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DEPARTAMENTO DE DIDÁCTICA DE LA EXPRESIÓN MUSICAL, PLÁSTICA Y CORPORAL

TESIS DOCTORAL

"FUNCIONES EJECUTIVAS Y CALIDAD DE VIDA RELACIONADAS AL ESTILO DE VIDA EN ESCOLARES CHILENOS"

PRESENTADA POR:

FELIPE CAAMAÑO NAVARRETE

DIRIGIDA POR:

DR. JUAN PÁRRAGA MONTILLA

DR. PEDRO ÁNGEL LATORRE ROMÁN

DR. PEDRO DELGADO FLOODY

JAÉN, 15 DE NOVIEMBRE DE 2021.

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Prof. Dr. Juan Párraga Montilla.
Profesor Titular de la Universidad.
Dpto. Didáctica de la Expresión Musical, Plástica y Corporal.

JUAN PÁRRAGA MONTILLA, PROFESOR TITULAR DE LA UNIVERSIDAD DE JAÉN.

CERTIFICA:

Que la Tesis Doctoral titulada "Funciones Ejecutivas y Calidad de Vida Relacionadas al Estilo de Vida en Escolares Chilenos" que presenta D. FELIPE CAAMAÑO NAVARRETE al superior juicio del Tribunal que designe la Universidad de Jaén, ha sido realizada bajo mi dirección durante los años 2018-2021, siendo expresión de la capacidad técnica e interpretativa de su autor en condiciones tan aventajadas que le hacen merecedora del Título de Doctor, siempre y cuando así lo considere el citado Tribunal.

En Jaén, 15 de noviembre de 2021.

Fdo. Juan Párraga Montilla.

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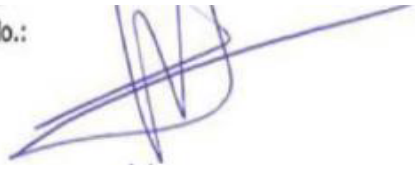
Fdo.:



Fdo. Pedro Ángel Latorre Román.

Prof. Dr. Pedro Delgado Floody.
Profesor Contratado Doctor.
Dpto. Educación Física, Deportes y Recreación.

PEDRO DELGADO FLOODY, PROFESOR CONTRATADO DOCTOR DE LA UNIVERSIDAD DE LA FRONTERA, CHILE.

CERTIFICA:

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En Jaén, 15 de noviembre de 2021

Fdo.: 

Fdo. Pedro Delgado Floody.

1.- LISTA DE PUBLICACIONES

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

I. Delgado-Floody, P., Carter-Thuillier, B., Guzmán-Guzmán, I. P., Latorre-Román, P., & Caamaño-Navarrete, F. (2020). Low indicators of personal and social development in Chilean schools are associated with unimproved academic performance: A national study. *International Journal of Educational Research*, 104, 101651.

II. Caamaño-Navarrete, F., Latorre-Román, P. Á., Párraga-Montilla, J. A., Álvarez, C., & Delgado-Floody, P. (2021). Association between Creativity and Memory with Cardiorespiratory Fitness and Lifestyle among Chilean Schoolchildren. *Nutrients*, 13(6), 1799.

III. Caamaño-Navarrete, F., Latorre-Román, P. Á., Párraga-Montilla, J. A., Jérez, D., & Delgado-Floody, P. (2021). Selective attention and concentration related to lifestyle in Chilean schoolchildren. *Children*, 8(10), 856.

IV. Caamaño-Navarrete, F., Latorre-Román, P., Guzmán-Guzmán, I. P., Párraga Montilla, J., Jerez-Mayorga, D., & Delgado-Floody, P. (2021). Lifestyle mediates the relationship between self-esteem and health-related quality of life in Chilean schoolchildren. Psychology, Health & Medicine, 1-11.

V. Caamaño-Navarrete, F., Guzmán-Guzmán, I. P., Palomino-Devia, C., Reyes-Oyola, F. A., Bustos-Barahona, R., Jerez-Mayorga, D., & Delgado-Floody, P. (2021). The association between modifiable lifestyle behaviour in Latin-American schoolchildren with abdominal obesity and excess weight. A comparison of Chile and Colombia. Endocrinología, Diabetes y Nutrición.

2.- RESUMEN

Las funciones ejecutivas se usan a diario y desempeñan un papel crucial en los procesos de aprendizaje. Además, se ha estudiado la hipótesis de que el funcionamiento cognitivo puede beneficiarse por un estilo de vida saludable (niveles de actividad física [AF], disminución de la conducta sedente y buenos hábitos alimentarios) y ciertas variables de la condición física (CF) a través de la plasticidad neuronal, por procesos neuro-adaptativos y neuro-protectores, lo que genera un creciente interés de estudio en el contexto escolar. Por otro lado, la calidad de vida relacionada a la salud (CVRS) es un término referido a una medida de felicidad y satisfacción con la vida; que incluye el bienestar psicológico, físico y social. De manera contemporánea, el estilo de vida no sólo se relaciona con el riesgo cardiometabólico, sino que que se establece como una interesante línea de investigación para establecer su relación con las funciones ejecutivas (FE) y también con la CVRS.

Los períodos de niñez y adolescencia, son claves en la adquisición de un estilo de vida saludable (por ejemplo, mayores niveles de AF, menor tiempo de pantalla [TP] y hábitos alimentarios saludables). Un estilo de vida saludable es clave para disminuir la incidencia y prevalencia de padecer enfermedades. El estilo de vida de los escolares ha sido predominantemente estudiado en el contexto de la salud, no obstante, existen argumentos suficientes, para establecer que también interviene en los procesos cognitivos y en el aprendizaje de niños y adolescentes. Además y como resultado de la vida contemporánea, el estilo de vida, caracterizado por una mala alimentación y un descenso en los niveles de AF, pueden afectar el bienestar subjetivo de niños y jóvenes. Asímismo, programas de intervención basados en AF, podrían ser una estrategia costo-efectiva para influir positivamente sobre las habilidades cognitivas, el bienestar subjetivo, además de disminuir la conducta sedente y mejorar los componentes de la CF en el contexto escolar.

El propósito principal de la investigación fue determinar la asociación entre el estilo de vida (niveles de actividad física, disminución del tiempo de pantalla y buenos hábitos alimentarios), medidas antropométricas y la condición física con las funciones ejecutivas y la calidad de vida relacionada a la salud en escolares chilenos.

Para cumplir con el objetivo general se requirieron una serie de estudios que fueron publicados en diferentes revistas especializadas y que tienen por título:

I. Low indicators of personal and social development in Chilean schools are associated with unimproved academic performance: A national study.
II. Association between Creativity and Memory with Cardiorespiratory Fitness and Lifestyle among Chilean Schoolchildren.
III. Selective attention and concentration related to lifestyle in Chilean schoolchildren.
IV. Lifestyle mediates the relationship between self-esteem and health-related quality of life in Chilean schoolchildren.
V. The association between modifiable lifestyle behaviour in Latin-American schoolchildren with abdominal obesity and excess weight. A comparison of Chile and Colombia.

Los principales resultados obtenidos en las investigaciones y que se presentan en la memoria de Tesis Doctoral son los siguientes:

I. Un estilo de vida saludable (desarrollo de AF y buenos hábitos alimentarios) se relacionó positivamente con el rendimiento académico en un estudio de carácter nacional en Chile.
II. Bajos niveles en el Fitness Cardiorrespiratorio (CRF) se asoció negativamente con algunas FE (creatividad y memoria) en escolares.
III. Bajos niveles de TP y la adherencia a la dieta mediterránea (DM) se asociaron positivamente con las FE (concentración y atención selectiva) en escolares.
IV. Un estilo de vida saludable (bajos niveles de tiempo de TP y buenos hábitos alimentarios) se asoció con una mejor CVRS en escolares.

V. La obesidad abdominal (OA) y el exceso de peso se asociaron con un mal estilo de vida (menor adherencia a la DM y AF, mayor TP y bajo rendimiento en el CRF) en escolares.

Estos resultados ponen de manifiesto la importancia de un estilo de vida saludable en la población escolar, dada su positiva relación con las FE y con la CVRS.

3.- ABREVIATURAS

Español

CC: Circunferencia de cintura.

CF: Condición física.

CRF: Fitness cardiorrespiratorio.

DM: Dieta mediterránea.

EF: Educación física.

FE: Funciones ejecutivas.

FM: Fuerza muscular.

IMC: Índice de masa corporal.

MG: Masa grasa.

RCE: Razón cintura estatura.

RCM: Riesgo cardiometabólico.

VO2max: Consumo máximo de oxígeno.

CVRS: Calidad de vida relacionada a la salud.

OMS: Organización mundial de la salud.

SIMCE: Sistema de medición de la calidad de la educación.

Inglés

BDNF: Brain-derived neurotrophic factor

BMI: Body mass index.

WC: Waist circumference.

MD: Mediterranean diet.

EF: Executive function.

PA: Physical activity.

PE: Physical education.

VO2max: maximal oxygen uptake.

CRF: Cardiorespiratory fitness.

ST: Screen time.

HRQoL: Health related quality of life.

4.- INTRODUCCIÓN

4.1 Funciones Ejecutivas

La calidad de la educación y el rendimiento académico en los estudiantes, representan un foco trascendental en la política educacional de los distintos países [1]. Las diferencias en el rendimiento académico de los estudiantes, han recibido una considerable atención por parte de profesores e investigadores, así como de las políticas educativas [2]. La literatura ha demostrado que diversos factores biopsicosociales y externos influyen en el rendimiento académico [3], cómo el nivel socioeconómico [4], las FE [5] y el bienestar subjetivo [6] por nombrar algunos.

De manera contemporánea, la relación entre la AF con las FE y la CVRS es un área de creciente interés para la disminución de las barreras sociales de los aprendizajes. En esta línea, la cognición es un término que refleja una serie de proceso mentales subyacentes [7] y a través del cual, el ser humano conoce y aprende por medio del uso de sus facultades mentales [8]. Dado lo anterior, se ha indicado que las FE se usan a diario y desempeñan un papel crucial en los procesos de aprendizaje [9] y presentan una importante relación con un estilo de vida saludable.

Desde un punto de vista de conceptualización, las FE son procesos metacognitivos necesarios para realizar operaciones complejas y tareas orientadas a la consecución de objetivos [10]. Asimismo, se ha propuesto que son fundamentales para planificar ideas, mantenerse enfocado y poner atención en una tarea determinada [11].

Diamond (2013) [11] propone tres núcleos relacionados a las FE:

- Inhibición y control de interferencia.
- Trabajo de memoria.
- Flexibilidad cognitiva.

Asimismo, un estudio de revisión reportó que las FE tienen relación con distintos aspectos relacionados a la vida diaria como se detalla en la tabla 1 [11]:

Aspecto de la vida	Relevancia de las funciones ejecutivas
Salud mental	Las FE alteradas se relacionan con desordenes de conducta, depresión y otros problemas de salud mental.
Salud física	Pobres niveles de FE se han asociado con obesidad.
Calidad de vida	Se ha reportado que mejores niveles se asocian con una mejor calidad de vida.
Preparación para la escuela	Son importantes para el desarrollo intelectual y se han relacionado con mejores niveles de entrada en lenguaje y matemáticas.
Desempeño en la escuela	Se consideran predictoras para el desarrollo de las competencias de lectura y matemáticas a través de los años de escuela.
Desempeño en el trabajo	Un pobre desempeño en las FE afecta la productividad en el trabajo.

Tabla 1. Elaboración propia. Extraído y adaptado de Diamond A: Executive functions. Annual review of psychology 2013, 64:135-168.

También, las FE juegan un rol fundamental en el aprendizaje de los escolares [12], así como en el desarrollo de habilidades necesarias para el logro académico [13]. Acorde con lo anterior, Mulder y Cols [14] indicaron que las FE podrían ser predictores de habilidades académicas en distintas edades del período escolar. Asimismo, este estudio longitudinal realizado con una muestra de 552 escolares holandeses, reportó que las FE fueron un predictor estadísticamente significativo en el rendimiento alcanzado en matemáticas y lenguaje, por lo tanto, es importante seguir generando estudios para dilucidar los mecanismos asociados al desarrollo de las FE.

Adicionalmente, se ha establecido que las FE son un área de creciente interés, debido a que tanto investigadores como educadores subrayan la importancia de poseer habilidades de planificación, organización y flexibilidad cognitiva para el éxito académico, por ende, las FE deben ser correctamente estimuladas, debido al papel central que juegan en el contexto escolar [15].

Acorde a lo anterior, algunas investigaciones indican la importancia de diferentes FE en el rendimiento académico. Un estudio longitudinal realizado con 1,273 escolares y con un seguimiento de 54 meses, demostró que después de controlar las variables demográficas y del entorno escolar, el trabajo de memoria fue un predictor significativo del rendimiento académico [16]. Otra investigación realizada en una muestra representativa nacional de estudiantes americanos y usando un sistema de evaluación cognitiva, demostró que la metacognición parece ayudar al desarrollo de las FE, además existió una relación positiva entre las FE y el rendimiento académico con diferencias según las edades [17]. Asimismo, se ha reportado que las FE en conjunto con las habilidades motoras básicas, parecen desempeñar un papel destacado en el aprendizaje temprano y en el rendimiento académico a largo plazo [18]. También es importante destacar que la literatura indica que la regulación de las FE, también se relacionan no sólo con aspectos académicos (dado su aporte en los procesos de razonamiento, comprensión lectora y logro de aprendizajes de índole más complejo), sino que también con elementos de la vida cotidiana y diaria [19].

Cabe destacar que estudios previos han reportado que algunos componentes cognitivos relacionados a las FE se han asociado al rendimiento académico, incluyendo la creatividad y la memoria [13]. La creatividad ha demostrado una asociación positiva con el rendimiento académico [20], y es considerada como una actividad humana imprescindible [21,] por lo tanto, varías políticas educativas van orientadas con el propósito de promover e impactar su desarrollo [22]. La creatividad está relacionada con la capacidad de generar un nuevo producto original y con un valor en el sentido más amplio, así como al desarrollo de un

pensamiento divergente para lograr nuevas ideas y soluciones en un mismo problema [23, 24].

En este contexto, otra variable cognitiva importante es la memoria [25]. También, se ha demostrado previamente una asociación entre la memoria y las habilidades académicas [13,] por lo que es una variable esencial para poder satisfacer de buena manera las demandas que establece el contexto escolar [26].

Por otro lado, la atención selectiva ha sido considerada como un elemento esencial para los procesos de aprendizaje y comprensión [27]. La atención selectiva permite procesar diferentes estímulos suprimiendo la atención en otros aspectos que puedan ser distractores [11, 28]. Asimismo, una mejor concentración ha sido relacionada con mejorar el rendimiento académico en escolares [29]. En concordancia a los estudios previamente citados, otra investigación reportó que tanto la atención como la concentración pueden jugar un rol preponderante en el rendimiento académico en escolares [30].

Es importante resaltar que la niñez y la adolescencia son períodos críticos para el desarrollo de las FE [31]. Las FE dependen del sistema nervioso central e incluyen funciones como la memoria, atención, concentración [32] y la creatividad [33]. La maduración del cerebro humano y el desarrollo de las FE durante la adolescencia están mediados de manera trascendental por el córtex pre-frontal, siendo la última región cerebral en madurar [34]. Asimismo, se ha reportado que las edades tempranas son períodos críticos para el desarrollo de la neuro-plasticidad sináptica del córtex pre-frontal [35]. Adicionalmente, las FE gobernadas por el córtex pre-frontal, exhiben un período prolongado de maduración en la adolescencia tardía, asimismo otros factores como los cambios en el volumen, han sido relacionados con una mejora en la función cognitiva [34]. Dado lo anterior, las etapas escolares son críticas para una correcta estimulación del desarrollo de las FE.

4.2 Calidad de Vida relacionada a la Salud

Actualmente, existe una clara motivación por estudiar el bienestar subjetivo de las personas, debido a su relación con algunas medidas de felicidad y de satisfacción

con la vida [36]. La salud pública considera el bienestar psicológico como un pilar fundamental para las personas [37]. En concordancia a lo anterior, la literatura científica ha destacado de manera explícita, la importancia de la salud mental en el ser humano [38], asimismo, la niñez y la adolescencia son períodos críticos para el desarrollo del bienestar psicológico [39], por lo tanto, establecer buenos niveles en edades tempranas, es crítico debido a las implicaciones que tendrá en el bienestar mental de la adultez [40].

También, se ha reportado que altos niveles de bienestar psicológico, se relacionaron con un amplio rango de medidas positivas para la vida y el funcionamiento diario de las personas [41]. Además, es importante destacar que distintos componentes del bienestar subjetivo como la calidad de vida, juegan un rol preponderante en la vida de las personas [42].

En este contexto, la CVRS, es un constructo que posee una mirada multidimensional, que incluye componentes claves del bienestar psicológico y el funcionamiento diario a nivel físico, emocional, mental y conductual [43]. Asimismo, la CVRS es un término relacionado a una medida de felicidad y satisfacción con la vida [44], y su mirada multidimensional y el énfasis en el funcionamiento diario de la calidad de vida, la convierte en una medida interesante para estudiar su relación con la salud y el rendimiento escolar [45]. Por lo tanto, la medición de la CVRS debiese ser preponderante a nivel sanitario para llevar un seguimiento adecuado de la salud de los jóvenes [46]. En esta línea, un estudio realizado en jóvenes reportó que la CVRS puede ser influenciada por distintos factores socioeconómicos, demográficos y educativos, además un análisis multivariado reportó que otras variables como la relación con los padres y el ingreso familiar por empleo se asociaron significativamente con el puntaje total de la CVRS [47].

Asimismo, la literatura ha planteado que la CVRS puede ser usada como una herramienta importante para medir el bienestar de los escolares, así como una forma de poder desarrollar métodos efectivos para promover aspectos relacionados a la salud en la escuela [48]. En este contexto, una investigación

realizada en escolares chilenos, indicó que se debe incluir la medición de la CVRS en la escuela, para tener una mejor comprensión de los indicadores de salud, así como también para predecir el bienestar subjetivo en el entorno escolar [49].

Por otro lado, la literatura ha reportado que otra medida importante en el bienestar subjetivo es la autoestima, debido a que juega un papel preponderante en la salud mental, y se ha establecido una relación positiva de la autoestima con factores emocionales, sociales, conductuales y de salud mental, especialmente durante la niñez y la adolescencia. De manera interesante, se ha determinado que altos niveles de autoestima se han asociado con un mejor desarrollo cognitivo [50] y con una mejor CVRS [51].

Por otro lado, se ha indicado que la autoestima podría predecir los niveles de CVRS en escolares [52]. Otro estudio realizado con 3,195 niños y adolescentes portugueses, reportó que las medidas psicológicas impactaron a la CVRS, asimismo los autores indicaron que es fundamental promover la salud física, mental y social para impactar en el bienestar subjetivo de los participantes [53]. Además, se ha propuesto un modelo que sugiere que la autoestima predice positivamente algunas medidas contenidas en la CVRS [54]. Dado el cúmulo de evidencia existente y en términos de salud pública, es clave establecer evaluaciones permanentes de la CVRS en niños y adolescentes, así como su promoción a través de intervenciones en el contexto escolar [53]. Actualmente existe evidencia acerca de como un estilo de vida saludable (cumplir con las recomendaciones de AF) se relaciona con mejores niveles de CVRS en niños y adolescentes [55].

4.3 Importancia de un estilo de vida saludable en las funciones ejecutivas y la calidad de vida relacionada a la salud

Los períodos de niñez y adolescencia son claves en la adquisición de un estilo de vida saludable (por ejemplo, niveles AF, disminuir el TP y hábitos alimentarios saludables) [56]. De acuerdo a lo indicado por Xiao y Cols, un estilo de vida es un

patron colectivo y organizado de conductas amplias e interrelacionadas que se desarrollan de acuerdo a la vida y a los antecedentes culturales [57]. Asimismo, un estilo de vida saludable, se relacionan con factores claves para la salud (desarrollo de AF, disminución del TP y hábitos alimentarios, entre otros) y que repercuten en disminuir la incidencia y prevalencia de padecer enfermedades [58]. Otra definición complementaria plantea que; son todos los comportamientos que las personas creen y aplican para estar saludables, mantener la salud y estar protegidos de las enfermedades [59]. En este sentido, una revisión sistemática con metaanálisis reportó que tener un estilo de de vida saludable se asoció con un menor riesgo de mortalidad, disminuyendo en un 66 % la reducción de muerte por todas las causas [60]. Actualmente, las investigaciones han buscado ampliar la mirada sobre la influencia de un estilo de vida saludable y en este sentido, se ha reportado que no sólo tienen una asociación positiva con parámetros de salud, sino que se relacionan con otras dimensiones trascendentales como el rendimiento académico [61] y las FE [62].

Acorde a lo anterior, una investigación indicó que el estilo de vida de los escolares, ha sido predominantemente estudiado en el contexto de la salud, no obstante, existen argumentos suficientes para establecer que también intervienen en los procesos cognitivos y en el aprendizaje de niños y adolescentes [63]. Por lo tanto, un estilo de vida saludable (buenos niveles de AF, bajo TP y hábitos alimentarios saludables) juega un papel clave en los procesos cognitivos hasta la edad adulta [64].

Por otro lado, se ha resaltado que la etapa escolar es clave en establecer comportamientos saludables, por lo que existe una clara mirada hacia la promoción y prevención [65]. Asimismo, existe una contundente evidencia durante las últimas décadas que establece una relación entre un estilo de vida no saludable durante la niñez y la adolescencia, con enfermedad cardiovascular en la adultez, por lo tanto, es preponderante promover intervenciones en el estilo de vida, así como concientizar acerca de las implicancias individuales y colectivas para la población, desde los distintos niveles de la política pública [66]. Además, la

escuela y el contexto educativo son claves en la promoción de un estilo de vida saludable [67].

Como resultado de la vida contemporánea, un estilo de vida caracterizado por una mala alimentación y un descenso en los patrones de AF, pueden afectar el bienestar subjetivo de niños y jóvenes [68]. En adición, se ha reportado que cambios en el estilo de vida como disminuir los niveles de AF e incrementar la conducta sedente como el tiempo frente a pantallas en jóvenes, podría tener consecuencias negativas en distintos parámetros de la salud mental [69, 70] y en la CVRS [71]. En esta línea, otra investigación indicó que un buen estilo de vida se relacionó positivamente con una mejor CVRS en estudiantes turcos independiente de los factores sociodemográficos [72]. Otra investigación destaca la importancia del desarrollo de AF y hábitos alimentarios como componentes claves para mejorar la CVRS en jóvenes [73]. Otro interesante estudio realizado en participantes en edad escolar, demostró que un estilo de vida saludable (compuesto por la realización de AF, alimentación saludable, tener menos de dos horas frente a pantalla y cumplir con las recomendaciones de sueño) se relacionó significativamente con una mejor salud auto-percibida y una mejor CVRS, por lo tanto, la política pública y educativa debiese poner un importante foco en comportamientos que son modificables [71]. Asimismo, la evidencia científica destaca la importancia de propender a estimular el desarrollo de un estilo de vida saludable en el contexto escolar, en este sentido una revisión sistemática resaltó la importancia de tener un estilo de vida saludable debido a los beneficios que entrega a nivel mental y para el bienestar subjetivo [74]. Por ende, es importante seguir investigando en la relación de comportamientos de estilo de vida modificables y diferentes variables de importancia en el contexto escolar como son las FE y la CVRS.

4.4 Patrones de Actividad física

La escuela proporciona un contexto importante para la participación en programas de AF regulares y estructurados [75] y la educación moderna propone que las experiencias de los escolares en el deporte y la educación física (EF) contribuyan

al desarrollo de la agudeza mental, además de internalizar habilidades y estrategias que son importantes para los desafíos que se enfrentarán a lo largo de toda la vida [76]. A pesar de lo anterior, la participación en programas de EF disminuye a medida que avanzan los grados, lo que se explica por el incorrecto esfuerzo del contexto escolar por mejorar los resultados de los estudiantes en test nacionales estandarizados, a través del reemplazo de la realización de AF por otras clases [77], disminuyendo así, los niveles de AF de la población escolar.

La AF proporciona numerosos beneficios saludables, no obstante, sólo un grupo menor de escolares cumple con las recomendaciones internacionales, denotando una disminución en los niveles de AF y un aumento de la conducta sedentaria [78]. Para escolares de entre 5 y 17 años, la Organización Mundial de la Salud (OMS), recomienda realizar AF moderada a vigorosa por 60 minutos diarios [79], sin embargo, estudios demuestran que en Europa, la práctica es insuficiente especialmente en las niñas [80]. Un estudio realizado en escolares de distintos países, reportó que sólo el 44 % de la muestra cumplía con las recomendaciones de AF [81]. En Chile, existen pocos estudios que establezcan el nivel de AF de la población escolar y que cuantifiquen si se cumplen con las recomendaciones internacionales para población menor de 18 años. Un estudio que utilizó acelerometría en una muestra de niños y adolescentes, reportó que dos tercios de los participantes superaban las dos horas diarias frente a la pantalla, siendo mayor en los sujetos con sobrepeso y obesidad en comparación con los normo-peso, por lo que se deben generar cambios efectivos en la conducta a través de programas de intervención [82]. En esta línea, un estudio reportó que sólo el 34 % de los escolares cumplían con las recomendaciones de AF [83]. También se ha indicado que para mejorar la participación y niveles de AF, la mirada debiese estar puesta en ampliar el foco y gama de posibilidades de AF, para que aumente la participación en edades tempranas, ejemplo de lo anterior es promover distintos tipos de AF como el desplazamiento activo en la escuela, la participación en equipos deportivos y el deporte organizado, junto con utilizar el juego y aumentar la participación en deportes después del horario escolar [84].

Asimismo, los beneficios de la AF en la niñez y adolescencia han sido bien establecidos [85]. La AF destaca por su papel positivo a nivel cardiometabólico, físico, mental y social [86]. También se ha establecido que jóvenes con altos niveles de AF, son menos propensos a desarrollar factores de riesgo cardiovascular, promoviendo las habilidades cognitivas, la salud mental y la auto-confianza [87]. Por otro lado y en contraparte a lo anterior, un estilo de vida no saludable como la conducta sedente, se asocian con un mayor riesgo de enfermedad cardiometabólica [88] y una peor salud mental [89].

La investigación de los procesos cognitivos en el área de la AF se ha incrementado en el último tiempo, debido a que se ha reportado evidencia a favor acerca de que un estilo de vida saludable se ha asociado positivamente con las FE en escolares. Asimismo, se ha establecido que el estudio de la AF en conjunto con las FE se encuentra en una etapa de incipiente desarrollo [90]. En este sentido, se ha reportado que tener una vida físicamente activa puede contribuir a tener mejores resultados en los procesos cognitivos [91].

En adición, un interesante estudio demostró que incrementar los niveles de AF en la escuela, puede impactar positivamente en mejorar las FE de los escolares [92]. Un estudio de intervención de AF, indicó que tanto el ejercicio agudo como el crónico promovieron positivamente las FE, asimismo, la AF aeróbica pudiese ser una buena herramienta costo-efectiva para impactar positivamente los procesos cognitivos en escolares [93]. Por otro lado, un estudio realizado en escolares noruegos pertenecientes a 57 escuelas, concluyó que la AF integral destinada a mejorar los niveles del CRF, en conjunto con las habilidades motoras, podría tener el potencial de beneficiar las FE y el rendimiento académico [94]. Asimismo, Vazou y Cols indicaron que un nuevo enfoque enmarcado en realizar AF dentro de las aulas también pudiese ser una herramienta positiva para mejorar los niveles de AF y el rendimiento académico en el contexto escolar [95]. También, otro estudio que comparó el rendimiento en algunas FE por nivel de AF, encontró que los estudiantes con niveles de AF más altos, obtuvieron un mejor resultado en las

pruebas cognitivas al compararlos con sus contrapartes que presentaron menores niveles de AF [96].

Además, otro estudio longitudinal reportó que los niveles de AF (medidos a los 9 años) impactarón las FE a la edad de 15 años en participantes escolares [97]. En adición, un reciente estudio llevado a cabo en 4,304 estudiantes, demostró que un estilo de vida saludable (altos de niveles de AF y bajo TP) se relacionó positivamente con tener un mejor desarrollo en las FE, por lo tanto, es importante realizar estrategias e intervenciones para promover altos niveles de AF en la escuela [98].

La literatura científica ha demostrado que manipular los niveles de AF, puede influir positivamente en el rendimiento académico [99], estableciendo una relación positiva con la función cognitiva [27]. Además, se ha estudiado la hipótesis de que el funcionamiento cognitivo puede beneficiarse por la AF a través de la plasticidad neuronal, por procesos neuro-adaptativos y neuro- protectores [100]. Un reciente metaanálisis reportó que la AF tiene efectos positivos sobre las FE, la atención y el rendimiento académico [101]. También, los niveles de AF están relacionados con las FE que son fundamentales para el rendimiento académico [102]. Además, una sesión de ejercicio aguda, puede ser una estrategia exitosa en estimular la atención de escolares de 6 a 12 años, sin embargo, programas regulares de intervención a través de AF, son estrategias más efectivas para mejorar FE y el rendimiento académico en población escolar [101].

Por otro lado, también existe una interesante arista referida a los patrones de AF y su relación con el bienestar subjetivo y la CVRS en el contexto escolar [103]. En esta línea, una investigación previa reportó que la AF estuvo relacionada con diferentes componentes positivos del bienestar y la CVRS en adolescentes [103]. Además, un metaanálisis indicó la importancia de la AF en el contexto del bienestar subjetivo [104]. Otro estudio realizado en escolares, demostró que los participantes que tenían mayor frecuencia de AF semanal, obtuvieron mejores niveles de bienestar subjetivo en comparación a aquellos escolares que reportaron menores niveles de AF [105]. Asimismo, otro estudio realizado en participantes en

la etapa escolar, demostró que la AF se asoció positivamente con el funcionamiento físico y mental de la CVRS [68].

Acorde a lo anterior, la evidencia ha señalado que incrementar los niveles de AF auto-reportada predijo todas las dimensiones de la CVRS en participantes escolares chinos, asimismo los autores destacan la importancia de promover en la escuela la AF, dada su relación positiva con la CVRS [106]. En este sentido, una investigación realizada en estudiantes australianos, demostró que la AF medida de manera objetiva a través de acelerometría, se relacionó positivamente con la CVRS en ambos sexos [107]. Una revisión sistemática con metaanálisis reportó evidencia de la relación positiva y beneficiosa de la AF con la CVRS, sin embargo, los autores indicaron la necesidad de seguir investigando para establecer el tipo de ejercicio, frecuencia, volumen, e intensidad necesarios para impactar en los niveles de CVRS en niños y adolescentes [108]. Asimismo, un reciente estudio realizado en estudiantes españoles indicó que en los hombres, los niveles de AF de intensidad moderada a vigorosa, se asociaron con una mejor CVRS [109]. Además, la evidencia científica señala que es fundamental generar estrategias de promoción de los patrones de AF para impactar positivamente en los componentes de la CVRS [110] y el bienestar subjetivo [111], especialmente en el contexto escolar.

4.5 Tiempo de Pantalla

Actualmente, dentro de un estilo de vida saludable, el TP está recibiendo una considerable atención por su influencia en los procesos cognitivos [112]. Asimismo, se ha demostrado que el TP tiene efectos negativos en distintos parámetros, en esta línea, diversas investigaciones señalan que la conducta sedente como el TP disminuye los niveles de AF [113], además de incrementar efectos adversos en aspectos físicos, psicológicos, sociales [114] y en los patrones de sueño [115].

En relación al TP y los procesos cognitivos en escolares, un reciente estudio reportó que tener menores niveles de TP se relacionó positivamente con un mejor

rendimiento en las funciones cognitivas [98]. Otro estudio realizado en adolescentes escolares, demostró que un mejor rendimiento en matemáticas, estuvo asociado a un menor tiempo de uso de computador y de uso de internet [116]. Además, un estudio previo indicó que niveles excesivos de TP pudiesen tener consecuencias negativas en la función cognitiva y en otras áreas asociadas a la salud [117]. Otro estudio realizado en niños escolares, demostró que aquellos participantes que nunca usaron tablet obtuvieron resultados significativamente mejores en pruebas cognitivas que sus pares con altos niveles de TP [118]. Walsh y Cols, en un estudio realizado con 11,875 estudiantes americanos, encontraron que altos niveles de TP se relacionaron de manera negativa con la cognición, asimismo aquellos estudiantes con un TP bajo, tuvieron un mejor desempeño en las mediciones de las pruebas cognitivas al compararlos con los participantes que tuvieron mayor cantidad de horas frente a pantallas [119].

Otro interesante estudio reportó que los niños que cumplían con realizar 60 minutos de AF, además de pasar menos de 2 horas frente a pantalla y cumplir con las recomendaciones de sueño, se asoció positivamente con una mejor cognición, por lo tanto, los autores indicaron que un estilo de vida saludable se relaciona con los procesos cognitivos en jóvenes [120]. Otra investigación reportó que altos niveles de TP como ver televisión o ver video juegos, se relacionó con un rendimiento pobre en algunas FE y habilidades sociales en escolares chinos [121]. Por lo tanto, el TP podría influir negativamente en las FE [122], por lo que disminuir las horas frente a una pantalla, debería beneficiar el rendimiento académico en la etapa escolar [123].

Asimismo, un reciente estudió indicó que altos niveles frente a la pantalla, se asoció con bajos niveles del factor neuro-trófico del cerebro (BDNF), lo que podría afectar el rendimiento en las FE e incrementar el riesgo potencial de desarrollar problemas neuro-cognitivos [124]. A pesar de lo planteado, otro estudio reportó que el uso de celulares inteligentes podría predecir positivamente algunas FE, por lo tanto, este estudio indicó que se debe agregar la frecuencia y el uso problemático de los dispositivos electrónicos y no solamente enfocarse en el TP

[112]. Una revisión sistemática demostró que el TP no tuvo efectos negativos en el desarrollo cognitivo [125]. Además, se ha indicado que el TP podría tener efectos negativos y positivos en la función cerebral, por lo que es fundamental seguir profundizando en las investigaciones para clarificar los mecanismos y las relaciones causales entre el TP y el desarrollo del cerebro, especialmente en las etapas en donde el cerebro posee mayor capacidad de plasticidad neuronal [126], por lo tanto, otro estudio recomienda la importancia de seguir investigando la relación del TP con las FE en el contexto escolar [127].

Por otro lado, actualmente existe un considerable foco de atención en lo referido al tiempo frente a pantalla y sus posibles efectos adversos en el bienestar subjetivo y en la CVRS en el contexto escolar. En concordancia a lo anterior, una revisión sistemática con metaanálisis indicó que la conducta sedente se asoció negativamente con menores niveles de bienestar psicológico y la CVRS auto-percibida en niños y jóvenes [128]. En este sentido, un estudio que examinó los efectos del TP sobre la salud mental, reportó que el tiempo frente a la pantalla se asoció con una peor salud mental y autoestima [129]. Otro estudio indicó que niveles más altos de TP se asociaron con una menor CVRS y un peor bienestar subjetivo en niños [130]. Un estudio realizado en escolares chilenos demostró que el tiempo de pantalla, junto con hábitos alimentarios saludables, jugaron el papel más importante en la CVRS, por lo tanto, se debe seguir investigando para determinar los efectos del TP en la salud mental de la población escolar [49].

4.6 Hábitos alimentarios

La alimentación y la nutrición juegan un papel preponderante en el desarrollo integral y en la maduración biopsicosocial de los escolares, además se ha planteado que la escuela debe jugar un rol clave en la promoción de factores protectores para el desarrollo de hábitos alimentarios saludables en la población jóven. Históricamente se ha establecido una clara relación entre los hábitos alimentarios y la salud de los escolares [131, 132], por ende, la calidad de la alimentación es un elemento esencial en el desarrollo de un estilo de vida saludable en la etapa escolar [133].

Actualmente, se están realizando estudios para establecer como los patrones de alimentación se relacionan con las FE y con aspectos del bienestar subjetivo y la CVRS. En relación a la alimentación y las FE, por ejemplo, se ha reportado que una dieta occidentalizada, caracterizada por el uso de carbohidratos refinados y de grasas saturadas puede dañar la correcta función cerebral [134]. Asimismo, en edades tempranas y en la etapa escolar, los niveles de neuro-plasticidad son mayores, por lo tanto, una dieta de baja calidad puede afectar negativamente el desarrollo cerebral y la función cognitiva [135]. En este sentido, un estudio reportó que aquellos estudiantes que poseían mejores hábitos alimentarios obtuvieron un mejor rendimiento académico en comparación a los participantes con una calidad de dieta más baja [136].

Además, se ha señalado que una dieta de baja calidad podría afectar negativamente el rendimiento académico, asimismo los hábitos alimentarios saludables se asociaron con mejores habilidades de lectura, pero no de matemáticas [137]. Otra investigación reportó que los participantes que tenían buenos hábitos alimentarios a través de la adherencia a la DM, se asoció con un mejor rendimiento en algunas FE [138].

Adicionalmente, otro estudio indicó que un peor rendimiento en FE se asoció con tener hábitos alimentarios no saludables [139]. Asimismo, estudios previos han demostrado que hábitos alimentarios saludables se relacionaron positivamente con los procesos de aprendizaje y la cognición en escolares [135, 140]. Además y en relación a las conductas alimentarias, un estudio reportó que una mala alimentación y una baja calidad en la dieta pueden afectar negativamente la función del hipocampo, región que es clave para la creatividad [141].

Por otro lado, también es importante estudiar y determinar cómo los hábitos alimentarios se relacionan y pudiesen afectar la salud mental y la CVRS de niños y jóvenes. En esta línea, se ha reportado que los hábitos alimentarios son un componente clave en el desarrollo de un estilo de vida saludable y pueden afectar el bienestar subjetivo, asimismo la adherencia a patrones de alimentación saludable reportó efectos positivos en diferentes variables del bienestar mental y

en componentes de la CVRS y la felicidad subjetiva [142, 143]. Por el contrario, hábitos alimentarios no saludables se han asociado con una disminución en la CVRS en niños y adolescentes [144]. Una investigación realizada en escolares, encontró que la adhesión a la DM se asoció positivamente con el bienestar subjetivo [142]. Además, una investigación que caracterizó los patrones de alimentación a través de un metaanálisis, indicó que los hábitos alimentarios no saludables y caracterizados por un bajo consumo de agua, frutas y vegetales, junto con un alto consumo de grasas y azúcares se asoció con decrecer la CVRS [145].

Asimismo, se ha reportado previamente que una mejor dieta se relaciona con aspectos positivos de la salud mental en jóvenes [146]. Otro interesante estudio, realizado con jóvenes portugueses, encontró que la combinación de una buena CF junto con hábitos alimentarios saludables medidos a través de la adherencia a la DM, se asoció positivamente con mejores niveles de CVRS [147]. Distinto a lo previamente descrito, otro estudio longitudinal no reportó una asociación estadísticamente significativa entre la adherencia a la DM y el bienestar subjetivo [148]. Por lo tanto, se debe seguir investigando la relación de los hábitos alimentarios con el bienestar mental y la CVRS.

4.7 Condición Física

El último informe del Ministerio de Educación de Chile, relativo al sistema de medición de la calidad de la Educación (SIMCE) de EF, señaló que un 45% de los estudiantes chilenos de octavo año básico, se encuentran con sobrepeso u obesidad, mientras tanto, el 14 % de los escolares necesita mejorar el CRF y el 64 % debe mejorar su fuerza muscular [149]. El CRF cuando es negativo, se asocia a múltiples factores que deben ser investigados [150]. Dentro de las capacidades que conforman la CF, la fuerza muscular (FM) es de gran relevancia debido a su relación con el estado de salud cardiovascular y metabólico, asimismo, se ha reportado que un mejor rendimiento de la FM se asocia de manera positiva con el rendimiento de pruebas de CRF en escolares [151]. El estudio Helena destaca la

importancia de agregar la fuerza de prensión cómo una medida importante para valorar la condición muscular en niños y jóvenes [152].

Actualmente el sistema nacional de medición en EF en Chile, no considera la evaluación de la fuerza prensil, por lo que es fundamental contar con datos tanto a nivel regional como nacional, que permitan tomar decisiones acerca del desarrollo de la CF y de salud en la población escolar. Se ha demostrado que la debilidad muscular en etapas tempranas, junto con un bajo CRF y obesidad, se asoció con discapacidad 30 años después [153], por lo que la medición periódica de la CF en la escuela debiese ser un objetivo prioritario para controlar la salud en la población escolar.

Es importante destacar que existe evidencia científica de la relación del CRF y la condición muscular desde una mirada asociada al riesgo cardiometabólico, no obstante, es interesante a nivel regional, estudiar su relación con aspectos como las FE y la CVRS. Lo anterior se justifica en que la AF junto con la CF, pueden a corto y largo plazo, afectar positivamente áreas importantes del cerebro que estimulan la cognición de niños [154]. En este sentido, una investigación previa reportó que altos niveles de CRF tuvo efectos positivos en la cognición de niños [155]. Otros estudios han indicado una asociación positiva entre el CRF y el rendimiento académico [10, 94].

Además, Latorre y Cols indicaron que el CRF fue un importante predictor de la creatividad en escolares [33]. En este sentido, una investigación realizada en escolares, demostró que un alto CRF se relacionó positivamente con las FE [156]. Asimismo, un estudio comparativo por nivel de CRF, indicó que los estudiantes clasificados con un alto CRF obtuvieron mejores resultados en memoria en comparación a aquellos participantes con un CRF bajo [157]. En adición, un estudio transversal reportó que el CRF estuvo positivamente relacionado con la función de memoria, asimismo los participantes clasificados con un alto CRF y buen desempeño en las FE obtuvieron un mejor rendimiento académico [158].

Por otro lado, previamente se ha demostrado que los sujetos con niveles altos de CRF han obtenido una mayor oxigenación a nivel cerebral en comparación a aquellos participantes con menores niveles, por lo tanto, cabe destacar que los procesos cognitivos dependen de manera crítica de un adecuado suministro de flujo sanguíneo y oxígeno para la producción de energía para el cerebro [159]. En esta línea, el CRF se relaciona con otros procesos claves en los procesos cognitivos (función endotelial y la angiogénesis) [160]. Asimismo otro estudio reportó que adecuados niveles de CRF podrían impactar de manera positiva los procesos de neuro-plasticidad vía estimulación del BDNF [161]. Dado lo previamente descrito, el desarrollo del CRF debiese ser un objetivo importante de mejora en el contexto escolar.

En adición, la CF y sus componentes también podrían jugar un rol importante en el bienestar subjetivo y en la CVRS. Acorde a lo anterior, un estudio previo demostró que escolares con una mejor CF tuvieron mayores índices de CVRS, además la asociación entre la CF y los componentes de la CVRS se diferenció de acuerdo al sexo, por lo tanto, los autores plantean que mejorar la CF podría ser una buena estrategia para mejorar la CVRS [162]. Asimismo, un estudio realizado en escolares españoles, reportó una correlación positiva entre el CRF y la CVRS [163]. Otro estudio reportó que aquellos estudiantes con un nivel medio y alto de CF obtuvieron mejores puntajes en el bienestar subjetivo [164]. Además, se ha descrito que intervenciones orientadas a la mejora de la CF tuvo un impacto positivo en la salud psicológica y social en población escolar [165]. Dado lo argumentado anteriormente, es importante generar investigaciones que puedan relacionar y analizar los efectos de la CF y sus componentes en variables importantes en el contexto escolar como lo son las FE y la CVRS.

4.8 Estado nutricional y composición corporal

La obesidad es una enfermedad multifactorial y que presenta una alta prevalencia a nivel mundial, en este sentido, se la define como una enfermedad crónica moderna. Actualmente en Chile, se ha modificado marcadamente el estilo de vida de la población, el cual se caracteriza por malos hábitos alimentarios y un

descenso de los niveles de AF, liderando a altos niveles de malnutrición por exceso, lo cual se considera un problema de salud pública [166, 167]. El informe de la agencia de la calidad de la educación en Chile, reportó una alta prevalencia de sobrepeso y obesidad acompañado de bajos niveles de CF en los escolares [149]. Asimismo, se ha establecido que la OA es una buena herramienta para medir el riesgo cardiometabólico [168]. Dado el contexto anterior y el perfil epidemiológico nacional, se debe establecer la relación de la malnutrición por exceso y algunas variables de la composición corporal con variables cognitivas y de salud mental.

Con respecto a la malnutrición por exceso y las FE, un estudio realizado en escolares, reportó una asociación entre ser obeso y obtener peores resultados en pruebas cognitivas en niños y adolescentes [169]. En esta línea, la obesidad infantil se ha asociado con un menor desempeño en pruebas cognitivas y con un rendimiento académico disminuido [170], así como una reducción de estructuras cerebrales relevantes que pudiesen perjudicar los procesos de aprendizaje [171]. Asimismo, estudios previos han reportado un descenso en los resultados en algunas FE como la atención y la memoria en jóvenes con sobrepeso y obesidad [172, 173]. Otro estudio indicó que aquellos estudiantes con malnutrición por exceso obtuvieron un peor resultado en el test d2 al compararlos con aquellos estudiantes con una clasificación del índice de masa corporal (IMC) normal [174]. Adicionalmente, otro estudio demostró que los estudiantes obesos reportaron menores niveles de atención, retención, inteligencia y flexibilidad cognitiva [175]. En este contexto, una interesante investigación reportó que la adiposidad corporal tiene un efecto negativo en la función cognitiva de pre-adolescentes [176]. Además, se ha planteado que la obesidad se asocia con una disminución del volumen cerebral, lo que repercute al afectar la correcta funcionalidad del hipocampo [177]. Asimismo, una revisión indicó que la obesidad afecta negativamente los procesos cognitivos y que es necesario seguir investigando qué papel juega la obesidad en la estructura y función cerebral [178].

Asimismo, la obesidad se ha relacionado con repercusiones negativas en variables biopsicosociales de participantes en el contexto escolar [179]. De acuerdo a lo anterior, se ha reportado que estudiantes coreanos obesos presentaron una menor autoestima que aquellos normo-peso [180]. Un estudio realizado con el propósito de establecer el estado nutricional y los niveles de autoestima en escolares chilenos, encontró que el IMC se asoció negativamente con la autoestima, por ende, la obesidad estaría afectando variables psicosociales [181]. Por otro lado, se ha indicado que la malnutrición por exceso también afecta la CVRS en jóvenes [182]. En esta línea, una investigación realizada en estudiantes españoles encontró que los participantes con normo-peso tuvieron una mejor CVRS en comparación a los participantes que presentaron malnutrición por exceso [183].

4.9 Intervenciones de actividad física en el contexto escolar

Una revisión sistemática reportó que la AF posee numerosos beneficios para niños y jóvenes en edad escolar [86]. Plantear intervenciones en el contexto escolar podría transformarse en una estrategia costo-eficiente para mejorar distintos parámetros asociados a la salud, FE y de CVRS.

En Chile, una investigación realizada en el contexto escolar y que aplicó un programa de intervención de AF a través de la utilización de ejercicios interválicos de alta intensidad durante 28 semanas, reportó que existieron mejoras estadísticamente significativas en el CRF, en variables antropométricas y en la presión arterial en estudiantes con malnutrición por exceso [184]. Asimismo, una intervención en el estilo de vida compuesta por AF y educación alimentaria con una prolongación de 5 meses, encontró que existió una disminución en la prevalencia de obesidad en escolares [185]. Otra investigación realizada en escuelas, demostró que un programa de intervención de AF que incluía cambios en el entorno escolar, mayores oportunidades para la AF y actividades de aprendizaje de AF, mejoró los niveles de AF y disminuyó el IMC y la circunferencia de cintura (CC) de los participantes [186]. Por otro lado, una investigación que utilizó un programa de AF en la escuela de 3 sesiones semana, con una duración

de 60 minutos por sesión, no mejoró significativamente el estado nutricional ni disminuyó los niveles de adiposidad en escolares españoles, sin embargo, el programa aumentó significativamente el CRF en las mujeres [187]. Dado lo anterior, los programas de AF se podrían transformar en una buena herramienta para impactar positivamente en la salud cardiometabólica, además se necesita seguir investigando los efectos de la AF en la escuela para determinar tipo, frecuencia, duración e intensidad de los programas para generar mejores adaptaciones al ejercicio.

