordingly, the increased prevalence of obesity, physical inactivity, low physical fitness, and symptoms of metabolic and cardiovascular diseases during childhood and adolescence highlight the need to consider PA and physical fitness in the development of an International Growth Standard for Preadolescent and Adolescent Children (Malina & Katzmarzyk, 2006). Increasing the amount of time devoted to physical education can improve the physical fitness and health of preschool children. Because most PA in preschoolers is gross motor play, the term 'play' should be used to encourage movement in preschoolers (Burdette & Whitaker, 2005).

Despite the fact that a sedentary lifestyle at this age is quite common (De Bock, Genser, Raat, Fischer, & Renz-Polster, 2013), few studies have analysed the effects of PA programmes in children aged 3 to 6 years old. In addition, despite the assumption that PA during early childhood is beneficial, there is very little research to support the hypothesis that increasing the level of PA in preschoolers will significantly improve their health. However, as little as an additional 60 min/week of exercise may improve bone properties, aerobic fitness, and motor skills in some children, and so more research with larger sample sizes is required to confirm these findings. In particular, there is a need for more evidence about the nature and amount of PA that benefits psychological and cognitive outcomes (Timmons et al., 2007). Therefore, the purpose of this study was to examine the effects of a 10-week physical activity programme on physical fitness and intellectual maturity in preschool children.

Methods

Participants

A total of 111 children, aged 3 to 6 years, participated in this study; 60 children were male (age: 4.28± 0.61 years old), and 51 were female (age 4.59 ± 0.49 years old). The children were selected from five schools in southern Spain. Inclusion criteria were schooling in early childhood and being free from physical and intellectual disabilities. Parents voluntarily signed an informed consent form for the participation of their children in this study.

Participants were randomly assigned to an experimental group (EG, n = 56) and a control group (CG, n = 55). The study was completed in accordance with the norms of the Declaration of Helsinki (2013 version) and following the directives of the European Union on Good Clinical Practice (111/3976/88 of July 1990), as specified in the Spanish legal framework for human clinical research (Royal Decree 561/1993 on clinical essays). The study was approved by the Ethics Committee of the University of Jaen (Jaen, Spain).

Materials and testing

Height (cm) was measured with a stadiometer (Seca 222, Hamburg, Germany) and weight with a bascule (Seca 899, Hamburg, Germany). Body mass index (BMI) was calculated by dividing weight (in kilograms) by height^2 (in metres). The 85th and 95th percentiles of the study by Sobradillo et al. (2004) were considered in classifying children as overweight or obese, respectively, in relation to BMI. Waist circumference was measured by using a Seca Ergonomic Circumference Measuring Tape SE201 (Seca, Germany).

The fitness test battery of Latorre, Mora, Fernández, Salas, and Moriana (2015) was used in the current study, which is focused on testing basic components of physical condition and motor development, such as endurance (10x20 metres[m]), strength (standing long jump), speed (20 m), and balance (flamingo). Latorre et al. (2015) showed test–retest reliability, by intra-class correlation coefficient, between 0.774 and 0.995. In the 10x20 m and sprint test, the test score was the running time, so a longer time indicates poorer performance. In the balance test, the test score was the runtime, so a longer time indicates greater performance. In the standing long jump, the test score was the distance reached, with a greater distance indicating greater performance.

For the assessment of intellectual maturity, we used the Goodenough–Harris drawing test (GHDT), developed by Goodenough and revised by Harris (1963). The assessment focuses on details and the general body proportion of a drawn figure of a man (73 details) and a woman (71 details). The GHDT was designed to assess both children and adolescents up to 15 years of age. In the GHDT, children are asked to make three drawings: one of a man, one of a woman, and a self-portrait. Harris developed scoring systems only for the drawings of the man and woman. The GHDT, as it was used in this study, showed good reliability and validity compared to other tests of intelligence in children aged 3 to 15(Abell, von Briesen, & Watz, 1996; Plubrukarn & Theeramanoparp, 2003). We used the average crude score of the two drawings.