También, algunas investigaciones han tenido como propósito ver los efectos de la AF sobre las FE. En este sentido, un estudio realizado en escolares chilenos, reportó que una intervención de 8 semanas de AF (30 minutos por sesión) después de la escuela mejoró el CRF, lo que podría impactar positivamente en también aumentar la atención y el rendimiento académico [188]. Asimismo, una intervención de AF a través de un programa de descansos activos (20 periodos semanales de descansos activos de 5-10 minutos, 3-5 veces al día, durante 17 semanas) mejoró todas las FE evaluadas [189]. Una revisión sistemática con metaanálisis indicó que los recreos activos pueden mejorar los niveles de AF y el comportamiento en clases [190]. Un metaanálisis reportó que las intervenciones de AF crónicas, especialmente aquellas que combinan AF con desafíos cognitivos, pueden ser una herramienta prometedora para promover el desarrollo de múltiples FE en niños [191]. Otro metaanálisis demostró que se encontraron efectos positivos de la AF sobre las FE, la atención y el rendimiento académico en pre-adolescentes [101]. También se ha demostrado que la AF aguda de intensidad moderada a vigorosa, mejora las funciones cognitivas en los niños [192]. Por otro lado, los hallazgos sobre los efectos de la AF regular sobre la cognición en los niños han sido inconsistentes debido a una serie de factores demográficos y de consideraciones experimentales de los estudios [193], por lo tanto, se debe seguir investigando los efectos agudos y crónicos de la AF sobre las FE en niños y jóvenes.

Por otro lado, se ha reportado la importancia de la AF sobre el bienestar subjetivo y la CVRS. La evidencia previa ha resaltado la importancia de la AF sobre el bienestar [104]. Asimismo, una intervención de educación física-deportiva mejoró significativamente indicadores del bienestar subjetivo junto con la inteligencia emocional del grupo experimental [194]. Otra investigación reportó que las intervenciones de AF en la escuela pueden reducir la ansiedad, mejorar el bienestar y aumentar la salud mental positiva en niños y adolescentes [195]. En este sentido, la AF puede ser un factor importante en la salud mental de jóvenes [196]. Sin embargo, se deben seguir revisando los aspectos metodológicos de las intervenciones [197] y aplicando programas de AF para establecer el tipo, frecuencia, intensidad y volumen y los efectos en el bienestar subjetivo y la CVRS en el contexto escolar.

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6.- OBJETIVOS

6.1 Objetivo general

El propósito principal de la investigación fue determinar la asociación entre el estilo de vida (Niveles de actividad física, disminución del tiempo de pantalla y buenos hábitos alimentarios), medidas antropométricas y la condición física con las funciones ejecutivas y la calidad de vida relacionada a la salud en escolares chilenos.

6.2 Objetivos específicos

- Establecer la relación entre el estilo de vida con el rendimiento académico en escolares chilenos a través de un estudio nacional.
- Determinar la asociación entre el estilo de vida, medidas antropométricas y la condición física con las funciones ejecutivas en escolares Chilenos.
- Determinar la relación entre el estilo de vida con la calidad de vida relacionada a la salud en escolares Chilenos.
- Determinar la asociación del estilo de vida y la condición física con la obesidad abdominal y el exceso de peso en escolares chilenos y colombianos.

7.- MATERIAL Y MÉTODOS

La sección de material y métodos de la presente memoria de Tesis Doctoral se describe de manera resumida en la tabla 2, que incluye la información metodológica más relevante de los artículos que componen el presente informe:

7.1 Tabla 2. Resumen de la metodología empleada en los artículos que componen la Tesis Doctoral.

Título del artículo	***Diseño de estudio***	***Participantes***	***Variables medidas***
I. Low indicators of personal and social development in Chilean schools are associated with unimproved academic performance: A national study.	Corte Longitudinal con análisis de las pruebas nacionales 2015-2016.	Participaron 2891 escuelas de Chile. El total de participantes fue de 196.344, muestra representativa nacional. Los datos fueron recolectados por la agencia nacional de calidad de la educación en Chile.	♦ Se evaluaron indicadores de desarrollo personal y social, hábitos de vida saludable y rendimiento académico en pruebas nacionales estandarizadas.
II. Association between Creativity and Memory with Cardiorespiratory Fitness and Lifestyle among Chilean Schoolchildren.	Corte transversal.	248 escolares, 111 niñas (11,58 ± 1,09 años) y 137 niños (11,80±1,17 años).	♦ Se recolectaron datos antropométricos; IMC, CC, AF, TP, Adherencia a la DM, VO2máx, creatividad y memoria.
III.Selective attention and concentration are related to lifestyle in Chilean schoolchildren.	Corte transversal.	248 escolares, 111 niñas (11,58 ± 1,09 años) y 137 niños (11,80±1,17 años).	♦ Se recolectaron datos antropométricos; IMC, CC, AF, TP, Adherencia a la DM, VO2máx, atención y concentración.

Tabla 2 (continuación):

Título del artículo	Diseño de estudio	Participantes	Variables medidas
IV. Lifestyle mediates the relationship between self-esteem and health-related quality of life in Chilean schoolchildren.	Corte transversal.	634 escolares, 282 niños (11,86 ± 0,82 años) y 352 niñas (12,02± 0,87 años).	♦ Se recolectaron datos antropométricos; IMC, CC, AF, TP, Adherencia a la DM, VO2máx y CVRS.
V. The association between modifiable lifestyle behaviour in Latin-American schoolchildren with abdominal obesity and excess weight. A comparison of Chile and Colombia.	Corte transversal.	969 escolares, niñas (n = 441; 5,24 ± 0,80 años) y niños (n = 528; 5,10 ± 0,78 años) de Chile (n = 611) y Colombia (n = 358).	♦ Se evaluaron el IMC, la CC, la adherencia a la DM, la AF, el TP y el CRF.

Además de lo expuesto anteriormente, en la tabla 3 se presenta la información relativa a los principales instrumentos de recolección de datos utilizados en cada una de las investigaciones, que forman parte de la memoria de la Tesis Doctoral:

7.2 Tabla 3. Resumen de los principales instrumentos de recolección de datos utilizados en los artículos que componen la Tesis Doctoral.

Variable medida	Instrumento
I. Indicadores de desarrollo personal y social/ Rendimiento académico	Los Indicadores de desarrollo personal y social se midieron a través de cuestionarios *ad hoc* (contenido reservado), creados especialmente para el estudio nacional. Todos los resultados se derivaron de las percepciones autodeclaradas por los encuestados. El rendimiento académico se midió utilizando los resultados de los estudiantes en pruebas estandarizadas de matemáticas, lenguaje y ciencias (que forman parte del estudio nacional SIMCE en Chile). El contenido de estas pruebas fue diseñado por especialistas gubernamentales y su uso es confidencial. Todas las pruebas para el rendimiento académico fueron de opción múltiple.
II. Creatividad	La creatividad se midió mediante el test CREA (1), que proporciona un valor cuantitativo global de la creatividad. El instrumento es una prueba del pensamiento divergente que se cronometra durante 4 minutos y se solicita a los encuestados que generen la mayor cantidad de preguntas sobre una imagen. Los puntajes se asignan en función de la complejidad de las respuestas según los manuales establecidos en; bajo, medio y alto (1,2, y 3 puntos respectivamente).
III. Memoria	La capacidad de memoria se midió mediante la prueba de aprendizaje auditivo verbal del Rey. Se presentó una lista de 15 palabras (lista A) en cinco ensayos consecutivos, evaluando (después de cada ensayo) el número de palabras recordadas por el participante. Asimismo se presentó la lista de interferencia (lista b). Después de 20 minutos, al final de la batería del test, se les pidió a los escolares que recuerden tantas palabras como fuera posible y que finalmente reconocieran las palabras dentro de una lista de 30, según los protocolos previamente establecidos (2).

Tabla 3 (continuación):

Variable medida	Instrumento
IV. Atención selectiva y concentración	La atención y la capacidad de concentración se midieron utilizando la prueba de atención d2 (3). El d2 es una prueba de lápiz y papel que comprende 14 filas, cada una con 47 caracteres "p" y "d" intercalados aleatoriamente. Cada letra (p o d) aparece con 1 o 2 guiones encima y/o debajo. Los participanetes deben seleccionar las letras d con dos guiones (encima y/o abajo). La prueba dura 4 minutos y 30 segundos (20 segundos por línea). La concentración se evaluó como: Número de aciertos— número de errores. Asimismo, se calculó la capacidad de atención selectiva como el número de elementos procesados— (omisiones + errores) (4).
V. Calidad de vida relacionada a la salud	La CVRS se midió utilizando el cuestionario Kidscreen-10 para población de 8 a 18 años (5). KIDSCREEN-10 es una evaluación validada y ampliamente utilizada para la CVRS global en niños y adolescentes. Tiene diez preguntas. Cada ítem se responde en una escala Likert de cinco puntos que indica la frecuencia de un comportamiento o sentimiento específico (1 = nunca; 2 = casi nunca; 3 = a veces; 4 = casi siempre; y 5 = siempre) o la intensidad de una actitud (1 = nada; 2 = levemente; 3 = moderadamente; 4 = muy; y 5 = extremadamente).
VI. Actividad física	Para la medición de la AF se utilizó el Cuestionario de Actividad Física (PAQ-C). El instrumento recopila información sobre la AF de los escolares durante los 7 días pasados. Cada elemento tiene una puntuación entre 1 y 5 (es decir, una puntuación más alta significa niveles más altos de AF). Los resultados se registraron y cuantificaron en horas semanales (6).
VII. Tiempo de pantalla	El test Krece Plus se utilizó para evaluar el tiempo frente a una pantalla. Esta prueba es un cuestionario rápido que clasifica el estilo de vida en función del número medio de horas dedicadas a ver televisión ó a la utilización de video-juegos a diario (7).

Tabla 3 (continuación):

Variable medida	Instrumento
VIII. Hábitos alimentarios	Los hábitos alimentarios de los escolares se determinaron mediante el test Krece Plus que se basa en la adherencia a la DM. Los items tienen una puntuación de +1 o -1 según las pautas establecidas. La puntuación de la prueba Krece Plus se categorizó de la siguiente manera: (1)> 8, DM óptima; (2) 4–7, adherencia moderada a la DM; y (3) ≤3, dieta de muy baja calidad (8). Puntajes más altos indican mejores hábitos alimentarios.
IX. Condición física	El CRF se evaluó mediante la prueba progresiva de Léger (9). Los estudiantes corrieron entre dos líneas paralelas de 20 metros de distancia entre sí. Se registró la última progresión ejecutada y se calculó el VO_2max (mL / kg / min). Asimismo se midió el salto a pies juntos y la fuerza de prensión manual según protocolos previamente establecidos (10,11).
X. Medidas antropométricas	Se utilizó una báscula TANITA (modelo UM – 028, Tokio) para evaluar el peso de los niños. La estatura de los niños se midió con un estadiómetro Seca® (modelo 214, Hamburgo, Alemania). El IMC se utilizó para clasificar el estado nutricional de la siguiente manera: IMC ≥ al percentil 95 y sobrepeso como un IMC ≥ del percentil 85 entre niños de la misma edad y sexo (12). Se utilizó una cinta Seca® (modelo 201, Hamburgo, Alemania) para medir la CC de acuerdo a protocolos anteriormente descritos (13).

7.3 Referencias instrumentos de recolección de datos

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8.- RESULTADOS

En la tabla 4 se presenta un resumen con los principales resultados obtenidos en las diferentes investigaciones que se integran en la Tesis Doctoral:

8.1 Tabla 4. Resumen de los resultados obtenidos en los artículos que componen la Tesis Doctoral.

Artículo	Resultados
I. Low indicators of personal and social development in Chilean schools are associated with unimproved academic performance: A national study	La mayoría de los estudiantes evaluados estaban en escuelas subvencionadas, seguidas de escuelas públicas. Asimismo, la mayoría de los estudiantes que asistieron a escuelas públicas provenían de entornos socioeconómicos bajos y medios-bajos. Existieron diferencias estadísticamente significativas en los indicadores de desarrollo personal y social en la comparación por dependencia (públicas, subvencionadas y privadas) en autoestima y motivación académica (p <.001), clima escolar (p <.001), participación cívica (p <.001) y hábitos saludables (p <.001), siendo las escuelas públicas las que obtuvieron los resultados más bajos. El estilo de vida saludable (AF y hábitos alimentarios) de la escuela ≤ 70 se asociaron con puntajes no mejorados en todas las áreas de las pruebas estandarizadas (lenguaje, matemáticas y ciencias naturales). Asimismo, el estilo de vida saludable se correlacionó con el rendimiento académico de los participantes.
II. Association between Creativity and Memory with Cardiorespiratory Fitness and Lifestyle among Chilean Schoolchildren	Al analizar los grupos por sexo, los hombres tuvieron puntuaciones significativamente mejores en las horas/semana de AF (2,58 vs. 2,16 p = 0,014) y V ̇O2max (ml / kg / min) (42,18 vs. 40,62, p = 0,001) que las mujeres. Las niñas se desempeñaron significativamente mejor en la memoria a largo plazo que los niños (8,96 vs.8, 02 p= 0,001). No existieron diferencias estadísticamente significativas en creatividad (p = 0,699), concentración (p = 0,137) y atención selectiva (p = 0,246) según sexo. En la muestra total, la creatividad se asoció con el V ̇O2max (ml / kg / min) (β; 0,209, IC del 95%; 0,02-0,40, p = p <0,05) y con la adherencia a la DM (puntuación) (β; 0,206, IC del 95%; 0,01; 0,74, p = p <0,05). La memoria a largo plazo reportó una asociación positiva con el CRF (β; 1.076, 95% CI; 0,02-2,13, p = p <0,05) y una asociación inversa con la adherencia a la DM (β; −0,155, 95% CI; −0,28–−0,03, p = p <0,05). Además, la memoria a largo plazo se asoció de manera inversa con el IMC (β; −0,167, IC del 95%; −0,33–−0,01, p = p <0,05). Al analizar los grupos por CRF (alto / bajo), los escolares con mayor CRF obtuvieron un desempeño estadísticamente mejor en la memoria a largo plazo (p <0,05) tras ser ajustados por edad, sexo e IMC.

Tabla 4 (continuación):

Artículo	Resultados
III. Selective attention and concentration are related to lifestyle in Chilean schoolchildren.	En el modelo 0 (no ajustado) y el modelo 1 (ajustado por edad y sexo), la atención selectiva mostró una asociación positiva con la puntuación de la adherencia a la DM (β; 5,612, IC del 95%; 0,63; 10,59, p = p <0,05) y (β ; 5,012, IC del 95%; 0,06; 9,95, p = p <0,05). La concentración se asoció inversamente al TP h/día en el modelo 0 (β; -5,569, IC del 95%; -9,46; -1,68, p = p <0,05) y en el modelo 1 (β; -5,498, IC del 95%; - 9,36; -1,63, p = p <0,05). Además, la concentración reportó una asociación positiva con la puntuación de adherencia a la DM en el modelo 0 (β; 2.864, IC del 95%; 0.80; 4.92, p = p <0,05) y en el modelo 1 (β; 2.904, IC del 95%; 0.87; 4.93, p = p <0.05). Al comparar los grupos por TP (<2hdía / ≥ 2h / día) por separado, los escolares con menores niveles reportaron significativamente mejor atención selectiva (p = 0,024), concentración (p = 0,000), aciertos totales (p = 0,000) y menores omisiones (p = 0,016) y errores (p = 0,007) a través del test d2 en comparación a aquellos escolares con un TP mayor. Los escolares con una adherencia a la DM óptima obtuvieron una mejor concentración (p = 0,003) y aciertos totales en la prueba d2 (p = 0,002) que los escolares con una clasificación de adherencia a la DM moderada y baja.
IV. Lifestyle mediates the relationship between self-esteem and health-related quality of life in Chilean schoolchildren.	En la comparación por sexo, la autoestima familiar y AF después de la escuela fueron ligeramente más altas en los niños que en las niñas (niñas: 4,85 ± 1,95 frente a los niños: 5,13 ± 1,81, p = 0,059; y niñas: 2.52 ± 1.38 vs niños: 2.74 ± 1.44). El estado nutricional (muestra total) fue principalmente bajo (35,02%) y moderado (47,48%), mientras que los patrones de AF fueron bajos (60,25%) y regulares (33,75%), sin diferencias según el sexo. Los patrones de AF mostraron una relación significativa con la autoestima general (r = 0.12, p = 0,001), la autoestima familiar (r = 0.12, p = 0,001) autoestima global (r = 0.12, p = 0,001), autoestima escolar (r = 0.33, p <0,001) y con CVRS (r = 0.72, p <0,001). La AF después de la escuela (β; 1,15, IC del 95%; 0,90, 1,39, P <0,001) se asoció positivamente con la CVRS. Por el contrario, el TP se asoció inversamente a la CVRS (β; −1,82, IC del 95%; −2,13, −1,52, P <0,001). La autoestima se asoció significativamente con la CVRS (efecto total = 0,48, p <0,01), y el TP medió esta asociación negativamente, en cambio, la AF y los hábitos alimentarios mediaron positivamente esta asociación.

Tabla 4 (continuación):

Artículo	Resultados
V. The association between modifiable lifestyle behaviour in Latin-American schoolchildren with abdominal obesity and excess weight. A comparison of Chile and Colombia.	Menores niveles de CRF en los niños chilenos se correlacionaron positivamente con la CC. El exceso de peso en escolares chilenos y colombianos se asoció positivamente con un mal estilo de vida. En adición, en los participantes chilenos, un mal estilo de vida se asoció con la OA basado en CC ≥ percentil 85 y OA basado en RCE ≥ percentil 85. En los niños chilenos, el exceso de peso (IMC ≥ percentil 85) se asoció positivamente con una mala adherencia a la DM. En relación a las variables antropométricas, los niños de Chile reportaron; IMC (P <0,001), CC (P <0,001) y RCE (P <0,001) más altos que los niños colombianos. Además, los participantes chilenos presentaron mejores resultados en la prueba de resistencia "10 × 20" que los niños colombianos (P <0,001). Sin embargo, en cuanto a la fuerza de agarre, los niños chilenos tuvieron peores resultados que los niños colombianos (P = 0,007). En el estilo de vida, los niños chilenos presentaron mayor adherencia a la DM (P = 0.040), horas de AF después de la escuela por semana (P <0,001) y TP por día (P <0,001) que los niños colombianos.

9.- ARTÍCULOS QUE COMPONEN LA TESIS DOCTORAL.

9.1 Artículo 1: Low indicators of personal and social development in Chilean schools are associated with unimproved academic performance: A national study.

Abstract:

The objective of the present study was to determine the association of academic performance with personal and social development indicators in Chilean schools from the results of the 2016 national education study and to determine the relationship of these results with the schools' socioeconomic background. The results from 2891 schools that participated in the 2016 national education study were analyzed. This examination considered academic performance (2016 vs 2015) and personal and social development indicators. The indicators with values ≤ 70 were associated with unimproved academic performance (i.e., maintained or decreased). Moreover, the indicators had a greater correlation with academic performance on low/middle-low socio- economic background Schools. This finding may be useful in the discussion and implementation of public policies in Chile.

Introduction:

Over the past few years, most Latin American countries have focused their efforts on constantly improving the quality of edu- cation in their territories (Feldeber & Andrade, 2016; Rivas & Sánchez, 2016). However, this has involved the emergence of new debates and theoretical positions about the concept of educational quality (Leal, Gamelas, Barros, & Pessanha, 2018), a term that is permanently in the process of resignification and reconceptualization (Díaz, 2015) based on the recommendations of official orga- nizations (Acuña & Pons, 2016) and the particular beliefs of Educational actors (Torche, Martínez, Madrid, & Araya, 2015). This also implies a questioning of the variables commonly associated with the concept of educational quality (Burchinal, 2018; Nutall, 2017; Salilul &

Shahadat, 2016; Slot, Leseman, Verhagen, & Mulder, 2015; Tokuhama-Espinosa, 2015). Different authors (Díaz, Reyes, Dueñas, & Bernal, 2017; Nutall, 2017; Sayed & Ahmed, 2015; Schindler, Welzat, Puls-Elvidge, & Crawford, 2015) have raised the need to analyze and deconstruct the representations and discourses that exist around the concept of educational quality with the aim of surpassing the traditional approaches that exclusively relate this term to an individual cognitive dimension.

The specialized literature suggests that a high-quality education must contribute to the biopsychosocial development of the subjects (Inman, Buck, & Tandy, 2003; Tattum & Tattum, 2017), meeting the personal, social, and cultural demands of future citizens (Bourn, 2015; Hardy & Woodcock, 2015). Different countries have implemented systems to evaluate the quality of education and to measure variables that can affect academic performance (UNESCO, 2017). In the case of Chile, the Ministry of Education (MINEDUC) has historically conducted standardized tests of language, math, and science to assess the quality of education in schools (i.e., academic performance). However, after different political and academic debates (Castillo & Contreras, 2014), the measurement of new variables at the national level has been included since 2013 to obtain data on fundamental non-academic aspects linked to students' all-round development (MINEDUC, 2019). This has given rise to the creation of "personal and social development indicators" that seek to assess (a) academic self-esteem and motivation, (b) school climate, (c) civic participation and education, and (d) healthy living habits. This makes it possible to evaluate educational quality from a broader perspective and design actions that improve how the schools operate (Leyton, Huepe, Mandiola, & Traslaviña, 2013).

Academic self-esteem and motivation.

In relation with the indicators, the academic self-esteem has been associated positively with academic outcomes, and there are several factors that influence their development such as family, social interactions constructed at school, and socioeconomic status, among others (Topçu & Leana-Taşcılar, 2016). Moreover,

Academic motivation also emerges as another fundamental variable to achieving high academic performance, this type of motivation can be defined as something that drives the accomplishment of learning tasks, determining the student interests and attitudes to school contents, in addition to the motivation to achieve and the attitudes expressed in the event of difficulties inherent to studying (Valenzuela, Muñoz Valenzuela, Silva-Peña, Gómez Nocetti, & Precht Gandarillas, 2015).

School climate.

School climate is defined as the quality of social and emotional interactions that students develop with one another in addition to the social relations that these stakeholders build with teachers (López-González & Oriol, 2016). Although the classroom climate is perceived differently by each student, it has been shown to have a direct impact on academic performance (Barreto & Álvarez, 2017; Barros & Frias, 2016; Berkowitz, Moore, Astor, & Benbenishty, 2017; López-González & Oriol, 2016). In other words, a positive school climate could promote greater learning (Castro & Morales, 2015) and potentially reduce gaps in academic performance among students (Berkowitz et al., 2017) as well as presenting fewer conflicts and less bullying in the student body (Acosta et al., 2019), favoring personal and social development (La Salle, Zabek, & Meyers, 2016). Likewise, a school climate supported by a warm, respectful atmosphere and supportive relations among all the stakeholders would enable students to perform optimally in academic terms, since they are committed emotionally to working in the classroom (Treviño, Toledo, & Gempp, 2013).

Civic participation and education

Civic education is a key aspect in education systems because it affords people essential competencies for a participatory life in current society (Caballero, Cárdenas, & Valle, 2016). In the same vein, Crick (2017) showed that it is crucial to promote civic education among students, as this will help students understand current democratic complexities and dilemmas. In other words, school is seen as a space that forms future citizens to participate in the public sphere using the skills

and knowledge necessary for political participation and better social inclusion (Bolívar, 2016). Hess and McAvoy (2014) indicated that promoting democratic education in the classroom allows students to develop their skills in deliberating different aspects of a political nature, which re- presents a great educational opportunity but also a pedagogical and ethical challenge in educational terms. For Sousa and Oxley (2019), school can be a privileged space for learning and reinforcing democratic values such as cooperation, participation, and tolerance.

Healthy habits.

The positive impact of healthy habits on academic performance as well as on personal and social development has been described before, in concrete terms, different studies (Burrows, Goldaman, Olson, Byrne, & Coventry, 2017; Haapala et al., 2017; Mclsaac, Kirk, & Khule, 2015; Stea & Torstveit, 2014) show that eating healthy food and being physically active are factors that have a positive effect on academic performance, cognitive development, and the perception of well-being in students. Likewise, a meta-analysis (Álvarez-Bueno et al., 2017) focused on studying the relation between physical activity and academic performance in students showed that higher levels of physical activity, especially in physical education (PE) classes, collaborate in a better classroom climate in addition to performing better academically, particularly in skills related to math and language. Based on previously reported findings, physical activity interventions have been applied in the classroom to understand their immediate effect on academic performance, obtaining positive results in most cases, as a systematic review by Watson, Timperio, Brown, Best and Hesketh (2017) pointed out. The personal and social development indicators (i.e. academic self-esteem and motivation, school climate, civic participation, healthy habits) allow to evaluating educational quality from a broader perspective and to determinate that variables can affect academic performance and designing actions that improve the schools levels and equity.

Therefore, the objective of the present study was to determine the association of academic performance with personal and social development indicators in Chilean schools (i.e., high schools) from the results of the 2016 national education study

and to determine the relationship of these results with the schools' socioeconomic background and the type of school (i.e., public, subsidised, or private). Thus, the research question is whether per- sonal and social development indicators are associated with academic performance in Chilean schools?.

Materials and methods.

Research context: The present study is based on data from a 2016 national education study 'SIMCE' (MINEDUC, 2016) in comparison with results in academic performance in language, maths, and science from 2015 in all high schools (level II). SIMCE is an acronym in Spanish: 'sistema de medición de la calidad de la educación' (quality education assessment system). The database was required through the Agency of Education Quality (2016) and it does not include comparisons or divisions according to gender. The Chilean educational system is divided into four stages: (a) infant education (up to five years old), (b) basic education (primary, from first to eighth grade), (c) middle education (high school, with a four-year duration, I-IV), (d) higher education (university or technical training institutes). The schools are divided into three types: (a) municipal: free schools for the population, administered by city councils and financed by central government, (b) subsidised schools, which are financed by a mixture of funding from central government and private contributions, and (c) private: private schools financed entirely by private contributions. Recent evidence shows that there is a high socioeconomic segregation in the Chilean educational system. Students who come from families with higher poverty rates mostly go to municipal schools that have the worst results in the national standardised test compared to private-subsidised and private schools, while those with better socioeconomic status attend subsidised or private educational centres (Mizala & Torche, 2012). Likewise, this situation has generated a significant number of critics, mainly because it substantially hinders social mobility, and tends to perpetuate the status quo, denying the best educational possibilities to the po- pulation with lower incomes (Cabalin, 2012).

Participants.

The results from 2891 high schools of level II were analysed (196,344 students). Performance-related data from the schools in language, maths, and natural sciences tests were used. The national study provided information to complement the analysis of student learning achievement in schools. Additionally, the results that each school obtained on the personal and social development indicators were included. Each of the indicators assessed is described below.

Measures.

All the data used in this study were officially requested from the Agency of Quality Education (2016), organisation that is part of the Ministry of Education in Chile. This state department formally granted all necessary permits to use the data for research purposes and subsequent publication. The Ministry of Education applied standardised tests in all of the schools in the country with the objective of evaluating four personal and social development dimensions: (a) academic self-esteem and motivation, (b) school cli- mate, (c) civic participation and education, (d) healthy habits. These variables were measured through ad hoc questionnaires (reserved content), created especially for the national study. All results were derived from self-declared perceptions by the respondents, and these tests were conducted in parallel with the academic tests (maths, language and science). As mentioned above, academic performance was measured using the students' results on standardised tests of maths, language, and science (which are part of the national SIMCE study). The content of these tests was designed by government specialists and their use is confidential. All tests were multiple-choice. The research team agreed ethical commitments with the Chilean state, in order to protect the schools and students' identity, and undertook to use the data solely for scientific purposes.

Academic self-esteem and motivation

This indicator was evaluated through the use of a questionnaire with students and included two sub-dimensions: (a) self-per- ception and academic self-assessment, which included both the students' perceptions of their aptitudes, skills, and

possibilities of self- improvement, and their assessment of their attributes in the academic field, and (b) academic motivation, which included the students' perceptions of their interest and willingness to learn, their academic expectations and motivation to achieve, and their attitudes to the difficulties involved in studying.

School climate.

In order to evaluate this indicator, questionnaires were used with students, teachers, and parents, and explored the perceptions and attitudes of these stakeholders in three sub-dimensions: (a) the atmosphere of respect, which took into account the stakeholders' perceptions and attitudes about respectful treatment among the members of the school community, as well as the value of diversity and the presence and/or absence of discrimination in the school, (b) an organised environment, which considered the stakeholders' perceptions of the existence of clear guidelines that are known, required, and respected by all, and the predominance of constructive conflict resolution mechanisms, and (c) a safe environment, which considered the stakeholders' perceptions of the degree of safety and physical or psychological violence that exists in the school, as well as the existence of action and prevention mechanisms in the event of these forms of violence.

Civic participation and education.

In order to evaluate this indicator, questionnaires were used with students and parents to learn about the stakeholders' per- ceptions of the following sub-dimensions: (a) participation opportunities for working together, spaces for collaboration promoted by the school, and the degree of commitment and involvement of the school community in such instances, (b) a feeling of be-longing—identification with the school's mission and the school community, and (c) democratic life—the degree to which the school fostered the development of skills and attitudes needed for life in a democracy.

Healthy habits.

This indicator evaluated the students' self-declared attitudes and behaviours in relation to healthy living. In addition, their perceptions about the degree to which the school promoted practices beneficial to health were analysed, including the following sub- dimensions: (a) eating habits—self-declared attitudes and behaviours with respect to students' eating habits and their perceptions of the degree to which the school promoted healthy eating habits, (b) active lifestyle—students' self-declared attitudes and behaviours related to an active lifestyle and their perceptions of how the school promoted physical activity, and (c) self-care habits—this considered the students' self-declared attitudes and behaviours regarding sexuality, the consumption of tobacco, alcohol, and drugs, and their perceptions about the degree to which the school prevented risk behaviours.

Statistical analysis.

Data were analysed with the statistics programs STATA v.13.0 and GraphPad Prism v.7.0. The data presented a nonparametric distribution. The absolute frequencies were determined for qualitative variables. The comparison between groups was evaluated with a Kruskal-Wallis test. Spearman correlation coefficients, multiple logistic regression models, and relative risk (RR) were used to determine the associations between the personal and social development indicators and academic performance. P-values < .05 were considered statistically significant.

Results.

Data from 2891 schools were analysed for personal and social development indicators in relation to academic performance in the areas of language, maths, and natural sciences. Most of the students evaluated were in subsidised schools followed by publics schools (see Fig. 1a). Likewise, the majority of students who attended publics schools were from low and middle-low socioeconomic back-grounds (see Fig. 1b). There were differences in the personal and social development indicators in the comparison of school types (public, subsidised, and private), in academic self-esteem and motivation ($p < .001$), school climate ($p <$

.001), civic participation and education ($p < .001$), and healthy habits ($p < .001$), with the public schools producing the lowest results. The same differences were found in the academic results for language ($p < .001$), maths ($p < .001$), and natural sciences ($p < .001$) (Table 1). The scores obtained on the language, maths, and science tests were assessed to determine the improvement or deterioration between the 2016 scores compared to the 2015 scores. Language and natural sciences were the most deteriorated (48 % and 61.2 %, respectively), whereas maths was the most improved (53 %) (Table 2).

Table 1 Comparison of indicators and academic performance of the schools according to dependence.

	Municipal	Subsidized	Private	P-value
Indicators				
Academic self-esteem and motivation	72.76 ± 3.149	74.20 ± 2.982	75.18 ± 3.744	P < 0.001
School climate	72.15 ± 5.350	75.84 ± 5.605	78.32 ± 5.238	P < 0.001
Civic participation and education	69.43 ± 5.318	69.97 ± 5.993	71.15 ± 7.000	P < 0.001
Healthy habits	75.87 ± 5.207	77.51 ± 6.033	79.82 ± 6.844	P < 0.001
Academic performance				
Language	229.28 ± 25.763	250.40 ± 26.64	276.04 ± 28.89	P < 0.001
Δ Language (2016 vs 2015)	−0.47 ± 16.06	0.39 ± 17.69	2.23 ± 21.81	P = 0.054
Math	229.30 ± 34.831	268.10 ± 39.30	319.66 ± 37.75	P < 0.001
Δ Math (2016 vs 2015)	2.43 ± 14.39	2.60 ± 15.63	3.63 ± 17.46	P = 0.441
Natural science	221.29 ± 21.532	243.15 ± 26.20	286.67 ± 30.95	P < 0.001
Δ Natural science (2016 vs 2015)	−3.66 ± 9.90	−6.96 ± 13.18	−7.40 ± 17.32	P < 0.001

Data are shown as mean ± SD. Values of p < 0.05 were considered statistically. Δ = Differences.2016−2015.

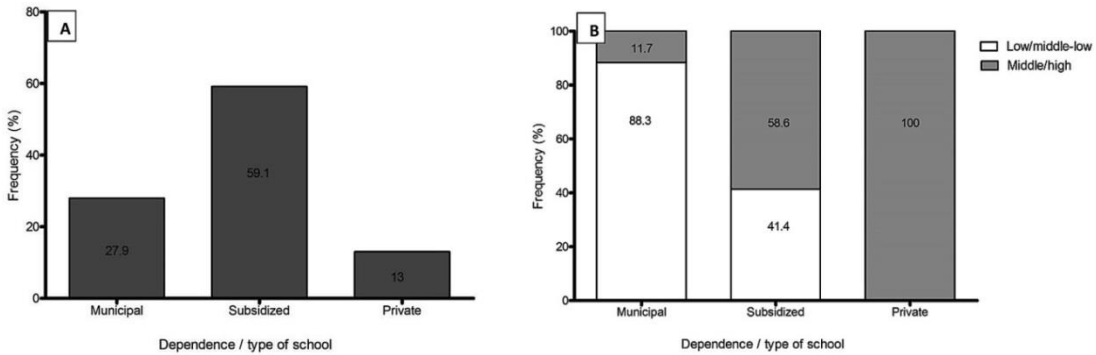

Fig. 1. Frequency of Schools according type of school Municipal (i.e., Public), Subsidized and Private (A). Frequency of Schools in low/middle-low in different according types of Schools (B).

Focussing on socioeconomic status, the analysis found a significant correlation between academic performance and personal and social development indicators. The highest correlations were in low/middle-low schools between indicators of school climate with language (r*0.56, $p < 0.001$), maths (r*0.47, $p < 0.001$), and natural sciences (r*0.50, $p < 0.001$) (Table 3). According schools dependence, the analysis found a significant correlation between academic performance and personal and social development indicators. The highest correlations were found in public schools between school climate indicators with lan- guage (r*0.55, $p < 0.001$), maths (r*0.48, $p < 0.001$), and natural sciences (r*0.49, $p < 0.001$) (Table 4). Turning to unimproved (i.e., maintained or decreased) academic performance in language, maths, and natural sciences, the association was analysed for (a) academic self-esteem and motivation, (b) school climate, (c) civic participation, and (d) healthy habits, with values ≤ 70 points. (a)Academic self-esteem and motivation scores ≤ 70 were associated with unimproved (i.e. maintained or decreased) in math and sciences. Moreover, (b) the school climate ≤ 70 was associated with unimproved scores in the three learning areas (languages, maths, and natural sciences), with a greater association in public schools. Likewise, (c) civic par- ticipation in the schools ≤ 70 showed association with unimproved scores in language and maths, whereas (d) the healthy habits of the school ≤ 70 was associated with unimproved scores in all areas (language, maths, and natural sciences) (Table 5).

Table 2 Distribution of the category of change in the academic test score.

Variable	Language	Math	Natural sciences
Unimproved	186 (6.4 %)	217 (7.5 %)	402 (13.9)
Deteriorated	1387 (48.0 %)	1143 (39.6 %)	1769 (61.2)
Improved	1318 (45.6 %)	1531 (52.9 %)	720 (24.9)

Data are shown n (proportion).

Table 3 Correlation between the indicators and academic performance according to the socioeconomic status.

Language r* (P-value)			Math r* (P-value)		Natural sciences r* (P-value)	
	low/middle-low	Middle/high	low/middle-low	Middle/high	low/middle-low	Middle/high
Academic self-esteem	0.45 (< 0.001)	0.44 (< 0.001)	0.40 (< 0.001)	0.40 (< 0.001)	0.39 (< 0.001)	0.42 (< 0.001)
School Climate	0.56 (< 0.001)	0.51 (< 0.001)	0.47 (< 0.001)	0.43 (< 0.001)	0.50 (< 0.001)	0.45 (< 0.001)
Civic participation	0.48 (< 0.001)	0.47 (< 0.001)	0.42 (< 0.001)	0.43 (< 0.001)	0.44 (< 0.001)	0.45 (< 0.001)
Healthy habits	0.45 (< 0.001)	0.36 (< 0.001)	0.34 (< 0.001)	0.31 (< 0.001)	0.38 (< 0.001)	0.32 (< 0.001)

Data shown represent r*: Spearman correlation coefficient. Values of $p < 0.05$ were considered statistically significant.

Table 4 Correlation between the indicators and academic performance according school dependence.

	Language r* (P-value)			Math r* (P-value)			Natural sciences r* (P-value)		
	Public	Subsidized	Private	Public	Subsidized	Private	Public	Subsidized	Private
School self-esteem	0.46 (< 0.001)	0.42 (< 0.001)	0.39 (< 0.001)	0.38 (< 0.001)	0.37 (< 0.001)	0.34 (< 0.001)	0.39 (< 0.001)	0.37 (< 0.001)	0.39 (< 0.001)
School climate	0.55 (< 0.001)	0.53 (< 0.001)	0.41 (< 0.001)	0.48 (< 0.001)	0.43 (< 0.001)	0.32 (< 0.001)	0.49 (< 0.001)	0.46 (< 0.001)	0.37 (< 0.001)
Civic participation	0.50 (< 0.001)	0.41 (< 0.001)	0.36 (< 0.001)	0.43 (< 0.001)	0.35 (< 0.001)	0.31 (< 0.001)	0.45 (< 0.001)	0.36 (< 0.001)	0.33 (< 0.001)
Healthy habits	0.40 (< 0.001)	0.32 (< 0.001)	0.38 (< 0.001)	0.28 (< 0.001)	0.23(< 0.001)	0.36 (< 0.001)	0.32 (< 0.001)	0.24 (< 0.001)	0.40 (< 0.001)

Data shown represent r*: Spearman correlation coefficient. Values of $p < 0.05$ were considered statistically.

Table 5 Association between indicators ≤70 points with unimproved academic performance (2016 vs 2015).

Indicators ≤70 points RR (95%CI), P-value				
Variables	School self-esteem	School climate	Civic participation	Healthy habits
Language				
Total	1.35 (1.08−1.69), 0.07	1.43 (1.19−1.72), < 0.001	1.35 (1.07−1.71), 0.01	1.21 (1.05−1.41), 0.008
Public	1.25 (0.89−1.77), 0.19	1.41 (1.05−1.89), 0.02	1.37 (0.90−2.09), 0.13	1.23 (0.93−1.64), 0.13
Subsidized	1.42 (1.02−1.98), 0.034	1.49 (1.14−1.95), 0.003	1.37 (1.01−1.86), 0.037	1.17 (0.97−1.42), 0.09
Private	1.16 (0.57−2.33), 0.67	0.85 (0.38−1.93), 0.71	1.04 (0.49−2.23), 0.90	1.26 (0.83−1.91), 0.27
Math				
Total	1.27(1.14−1.43), < 0.001	1.20 (1.09−1.32), < 0.001	1.23 (1.09−1.38), 0.001	1.13 (1.04−1.22), 0.002
Public	1.44 (1.02−2.02), 0.034	1.65 (1.23−2.21), 0.01	1.70 (1.12−2.58), 0.01	1.31 (0.99−1.74), 0.057
Subsidized	1.38 (1.0−1.90), 0.049	1.26 (0.97−1.64), 0.07	1.27 (0.94−1.71), 0.11	1.13 (0.93−1.37), 0.19
Private	4.5 (1.99−10.2), < 0.001	2.14 (0.92−5.0), 0.07	2.85 (1.26−6.5), 0.01	1.86 (1.22−2.84), 0.004
Natural sciences				
Total	1.60 (1.21−2.11), 0.001	1.50 (1.20−1.87), < 0.001	1.1 (0.84−1.44), 0.45	1.24 (1.04−1.46), 0.012
Public	1.94 (1.2−3.12), 0.006	1.46 (1.01−2.11), 0.039	1.25 (0.74−2.13), 0.39	1.65 (1.17−2.32), 0.004
Subsidized	1.36 (0.92−2.0), 0.11	1.32 (0.97−1.80), 0.07	1.04 (0.74−1.46), 0.80	1.05 (0.84−1.30), 0.63
Private	1.08 (0.48−2.39), 0.84	2.05 (0.68−6.13), 0.19	0.98 (0.42−2.29), 0.96	1.34 (0.83−2.16), 0.22

Relative Risk RR (Confidence Interval, 95 % CI), p value. P < 0.05 was considered statistically significant.

Discussion.

The objective of the present study was to determine the association of academic performance with personal and social devel- opment indicators in Chilean schools from the results of the 2016 national education study and to determine the relationship of these results with the schools' socioeconomic background and the type of school (i.e., public, subsidised, or private). In the present national study, the indicators of personal and social development (academic self-esteem and motivation, school climate, civic participation and education, and healthy habits) that had a score ≤ 70 were associated with unimproved academic performance. Moreover, in language and natural sciences, the largest of the schools showed a decline in its score (when comparing scores from 2016 and 2015), while the majority improved in maths. As previously observed, in Chile, there are three kinds of schools: public schools (the administration of which are decentralised to the municipal level), private subsidised schools (they have a co-pay system) and private voucher schools (private non-subsidised) (Bellei, 2005). The problem of educational inequity is that in recent decades (i.e., in Chile), the academic results of private schools were significantly higher than those obtained by public and subsidised schools, presenting a greater difference than currently exists. This means that the learning gaps between schools with students from a high socioeconomic background and those with students from a low socioeconomic background have narrowed. However, in both cases, 'results are far from high when they are compared to international levels of academic attainment. In this way, equity in education is principally understood as students' learning outcomes in national and international tests. However, the analysis is more complex (Volckmar, 2019). Harris and Jones (2019) state that equitable education is when a school system is essentially one where all students reach their full potential irrespective of their background, and any differences in learner outcomes do not result from socioeconomic differences. The OECD (2018) report shows that while some countries that participate in PISA have managed to build education systems where socioeconomic status makes less of a difference in students' learning, in all countries that participated in PISA 2015, socioeconomic status has a large

influence on students' performance in science, reading and mathematics. Thus every country can do more to improve equity in education (OECD, 2018). However, the educational system in Chile faces the challenge of implementing equity-oriented policies within the legal confines of an education system constructed under the neoliberal model (Matear, 2007). Also, there is a deficit in quality that cuts across all of Chilean education (OECD, 2016). The personal and social development indicators have a greater correlation on the academic performance of students from a low/ middle-low socioeconomic background. A study conducted on a Chilean student sample showed that socioeconomic background (measured by family income) has a strong influence on academic performance in children (Claro, Paunesku, & Dweck, 2016). Another study conducted with schoolchildren shows a high, statistically significant correlation between socioeconomic background and academic performance in maths (Suárez-Álvarez, Fernández-Alonso, & Muñiz, 2014). Likewise, socioeconomic status amplifies the achievement gap throughout compulsory education, independent of intelligence (Von Stumm, 2017). Several elements influence academic performance, with socioeconomic background being the greatest predictor in educational achievement in most contexts (Dietrichson, Bøg, Filges, & Klint, 2017). An OECD analysis of the Chilean education system confirmed that access to a quality education is strongly influenced and differentiated by the socioeconomic characteristics of the families in addition to the selection processes of the schools themselves (González, 2017). Other international studies show a similar situation, demonstrating that socioeconomic background is correlated positively with academic performance (Dixson, Keltner, Worrell, & Mello, 2018). However, the differences in academic performance are not related solely to socioeconomic background or student selection, but classroom environment is also a factor, in particular the climate of the school, which habitually undermines the sectors with the greatest social and economic vulnerabilities (Ascorra et al., 2016). The academic self-esteem and school motivation indicator was correlated with academic performance in the three academic areas (language, maths and natural sciences). In this way, a of the educational challenges is fostering motivation in academic achievement and responding to three questions

that the students may ask themselves: can I be successful? Do I want to do this task? And why am I doing this task? To a great extent, the differences in motivation to achieve can be explained by the lack of the students' confidence in their own ability to be successful and in their lack of extrinsic motivation (Eccles & Wigfield, 2015). A study classified students into affective profiles, reporting that those who had a positive profile were more engaged and performed better in a particular subject (Robinson et al., 2017). For this reason, the present results demonstrate that those schools with lower scores in academic self-esteem and motivation will not improve in academic performance. School climate was also correlated with academic performance. Evidence of the relationship between academic performance and classroom climate indicates that an appropriate classroom environment creates a social learning space that favours positive academic results in schools (Maxwell, 2016). Moreover, school climate can even mediate as a protective factor in contexts with students who have an adverse socioeconomic situation (Berkowitz et al., 2017) and students who come from untraditional family structures or circumstances of social risk (O'Malley, Voight, Renshaw, & Eklund, 2015). The school climate can positively influence students' academic results, thus potentially reducing the gaps in academic performance, overcoming even social and economic barriers (Berkowitz et al., 2017). A recently published study in which a structural equations model relating academic performance to eight dimensions of school climate accurately shows that this model explains 39.6 % of the variability of school performance (Cerda, Pérez, Elipe, Casas, & Del Rey, 2019). Therefore, most of the literature suggests that intervening in the classroom climate is fundamental to achieving significant changes in students' well-being and academic performance as well as being a fundamental aspect that should be considered in every country prior to making education reforms (Wang & Degol, 2016). Civic participation and education indicators were correlated with academic performance in language and maths. The Quality Agency considers it fundamental to teach civic participation and education because this is related to the values essential to living in a community and developing virtues for a healthy democratic coexistence. Currently, the crisis of democracy is receiving attention because it has been

spreading within western institutions that were supposed to have been paragons of the democratic ideal and from which many other (non-western) countries were supposed to learn (Muliro, 2017). In this way, while the tradition of a stable political party system and efficient state apparatus seemed to make Chile less vulnerable than many of its neighbours in Latin America, today the country faces an important crisis of political legitimacy (Heiss, 2017). However, the literature is not completely consistent on the matter. There are results from other studies conducted with students of different ages in which the development of practices linked to civic commitment and democratic practices do not show any connection to academic performance or self-efficacy, although there is one study about motivation and levels of happiness (Guillaume, Jagers, & Rivas-Drake, 2015). Another important subject for con- sideration is the political participation within the school, and a study concluded that the influence of school is mainly related to school governance and teacher practices, while the students' civic and political background has the greatest influence in political participation (Treviño, Villalobos, Béjares, & Naranjo, 2019). Healthy habits in the measurement of social and personal development indicators include physical activity, healthy eating, and the prevention of alcohol and tobacco. A study on schoolchildren reported that the compliance with dietary recommendations was associated with an increased likelihood of fulfilling academic expectations in mathematics, reading, and writing (Faught, Ekwaru et al., 2017; Faught, Gleddie, Storey, Davison, & Veugelers, 2017). In addition, it has been shown that physical activity aimed at increasing aerobic capacity and motor skills could have the potential to improve academic performance (Aadland et al., 2017). A systematic review concludes that physical activity is associated with cognition (Esteban-Cornejo, Tejero-Gonzalez, Sallis, & Veiga, 2015). Disturbingly, the 2016 SIMCE reports that only 16 % of students in the second year of secondary school are in the high segment of healthy lifestyles, which is why education policies should consider measures that tend to increase the levels of physical activity in the school population to improve not only health markers, but also biopsychosocial factors. A study show that healthy living habits are decisive in academic performance, even independently of body weight, identifying these

lifestyle behaviours as key factors to consider for improving academic performance during the first years of adolescence (Faught, Ekwaru et al., 2017; Faught, Gleddie et al., 2017).

Limitations.

Some limitations of the present study were not being able to determine differences of gender or ethnicity for each school. Also, all measures of social indicators were self-declared perceptions. Furthermore, it is necessary to continue improving the construction and validation of the questionnaires which the Chilean educational Quality Agency uses to measure the indicators of personal and social development. The great strength of this study is its great sample and which makes it highly representative of the Chilean school population.

Conclusions.

In conclusion, the schools that presented scores ≤70 points in personal and social development indicators had a significant association with no change or deteriorating results on the academic tests assessed. In addition, personal and social development indicators were correlated with academic performance in language, maths and natural sciences, mainly affecting schools that serve students from a low/middle-low socioeconomic background. This finding may be useful in the discussion, design and implementation of public policies and other education initiatives in Chile. Likewise, the Chilean educational system must generate policies that improve equity in education so that socioeconomic factors do not limit the development potential of students. The results highlight how personal and social development indicators affect academic performance. This underscores the need to develop actions that foster the development and permanent evaluation of these indicators in the Chilean educational context, in addition to generating a space for the resignification of the concept of 'education quality', giving relevance to the comprehensive education of the subjects, and understanding the education process as a construct indivisibly bound to the sociocultural character- istics that each subject and group must face.