Procedure

After obtaining the appropriate permits in schools and informed parental consents, we applied the test battery, which was performed in the same way in the pretest and posttest. In three separate sessions, a team of previously trained researchers performed the evaluation. The drawing test, the GHDT, was assessed during the first testing session. In the second session, the horizontal jumping test and the balance test were performed. Two days later, during the third testing session, the 20 m sprint and 10x20 m tests were performed. Prior to the physical testing sessions, the children performed a typical warm-up consisting of 5 min of low-intensity running and 5 min of general exercise (i.e., skipping, leg lifts, lateral running, and front-to-behind arm rotations). The children also performed some familiarisation trials for the balance test and the horizontal jump. Each child was assessed individually. The research team conducted a demonstration. The children were motivated and encouraged to reach the best score possible in every test.

Training programme

The programme was based on the execution of play exercise or gross locomotor movement. In the programme design, we took into account the recommendations of Timmons et al., (2007). The function of aerobic games is for physical development: strength, endurance, and motor skill. Furthermore, according to evidence from older children and adults (Timmons et al., 2007), this programme may also bring cognitive benefits. The children in the EG performed three weekly training sessions (Monday, Wednesday, and Friday) in a classroom during a 10-week period. Every EG session lasted about 30 min. Participants in the EG performed exercises that consisted of aerobic games. The progression order of exercises in the EG is reported in Table 1. One teacher per school conducted the training programmes.

Table 1. Progression of aerobic games programmes

Weeks (1–10)	Field area (m x m)	Methodology (sets x min)	Duration of recovery interbouts (min)	Total AG duration (min)
1–2	20x40	5x3	1	19
3–4	20x40	4x4	1	19
5–6	20x40	3X6	2	22
7–8	20x40	3X6	2	22
9–10	20x40	2X9	3	21

Statistical Analysis

Data were analysed using SPSS v.19.0 for Windows (SPSS Inc., Chicago, USA), and the significance level was set at $p<0.05$. The data are shown in descriptive statistics for mean and standard deviation (SD). Tests of normal distribution and homogeneity (Kolmogorov–Smirnov and Levene's, respectively) were conducted on all data before analysis. Differences between groups were analysed using analysis of variance (ANOVA) on pretest, posttest, and posttest–pretest. A Pearson's correlation result between the increases (difference post-pretest training) was used. Finally, multiple linear regression analyses between crude score of intellectual maturity and physical fitness adjusted to age and sex were used.

Results

Table 2 shows the age, time watching screens, PA, and percentage of boys and girls in both the CG and EG. There were no significant differences in any variable. Differences between the CG and EG in relation to pretest, posttest, and posttest–pretest measures are shown in Table 3. There were no significant differences in any variable in the pretest between the groups. In the posttest, the EG achieved better results in horizontal jump and sprint. In relation to posttest–pretest differences, the EG showed a larger increase in horizontal jump, sprint, endurance, and intellectual maturity. A Pearson correlation between posttest–pretest measures is shown in Table 4. Importantly, a significant correlation was found between Δ intellectual maturity and Δ body height ($r=0.297$, $p<0.05$), Δbalance ($r=0.238$, $p<0.05$), and Δsprint ($r=-0.275$, $p<0.01$). Finally, Table 5 depicts multiple linear regression analyses between intellectual maturity with balance and sprint adjusted for age and sex.

Table 2. Age, time watching screens, physical activity, and percentage of boys and girls in both the CG and EG

	CG Mean (SD) n=55	EG Mean (SD) n=56	p-value
Age (years)	4.42 (0.53)	4.43 (0.62)	0.925
Time watching screens (h/day)	1.78 (0.86)	1.84 (0.81)	0.715
Physical activity (h/week)	2.17 (1.69)	2.05 (1.56)	0.720
Boys/girls (%)	58.2/41.8	50/50	0.387

Table 3. Anthropometric characteristics, physical fitness, and intellectual maturity in the pretest, posttest, and posttest–pretest in the CG and EG.