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Appendix A. Supplementary data Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ijer.2020. 101651.

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9.2 Artículo II.- Association between Creativity and Memory with Cardiorespiratory Fitness and Lifestyle among Chilean Schoolchildren.

Abstract:

The objective was to investigate the association between creativity and memory with cardiorespiratory fitness (CRF; i.e., CRF classification and V̇O2max); lifestyle parameters (i.e., physical activity (PA), sleep duration, screen time (ST), and food habits); and anthropometric measures (i.e., body mass index (BMI), waist circumference (WC)) among Chilean schoolchildren. A total of 248 schoolchildren (137 boys, 111 girls, 11.80 ± 1.17 and 11.58 ± 1.09 years, respectively) participated in the cross-sectional study. Creativity, memory, concentration, and selective attention and lifestyle (PA, ST, sleep duration, and Mediterranean diet (MD) adherence) were measured using a standard questionnaire. CRF (measured by the 20 m shuttle run test and expressed as maximum oxygen consumption (V̇O2max) and anthropometric measures (BMI and WC) were also included. Creativity showed a positive association with V̇O2max (ml/kg/min) (β; 0.209, 95% CI; 0.02–0.40, p = p < 0.05) and MD Adherence (score) (β; 0.206, 95% CI; 0.01; 0.74, p = p < 0.05). Long-term memory reported a positive association with CRF (β; 1.076, 95% CI; 0.02–2.13, p = p < 0.05). An increase in CRF levels, together with healthy food habits and normal nutritional status, should be a target for community- and school-based interventions to promote cognitive development in creativity and memory among schoolchildren.

Keywords: creativity; memory; cardiorespiratory fitness; mediterranean diet; schoolchildren

Introduction

Childhood and adolescence are sensitive periods for cognitive development [1,2]. Executive function is the meta-cognitive function necessary for conducting complex and goal-oriented operations [3]. Executive function plays an important role in children's and adolescents' academic performance [4]. The results of a study by Demetriou et al. [5] indicated that cognitive ability was the strongest predictor of school performance in childhood and adolescence. Similarly, it has been found that different cognitive components related to executive function are associated with academic skills, including creativity and memory [6]. Creativity is an important human activity and is considered a key element to cognition, and among the least investigated [7]. Creativity has also shown a positive association with academic achievement [8], and many authorities have begun to adopt educational policies designed to promote creativity [9]. Memory is not a singular construct, and the most commonly studied types of memory are short-term memory, working memory, and long-term memory [10]. Different cognitive components (i.e., types of memory) are associated with academic skills [6], and attention capacity is a crucial element for comprehension and learning processes [11].

Assessment of physical fitness among schoolchildren should be essential for controlling the health of this population. Adequate cardiorespiratory fitness (CRF) in childhood may be important to the development of cognitive processes [12]. CRF is a direct indicator of an individual's cardiovascular and respiratory systems' overall capacity to perform physical activities [3]. In recent years, the study of cognitive processes has increased in the field of physical activity (PA) [13]. Current evidence suggests that better levels of CRF have positive effects on children's cognition [14]. Aditionally, among children and youth, previous studies have shown that individuals with high levels of CRF had better performances in physical education [3]. Such studies have been consistent in reporting a positive association between CRF and academic performance [3,15]. Regarding creativity, the results of the study by Latorre et al. [12] conducted in children showed that CRF was a predictor for creativity. Likewise, better CRF was also associated with better

memory (i.e., working memory) [16]. A positive relationship between CRF, selective attention and concentration has also been reported [17].

Several mechanisms have been proposed to explain the association of CRF with cognition [18]. For example, subjects who demonstrated better CRF functions (as measured by V˙V˙O2max) show faster reaction times and greater cerebral oxygenation, and cognitive processing is critically dependent on adequate blood flow to respond the energy and oxygen needs of the tissue [19]. Cognitive performance is tightly associated with CRF through cerebrovascular endothelial function and angiogenesis [20]. CRF may benefit brain health and plasticity, possibly via a brain-derived neurotropic factor (BDNF)-regulated mechanism [21].

Children's lifestyle (i.e., diet, PA, etc.) has commonly been studied in the context of health [22]. However, it is reasonable to expect that lifestyle factors are intertwined with cognition and learning processes in children [23]. For example, Kim et al. reported a positive association between school performance and dietary habits [24]. Healthy diet habits (i.e., breakfast consumption), for example, may improve cognitive function and test grades [25]. However, little is known regarding the associations of nutrition with components of executive function in adolescence [26], especially among Chilean schoolchildren. It is important to consider that a Chilean national study of physical education focused on physical condition and anthropometric parameters showed that 70% of students need to improve their CRF [27]. Additionally, in Chile, a high prevalence of children with overweight and obesity have been reported (approximately 44% of students at the age of 13 years old) [28]. Therefore, it is considered a public health problem [22]. In this line, it is important to evaluate the association between CRF and nutritional status with executive function, particularly in Chilean schoolchildren. Likewise, to the best of our knowledge, no other study has explored the association of creativity and memory with CRF, lifestyle, and anthropometric parameters in Chilean schoolchildren.

The objective of the present study was to determine the association between creativity and memory with CRF (i.e., CRF classification and V̇O2max), lifestyle parameters (i.e., PA, screen time, sleep duration, and food habits), and anthropometric measures (i.e., body mass index and waist circumference) among Chilean schoolchildren. A secondary aim was to compare creativity, memory, concentration, and selective attention according to CRF levels (i.e., high and low) and nutritional status.

Materials and Methods

Participants

A descriptive study with a cross-sectional design was developed. A total of 248 schoolchildren (137 boys and 111 girls, 11.80 ± 1.17 and 11.58 ± 1.09 years, respectively) from a subsidized private school, which are financed by a mixture of funding from central government and private contributions [29] in Temuco, Chile participated in the study. The students who attended the school were of the same sociocultural level and lived in the same geographical area (urban). There were 33 subjects excluded (girls not meeting inclusion criteria or other reasons (n = 23); boys not meeting inclusion criteria or other reasons (n = 10)). The sample was intentional and non-probabilistic. The inclusion criteria were: Chilean schoolchildren aged between 10 and 14, without musculoskeletal diseases or physical/medical conditions that might alter the participants' health and physical fitness levels and also children who complete every test administered as part of this study. Schoolchildren with intellectual or physical disabilities were excluded. The investigation complied with the Declaration of Helsinki (2013) and was approved by an Ethics Committee (ABR.19/8.TES Act). This study is part of a Doctoral Thesis. Parents and guardians were informed about the study and provided written signed consent for participation. Additionally, all participants gave their written consent on the day of the assessment.

Figure 1 shows the study design

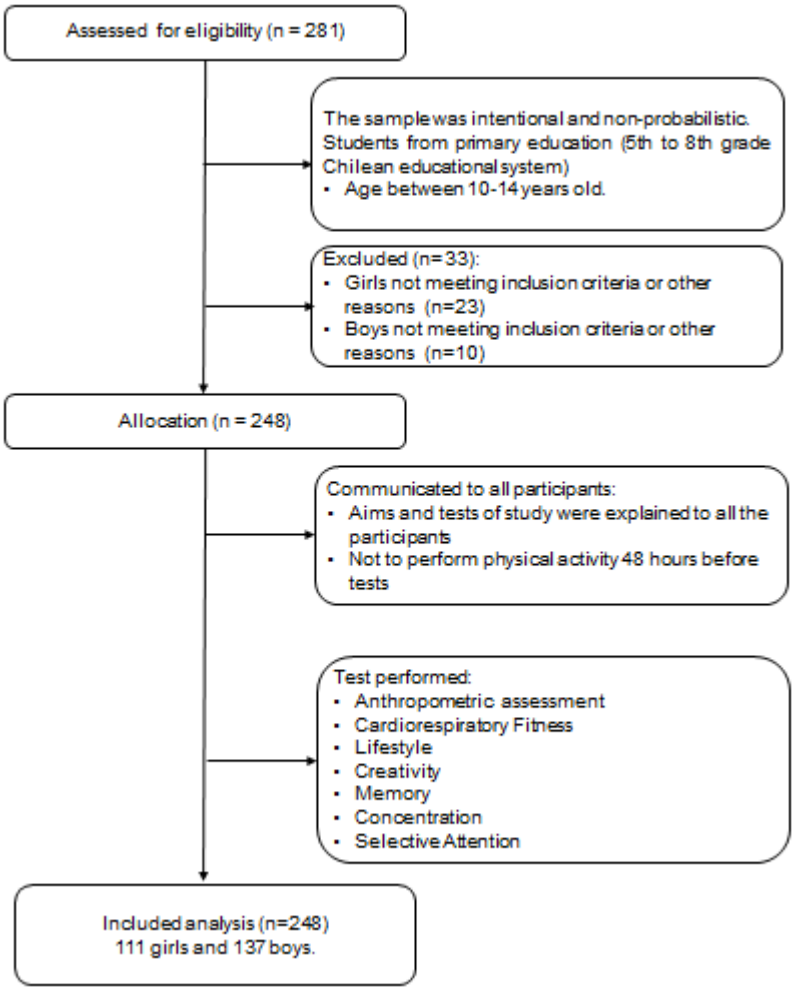

Figure 1. Study design.

Measures

Creativity

Creativity was measured using a CREA test [30] which provides a global quantitative measure of creativity [31]. The test is a timed 4-min divergent thinking test that contains a picture and asks respondents to generate questions about the picture [32]. From an image, the schoolchildren elaborated as many questions as possible for 4 min. A score was assigned to each question according to its quality and complexity based on criteria established by the authors in the manual for the test (1 = low, 2 = medium, 3 = high). In this study, we used the original version in

Spanish. The test manual reports strong reliability, convergent validity with Guilford's divergent thinking tasks [33], and has high and stable correlations over time with other instruments and measures of creativity [32].

Memory

Memory capacity was measured by Ray's Auditory Verbal Learning Test (RAVLT). A list of 15 words (list A) was presented in five consecutive trials, assessing (after each trial) the number of words remembered by the participant. They were immediately shown an interference list (list B), which they were asked to recall from memory. Then, the free memory of the first list of words was requested, and the process was repeated after 20 min [34]. A long-term memory test (after 20 min, at the end of the test battery, participants were asked to recall as many words as possible and to recognize the words within a list of 30 words) was used as an outcome measure [35]. A previous study showed that RAVLT showed reasonable test-retest reliability [36].

Concentration and Selective Attention

Concentration and attention capacity were measured with the d2 Test of Attention (d2), which has reliability from 0.95 to 0.98 [37]. The d2 consists of a paper and pencil test comprising 14 rows, each with 47 randomly interspersed 'p' and 'd' characters. Each character appears with 1 or 2 dashes placed above and/or below it [11]. The test takes 4 min and 30 s to be performed (20 s per line). Concentration was evaluated as: Number of hits—number of mistakes. Likewise, selective attention capacity was calculated as the number of processed elements—(omissions + mistakes) [38].

Cardiorespiratory Fitness

CRF was evaluated by the progressive Léger test. The students run between two parallel lines 20 m away from each other [39]. The last progression executed was recorded and calculated as the V̇O2max (mL/kg/min) using the Equation as follows: V̇O2peak = 31.025 + 3.238 (V) − 3.248 (A) + 0.1536 (VA), where V is the

velocity in km/h reached at the last stage and A stands for the student's age [39]. In addition, students were divided into two groups: High/low CRF (i.e., V̇O2peak outcome) according to previously cut-off points in school population as follows: 42 mL•kg−1•min−1 in boys and 35 mL•kg−1•min−1 in girls [40]. A higher V̇O2peak indicated better CRF.

Mediterranean Diet Adherence

The food habits of schoolchildren were determined by the Krece Plus test which is based on adherence to the Mediterranean diet (MD). The items have a score of +1 or −1 according to the established guidelines. The score from the Krece Plus test was categorized as follows: (1) >8, optimal MD; (2) 4–7, moderate MD adherence; and (3) ≤3, very low diet quality [41]. Higher scores indicate better food habits.

Levels of Physical Activity

A Physical Activity Questionnaire (PAQ-C) was used to measure the PA levels of children. This instrument collects information about schoolchildren's PA during the past 7 days. [42]. Each item has a score between 1 and 5 (i.e., higher score means higher levels of PA). This self-administered instrument reported good reliability [42]. The results for PA are registered and quantified in hours per week.

Screen Time

The Krece Plus test was used to evaluated screen time [43]. This test is a quick questionnaire that classifies lifestyle based on the average number of hours spent watching television or playing video games daily.

Sleep Duration

To evaluate children's sleep duration, parents completed the Pediatric Sleep Questionnaire [44]. Parents or guardians answered questions referring to the quality and quantity of their children's sleep. Correspondingly, this questionnaire has been reported with good reliability [45].

Anthropometric Assessment

A TANITA scale (model UM–028, Tokyo) was used to evaluate the children's weight (kg). Children's height (m) was measured with a Seca® stadiometer (model 214, Hamburg, Germany). BMI was used to classify the nutritional status as follows: BMI ≥than 95th percentile and overweight as a BMI ≥than percentile 85th among children of the same age and sex [46]. A Seca® tape (model 201, Hamburg, Germany) was used to measure the waist circumference according to the previously described protocols [47].

Procedure

Research assistants attended the school during the 2019 school year in Chile, and carried out the assessments on those children who had the consent of parents and also gave their own assent. The evaluations were carried out over four separate sessions by a team of researchers trained in conducting the different tests. CRF was assessed in the first session: Prior to the testing sessions, the children performed a typical warm-up. In the second session, anthropometric assessments were carried out in a favourable space facilitated by the school. Then, lifestyle surveys were applied in the classrooms. A cognitive test was applied in a classroom and divided into the creativity plus memory (third session) and d2 test (final session). The questionnaires and cognitive instruments were completed individually and in the presence of researchers (they respected data confidentiality and clarified any potential doubts or questions). All the evaluations took place during the physical education classes in the morning. Parents completed the Pediatric Sleep Questionnaire during the first 2 weeks. Researchers returned to one more session to work with children whose measurements were missing.

Statistical Analysis

Statistical analyses were performed using SPSS version 21.0 (SPSS Inc., Chicago, IL, USA). The Kolmogorov–Smirnov test and Levene's test were used for the normal distribution of data and homogeneity of variances. Continuous variables were expressed as means and confidence intervals. Differences in the comparison

between sex, CRF, and nutritional status groups were determined using an analysis of variance (ANOVA) test. The Bonferroni test was performed to detect differences between nutritional status groups.

To determine the association between creativity and memory with physical fitness, lifestyle, and anthropometrics parameters, a simple linear regression was used. The Chi-Squared test was applied to compare proportions according to sex and nutritional level. The multivariate analysis of variance (ANCOVA) was conducted with CRF groups and cognitive variables for grouping variables and sex, age and BMI as covariates. Cohen's D was performed to determine the effect size. The significance level was set at $p < 0.05$.

Results

A total of 248 schoolchildren were included (Table 1). When analysing the sex groups separately, boys had significantly better scores in PA week (h) (2.58 vs. 2.16 $p = 0.014$) and $V\dot{O}2max$ (ml/kg/min) (42.18 vs. 40.62, $p = 0.001$) than girl peers. Girls performed significantly better in long-term memory than boys (8.96 vs. 8.02, $p = 0.001$). There were no significant differences in creativity ($p = 0.699$), concentration ($p = 0.137$), and selective attention ($p = 0.246$) according to sex.

Table 1. Characteristics of the children participants according to sex groups at the level of anthropometry, cardiorespiratory fitness, physical activity patterns, creativity, memory, concentration, and selective attention.

	Total (248)	Girls (111)	Boys (137)	*p*-Value	Cohen's d
Age (y)	11.70 (11.6,11.8)	11.58 (11.4, 11.8)	11.80 (11.6,12.0)	$p = 0.132$	0.193
Anthropometric variables					
BMI	22.06 (21.6, 22.5)	22.14 (21.5, 22.8)	21.99 (21.3, 22.7)	$p = 0.746$	−0.041
Obesity prevalence¶					
Normal weight, (*n* = /%)	109 (44)	46 (41.4)	63 (46)		0.383
Overweight, (*n* = /%)	76 (30.6)	39 (35.1)	37 (27)		
Obesity, (*n* = /%)	63 (25.4)	26 (23.4)	37 (27)		
WC (cm)	77.57 (76.3, 78.8)	76.70 (75.0, 78.4)	78.25 (76.4, 80.1)	$p = 0.235$	−0.015
Lifestyle/fitness					
Physical activity week (h)	2.39 (2.2, 2.6)	2.16 (1.9, 2.4)	2.58 (2.3, 2.8)	$p = 0.014$	0.154
Sleep duration (h/day)	8.48 (8.4, 8.6)	8.48 (8.3, 8.6)	8.48 (8.3, 8.6)	$p = 0.977$	0.003
ST (h/day)	2.90 (2.7, 3.1)	2.99 (2.7, 3.2)	2.82 (2.6, 3.0)	$p = 0.337$	−0.124
MD Adherence (score)	5.96 (5.63, 6.28)	5.85 (5.43, 6.37)	6.05 (5.63, 6.47)	$p = 0.561$	0.078
$\dot{V}O_{2max}$ (ml/kg/min)	41.49 (41.0, 42.0)	40.62 (40.0, 41.3)	42.18 (41.5, 42.9)	$p = 0.001$	0.426
Cognitive Measures					
Creativity (score)	10.64 (10.2, 11.1)	10.54 (9.8, 11.2)	10.72 (10.1, 11.3)	$p = 0.699$	0.049
Memory (score)	8.45 (8.2, 8.7)	8.96 (8.5, 9.4)	8.02 (7.6, 8.4)	$p = 0.001$	−0.420
Concentration (score)	130.98 (126.7, 135.3)	127.36 (120.6, 134.1)	133.88 (128.3, 139.4)	$p = 0.137$	0.191
Selective Attention (score)	321.69 (311.4, 332.0)	314.91 (299.2, 330.6)	327.13 (313.4, 340.8)	$p = 0.246$	0.149

Data are presented as mean with 95% confidence interval (CI). Values of $p < 0.05$ were considered statistically significant. BMI: Body mass index; WC: Waist circumference; ST: Screen time; MD: Mediterranean diet; $\dot{V}O_{2max}$: Maximal oxygen consumption. Obesity prevalence calculated based on the CDC criteria.

When analysing the CRF (high/low) groups separately, schoolchildren with higher CRF reported significantly better long-term memory than lower CRF peers after adjusting for by age, sex, and BMI. There were no significant differences in creativity according to the CRF groups after adjusting for age, sex, and BMI. For selective attention and concentration, there were no significant differences, although schoolchildren with higher CRF obtained better scores than lower CRF peers (Table 2).

When analysing the nutritional status groups separately, children with obesity reported lower creativity and long-term memory than normal weight children ($p < 0.05$). Additionally, children with obesity had lower scores in MD adherence ($p <$

0.05), V ̇O2max (mL/kg/min) (p < 0.001) and presented more ST (p < 0.001) (Table 3).

Table 2. Creativity, memory, concentration, and selective attention variables by cardiorespiratory.

	High-CRF (164)	Low-CRF (69)	*p*-Value	Cohen's d
Creativity (score)	11.15 (10.6, 11.7)	9.65 (8.8, 10.5)	NS	0.425
Memory (score)	8.88 (8.5, 9.2)	7.39 (6.9, 7.9)	$p < 0.05$	0.673
Concentration (score)	133.22 (127.7, 138.7)	126.43 (119.3, 133.6)	NS	0.199
Selective Attention (score)	324.09 (311.2, 337.0)	316.90 (299.9, 333.9)	NS	0.106

Data are presented as mean with 95% confidence interval (CI). Values of $p < 0.05$ were considered statistically significant after adjusting for sex, age, and BMI. CRF: cardiorespiratory fitness; NS: No considered statistically significant.

Table 3. Creativity, memory, concentration, selective attention variables, and lifestyle by nutritional

	Normal (109) A	Overweight (65) B	Obesity (74) C	*p*-Value	Post-Hoc
Creativity (score)	11.24 (10.6, 11.9)	11.19 (10.4, 12.0)	8.93 (8.1,9.8)	$p < 0.001$	A > C
Memory (score)	9.33 (9.0, 9.7)	7.51(7.0, 8.0)	8.05 (7.4,8.7)	$p < 0.001$	A > B,A > C
Concentration (score)	134.03 (127.9, 140.2)	132.72 (124.0, 141.4)	123.63 (115.5,131.8)	0.138	
Selective Attention (score)	335.63 (320,6, 350.7)	307.69 (288.4, 327.0)	314.22 (293.5,335.0)	0.053	
Screen time (h/day)	2.9 (2.69, 3.22)	2.5 (2.23, 2.78)	3.2 (2.92,3.58)	$p < 0.05$	C > B
MD Adherence (score)	6.38 (5.93, 6.82)	6.36 (5.72, 7.0)	4.77 (4.17,5.37)	$p < 0.001$	C < A,C < B
$\dot{V}O_{2max}$ (ml/kg/min)	42.28 (41.48, 43.09)	41.63 (40.86, 42.40)	39.90 (39.11,40.69)	$p < 0.001$	C < A,C < B

Data are presented as mean with 95% confidence interval (CI). Values of $p < 0.05$ were considered statistically significant.

In the total sample, creativity showed an association with V ̇O2max (ml/kg/min) (β; 0.209, 95% CI; 0.02–0.40, p = p < 0.05) and with MD adherence (score) (β; 0.206, 95% CI; 0.01; 0.74, p = p < 0.05). Long-term memory showed an association with

CRF (β; 1.076, 95% CI; 0.02–2.13, p = p < 0.05) and an inverse association with MD adherence (β; −0.155, 95% CI; −0.28–−0.03, p = p < 0.05) (Table 4). Moreover, long-term memory showed an inverse association with BMI (β; −0.167, 95% CI; −0.33–−0.01, p = p < 0.05).

Table 4. Association of creativity and memory score with socio-demographic, anthropometric, lifestyle, and cardiorespiratory fitness variables in schoolchildren

Outcomes	Creativity			Memory		
	Beta (95% CI)	*p*-Value	Standardised Beta (SE)	Beta (95% CI)	*p*-Value	Standardised Beta (SE)
Age (y)	0.471 (0.02; 0.92)	$p = 0.039$	0.14 (0.23)	0.345 (0.05; 0.64)	$p = 0.023$	0.16 (0.15)
Anthropometric variables						
BMI (kg/m²)	−0.022 (−0.27; 0.22)	$p = 0.859$	−0.02 (0.12)	−0.167 (−0.33; −0.01)	$p < 0.05$	−0.27 (0.08)
WC (cm)	0.000 (−0.09; 0.09)	$p = 0.994$	0.00 (0.05)	0.004 (−0.06; 0.06)	$p = 0.909$	0.02 (0.03)
Lifestyle						
PA/week (h)	0.347 (−0.04; 0.74)	$p = 0.994$	0.13 (0.20)	0.041 (−0.22; 0.30)	$p = 0.753$	0.02 (0.13)
PAC score	−0.025 (−0.10; 0.05)	$p = 0.519$	−0.05 (0.04)	0.005 (−0.05; 0.05)	$p = 0.850$	0.01 (0.03)
Sleep duration (h/day)	0.410 (−0.01; 0.94)	$p = 0.132$	0.10 (0.27)	−0.039 (−0.40; 0.32)	$p = 0.832$	−0.01 (0.18)
Screen time (h/day)	−0.293 (−0.66; 0.07)	$p = 0.116$	−0.11 (0.19)	0.020 (−0.22; 0.26)	$p = 0.874$	0.01 (0.12)
MD Adherence (score)	0.206 (0.01; 0.74)	$p < 0.05$	0.015 (0.99)	−0.155 (−0.28; −0.03)	$p < 0.05$	−0.17 (0.07)
Physical fitness						
$\dot{V}O_{2max}$ (ml/kg/min)	0.209 (0.02; 0.40)	$p < 0.05$	0.22 (0.10)	−0.001 (−0.13; 0.12)	$p = 0.988$	0.00 (0.06)
High CRF (Ref. Low)	0.197 (−1.39; 1.79)	$p = 0.807$	0.03 (0.81)	1.076 (0.02; 2.13)	$p < 0.05$	0.21 (0.53)

Data shown represent beta and 95% confidence interval (95% CI), and standardized beta and standard error (SE). Values of $p < 0.05$ were considered statistically significant. Model adjusted by sex. BMI: Body mass index; WC: Waist circumference; PA: Physical activity; MD: Mediterranean diet; $\dot{V}O_{2max}$: Maximal oxygen consumption; CRF: Cardiorespiratory fitness; PAC: Physical activity questionnaire.

Discussion

In the present study, the objective was to determine the association between creativity/memory and CRF, lifestyle parameters, and anthropometric measures in Chilean schoolchildren. A secondary aim was to compare creativity, memory, concentration, and selective attention according to CRF levels (i.e., high and low) and nutritional status. The main findings of this study were, first, creativity was associated with V ̇O2max (mL/kg/min) and with MD adherence (score), while long-term memory was associated with CRF and BMI. Second, schoolchildren with

higher CRF reported significantly better long-term memory than lower CRF peers after adjusting for age, sex, and BMI. Third, children with obesity reported lower creativity and long-term memory than normal weight children ($p < 0.05$).

In this study, creativity was positively associated with $V\dot{O}2max$ and with MD adherence (score), this is in line with Latorre et al. [12], who reported that the highly creative group performed better in a CRF test than children with lower creativity levels. Moreover, the authors indicated that CRF was a predictor of creativity in schoolchildren. Likewise, Piya-amornphan et al. [48] reported a positive correlation between PA and creativity ability in adolescents. Similarly, Florence et al. [49] showed an association between diet quality and academic performance in Canadian schoolchildren, while Hidalgo et al. indicated that children with higher CRF had better creativity levels using the CREA test in Spanish adolescents [50]. Likewise, it has been reported that creativity is positively related to school achievement, and the authors demonstrated that middle school may be an especially creative period in adolescents' development [51]. Therefore, it is essential to research how to stimulate creativity in school-age children [52]. We found that creativity reported a positive association with MD adherence. Concerning food habits, another study reported that a poor-quality diet negatively affects hippocampal function and thereby impairs performance of cognitive tasks such as creativity [53]. Similarly, a higher quality diet index and ideal diet (i.e., MD adherence score) were associated with better cognitive function in adolescents. The authors concluded that this association was strong enough to be relevant from a public health perspective [26]. Similarly, it has been indicated that diet habits are important among schoolchildren since they have high brain metabolic needs [24]. It is important to considerer that in Chilean schoolchildren, unhealthy lifestyle patterns such as low adherence to MD, could be explained by socio-economic status [54].

In this study, long-term memory was associated with CRF, and schoolchildren with higher CRF reported significantly better long-term memory after adjusting for age, sex, and BMI. Therefore, the study indicated that less fit preadolescents (i.e., lower

CRF levels) had poorer memory recognition compared with more fit children [55]. Likewise, a cross-sectional study reported that CRF was positively correlated with working memory in male Spanish schoolchildren, and children in higher CRF and executive function categories obtained betters academic performance (i.e., mathematics and language) than children in lower categories [56]. Similarly, it has been reported that less fit preadolescent children had poorer relational memory task and smaller hippocampal volume compared to higher CRF preadolescent children, and the authors also indicated that it is fundamental to understand the neurocognitive benefits of an active lifestyle in educational and public health areas [57]. Another study showed that CRF was associated with working memory and reaction time [16]. Despite these associations, no relationships have been found between CRF and verbal working memory in primary schoolchildren [7]. Moreover, in this study, girls performed significantly better in long-term memory than boys. In this sense, a meta-analysis of sex differences in memory showed an overall female advantage in episodic memory task. Additionally, the authors indicated that the sex differences for verbal episodic memory tasks which are smaller in childhood than during other age periods, may indicate that fluctuating endogenous sex hormones and environmental influence contribute to the variation [58]. On the other hand, another study reported that several differences between gender in some executive function (i.e., reaction time in inhibition, cognitive flexibility) and language, were higher for girls but not in episodic memory [56].

In the present study, BMI was inversely associated with long-term memory. In addition, children with obesity reported lower creativity and long-term memory than normal weight children. In this sense, the evidence has shown an association between obesity and low cognition in children and adolescents, where children with obesity reported poor cognitive function compared with normal weight peers [59]. In this line, obesity in children has been associated with impaired cognitive function, poorer academic performance [60], reduction of executive cognitive performance on neuropsychological evaluations, and presented differences in brain structures related to learning, memory, and executive functions [61].

On the other hand, in this study, there were no significant differences in concentration and selective attention according to nutritional status groups. Contrary to our results, it has been reported that students with obesity presented worse results than normal peers in the d2 test (i.e., selective attention) [62]. In addition, previous studies indicated that deficits in attention, working memory, and sustained attention decrements do exist among overweight/obese adolescents [63,64]. However, other authors showed that there was no association between sustained attention and BMI [65]. In addition, another study reported that obese and non-obese children had similar results in attention and concentration [66]. Future studies on the current topic are therefore recommended to clarify these controversial results. Likewise, children with obesity had lower scores in MD adherence, V˙O2max (ml/kg/min), and presented more ST. In this sense, a previous study reported that obese students had lower scores in MD and V˙O2max compared with their normal weight peers [67].

For selective attention and concentration, there were no significant differences after adjusting for age, sex, and BMI, but schoolchildren with higher CRF obtained better scores than lower CRF peers. We believe that these results diverge from other studies since the sample was relatively small and the high CRF groups had more participants. In this sense, and contrary to our results, another study reported that children with high fitness levels (i.e., CRF, speed, and change of direction) had significantly better cognitive performance (i.e., selective attention and concentration using d2 tests) compared to children with low fitness levels. That study also indicated that CRF was the variable that explained the largest variance in the relationship between cognitive functioning and fitness [17]. Another previous study indicated that CRF was one of the variables of physical fitness that best explains the association with selective attention and concentration [68]. Reigal et al. [69] conducted a study of Spanish adolescents and showed that adolescents who practised more exercise per week obtained better scores in selective attention, concentration, and processing speed. CRF was also the best predictor of

test scores to evaluate cognitive function. Pontifex et al. [70] have provided evidence that less fit children (i.e., low CRF) had reduced capacity to allocate attentional resources, greater response conflict, and slower processing speed than their more fit counterparts. Additionally, Ruíz-Ariza et al. [18] have indicated that variables relating to executive function such as memory, selective attention or concentration play important roles in cognitive performance among adolescents.

The main limitation of the present investigation is its cross-sectional design. These variables should be measured in a longitudinal study to clarify the direction of the associations. This study included the use of a convenience sample, and the results are not necessarily representative of the national population. Another limitation was that cognitive measures were obtained using a write-report instrument. Moreover, we did not carry out the analyses by biological maturation age or socioeconomic status. There is a limitation due to the Chilean educational system, in which children belonging to educational establishments with fewer resources most affected their healthy lifestyle (i.e., foods habits and PA patterns).

In conclusion, creativity was associated with CRF and MD adherence and memory was associated with CRF (i.e., CRF classification and $\dot{V}O_2max$) and BMI in Chilean schoolchildren. Children with high CRF levels performed better in creativity and memory than those with low CRF levels. Likewise, children with obesity reported lower creativity and long-term memory than normal weight children. Likewise, children with obesity had lower scores in MD adherence, $\dot{V}O_2max$ (ml/kg/min), and presented more ST.

Therefore, a physical fitness assessment and healthy lifestyle of schoolchildren should be essential for controlling the health of this population. In addition, an increase in CRF levels together with healthy food habits and normal BMI among these children should be a target for community- and school-based interventions to promote cognitive development such as creativity and memory.

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Abbreviations: BMI: Body mass index; CRF: Cardiorespiratory fitness; MD: Mediterranean diet; WC: Waist circumference; PA: Physical activity; ST: Screen time; V̇O2max: Maximal oxygen consumption.

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9.3 Artículo III. - Selective attention and concentration are related to lifestyle in Chilean schoolchildren.

Abstract:

The objective of this investigation was to determine the association between selective attention and concentration with physical fitness (i.e., cardiorespiratory fitness (CRF), V̇O2max, the standing long jump test (SLJ) and handgrip muscle strength (HGS)), lifestyle parameters (i.e., physical activity (PA) level, screen time (ST), sleep duration and food habits) and anthropometric measures (i.e., body mass index (BMI) and waist circumference (WC)) among Chilean schoolchildren. Two hundred and forty-eight schoolchildren (137 boys, 111 girls, 11.80 ± 1.17 and 11.58 ± 1.09 years, respectively) participated. Selective attention, concentration and lifestyle (PA, ST, sleep duration and Mediterranean diet (MD) adherence) were determined using a standard questionnaire. CRF, SLJ, HGS and anthropometric indicators (BMI and WC) were also measured. Selective attention showed a positive association with MD adherence score (β; 5.012, p = p < 0.05). Concentration was linked inversely to ST (β; −5.498, p = p < 0.05). Likewise, concentration presented a positive association with MD adherence (β; 2.904, p = p < 0.05). In conclusion, children's lifestyles are related to the selective attention and concentration of children; therefore, promoting healthy habits could be a cost-effective strategy in the promotion of cognitive development, as it relates to selective attention and concentration.

Keywords: executive function; cognition; dietary patterns; screen time; schoolchildren

Introduction

School age is a critical stage for cognitive development [1]. In this sense, executive function is a meta-cognitive process necessary for conducting complex and goal-oriented operations [2] that include the follow capacities: inhibitory control, working memory, attention and planning [3]. In this context, executive function plays a

fundamental role in children's learning [4] and is essential for the development of academic skills [5], as evidence has shown that higher levels of executive function are related to better fluid intelligence and success in school [6]. Selective attention allows for the processing of different stimuli [7] by suppressing attention to other distracting stimuli [6]. Recently, empirical evidence has confirmed that it is a crucial element for comprehension and learning processes [8]. It has been indicated that concentration is the capacity to maintain attention with precision [9]. In addition, it has been reported that good concentration improves schoolchildren's performances on academic tests [10]. In this context, one study showed that attention and concentration are fundamental in cognitive performance [11].

The study of executive function has increased in recent years [12]. A recent study reported that healthy lifestyle factors were positively associated with executive functions in schoolchildren [13]. Likewise, a recent systematic review and meta-analysis indicated that healthy lifestyle factors (e.g., physical activity (PA)) are important for improving executive function [14]. For example, Jirout et al. indicated that although children's lifestyles have been investigated in the context of health, they are also related with cognition processes in schoolchildren [15]. It has been established that a good lifestyle plays a fundamental role in maintaining cognitive processes into old age [16]. More specifically, the quality of nutrition is a fundamental component of healthy lifestyle behaviours of school-age children [17]. Evidence has shown that a Western diet (i.e., high in refined carbohydrates and saturated fat) may damage brain function [18]. In addition, at this age, the brain's neuroplasticity is higher; therefore, a low quality of diet may negatively affect the brain's neurodevelopment and cognitive function [19]. Previous studies have confirmed that dietary habits during childhood are related to learning processes [15] and cognition in schoolchildren [20]. A recent study reported that schoolchildren with better food habits had better cognitive performance [21]. Recently, it was shown that good food habits were positively associated with academic performance [22]. In addition, Allom et al. reported that poor executive function is related to unhealthy eating behaviour [23]. On the contrary, healthy

dietary habits, for example, may improve cognitive function and test grades [24]; nonetheless, little is known regarding the relation of diet quality with selective attention and concentration among Chilean schoolchildren [13]. Additionally, more investigations are needed to estimate the effects of healthy food habits on cognitive performance in students [25].

There is a growing interest regarding the impacts of screen time (ST) on cognitive processes [26]. A recent study indicated that a low level of ST was associated with better cognitive function [27]. In this sense, unhealthy lifestyle factors, such as excessive ST, could have negative effects on executive function [28]. Likewise, it has been indicated that ST affects the accuracy of cognitive tasks [29]. Similarly, a previous study has shown that inappropriate ST has negative consequences on cognitive function and other areas related to health [30]; however, a systematic review reported that ST had no negative effects on cognitive development [31]. Therefore, more investigation related to ST and executive function are needed [28]. Along this same line, it is important to evaluate the association between a healthy lifestyle and selective attention and concentration. In addition, to the best of our knowledge, no other investigation has analysed the association of selective attention and concentration with ST recommendations and good food habits in Chilean schoolchildren.

The objective of this investigation was to determine the association between selective attention and concentration with physical fitness (i.e., cardiorespiratory fitness (CRF) classification, $V\dot{O}2max$, the standing long jump test (SLJ) and handgrip muscle strength (HGS)), lifestyle parameters (i.e., physical activity (PA) level, ST, sleep duration and food habits) and anthropometric measures (i.e., body mass index (BMI) and waist circumference (WC)) among Chilean schoolchildren. A secondary objective was to compare selective attention and concentration according to ST classifications (<2 h = low ST; ≥2 h = high ST) and Mediterranean diet (MD) adherence levels.

Materials and Methods

Participants

This cross-sectional study included 248 schoolchildren (137 boys and 111 girls, 11.80 ± 1.17 and 11.58 ± 1.09 years, respectively) from a subsidised private school in Temuco (Chile). These schools are financed by a mixture of funding from the central government and private contributions [32]. A prior sample size was performed using G*Power software. The following parameters were selected for ANOVA: effect size f = 0.250, α level of 0.05, power level of 0.95, two groups, critical F = 3.886 and a non-sphericity parameter of λ = 13.125. The sample size was determined to be at minimum 210 participants. The sample was determined by convenience. The inclusion criteria were that participants must be Chilean schoolchildren between 10 and 14 years of age and not have any medical conditions or musculoskeletal disorders that might alter their health and physical fitness results. Likewise, schoolchildren with physical, sensorial or intellectual disabilities were excluded. In addition, schoolchildren with missing data and/or who did not present written signed consent were omitted, the study design is shown in Figure 1. The study complied with the Declaration of Helsinki (2013) and was authorised by an Ethics Committee (ABR.19/8.TES Act). The present investigation is part of a doctoral thesis. Informed consent was obtained from all participants. In addition, parents and guardians provided written signed consent for participation.

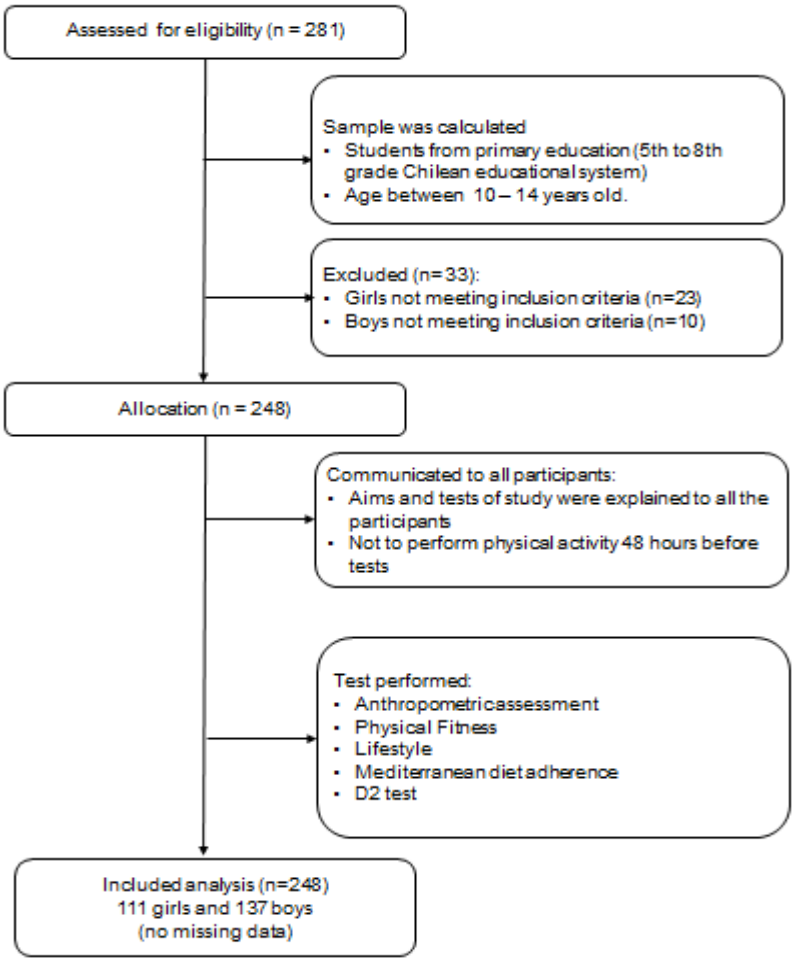

Figure 1. Study design.

Measures

Executive Functions

Concentration and attention capacity were obtained using the d2 test [33]. Previous studies have used this test in populations of schoolchildren [9,34]. The d2 consists of a paper and pencil test composed of 14 rows, each with 47 randomly alternated "p" and "d" characters. Each character appears with 1 or 2 dashes placed above and/or below it [8]. Concentration was determined as: number of hits – number of mistakes. Likewise, selective attention was obtained as the number of processed elements – (omissions + mistakes) [34].

Physical Fitness

Cardiorespiratory fitness was determined with the Léger test according to previous indications [35]. The $\dot{V}O_2max$ (mL/kg/min) was determined using the following equation: $\dot{V}O_2peak = 31.025 + 3.238 (V) − 3.248 (A) + 0.1536 (VA)$, where V is the velocity in km/h achieved at the last stage, and A stands for the participant's age [35]. High/low CRF was established according to previously determined cut-off points [36]. The SLJT was executed. Each student jumped twice, and the best result was recorded [37]. Handgrip strength was evaluated using a hand dynamometer (TKK 5101TM, Grip D; Takei, Tokyo, Japan) according to previously described protocols [38]. The test was performed twice, and the maximum score for each hand was recorded in kilograms. The grip adjustment was made according to the recommendations of Ruiz et al. [39].

Mediterranean Diet Adherence

Food habits were measured by the Krece Plus test, which is based on adherence to the MD. The score from the test was divided as follows: (1) >8, optimal MD; (2) 4–7, moderate; (3) ≤3, very low-quality diet [40].

Levels of Physical Activity

A Physical Activity Questionnaire (PAQ-C) was used to determine the PA levels of the participants. The questionnaire collects information about schoolchildren's PA over the past seven days [41]. The results for PA were quantified in hours per week.

Screen Time

To evaluate children's screen time, we used the Krece Plus [42]. This test classifies lifestyle based on the average number of hours spent watching television or playing video games daily. In addition, the participants were divided into two ST groups (<2 h = low ST; ≥2 h = high ST) according to previous indications [43].

Sleep Duration

The Pediatric Sleep Questionnaire was used to determine sleep duration [44]. Parents answered questions referring to the quality and quantity of their children's sleep.

Anthropometric Assessment

A TANITA scale (model UM–028, Tokyo) was used to measure the children's weight (kg). The children's height (m) was calculated with a Seca® stadiometer (model 214, Hamburg, Germany). BMI was calculated following the international formula [45]. A Seca® tape (model 201, Hamburg, Germany) was used to register the waist circumference according to previous recommendations [46].

Procedure

Research assistants visited the selected school during 2019. Parents answered the sleep hour questionnaire during the first two weeks. The evaluations were carried out over four separate sessions by a team of researchers trained in conducting the different tests. CRF, SLJ and HGS were assessed in the first session: 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. In the second session, anthropometric assessments were carried out in a favourable space facilitated by the school with optimum temperature, reliable privacy and light clothing. Then, lifestyle surveys were applied in the classrooms. A cognitive test was applied in a classroom (final session).

Statistical Analysis

The statistical analyses were developed by SPSS version 21.0 (SPSS Inc., Chicago, IL, USA). The normal distribution was evaluated by the Kolmogorov–Smirnov test. Differences in the comparison between sex, ST and MD adherence groups were determined using an analysis of variance (ANOVA) test. To determine the association between selective attention and concentration and a child's lifestyle, a simple linear regression and the inclusion of beta (β with 95% confidence intervals (CIs)) were used. The effect size (ES) was calculated using Cohen's d. Results with a $p < 0.05$ were considered statistically significant.

Results

Table 1 shows the sociodemographic, anthropometric, lifestyle and executive function characteristics according to sex. Boys reported significantly better scores in $V\dot{O}2max$ (ml/kg/min) ($p = 0.001$), HGS right ($p = 0.001$), HGS left ($p = 0.000$), SJL ($p = 0.000$), PA week ($p = 0.014$) and PAC score ($p = 0.000$) than their female peers.

Table 1. Baseline characteristics of the schoolchildren participants by sex at the level of anthropometry, cardiorespiratory fitness, physical activity patterns, concentration and selective attention.

	Total (248)	Girls (111)	Boys (137)	*p*-Value	Cohen's d
Age (y)	11.70 (11.6, 11.8)	11.58 (11.4, 11.8)	11.80 (11.6, 12.0)	$p = 0.132$	0.193
Anthropometric/body composition					
Body mass (kg)	52.82 (51.3, 54.4)	51.66 (49.6, 53.7)	53.77 (51.5, 56.1)	$p = 0.183$	0.171
BMI	22.06 (21.6, 22.5)	22.14 (21.5, 22.8)	21.99 (21.3, 22.7)	$p = 0.746$	−0.041
WC (cm)	77.57 (76.3, 78.8)	76.70 (75.0, 78.4)	78.25 (76.4, 80.1)	$p = 0.235$	−0.015
Lifestyle/fitness					
Physical activity week (h)	2.39 (2.2, 2.6)	2.16 (1.9, 2.4)	2.58 (2.3, 2.8)	$p = 0.014$	0.154
PAC (score)	28.84 (27.98, 29.69)	26.80 (25.71, 27.89)	30.49 (29.27, 31.70)	$p = 0.000$	
Sleep duration (h/day)	8.48 (8.4, 8.6)	8.48 (8.3, 8.6)	8.48 (8.3, 8.6)	$p = 0.977$	0.003
ST (h/day)	2.90 (2.7, 3.1)	2.99 (2.7, 3.2)	2.82 (2.6, 3.0)	$p = 0.337$	−0.124
MD Adherence (score)	5.96 (5.63, 6.28)	5.85 (5.43, 6.37)	6.05 (5.63, 6.47)	$p = 0.561$	0.078
$\dot{V}O_{2max}$ (ml/kg/min)	41.49 (41.0, 42.0)	40.62 (40.0, 41.3)	42.18 (41.5, 42.9)	$p = 0.001$	0.426
HGS Right (kg)	22.13 (21.43, 22.83)	20.77 (19.94, 21.60)	23.21 (22.16, 24.25)	$p = 0.001$	−0.452
HGS Left (kg)	20.33 (19.63, 21.02)	18.73 (17.93, 19.52)	21.61 (20.58, 22.64)	$p = 0.000$	−0.548
SLJ (cm)	120.94(117.62, 124.26)	108.03(104.23, 111.83)	131.50(127.05, 135.95)	$p = 0.000$	1.008
Cognitive Measures					
Selective Attention (score)	321.69 (311.4, 332.0)	314.91 (299.2, 330.6)	327.13 (313.4, 340.8)	$p = 0.246$	0.149
Concentration (score)	130.98 (126.7, 135.3)	127.36 (120.6, 134.1)	133.88 (128.3, 139.4)	$p = 0.137$	0.191
Total attempts (number)	346.99(336.40, 357.57)	342.80(327.19, 358.41)	350.35(335.80, 364.90)	$p = 0.486$	−0.089
Total hits (number)	140.61(136.47, 144.74)	138.09(131.85, 144.34)	142.63(137.06, 148.19)	$p = 0.284$	−0.138
Omissions (number)	15.96 (13.31, 18.62)	17.16 (12.74, 21.59)	15.00 (11.75, 18.25)	$p = 0.426$	0.103
Commissions (number)	9.47 (8.11, 10.82)	10.73 (8.27, 13.19)	8.45 (7.01, 9.90)	$p = 0.101$	0.192

Data are presented as the mean with a 95% confidence interval (CI). $p < 0.05$ was considered statistically significant. BMI = body mass index, WC = waist circumference, ST = screen time, MD = Mediterranean diet, $\dot{V}O_{2max}$ = maximal oxygen consumption, HGS = handgrip strength and SLJ = standing long jump.

In the association between executive function and lifestyle parameters, in model 0 (not adjusted) and model 1 (adjusted by age and sex), selective attention showed a positive association with MD adherence score (β; 5.612, p = p < 0.05) and (β; 5.012, p = p < 0.05), respectively. Concentration had an inverse association with ST h/day in model 0 (β; −5.569, p = p < 0.05) and model 1 (β; −5.498, p = p < 0.05). Moreover, concentration showed a positive association with MD adherence score in model 0 (β; 2.864, p = p < 0.05) and model 1 (β; 2.904, p = p < 0.05) as seen in Table 2.

Table 2. Association of selective attention and memory score with sociodemographic, anthropometric, lifestyle and fitness variables in schoolchildren.

Outcomes		Selective Attention			Concentration		
		Beta (95% CI)	*p*-Value	Standardised Beta (SE)	Beta (95% CI)	*p*-Value	Standardised Beta (SE)
Anthropometric variables							
Body weight (Kg)	Model 0	−0.451 (−3.18;2.28)	$p = 0.745$	−0.07 (1.39)	−0.214 (−1.34; 0.92)	$p = 0.709$	−0.08 (0.57)
	Model 1	−0.642 (−3.35; 2.07)	$p = 0.641$	−0.09 (1.379	−0.169 (−1.28:0.94)	$p = 0.765$	−0.05 (0.56)
BMI (kg/m^2)	Model 0	−0.085 (−8.59; 8.43)	$p = 0.984$	0.00 (4.31)	−0.337 (−3.86; 3.18)	$p = 0.850$	−0.04 (1.78)
	Model 1	−0.122 (−8.58: 8.34)	$p = 0.977$	−0.00 (4.29)	−0.511 (−3.98;2.96))	$p = 0.772$	−0.05 (1.76)
WC (cm)	Model 0	0.536 (−1.90; 2.97)	$p = 0.664$	0.07 (1.23)	0.365 (−0.64; 1.37)	$p = 0.475$	0.11 (0.51)
	Model 1	0.796 (−1.61: 3.20)	$p = 0.515$	0.09 (1.22)	0.408 (−0.58;1.39)	$p = 0.417$	0.11 (0.50)
Lifestyle							
PA/week (h)	Model 0	1.661 (−8.19; 11.51)	$p = 0.740$	0.03 (4.99)	0.828 (−3.24; 4.90)	$p = 0.689$	0.03 (2.06)
	Model 1	1.797 (−8.07; 11.67)	$p = 0.720$	0.02 (5.00)	0.873 (−3.18;4.92)	$p = 0.672$	0.03 (2.05)
PAC score	Model 0	−0.508 (−2.49; 1.47)	$p = 0.613$	−0.04 (1.00)	−0.178 (−1.00; 0.64)	$p = 0.668$	−0.03 (0.41)
	Model 1	−0.283 (−2.20; 1.64)	$p = 0.773$	−0.02 (0.97)	−0.113 (−0.90:0.67)	$p = 0.778$	−0.02 (0.40)
Sleep duration (h/day)	Model 0	−0.794 (−14.40; 12.81)	$p = 0.909$	−0.01 (6.90)	0.908 (−4.72; 6.53)	$p = 0.751$	0.02 (2.85)
	Model 1	−0.313 (−13.87; 13.24)	$p = 0.964$	−0.00 (6.87)	1.133 (−4.43;6.70)	$p = 0.689$	0.02 (2.82)
Screen time (h/day)	Model 0	−1.179 (−10.59; 8.24)	$p = 0.805$	−0.02 (4.77)	−5.569 (−9.46; −1.68)	$p < 0.05$	−0.21 (1.97)
	Model 1	−0.697 (−10.11; 8.72)	$p = 0.884$	−0.01 (4.77)	−5.498 (−9.36;−1.63)	$p = 0.006$	−0.20(1.96)
MD adherence (score)	Model 0	5.612 (0.63; 10.59)	$p < 0.05$	0.18 (2.53)	2.864 (0.80; 4.92)	$p < 0.05$	0.21 (1.04)
	Model 1	5.012 (0.06; 9.95)	$p = 0.047$	0.15 (2.50)	2.904 (0.87;4.93)	$p = 0.005$	0.21 (1.03)
Physical fitness							
Léger test (paliers)	Model 0	−216.388 (−454.24; 21.46)	$p = 0.074$	−3.91 (120.59)	7.298 (−91.07; 105.66)	$p = 0.884$	0.31 (49.87)
	Model 1	−2.047 (−23.80; 19.71)	$p = 0.853$	−0.03 (11.03)	4.968 (−3.96;13.90)	$p = 0.274$	0.21 (4.5)
$\dot{V}O_{2max}$ (ml/kg/min)	Model 0	87.690 (−6.20; 181.58)	$p = 0.067$	4.10 (47.60)	−2.935 (−41.76; 35.89)	$p = 0.882$	−0.32 (19.68)
	Model 1	3.287 (−5.00; 11.57)	$p = 0.435$	0.15 (4.20)	−1.683 (−5.08;1.72)	$p = 0.331$	−0.18 (1.72)
High/low CRF	Model 0	−3.968 (−44.68; 36.74)	$p = 0.848$	−0.02 (20.64)	8.594 (−8.24; 25.43)	$p = 0.315$	0.11 (8.54)
	Model 1	−4.805 (−34.59; 24.98)	$p = 0.751$	−0.02 (15.10)	4.289 (−7.94; 16.52)	$p = 0.490$	0.05 (6.20)
HGS right (kg)	Model 0	0.291 (−4.59;5.17)	$p = 0.907$	0.02 (2.47)	−0.559 (−2.58; 1.46)	$p = 0.586$	−0.09 (1.02)
	Model 1	0.988 (−3.83; 5.81)	$p = 0.687$	0.06 (2.44)	−0.611 (−2.59;1.37)	$p = 0.544$	−0.09 (1.00)
HGS left (kg)	Model 0	−1.430 (−6.23; 3.37)	$p = 0.558$	−0.10 (2.44)	0.360 (−1.63; 2.35)	$p = 0.721$	0.06 (1.01)
	Model 1	−1.612 (−6.40; 3.18)	$p = 0.508$	−0.11 (2.43)	0.424 (−1.54:2.39)	$p = 0.672$	0.06 (0.99)
SLJ (cm)	Model 0	0.269 (−0.36; 0.90)	$p = 0.400$	0.09 (0.32)	0.083 (−0.18; 0.34)	$p = 0.529$	0.06 (0.13)
	Model 1	0.326 (−0.29; 0.95)	$p = 0.304$	0.10 (0.31)	0.093 (−0.16;0.35)	$p = 0.473$	0.07 (0.13)

The data shown represent beta (95% CI) and standardised beta and standard error (SE). Values of $p < 0.05$ were considered statistically significant. Model 0 = non-adjusted, Model 1 = adjusted by sex and age. BMI = body mass index, WC = waist circumference, PA = physical activity, PAC: physical activity questionnaire, MD = Mediterranean diet, $\dot{V}O_{2max}$ = maximal oxygen consumption, CRF = cardiorespiratory fitness, HGS = handgrip strength and SLJ = standing long jump.

When comparing the ST (<2 h/day/≥2 h/day) groups, students with lower STs showed significantly better selective attention (p = 0.024), concentration (p = 0.000), total hits (p = 0.000) and lower omissions (p = 0.016) and commissions (p = 0.007) in the d2 test than schoolchildren who reported more ST (Figure 2).

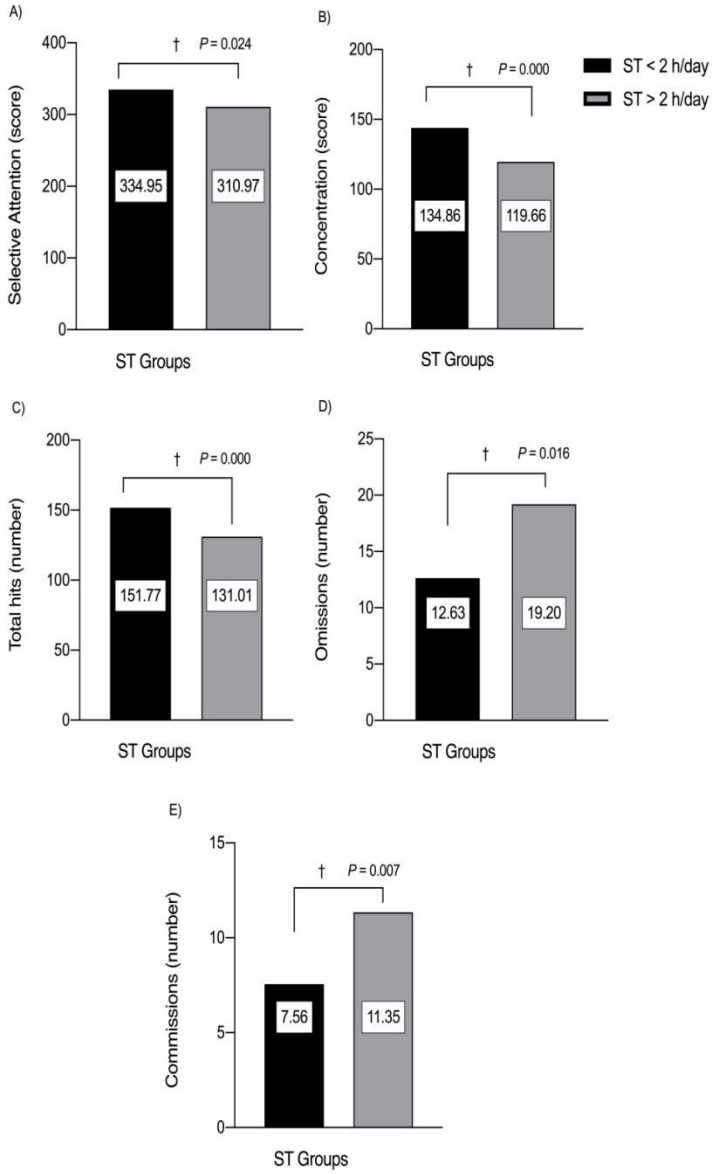

Figure 2. Selective attention (A), concentration (B), total hits (C), omissions (D) and commissions (E) characteristics in schoolchildren participants by ST groups (<2 h/day/≥2 h/day). (†) Daggers denote significant differences by group at each respective p-value.

Figure 2:

Schoolchildren with optimal MD adherence reported better concentration (p = 0.003) and total hits in the d2 test (p = 0.002) than moderate and low MD adherence classifications (Figure 3).

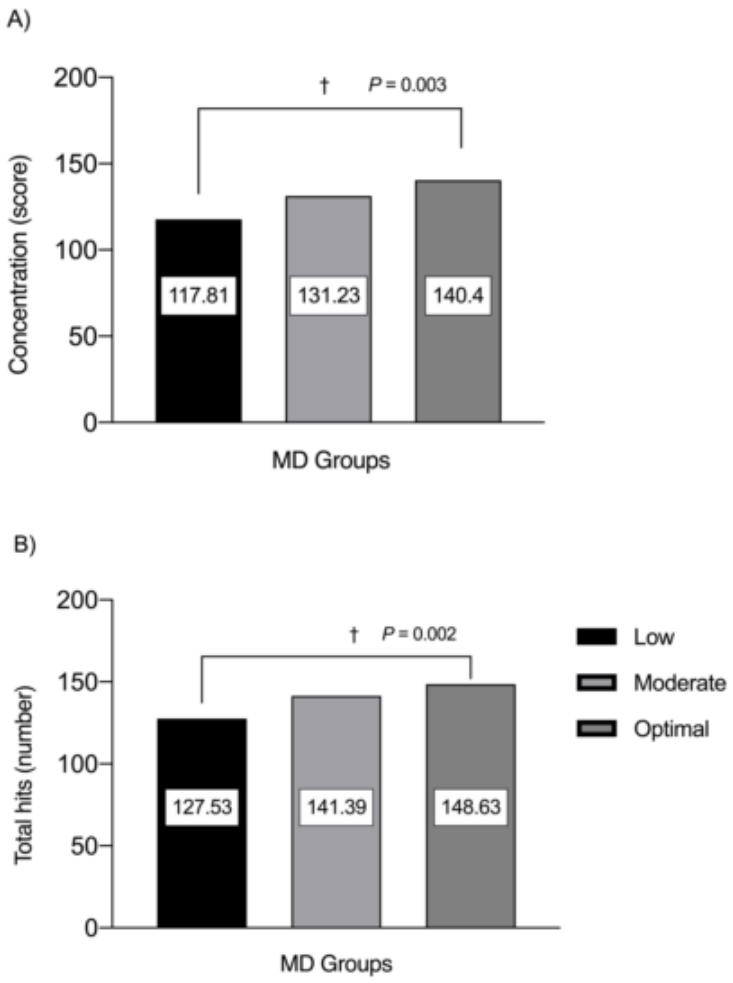

Figure 3: Concentration (A) and total hits (B) scores in schoolchildren participants by MD groups (low, moderate and optimal). (†) Daggers denote significant differences by group at each respective p-value.

Discussion

The objective of this investigation was to determine the association between selective attention and concentration with physical fitness, lifestyle parameters and anthropometric measures in Chileans students. A secondary aim was to compare selective attention and concentration according to ST classification and MD adherence levels.

The results indicate that (i) selective attention was positively associated with MD adherence (score), while concentration was negatively associated with ST and positively associated with MD adherence (score) in both the unadjusted and adjusted models; (ii) schoolchildren with lower STs showed better selective attention and concentration; (iii) schoolchildren with higher MD adherence scores reported better concentration.

We found that selective attention and concentration were both positively associated with MD adherence (score). Likewise, another investigation conducted among European adolescents reported that higher diet quality scores were linked with attention capacity, and the authors also indicated that dietary patterns were a better determinant of executive function than the analysis of single nutrients [47]. Furthermore, Peña et al. conducted a cross-sectional project with Chilean schoolchildren and reported that students with healthy food habits (i.e., who have a breakfast of high quality) presented better cognitive performance compared with students who did not [21]. Moreover, the findings of another study indicated that poorer food choices were related with reduced performance in verbal and cognitive ability [48]. It has been demonstrated that healthy foods are positively associated with higher performance in executive functions in students [13]. Thus, evidence has shown that a healthy diet, such as having a breakfast, may positively affect cognitive function and school attendance [24]. Additionally, there is strong evidence regarding the impact of nutrition on cognitive function; in this sense, Bellisle [49] indicated that diet can affect cognitive functions in children and adolescents. Similarly, the findings of a systematic review concluded that there was a positive association between good and healthy food habits and executive

function [3]. The present results showed that schoolchildren with higher MD adherence scores reported better concentration. Nyaradi et al. [50] conducted a longitudinal study in Australian adolescents and reported that the Western diet score (i.e., characterised by high intakes of take-away food, processed meat and refined food) was related to more total errors in a cognitive test, while students who increased their healthy food intake with fruits and vegetable showed a positive relationship with better cognitive performance. The author of this study also found that having unhealthy food habits at age 14 was associated with poorer psychomotor speed, visual spatial learning and long-term memory performance by 17 years of age. Likewise, Florence et al. [51] showed that specific aspects of diet quality may affect children's academic performance. Another study reported that a low-quality diet was associated with worse cognitive performance in schoolchildren [52]. In this context, DiGirolamo et al. [53] indicated that it is fundamental to determine nutritional requirements for their possible positive impact on the development of cognitive processes for schoolchildren.

Concentration was negatively associated with ST. In addition, we found that schoolchildren with lower STs showed better selective attention and concentration than their high ST peers. It has been well established that ST is related to different health harms [54]. In addition, there is a growing concern today about the effects of ST on cognition [26]. In this context, Choi and Park [55] reported that there was a correlation between ST and executive function, and that ST mediated the effect on school adjustment through academic performance. A recent study reported that children who never use tablets had significantly better cognitive performance than those who had high STs, with significant differences in prefrontal cortex activation [56]. Likewise, empirical evidence has shown that excessive ST was negatively correlated with the visual word form and the regions related to cognitive control and language; therefore, the authors concluded that limiting ST for schoolchildren was important [57]. Walsh et al. [58] conducted a cross-sectional study with 11,875 American schoolchildren and reported that ST was negatively associated with cognition; likewise, children with high and middle ST classifications had poorer cognition measures than theirs peers in the low classification of ST. Along this

same line, another study showed that healthy lifestyle behaviours (i.e., met 60 min of PA, 2 h or less of ST and 9–11 h sleep per night) were associated with better cognition in children [59]. Madigan et al. [60] reported that there was a directional association between levels of ST and child development in a longitudinal study. Likewise, another scoping review indicated that excessive ST was associated with premature cognitive decline and learning problems [61]. Another investigation conducted with Chinese children showed that passive ST (watching TV or videos) was associated with poorer executive function performance and social skills [62]. A recent study conducted in adolescents showed that higher STs were associated with a lower brain derived-neurotrophic factor (BDNF), which can negatively affect cognitive functions and increase the risk factors of neurocognitive deficits [63]. Despite these findings, it has been reported that ST has both negative and positive effects on brain function; therefore, more investigations are needed to clarify the mechanism and possible causal relationships between ST and brain development, especially at ages when brain plasticity is significant [64]. To this end and, contrary to our results, another study reported that smartphone use positively predicted some executive function; therefore, this study indicated that it is important to evaluate the frequency and problematic use of technology rather than ST [26]. Moreover, another study showed that more video game time was positively related to cognition compared with students who played for fewer hours per day [58]. Future studies are needed to clarify the prolonged effects of ST on children's cognition in different contexts [61].

The limitations of this investigation included its cross-sectional design. In addition, this study selected the sample by convenience. Another limitation was that cognition, food habits and ST results were determined using a written report instrument. In addition, we must consider studying more sociodemographic variables and longitudinal designs to clarify the associations. Likewise, in this study we measured concentration only through the d2 test; therefore, we plan to look for other ways to measure concentration. Moreover, we need to improve the exclusion criteria to limit the sample. Furthermore, as a practical application, it would be

important to consider physical activity and educational nutrition interventions in schools to improve executive functions in schoolchildren.

In conclusion, children's lifestyles were related to the selective attention and concentration of children; thus, the promotion of healthy lifestyle strategies should be prioritised in the education community context. Likewise, healthy food habits, together with decreased ST, could be a cost-effective strategy in promoting cognitive development as it relates to selective attention and concentration.

Author Contributions: P.D.-F. and F.C.-N. contributed to the conception, organisation and oversight of the study, the drafting of the analysis plan, the writing of the original manuscript draft and final approval of the version to be published. P.A.L.-R., J.A.P.-M. and D.J.-M. contributed to critical manuscript revision and final approval of the version to be published. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committee (ABR.19/8.TES Act).

Informed Consent Statement: Informed consent of parents and assent was obtained from all schoolchildren involved in the study

Data Availability Statement: Not applicable.

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

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9.4 Article IV: Lifestyle Mediates the Relationship Between Self-Esteem and Health-Related Quality of Life in Chilean Schoolchildren

Abstract

A healthy lifestyle, including food habits, physical activity (PA) and screen time (ST), is an important factor for well-being. The main purpose of this study was to determine the association between children's foods habits with self-esteem and health-related quality of life (HRQoL), determining the mediation effect of PA patterns. A second objective was to determine the association between self-esteem with HRQoL, considering the mediating effect of lifestyle. A descriptive and cross-sectional study was performed, involving both girls (n = 282, 11.86 ± 0.82 years) and boys (n = 352, 12.02 ± 0.87 years). Mediterranean diet (MD) adherence, PA patterns, ST, self-esteem, and HRQoL were evaluated. Self-esteem had a significant association with HRQoL (0.48, $p < 0.01$). However, ST (c´-2.76, $p < 0.001$) mediated this association negatively and significantly. On the other hand, PA (c´2.05, $p < 0.001$) and MD adherence (c´0.16, $p < 0.05$) positively mediated the association between self-esteem and HRQoL, with a greater mediation by PA being observed. In conclusion, increase in healthy lifestyles among children should be a target of community- and school-based interventions to promote well-being.

Introduction

In contemporary society, promoting subjective well-being in terms of self-esteem and health-related quality of life (HRQoL) among adolescents is of great public health and social significance (Rose et al., 2017), as high levels of subjective well-being are associated with a range of positive life outcomes (Lubans et al., 2016). In this sense, psychological factors such as self-esteem play an important role in subjective well-being, and can be associated with children's social, emotional, behavioural, and mental health). (Wang et al., 2009). In addition, another important factor related to subjective well-being is HRQoL, which is a multidimensional

construct that includes physical, emotional, mental, social and behavioural components of well-being and functioning (Resaland et al., 2019).

Healthy lifestyles, which include food habits, physical activity (PA) patterns, and screen time (ST), are defined as collective and organised patterns of broad and interrelated behaviours that are in accordance with life circumstances and cultural backgrounds (Xiao, Romanelli, & Lindsey, 2019). The importance of psychological well-being has also long been recognised (Gregory et al., 2019) and, in fact, late childhood and adolescence are important periods of life for the acquisition of healthy lifestyle habits, such as PA and healthy food habits (Lopez-Gil et al., 2020), as well as the development of subjective well-being (McDool et al., 2020).

Moreover, as a result of the typical lifestyle of contemporary society, an increased consumption of processed foods with low nutritional value and a decrease in PA patterns have affected children's well-being (Gu, Chang & Solmon, 2016). It has been reported that a healthy lifestyle, especially with regards to children's foods habits, is an essential factor of subjective well-being, and adherence to a Mediterranean diet (MD) has shown positive effects in terms of different factors of mental well-being (Muros et al., 2017) and specific components of HRQoL and subjective happiness (Ferrer et al., 2019). Additionally, changes in lifestyle, such as a decrease in PA patterns (Ra & Gang, 2016) and an increase in ST among children, have been shown to affect both subjective well-being (Twenge, Martin & Spitzberg, 2019) and HRQoL (Stiglic & Viner, 2019).

Likewise, there is also evidence regarding the effect of self-esteem on HRQoL; for example, a study in children reported that self-esteem predicted HRQoL (Marriage & Cummins, 2004). Another study reported a model suggesting that self-esteem positively predicts variables aligned to those incorporated into measures of HRQoL (Standage & Gillison, 2007). In Chile, a national study of physical education focused on physical condition and anthropometric parameters, without considering self-esteem and HRQoL (SIMCE, 2018). Further, it has been suggested that good mental health (i.e., self-esteem) seems to have a positive effect on HRQoL, and high self-esteem might have a protective role in terms of negative psychological

dimensions (Freire & Ferreira, 2018). It appears that it is not enough to have good self-esteem in order to have better HRQoL; it is also essential to have a healthy lifestyle. Based on the fact that food habits and self-esteem are associated with HRQoL, it is necessary to determine how PA patterns can interfere with or mediate this effect. The main purpose of this study was to determine the association between children's foods habits with self-esteem and health-related quality of life (HRQoL), determining the mediation effect of PA patterns. A second objective was to determine the association between self-esteem with HRQoL, considering the mediating effect of lifestyle.

Method

Participants

A descriptive and cross-sectional study was performed. A total of 634 schoolchildren (352 boys and 282 girls, 12.02 ± 0.87 and 11.86 ± 0.82 years, respectively) from four public (financed by central government and administered by city councils) (Delgado et al, 2020) primary schools in Temuco (Chile). Temuco is the regional capital of Araucania, Chile and the schools were chosen for their accessibility in data collection. The sample was intentional and non-probabilistic. The students lived in the same geographical area and presented identic socio-demographic characteristics. The inclusion criteria were: Chilean schoolchildren aged between 11 and 13, without musculoskeletal disorders or any other known medical conditions that might alter the participants' health and PA levels. There were 34 students excluded. Girls not meeting inclusion criteria or other reasons (n=14). Boys not meeting inclusion criteria (n=20). The investigation complied with the Declaration of Helsinki (2013) and was approved by the Ethics Committee of the La Frontera University, Chile (ACT N˚086_2017). Parents and guardians were informed about the study and provided written signed consent for participation. Additionally, all participants gave their written assent on the day of the assessment.

Measures

Health-Related Quality of Life

HRQoL for children and young people was measured using the KIDSCREEN-10 questionnaire. KIDSCREEN-10 is a validated and widely used assessment developed for monitoring global HRQoL in 8 to 18-year-old children and adolescents. It has ten items. Each item is answered on a five-point Likert scale indicating the frequency of a specific behaviour or feeling (1 = never; 2 = almost never; 3 = sometimes; 4 = almost always; and 5 = always) or the intensity of an attitude (1 = not at all; 2 = slightly; 3 = moderately; 4 = very; and 5 = extremely). The responses that are negatively formulated (items 3 and 4) were given scores from 1 to 5, and the raw scores were used for different analyses (with higher values indicating a higher HRQoL) (Ravens et al., 2010).

Self-Esteem

For the self-esteem measurement we used the Coppersmith Self-Esteem Inventory (Boyes, et al., 2018). This self-esteem questionnaire that describe the feelings, opinions, or reactions of an individual. There are two answer choices: like me (Yes) and unlike me (No).

The scores for self-esteem were categorised as follows (a higher score indicated higher self-esteem): a) less than 22 points: “very low”; b) 22–26 points: “low”; c) 26–35 points: “normal”; d) 35–39 points: “high”; and e) greater than 39 points: “very high”. The inventory has been validated in a Chilean child population (Brinkmann, Segure & Solar, 1989). Global self-esteem contains four subscales:

1) General self-esteem range of acceptance with which self-descriptive behaviours are estimated.

2) Social self-esteem: refers to relationships with their peers and the valuation of acting in instances of interaction, according to the context.

3) Family self-esteem: self-perception regarding relationships with their direct relatives.

4) School self-esteem: level of conformity with which the relationships with their peers and teachers in the school environment.

The Children's Food Habits

Mediterranean diet adherence were assessed using the Krece Plus test (Serra et al., 2003), which is a tool for assessing eating patterns and their relationship with the nutritional status, based on the MD. The format assesses a set of items concerning the diet that is consumed. Each item has a score of +1 or –1, depending on whether it approximates the ideal of the MD. The sum of all values from the administered test is categorised into three different levels: (1) >8, optimal MD; (2) 4–7, improvement needed to adjust intake to Mediterranean patterns; and (3) ≤3, very low diet quality (Serra et al., 2004). Higher scores indicate better food habits.

Screen Time and Physical Activity After School

The PA patterns were evaluated with the Krece Plus test (Serra et al., 2003). This test is a quick questionnaire that classifies lifestyle based on the daily average number of hours spent watching television or playing video games (ST), and the hours of PA after school per week. The classification is made according to the number of hours spent on each item. The total number of points is added, and the person is classified as good (men: ≥9 points, women: ≥8 points), regular (men: 6–8 points, women: 5–7 points) or bad (men: ≤5 points, women: ≤4 points), according to the lifestyle score.

Anthropometric Assessment

The weight (kg) of the participants was measured using a TANITA scale (model Scale Plus UM–028, Tokyo, Japan); they were weighed in their underclothes without shoes. Their height (m) was estimated with a Seca® stadiometer (model 214, Hamburg, Germany) that was graduated in mm. The body mass index (BMI), calculated as the weight divided by the square of the height in metres (kg/m2), was used to estimate the degree of obesity. The BMI is shown in the growth table of the

Centers for Disease Control and Prevention (CDC), verifying the corresponding age and sex-related percentile. Child obesity is defined as a BMI equal to or greater than the 95th percentile, while overweight is defined as a BMI equal to or greater than the 85th percentile among children of the same age and sex (Karnik & Kanekar, 2012). The waist circumference (WC) was measured using a Seca® tape measure (model 201, Hamburg, Germany) at the height of the umbilical scar (Schröder et al., 2014). The waist-to-height ratio (WHtR) was obtained by dividing the WC by the height, and was used as a tool for estimating the accumulation of fat in the central zone of the body. A WHtR cut-off of 0.5 is generally accepted as a universal cut-off for central obesity in children (aged ≥6 years) (Chung et al., 2016).

Procedure

Research assistants visited the selected school during the 2019 Chilean school year (April to November). The team of researchers who evaluated the participants were previously trained in conducting the different tests. In the first session, anthropometric assessments were carried out in a favourable space facilitated by the school, with optimum temperature, reliable privacy, and light clothing. Surveys were applied on different days to the anthropometric evaluations in classrooms (second and third session). The evaluations took place during physical education classes and in the morning. The questionnaires were completed individually and in the presence of researchers.

Statistical Analysis

The statistical analyses were performed using the following software: Stata version 13.0 (StataCorp, College Station, TX, USA), SPSS version 21.0 (SPSS Inc., Chicago, IL, USA), and GraphPad Prism version 7.0 (GraphPad Software, San Diego, CA, USA). The normal distribution of the data and the equality of variances were checked using the Kolmogorov–Smirnov test and Levene's test, respectively. The continuous variables were expressed as means and standard deviations. Differences between sexes were determined using an analysis of variance (ANOVA) test. Qualitative variables were expressed in proportions and compared

between groups with the chi-squared test. The effect size (ES) was calculated using Cohen's d. Effect sizes of less than 0.4 represented a small difference, whereas effect sizes of 0.41–0.7 and greater than 0.7 represented a moderate or large difference. Regression analyses were performed to verify the effect of the mediating variables. Within the analysis, direct effect, (c), the indirect effect (a * b), and the calculation of the 95% confidence intervals (CIs) using the macro/interface process for SPSS and the bootstrapping method, with a resampling rate of 5000, were calculated for the samples according to the recommendations of Preacher and Hayes (2004) (Preacher & Hayes, 2004). In the present study, we develop the next theoretical model; Lifestyle parameters (i.e., PA, ST and MD adherence) such as mediation variable between the association of self-esteem with health-related quality of life. Confidence intervals that do not contain zero indicate a significant indirect effect (mediation). The relationship between psychological well-being and MD adherence and PA patterns was estimated with the Pearson correlation coefficient (r) (Hinkle, Wiersma & Jurs, 2003)

Results

Table 1 shows the results according to sex. Family self-esteem and PA after school were slightly higher in boys than girls (girls: 4.85 ± 1.95 vs. boys: 5.13 ± 1.81, $p = 0.059$; and girls: 2.52 ± 1.38 vs boys: 2.74 ± 1.44, $p = 0.049$, respectively). The nutritional level (total sample) was mainly low (35.02%) and moderate (47.48%), while the PA patterns were bad (60.25%) and regular (33.75%), without differences according to sex.

The Pearson correlation analysis found significant relationships between MD adherence and family self-esteem ($r = –0.08$, $p = 0.032$) and HRQoL ($r = 0.22$, $p = 0.039$). A significant relationship was reported for ST and general self-esteem ($r = –0.23$, $p < 0.001$), social self-esteem ($r = –0.08$, $p = 0.020$), family self-esteem ($r = –0.11$, $p = 0.004$), and school self-esteem ($r = –0.30$, $p < 0.001$), as well as with

global self-esteem (r = –0.44, p < 0.001) and HRQoL (r = –0.71, p < 0.001). The PA patterns showed a significant relationship with general self-esteem (r = 0.12, p = 0.001), family self-esteem (r = 0.12, p = 0.001) global self-esteem (r = 0.12, p = 0.001), school self-esteem (r = 0.33, p < 0.001) and with HRQoL (r = 0.72, p < 0.001) (Table 2).

Table 3. Shows the association of self-esteem and life style with HRQoL. In this sense, the self-esteem (β; 0.04, 95%CI; 0.00, 0.07, P=0.49) and PA after school (β; 1.15, 95%CI; 0.90, 1.39, P<0.001) reported positive association with HRQoL. By contrast ST was linked in an inverse way to HRQoL (β; -1.82 , 95%CI; -2.13, -1.52, P<0.001).

Self-esteem had a significant association with HRQoL (0.48, p < 0.01). However, ST (c´-2.76, p < 0.001) mediated this association negatively and significantly. On the other hand, PA (c´2.05, p < 0.001) and MD adherence (c´0.16, p < 0.05) positively mediated the association between self-esteem and HRQoL, with a greater mediation by PA being observed (Figure 1). When performing the interpretation considering the values of the indirect effects (a * b), the relationship between self-esteem and quality of life is partially mediated by the mediating variables of the model; ST (ab; β = 0.455, SE 0.017, 95%CI; 0.23, 0.68), PA (ab; β = 0.219, SE 0.107, 95%CI; 0.01, 0.04) and MD adherence (ab; β =- 0.030, SE 0.021, 95%CI; -0.08, 0.00).

Discussion

The main purpose of this study was to determine the association between children's foods habits with self-esteem and health-related quality of life (HRQoL), determining the mediation effect of PA patterns. A second objective was to determine the association between self-esteem with HRQoL, considering the mediating effect of lifestyle. The main findings of this study were i) MD adherence had a positive association with general self-esteem and HRQoL; ii) self-esteem was linked to HRQoL; iii) ST negatively mediates the linked of self-esteem on HRQoL; and iv) PA and MD Adherence positively mediates the association of self-esteem on HRQoL.

In the present study, MD adherence had a positive relationship with general self-esteem and global self-esteem; however PA does not seem to have a mediation effect in the interaction between MD adherence and self-esteem. Another study showed a significant relationship between food habits and mental health in young adolescents, independently of PA levels and sedentary activity (Oellingrath, Svendsen & Hestetun 2014). Furthermore, a different study showed that MD adherence was positively associated with self-esteem in Spanish adolescents (Knox & Muros, 2017). Our findings support the proposition that better MD adherence have positive effects on self-esteem in Chilean children.

Similarly, in the present study MD adherence was linked with the HRQoL. In this sense, another study that used a meditational analysis reported that MD adherence and PA were associated with four components of HRQoL; likewise, PA has been positively associated with self-esteem through positive associations with physical and psychological well-being (Knox & Muros, 2017). In this context, MD adherence was positively associated with subjective well-being (Muros et al., 2017) and HRQoL in adolescents (Evaristo et al., 2018). However, one study found no prospective associations between MD adherence at baseline and well-being indicators at two-year follow-up after controlling for baseline levels (Esteban et al., 2019).

In this study, self-esteem was associated with HRQoL while ST negatively mediates the linked of self-esteem on HRQoL For this reason, self-esteem is considered a predictor of HRQoL, as opposed to an outcome variable (Standage & Gillison, 2007). A study that used a mediation model reported that HRQoL was predominantly explained by mental health (d = 30%) and satisfaction with self (d = 42%) in adolescents (Sawatzky et al., 2010). In the same vein, a study concluded that positive psychological dimensions (high self-esteem) might have a buffering role for negative psychological dimensions in adolescents, and thus should be promoted (Freire & Ferreira, 2018). In addition, it has been reported that self-esteem is negatively associated with sedentary behaviour; high levels of ST have been linked to lower self-esteem scores, as well as decreased psychological well-being and perceived HRQoL (Suchert, Hanewinkel & Isensee, 2015). Similarly, there is evidence that higher levels of ST are associated with poorer HRQoL and well-being in children (Stiglic & Viner, 2019). These findings contribute to the understanding of other relevant findings about the role of different variables affecting perceptions of HRQoL, when considering self-esteem and children's lifestyles. Similarly, PA and MD Adherence positively mediates the association of self-esteem on HRQoL. Another study reported that PA was positively related to all positive health indices, including physical self-image, physical health status, HRQoL, and quality of family and peer relationships in adolescents (Iannotti et al., 2009).

The main limitation of this study is its cross-sectional design; these factors should also be measured in a longitudinal study in future to clarify the direction of the associations. This study included the use of a convenience sample, and the results are not necessarily representative of the national population. Another limitation was that PA and ST were obtained using a self-report instrument.

In conclusion, MD adherence had a positive association with general self-esteem and HRQoL and self-esteem was linked to HRQoL while ST negatively mediates the linked of self-esteem on HRQoL. In contrast, MD Adherence positively mediates the association of self-esteem on HRQoL. Thus, an increase in healthy

lifestyles among children should be a target of community- and school-based interventions to promote well-being. These results highlight the need to make children aware at an early age of the importance of food habits and PA patterns.

Conflicts of Interest The authors declare no conflicts of interest.

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Legends for Tables and Figures

Table 1. Characteristics of the study sample and comparisons according to sex.

Table 2. Correlation between different types of self-esteem and Mediterranean diet adherence, physical activity, and health-related quality of life

Table 3. Association of self-esteem and lifestyle with health related to quality of life

Figure 1. Mediation models of the association between self-esteem with health-related quality of life mediated by lifestyle parameters. *p <0.05; **p < 0.001.

Table 1. Characteristics of the study sample and comparison according to sex

Variable	Total n=634	Girls n=282 (44.5%)	Boys n=352 (55.5%)	P-Value	*Cohen's d*
Age (years)	11.95±0.85	11.86±0.82	12.02±0.87	0.023	
BMI (kg/m^2)	21.6±4.58	21.76±4.4	21.47±4.73	0.409	-2.1
WC (cm)	73.44±11.5	72.7±10.61	74.0±12.16	0.139	-0.1
WtHR (height /WC)	0.47±0.07	0.47±0.06	0.47±0.07	0.959	0
Self-esteem					
General (score)	17.1±4.57	16.82±4.61	17.39±4.53	0.169	-0.1
Social (score)	5.06±1.41	4.98±1.4	5.12±1.41	0.200	-0.1
Family (score)	5.0±1.88	4.85±1.95	5.13±1.81	0.059	-0.1
School (score)	4.93±1.67	4.89±1.7	4.96±1.64	0.590	-0,04
Global (score)	32.1±7.44	31.56±7.62	32.55±7.27	0.092	-0.1
Physical Activity Patterns					
Screen Time (h/day)	3.27±1.13	3.31±1.15	3.24±1.11	0.445	0.06
PA after school (h/week)	2.64±1.42	2.52±1.38	2.74±1.44	0.049	-0.2
PA Patterns (PA+ST)	4.36±2.32	4.20±2.34	4.46±2.30	0.120	-0.1
Bad	382 (60.25)	152 (53.90)	210 (59.66)	0.090	
Regular	214 (33.75)	108 (38.30)	120 (34.09)		
Good	38 (5.99)	22 (7.80)	22 (6.25)		
Nutritional levels					
MD adherence (score)	6.11±2.34	5.97±2.38	6.21±2.31	0.189	-0.1
Low	222 (35.02)	107 (37.94)	115 (35.67)	0.344	
Moderate	301 (47.48)	130 (46.1)	171 (48.58)		
High	111 (17.51)	45 (15.96)	66 (18.75)		
Health Related to Quality of life					
HRQoL (Raw score)	37.37±4.77	37.24±4.66	37.47±4.87	0.554	-0.1

The values shown are mean ± SD, P-value <0.05 is considered statistically significant. BMI; Body Mass Index, WC; waist circumference, WtHR; Height to Waist ratio, PA; physical activity, ST; screen time, MD; Mediterranean diet, HRQoL; health-related to quality of life.

Table 2. Correlation between psychological well-being and Mediterranean diet adherence and physical activity patterns

	General	Social	Family	School	Global	HRQoL
Food habits	-0.03 (0.444)	-0.04 (0.230)	-0.08 (0.032)	-0.06 (0.101)	-0.06 (0.113)	0.22 (0.039)
Screen Time	-0.23(<0.001)	-0.08 (0.020)	-0.11 (0.004)	-0.30 (<0.001)	-0.44 (<0.001)	-0.71 (<0.001)
PA after school	0.10 (0.006)	0.05 (0.190)	0.11 (0.004)	0.08 (0.021)	0.09 (0.01)	0.63 (<0.001)
PA Patterns	0.12 (0.001)	0.07 (0.053)	0.12 (0.001)	0.33 (<0.001)	0.12 (0.001)	0.72 (<0.001)

The values shown values r* (P-value). PA; Physical activity, HRQoL; Health Related to Quality of life

Table 3. Association of self-esteem and lifestyle with health related to quality of life

Outcomes	Beta (95% CI)	P-value	Standardised Beta (SE)
Sex	-0.20 (-0.73;0.33)	P=0.465	-0.02 (0.27)
Age (y)	-0.10 (-0.40;0.21)	P=0.535	-0.02 (0.16)
Self-esteem (score)	0.04 (0.00;0.07)	P=0.049	0.06 (0.02)
MD adherence (score)	0.11 (0.00;0.22)	P=0.059	0.05 (0.06)
ST (h/day)	-1.82 (-2.13;-1.52)	P<0.001	-0.43 (0.16)
PA after school (h/week)	1.15 (0.90;1.39)	P<0.001	0.34 (0.12)

The data shown represent Beta (95% CI), and Standardised Beta and standard error (SE). Values of P<0.05 were considered statistically significant. MD; Mediterranean diet, ST; screen time, PA; physical activity.

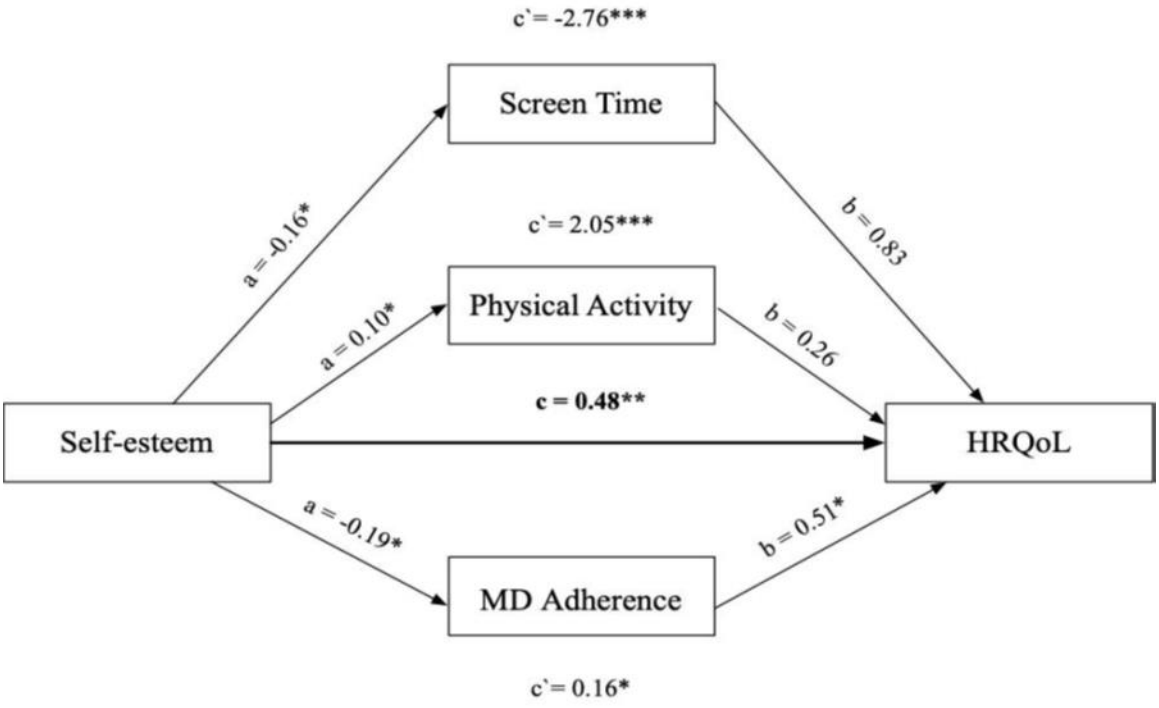

Figure 1. Mediation models of the association between self-esteem with health-related quality of life mediated by lifestyle parameters. *p < 0.05; **p < 0.001.

9.5 Article V. Association between modifiable lifestyle behaviours with abdominal obesity and excess weight in Latin-Americans preschoolers. Analysis between Chile and Colombia

Abstract

Objective: The purpose was to determine the association of lifestyle (i.e., Mediterranean diet [MD] adherence, physical activity [PA], screen time [ST]) and fitness with abdominal obesity AO and excess weight in Chilean and Colombian preschoolers.

Research Methods & Procedures: This cross-sectional study included 969 preschoolers, girls (n = 441, 5.24 ± 0.80 years old) and boys (n = 528, 5.10 ± 0.78 years old) from Chile (n = 611) and Colombia (n = 358). Body mass index (BMI), waist circumference (WC), waist-to-height ratio (WtHR), MD adherence, PA, ST and cardiorespiratory fitness (CRF) were evaluated. The association of AO and anthropometric variables with lifestyle was estimated through multiple linear regression. To determine the association between AO and lifestyle, a logistic regression and the inclusion of odds ratios (ORs) with 95% confidence intervals (CIs) were used.

Results: Worse CRF in Chilean children were positively correlated with WC. Excess weight in Chilean and Colombian preschoolers was positively associated with a bad lifestyle (3–5 years old). Moreover, in Chilean children aged 3–5 years, a bad lifestyle was associated with AO based on WC ≥ 85th percentile and AO based on WtHR ≥ 85th percentile. In Chilean children, excess weight (BMI ≥ 85th percentile) was positively associated with poor MD adherence.

Conclusion: AO and excess weight were associated with a bad lifestyle in Latin-American preschoolers. Interventions to reduce the prevalence of AO should include promoting a healthy lifestyle (i.e., increasing PA after school, reducing ST and improving CRF) in Latin-American preschoolers.

Keywords: Preschoolers; Nutritional level; Physical activity; Resistance endurance; Abdominal obesity

Resumen

Objetivo: El propósito fue determinar la asociación del estilo de vida (es decir, adherencia a la dieta mediterránea [DM], actividad física [AF], tiempo frente a la pantalla [ST]) y aptitud física con obesidad abdominal OA y exceso de peso en preescolares chilenos y colombianos.

Métodos y procedimientos de investigación: Este estudio transversal incluyó a 969 preescolares, niñas (n = 441, 5,24 ± 0,80 años) y niños (n = 528, 5,10 ± 0,78 años) de Chile (n = 611) y Colombia (n = 358). Se evaluaron el índice de masa corporal (IMC), la circunferencia de la cintura (CC), la relación cintura-altura (WtHR), la adherencia a la DM, la AF, la ST y la aptitud cardiorrespiratoria (CRF). La asociación de OA y variables antropométricas con el estilo de vida se estimó mediante regresión lineal múltiple. Para determinar la asociación entre OA y estilo de vida, se utilizó una regresión logística y la inclusión de odds ratios (OR) con intervalos de confianza (IC) del 95%.

Resultados: Menor CRF los niños chilenos se correlacionó positivamente con la CC. El exceso de peso en preescolares chilenos y colombianos se asoció positivamente con un mal estilo de vida (3-5 años). Además, en los niños chilenos de 3 a 5 años, un mal estilo de vida se asoció con AO basado en WC ≥ percentil 85 y OA basado en WtHR ≥ percentil 85. En los niños chilenos, el exceso de peso (IMC ≥ percentil 85) se asoció positivamente con una mala adherencia a la DM.

Conclusión: la OA y el exceso de peso se asociaron con un mal estilo de vida en preescolares latinoamericanos. Las intervenciones para reducir la prevalencia de OA deben incluir la promoción de un estilo de vida saludable (es decir, aumentar la AF después de la escuela, reducir el ST y mejorar la CRF) en preescolares latinoamericanos.

Keywords: Preescolares; Nivel nutricional; Actividad física; Resistencia a la resistencia; Obesidad abdominal

Introduction

The prevalence of childhood obesity is reaching epidemic proportions all over the world even among preschool children(1), and has been declared a global public health problem (2). Childhood obesity is one of the major concerns in recent years due to its association with future health problems (3). Likewise, abdominal obesity (AO) is a major clinical and public health issue compared with generalized obesity in children, as AO (i.e., central obesity) is more strongly correlated with cardiometabolic risk (CMR) (4) and seems to have increased during the last few decades (5). Moreover, it has been reported that AO in children increases CMR factors such as dyslipidaemia, hypertension and hyperglycaemia (4). Likewise, AO predicts a wide range of adverse health outcomes such as diabetes and cardiovascular diseases(6). Thus, more attention should be paid in epidemiological studies to AO in children, and identifying modifiable lifestyle behaviours linked to AO is necessary to develop preventive strategies.

The decrease in physical activity (PA) and increase in sedentary behaviours in children have affected the development of healthy(7). In this sense, a high screen time (ST, the most popular sedentary behaviour) has been associated with a cluster of CMR factors (8) such as AO in children (9). Additionally, PA has been indicated as an important factor to prevent CMR (10), and PA is a modifiable factor that is inversely associated with AO. The relevance of this is that, if carried out from childhood, it can influence the adoption of an active lifestyle (11).

Children's food habits are one of the most frequent human behaviours and are determinant factors that influence the development of obesity (12). There is evidence that adherence to a Mediterranean diet (MD) is associated with positive effects on specific components of well-being (13). Likewise, children's food habits have an influence on health in later life (14), and may be protective factors for well-being in children. Nevertheless, there is a high prevalence of children aged 6–7 years with poor-to-moderate MD adherence (15). Additionally, better MD adherence in preschool children is associated with a lower risk of developing AO in children and adolescents (16).

Another relevant factor is fitness in preschoolers; during childhood it has different health benefits, especially cardiorespiratory fitness (CRF) that is a basic component of a healthy lifestyle (17) and is related to lower CMR (18). It has also been shown that overweight children with high CRF have a healthier cardiovascular profile (19). Moreover, higher levels of CRF substantially reduce CMR in adulthood, even among those with AO in childhood(20). Developing assessments of children's health-related physical fitness at an early stage is a priority (21), since improving physical fitness provides protection against CMR (22) and is an important biomarker of health (23). The association between modifiable behaviours such as fitness and lifestyle (i.e., PA, ST and MD adherence) and obesity are well documented in children, but such association remains to be determined in Latin-American preschoolers. Therefore, the purpose of this study was to determine the association of lifestyle (i.e., MD adherence, PA and ST) and fitness with AO and excess weight in Chilean and Colombian preschoolers.