	CG Pretest Mean (SD)	EG Pretest Mean (SD)	p-value	CG Posttest Mean (SD)	EG Posttest Mean (SD)	p-value	CG Posttest–Pretest (Δ) Mean (SD)	EG Posttest–Pretest (Δ) Mean (SD)	p-value
Body mass (kg)	20.47 (3.44)	20.36 (4.26)	0.878	21.50 (3.68)	21.19 (4.22)	0.711	0.87 (1.47)	0.65 (1.44)	0.473
Body height (m)	111.47 (5.43)	111.24 (7.30)	0.873	114.63 (5.85)	115.15 (6.23)	0.692	2.47 (1.26)	3.09 (1.93)	0.124
BMI (kg/m^2)	17.02 (2.81)	16.30 (2.50)	0.206	16.36 (1.72)	15.63 (1.83)	0.060	-0.07 (0.93)	-0.13 (2.72)	0.890
Waist circumference (cm)	55.88 (4.13)	55.41 (4.90)	0.619	56.03 (5.98)	56.16 (5.14)	0.909	0.16 (3.87)	0.71 (2.90)	0.432
Balance (s)	14.07 (13.52)	14.05 (12.87)	0.995	17.20 (12.12)	14.63 (11.13)	0.253	3.23 (12.77)	1.62 (12.85)	0.524
Horizontal jump (cm)	67.01 (17.40)	64.56 (17.06)	0.457	73.15 (17.67)	80.64 (18.89)	0.034	9.42 (12.37)	17.20 (14.36)	0.004
Sprint (s)	5.95 (0.83)	6.02 (0.92)	0.697	6.09 (0.98)	5.53 (0.64)	0.001	0.24 (1.19)	-0.48 (0.76)	<0.001
Endurance (s)	74.53 (8.57)	77.05 (9.39)	0.143	70.94 (12.71)	68.65 (10.46)	0.304	-3.58 (12.01)	-8.56 (7.35)	0.010
Intellectual maturity (0–73)	12.80 (2.24)	11.91 (3.13)	0.094	15.21 (2.06)	15.56 (3.18)	0.500	2.41 (2.32)	3.65 (1.92)	0.003

SD: Standar deviation. BMI: Body mass index.

Figure 1. Drawing of a woman by a 5-year-old girl (control group). Left = pretest (intellectual maturity = 14); right = posttest (intellectual maturity = 15).

Figure 2. Drawing of a woman by a 5-year-old girl (experimental group). Left = pretest (intellectual maturity = 14); right = posttest (intellectual maturity = 18).

Table 3. Pearson correlation between posttest–pretest measures

	A	B	C	D	E	F	G	H	I
Δ body mass (A)	1	0.565**	0.382**	0.320**	0.307**	-0.027	-0.166	0.150	0.038
Δ body height (B)		1	0.123	0.152	0.201	0.135	-0.202	-0.054	0.297*
Δ BMI (C)			1	0.144	0.164	0.009	-0.018	0.040	-0.100
Δ waist circumference (D)				1	0.206	0.059	-0.149	0.165	0.011
Δ balance (E)					1	0.064	-0.041	0.010	0.238*
Δ horizontal jump (F)						1	-0.157	0.196*	-0.081
Δ sprint (G)							1	-0.030	-0.275**
Δ endurance (H)								1	-0.104
Δ intellectual maturity (I)									1

*p<0.05, **p<0.01. BMI. Body mass index.

Table 4. Multiple linear regression analyses between intellectual maturity, balance and sprint adjusted for age and sex

	B	t	p-value	95% confidence interval to B	
				Lower limit	Higher limit
Constant	2.687	9.620	<0.001	2.128	3.247
Δ balance	0.056	2.925	0.005	0.018	0.095
Δ sprint	-0.447	-2.133	0.037	-0.866	-0.027
R^2	0.200				