Methods

Study design and participants

This cross-sectional study included 969 preschool children, girls (n = 441, 5.27 ± 0.71 years old) and boys (n = 528, 5.14 ± 0.82 years old) from Chile (n = 611) and Colombia (n = 358), who were selected by convenience. Parents and guardians were informed about the study and provided signed written consent for participation. Additionally, all children gave their oral or written assent on the day of the assessment. The investigation complied with the 2013 Helsinki Declaration and was approved by the Local Ethics Committee and International Committee of University of Jaen, Spain (Doctoral Thesis).

The inclusion criteria were: i) presenting informed consent of the parents and assent of the participant, ii) belonging to educational centres and iii) being between 3 and 7 years old. The exclusion criteria were having a musculoskeletal disorder or any other known medical condition, which might alter the participant's health and PA levels. Moreover, schoolchildren with physical, sensorial or intellectual disabilities were excluded.

Sociodemographic characteristics

An ad hoc sociodemographic questionnaire was used; information such as educational level, marital status and socioeconomic background (based on their socioeconomic self-perception) was collected from parents. Moreover, parents completed the information about the preschool children's PA and ST (Krece Plus test).

General obesity

Body mass index (BMI), calculated as the body mass divided by the square of the height in metres (kg/m2), was used to estimate the degree of obesity. Body mass (kg) was measured using a Tanita UM-028 scale (Tokyo, Japan); the children were weighed in their underclothes without shoes. Height (m) was estimated with a Seca® 214 stadiometer (Hamburg, Germany) that was graduated in mm. For BMI, World Health Organization (WHO) curves were used to identify excess weight, according to sex and age (24).

Abdominal obesity

Waist circumference (WC) was measured using a Seca® 201 tape measure (Hamburg, Germany) at the height of the umbilical scar (25). The waist-to-height ratio (WtHR) was obtained by dividing the WC by the height. To define AO, four aspects were considered: i) WC in the 90th percentile of the sample study (≥ 65 cm), ii) WC ≥ 85th percentile of the sample study (≥ 63 cm), iii) WtHR in the 90th percentile of the sample study (≥ 0.59) and iv) WtHR ≥ 85th percentile (≥ 0.57) of the sample study (26-28).

Food habits

MD adherence of the preschool children was assessed by the Krece Plus test (29), a tool to assess eating patterns and their relationship with nutritional status based on the MD. The questionnaire has 15 items, and the format assesses a set of items about the food consumed in the diet. Each item has a score of +1 or −1, depending on whether it approximates the ideal of the MD. The maximum score is 11 points and the minimum −5. The total points are added, and according to the score, the nutritional status is classified as follows: i) low nutritional level: ≤ 5; ii) moderate nutritional level: 6–8; or iii)

high nutritional level: ≥ 9. This questionnaire has been used in Chilean schoolchildren (10).

Physical activity patterns

Lifestyle was evaluated with the Krece Plus test (29), a quick questionnaire that classifies lifestyle according to the daily average of hours spent watching television or playing video games (h/day) and hours of PA after school per week (h/week). Classification is made according to the number of hours used for each point. The total points are added, and the person is classified as having: i) good lifestyle (men: ≥ 9, women ≥ 8), ii) regular lifestyle (men: 6–8, women: 5–7) or iii) bad lifestyle (men: ≤ 5, women: ≤ 4).

Physical fitness

For the evaluation of physical fitness, leg strength, CRF and handgrip strength were measured.

Lower-body explosive strength was assessed by a standing long jump test (SLJ) [(30)]. The SLJ has been used in preschool children (31) and consists of jumping a distance with both feet at the same time. For this, the student stands behind the jump line, and with a foot separation equal to the width of their shoulders; the knees are then bent with the arms in front of the body and parallel to the ground. From this position, they swing their arms, push hard and jump as far as possible, making contact with the ground with both feet simultaneously and in a vertical position. This is done twice, and the best result is recorded.

Handgrip strength was used to measure upper body strength through a hand dynamometer (TKK 5101 Grip D; Takei, Tokyo, Japan). The test consists of holding a dynamometer in one hand and squeezing as tightly as possible without allowing the dynamometer to touch the body; force is applied gradually and continuously for a maximum of 3–5 s (30). The test was performed twice, and the maximum score for each hand was recorded in kilograms. The average of the scores achieved by the left and right hands was used in the analysis. Higher scores indicate better performance.

CRF was assessed using the 10 × 20 m test, inspired by the spatial structure of the Léger test (32). The 10 × 20 m test has been used in preschool children and has been validated (33). 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 (20 m), two boxes, five balloons and a stopwatch. It is a 20 m shuttle test, in which participants have to move five balloons from box A, located at one extreme, to box B, located at the opposite extreme. The total distance covered is 200 m, timed from the signal "Go" until the participant deposits the last balloon. It does not matter if the balloon does not enter the box. If during movement the balloon is dropped, the participant 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 place. The test score was the running time, a longer time indicating a poorer performance.

Statistical analysis

Statistical analyses were performed using STATA V.13.0. (StataCorp, College Station, TX, USA). Normal distribution was tested using the Kolmogorov–Smirnov test. For continuous variables, values were presented as means and standard deviations (SDs), whereas for categorical variables, data were presented as proportions. Differences between groups were determined using one-way ANOVA and $\chi 2$ test. The association of AO and anthropometric variables with lifestyle was estimated through multiple linear regression. To determine the association between AO and lifestyle, a logistic regression and the inclusion of odds ratios (ORs) with 95% confidence intervals (CIs) were used. Values of $P < 0.05$ were considered statistically significant.

Results

Sociodemographic antecedents

There were no significant differences between the proportion of girls and boys and the parents' antecedents (i.e., marital status, study level and socioeconomic background) in the comparison between Chilean and Colombian preschool children (Table 1).

Comparison between sexes in Chilean vs Colombian preschool children

According to anthropometric parameters, the boys in Chile had higher BMI ($P < 0.001$), WC ($P < 0.001$) and WtHR ($P < 0.001$) than the Colombian children. In relation to fitness, Chilean children presented better results in the '10 × 20' resistance test than Colombian children ($P < 0.001$); however, for handgrip strength the Chilean children had worse results than the Colombian children ($P = 0.007$). For lifestyle, Chilean children presented higher MD adherence ($P = 0.040$), hours of PA after school per week ($P < 0.001$) and ST per day ($P < 0.001$) than Colombian children. Chilean girls had higher WC ($P < 0.001$) than Colombian girls; likewise, they had better results in the 10 × 20 resistance test ($P < 0.001$). For lifestyle, the Chilean girls had higher levels of moderate and high MD adherence ($P = 0.040$), hours of PA after school per week ($P < 0.001$) and ST per day than Colombian girls ($P < 0.001$) (Table 2).

Prevalence of obesity in Chilean vs Colombia preschool children

In Chilean girls, excess weight was present in 36.5%, of which 21.3% is represented by the obesity category, while 9.1% of Colombian girls were obese. Similarly, 39.5% of Chilean boys had excess weight, of which 27.2% were obese, while 13.9% of Colombian boys were obese (Figure 1).

In relation to AO, more Chilean girls (24.2% vs 7.9%, $P < 0.001$) and boys (18.3% vs 10.3%, $P = 0.0014$) had a higher AO based on WC ≥ 85th percentile (≥ 63 cm) than their Colombian peers. Assessing AO based on WtHR ≥ 85th percentile (≥ 0.57), more Chilean girls (25.3% vs 7.3%) had AO than Colombian girls and Chilean boys (25.3% vs 17.1%, $P = 0.013$) (Table 3).

Linear correlation between abdominal obesity markers and lifestyle

Worse results in the 10 × 20 resistance test (i.e., CRF) in Chilean girls and boys were positively correlated with WC (girls, r = 0.34, P < 0.001; boys, r = 0.26, P < 0.001) and WtHR (girls, r = 0.27, P < 0.001; boys r = 0.22, P < 0.001). PA after school was inversely correlated with WC in girls (r = −0.15, P = 0.009) and boys (r = −0.23, P < 0.001). In Colombian girls (r = 0.20, P = 0.009) and boys (r = 0.24, P < 0.001), MD adherence was positively correlated with WC. ST was positively correlated with WC in Chilean girls (r = 0.23, P < 0.001) and boys (r = 0.24, P < 0.001). The same relation was found in Colombian girls and boys (r = 0.16, P = 0.030 and r = 0.16, P = 0.040, respectively) (Table 4).

Association of variables with abdominal obesity

Excess weight in Chilean (OR: 1.73, 95%CI: 1.1–2.73, P = 0.018) and Colombian children (OR: 1.83, 95%CI: 0.96–3.47, P = 0.06) was positively associated with bad lifestyle (3–5 years old). In Chilean children aged 3–5 years, a bad lifestyle was also associated with AO based on WC in the 90th percentile (OR: 2.36, 95%CI: 1.22–4.54, P = 0.010), AO based on WC ≥ 85th percentile (OR: 1.74, 95%CI: 1.04–2.9, P = 0.032) and AO based on WtHR ≥ 85th percentile (OR: 1.75, 95%CI: 1.06–2.89, P = 0.028). Moreover, in Colombian children aged 3–5 years, low MD adherence was inversely associated with AO based on WC ≥ 85th percentile (OR: 0.44, 95%CI: 0.23–0.84, P = 0.010). By contrast, in Chilean children, excess weight – BMI ≥ 85th percentile – was positively associated with bad MD adherence (OR: 1.43, 95%CI: 1.0–2.05, P = 0.04) (Table 5).

Discussion

The purpose of this study was to determine the association of lifestyle (i.e., MD adherence, PA and ST) and fitness with AO and excess weight in Chilean and Colombian preschoolers. The main results were: i) in Chilean and Colombian children, AO was associated with a bad lifestyle, ii) ST was positively correlated with WC in Chilean and Colombian preschool children, and iii) worse CRF results (10 × 20 test) were positively correlated with WC and WtHR in Chilean girls and boys, but not in

Colombian children.

In the present study, we found a high prevalence of AO in Chilean girls (25.3%), higher than boys and Colombian girls. In a study conducted in 5,231 Greek children, the prevalence of AO did not differ between boys and girls at the age of 7 (25.2% and 25.3% respectively), while at the age of 9 more boys than girls had AO (33.2% and 28.2%, respectively) [(34). In another study evaluating 1,433 Portuguese children (6–12 years old), the prevalence of AO based on the measurement of WC was similar in girls and boys; however, according to WtHR, boys had a higher prevalence than girls (35). Another investigation reported a high prevalence of AO in children between 3 and 10 years old, where 30.5% of the children had AO (36). Evidence of the prevalence of AO in children is worrying, as it is a risk factor for cardiovascular diseases and cancer in adults (37). Another study reported that those presenting high WC values are more likely to have hypertension, diabetes, dyslipidaemia and CMR compared with those with normal WC values (38).

In Chilean and Colombian preschoolers, excess weight (i.e., overweight and obesity) and AO was associated with a bad lifestyle (i.e., low PA after school and high ST). In accordance with our results, a study conducted in Canadian preschool children reported that a healthy lifestyle such as good PA patterns and low sedentary behaviour is significantly associated with healthy BMI z-scores but not with WC (39). Similarly, a longitudinal study demonstrated that an unhealthy lifestyle (i.e., bad food habits and high ST) is associated with high body fat in preschool girls (40). On the contrary, a recent study reported that BMI and WC are not associated with lifestyle (i.e., PA and sedentary behaviour) in preschool children (41), results in discordance with ours. In addition, childhood obesity has re-focused attention on the importance of a healthy lifestyle (i.e., PA and ST) in this age group (42).

In the present study, we found that ST is positively related to WC in Chilean and Colombian preschool children. In accordance with our results, it has been reported that those preschool children exhibiting more sedentary behaviour such as ST are more likely to have more AO (43). Moreover, Wuan et al. (44) reported that preschool children who do not meet the ST guidelines are at higher risk for overweight and obesity.

Similarly, Li et al. (45) reported that ST is independently associated with childhood obesity. In accordance with our results, it has been demonstrated that ST increases BMI, BMI z-score and AO in European preschool children (46).

In the present study, we found that worse CRF (i.e., high time in test 10x20) were positively correlated with WC and WtHR in Chilean girls and boys, but not in Colombian preschoolers. In line with this, a study reported that higher CRF is associated with lower AO in Spanish preschool children (47). Similarly, Martínez et al (48) reported significant associations of the 20 m shuttle run test (i.e., CRF) with BMI and WC in preschool children. Additionally, it has been reported that free fat mass is associated with better CRF in preschool children (49). A longitudinal study reported that a high CRF at 4.5 years old is associated with better corporal composition at 5.5 years old in preschool children (50). Finally, more investigation is needed with the aim to clarify the effects of physical fitness at preschool age with later health outcomes (50).

In Chilean preschool children, AO was positively associated with low MD adherence; by contrast, in Colombian preschool children, low MD adherence had an inverse association with AO. It has been reported that high MD adherence is related to lower WC (47) and associated with a lower risk of preschoolers developing overweight, obesity and AO in the future (16). Therefore, MD adherence is a relevant modifiable factor to be targeted in educational strategies aiming to prevent central obesity (47).

Limitations

The limitations of the present study include those inherent to its transversal character. Another limitation would be the self-reporting in relation to the preschool children's PA and food habits, which could mean that these data are underestimated or overestimated. The strengths of this study are that we examined several variables that affect children's development and have contributed to a better understanding of the serious problem of bad lifestyle in Latin-American preschool children.

Conclusion

Chilean preschoolers have a higher prevalence of AO than their Colombian peers. Moreover, AO and excess weight were associated with a bad lifestyle in preschoolers of both countries, and is related to worse CRF results. Therefore, interventions to reduce the prevalence of AO should include promoting a healthy lifestyle (i.e., increasing PA after school, reducing ST and improving CRF) in Latin-American preschoolers. Strategies for preventing and reducing children's AO, through an accessible, economical and worldwide effort, should be considered to aid in the development of healthy habits and behaviours in preschool children.

Authors' contributions

PD-F contributed to the conception, organization and oversight of the study, the drafting of the analysis plan, writing the original manuscript draft and final approval of the version to be published. FC-N, DJ-M, CP-V, RB-R and AR-O contributed to writing the original manuscript draft and final approval of the version to be published. IPGG drafted the analysis plan, wrote the original manuscript draft and gave final approval of the version to be published.

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Conflicts of interest

The authors declare no conflict of interest.

Figure Legend

Figure 1. Prevalence of abdominal obesity according to sex. Cl = Chile, Col = Colombia.

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Table 1. Sociodemographic characteristics of the study sample

	Chile (n=611)	Colombia (n=358)	P-value
Sex			
Girls	277 (45.3)	164 (45.8)	0.88
Boys	334 (54.7)	194 (54.2)	
Age, y (5-95th)	5 (4-6)	5 (4-6)	0.26
Age category			
3-5 years old	400 (64.1)	211 (61.2)	0.36
6-7 years old	224 (35.9)	134 38.8)	
Parents information			
Socioeconomic background n (%)			
Low/middle low	248 (40.6)	136 (38)	0.59
Middle	345 (56.5)	208 (58.1)	
Middle high/High	18 (2.9)	14 (3.9)	
Study level n (%)			
Primary	112 (18.3)	67 (18.7)	0.95
Secondary	237 (38.8)	141 (39.4)	
University	262 (42.9)	150 (41.9)	
Marital status n (%)			
Single	190 (31.1)	98 (27.4)	0.57
Married	271 (44.3)	163 (45.5)	
Divorced	94 (15.4)	64 (17.9)	
Widow	56 (9.2)	33 (9.2)	

The data shown represent n (proportions). P<0.05 considered statistically significant.

Table 2. Comparison of anthropometric and physical characteristics of the study sample

	Chile n=611		Colombia n=358		P value	P value
	Girls **(A)**	Boys **(B)**	Girls **(C)**	Boys **(D)**	**A x C** **A x B°**	**B x D** **C x D°**
Age (y)	5 (4-5)	6 (4-6)	5 (4-5)	6 (4-7)	0.76 <0.001°	0.07 <0.001°
Body mass (kg)	19 (14-27.2)	21.4 (16-33)	19.0 (14-25)	21.35 (17.3-31.9)	0.43 <0.001°	0.61 <0.001°
Size (m)	1.13 (0.99-1.29)	1.13 (1.0-1.34)	1.11 (0.99-1.2)	1.17 (1.06-1.32)	<0.001 0.79°	<0.001 <0.001°
BMI (kg/m^2)	14.9 (9.7-22.5)	17 (12.0-22.6)	15.4 (11.6-19.9)	15.7 (13-20.6)	0.05 <0.001°	<0.001 0.07°
WC (cm)	59 (50.7-66)	58 (51-66)	56.1 (50-67)	55.5 (50-65.5)	<0.001 0.06°	<0.001 0.21°
WtHR (WC/size)	0.52 (0.43-0.63)	0.51 (0.43-0.59)	0.50 (0.44-0.62)	0.47 (0.40-0.58)	0.20 0.08°	<0.001 <0.001
Fitness						
SJT (cm)	82 (46-114.5)	83 (43-117)	83 (39-117)	82 (49-116)	0.80 0.65	0.98 0.83°
Speed 20 m (s)	6 (4.8-7.6)	6.02 (4.7-7.7)	6.3 (4.8-7.5)	5.9 (4.5-7.8)	0.20 0.80°	0.40 0.05°
Resistance 10x20 (s)	75.6 (63.5-95.4)	75.0 (66-95)	84.8 (60-112)	90 (60-120)	<0.001 0.58°	**<0.001** <0.001
Handgrip strength (kg)	5.7 (2-8)	5.5 (2.0-8.2)	6 (2-11.8)	6 (2-17.3)	0.001 0.35°	**0.007** 0.80

Lifestyle						
MD adherence (-5 to 11)	5 (-2 to 9)	5 (-2 to 9)	3 (-1 to 9)	3 (-1 to 8)	0.39 0.52°	**0.040** 0.50°
Mediterranean diet Adherence					0.04 0.47°	0.003 0.70°
Low MD	229 (57.3)	151 (67.4)	151 (67.4)	96 (71.6)		
Moderate MD	143 (35.7)	61 (27.2)	61 (27.2)	32 (23.9)		
High MD	28 (7.0)	12 (5.4)	12 (5.4)	6 (4.5)		
PA after school (h/week)	3 (1-5)	3 (1-5)	3 (0-5)	2 (0-5)	<0.001 0.91°	<0.001 0.14°
ST (h/day)	4 (1-4)	4 (1-5)	3 (1-5)	2 (1-4)	<0.001 0.99°	<0.001 0.75°
Lifestyle (PA +ST)					<0.001 0.051°	0.34 0.10°
Bad PA	252 (63.0)	125 (59.2)	106 (47.3)	78 (58.2)		
Regular PA	111 (27.8)	75 (35.55)	108 (48.2)	53 (39.5)		
Good PA	37 (9.2)	11 (5.2)	10 (4.5)	3 (2.24)		

The quantitative variables shown median (percentiles 5-95), qualitative variables represent n (proportions). P<0.05 considered statistically significant. BMI= body max index, WC= waist circumference, WtHR= waist-to-height ratio, SLJ= standing long jump test, MD=Mediterranean die, PA= physical activity, ST= screen time.

Table 3. Prevalence of abdominal obesity according sex and country.

	Chile n=611		Colombia n=358		P value	
	Girls n=277	Boys n=334	Girls n=164	Boys n=194	A x C A x B°	B x D C x D°
	(A)	**(B)**	**(C)**	**(D)**		
AO by WC 90th percentile (≥65 cm)					0.006 0.20°	0.25 0.43°
AO	41 (14.8)	38 (11.38)	10 (6.1)	16 (8.25)		
Non-AO	236 (85.2)	296 (88.62)	154 (93.9)	178 (91.75)		
AO by WC 85th percentile (≥63 cm)					<0.001 0.073°	0.014 0.43°
AO	67 (24.2)	61 (18.3)	13 (7.9)	20 (10.3)		
Non-AO	210 (75.8)	273 (81.7)	151 (92.1)	174 (89.7)		
AO by WtHR 90th percentile(≥0.59 ratio)					0.003 0.035°	0.73 0.11°
AO	43 (15.52)	33 (9.88)	10 (6.1)	21 (10.82)		
Non-AO	234 (84.48)	301 (90.1)	154 (93.9)	173 (89.2)		
AO by WtHR 85th percentile (≥0.57 ratio)					<0.001 0.013°	0.52 0.024°
AO	70 (25.3)	57 (17.1)	12 (7.3)	29 (15.0)		
Non-AO	207 (74.7)	277 (82.9)	152 (92.7)	165 (85.0)		

Data represent n (proportions), p value determined by Chi2. P<0.05 were considered statistically significant. AO=abdominal obesity. WC= waist circumference, WtHR= waist-to-height ratio.

Table 4. Lineal correlation between WC and WHTR with physical factors in Latin-American preschools children

	Chile		Colombia	
WC (cm) ^WHtR (ratio)	Girls r* (p value)	Boys r* (p value)	Girls r* (p value)	Boys r* (p value)
Age (y)	-0.05 (0.35) -0.05 (0.32) ^	-0.07 (0.17) -0.07 (0.15) ^	-0.15 (0.04) -0.49 (<0.001)^	0.006 (0.92) -0.31 (<0.001) ^
BMI (kg/m^2)	0.15 (0.01) 0.44 (<0.001)	0.06 (0.21) 0.24 (<0.001) ^	-0.07 (0.33) 0.04 (0.59)^	0.01 (0.85) 0.24 (<0.001) ^
WtHR (WC/size)	0.71 (<0.001) -^	0.69 (<0.001) -^	0.73 (<0.001) -^	0.73 (<0.001) -^
BMI percentile	0.14 (0.019) 0.42 (<0.001) ^	0.05 (0.30) 0.22 (<0.001) ^	-0.07 (0.33) 0.05 (0.48)^	0.006 (0.92) 0.23 (0.001) ^
Fitness				
SJT (cm)	-0.01 (0.84) -0.06 (0.28) ^	-0.04 (0.37) -0.01 (0.80) ^	0.11 (0.15) 0.18 (0.01)^	0.001 (0.98) 0.02 (0.68)^
Speed 20 m (s)	0.09 (0.10) 0.13 (0.029) ^	-0.05 (0.29) -0.01 (0.80) ^	0.01 (0.86) -0.03 (0.62)^	-0.15 (0.03) -0.20 (0.004)^
Resistance 10x20 (s)	0.34 (<0.001) 0.27 (<0.001) ^	0.26 (<0.001) 0.22 (<0.001) ^	0.007 (0.92) -0.08 (0.28) ^	0.01 (0.87) 0.01 (0.85)^
Handgrip strength (kg)	0.09 (0.12) 0.04 (0.49) ^	-0.01 (0.83) -0.02 (0.64) ^	0.04 (0.55) 0.13 (0.07)^	0.003 (0.95) -0.02 (0.72)^
Lifestyle				
MD adherence (-5 to 11)	0.006 (0.91) -0.05 (0.34) ^	0.05 (0.27) 0.05 (0.28) ^	0.20 (0.009) 0.20 (0.008) ^	0.24 (<0.001) 0.10 (0.14)^
PA after school (h/week)	-0.15 (0.009) -0.08 (0.16) ^	-0.23 (<0.001) -0.18 (<0.001) ^	0.05 (0.46) 0.04 (0.53)^	0.007 (0.91) 0.08 (0.23)^
ST (h/day)	0.23 (<0.001) 0.14 (0.01) ^	0.24 (<0.001) 0.17 (0.001) ^	0.16 (0.03) 0.12 (0.11)^	0.14 (0.04) 0.04 (0.54)^

Data represent r*= Pearson correlation coefficient (p value), P<0.05 considered statistically significant. BMI= body max index, WC= waist circumference, WtHR= waist-to-height ratio, SLJ= standing long jump test, MD=Mediterranean diet, PA= physical activity, ST= screen time.

Table 5. Association between abdominal obesity and lifestyle in Latin-American preschools children.

	Chile n=611		Colombia n=358	
	3-5 years old	6-7 years old	3-5 years old	6-7 years old
	OR (CI95%) P Value	OR (CI95%) P Value	OR (CI95%) P Value	OR (CI95%) P Value
Bad lifestyle (PA +ST)				
EW- BMI ≥85th	1.73 (1.1 to 2.73), 0.018	1.14 (0.65 to 2.0), 0.63	1.83 (0.96 to 3.47), 0.06	1.60 (0.70 to 3.65), 0.25
AO by WC 90th	2.36 (1.22 to 4.54), 0.010	3.31 (1.05 to 10.4), 0.04	1.65 (0.60 to 4.5), 0.32	6.42 (0.77 to 53.2), 0.08
AO by WC 85th	1.74 (1.04 to 2.90), 0.032	1.69 (0.77 to 3.7), 0.18	1.69 (0.69 to 4.1), 0.25	3.53 (0.73 to 17.0), 0.11
AO by WtHR 90th	1.66 (0.91 to 3.04), 0.09	1.73 (0.55 to 5.37), 0.34	1.23 (0.53 to 2.84), 0.62	1.46 (0.25 to 8.26), 0.66
AO by WtHR 85th	1.75 (1.06 to 2.89), 0.028	0.89 (0.40 to 1.99), 0.78	1.21 (0.56 to 2.62), 0.61	3.08 (0.63 to 15.1), 0.16
Low MD adherence				
EW- BMI ≥85th	1.43 (1.0 to 2.05), 0.04	0.86 (0.56 to 1.30), 0.48	1.27 (0.72 to 2.26), 0.39	0.97 (0.48 to 1.97), 0.95
AO by WC 90th	1.33 (0.83 to 2.14), 0.22	1.17 (0.56 to 2.44), 0.65	0.49 (0.24 to 1.01), 0.056	0.53 (0.19 to 1.46), 0.22
AO by WC 85th	1.01 (0.69 to 1.46), 0.95	0.97 (0.56 to 1.67), 0.91	0.44 (0.23 to 0.84), 0.010	0.42 (0.17 to 1.06), 0.06
AO by WtHR 90th	1.25 (0.79 to 1.98), 0.33	0.57 (0.26 to 1.22), 0.15	0.72 (0.37 to 1.39), 0.33	0.61 (0.17 to 2.15), 0.44
AO by WtHR 85th	1.08 (0.74 to 1.57), 0.67	0.82 (0.45 to 1.49), 0.53	0.63 (0.34 to 1.15), 050	0.37 (0.14 to 0.95), 0.040

The data show represent OR, (95%CI), P-Value. The OR was adjusted by sex. AO; abdominal obesity, WC; waist circumference, WtHR; waist to height ratio, EW; excessive weight.

10. DISCUSIÓN

En la tabla 5 se presenta un resumen del apartado de discusión de cada una de las investigaciones que componen la Tesis Doctoral:

10.1 Tabla 3. Resumen del apartado de discusión de los artículos que componen la Tesis Doctoral.

Artículo	Discusiones
I. Low indicators of personal and social development in Chilean schools are associated with unimproved academic performance: A national study	En el presente estudio, las escuelas con un puntaje ≤ a 70 en los indicadores de desarrollo personal y social, se asoció con no mejorar el rendimiento académico. Los indicadores de desarrollo personal y social tuvieron una alta correlación con el rendimiento académico en estudiantes de nivel socioeconómico medio y bajo. En este sentido, un estudio realizado en estudiantes chilenos reportó que el nivel socioeconómico tuvo una gran influencia sobre el rendimiento académico (1). Otro estudio indicó una correlación entre el nivel socioeconómico y el rendimiento en matemáticas (2). El estilo de vida saludable se relacionó postitivamente con el rendimiento académico de los participantes. En este contexto, se ha reportado previamente que escolares que cumplieron con las recomendaciones de alimentación saludable, obtuvieron mejores expectativas académicas en pruebas de matemáticas, lectura y escritura (3). Asimismo, otro estudio reportó que la AF tiene el potencial de mejorar el rendimiento académico (4). También se ha indicado que un estilo de vida saludable, es clave en el rendimiento académico (3). También, una revisión sistemática indicó que la AF se asoció con la cognición en adolescentes (5).
II. Association between Creativity and Memory with Cardiorespiratory Fitness and Lifestyle among Chilean Schoolchildren	En este estudio la creatividad se asoció positivamente con el CRF y con la adherencia a la DM. En esta línea, Latorre y Cols reportaron que estudiantes clasificados en el grupo de alta creatividad obtuvieron un mejor desempeño en el CRF (6). Asimismo, Hidalgo y Cols encontraron que estudiantes con mayores niveles de CRF tuvieron mayores puntajes de creatividad que sus contrapartes con menor CRF (7). También se ha indicado que una alta adhesión a la DM se asoció con una mejor función cognitiva en adolescentes (8). Adicionalmente, otro estudio reportó que una dieta no saludable puede dañar la función del hipocampo, lo que repercutiría en los niveles de creatividad (9). En el presente estudio la memoria a largo plazo se asoció con el CRF. Además la memoria a largo plazo fue significativamente mejor en estudiantes clasificados con un CRF alto. En este sentido, un estudio previo reportó que el CRF se relacionó positivamente con el trabajo de memoria en escolares (10). Además, se ha demostrado que estudiantes con niveles más bajo de CRF presentan un peor rendimiento en pruebas de memoria (11). Asimismo, otra investigación demostró que el CRF se asoció con la memoria y la velocidad de reacción en pruebas cognitivas (12). Asimismo, en el presente estudio el IMC se asoció negativamente con la memoria a largo plazo. En adición, los escolares obesos obtuvieron un peor rendimiento en la creatividad y en la memoria al

	compararlos con los escolares normo-peso. En este sentido, la evidencia ha demostrado una asociación negativa entre la obesidad y las FE en niños y adolescentes, en donde los participantes con obesidad reportaron menores puntajes en pruebas cognitivas en comparación a aquellos estudiantes con peso normal (13). En esta línea, otro estudio reportó que la obesidad se asoció con FE disminuidas y con un peor rendimiento académico (14).
III. Selective attention and concentration are related to lifestyle in Chilean schoolchildren.	En este estudio la atención selectiva y la concentración se asociaron positivamente con la adherencia a la DM. En esta línea una investigación reportó que una dieta saludable se relacionó con una mejor atención selectiva (15). Además, un estudio realizado en escolares chilenos reportó que los estudiantes con hábitos alimentarios saludables presentaron un mejor desempeño cognitivo (16). Otro estudio reportó que existe una sólida evidencia sobre el impacto de la nutrición sobre las FE, por lo tanto, la alimentación juega un papel preponderante en las FE de niños y adolescentes (17). En el presente estudio la concentración se asoció negativamente con el TP. Además los escolares con menor TP obtuvieron un mejor desempeño en la atención selectiva y en la concentración en comparación a los escolares que reportaron un mayor TP. Un reciente estudio rerportó que aquellos niños que nunca usaron Tablet tuvieron un desempeño cognitvo estadísticamente mejor que aquellos que si la usaban (18). Además, otro estudio reportó que el TP de asoció negativamente con las FE (19). En esta línea, otro estudio demostró que el TP se correlacionó negativamente con el desempeño en las FE (20). Otro estudio realizado con escolares chinos, reportó que el TP de asoció con un peor desempeño en las FE (21).
IV. Lifestyle mediates the relationship between self-esteem and health-related quality of life in Chilean schoolchildren.	En el presente estudio la adherencia a la DM medió positivamente la asociación de la autoestima con la CVRS. De acuerdo a nuestros resultados, otra investigación demostró una asociación positiva entre hábitos alimentarios saludables y la salud mental en adolescentes independiente de los niveles de AF (22). Otro estudio indicó que la adherencia a la DM se asoció positivamente con la autoestima en adolescentes, además el modelo de mediación encontró que la adherencia a la DM y la AF se asociaron con los componentes de la CVRS (23). En este estudio la autoestima se asoció con la CVRS, el TP medió negativamente la asociación entre la autoestima y la CVRS, mientras que la adherencia a la DM y la AF mediaron positivamente esta relación. En esta línea, se ha indicado previamente que la autoestima se considera una variable predictiva de la CVRS (24). Además, se ha reportado que el TP se asoció con menores niveles de autoestima (25). Además otro estudio indicó que un mayor TP se asoció con una peor CVRS en niños (26). También se ha indicado que la AF se ha asociado positivamente con distintas

	dimensiones de la CVRS en adolescentes (27).
V. The association between modifiable lifestyle behaviour in Latin-American schoolchildren with abdominal obesity and excess weight. A comparison of Chile and Colombia.	En el presente estudio menores niveles de CRF se correlacionaron positivamente con la CC. En este sentido, otra investigación reportó que un peor rendimiento en el CRF se asoció con el IMC y la CC en niños (28). También se ha establecido previamente que mejores niveles de CRF se relacionó con una mejor composición corporal en escolares (29). El exceso de peso y la OA en escolares chilenos y colombianos se asoció con un mal estilo de vida. En esta línea, un un estudio realizado en escolares canadienses reportó que un estilo de vida saludable caracterizado por buenos niveles de AF y bajos niveles de TP se asociaron con un IMC saludable (30). De manera similar, un estudio longitudinal demostró que un estilo de vida no saludable se asoció con un peso corporal elevado y con un mayor porcentaje de grasa corporal en niñas (31). Por otro lado y contrario a nuestros resultados, un estudio reportó que el IMC y la CC no se relacionaron estadísticamente con la AF y el TP (32).

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11.- CONCLUSIÓN GENERAL

El principal objetivo de la Tesis Doctoral fue determinar la asociación entre el estilo de vida, medidas antropométricas y la CF con las FE y la CVRS en escolares. Un estilo de vida saludable (niveles de AF, menor tiempo frente a pantalla y adherencia a patrones de alimentación saludable) tiene, según los estudios realizados, una gran preponderancia en algunas FE como la creatividad, la memoria, la atención selectiva y la concentración en particpantes en edad escolar. A lo anterior, debemos sumar que mantener adecuados niveles de la CF y en especial del CRF, podría impactar positivamente en promover el desarrollo cognitivo en la etapa escolar. Además, un estilo de vida saludable en los escolares participantes se relacionó positivamente con la CVRS, la cual es una variable fundamental del bienestar subjetivo de las personas. Por lo tanto y dado los argumentos anteriormente planteados, la promoción de un estilo de vida saludable en la escuela, junto con la concientización de su importancia, debiese ser una prioridad de las políticas educativas, debido a los múltiples beneficios costo-efectivos que pueden causar en los escolares a nivel cognitivo, de bienestar subjetivo y de salud en general.

11.1 Conclusiones

- Un estilo de vida saludable se relacionó positivamente con el rendimiento académico en lenguaje, matemáticas y ciencias naturales. Este hallazgo puede ser útil en la discusión, el diseño y la implementación de políticas públicas y otras iniciativas educativas en Chile. Esto subraya la necesidad de generar acciones que fomenten el desarrollo y la evaluación permanente de un estilo de vida saludable en el contexto educativo chileno, además de generar un espacio para la resignificación del concepto de 'calidad educativa'.

- Al determinar la asociación entre el estilo de vida, medidas antropométricas y la CF con algunas FE, encontramos que la creatividad se asoció con la adherencia a la DM y con el CRF. La memoria se asoció con la clasificación del CRF y con el

IMC. Además, los escolares con altos niveles de CRF obtuvieron un mejor desempeño en las medidas de creatividad y memoria en comparación a aquellos participantes que obtuvieron menores niveles de CRF. Asimismo, los niños con obesidad reportaron menor creatividad y memoria a largo plazo que los niños con peso normal. También, tener menor TP y buenos hábitos alimentarios, se asoció positivamente con la atención y concentración en los escolares participantes. Por lo tanto, tener un estilo de vida saludable, en conjunto con desarrollar buenos niveles de CRF y mantener un estado nutricional normal, debiese ser un objetivo trascendental en las intervenciones educativas, con el propósito de promover el desarrollo cognitivo en el contexto escolar.

- Al determinar la relación entre el estilo de vida con la CVRS en escolares chilenos, la AF se asoció positivamente con la CVRS. Por el contrario el TP se asoció inversamente. Además buenos hábitos alimentarios mediaron la asociación de la autoestima con la CVRS. Impactar positivamente en el estilo de vida, debería ser un objetivo prioritario de las intervenciones comunitarias y escolares para promover el bienestar. Los resultados destacan la necesidad de concientizar a la comunidad educativa sobre la importancia de un estilo de vida saludable, sobretodo en edades tempranas para impactar de manera positiva en el bienestar subjetivo de los escolares.

- Al determinar la asociación del estilo de vida y la CF con la OA y el exceso de peso en escolares chilenos y colombianos, el exceso de peso y la OA se asociaron con un mal estilo de vida y con peores niveles de CRF. Por lo tanto, las intervenciones para reducir la prevalencia de OA, deben incluir la promoción de un estilo de vida saludable (es decir, aumentar la AF después de la escuela, reducir el TP y mejorar el CRF) en los niños latinoamericanos.

12.- LIMITACIONES

Las principales limitaciones de las investigaciones fueron:

1. El diseño transversal de los estudios. Es importante aplicar diseños longitudinales para clarificar la dirección de las asociaciones entre las variables. Además el uso de un muestreo por conveniencia en la mayoría de los estudios, puede ser una limitante a mejorar en el futuro.

2. Otra limitación es el uso de instrumentos de recolección de datos auto-reportados y el uso de test indirectos, lo cual puede subestimar o sobrestimar los resultados alcanzados.

3. No se consideró el nivel socioeconómico ni la maduración biológica. Se deben controlar más variables como las previamente nombradas.

4. Faltó desarrollar estudios de intervención que son muy relevantes en el área investigada y que pueden determinar estrategias relevantes para impactar en las FE y en la CVRS de los escolares.

13.- PROSPECTIVAS FUTURAS DE ESTUDIO

Los resultados sugieren que un estilo de vida saludable es fundamental para las FE, la CVRS y algunos marcadores de salud. Lo anterior genera la necesidad de establecer la importancia de un estilo de vida saludable en el contexto escolar y en la política educativa.

Para futuros estudios se deben agregar varios elementos que pueden contribuir a tener información relevante en el área de investigación:

- Aplicar diseños longitudinales para clarificar las asociaciones entre el estilo de vida, las FE y el bienestar subjetivo en la etapa escolar.
- Diversificar los instrumentos de recolección de datos, así como agregar nuevas medidas de FE (flexibilidad cognitiva, habilidad de planificación e inhibición cognitiva). En el estilo de vida, también se deben proyectar nuevas medidas como por ejemplo los parámetros de sueño. También se deben agregar más variables sociodemográficas.
- Aplicar intervenciones de AF en el contexto escolar para medir su impacto en distintas variables de importancia.
- Establecer qué tipo de ejercicio en cuanto a tipo, dosis, volumen, intensidad y frecuencia son efectivos para mejorar las variables previamente descritas.
- Proyectar la realización de una investigación con revisión sistemática y metaanálisis.

14. PRESENTACIONES EN CONGRESOS

- ✓ Relación de los estilos de vida con la autoestima y la calidad de vida en una muestra de escolares chilenos. Seminario nacional e internacional en ciencias de la actividad física. Universidad De Los Lagos, Osorno, Chile. 2020

- ✓ Atención y concentración según Fitness cardiorrespiratorio y estado nutricional en una muestra de escolares Chilenos. Seminario nacional e internacional en ciencias de la actividad física. Universidad De Los Lagos, Osorno, Chile. 2020

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16.- ANEXOS.

16.1 Artículos que componen la Tesis Doctoral en el formato de las revistas de publicación.

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Low indicators of personal and social development in Chilean schools are associated with unimproved academic performance: A national study

Pedro Delgado-Floody[a,*], Bastián Carter-Thuillier[b,e], Iris Paola Guzmán-Guzmán[c], Pedro Latorrre-Román[d], Felipe Caamaño-Navarrete[e]

[a] Faculty of Education, Social Sciences and Humanities, Universidad de La Frontera, Temuco, Chile
[b] Department of Education, Universidad de Los Lagos, Osorno, Chile
[c] Universidad Autónoma de Guerrero, Guerrero, Mexico
[d] Department of Didactics of Corporal Expression. University of Jaen, Spain
[e] Faculty of Education, Universidad Católica de Temuco, Chile

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ABSTRACT

The objective of the present study was to determine the association of academic performance with personal and social development indicators in Chilean schools from the results of the 2016 national education study and to determine the relationship of these results with the schools' socioeconomic background. The results from 2891 schools that participated in the 2016 national education study were analyzed. This examination considered academic performance (2016 vs 2015) and personal and social development indicators. The indicators with values ≤ 70 were associated with unimproved academic performance (i.e., maintained or decreased). Moreover, the indicators had a greater correlation with academic performance on low/middle-low socioeconomic background Schools. This finding may be useful in the discussion and implementation of public policies in Chile.

1. Introduction

Over the past few years, most Latin American countries have focused their efforts on constantly improving the quality of education in their territories (Feldeber & Andrade, 2016; Rivas & Sánchez, 2016). However, this has involved the emergence of new debates and theoretical positions about the concept of educational quality (Leal, Gamelas, Barros, & Pessanha, 2018), a term that is permanently in the process of resignification and reconceptualization (Díaz, 2015) based on the recommendations of official organizations (Acuña & Pons, 2016) and the particular beliefs of Educational actors (Torche, Martínez, Madrid, & Araya, 2015). This also implies a questioning of the variables commonly associated with the concept of educational quality (Burchinal, 2018; Nutall, 2017; Salilul & Shahadat, 2016; Slot, Leseman, Verhagen, & Mulder, 2015; Tokuhama-Espinosa, 2015).

Different authors (Díaz, Reyes, Dueñas, & Bernal, 2017; Nutall, 2017; Sayed & Ahmed, 2015; Schindler, Welzat, Puls-Elvidge, & Crawford, 2015) have raised the need to analyze and deconstruct the representations and discourses that exist around the concept of educational quality with the aim of surpassing the traditional approaches that exclusively relate this term to an individual cognitive dimension. The specialized literature suggests that a high-quality education must contribute to the biopsychosocial development of

* Corresponding author at: Universidad de La Frontera. Uruguay No. 1980. Temuco. Chile.
E-mail address: pedro.delgado@ufrontera.cl (P. Delgado-Floody).

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the subjects (Inman, Buck, & Tandy, 2003; Tattum & Tattum, 2017), meeting the personal, social, and cultural demands of future citizens (Bourn, 2015; Hardy & Woodcock, 2015).

Different countries have implemented systems to evaluate the quality of education and to measure variables that can affect academic performance (UNESCO, 2017). In the case of Chile, the Ministry of Education (MINEDUC) has historically conducted standardized tests of language, math, and science to assess the quality of education in schools (i.e., academic performance). However, after different political and academic debates (Castillo & Contreras, 2014), the measurement of new variables at the national level has been included since 2013 to obtain data on fundamental non-academic aspects linked to students' all-round development (MINEDUC, 2019). This has given rise to the creation of "personal and social development indicators" that seek to assess (a) academic self-esteem and motivation, (b) school climate, (c) civic participation and education, and (d) healthy living habits. This makes it possible to evaluate educational quality from a broader perspective and design actions that improve how the schools operate (Leyton, Huepe, Mandiola, & Traslaviña, 2013).

1.1. Academic self-esteem and motivation

In relation with the indicators, the academic self-esteem has been associated positively with academic outcomes, and there are several factors that influence their development such as family, social interactions constructed at school, and socioeconomic status, among others (Topçu & Leana-Taşcılar, 2016). Moreover, Academic motivation also emerges as another fundamental variable to achieving high academic performance, this type of motivation can be defined as something that drives the accomplishment of learning tasks, determining the student interests and attitudes to school contents, in addition to the motivation to achieve and the attitudes expressed in the event of difficulties inherent to studying (Valenzuela, Muñoz Valenzuela, Silva-Peña, Gómez Nocetti, & Precht Gandarillas, 2015).

1.2. School climate

School climate is defined as the quality of social and emotional interactions that students develop with one another in addition to the social relations that these stakeholders build with teachers (López-González & Oriol, 2016). Although the classroom climate is perceived differently by each student, it has been shown to have a direct impact on academic performance (Barreto & Álvarez, 2017; Barros & Frias, 2016; Berkowitz, Moore, Astor, & Benbenishty, 2017; López-González & Oriol, 2016). In other words, a positive school climate could promote greater learning (Castro & Morales, 2015) and potentially reduce gaps in academic performance among students (Berkowitz et al., 2017) as well as presenting fewer conflicts and less bullying in the student body (Acosta et al., 2019), favoring personal and social development (La Salle, Zabek, & Meyers, 2016). Likewise, a school climate supported by a warm, respectful atmosphere and supportive relations among all the stakeholders would enable students to perform optimally in academic terms, since they are committed emotionally to working in the classroom (Treviño, Toledo, & Gempp, 2013).

1.3. Civic participation and education

Civic education is a key aspect in education systems because it affords people essential competencies for a participatory life in current society (Caballero, Cárdenas, & Valle, 2016). In the same vein, Crick (2017) showed that it is crucial to promote civic education among students, as this will help students understand current democratic complexities and dilemmas. In other words, school is seen as a space that forms future citizens to participate in the public sphere using the skills and knowledge necessary for political participation and better social inclusion (Bolívar, 2016). Hess and McAvoy (2014) indicated that promoting democratic education in the classroom allows students to develop their skills in deliberating different aspects of a political nature, which represents a great educational opportunity but also a pedagogical and ethical challenge in educational terms. For Sousa and Oxley (2019), school can be a privileged space for learning and reinforcing democratic values such as cooperation, participation, and tolerance.

1.4. Healthy habits

The positive impact of healthy habits on academic performance as well as on personal and social development has been described before, in concrete terms, different studies (Burrows, Goldaman, Olson, Byrne, & Coventry, 2017; Haapala et al., 2017; Mclsaac, Kirk, & Khule, 2015; Stea & Torstveit, 2014) show that eating healthy food and being physically active are factors that have a positive effect on academic performance, cognitive development, and the perception of well-being in students. Likewise, a meta-analysis (Álvarez-Bueno et al., 2017) focused on studying the relation between physical activity and academic performance in students showed that higher levels of physical activity, especially in physical education (PE) classes, collaborate in a better classroom climate in addition to performing better academically, particularly in skills related to math and language. Based on previously reported findings, physical activity interventions have been applied in the classroom to understand their immediate effect on academic performance, obtaining positive results in most cases, as a systematic review by Watson, Timperio, Brown, Best and Hesketh (2017) pointed out.

The personal and social development indicators (i.e. academic self-esteem and motivation, school climate, civic participation, healthy habits) allow to evaluating educational quality from a broader perspective and to determinate that variables can affect academic performance and designing actions that improve the schools levels and equity. Therefore, the objective of the present study

was to determine the association of academic performance with personal and social development indicators in Chilean schools (i.e., high schools) from the results of the 2016 national education study and to determine the relationship of these results with the schools' socioeconomic background and the type of school (i.e., public, subsidised, or private). Thus, the research question is whether personal and social development indicators are associated with academic performance in Chilean schools?

2. Materials and methods

2.1. Research context

The present study is based on data from a 2016 national education study 'SIMCE' (MINEDUC, 2016) in comparison with results in academic performance in language, maths, and science from 2015 in all high schools (level II). SIMCE is an acronym in Spanish: 'sistema de medición de la calidad de la educación' (quality education assessment system). The database was required through the Agency of Education Quality (2016) and it does not include comparisons or divisions according to gender.

The Chilean educational system is divided into four stages: (a) infant education (up to five years old), (b) basic education (primary, from first to eighth grade), (c) middle education (high school, with a four-year duration, I-IV), (d) higher education (university or technical training institutes). The schools are divided into three types: (a) municipal: free schools for the population, administered by city councils and financed by central government, (b) subsidised schools, which are financed by a mixture of funding from central government and private contributions, and (c) private: private schools financed entirely by private contributions.

Recent evidence shows that there is a high socioeconomic segregation in the Chilean educational system. Students who come from families with higher poverty rates mostly go to municipal schools that have the worst results in the national standardised test compared to private–subsidised and private schools, while those with better socioeconomic status attend subsidised or private educational centres (Mizala & Torche, 2012). Likewise, this situation has generated a significant number of critics, mainly because it substantially hinders social mobility, and tends to perpetuate the status quo, denying the best educational possibilities to the population with lower incomes (Cabalin, 2012).

2.2. Participants

The results from 2891 high schools of level II were analysed (196,344 students). Performance-related data from the schools in language, maths, and natural sciences tests were used. The national study provided information to complement the analysis of student learning achievement in schools. Additionally, the results that each school obtained on the personal and social development indicators were included. Each of the indicators assessed is described below.

3. Measures

All the data used in this study were officially requested from the Agency of Quality Education (2016), organisation that is part of the Ministry of Education in Chile. This state department formally granted all necessary permits to use the data for research purposes and subsequent publication. The Ministry of Education applied standardised tests in all of the schools in the country with the objective of evaluating four personal and social development dimensions: (a) academic self-esteem and motivation, (b) school climate, (c) civic participation and education, (d) healthy habits.

These variables were measured through ad hoc questionnaires (reserved content), created especially for the national study. All results were derived from self-declared perceptions by the respondents, and these tests were conducted in parallel with the academic tests (maths, language and science).

As mentioned above, academic performance was measured using the students' results on standardised tests of maths, language, and science (which are part of the national SIMCE study). The content of these tests was designed by government specialists and their use is confidential. All tests were multiple-choice. The research team agreed ethical commitments with the Chilean state, in order to protect the schools and students' identity, and undertook to use the data solely for scientific purposes.

3.1. Academic self-esteem and motivation

This indicator was evaluated through the use of a questionnaire with students and included two sub-dimensions: (a) self-perception and academic self-assessment, which included both the students' perceptions of their aptitudes, skills, and possibilities of self-improvement, and their assessment of their attributes in the academic field, and (b) academic motivation, which included the students' perceptions of their interest and willingness to learn, their academic expectations and motivation to achieve, and their attitudes to the difficulties involved in studying.

3.2. School climate

In order to evaluate this indicator, questionnaires were used with students, teachers, and parents, and explored the perceptions and attitudes of these stakeholders in three sub-dimensions: (a) the atmosphere of respect, which took into account the stakeholders' perceptions and attitudes about respectful treatment among the members of the school community, as well as the value of diversity and the presence and/or absence of discrimination in the school, (b) an organised environment, which considered the stakeholders'

perceptions of the existence of clear guidelines that are known, required, and respected by all, and the predominance of constructive conflict resolution mechanisms, and (c) a safe environment, which considered the stakeholders' perceptions of the degree of safety and physical or psychological violence that exists in the school, as well as the existence of action and prevention mechanisms in the event of these forms of violence.

3.3. Civic participation and education

In order to evaluate this indicator, questionnaires were used with students and parents to learn about the stakeholders' perceptions of the following sub-dimensions: (a) participation opportunities for working together, spaces for collaboration promoted by the school, and the degree of commitment and involvement of the school community in such instances, (b) a feeling of belonging—identification with the school's mission and the school community, and (c) democratic life—the degree to which the school fostered the development of skills and attitudes needed for life in a democracy.

3.4. Healthy habits

This indicator evaluated the students' self-declared attitudes and behaviours in relation to healthy living. In addition, their perceptions about the degree to which the school promoted practices beneficial to health were analysed, including the following sub-dimensions: (a) eating habits—self-declared attitudes and behaviours with respect to students' eating habits and their perceptions of the degree to which the school promoted healthy eating habits, (b) active lifestyle—students' self-declared attitudes and behaviours related to an active lifestyle and their perceptions of how the school promoted physical activity, and (c) self-care habits—this considered the students' self-declared attitudes and behaviours regarding sexuality, the consumption of tobacco, alcohol, and drugs, and their perceptions about the degree to which the school prevented risk behaviours.

4. Statistical analysis

Data were analysed with the statistics programs STATA v.13.0 and GraphPad Prism v.7.0. The data presented a nonparametric distribution. The absolute frequencies were determined for qualitative variables. The comparison between groups was evaluated with a Kruskal–Wallis test. Spearman correlation coefficients, multiple logistic regression models, and relative risk (RR) were used to determine the associations between the personal and social development indicators and academic performance. P-values $< .05$ were considered statistically significant.

5. Results

Data from 2891 schools were analysed for personal and social development indicators in relation to academic performance in the areas of language, maths, and natural sciences. Most of the students evaluated were in subsidised schools followed by publics schools (see Fig. 1a). Likewise, the majority of students who attended publics schools were from low and middle-low socioeconomic backgrounds (see Fig. 1b).

There were differences in the personal and social development indicators in the comparison of school types (public, subsidised, and private), in academic self-esteem and motivation ($p < .001$), school climate ($p < .001$), civic participation and education ($p < .001$), and healthy habits ($p < .001$), with the public schools producing the lowest results. The same differences were found in the academic results for language ($p < .001$), maths ($p < .001$), and natural sciences ($p < .001$) (Table 1).

The scores obtained on the language, maths, and science tests were assessed to determine the improvement or deterioration between the 2016 scores compared to the 2015 scores. Language and natural sciences were the most deteriorated (48 % and 61.2 %,

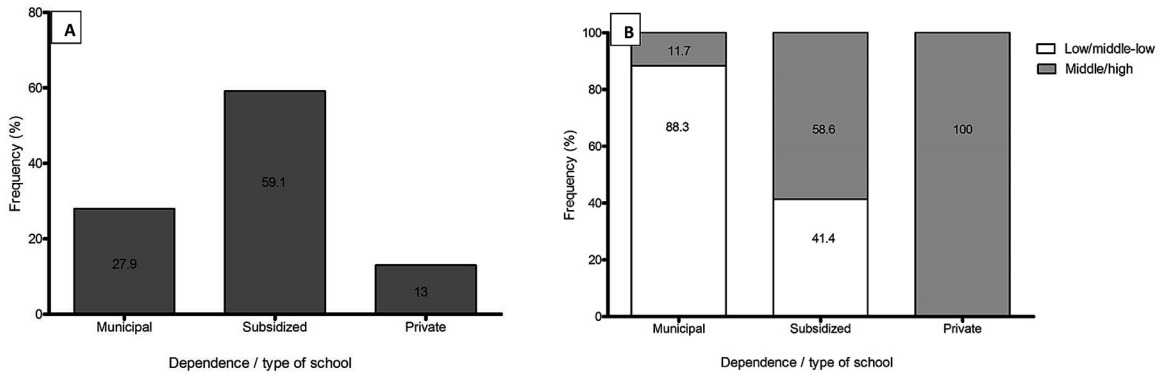

Fig. 1. Frequency of Schools according type of school Municipal (i.e., Public), Subsidized and Private (A). Frequency of Schools in low/middle-low in different according types of Schools (B).

Table 1
Comparison of indicators and academic performance of the schools according to dependence.

	Municipal	Subsidized	Private	P-value
Indicators				
Academic self-esteem and motivation	72.76 ± 3.149	74.20 ± 2.982	75.18 ± 3.744	P < 0.001
School climate	72.15 ± 5.350	75.84 ± 5.605	78.32 ± 5.238	P < 0.001
Civic participation and education	69.43 ± 5.318	69.97 ± 5.993	71.15 ± 7.000	P < 0.001
Healthy habits	75.87 ± 5.207	77.51 ± 6.033	79.82 ± 6.844	P < 0.001
Academic performance				
Language	229.28 ± 25.763	250.40 ± 26.64	276.04 ± 28.89	P < 0.001
Δ Language (2016 vs 2015)	−0.47 ± 16.06	0.39 ± 17.69	2.23 ± 21.81	P = 0.054
Math	229.30 ± 34.831	268.10 ± 39.30	319.66 ± 37.75	P < 0.001
Δ Math (2016 vs 2015)	2.43 ± 14.39	2.60 ± 15.63	3.63 ± 17.46	P = 0.441
Natural science	221.29 ± 21.532	243.15 ± 26.20	286.67 ± 30.95	P < 0.001
Δ Natural science (2016 vs 2015)	−3.66 ± 9.90	−6.96 ± 13.18	−7.40 ± 17.32	P < 0.001

Data are shown as mean ± SD. Values of $p < 0.05$ were considered statistically. Δ = Differences.2016 − 2015.

respectively), whereas maths was the most improved (53 %) (Table 2).

Focussing on socioeconomic status, the analysis found a significant correlation between academic performance and personal and social development indicators. The highest correlations were in low/middle-low schools between indicators of school climate with language (r*0.56, $p < 0.001$), maths (r*0.47, $p < 0.001$), and natural sciences (r*0.50, $p < 0.001$) (Table 3).

According schools dependence, the analysis found a significant correlation between academic performance and personal and social development indicators. The highest correlations were found in public schools between **school climate** indicators with language (r*0.55, $p < 0.001$), maths (r*0.48, $p < 0.001$), and natural sciences (r*0.49, $p < 0.001$) (Table 4).

Turning to unimproved (i.e., maintained or decreased) academic performance in language, maths, and natural sciences, the association was analysed for (a) academic self-esteem and motivation, (b) school climate, (c) civic participation, and (d) healthy habits, with values ≤ 70 points. (a)Academic self-esteem and motivation scores ≤ 70 were associated with unimproved (i.e. maintained or decreased) in math and sciences. Moreover, (b) the school climate ≤ 70 was associated with unimproved scores in the three learning areas (languages, maths, and natural sciences), with a greater association in public schools. Likewise, (c) civic participation in the schools ≤ 70 showed association with unimproved scores in language and maths, whereas (d) the healthy habits of the school ≤ 70 was associated with unimproved scores in all areas (language, maths, and natural sciences) (Table 5)

6. Discussion

The objective of the present study was to determine the association of academic performance with personal and social development indicators in Chilean schools from the results of the 2016 national education study and to determine the relationship of these results with the schools' socioeconomic background and the type of school (i.e., public, subsidised, or private).

In the present national study, the indicators of personal and social development (academic self-esteem and motivation, school climate, civic participation and education, and healthy habits) that had a score ≤ 70 were associated with unimproved academic performance. Moreover, in language and natural sciences, the largest of the schools showed a decline in its score (when comparing scores from 2016 and 2015), while the majority improved in maths. As previously observed, in Chile, there are three kinds of schools: public schools (the administration of which are decentralised to the municipal level), private subsidised schools (they have a co-pay system) and private voucher schools (private non-subsidised) (Bellei, 2005). The problem of educational inequity is that in recent decades (i.e., in Chile), the academic results of private schools were significantly higher than those obtained by public and subsidised schools, presenting a greater difference than currently exists. This means that the learning gaps between schools with students from a high socioeconomic background and those with students from a low socioeconomic background have narrowed. However, in both cases, 'results are far from high when they are compared to international levels of academic attainment. In this way, equity in education is principally understood as students' learning outcomes in national and international tests. However, the analysis is more complex (Volckmar, 2019). Harris and Jones (2019) state that equitable education is when a school system is essentially one where all students reach their full potential irrespective of their background, and any differences in learner outcomes do not result from socioeconomic differences. The OECD (2018) report shows that while some countries that participate in PISA have managed to build

Table 2
Distribution of the category of change in the academic test score.

Variable	Language	Math	Natural sciences
Unimproved	186 (6.4 %)	217 (7.5 %)	402 (13.9)
Deteriorated	1387 (48.0 %)	1143 (39.6 %)	1769 (61.2)
Improved	1318 (45.6 %)	1531 (52.9 %)	720 (24.9)

Data are shown n (proportion).

Table 3
Correlation between the indicators and academic performance according to the socioeconomic status.

	Language r* (P-value)		Math r* (P-value)		Natural sciences r* (P-value)	
	low/middle-low	*Middle/high*	*low/middle-low*	*Middle/high*	*low/middle-low*	*Middle/high*
Academic self-esteem	0.45 (< 0.001)	0.44 (< 0.001)	0.40 (< 0.001)	0.40 (< 0.001)	0.39 (< 0.001)	0.42 (< 0.001)
School Climate	0.56 (< 0.001)	0.51 (< 0.001)	0.47 (< 0.001)	0.43 (< 0.001)	0.50 (< 0.001)	0.45 (< 0.001)
Civic participation	0.48 (< 0.001)	0.47 (< 0.001)	0.42 (< 0.001)	0.43 (< 0.001)	0.44 (< 0.001)	0.45 (< 0.001)
Healthy habits	0.45 (< 0.001)	0.36 (< 0.001)	0.34 (< 0.001)	0.31 (< 0.001)	0.38 (< 0.001)	0.32 (< 0.001)

Data shown represent r*: Spearman correlation coefficient. Values of $p < 0.05$ were considered statistically significant.

education systems where socioeconomic status makes less of a difference in students' learning, in all countries that participated in PISA 2015, socioeconomic status has a large influence on students' performance in science, reading and mathematics. Thus every country can do more to improve equity in education (OECD, 2018). However, the educational system in Chile faces the challenge of implementing equity-oriented policies within the legal confines of an education system constructed under the neoliberal model (Matear, 2007). Also, there is a deficit in quality that cuts across all of Chilean education (OECD, 2016).

The personal and social development indicators have a greater correlation on the academic performance of students from a low/middle-low socioeconomic background. A study conducted on a Chilean student sample showed that socioeconomic background (measured by family income) has a strong influence on academic performance in children (Claro, Paunesku, & Dweck, 2016). Another study conducted with schoolchildren shows a high, statistically significant correlation between socioeconomic background and academic performance in maths (Suárez-Álvarez, Fernández-Alonso, & Muñiz, 2014). Likewise, socioeconomic status amplifies the achievement gap throughout compulsory education, independent of intelligence (Von Stumm, 2017).

Several elements influence academic performance, with socioeconomic background being the greatest predictor in educational achievement in most contexts (Dietrichson, Bøg, Filges, & Klint, 2017). An OECD analysis of the Chilean education system confirmed that access to a quality education is strongly influenced and differentiated by the socioeconomic characteristics of the families in addition to the selection processes of the schools themselves (González, 2017). Other international studies show a similar situation, demonstrating that socioeconomic background is correlated positively with academic performance (Dixson, Keltner, Worrell, & Mello, 2018). However, the differences in academic performance are not related solely to socioeconomic background or student selection, but classroom environment is also a factor, in particular the climate of the school, which habitually undermines the sectors with the greatest social and economic vulnerabilities (Ascorra et al., 2016).

The academic self-esteem and school motivation indicator was correlated with academic performance in the three academic areas (language, maths and natural sciences). In this way, a of the educational challenges is fostering motivation in academic achievement and responding to three questions that the students may ask themselves: can I be successful? Do I want to do this task? And why am I doing this task? To a great extent, the differences in motivation to achieve can be explained by the lack of the students' confidence in their own ability to be successful and in their lack of extrinsic motivation (Eccles & Wigfield, 2015). A study classified students into affective profiles, reporting that those who had a positive profile were more engaged and performed better in a particular subject (Robinson et al., 2017). For this reason, the present results demonstrate that those schools with lower scores in academic self-esteem and motivation will not improve in academic performance.

School climate was also correlated with academic performance. Evidence of the relationship between academic performance and classroom climate indicates that an appropriate classroom environment creates a social learning space that favours positive academic results in schools (Maxwell, 2016). Moreover, school climate can even mediate as a protective factor in contexts with students who have an adverse socioeconomic situation (Berkowitz et al., 2017) and students who come from untraditional family structures or circumstances of social risk (O'Malley, Voight, Renshaw, & Eklund, 2015). The school climate can positively influence students' academic results, thus potentially reducing the gaps in academic performance, overcoming even social and economic barriers (Berkowitz et al., 2017). A recently published study in which a structural equations model relating academic performance to eight dimensions of school climate accurately shows that this model explains 39.6 % of the variability of school performance (Cerda, Pérez, Elipe, Casas, & Del Rey, 2019). Therefore, most of the literature suggests that intervening in the classroom climate is fundamental to achieving significant changes in students' well-being and academic performance as well as being a fundamental aspect that should be considered in every country prior to making education reforms (Wang & Degol, 2016).

Civic participation and education indicators were correlated with academic performance in language and maths. The Quality Agency considers it fundamental to teach civic participation and education because this is related to the values essential to living in a community and developing virtues for a healthy democratic coexistence. Currently, the crisis of democracy is receiving attention because it has been spreading within western institutions that were supposed to have been paragons of the democratic ideal and from which many other (non-western) countries were supposed to learn (Muliro, 2017). In this way, while the tradition of a stable political party system and efficient state apparatus seemed to make Chile less vulnerable than many of its neighbours in Latin America, today the country faces an important crisis of political legitimacy (Heiss, 2017). However, the literature is not completely consistent on the matter. There are results from other studies conducted with students of different ages in which the development of practices linked to civic commitment and democratic practices do not show any connection to academic performance or self-efficacy, although there is one study about motivation and levels of happiness (Guillaume, Jagers, & Rivas-Drake, 2015). Another important subject for consideration is the political participation within the school, and a study concluded that the influence of school is mainly related to

Table 4
Correlation between the indicators and academic performance according school dependence.

	Language r* (P-value)			Math r* (P-value)			Natural sciences r* (P-value)		
	Public	Subsidized	Private	Public	Subsidized	Private	Public	Subsidized	Private
School self-esteem	0.46 (< 0.001)	0.42 (< 0.001)	0.39 (< 0.001)	0.38 (< 0.001)	0.37(< 0.001)	0.34 (< 0.001)	0.39 (< 0.001)	0.37 (< 0.001)	0.39 (< 0.001)
School climate	0.55 (< 0.001)	0.53 (< 0.001)	0.41 (< 0.001)	0.48(< 0.001)	0.43 (< 0.001)	0.32 (< 0.001)	0.49 (< 0.001)	0.46 (< 0.001)	0.37 (< 0.001)
Civic participation	0.50 (< 0.001)	0.41 (< 0.001)	0.36 (< 0.001)	0.43 (< 0.001)	0.35 (< 0.001)	0.31 (< 0.001)	0.45 (< 0.001)	0.36 (< 0.001)	0.33 (< 0.001)
Healthy habits	0.40 (< 0.001)	0.32 (< 0.001)	0.38 (< 0.001)	0.28 (< 0.001)	0.23(< 0.001)	0.36 (< 0.001)	0.32 (< 0.001)	0.24 (< 0.001)	0.40 (< 0.001)

Data shown represent r*: Spearman correlation coefficient. Values of $p < 0.05$ were considered statistically.

Table 5
Association between indicators ≤70 points with unimproved academic performance (2016 vs 2015).

	Indicators ≤70 points RR (95%CI), P-value			
Variables	School self-esteem	School climate	Civic participation	Healthy habits
Language				
Total	1.35 (1.08−1.69), 0.07	1.43 (1.19−1.72), < 0.001	1.35 (1.07−1.71), 0.01	1.21 (1.05−1.41), 0.008
Public	1.25 (0.89−1.77), 0.19	1.41 (1.05−1.89), 0.02	1.37 (0.90−2.09), 0.13	1.23 (0.93−1.64), 0.13
Subsidized	1.42 (1.02−1.98), 0.034	1.49 (1.14−1.95), 0.003	1.37 (1.01−1.86), 0.037	1.17 (0.97−1.42), 0.09
Private	1.16 (0.57−2.33), 0.67	0.85 (0.38−1.93), 0.71	1.04 (0.49−2.23), 0.90	1.26 (0.83−1.91), 0.27
Math				
Total	1.27(1.14−1.43), < 0.001	1.20 (1.09−1.32), < 0.001	1.23 (1.09−1.38), 0.001	1.13 (1.04−1.22), 0.002
Public	1.44 (1.02−2.02), 0.034	1.65 (1.23−2.21), 0.01	1.70 (1.12−2.58), 0.01	1.31 (0.99−1.74), 0.057
Subsidized	1.38 (1.0−1.90), 0.049	1.26 (0.97−1.64), 0.07	1.27 (0.94−1.71), 0.11	1.13 (0.93−1.37), 0.19
Private	4.5 (1.99−10.2), < 0.001	2.14 (0.92−5.0), 0.07	2.85 (1.26−6.5), 0.01	1.86 (1.22−2.84), 0.004
Natural sciences				
Total	1.60 (1.21−2.11), 0.001	1.50 (1.20−1.87), < 0.001	1.1 (0.84−1.44), 0.45	1.24 (1.04−1.46), 0.012
Public	1.94 (1.2−3.12), 0.006	1.46 (1.01−2.11), 0.039	1.25 (0.74−2.13), 0.39	1.65 (1.17−2.32), 0.004
Subsidized	1.36 (0.92−2.0), 0.11	1.32 (0.97−1.80), 0.07	1.04 (0.74−1.46), 0.80	1.05 (0.84−1.30), 0.63
Private	1.08 (0.48−2.39), 0.84	2.05 (0.68−6.13), 0.19	0.98 (0.42−2.29), 0.96	1.34 (0.83−2.16), 0.22

Relative Risk RR (Confidence Interval, 95 % CI), p value. P < 0.05 was considered statistically significant.

school governance and teacher practices, while the students' civic and political background has the greatest influence in political participation (Treviño, Villalobos, Béjares, & Naranjo, 2019).

Healthy habits in the measurement of social and personal development indicators include physical activity, healthy eating, and the prevention of alcohol and tobacco. A study on schoolchildren reported that the compliance with dietary recommendations was associated with an increased likelihood of fulfilling academic expectations in mathematics, reading, and writing (Faught, Ekwaru et al., 2017; Faught, Gleddie, Storey, Davison, & Veugelers, 2017). In addition, it has been shown that physical activity aimed at increasing aerobic capacity and motor skills could have the potential to improve academic performance (Aadland et al., 2017). A systematic review concludes that physical activity is associated with cognition (Esteban-Cornejo, Tejero-Gonzalez, Sallis, & Veiga, 2015). Disturbingly, the 2016 SIMCE reports that only 16 % of students in the second year of secondary school are in the high segment of healthy lifestyles, which is why education policies should consider measures that tend to increase the levels of physical activity in the school population to improve not only health markers, but also biopsychosocial factors. A study show that healthy living habits are decisive in academic performance, even independently of body weight, identifying these lifestyle behaviours as key factors to consider for improving academic performance during the first years of adolescence (Faught, Ekwaru et al., 2017; Faught, Gleddie et al., 2017).

7. Limitations

Some limitations of the present study were not being able to determine differences of gender or ethnicity for each school. Also, all measures of social indicators were self-declared perceptions. Furthermore, it is necessary to continue improving the construction and validation of the questionnaires which the Chilean educational Quality Agency uses to measure the indicators of personal and social development. The great strength of this study is its great sample and which makes it highly representative of the Chilean school population.

8. Conclusions

In conclusion, the schools that presented scores ≤70 points in personal and social development indicators had a significant association with no change or deteriorating results on the academic tests assessed. In addition, personal and social development indicators were correlated with academic performance in language, maths and natural sciences, mainly affecting schools that serve students from a low/middle-low socioeconomic background. This finding may be useful in the discussion, design and implementation of public policies and other education initiatives in Chile. Likewise, the Chilean educational system must generate policies that improve equity in education so that socioeconomic factors do not limit the development potential of students.

The results highlight how personal and social development indicators affect academic performance. This underscores the need to develop actions that foster the development and permanent evaluation of these indicators in the Chilean educational context, in addition to generating a space for the resignification of the concept of 'education quality', giving relevance to the comprehensive education of the subjects, and understanding the education process as a construct indivisibly bound to the sociocultural characteristics that each subject and group must face.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ijer.2020.101651.

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MDPI

Article

Association between Creativity and Memory with Cardiorespiratory Fitness and Lifestyle among Chilean Schoolchildren

Felipe Caamaño-Navarrete [1], Pedro Á. Latorre-Román [2], Juan A. Párraga-Montilla [2], Cristian Álvarez [3] and Pedro Delgado-Floody [4,*]

[1] Faculty of Education, Universidad Católica de Temuco, Temuco 478000, Chile; marfel77@gmail.com
[2] Department of Didactics of Music, Plastic and Corporal Expression, University of Jaén, 23071 Jaén, Spain; platorre@ujaen.es (P.Á.L.-R.); jparraga@ujaen.es (J.A.P.-M.)
[3] Quality of Life and Wellness Research Group API4, Laboratory of Human Performance, Department of Physical Activity Sciences, Universidad de Los Lagos, Osorno 5290000, Chile; cristian.alvarez@ulagos.cl
[4] Department of Physical Education, Sport and Recreation, Universidad de La Frontera, Temuco 478000, Chile
* Correspondence: pedro.delgado@ufrontera.cl; Tel.: +56-962489239

Abstract: The objective was to investigate the association between creativity and memory with cardiorespiratory fitness (CRF; i.e., CFR classification and $\dot{V}O_{2max}$); lifestyle parameters (i.e., physical activity (PA), sleep duration, screen time (ST), and food habits); and anthropometric measures (i.e., body mass index (BMI), waist circumference (WC)) among Chilean schoolchildren. A total of 248 schoolchildren (137 boys, 111 girls, 11.80 ± 1.17 and 11.58 ± 1.09 years, respectively) participated in the cross-sectional study. Creativity, memory, concentration, and selective attention and lifestyle (PA, ST, sleep duration, and Mediterranean diet (MD) adherence) were measured using a standard questionnaire. CRF (measured by the 20 m shuttle run test and expressed as maximum oxygen consumption ($\dot{V}O_{2max}$) and anthropometric measures (BMI and WC) were also included. Creativity showed a positive association with $\dot{V}O_{2max}$ (ml/kg/min) (β; 0.209, 95% CI; 0.02–0.40, $p = p < 0.05$) and MD Adherence (score) (β; 0.206, 95% CI; 0.01; 0.74, $p = p < 0.05$). Long-term memory reported a positive association with CRF (β; 1.076, 95% CI; 0.02–2.13, $p = p < 0.05$). An increase in CRF levels, together with healthy food habits and normal nutritional status, should be a target for community- and school-based interventions to promote cognitive development in creativity and memory among schoolchildren.

Keywords: creativity; memory; cardiorespiratory fitness; mediterranean diet; schoolchildren

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1. Introduction

Childhood and adolescence are sensitive periods for cognitive development [1,2]. Executive function is the meta-cognitive function necessary for conducting complex and goal-oriented operations [3]. Executive function plays an important role in children's and adolescents' academic performance [4]. The results of a study by Demetriou et al. [5] indicated that cognitive ability was the strongest predictor of school performance in childhood and adolescence. Similarly, it has been found that different cognitive components related to executive function are associated with academic skills, including creativity and memory [6]. Creativity is an important human activity and is considered a key element to cognition, and among the least investigated [7]. Creativity has also shown a positive association with academic achievement [8], and many authorities have begun to adopt educational policies designed to promote creativity [9]. Memory is not a singular construct, and the most commonly studied types of memory are short-term memory, working

memory, and long-term memory [10]. Different cognitive components (i.e., types of memory) are associated with academic skills [6], and attention capacity is a crucial element for comprehension and learning processes [11].

Assessment of physical fitness among schoolchildren should be essential for controlling the health of this population. Adequate cardiorespiratory fitness (CRF) in childhood may be important to the development of cognitive processes [12]. CRF is a direct indicator of an individual's cardiovascular and respiratory systems' overall capacity to perform physical activities [3]. In recent years, the study of cognitive processes has increased in the field of physical activity (PA) [13]. Current evidence suggests that better levels of CRF have positive effects on children's cognition [14]. Aditionally, among children and youth, previous studies have shown that individuals with high levels of CRF had better performances in physical education [3]. Such studies have been consistent in reporting a positive association between CRF and academic performance [3,15]. Regarding creativity, the results of the study by Latorre et al. [12] conducted in children showed that CRF was a predictor for creativity. Likewise, better CRF was also associated with better memory (i.e., working memory) [16]. A positive relationship between CRF, selective attention and concentration has also been reported [17]. Several mechanisms have been proposed to explain the association of CRF with cognition [18]. For example, subjects who demonstrated better CRF functions (as measured by $V\dot{V}O_{2max}$) show faster reaction times and greater cerebral oxygenation, and cognitive processing is critically dependent on adequate blood flow to respond the energy and oxygen needs of the tissue [19]. Cognitive performance is tightly associated with CRF through cerebrovascular endothelial function and angiogenesis [20]. CRF may benefit brain health and plasticity, possibly via a brain-derived neurotropic factor (BDNF)-regulated mechanism [21].

Children's lifestyle (i.e., diet, PA, etc.) has commonly been studied in the context of health [22]. However, it is reasonable to expect that lifestyle factors are intertwined with cognition and learning processes in children [23]. For example, Kim et al. reported a positive association between school performance and dietary habits [24]. Healthy diet habits (i.e., breakfast consumption), for example, may improve cognitive function and test grades [25]. However, little is known regarding the associations of nutrition with components of executive function in adolescence [26], especially among Chilean schoolchildren. It is important to consider that a Chilean national study of physical education focused on physical condition and anthropometric parameters showed that 70% of students need to improve their CRF [27]. Additionally, in Chile, a high prevalence of children with overweight and obesity have been reported (approximately 44% of students at the age of 13 years old) [28]. Therefore, it is considered a public health problem [22]. In this line, it is important to evaluate the association between CFR and nutritional status with executive function, particularly in Chilean schoolchildren. Likewise, to the best of our knowledge, no other study has explored the association of creativity and memory with CRF, lifestyle, and anthropometric parameters in Chilean schoolchildren. The objective of the present study was to determine the association between creativity and memory with CRF (i.e., CFR classification and $\dot{V}O_{2max}$), lifestyle parameters (i.e., PA, screen time, sleep duration, and food habits), and anthropometric measures (i.e., body mass index and waist circumference) among Chilean schoolchildren. A secondary aim was to compare creativity, memory, concentration, and selective attention according to CRF levels (i.e., high and low) and nutritional status.

2. Materials and Methods

2.1. Participants

A descriptive study with a cross-sectional design was developed. A total of 248 schoolchildren (137 boys and 111 girls, 11.80 ± 1.17 and 11.58 ± 1.09 years, respectively) from a subsidized private school, which are financed by a mixture of funding from central government and private contributions [29] in Temuco, Chile participated in the study.

The students who attended the school were of the same sociocultural level and lived in the same geographical area (urban). There were 33 subjects excluded (girls not meeting inclusion criteria or other reasons (n = 23); boys not meeting inclusion criteria or other reasons (n = 10)). The sample was intentional and non-probabilistic. The inclusion criteria were: Chilean schoolchildren aged between 10 and 14, without musculoskeletal diseases or physical/medical conditions that might alter the participants' health and physical fitness levels and also children who complete every test administered as part of this study. Schoolchildren with intellectual or physical disabilities were excluded. The investigation complied with the Declaration of Helsinki (2013) and was approved by an Ethics Committee (ABR.19/8.TES Act). This study is part of a Doctoral Thesis.

Parents and guardians were informed about the study and provided written signed consent for participation. Additionally, all participants gave their written consent on the day of the assessment. Figure 1 shows the study design.

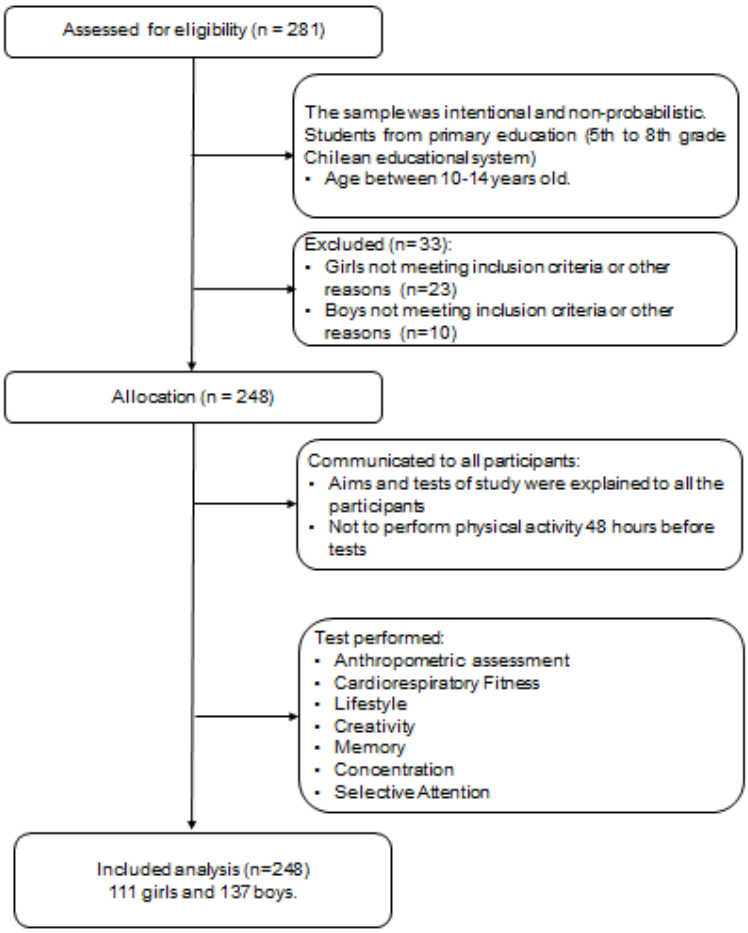

Figure 1. Study design.

2.2. Measures

2.2.1. Creativity

Creativity was measured using a CREA test [30] which provides a global quantitative measure of creativity [31]. The test is a timed 4-min divergent thinking test that contains a picture and asks respondents to generate questions about the picture [32]. From an image, the schoolchildren elaborated as many questions as possible for 4 min. A score was

assigned to each question according to its quality and complexity based on criteria established by the authors in the manual for the test (1 = low, 2 = medium, 3 = high). In this study, we used the original version in Spanish. The test manual reports strong reliability, convergent validity with Guilford's divergent thinking tasks [33], and has high and stable correlations over time with other instruments and measures of creativity [32].

2.2.2. Memory

Memory capacity was measured by Ray's Auditory Verbal Learning Test (RAVLT). A list of 15 words (list A) was presented in five consecutive trials, assessing (after each trial) the number of words remembered by the participant. They were immediately shown an interference list (list B), which they were asked to recall from memory. Then, the free memory of the first list of words was requested, and the process was repeated after 20 min [34]. A long-term memory test (after 20 min, at the end of the test battery, participants were asked to recall as many words as possible and to recognize the words within a list of 30 words) was used as an outcome measure [35]. A previous study showed that RAVLT showed reasonable test-retest reliability [36].

2.2.3. Concentration and Selective Attention

Concentration and attention capacity were measured with the d2 Test of Attention (d2), which has reliability from 0.95 to 0.98 [37]. The d2 consists of a paper and pencil test comprising 14 rows, each with 47 randomly interspersed 'p' and 'd' characters. Each character appears with 1 or 2 dashes placed above and/or below it [11]. The test takes 4 min and 30 s to be performed (20 s per line). Concentration was evaluated as: Number of hits—number of mistakes. Likewise, selective attention capacity was calculated as the number of processed elements—(omissions + mistakes) [38].

2.2.4. Cardiorespiratory Fitness

CRF was evaluated by the progressive Léger test. The students run between two parallel lines 20 m away from each other [39]. The last progression executed was recorded and calculated as the $\dot{V}O_{2max}$ (mL/kg/min) using the Equation as follows: $\dot{V}O_2$peak = 31.025 + 3.238 (V) − 3.248 (A) + 0.1536 (VA), where V is the velocity in km/h reached at the last stage and A stands for the student's age [39]. In addition, students were divided into two groups: High/low CRF (i.e., $\dot{V}O_2$peak outcome) according to previously cut-off points in school population as follows: 42 mL·kg−1·min−1 in boys and 35 mL·kg−1·min−1 in girls [40]. A higher $\dot{V}O_2$peak indicated better CRF.

2.2.5. Mediterranean Diet Adherence

The food habits of schoolchildren were determined by the Krece Plus test which is based on adherence to the Mediterranean diet (MD). The items have a score of +1 or −1 according to the established guidelines. The score from the Krece Plus test was categorized as follows: (1) >8, optimal MD; (2) 4–7, moderate MD adherence; and (3) ≤3, very low diet quality [41]. Higher scores indicate better food habits.

2.2.6. Levels of Physical Activity

A Physical Activity Questionnaire (PAQ-C) was used to measure the PA levels of children. This instrument collects information about schoolchildren's PA during the past 7 days. [42]. Each item has a score between 1 and 5 (i.e., higher score means higher levels of PA). This self-administered instrument reported good reliability [42]. The results for PA are registered and quantified in hours per week.

2.2.7. Screen Time

The Krece Plus test was used to evaluated screen time [43]. This test is a quick questionnaire that classifies lifestyle based on the average number of hours spent watching television or playing video games daily.

2.2.8. Sleep Duration

To evaluate children's sleep duration, parents completed the Pediatric Sleep Questionnaire [44]. Parents or guardians answered questions referring to the quality and quantity of their children's sleep. Correspondingly, this questionnaire has been reported with good reliability [45].

2.2.9. Anthropometric Assessment

A TANITA scale (model UM–028, Tokyo) was used to evaluate the children's weight (kg). Children's height (m) was measured with a Seca® stadiometer (model 214, Hamburg, Germany). BMI was used to classify the nutritional status as follows: BMI ≥than 95th percentile and overweight as a BMI ≥than percentile 85th among children of the same age and sex [46]. A Seca® tape (model 201, Hamburg, Germany) was used to measure the waist circumference according to the previously described protocols [47].

2.3. Procedure

Research assistants attended the school during the 2019 school year in Chile, and carried out the assessments on those children who had the consent of parents and also gave their own assent. The evaluations were carried out over four separate sessions by a team of researchers trained in conducting the different tests. CRF was assessed in the first session: Prior to the testing sessions, the children performed a typical warm-up. In the second session, anthropometric assessments were carried out in a favourable space facilitated by the school. Then, lifestyle surveys were applied in the classrooms. A cognitive test was applied in a classroom and divided into the creativity plus memory (third session) and d2 test (final session). The questionnaires and cognitive instruments were completed individually and in the presence of researchers (they respected data confidentiality and clarified any potential doubts or questions). All the evaluations took place during the physical education classes in the morning. Parents completed the Pediatric Sleep Questionnaire during the first 2 weeks. Researchers returned to one more session to work with children whose measurements were missing.

2.4. Statistical Analysis

Statistical analyses were performed using SPSS version 21.0 (SPSS Inc., Chicago, IL, USA). The Kolmogorov–Smirnov test and Levene's test were used for the normal distribution of data and homogeneity of variances. Continuous variables were expressed as means and confidence intervals. Differences in the comparison between sex, CRF, and nutritional status groups were determined using an analysis of variance (ANOVA) test. The Bonferroni test was performed to detect differences between nutritional status groups.

To determine the association between creativity and memory with physical fitness, lifestyle, and anthropometrics parameters, a simple linear regression was used. The Chi-Squared test was applied to compare proportions according to sex and nutritional level. The multivariate analysis of variance (ANCOVA) was conducted with CRF groups and cognitive variables for grouping variables and sex, age and BMI as covariates. Cohen's D was performed to determine the effect size. The significance level was set at $p < 0.05$.

3. Results

A total of 248 schoolchildren were included (Table 1). When analysing the sex groups separately, boys had significantly better scores in PA week (h) (2.58 vs. 2.16 $p = 0.014$) and $\dot{V}O_{2max}$ (ml/kg/min) (42.18 vs. 40.62, $p = 0.001$) than girl peers. Girls performed significantly better in long-term memory than boys (8.96 vs. 8.02, $p = 0.001$). There were no significant differences in creativity ($p = 0.699$), concentration ($p = 0.137$), and selective attention ($p = 0.246$) according to sex.

Table 1. Characteristics of the children participants according to sex groups at the level of anthropometry, cardiorespiratory fitness, physical activity patterns, creativity, memory, concentration, and selective attention.

	Total (248)	Girls (111)	Boys (137)	*p*-Value	Cohen's d
Age (y)	11.70 (11.6,11.8)	11.58 (11.4, 11.8)	11.80 (11.6,12.0)	$p = 0.132$	0.193
Anthropometric variables					
BMI	22.06 (21.6, 22.5)	22.14 (21.5, 22.8)	21.99 (21.3, 22.7)	$p = 0.746$	−0.041
Obesity prevalence¶					
Normal weight, (n = /%)	109 (44)	46 (41.4)	63 (46)		0.383
Overweight, (n = /%)	76 (30.6)	39 (35.1)	37 (27)		
Obesity, (n = /%)	63 (25.4)	26 (23.4)	37 (27)		
WC (cm)	77.57 (76.3, 78.8)	76.70 (75.0, 78.4)	78.25 (76.4, 80.1)	$p = 0.235$	−0.015
Lifestyle/fitness					
Physical activity week (h)	2.39 (2.2, 2.6)	2.16 (1.9, 2.4)	2.58 (2.3, 2.8)	$p = 0.014$	0.154
Sleep duration (h/day)	8.48 (8.4, 8.6)	8.48 (8.3, 8.6)	8.48 (8.3, 8.6)	$p = 0.977$	0.003
ST (h/day)	2.90 (2.7, 3.1)	2.99 (2.7, 3.2)	2.82 (2.6, 3.0)	$p = 0.337$	−0.124
MD Adherence (score)	5.96 (5.63, 6.28)	5.85 (5.43, 6.37)	6.05 (5.63, 6.47)	$p = 0.561$	0.078
$\dot{V}O_{2max}$ (ml/kg/min)	41.49 (41.0, 42.0)	40.62 (40.0, 41.3)	42.18 (41.5, 42.9)	$p = 0.001$	0.426
Cognitive Measures					
Creativity (score)	10.64 (10.2, 11.1)	10.54 (9.8, 11.2)	10.72 (10.1, 11.3)	$p = 0.699$	0.049
Memory (score)	8.45 (8.2, 8.7)	8.96 (8.5, 9.4)	8.02 (7.6, 8.4)	$p = 0.001$	−0.420
Concentration (score)	130.98 (126.7, 135.3)	127.36 (120.6, 134.1)	133.88 (128.3, 139.4)	$p = 0.137$	0.191
Selective Attention (score)	321.69 (311.4, 332.0)	314.91 (299.2, 330.6)	327.13 (313.4, 340.8)	$p = 0.246$	0.149

Data are presented as mean with 95% confidence interval (CI). Values of $p < 0.05$ were considered statistically significant. BMI: Body mass index; WC: Waist circumference; ST: Screen time; MD: Mediterranean diet; $\dot{V}O_{2max}$: Maximal oxygen consumption. Obesity prevalence calculated based on the CDC criteria.

When analysing the CRF (high/low) groups separately, schoolchildren with higher CRF reported significantly better long-term memory than lower CRF peers after adjusting for by age, sex, and BMI. There were no significant differences in creativity according to the CRF groups after adjusting for age, sex, and BMI. For selective attention and concentration, there were no significant differences, although schoolchildren with higher CRF obtained better scores than lower CRF peers (Table 2).

Table 2. Creativity, memory, concentration, and selective attention variables by cardiorespiratory fitness.

	High-CRF (164)	Low-CRF (69)	*p*-Value	Cohen's d
Creativity (score)	11.15 (10.6, 11.7)	9.65 (8.8, 10.5)	NS	0.425
Memory (score)	8.88 (8.5, 9.2)	7.39 (6.9, 7.9)	$p < 0.05$	0.673
Concentration (score)	133.22 (127.7, 138.7)	126.43 (119.3, 133.6)	NS	0.199
Selective Attention (score)	324.09 (311.2, 337.0)	316.90 (299.9, 333.9)	NS	0.106

Data are presented as mean with 95% confidence interval (CI). Values of $p < 0.05$ were considered statistically significant after adjusting for sex, age, and BMI. CRF: cardiorespiratory fitness; NS: No considered statistically significant.

When analysing the nutritional status groups separately, children with obesity reported lower creativity and long-term memory than normal weight children ($p < 0.05$).

Additionally, children with obesity had lower scores in MD adherence ($p < 0.05$), $\dot{V}O_{2max}$ (mL/kg/min) ($p < 0.001$) and presented more ST ($p < 0.001$) (Table 3).

Table 3. Creativity, memory, concentration, selective attention variables, and lifestyle by nutritional status.

	Normal (109) A	Overweight (65) B	Obesity (74) C	*p*-Value	Post-Hoc
Creativity (score)	11.24 (10.6, 11.9)	11.19 (10.4, 12.0)	8.93 (8.1,9.8)	$p < 0.001$	A > C
Memory (score)	9.33 (9.0, 9.7)	7.51(7.0, 8.0)	8.05 (7.4,8.7)	$p < 0.001$	A > B,A > C
Concentration (score)	134.03 (127.9, 140.2)	132.72 (124.0, 141.4)	123.63 (115.5,131.8)	0.138	
Selective Attention (score)	335.63 (320.6, 350.7)	307.69 (288.4, 327.0)	314.22 (293.5,335.0)	0.053	
Screen time (h/day)	2.9 (2.69, 3.22)	2.5 (2.23, 2.78)	3.2 (2.92,3.58)	$p < 0.05$	C > B
MD Adherence (score)	6.38 (5.93, 6.82)	6.36 (5.72, 7.0)	4.77 (4.17,5.37)	$p < 0.001$	C < A,C < B
$\dot{V}O_{2max}$ (ml/kg/min)	42.28 (41.48, 43.09)	41.63 (40.86, 42.40)	39.90 (39.11,40.69)	$p < 0.001$	C < A,C < B

Data are presented as mean with 95% confidence interval (CI). Values of $p < 0.05$ were considered statistically significant.

In the total sample, creativity showed an association with $\dot{V}O_{2max}$ (ml/kg/min) (β; 0.209, 95% CI; 0.02–0.40, $p = p < 0.05$) and with MD adherence (score) (β; 0.206, 95% CI; 0.01; 0.74, $p = p < 0.05$). Long-term memory showed an association with CRF (β; 1.076, 95% CI; 0.02–2.13, $p = p < 0.05$) and an inverse association with MD adherence (β; −0.155, 95% CI; −0.28–−0.03, $p = p < 0.05$) (Table 4). Moreover, long-term memory showed an inverse association with BMI (β; −0.167, 95% CI; −0.33–−0.01, $p = p < 0.05$).

Table 4. Association of creativity and memory score with socio-demographic, anthropometric, lifestyle, and cardiorespiratory fitness variables in schoolchildren.

	Creativity			Memory		
Outcomes	**Beta (95% CI)**	***p*-Value**	**Standardised Beta (SE)**	**Beta (95% CI)**	***p*-Value**	**Standardised Beta (SE)**
Age (y)	0.471 (0.02; 0.92)	$p = 0.039$	0.14 (0.23)	0.345 (0.05; 0.64)	$p = 0.023$	0.16 (0.15)
Anthropometric variables						
BMI (kg/m^2)	−0.022 (−0.27; 0.22)	$p = 0.859$	−0.02 (0.12)	−0.167 (−0.33; −0.01)	$p < 0.05$	−0.27 (0.08)
WC (cm)	0.000 (−0.09; 0.09)	$p = 0.994$	0.00 (0.05)	0.004 (−0.06; 0.06)	$p = 0.909$	0.02 (0.03)
Lifestyle						
PA/week (h)	0.347 (−0.04; 0.74)	$p = 0.994$	0.13 (0.20)	0.041 (−0.22; 0.30)	$p = 0.753$	0.02 (0.13)
PAC score	−0.025 (−0.10; 0.05)	$p = 0.519$	−0.05 (0.04)	0.005 (−0.05; 0.05)	$p = 0.850$	0.01 (0.03)
Sleep duration (h/day)	0.410 (−0.01; 0.94)	$p = 0.132$	0.10 (0.27)	−0.039 (−0.40; 0.32)	$p = 0.832$	−0.01 (0.18)
Screen time (h/day)	−0.293 (−0.66; 0.07)	$p = 0.116$	−0.11 (0.19)	0.020 (−0.22; 0.26)	$p = 0.874$	0.01 (0.12)
MD Adherence (score)	0.206 (0.01; 0.74)	$p < 0.05$	0.015 (0.99)	−0.155 (−0.28; −0.03)	$p < 0.05$	−0.17 (0.07)
Physical fitness						

$\dot{V}O_{2max}$ (ml/kg/min)	0.209 (0.02; 0.40)	$p < 0.05$	0.22 (0.10)	−0.001 (−0.13; 0.12)	$p = 0.988$	0.00 (0.06)
High CRF (Ref. Low)	0.197 (−1.39; 1.79)	$p = 0.807$	0.03 (0.81)	1.076 (0.02; 2.13)	$p < 0.05$	0.21 (0.53)

Data shown represent beta and 95% confidence interval (95% CI), and standardized beta and standard error (SE). Values of $p < 0.05$ were considered statistically significant. Model adjusted by sex. BMI: Body mass index; WC: Waist circumference; PA: Physical activity; MD: Mediterranean diet; $\dot{V}O_{2max}$: Maximal oxygen consumption; CRF: Cardiorespiratory fitness; PAC: Physical activity questionnaire.

4. Discussion

In the present study, the objective was to determine the association between creativity/memory and CRF, lifestyle parameters, and anthropometric measures in Chilean schoolchildren. A secondary aim was to compare creativity, memory, concentration, and selective attention according to CRF levels (i.e., high and low) and nutritional status. The main findings of this study were, first, creativity was associated with $\dot{V}O_{2max}$ (mL/kg/min) and with MD adherence (score), while long-term memory was associated with CRF and BMI. Second, schoolchildren with higher CRF reported significantly better long-term memory than lower CRF peers after adjusting for age, sex, and BMI. Third, children with obesity reported lower creativity and long-term memory than normal weight children ($p < 0.05$).