Discussion

The purpose of this study was to examine the effects of a 10-week physical activity programme on physical fitness and intellectual maturity in preschool children. The main finding of this study was that this intervention caused higher improvements in physical fitness and intellectual maturity in the EG in relation to the CG. These data indicate that preschool children exhibit considerable trainability. Furthermore, in this study correlations were found between intellectual maturity and body height, balance, and sprint. Concurrently, balance and sprint are predictors of intellectual maturity. Previous studies on PA interventions in preschools have reported limited effectiveness(De Bock et al., 2013). However, Trost (2011) showed that training teachers to incorporate movement into the standard classroom curriculum appears to be effective in increasing PA levels during the preschool day. In this regard, Eliakim, Nemet, Balakirski, & Epstein (2007) showed that a 14-week combined dietary–behavioural–PA in a school-based intervention improved the endurance time in preschoolers. In another study, a multidimensional intervention based on PA programme lessons, nutrition, media use, and sleep and adaptation to the built environment of the preschool class increased aerobic fitness in preschool children (Puder et al., 2011). In this study, the aerobic fitness improvement was 11%, a result similar to the study of Puder et al., (2011). As noted by Ortega, Ruiz, Castillo, & Sjöström (2008), fitness level is a potent biomarker of health from an early age; therefore, improvements of physical fitness through aerobic games could have an impact on the health and suitable growth of preschool children.

This intervention caused no changes in BMI. In this regard, Metcalf, Henley, & Wilkin (2012) noted that PA interventions have little effect on the prevention of childhood obesity. Moreover, Reilly et al., (2006) showed that a PA programme in a nursery (three 30-min sessions a week over 24 weeks) did not reduce BMI in preschoolers. Along the same lines, Latorre et al., (2016) argued that the relationship between physical fitness and BMI is inconsistent in preschool children. Conversely, overweight children (ages 43 to 84 months) show lower performance in gross motor skills in relation to healthy-weight children

(Krombholz, 2013). In addition, Eliakim et al., (2007) showed a reduction in BMI after an intervention of 14 weeks combined with dietary–behavioural–PA. However, Puder et al. (2011) showed that a multidimensional intervention reduced body fat but not BMI. Therefore, the presence of conflicting results regarding the relationship between weight status and PA in preschool children requires further studies to address this issue. Other intervention programmes with different parameters of intensity, frequency, and duration of sessions should check the effect of PA programmes on overweight and obesity.

In relation to intellectual maturity, Latorre et al., (2016) showed that from an early age, physical fitness and intellectual maturity are linked; accordingly, fitness status is able to predict intellectual maturity. Our findings add to this research. In this study, balance and sprint are linked to intellectual maturity. Wassenberg et al., (2005) showed the parallel development of specific cognitive and motor performance in children during normal or delayed development: specific brain structures, such as the basal ganglia and frontal cortex, and dopamine transmission are mutual to both cognitive and motor performance. Increasing the amount of time devoted to physical education can promote health and cognitive benefits in preschool children (Latorre et al., 2016).

Opportunities to be physically active in school are limited because of pressure to perform well scholastically (Mahar et al., 2006). Therefore, the academic achievement, physical fitness, and health of children will not be improved by limiting the time allocated to physical exercise and PA (Trudeau & Shephard, 2008). In this regard, more time allocated to structured PA, including play at moderate to high intensity, seems needed for preschool children (Cardon, Labarque, Smits, & Bourdeaudhuij, 2009). Summerbell et al., (2012)recommend promoting non-competitive PA in school, offering games during school breaks, encouraging children to be active, and reducing overall classroom sedentary time. Improvement of the motor proficiency of preschool children has the potential to influence PA beyond the preschool years (Lopes, Rodrigues, Maia, & Malina, 2011). Therefore, aerobic games programmes as performed in this study are important for promoting PA in preschoolers.

A limitation of this study is that we could not record the intensity of the sessions. In conclusion, a physical activity programme in the school setting improved physical fitness and intellectual maturity in preschool children. In addition, physical fitness and intellectual maturity are linked in this age period.

Key messages

- A physical activity programme in the school setting improved physical fitness and intellectual maturity in preschool children.
- In preschoolers, there is a parallel development of physical condition and intellectual maturity.

- Promoting physical activity in preschool children is of considerable importance from a health perspective.
- The involvement of those working in health care, education, and politics is important to promoting physical activity in preschoolers.

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