In this study, creativity was positively associated with $\dot{V}O_{2max}$ and with MD adherence (score), this is in line with Latorre et al. [12], who reported that the highly creative group performed better in a CRF test than children with lower creativity levels. Moreover, the authors indicated that CRF was a predictor of creativity in schoolchildren. Likewise, Piya-amornphan et al. [48] reported a positive correlation between PA and creativity ability in adolescents. Similarly, Florence et al. [49] showed an association between diet quality and academic performance in Canadian schoolchildren, while Hidalgo et al. indicated that children with higher CRF had better creativity levels using the CREA test in Spanish adolescents [50]. Likewise, it has been reported that creativity is positively related to school achievement, and the authors demonstrated that middle school may be an especially creative period in adolescents' development [51]. Therefore, it is essential to research how to stimulate creativity in school-age children [52]. We found that creativity reported a positive association with MD adherence. Concerning food habits, another study reported that a poor-quality diet negatively affects hippocampal function and thereby impairs performance of cognitive tasks such as creativity [53]. Similarly, a higher quality diet index and ideal diet (i.e., MD adherence score) were associated with better cognitive function in adolescents. The authors concluded that this association was strong enough to be relevant from a public health perspective [26]. Similarly, it has been indicated that diet habits are important among schoolchildren since they have high brain metabolic needs [24]. It is important to considerer that in Chilean schoolchildren, unhealthy lifestyle patterns such as low adherence to MD, could be explained by socio-economic status [54].

In this study, long-term memory was associated with CRF, and schoolchildren with higher CRF reported significantly better long-term memory after adjusting for age, sex, and BMI. Therefore, the study indicated that less fit preadolescents (i.e., lower CFR levels) had poorer memory recognition compared with more fit children [55]. Likewise, a cross-sectional study reported that CRF was positively correlated with working memory in male Spanish schoolchildren, and children in higher CRF and executive function categories obtained betters academic performance (i.e., mathematics and language) than children in lower categories [56]. Similarly, it has been reported that less fit preadolescent children had poorer relational memory task and smaller hippocampal volume compared to higher CRF preadolescent children, and the authors also indicated that it is fundamental to understand the neurocognitive benefits of an active lifestyle in educational and public health areas [57]. Another study showed that CRF was associated with working memory and reaction time [16]. Despite these associations, no relationships have been

found between CRF and verbal working memory in primary schoolchildren [7]. Moreover, in this study, girls performed significantly better in long-term memory than boys. In this sense, a meta-analysis of sex differences in memory showed an overall female advantage in episodic memory task. Additionally, the authors indicated that the sex differences for verbal episodic memory tasks which are smaller in childhood than during other age periods, may indicate that fluctuating endogenous sex hormones and environmental influence contribute to the variation [58]. On the other hand, another study reported that several differences between gender in some executive function (i.e., reaction time in inhibition, cognitive flexibility) and language, were higher for girls but not in episodic memory [56].

In the present study, BMI was inversely associated with long-term memory. In addition, children with obesity reported lower creativity and long-term memory than normal weight children. In this sense, the evidence has shown an association between obesity and low cognition in children and adolescents, where children with obesity reported poor cognitive function compared with normal weight peers [59]. In this line, obesity in children has been associated with impaired cognitive function, poorer academic performance [60], reduction of executive cognitive performance on neuropsychological evaluations, and presented differences in brain structures related to learning, memory, and executive functions [61].

On the other hand, in this study, there were no significant differences in concentration and selective attention according to nutritional status groups. Contrary to our results, it has been reported that students with obesity presented worse results than normal peers in the d2 test (i.e., selective attention) [62]. In addition, previous studies indicated that deficits in attention, working memory, and sustained attention decrements do exist among overweight/obese adolescents [63,64]. However, other authors showed that there was no association between sustained attention and BMI [65]. In addition, another study reported that obese and non-obese children had similar results in attention and concentration [66]. Future studies on the current topic are therefore recommended to clarify these controversial results. Likewise, children with obesity had lower scores in MD adherence, $\dot{V}O_{2max}$ (ml/kg/min), and presented more ST. In this sense, a previous study reported that obese students had lower scores in MD and $\dot{V}O_{2max}$ compared with their normal weight peers [67].

For selective attention and concentration, there were no significant differences after adjusting for age, sex, and BMI, but schoolchildren with higher CRF obtained better scores than lower CRF peers. We believe that these results diverge from other studies since the sample was relatively small and the high CRF groups had more participants. In this sense, and contrary to our results, another study reported that children with high fitness levels (i.e., CRF, speed, and change of direction) had significantly better cognitive performance (i.e., selective attention and concentration using d2 tests) compared to children with low fitness levels. That study also indicated that CRF was the variable that explained the largest variance in the relationship between cognitive functioning and fitness [17]. Another previous study indicated that CRF was one of the variables of physical fitness that best explains the association with selective attention and concentration [68]. Reigal et al. [69] conducted a study of Spanish adolescents and showed that adolescents who practised more exercise per week obtained better scores in selective attention, concentration, and processing speed. CRF was also the best predictor of test scores to evaluate cognitive function. Pontifex et al. [70] have provided evidence that less fit children (i.e., low CRF) had reduced capacity to allocate attentional resources, greater response conflict, and slower processing speed than their more fit counterparts. Additionally, Ruíz-Ariza et al. [18] have indicated that variables relating to executive function such as memory, selective attention or concentration play important roles in cognitive performance among adolescents.

The main limitation of the present investigation is its cross-sectional design. These variables should be measured in a longitudinal study to clarify the direction of the asso-

ciations. This study included the use of a convenience sample, and the results are not necessarily representative of the national population. Another limitation was that cognitive measures were obtained using a write-report instrument. Moreover, we did not carry out the analyses by biological maturation age or socioeconomic status. There is a limitation due to the Chilean educational system, in which children belonging to educational establishments with fewer resources most affected their healthy lifestyle (i.e., foods habits and PA patterns).

In conclusion, creativity was associated with CRF and MD adherence and memory was associated with CRF (i.e., CFR classification and $\dot{V}O_{2max}$) and BMI in Chilean schoolchildren. Children with high CRF levels performed better in creativity and memory than those with low CRF levels. Likewise, children with obesity reported lower creativity and long-term memory than normal weight children. Likewise, children with obesity had lower scores in MD adherence, $\dot{V}O_{2max}$ (ml/kg/min), and presented more ST.

Therefore, a physical fitness assessment and healthy lifestyle of schoolchildren should be essential for controlling the health of this population. In addition, an increase in CRF levels together with healthy food habits and normal BMI among these children should be a target for community- and school-based interventions to promote cognitive development such as creativity and memory.

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Abbreviations: BMI: Body mass index; CRF: Cardiorespiratory fitness; MD: Mediterranean diet; WC: Waist circumference; PA: Physical activity; ST: Screen time; $\dot{V}O_{2max}$: Maximal oxygen consumption.

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children

MDPI

Article

Selective Attention and Concentration Are Related to Lifestyle in Chilean Schoolchildren

Felipe Caamaño-Navarrete [1], Pedro Ángel Latorre-Román [2], Juan Párraga-Montilla [2], Daniel Jerez-Mayorga [3] and Pedro Delgado-Floody [4,*]

1 Faculty of Education, Universidad Católica de Temuco, Temuco 4780000, Chile; marfel77@gmail.com
2 Department of Didactics of Music, Plastic and Corporal Expression, University of Jaen, 27301 Jaen, Spain; platorre@ujaen.es (P.Á.L.-R.); jparraga@ujaen.es (J.P.-M.)
3 Faculty of Rehabilitation Sciences, Universidad Andres Bello, Santiago 7591538, Chile; daniel.jerez@unab.cl
4 Department of Physical Education, Sport and Recreation, Universidad de La Frontera, Temuco 4780000, Chile
* Correspondence: pedro.delgado@ufrontera.cl; Tel.: +56-45-2-325200

Abstract: The objective of this investigation was to determine the association between selective attention and concentration with physical fitness (i.e., cardiorespiratory fitness (CRF), $\dot{V}O_{2max}$, the standing long jump test (SLJ) and handgrip muscle strength (HGS)), lifestyle parameters (i.e., physical activity (PA) level, screen time (ST), sleep duration and food habits) and anthropometric measures (i.e., body mass index (BMI) and waist circumference (WC)) among Chilean schoolchildren. Two hundred and forty-eight schoolchildren (137 boys, 111 girls, 11.80 ± 1.17 and 11.58 ± 1.09 years, respectively) participated. Selective attention, concentration and lifestyle (PA, ST, sleep duration and Mediterranean diet (MD) adherence) were determined using a standard questionnaire. CRF, SLJ, HGS and anthropometric indicators (BMI and WC) were also measured. Selective attention showed a positive association with MD adherence score (β; 5.012, $p = p < 0.05$). Concentration was linked inversely to ST (β; −5.498, $p = p < 0.05$). Likewise, concentration presented a positive association with MD adherence (β; 2.904, $p = p < 0.05$). In conclusion, children's lifestyles are related to the selective attention and concentration of children; therefore, promoting healthy habits could be a cost-effective strategy in the promotion of cognitive development, as it relates to selective attention and concentration.

Keywords: executive function; cognition; dietary patterns; screen time; schoolchildren

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1. Introduction

School age is a critical stage for cognitive development [1]. In this sense, executive function is a meta-cognitive process necessary for conducting complex and goal-oriented operations [2] that include the follow capacities: inhibitory control, working memory, attention and planning [3]. In this context, executive function plays a fundamental role in children's learning [4] and is essential for the development of academic skills [5], as evidence has shown that higher levels of executive function are related to better fluid intelligence and success in school [6]. Selective attention allows for the processing of different stimuli [7] by suppressing attention to other distracting stimuli [6]. Recently, empirical evidence has confirmed that it is a crucial element for comprehension and learning processes [8]. It has been indicated that concentration is the capacity to maintain attention with precision [9]. In addition, it has been reported that good concentration improves schoolchildren's performances on academic tests [10]. In this context, one study showed that attention and concentration are fundamental in cognitive performance [11].

The study of executive function has increased in recent years [12]. A recent study reported that healthy lifestyle factors were positively associated with executive functions in schoolchildren [13]. Likewise, a recent systematic review and meta-analysis indicated that healthy lifestyle factors (e.g., physical activity (PA)) are important for improving executive

function [14]. For example, Jirout et al. indicated that although children's lifestyles have been investigated in the context of health, they are also related with cognition processes in schoolchildren [15]. It has been established that a good lifestyle plays a fundamental role in maintaining cognitive processes into old age [16]. More specifically, the quality of nutrition is a fundamental component of healthy lifestyle behaviours of school-age children [17]. Evidence has shown that a Western diet (i.e., high in refined carbohydrates and saturated fat) may damage brain function [18]. In addition, at this age, the brain's neuroplasticity is higher; therefore, a low quality of diet may negatively affect the brain's neurodevelopment and cognitive function [19]. Previous studies have confirmed that dietary habits during childhood are related to learning processes [15] and cognition in schoolchildren [20]. A recent study reported that schoolchildren with better food habits had better cognitive performance [21]. Recently, it was shown that good food habits were positively associated with academic performance [22]. In addition, Allom et al. reported that poor executive function is related to unhealthy eating behaviour [23]. On the contrary, healthy dietary habits, for example, may improve cognitive function and test grades [24]; nonetheless, little is known regarding the relation of diet quality with selective attention and concentration among Chilean schoolchildren [13]. Additionally, more investigations are needed to estimate the effects of healthy food habits on cognitive performance in students [25].

There is a growing interest regarding the impacts of screen time (ST) on cognitive processes [26]. A recent study indicated that a low level of ST was associated with better cognitive function [27]. In this sense, unhealthy lifestyle factors, such as excessive ST, could have negative effects on executive function [28]. Likewise, it has been indicated that ST affects the accuracy of cognitive tasks [29]. Similarly, a previous study has shown that inappropriate ST has negative consequences on cognitive function and other areas related to health [30]; however, a systematic review reported that ST had no negative effects on cognitive development [31]. Therefore, more investigation related to ST and executive function are needed [28]. Along this same line, it is important to evaluate the association between a healthy lifestyle and selective attention and concentration. In addition, to the best of our knowledge, no other investigation has analysed the association of selective attention and concentration with ST recommendations and good food habits in Chilean schoolchildren.

The objective of this investigation was to determine the association between selective attention and concentration with physical fitness (i.e., cardiorespiratory fitness (CRF) classification, $\dot{V}O_{2max}$, the standing long jump test (SLJ) and handgrip muscle strength (HGS)), lifestyle parameters (i.e., physical activity (PA) level, ST, sleep duration and food habits) and anthropometric measures (i.e., body mass index (BMI) and waist circumference (WC)) among Chilean schoolchildren. A secondary objective was to compare selective attention and concentration according to ST classifications (<2 h = low ST; ≥2 h = high ST) and Mediterranean diet (MD) adherence levels.

2. Materials and Methods

2.1. Participants

This cross-sectional study included 248 schoolchildren (137 boys and 111 girls, 11.80 ± 1.17 and 11.58 ± 1.09 years, respectively) from a subsidised private school in Temuco (Chile). These schools are financed by a mixture of funding from the central government and private contributions [32]. A prior sample size was performed using G*Power software. The following parameters were selected for ANOVA: effect size f = 0.250, α level of 0.05, power level of 0.95, two groups, critical F = 3.886 and a non-sphericity parameter of λ = 13.125. The sample size was determined to be at minimum 210 participants. The sample was determined by convenience. The inclusion criteria were that participants must be Chilean schoolchildren between 10 and 14 years of age and not have any medical conditions or musculoskeletal disorders that might alter their health and physical fitness results. Likewise, schoolchildren with physical, sensorial or intellectual disabilities were excluded.

In addition, schoolchildren with missing data and/or who did not present written signed consent were omitted, the study design is shown in Figure 1. The study complied with the Declaration of Helsinki (2013) and was authorised by an Ethics Committee (ABR.19/8.TES Act). The present investigation is part of a doctoral thesis. Informed consent was obtained from all participants. In addition, parents and guardians provided written signed consent for participation.

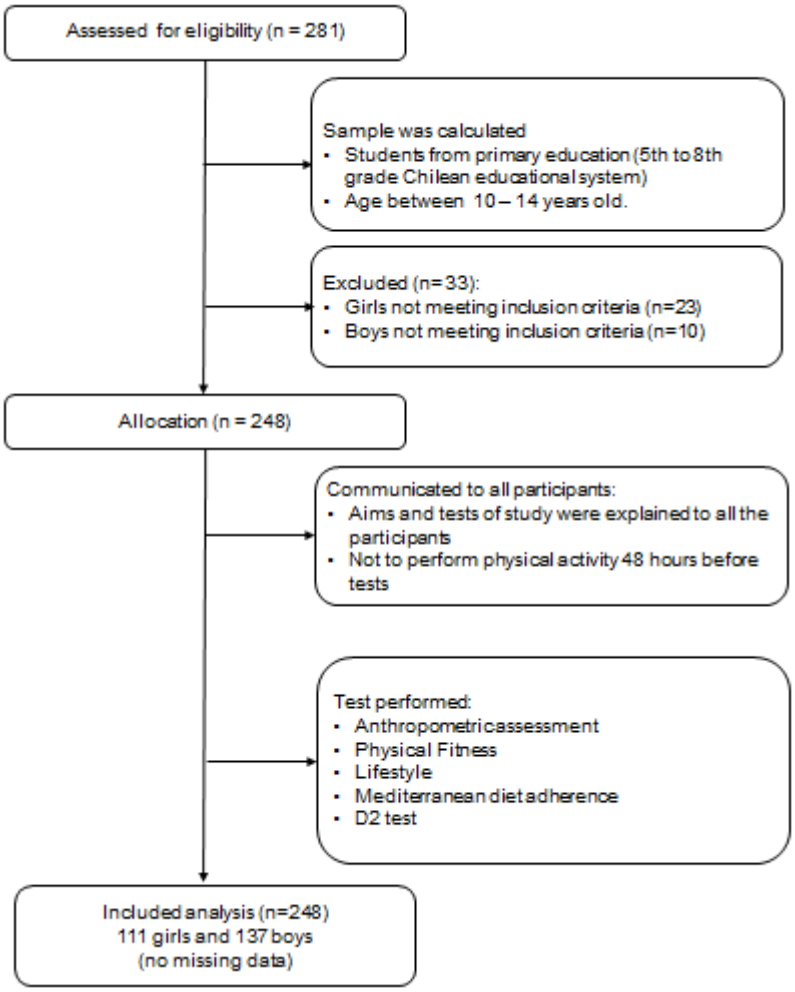

Figure 1. Study design.

2.2. Measures

2.2.1. Executive Functions

Concentration and attention capacity were obtained using the d2 test [33]. Previous studies have used this test in populations of schoolchildren [9,34]. The d2 consists of a paper and pencil test composed of 14 rows, each with 47 randomly alternated "p" and "d" characters. Each character appears with 1 or 2 dashes placed above and/or below it [8]. Concentration was determined as: number of hits – number of mistakes. Likewise, selective attention was obtained as the number of processed elements – (omissions + mistakes) [34].

2.2.2. Physical Fitness

Cardiorespiratory fitness was determined with the Léger test according to previous indications [35]. The $\dot{V}O_{2max}$ (mL/kg/min) was determined using the following equation: $\dot{V}O_2$peak = 31.025 + 3.238 (V) − 3.248 (A) + 0.1536 (VA), where V is the velocity in km/h achieved at the last stage, and A stands for the participant's age [35]. High/low CRF was established according to previously determined cut-off points [36].

The SLJT was executed. Each student jumped twice, and the best result was recorded [37]. Handgrip strength was evaluated using a hand dynamometer (TKK 5101^{TM}, Grip D; Takei, Tokyo, Japan) according to previously described protocols [38]. The test was performed twice, and the maximum score for each hand was recorded in kilograms. The grip adjustment was made according to the recommendations of Ruiz et al. [39].

2.2.3. Mediterranean Diet Adherence

Food habits were measured by the Krece Plus test, which is based on adherence to the MD. The score from the test was divided as follows: (1) >8, optimal MD; (2) 4–7, moderate; (3) ≤3, very low-quality diet [40].

2.2.4. Levels of Physical Activity

A Physical Activity Questionnaire (PAQ-C) was used to determine the PA levels of the participants. The questionnaire collects information about schoolchildren's PA over the past seven days [41]. The results for PA were quantified in hours per week.

2.2.5. Screen Time

To evaluate children's screen time, we used the Krece Plus [42]. This test classifies lifestyle based on the average number of hours spent watching television or playing video games daily. In addition, the participants were divided into two ST groups (<2 h = low ST; ≥2 h = high ST) according to previous indications [43].

2.2.6. Sleep Duration

The Pediatric Sleep Questionnaire was used to determine sleep duration [44]. Parents answered questions referring to the quality and quantity of their children's sleep.

2.2.7. Anthropometric Assessment

A TANITA scale (model UM–028, Tokyo) was used to measure the children's weight (kg). The children's height (m) was calculated with a Seca® stadiometer (model 214, Hamburg, Germany). BMI was calculated following the international formula [45]. A Seca® tape (model 201, Hamburg, Germany) was used to register the waist circumference according to previous recommendations [46].

2.3. Procedure

Research assistants visited the selected school during 2019. Parents answered the sleep hour questionnaire during the first two weeks. The evaluations were carried out over four separate sessions by a team of researchers trained in conducting the different tests. CRF, SLJ and HGS were assessed in the first session: 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. In the second session, anthropometric assessments were carried out in a favourable space facilitated by the school with optimum temperature, reliable privacy and light clothing. Then, lifestyle surveys were applied in the classrooms. A cognitive test was applied in a classroom (final session).

2.4. Statistical Analysis

The statistical analyses were developed by SPSS version 21.0 (SPSS Inc., Chicago, IL, USA). The normal distribution was evaluated by the Kolmogorov–Smirnov test. Differences in the comparison between sex, ST and MD adherence groups were determined using an analysis of variance (ANOVA) test. To determine the association between selective attention and concentration and a child's lifestyle, a simple linear regression and the inclusion of beta (β with 95% confidence intervals (CIs)) were used. The effect size (ES) was calculated using Cohen's d. Results with a $p < 0.05$ were considered statistically significant.

3. Results

Table 1 shows the sociodemographic, anthropometric, lifestyle and executive function characteristics according to sex. Boys reported significantly better scores in $\dot{V}O_{2max}$ (mL/kg/min) (p = 0.001), HGS right (p = 0.001), HGS left (p = 0.000), SJL (p = 0.000), PA week (p = 0.014) and PAC score (p = 0.000) than their female peers.

Table 1. Baseline characteristics of the schoolchildren participants by sex at the level of anthropometry, cardiorespiratory fitness, physical activity patterns, concentration and selective attention.

	Total (248)	Girls (111)	Boys (137)	*p*-Value	Cohen's d
Age (y)	11.70 (11.6, 11.8)	11.58 (11.4, 11.8)	11.80 (11.6, 12.0)	p = 0.132	0.193
Anthropometric/body composition					
Body mass (kg)	52.82 (51.3, 54.4)	51.66 (49.6, 53.7)	53.77 (51.5, 56.1)	p = 0.183	0.171
BMI	22.06 (21.6, 22.5)	22.14 (21.5, 22.8)	21.99 (21.3, 22.7)	p = 0.746	−0.041
WC (cm)	77.57 (76.3, 78.8)	76.70 (75.0, 78.4)	78.25 (76.4, 80.1)	p = 0.235	−0.015
Lifestyle/fitness					
Physical activity week (h)	2.39 (2.2, 2.6)	2.16 (1.9, 2.4)	2.58 (2.3, 2.8)	p = 0.014	0.154
PAC (score)	28.84 (27.98, 29.69)	26.80 (25.71, 27.89)	30.49 (29.27, 31.70)	p = 0.000	
Sleep duration (h/day)	8.48 (8.4, 8.6)	8.48 (8.3, 8.6)	8.48 (8.3, 8.6)	p = 0.977	0.003
ST (h/day)	2.90 (2.7, 3.1)	2.99 (2.7, 3.2)	2.82 (2.6, 3.0)	p = 0.337	−0.124
MD Adherence (score)	5.96 (5.63, 6.28)	5.85 (5.43, 6.37)	6.05 (5.63, 6.47)	p = 0.561	0.078
$\dot{V}O_{2max}$ (mL/kg/min)	41.49 (41.0, 42.0)	40.62 (40.0, 41.3)	42.18 (41.5, 42.9)	p = 0.001	0.426
HGS Right (kg)	22.13 (21.43, 22.83)	20.77 (19.94, 21.60)	23.21 (22.16, 24.25)	p = 0.001	−0.452
HGS Left (kg)	20.33 (19.63, 21.02)	18.73 (17.93, 19.52)	21.61 (20.58, 22.64)	p = 0.000	−0.548
SLJ (cm)	120.94 (117.62, 124.26)	108.03 (104.23, 111.83)	131.50 (127.05, 135.95)	p = 0.000	1.008
Cognitive Measures					
Selective Attention (score)	321.69 (311.4, 332.0)	314.91 (299.2, 330.6)	327.13 (313.4, 340.8)	p = 0.246	0.149
Concentration (score)	130.98 (126.7, 135.3)	127.36 (120.6, 134.1)	133.88 (128.3, 139.4)	p = 0.137	0.191
Total attempts (number)	346.99 (336.40, 357.57)	342.80 (327.19, 358.41)	350.35 (335.80, 364.90)	p = 0.486	−0.089
Total hits (number)	140.61 (136.47, 144.74)	138.09 (131.85, 144.34)	142.63 (137.06, 148.19)	p = 0.284	−0.138
Omissions (number)	15.96 (13.31, 18.62)	17.16 (12.74, 21.59)	15.00 (11.75, 18.25)	p = 0.426	0.103
Commissions (number)	9.47 (8.11, 10.82)	10.73 (8.27, 13.19)	8.45 (7.01, 9.90)	p = 0.101	0.192

Data are presented as the mean with a 95% confidence interval (CI). $p < 0.05$ was considered statistically significant. BMI = body mass index, WC = waist circumference, ST = screen time, MD = Mediterranean diet, $\dot{V}O_{2max}$ = maximal oxygen consumption, HGS = handgrip strength and SLJ = standing long jump.

In the association between executive function and lifestyle parameters, in model 0 (not adjusted) and model 1 (adjusted by age and sex), selective attention showed a positive association with MD adherence score (β; 5.612, $p = p < 0.05$) and (β; 5.012, $p = p < 0.05$), respectively. Concentration had an inverse association with ST h/day in model 0 (β; −5.569, $p = p < 0.05$) and model 1 (β; −5.498, $p = p < 0.05$). Moreover, concentration showed a positive association with MD adherence score in model 0 (β; 2.864, $p = p < 0.05$) and model 1 (β; 2.904, $p = p < 0.05$) as seen in Table 2.

Table 2. Association of selective attention and memory score with sociodemographic, anthropometric, lifestyle and fitness variables in schoolchildren.

Outcomes		Selective Attention			Concentration		
		Beta (95% CI)	***p*-Value**	**Standardised Beta (SE)**	**Beta (95% CI)**	***p*-Value**	**Standardised Beta (SE)**
Anthropometric variables							
Body weight (kg)	Model 0	−0.451 (−3.18; 2.28)	$p = 0.745$	−0.07 (1.39)	−0.214 (−1.34; 0.92)	$p = 0.709$	−0.08 (0.57)
	Model 1	−0.642 (−3.35; 2.07)	$p = 0.641$	−0.09 (1.379)	−0.169 (−1.28; 0.94)	$p = 0.765$	−0.05 (0.56)
BMI (kg/m^2)	Model 0	−0.085 (−8.59; 8.43)	$p = 0.984$	0.00 (4.31)	−0.337 (−3.86; 3.18)	$p = 0.850$	−0.04 (1.78)
	Model 1	−0.122 (−8.58; 8.34)	$p = 0.977$	−0.00 (4.29)	−0.511 (−3.98; 2.96))	$p = 0.772$	−0.05 (1.76)
WC (cm)	Model 0	0.536 (−1.90; 2.97)	$p = 0.664$	0.07 (1.23)	0.365 (−0.64; 1.37)	$p = 0.475$	0.11 (0.51)
	Model 1	0.796 (−1.61; 3.20)	$p = 0.515$	0.09 (1.22)	0.408 (−0.58; 1.39)	$p = 0.417$	0.11 (0.50)
Lifestyle							
PA/week (h)	Model 0	1.661 (−8.19; 11.51)	$p = 0.740$	0.03 (4.99)	0.828 (−3.24; 4.90)	$p = 0.689$	0.03 (2.06)
	Model 1	1.797 (−8.07; 11.67)	$p = 0.720$	0.02 (5.00)	0.873 (−3.18; 4.92)	$p = 0.672$	0.03 (2.05)
PAC score	Model 0	−0.508 (−2.49; 1.47)	$p = 0.613$	−0.04 (1.00)	−0.178 (−1.00; 0.64)	$p = 0.668$	−0.03 (0.41)
	Model 1	−0.283 (−2.20; 1.64)	$p = 0.773$	−0.02 (0.97)	−0.113 (−0.90; 0.67)	$p = 0.778$	−0.02 (0.40)
Sleep duration (h/day)	Model 0	−0.794 (−14.40; 12.81)	$p = 0.909$	−0.01 (6.90)	0.908 (−4.72; 6.53)	$p = 0.751$	0.02 (2.85)
	Model 1	−0.313 (−13.87; 13.24)	$p = 0.964$	−0.00 (6.87)	1.133 (−4.43; 6.70)	$p = 0.689$	0.02 (2.82)
Screen time (h/day)	Model 0	−1.179 (−10.59; 8.24)	$p = 0.805$	−0.02 (4.77)	−5.569 (−9.46; −1.68)	$p < 0.05$	−0.21 (1.97)
	Model 1	−0.697 (−10.11; 8.72)	$p = 0.884$	−0.01 (4.77)	−5.498 (−9.36; −1.63)	$p = 0.006$	−0.20(1.96)
MD adherence (score)	Model 0	5.612 (0.63; 10.59)	$p < 0.05$	0.18 (2.53)	2.864 (0.80; 4.92)	$p < 0.05$	0.21 (1.04)
	Model 1	5.012 (0.06; 9.95)	$p = 0.047$	0.15 (2.50)	2.904 (0.87; 4.93)	$p = 0.005$	0.21 (1.03)
Physical fitness							
Léger test (paliers)	Model 0	−216.388 (−454.24; 21.46)	$p = 0.074$	−3.91 (120.59)	7.298 (−91.07; 105.66)	$p = 0.884$	0.31 (49.87)
	Model 1	−2.047 (−23.80; 19.71)	$p = 0.853$	−0.03 (11.03)	4.968 (−3.96; 13.90)	$p = 0.274$	0.21 (4.5)
$\dot{V}O_{2max}$ (mL/kg/min)	Model 0	87.690 (−6.20; 181.58)	$p = 0.067$	4.10 (47.60)	−2.935 (−41.76; 35.89)	$p = 0.882$	−0.32 (19.68)
	Model 1	3.287 (−5.00; 11.57)	$p = 0.435$	0.15 (4.20)	−1.683 (−5.08; 1.72)	$p = 0.331$	−0.18 (1.72)
High/low CRF	Model 0	−3.968 (−44.68; 36.74)	$p = 0.848$	−0.02 (20.64)	8.594 (−8.24; 25.43)	$p = 0.315$	0.11 (8.54)
	Model 1	−4.805 (−34.59; 24.98)	$p = 0.751$	−0.02 (15.10)	4.289 (−7.94; 16.52)	$p = 0.490$	0.05 (6.20)
HGS right (kg)	Model 0	0.291 (−4.59; 5.17)	$p = 0.907$	0.02 (2.47)	−0.559 (−2.58; 1.46)	$p = 0.586$	−0.09 (1.02)
	Model 1	0.988 (−3.83; 5.81)	$p = 0.687$	0.06 (2.44)	−0.611 (−2.59; 1.37)	$p = 0.544$	−0.09 (1.00)

Table 2. *Cont.*

Outcomes		Selective Attention			Concentration		
		Beta (95% CI)	***p*-Value**	**Standardised Beta (SE)**	**Beta (95% CI)**	***p*-Value**	**Standardised Beta (SE)**
HGS left (kg)	Model 0	−1.430 (−6.23; 3.37)	$p = 0.558$	−0.10 (2.44)	0.360 (−1.63; 2.35)	$p = 0.721$	0.06 (1.01)
	Model 1	−1.612 (−6.40; 3.18)	$p = 0.508$	−0.11 (2.43)	0.424 (−1.54; 2.39)	$p = 0.672$	0.06 (0.99)
SLJ (cm)	Model 0	0.269 (−0.36; 0.90)	$p = 0.400$	0.09 (0.32)	0.083 (−0.18; 0.34)	$p = 0.529$	0.06 (0.13)
	Model 1	0.326 (−0.29; 0.95)	$p = 0.304$	0.10 (0.31)	0.093 (−0.16; 0.35)	$p = 0.473$	0.07 (0.13)

The data shown represent beta (95% CI) and standardised beta and standard error (SE). Values of $p < 0.05$ were considered statistically significant. Model 0 = non-adjusted, Model 1 = adjusted by sex and age.

BMI = body mass index, WC = waist circumference, PA = physical activity, PAC: physical activity questionnaire, MD = Mediterranean diet, $\dot{V}O_{2max}$ = maximal oxygen consumption, CRF = cardiorespiratory fitness, HGS = handgrip strength and SLJ = standing long jump.

When comparing the ST (<2 h/day/≥2 h/day) groups, students with lower STs showed significantly better selective attention ($p = 0.024$), concentration ($p = 0.000$), total hits ($p = 0.000$) and lower omissions ($p = 0.016$) and commissions ($p = 0.007$) in the d2 test than schoolchildren who reported more ST (Figure 2).

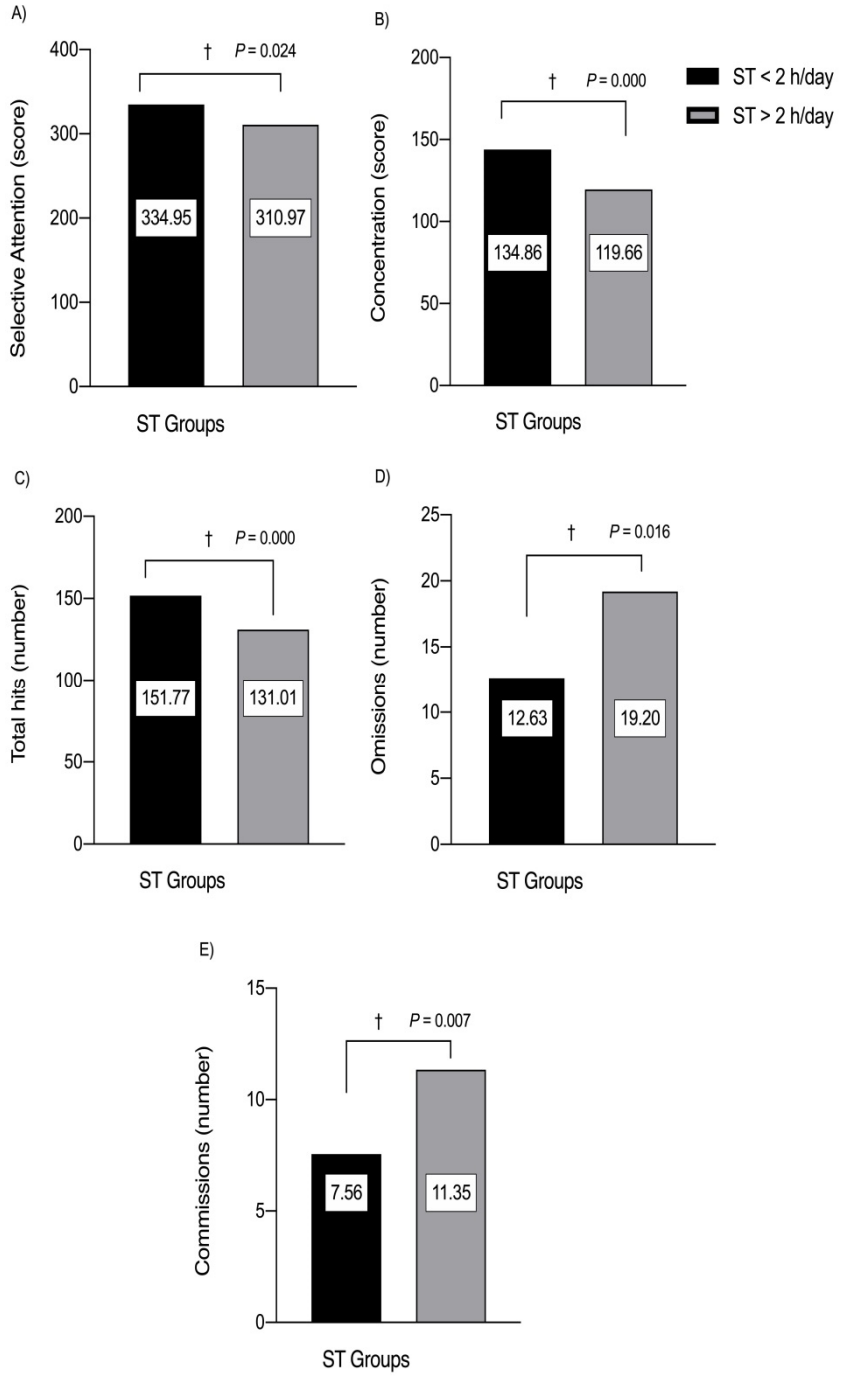

Figure 2. Selective attention (**A**), concentration (**B**), total hits (**C**), omissions (**D**) and commissions (**E**) characteristics in schoolchildren participants by ST groups (<2 h/day/≥2 h/day). (†) Daggers denotes significant differences by group at each respective *p*-value.

Schoolchildren with optimal MD adherence reported better concentration ($p = 0.003$) and total hits in the d2 test ($p = 0.002$) than moderate and low MD adherence classifications (Figure 3).

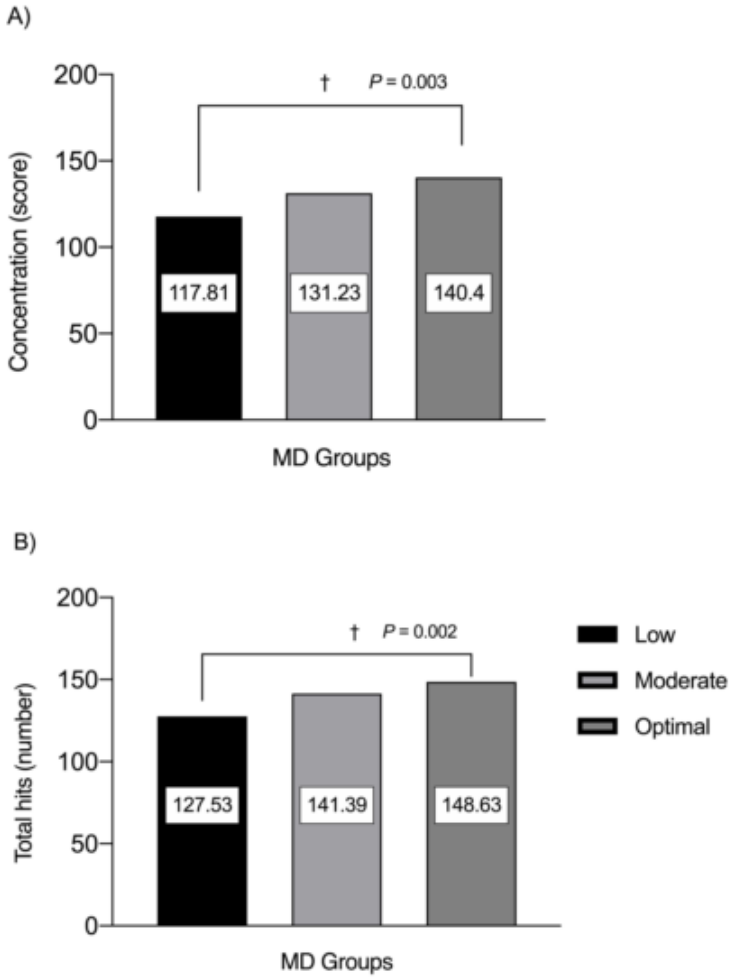

Figure 3. Concentration (**A**) and total hits (**B**) scores in schoolchildren participants by MD groups (low, moderate and optimal). (†) Daggers denotes significant differences by group at each respective *p*-value.

4. Discussion

The objective of this investigation was to determine the association between selective attention and concentration with physical fitness, lifestyle parameters and anthropometric measures in Chileans students. A secondary aim was to compare selective attention and concentration according to ST classification and MD adherence levels.

The results indicate that (i) selective attention was positively associated with MD adherence (score), while concentration was negatively associated with ST and positively associated with MD adherence (score) in both the unadjusted and adjusted models; (ii) schoolchildren with lower STs showed better selective attention and concentration; (iii) schoolchildren with higher MD adherence scores reported better concentration.

We found that selective attention and concentration were both positively associated with MD adherence (score). Likewise, another investigation conducted among European adolescents reported that higher diet quality scores were linked with attention capacity, and the authors also indicated that dietary patterns were a better determinant of executive function than the analysis of single nutrients [47]. Furthermore, Peña et al. conducted a cross-sectional project with Chilean schoolchildren and reported that students with healthy food habits (i.e., who have a breakfast of high quality) presented better cognitive performance compared with students who did not [21]. Moreover, the findings of another study indicated that poorer food choices were related with reduced performance in verbal and cognitive ability [48]. It has been demonstrated that healthy foods are positively associated with higher performance in executive functions in students [13]. Thus, evidence

has shown that a healthy diet, such as having a breakfast, may positively affect cognitive function and school attendance [24]. Additionally, there is strong evidence regarding the impact of nutrition on cognitive function; in this sense, Bellisle [49] indicated that diet can affect cognitive functions in children and adolescents. Similarly, the findings of a systematic review concluded that there was a positive association between good and healthy food habits and executive function [3]. The present results showed that schoolchildren with higher MD adherence scores reported better concentration. Nyaradi et al. [50] conducted a longitudinal study in Australian adolescents and reported that the Western diet score (i.e., characterised by high intakes of take-away food, processed meat and refined food) was related to more total errors in a cognitive test, while students who increased their healthy food intake with fruits and vegetable showed a positive relationship with better cognitive performance. The author of this study also found that having unhealthy food habits at age 14 was associated with poorer psychomotor speed, visual spatial learning and long-term memory performance by 17 years of age. Likewise, Florence et al. [51] showed that specific aspects of diet quality may affect children's academic performance. Another study reported that a low-quality diet was associated with worse cognitive performance in schoolchildren [52]. In this context, DiGirolamo et al. [53] indicated that it is fundamental to determine nutritional requirements for their possible positive impact on the development of cognitive processes for schoolchildren.

Concentration was negatively associated with ST. In addition, we found that schoolchildren with lower STs showed better selective attention and concentration than their high ST peers. It has been well established that ST is related to different health harms [54]. In addition, there is a growing concern today about the effects of ST on cognition [26]. In this context, Choi and Park [55] reported that there was a correlation between ST and executive function, and that ST mediated the effect on school adjustment through academic performance. A recent study reported that children who never use tablets had significantly better cognitive performance than those who had high STs, with significant differences in prefrontal cortex activation [56]. Likewise, empirical evidence has shown that excessive ST was negatively correlated with the visual word form and the regions related to cognitive control and language; therefore, the authors concluded that limiting ST for schoolchildren was important [57]. Walsh et al. [58] conducted a cross-sectional study with 11,875 American schoolchildren and reported that ST was negatively associated with cognition; likewise, children with high and middle ST classifications had poorer cognition measures than theirs peers in the low classification of ST. Along this same line, another study showed that healthy lifestyle behaviours (i.e., met 60 min of PA, 2 h or less of ST and 9–11 h sleep per night) were associated with better cognition in children [59]. Madigan et al. [60] reported that there was a directional association between levels of ST and child development in a longitudinal study. Likewise, another scoping review indicated that excessive ST was associated with premature cognitive decline and learning problems [61]. Another investigation conducted with Chinese children showed that passive ST (watching TV or videos) was associated with poorer executive function performance and social skills [62]. A recent study conducted in adolescents showed that higher STs were associated with a lower brain derived-neurotrophic factor (BDNF), which can negatively affect cognitive functions and increase the risk factors of neurocognitive deficits [63]. Despite these findings, it has been reported that ST has both negative and positive effects on brain function; therefore, more investigations are needed to clarify the mechanism and possible causal relationships between ST and brain development, especially at ages when brain plasticity is significant [64]. To this end and, contrary to our results, another study reported that smartphone use positively predicted some executive function; therefore, this study indicated that it is important to evaluate the frequency and problematic use of technology rather than ST [26]. Moreover, another study showed that more video game time was positively related to cognition compared with students who played for fewer hours per day [58]. Future studies are needed to clarify the prolonged effects of ST on children's cognition in different contexts [61].

The limitations of this investigation included its cross-sectional design. In addition, this study selected the sample by convenience. Another limitation was that cognition, food habits and ST results were determined using a written report instrument. In addition, we must consider studying more sociodemographic variables and longitudinal designs to clarify the associations. Likewise, in this study we measured concentration only through the d2 test; therefore, we plan to look for other ways to measure concentration. Moreover, we need to improve the exclusion criteria to limit the sample. Furthermore, as a practical application, it would be important to consider physical activity and educational nutrition interventions in schools to improve executive functions in schoolchildren.

In conclusion, children's lifestyles were related to the selective attention and concentration of children; thus, the promotion of healthy lifestyle strategies should be prioritised in the education community context. Likewise, healthy food habits, together with decreased ST, could be a cost-effective strategy in promoting cognitive development as it relates to selective attention and concentration.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committee (ABR.19/8.TES Act).

Informed Consent Statement: Informed consent of parents and assent was obtained from all schoolchildren involved in the study.

Data Availability Statement: Not applicable.

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

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Lifestyle mediates the relationship between self-esteem and health-related quality of life in Chilean schoolchildren

Felipe Caamaño-Navarrete [a], Pedro Ángel Latorre-Román [b], Iris Paola Guzmán-Guzmán [c], Juan Párraga Montilla [b], Daniel Jerez-Mayorga [d] and Pedro Delgado-Floody [e]

[a]Faculty of Education, Universidad Católica De Temuco, Chile; [b]Department of Didactics of Music, Plastic and Corporal Expression, University of Jaén, Jaén, Spain; [c]Faculty of Chemical-Biological Sciences, Universidad Autónoma De Guerrero, Guerrero, México; [d]Faculty of Rehabilitation Sciences, Universidad Andres Bello, Santiago, Chile; [e]Department of Physical Education, Sport and Recreation, Universidad De La Frontera, Temuco, Chile

ABSTRACT

A healthy lifestyle, including food habits, physical activity (PA) and screen time (ST), is an important factor for well-being. The main purpose of this study was to analyze the association between lifestyle (i.e., PA, ST and food habits), self-esteem and health-related quality of life (HRQoL). A second objective was to determine the association between self-esteem with HRQoL, considering the mediating effect of lifestyle. A descriptive and cross-sectional study was performed, involving both girls (n = 282, 11.86 ± 0.82 years) and boys (n = 352, 12.02 ± 0.87 years). Lifestyle, self-esteem, HRQoL and anthropometrics parameters were evaluated. The study reported that self-esteem (β; 0.04, P = 0.49) and PA (β; 1.15, P < 0.001) had positive association with HRQoL. By contrast,ST was linked in an inverse way to HRQoL (β; −1.82,, P < 0.001). According to the second objective, self-esteem had a significant association with HRQoL (total effect = 0.48, p < 0.01), and ST mediated this association negatively, instead, PA and food habits positively mediated this association. In conclusion, self-esteem presented association with HRQoL and lifestyle mediates this relationship positively (PA, MD adherence) and negatively (ST). Therefore, promoting healthy lifestyle among children should be a target of community- and school-based interventions to promote well-being.

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Introduction

In contemporary society, promoting mental and physical well-being in terms of self-esteem and HRQoL among children and adolescents is of great public health and social significance (Rose et al., 2017), as high levels of subjective well-being are associated with a range of positive life outcomes (Lubans et al., 2016). In this sense, psychological factors such as self-esteem play an important role in subjective well-being, and can be associated with children's social, emotional, behavioural, and mental health (Wang et al., 2009). In

CONTACT Pedro Delgado-Floody pedro.delgado@ufrontera.cl, Universidad De La Frontera. Uruguay No. 1980, Temuco, Chile. Tel.: +56962489239

addition, another important factor related to subjective well-being is HRQoL, which is a multidimensional construct that includes physical, emotional, mental, social and behavioural components of well-being and functioning (Resaland et al., 2019). Moreover, the importance of psychological well-being has also long been recognised (Gregory et al., 2019).

Childhood and adolescence are important periods of life for the acquisition of healthy lifestyle habits, such as PA and healthy food habits (Lopez-Gil et al., 2020), as well as the development of subjective well-being (McDool et al., 2020). In this sense, the lifestyle, which include food habits, PA patterns, and ST, are defined as collective and organised patterns of broad and interrelated behaviours that are in accordance with life circumstances and cultural backgrounds (Xiao et al., 2019).

Moreover, as a result of the typical lifestyle of contemporary society, an increased consumption of processed foods with low nutritional value and a decrease in PA patterns have affected children's well-being (Gu et al., 2016). It has been reported that a healthy lifestyle, especially with regards to children's foods habits, is an essential factor of subjective well-being, and adherence to a MD has shown positive effects in terms of different factors of mental well-being (Muros et al., 2017) and specific components of HRQoL and subjective happiness (Ferrer-Cascales et al., 2019). Additionally, changes in lifestyle, such as a decrease in PA patterns (Ra & Gang, 2016) and an increase in ST among children, have been shown to affect both subjective well-being (Twenge et al., 2019) and HRQoL (Stiglic & Viner, 2019).

Likewise, there is also evidence regarding the effect of self-esteem on HRQoL; for example, a study in children reported that self-esteem predicted HRQoL (Marriage & Cummins, 2004). Another study reported a model suggesting that self-esteem positively predicts variables aligned to those incorporated into measures of HRQoL (Standage & Gillison, 2007). Further, it has been suggested that good self-esteem seems to have a positive effect on HRQoL, and high self-esteem might have a protective role in terms of negative psychological dimensions (Freire & Ferreira, 2018). It appears that it is not enough to have good self-esteem in order to have better HRQoL; it is also essential to have a healthy lifestyle. Based on the fact that self-esteem is associated with HRQoL, it is necessary to determine how lifestyle can interfere with or mediate this effect. The main purpose of this study was to analyze the association between lifestyle (i.e., PA, ST, MD adherence), self-esteem and HRQoL. A second objective was to determine the association between self-esteem with HRQoL, considering the mediating effect of lifestyle.

Method

Participants

A descriptive and cross-sectional study was performed. A total of 634 schoolchildren (352 boys and 282 girls, 12.02 ± 0.87 and 11.86 ± 0.82 years, respectively) from four public (financed by central government and administered by city councils) (Delgado-Floody et al., 2020) primary schools in Temuco (Chile). Temuco is the regional capital of Araucania, Chile and the schools were chosen for their accessibility in data collection. The sample was intentional and non-probabilistic. The students lived in the same geographical area and presented identic socio-demographic characteristics. The

inclusion criteria were: Chilean schoolchildren aged between 11 and 13, without musculoskeletal disorders or any other known medical conditions that might alter the participants' health and PA levels. There were 34 students excluded. Girls not meeting inclusion criteria (n = 14). Boys not meeting inclusion criteria (n = 20). The investigation complied with the Declaration of Helsinki (2013) and was approved by the Ethics Committee of the La Frontera University, Chile (ACT N°086_2017). Parents and guardians were informed about the study and provided written signed consent for participation. Additionally, all participants gave their written assent on the day of the assessment.

Measures

Health-related quality of life

HRQoL for children and young people was measured using the KIDSCREEN-10 questionnaire. KIDSCREEN-10 is a validated and widely used assessment developed for monitoring global HRQoL in 8 to 18-year-old children and adolescents. It has ten items. Each item is answered on a five-point Likert scale indicating the frequency of a specific behaviour or feeling (1 = never; 2 = almost never; 3 = sometimes; 4 = almost always; and 5 = always) or the intensity of an attitude (1 = not at all; 2 = slightly; 3 = moderately; 4 = very; and 5 = extremely). The responses that are negatively formulated (items 3 and 4) were given scores from 1 to 5, and the raw scores were used for different analyses (with higher values indicating a higher HRQoL) (Ravens-Sieberer et al., 2010).

Self-Esteem

For the self-esteem measurement we used the Coppersmith Self-Esteem Inventory (Boyes et al., 2018). This self-esteem questionnaire that describe the feelings, opinions, or reactions of an individual. There are two answer choices: like me (Yes) and unlike me (No).

The scores for self-esteem were categorised as follows (a higher score indicated higher self-esteem): a) less than 22 points: 'very low'; b) 22–26 points: 'low'; c) 26–35 points: 'normal'; d) 35–39 points: 'high'; and e) greater than 39 points: 'very high'. The inventory has been validated in a Chilean child population (Brinkmann et al., 1989). Global self-esteem contains four subscales:

(1) General self-esteem range of acceptance with which self-descriptive behaviours are estimated.
(2) Social self-esteem: refers to relationships with their peers and the valuation of acting in instances of interaction, according to the context.
(3) Family self-esteem: self-perception regarding relationships with their direct relatives.
(4) School self-esteem: level of conformity with which the relationships with their peers and teachers in the school environment.

The children's food habits

MD adherence were assessed using the Krece Plus test (Serra-Majem et al., 2003), which is a tool for assessing eating patterns and their relationship with the nutritional status, based on the MD. The format assesses a set of items concerning the diet that is consumed. Each item has a score of +1 or – 1, depending on whether it approximates the ideal of the MD. The sum of all values from the administered test is categorised into three different levels: (1) >8, optimal MD; (2) 4–7, improvement needed to adjust intake to Mediterranean patterns; and (3) ≤3, very low diet quality (Serra-Majem et al., 2004). Higher scores indicate better food habits.

Screen time and physical activity after school

The PA patterns were evaluated with the Krece Plus test (Serra-Majem et al., 2003). This test is a quick questionnaire that classifies lifestyle based on the daily average number of hours spent watching television or playing video games (ST), and the hours of PA after school per week. The classification is made according to the number of hours spent on each item. The total number of points is added, and the person is classified as good (men: ≥9 points, women: ≥8 points), regular (men: 6–8 points, women: 5–7 points) or bad (men: ≤5 points, women: ≤4 points), according to the lifestyle score.

Anthropometric assessment

The weight (kg) of the participants was measured using a TANITA scale (model Scale Plus UM–028, Tokyo, Japan); they were weighed in their underclothes without shoes. Their height (m) was estimated with a Seca® stadiometer (model 214, Hamburg, Germany) that was graduated in mm. The body mass index (BMI), calculated as the weight divided by the square of the height in metres (kg/m^2), was used to estimate the degree of obesity. The Body mass index (BMI) is shown in the growth table of the Centers for Disease Control and Prevention (CDC), verifying the corresponding age and sex-related percentile. Child obesity is defined as a BMI equal to or greater than the 95th percentile, while overweight is defined as a BMI equal to or greater than the 85th percentile among children of the same age and sex (Karnik & Kanekar, 2012). The waist circumference (WC) was measured using a Seca® tape measure (model 201, Hamburg, Germany) at the height of the umbilical scar (Schröder et al., 2014). The waist-to-height ratio (WHtR) was obtained by dividing the WC by the height, and was used as a tool for estimating the accumulation of fat in the central zone of the body (Chung et al., 2016).

Procedure

Research assistants visited the selected school during the 2017–2018. The team of researchers who evaluated the participants were previously trained in conducting the different tests. In the first session, anthropometric assessments were carried out in a favourable space facilitated by the school, with optimum temperature, reliable privacy, and light clothing. Surveys were applied on different days to the anthropometric

evaluations in classrooms (second and third session). The evaluations took place during physical education classes and in the morning. The questionnaires were completed individually and in the presence of researchers.

Statistical analysis

The statistical analyses were performed using the following software: Stata version 13.0 (StataCorp, College Station, TX, USA), SPSS version 21.0 (SPSS Inc., Chicago, IL, USA), and GraphPad Prism version 7.0 (GraphPad Software, San Diego, CA, USA). The normal distribution of the data and the equality of variances were checked using the Kolmogorov–Smirnov test and Levene's test, respectively. The continuous variables were expressed as means and standard deviations. Differences between sexes were determined using an T-test. Qualitative variables were expressed in proportions and compared between groups with the chi-squared test. The effect size (ES) was calculated using Cohen's d. Effect sizes of less than 0.4 represented a small difference, whereas effect sizes of 0.41–0.7 and greater than 0.7 represented a moderate or large difference. Regression analyses were performed to verify the effect of the mediating variables. Within the analysis, total effect, (c), direct effect (c`) and the indirect effect (a * b), and the calculation of the 95% confidence interval (CI) using the macro/interface process for SPSS and the bootstrapping method, with a resampling rate of 5000, were calculated for the samples according to the recommendations of Preacher and Hayes (2004) (Preacher & Hayes, 2004). In the present study, we develop a theoretical model; Lifestyle parameters (i.e., PA, ST and MD adherence) such as mediating variables between the association of self-esteem with HRQoL. The relationship between psychological self-esteem, HRQoL and lifestyle was estimated with the Pearson correlation coefficient (r) (Hinkle et al., 2003)

Results

Table 1 shows the results according to sex. Family self-esteem and PA after school were slightly higher in boys than girls (girls: 4.85 ± 1.95 vs. boys: 5.13 ± 1.81, $p = 0.059$; and girls: 2.52 ± 1.38 vs boys: 2.74 ± 1.44, $p = 0.049$, respectively). The nutritional level (total sample) was mainly low (35.02%) and moderate (47.48%), while the PA patterns were bad (60.25%) and regular (33.75%), without differences according to sex.

The Pearson correlation analysis found significant relationships between MD adherence and family self-esteem ($r = -0.08$, $p = 0.032$) and HRQoL ($r = 0.22$, $p = 0.039$). A significant relationship was reported for ST and general self-esteem ($r = -0.23$, $p < 0.001$), social self-esteem ($r = -0.08$, $p = 0.020$), family self-esteem ($r = -0.11$, $p = 0.004$), and school self-esteem ($r = -0.30$, $p < 0.001$), as well as with global self-esteem ($r = -0.44$, $p < 0.001$) and HRQoL ($r = -0.71$, $p < 0.001$). The PA patterns showed a significant relationship with general self-esteem ($r = 0.12$, $p = 0.001$), family self-esteem ($r = 0.12$, $p = 0.001$) global self-esteem ($r = 0.12$, $p = 0.001$), school self-esteem ($r = 0.33$, $p < 0.001$) and with HRQoL ($r = 0.72$, $p < 0.001$) (Table 2).

Table 3. shows the association of self-esteem and lifestyle with HRQoL. In this sense, the self-esteem (β; 0.04, 95%CI; 0.00, 0.07, P = 0.49) and PA after school (β; 1.15, 95%CI;

Table 1. Characteristics of the study sample and comparison according to sex.

Variable	Total n = 634	Girls n = 282 (44.5%)	Boys n = 352 (55.5%)	*P-Value*	*Cohen's d*
Age (years)	11.95 ± 0.85	11.86 ± 0.82	12.02 ± 0.87	0.023	
BMI (kg/m^2)	21.6 ± 4.58	21.76 ± 4.4	21.47 ± 4.73	0.409	−2.1
WC (cm)	73.44 ± 11.5	72.7 ± 10.61	74.0 ± 12.16	0.139	−0.1
WtHR (height/WC)	0.47 ± 0.07	0.47 ± 0.06	0.47 ± 0.07	0.959	0
Self-esteem					
General (score)	17.1 ± 4.57	16.82 ± 4.61	17.39 ± 4.53	0.169	−0.1
Social (score)	5.06 ± 1.41	4.98 ± 1.4	5.12 ± 1.41	0.200	−0.1
Family (score)	5.0 ± 1.88	4.85 ± 1.95	5.13 ± 1.81	0.059	−0.1
School (score)	4.93 ± 1.67	4.89 ± 1.7	4.96 ± 1.64	0.590	−0,04
Global (score)	32.1 ± 7.44	31.56 ± 7.62	32.55 ± 7.27	0.092	−0.1
Physical Activity Patterns					
Screen Time (h/day)	3.27 ± 1.13	3.31 ± 1.15	3.24 ± 1.11	0.445	0.06
PA after school (h/week)	2.64 ± 1.42	2.52 ± 1.38	2.74 ± 1.44	0.049	−0.2
PA Patterns (PA+ST)	4.36 ± 2.32	4.20 ± 2.34	4.46 ± 2.30	0.120	−0.1
Bad	*382 (60.25)*	*152 (53.90)*	*210 (59.66)*	0.090	
Regular	*214 (33.75)*	*108 (38.30)*	*120 (34.09)*		
Good	*38 (5.99)*	*22 (7.80)*	*22 (6.25)*		
Nutritional levels					
MD adherence (score)	6.11 ± 2.34	5.97 ± 2.38	6.21 ± 2.31	0.189	−0.1
Low	222 (35.02)	107 (37.94)	115 (35.67)	0.344	
Moderate	301 (47.48)	130 (46.1)	171 (48.58)		
High	111 (17.51)	45 (15.96)	66 (18.75)		
Health Related to Quality of life					
HRQoL (Raw score)	37.37 ± 4.77	37.24 ± 4.66	37.47 ± 4.87	0.554	−0.1

The values shown are mean ± SD, P-value <0.05 is considered statistically significant. BMI; Body Mass Index, WC; waist circumference, WtHR; Height to Waist ratio, PA; physical activity, ST; screen time, MD; Mediterranean diet, HRQoL; health-related to quality of life

Table 2. Correlation between different types of self-esteem and health-related quality of life with lifestyle parameters.

	General	Social	Family	School	Global	HRQoL
Food habits	−0.03 (0.444)	−0.04 (0.230)	−0.08 (0.032)	−0.06 (0.101)	−0.06 (0.113)	0.22 (0.039)
Screen Time	−0.23(<0.001)	−0.08 (0.020)	−0.11 (0.004)	−0.30 (<0.001)	−0.44 (<0.001)	−0.71 (<0.001)
PA after school	0.10 (0.006)	0.05 (0.190)	0.11 (0.004)	0.08 (0.021)	0.09 (0.01)	0.63 (<0.001)
PA Patterns	0.12 (0.001)	0.07 (0.053)	0.12 (0.001)	0.33 (<0.001)	0.12 (0.001)	0.72 (<0.001)

The values shown values r* (P-value). PA; Physical activity, HRQoL; Health Related to Quality of life

Table 3. Association of self-esteem and lifestyle with health related to quality of life.

Outcomes	Beta (95% CI)	P-value	Standardised Beta (SE)
Sex	−0.20 (−0.73;0.33)	P = 0.465	−0.02 (0.27)
Age (y)	−0.10 (−0.40;0.21)	P = 0.535	−0.02 (0.16)
Self-esteem (score)	0.04 (0.00;0.07)	P = 0.049	0.06 (0.02)
MD adherence (score)	0.11 (0.00;0.22)	P = 0.059	0.05 (0.06)
ST (h/day)	−1.82 (−2.13;-1.52)	P < 0.001	−0.43 (0.16)
PA after school (h/week)	1.15 (0.90;1.39)	P < 0.001	0.34 (0.12)

The data shown represent Beta (95% CI), and Standardised Beta and standard error (SE). Values of P < 0.05 were considered statistically significant. MD; Mediterranean diet, ST; screen time, PA; physical activity.

0.90, 1.39, P < 0.001) reported positive association with HRQoL. By contrast ST was linked in an inverse way to HRQoL (β; −1.82, 95%CI; −2.13, −1.52, P < 0.001).

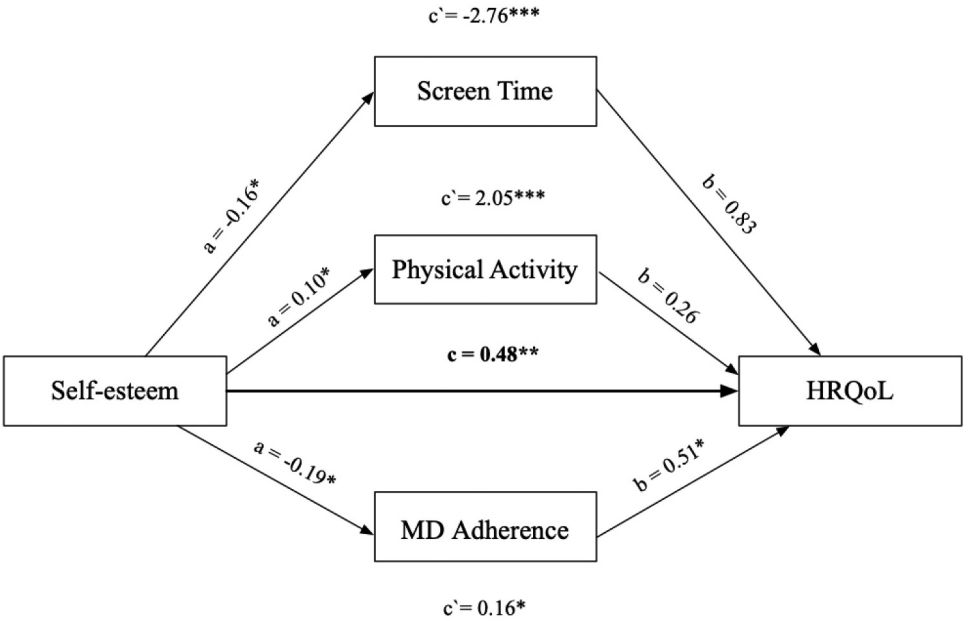

Figure 1. Mediation models of the association between self-esteem with health-related quality of life mediated by lifestyle parameters. *p < 0.05; **p < 0.001.

Self-esteem had a significant association with HRQoL (total effect; 0.48, p < 0.01). However, ST (c´-2.76, p < 0.001) mediated this association negatively and significantly. On the other hand, PA (c´2.05, p < 0.001) and MD adherence (c´0.16, p < 0.05) positively mediated the association between self-esteem and HRQoL (Figure 1). When performing the interpretation considering the values of the indirect effects (a * b), the relationship between self-esteem and HRQoL is partially mediated by ST (ab; β = 0.455, SE 0.017, 95% CI; 0.23, 0.68), PA (ab; β = 0.219, SE 0.107, 95%CI; 0.01, 0.04) and MD adherence (ab; β = - 0.030, SE 0.021, 95%CI; −0.08, 0.00).

Discussion

The main purpose of this study was to analyze the association between lifestyle (i.e., PA, ST, MD adherence), self-esteem and HRQoL. A second objective was to determine the association between self-esteem with HRQoL, considering the mediating effect of lifestyle. The main findings of this study were i) self-esteem was linked to HRQoL; iii) ST negatively mediates the linked of self-esteem on HRQoL; and iv) PA and MD adherence positively mediates the association of self-esteem on HRQoL.

In the present study, MD adherence positively mediates the association of self-esteem with HRQoL. According to our results, an investigation showed a significant relationship between food habits and mental health in young adolescents, independently of PA levels and sedentary behavior (Oellingrath et al., 2014). Furthermore, a different study showed that MD adherence was positively associated with self-esteem in Spanish adolescents (Knox & Muros, 2017). Similarly, another study that used a meditational analysis reported that MD adherence and PA were associated with

four components of HRQoL; likewise, PA has been positively associated with self-esteem through positive associations with physical and psychological well-being (Knox & Muros, 2017). In this context, MD adherence was positively associated with subjective well-being (Muros et al., 2017) and HRQoL in adolescents (Evaristo et al., 2018). However, one study found no prospective associations between MD adherence at baseline and well-being indicators at two-year follow-up after controlling for baseline levels (Esteban-Gonzalo et al., 2019).

In this study, self-esteem was associated to HRQoL, for this reason, self-esteem is considered a predictor of HRQoL, as opposed to an outcome variable (Standage & Gillison, 2007). A study that used a mediation model reported that HRQoL was predominantly explained by mental health (d = 30%) and satisfaction with self (d = 42%) in adolescents (Sawatzky et al., 2010). In the same way, a study concluded that positive psychological dimensions (i.e., high self-esteem) might have a buffering role for negative psychological dimensions in adolescents, and thus should be promoted (Freire & Ferreira, 2018). In addition, it has been reported that self-esteem is negatively associated with sedentary behaviour; high levels of ST have been linked to lower self-esteem scores, as well as decreased psychological well-being and HRQoL (Suchert et al., 2015). Similarly, there is evidence that higher levels of ST are associated with poorer HRQoL and well-being in children (Stiglic & Viner, 2019). These findings contribute to the understanding of other relevant findings about the role of different variables affecting perceptions of HRQoL, when considering self-esteem and children's lifestyles. Similarly, PA and MD adherence positively mediates the association between self-esteem and HRQoL. Another study reported that PA was positively related to all positive health indices, including physical self-image, physical health status, HRQoL, and quality of family and peer relationships in adolescents (Iannotti et al., 2009).

The main limitation of this study is its cross-sectional design; these factors should also be measured in a longitudinal study in future to clarify the direction of the associations. This study included the use of a convenience sample, and the results are not necessarily representative of the national population. Another limitation was that PA and ST were obtained using a self-report instrument.

In conclusion, self-esteem presented association with HRQoL and lifestyle mediates this relationship positively (PA, MD adherence) and negatively (ST). Thus, an increase in healthy lifestyles among children should be a target of community- and school-based interventions to promote well-being. These results highlight the need to make children aware at an early age of the importance of food habits and PA patterns.

Disclosure of potential conflicts of interest

No potential conflict of interest was reported by the author(s).

ORCID

Felipe Caamaño-Navarrete http://orcid.org/0000-0002-6884-589X
Pedro Ángel Latorre-Román http://orcid.org/0000-0002-0517-3627

Iris Paola Guzmán-Guzmán http://orcid.org/0000-0003-1535-4226
Juan Párraga Montilla http://orcid.org/0000-0002-0250-0717
Daniel Jerez-Mayorga http://orcid.org/0000-0002-6878-8004
Pedro Delgado-Floody http://orcid.org/0000-0001-9952-993X

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ORIGINAL ARTICLE

The association between modifiable lifestyle behaviour in Latin-American schoolchildren with abdominal obesity and excess weight. A comparison of Chile and Colombia

Felipe Caamaño-Navarrete[a], Iris Paola Guzmán-Guzmán[b], Constanza Palomino-Devia[c], Felipe Augusto Reyes-Oyola[c], Rocío Bustos-Barahona[d], Daniel Jerez-Mayorga[e], Pedro Delgado-Floody[f,*]

[a] *Faculty of Education, Universidad Católica de Temuco, Chile*
[b] *Faculty of Chemical-Biological Sciences, Universidad Autónoma de Guerrero, Guerrero, Mexico*
[c] *Faculty of Education Sciences, Universidad de Tolima, Colombia*
[d] *Faculty of Health, School of Kinesiology, Universidad Santo Tomás, Valdivia, Chile*
[e] *Faculty of Rehabilitation Sciences, Universidad Andres Bello, Santiago, Chile*
[f] *Department of Physical Education, Sport, and Recreation, Universidad de La Frontera, Temuco, Chile*

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Nutritional level;
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Abdominal obesity

Abstract
Objective: The purpose was to determine the association of lifestyle (i.e., Mediterranean diet [MD] adherence, physical activity [PA], screen time [ST]) and fitness with abdominal obesity (AO) and excess weight in the Chilean and Colombian schoolchildren.
Research methods & procedures: This cross-sectional study included 969 schoolchildren, girls ($n = 441$, 5.24 ± 0.80 years old) and boys ($n = 528$, 5.10 ± 0.78 years old) from Chile ($n = 611$) and Colombia ($n = 358$). The body mass index (BMI), waist circumference (WC), waist-to-height ratio (WtHR), MD adherence, PA, ST and cardiorespiratory fitness (CRF) were evaluated. The association of AO and anthropometric variables with lifestyle was estimated through multiple linear regression. To determine the association between AO and lifestyle, a logistic regression and the inclusion of odds ratios (ORs) with 95% confidence intervals (CIs) were used.
Results: Worse CRF in Chilean children were positively correlated with WC. Excess weight in Chilean and Colombian children was positively associated with an unhealthy lifestyle. In Chilean children unhealthy lifestyle was also associated with AO based on WC $\geq$ 85th percentile and AO based on WtHR $\geq$ 85th percentile. In Chilean children, excess weight (BMI $\geq$ 85th percentile) was positively associated with poor MD adherence.

* Corresponding author.
E-mail address: pedro.delgado@ufrontera.cl (P. Delgado-Floody).

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Conclusion: AO and excess weight were associated with an unhealthy lifestyle in Latin-American schoolchildren. Interventions to reduce the prevalence of AO should include promoting healthier lifestyle choices (i.e., increasing PA after school, reducing ST and improving CRF).

PALABRAS CLAVE
Nivel nutricional;
Actividad física;
Resistencia;
Obesidad abdominal

Asociación entre comportamientos de estilo de vida modificables con obesidad abdominal y exceso de peso en preescolares latinoamericanos. Análisis entre Chile y Colombia

Resumen
Objetivo: El propósito fue determinar la asociación del estilo de vida (es decir, adherencia a la dieta mediterránea [DM], actividad física [AF], tiempo frente a la pantalla [TP]) y aptitud física con obesidad abdominal (OA) y exceso de peso en escolares chilenos y colombianos.
Métodos y procedimientos de investigación: Este estudio transversal incluyó a 969 escolares, niñas (n = 441; 5,24 ± 0,80 años) y niños (n = 528; 5,10 ± 0,78 años) de Chile (n = 611) y Colombia (n = 358). Se evaluaron el índice de masa corporal (IMC), la circunferencia de la cintura (CC), la relación cintura-altura (RCE), la adherencia a la DM, la AF, la TP y la aptitud cardiorrespiratoria (CRF). La asociación de OA y variables antropométricas con el estilo de vida se estimó mediante regresión lineal múltiple. Para determinar la asociación entre OA y estilo de vida se utilizó una regresión logística y la inclusión de odds ratios (OR) con intervalos de confianza (IC) del 95%.
Resultados: Menor CRF en los niños chilenos se correlacionó positivamente con la CC. El exceso de peso en preescolares chilenos y colombianos se asoció positivamente con un mal estilo de vida (3-5 años). Además, en los niños chilenos de 3 a 5 años un mal estilo de vida se asoció con AO basado en CC ≥ percentil 85 y OA basado en RCE ≥ percentil 85. En los niños chilenos, el exceso de peso (IMC ≥ percentil 85) se asoció positivamente con una mala adherencia a la DM.
Conclusión: La OA y el exceso de peso se asociaron con un mal estilo de vida en preescolares latinoamericanos. Las intervenciones para reducir la prevalencia de OA deben incluir la promoción de un estilo de vida saludable (es decir, aumentar la AF después de la escuela, reducir el TP y mejorar la CRF).

Introduction

The prevalence of childhood obesity is reaching epidemic proportions all over the world even among preschool children,[1] and has been declared a global public health problem.[2] Childhood obesity has become one of the major concerns in recent years due to its association with future health problems.[3] Obesity is a global phenomenon in both developed and undeveloped countries. However, as Mazza and Kovalskys have noted, there is little information regarding this issue in Latin America.[4] The high prevalence of obesity in Latin America is basically caused by important changes in food habits and PA patterns and by other sociocultural factors (i.e., a lower educational and socioeconomic level), which have produced a nutritional transition process.[5]

Likewise, abdominal obesity (AO) is a major clinical and public health issue compared with generalized obesity in children, as AO (i.e., central obesity) is more strongly correlated with cardiometabolic risk (CMR)[6] and seems to have increased during the last few decades.[7] Moreover, it has been reported that AO in children increases CMR factors such as dyslipidaemia, hypertension and hyperglycaemia.[6] Likewise, AO predicts a wide range of adverse health outcomes such as diabetes and cardiovascular diseases.[8] Thus, more attention should be paid in epidemiological studies to AO in children, while identifying modifiable lifestyle behaviour linked to AO is necessary for developing preventive strategies.

The decrease in physical activity (PA) and the increase in sedentary behaviour in children have affected the development of healthy children.[9] In this sense, a high amount of screen time (ST, the most popular sedentary behaviour) has been associated with a cluster of CMR factors[10] such as AO in children.[11] Additionally, PA has been indicated as an important factor in preventing CMR,[12] and is a modifiable factor that is inversely associated with AO. Thus, if carried out from childhood, it can influence the adoption of an active lifestyle.[13]

Children's food habits represent one of the main determinant factors that influence the development of obesity.[14] There is evidence that adherence to a Mediterranean diet (MD) is associated with positive effects on specific components of well-being.[15] Likewise, children's food habits have an influence on health in later life,[16] and may be protective factors for well-being in children. Nevertheless,

there is a high prevalence of children aged 6–7 years with poor-to-moderate MD adherence.[17] Additionally, better MD adherence in preschool children is associated with a lower risk of developing AO in children and adolescents.[18]

Another relevant factor is fitness in pre-schoolers. During childhood it has different health benefits, especially cardiorespiratory fitness (CRF), which is a basic component of a healthy lifestyle[19] and is related to lower CMR.[20] It has also been shown that overweight children with high CRF have a healthier cardiovascular profile.[21] Moreover, higher levels of CRF substantially reduce CMR in adulthood, even among those with AO in childhood.[22] Developing assessments of children's health-related physical fitness at an early stage is a priority,[23] since improving physical fitness provides protection against CMR[24] and is an important biomarker of health.[25] The association between such modifiable behaviour as fitness and lifestyle (i.e., PA, ST and MD adherence) and obesity is well documented in children, but this association remains to be determined in Latin-American children. Therefore, the purpose of this study was to determine the association of lifestyle (i.e., MD adherence, PA and ST) and fitness with AO and excess weight in Chilean and Colombian schoolchildren.

Methods

Study design and participants

This cross-sectional study included 969 children, girls ($n = 441$, 5.27 ± 0.71 years old) and boys ($n = 528$, 5.14 ± 0.82 years old) from Chile ($n = 611$) and Colombia ($n = 358$), selected by convenience sampling. Parents and guardians were informed about the study and provided signed written consent for participation. Additionally, all children gave their oral or written assent on the day of the assessment. The investigation complied with the 2013 Helsinki Declaration and was approved by the Ethics Committee (Doctoral Project, Jaen University and Local Ethics Committee).

The inclusion criteria were: (i) presenting informed consent of the parents and assent of the participant, (ii) belonging to educational centres and (iii) being between 3 and 7 years old. The exclusion criteria were having a musculoskeletal disorder or any other known medical condition, which might alter the participant's health and PA levels. Moreover, schoolchildren with physical, sensorial or intellectual disabilities were excluded.

Sociodemographic characteristics

An ad hoc sociodemographic questionnaire was used; information such as educational level, marital status and socioeconomic background (based on their socioeconomic self-perception) was collected from parents. Moreover, parents completed the information about the preschool children's PA and ST (Krece Plus test).

General obesity

The body mass index (BMI), calculated as the body mass divided by the square of the height in metres (kg/m^2), was used to estimate the degree of obesity. Body mass (kg) was measured using a Tanita UM-028 scale (Tokyo, Japan); the children were weighed in their underclothes without shoes. Height (m) was estimated with a Seca® 214 stadiometer (Hamburg, Germany) that was graduated in mm. For the BMI, World Health Organization (WHO) curves were used to identify excess weight, according to sex and age.[26]

Abdominal obesity

Waist circumference (WC) was measured using a Seca® 201 tape measure (Hamburg, Germany) at the height of the umbilical scar.[27] The waist-to-height ratio (WtHR) was obtained by dividing the WC by the height. To define AO, four aspects were considered: (i) WC in the 90th percentile of the sample study ($\geq$65 cm), (ii) WC $\geq$ 85th percentile of the sample study ($\geq$63 cm), (iii) WtHR in the 90th percentile of the sample study ($\geq$0.59) and (iv) WtHR $\geq$ 85th percentile ($\geq$0.57) of the sample study.[28–30]

Food habits

MD adherence of the children was assessed by the Krece Plus test,[31] a tool for assessing eating patterns and their relationship with nutritional status based on the MD. The questionnaire has 15 items, and the format assesses a set of items about the food consumed in the diet. Each item has a score of +1 or −1, depending on whether it approximates the ideal of the MD. The maximum score is 11 points and the minimum −5. The total points are added, and according to the score, the nutritional status is classified as follows: (i) low nutritional level: $\leq$5; (ii) moderate nutritional level: 6–8; or (iii) high nutritional level: $\geq$9. This questionnaire has been used in Chilean schoolchildren.[12]

Physical activity patterns

Lifestyle was evaluated with the Krece Plus test,[31] a quick questionnaire that classifies lifestyle according to the daily average of hours spent watching television or playing video games (h/day) and hours of PA after school per week (h/week). Classification is made according to the number of hours used for each point. The total points are added, and the person is classified as having: (i) good lifestyle (men: $\geq$9, women $\geq$ 8), (ii) regular lifestyle (men: 6–8, women: 5–7) or (iii) bad lifestyle (men: $\leq$5, women: $\leq$4).

Physical fitness

For the evaluation of physical fitness, leg strength, CRF and handgrip strength were measured.

Lower-body explosive strength was assessed by a standing long jump test (SLJ).[32] The SLJ has been used in preschool children[33] and consists of jumping a distance with both feet at the same time. For this, the student stands behind the jump line, and with a foot separation equal to the width of their shoulders; the knees are then bent with the arms in front of the body and parallel to the ground. From this position, they swing their arms, push hard and jump as far as possible, making contact with the ground with both feet

simultaneously and in a vertical position. This is done twice, and the best result is recorded.

Handgrip strength was used to measure upper body strength through a hand dynamometer (TKK 5101 Grip D; Takei, Tokyo, Japan). The test consists of holding a dynamometer in one hand and squeezing as tightly as possible without allowing the dynamometer to touch the body; force is applied gradually and continuously for a maximum of 3–5 s.[32] The test was performed twice, and the maximum score for each hand was recorded in kilograms. The average of the scores achieved by the left and right hands was used in the analysis. Higher scores indicate better performance.

CRF was assessed using the 100 m × 20 m test, inspired by the spatial structure of the Léger test.[34] The 100 m × 20 m test has been used in preschool children and has been validated.[35] Its design takes into account the age of the children, the rules being very simple and the test enjoyable to perform. The materials required are a tape measure to mark the distances of the runway (20 m), two boxes, five balloons and a stopwatch. It is a 20 m shuttle test, in which participants have to move five balloons from box A, located at one extreme, to box B, located at the opposite extreme. The total distance covered is 200 m, timed from the signal ''Go'' until the participant deposits the last balloon. It is unimportant whether or not the balloon enters the box. If dropped, the participant has to pick it up and continue moving. Supervisors indicate that the balloon has to be held with both hands. Only one attempt is made and running and walking are allowed. The result is recorded in seconds with one decimal place, a slower time indicating a poorer performance.

Statistical analysis

Statistical analyses were performed using STATA V.13.0. (StataCorp, College Station, TX, USA). Normal distribution was tested using the Kolmogorov–Smirnov test. For continuous variables, values were presented as means and standard deviations (SDs), whereas for categorical variables, data were presented as proportions. Differences between groups were determined using one-way ANOVA and the χ^2 test. The association of AO and anthropometric variables with lifestyle was estimated through multiple linear regression. To determine the association between AO and lifestyle, a logistic regression and the inclusion of odds ratios (ORs) with 95% confidence intervals (CIs) were used. Values of $P < 0.05$ were considered statistically significant.

Results

Sociodemographic antecedents

There were no significant differences between the proportion of girls and boys or the parents' antecedents (i.e., marital status, study level and socioeconomic background) in the comparison between Chilean and Colombian children (Table 1).

Table 1 Sociodemographic characteristics of the study sample.

	Chile ($n = 611$)	Colombia ($n = 358$)	*P*-value
Sex			
Girls	277 (45.3)	164 (45.8)	0.88
Boys	334 (54.7)	194 (54.2)	
Age, y (5–95th)	5 (4–6)	5 (4–6)	0.26
Age category			
3–5 years old	400 (64.1)	211 (61.2)	0.36
6–7 years old	224 (35.9)	134 (38.8)	
Parents information			
Socioeconomic background n (%)			
Low/middle low	248 (40.6)	136 (38)	0.59
Middle	345 (56.5)	208 (58.1)	
Middle high/high	18 (2.9)	14 (3.9)	
Study level n (%)			
Primary	112 (18.3)	67 (18.7)	0.95
Secondary	237 (38.8)	141 (39.4)	
University	262 (42.9)	150 (41.9)	
Marital status n (%)			
Single	190 (31.1)	98 (27.4)	0.57
Married	271 (44.3)	163 (45.5)	
Divorced	94 (15.4)	64 (17.9)	
Widow	56 (9.2)	33 (9.2)	

The data shown represent *n* (proportions). $P < 0.05$ considered statistically significant.

Comparison between sexes in Chilean vs. Colombian preschool children

According to the anthropometric parameters, the boys in Chile had a higher BMI ($P < 0.001$), WC ($P < 0.001$) and WtHR ($P < 0.001$) than the Colombian children. In relation to fitness, Chilean children presented better results in the '10 × 20' resistance test than Colombian children ($P < 0.001$). However, regarding handgrip strength the Chilean children had worse results than the Colombian children ($P = 0.007$). For lifestyle, Chilean children presented higher MD adherence ($P = 0.040$), hours of PA after school per week ($P < 0.001$) and ST per day ($P < 0.001$) than Colombian children. Chilean girls had higher WC ($P < 0.001$) than Colombian girls; likewise, they had better results in the 10 × 20 resistance test ($P < 0.001$). For lifestyle, the Chilean girls had higher levels of moderate and high MD adherence ($P = 0.040$), hours of PA after school per week ($P < 0.001$) and ST per day than Colombian girls ($P < 0.001$) (Table 2).

Prevalence of obesity in Chilean vs. Colombia preschool children

In Chilean girls, excess weight was present in 36.5%, of which 21.3% fell into the obesity category, while 9.1% of Colombian girls were obese. Similarly, 39.5% of Chilean boys had excess weight, of which 27.2% were obese, while 13.9% of Colombian boys were obese (Fig. 1).

In relation to AO, more Chilean girls (24.2% vs. 7.9%, $P < 0.001$) and boys (18.3% vs. 10.3%, $P = 0.0014$) had a higher AO based on WC ≥ 85th percentile (≥ 63 cm) than their Colombian peers. Assessing AO based on WtHR ≥ 85th percentile (≥ 0.57), more Chilean girls (25.3% vs. 7.3%) had AO than Colombian girls and Chilean boys (25.3% vs. 17.1%, $P = 0.013$) (Table 3).

Linear correlation between abdominal obesity markers and lifestyle

Worse results in the 10 × 20 resistance test (i.e., CRF) in Chilean girls and boys were positively correlated with WC (girls, $r = 0.34$, $P < 0.001$; boys, $r = 0.26$, $P < 0.001$) and WtHR (girls, $r = 0.27$, $P < 0.001$; boys $r = 0.22$, $P < 0.001$). PA after school was inversely correlated with WC in girls ($r = -0.15$, $P = 0.009$) and boys ($r = -0.23$, $P < 0.001$). In Colombian girls ($r = 0.20$, $P = 0.009$) and boys ($r = 0.24$, $P < 0.001$), MD adherence was positively correlated with WC. ST was positively correlated with WC in Chilean girls ($r = 0.23$, $P < 0.001$) and boys ($r = 0.24$, $P < 0.001$). The same relation was found in Colombian girls and boys ($r = 0.16$, $P = 0.030$ and $r = 0.16$, $P = 0.040$, respectively) (Table 4).

Association of variables with abdominal obesity

Excess weight in Chilean (OR: 1.73, 95%CI: 1.1–2.73, $P = 0.018$) and Colombian children (OR: 1.83, 95%CI: 0.96–3.47, $P = 0.06$) was positively associated with bad lifestyle. In Chilean children, a bad lifestyle was also associated with AO based on WC in the 90th percentile (OR: 2.36, 95%CI: 1.22–4.54, $P = 0.010$), AO based on WC ≥ 85th percentile (OR: 1.74, 95%CI: 1.04–2.9, $P = 0.032$) and AO based on WtHR ≥ 85th percentile (OR: 1.75, 95%CI: 1.06–2.89, $P = 0.028$). Moreover, in Colombian children, low MD adherence was inversely associated with AO based on WC ≥ 85th percentile (OR: 0.44, 95%CI: 0.23–0.84, $P = 0.010$). By contrast, in Chilean children, excess weight – a BMI ≥ 85th percentile – was positively associated with bad MD adherence (OR: 1.43, 95%CI: 1.0–2.05, $P = 0.04$) (Table 5).

Discussion

The purpose of this study was to determine the association of lifestyle (i.e., MD adherence, PA and ST) and fitness with AO and excess weight in Chilean and Colombian children. The main results were: (i) in Chilean and Colombian children, AO was associated with a poor lifestyle, (ii) ST was positively correlated with WC in Chilean and Colombian preschool children, and (iii) worse CRF results (10 × 20 test) were positively correlated with WC and WtHR in Chilean girls and boys, but not in Colombian children.

In the present study, we found a higher prevalence of AO in Chilean girls (25.3%), than boys and Colombian girls. In a study conducted in 5231 Greek children, the prevalence of AO did not differ between boys and girls at the age of 7 (25.2% and 25.3% respectively), while at the age of 9 more boys than girls had AO (33.2% and 28.2%, respectively).[36] In another study evaluating 1433 Portuguese children (6–12 years old), the prevalence of AO based on the measurement of WC was similar in girls and boys; however, according to WtHR, boys had a higher prevalence than girls.[37] Another investigation reported a high prevalence of AO in children between 3 and 10 years old, where 30.5% of the children had AO.[38] Evidence of the prevalence of AO in children is worrying, as it is a risk factor for cardiovascular diseases and cancer in adults.[39] Another study reported that those presenting high WC values are more likely to have hypertension, diabetes, dyslipidaemia and CMR compared with those with normal WC values.[40]

In Chilean and Colombian children, excess weight (i.e., overweight and obesity) and AO was associated with a bad lifestyle (i.e., low PA after school and high ST). In accordance with our results, a study conducted in Canadian preschool children reported that a healthy lifestyle such as good PA patterns and low sedentary behaviour is significantly associated with healthy BMI z-scores but not with WC.[41] Similarly, a longitudinal study demonstrated that an unhealthy lifestyle (i.e., bad food habits and high ST) is associated with high body fat in preschool girls.[42] On the other hand, a recent study reported that BMI and WC are not associated with lifestyle (i.e., PA and sedentary behaviour) in preschool children,[43] results in discordance with ours. In addition, childhood obesity has re-focused attention on the importance of a healthy lifestyle (i.e., PA and ST) in this age group.[44] In this context, another study conducted in school age children and adolescents concluded that obesity in childhood and adolescence should be considered a health problem in Latin American countries.[4]

In the present study, we found that ST is positively related to WC in Chilean and Colombian children. In accordance with our results, it has been reported that those preschool

Table 2 Comparison of anthropometric and physical characteristics of the study sample.

	Chile $n = 611$		Colombia $n = 358$		*P* value	*P* value
	Girls (*A*)	Boys (*B*)	Girls (*C*)	Boys (*D*)	$A \times C$ $A \times B$°	$B \times D$ $C \times D$°
Age (y)	5 (4–5)	6 (4–6)	5 (4–5)	6 (4–7)	0.76 <0.001°	0.07 <0.001°
Body mass (kg)	19 (14–27.2)	21.4 (16–33)	19.0 (14–25)	21.35 (17.3–31.9)	0.43 <0.001°	0.61 <0.001°
Size (m)	1.13 (0.99–1.29)	1.13 (1.0–1.34)	1.11 (0.99–1.2)	1.17 (1.06–1.32)	<0.001 0.79°	<0.001 <0.001°
BMI (kg/m²)	14.9 (9.7–22.5)	17 (12.0–22.6)	15.4 (11.6–19.9)	15.7 (13–20.6)	0.05 <0.001°	<0.001 0.07°
WC (cm)	59 (50.7–66)	58 (51–66)	56.1 (50–67)	55.5 (50–65.5)	<0.001 0.06°	<0.001 0.21°
WtHR (WC/size)	0.52 (0.43–0.63)	0.51 (0.43–0.59)	0.50 (0.44–0.62)	0.47 (0.40–0.58)	0.20 0.08°	<0.001 <0.001
Fitness						
SJT (cm)	82 (46–114.5)	83 (43–117)	83 (39–117)	82 (49–116)	0.80 0.65	0.98 0.83°
Speed 20 m (s)	6 (4.8–7.6)	6.02 (4.7–7.7)	6.3 (4.8–7.5)	5.9 (4.5–7.8)	0.20 0.80°	0.40 0.05°
Resistance 10 × 20 (s)	75.6 (63.5–95.4)	75.0 (66–95)	84.8 (60–112)	90 (60–120)	<0.001 0.58°	<0.001 <0.001
Handgrip strength (kg)	5.7 (2–8)	5.5 (2.0–8.2)	6 (2–11.8)	6 (2–17.3)	0.001 0.35°	0.007 0.80
Lifestyle						
MD adherence (−5 to 11)	5 (−2 to 9)	5 (−2 to 9)	3 (−1 to 9)	3 (−1 to 8)	0.39 0.52°	0.040 0.50°
Mediterranean diet adherence					0.04 0.47°	0.003 0.70°
Low MD	229 (57.3)	151 (67.4)	151 (67.4)	96 (71.6)		
Moderate MD	143 (35.7)	61 (27.2)	61 (27.2)	32 (23.9)		
High MD	28 (7.0)	12 (5.4)	12 (5.4)	6 (4.5)		
PA after school (h/week)	3 (1–5)	3 (1–5)	3 (0–5)	2 (0–5)	<0.001 0.91°	<0.001 0.14°
ST (h/day)	4 (1–4)	4 (1–5)	3 (1–5)	2 (1–4)	<0.001 0.99°	<0.001 0.75°
Lifestyle (PA + ST)					<0.001 0.051°	0.34 0.10°
Bad PA	252 (63.0)	125 (59.2)	106 (47.3)	78 (58.2)		
Regular PA	111 (27.8)	75 (35.55)	108 (48.2)	53 (39.5)		
Good PA	37 (9.2)	11 (5.2)	10 (4.5)	3 (2.24)		

The quantitative variables shown median (percentiles 5–95), qualitative variables represent *n* (proportions). $P < 0.05$ considered statistically significant. BMI = body max index, WC = waist circumference, WtHR = waist-to-height ratio, SLJ = standing long jump test, MD = Mediterranean diet, PA = physical activity, ST = screen time.

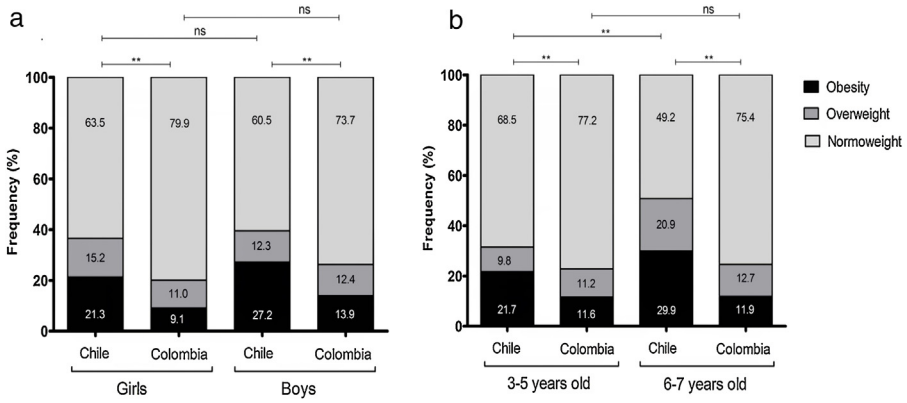

Figure 1 Prevalence of obesity according to sex. Cl = Chile, Col = Colombia.

children exhibiting more sedentary behaviour such as ST are more likely to have more AO.[45] Moreover, Wuan et al.[46] reported that preschool children who do not meet the ST guidelines are at higher risk for overweight and obesity. Similarly, Li et al.[47] reported that ST is independently associated with childhood obesity. In accordance with our results, it has been demonstrated that ST increases the BMI, BMI *z*-score and AO in European preschool children.[48]

In the present study, we found that worse CRF (i.e., a slow time in test 10 × 20) was positively correlated with WC and WtHR in Chilean girls and boys, but not in Colombian children. Another study reported that higher CRF is associated with lower AO in Spanish preschool children.[49] Similarly, Martínez et al.[50] reported a significant association of the 20 m shuttle run test (i.e., CRF) with the BMI and WC in preschool children. Additionally, it has been reported that free fat mass is associated with better CRF in preschool children.[51] A longitudinal study reported that a high CRF at 4.5 years old is associated with better corporal composition at 5.5 years old in preschool children.[52] Finally, further investigation is needed with the aim of clarifying the effects of physical fitness at preschool age on later health outcomes.[52]

In Chilean children, AO was positively associated with low MD adherence; by contrast, in Colombian children, low MD adherence had an inverse association with AO. It has been reported that high MD adherence is related to lower WC[49] and associated with a lower risk of preschoolers developing overweight, obesity and AO in the future.[18] Therefore, MD adherence is a relevant modifiable factor to be targeted in

Table 3 Prevalence of abdominal obesity according to sex and country.

	Chile *n* = 611		Colombia *n* = 358		*P* value	
	Girls *n* = 277 (*A*)	Boys *n* = 334 (*B*)	Girls *n* = 164 (*C*)	Boys *n* = 194 (*D*)	*A* × *C* *A* × *B*°	*B* × *D* *C* × *D*°
AO by WC 90th percentile (≥65 cm)					0.006 0.20°	0.25 0.43°
AO	41 (14.8)	38 (11.38)	10 (6.1)	16 (8.25)		
Non-AO	236 (85.2)	296 (88.62)	154 (93.9)	178 (91.75)		
AO by WC 85th percentile (≥63 cm)					<0.001 0.073°	0.014 0.43°
AO	67 (24.2)	61 (18.3)	13 (7.9)	20 (10.3)		
Non-AO	210 (75.8)	273 (81.7)	151 (92.1)	174 (89.7)		
AO by WtHR 90th percentile(≥0.59 ratio)					0.003 0.035°	0.73 0.11°
AO	43 (15.52)	33 (9.88)	10 (6.1)	21 (10.82)		
Non-AO	234 (84.48)	301 (90.1)	154 (93.9)	173 (89.2)		
AO by WtHR 85th percentile (≥0.57 ratio)					<0.001 0.013°	0.52 0.024°
AO	70 (25.3)	57 (17.1)	12 (7.3)	29 (15.0)		
Non-AO	207 (74.7)	277 (82.9)	152 (92.7)	165 (85.0)		

Data represent *n* (proportions), *P* value determined by Chi^2. $P < 0.05$ was considered statistically significant. AO = abdominal obesity. WC = waist circumference, WtHR = waist-to-height ratio.

Table 4 Lineal correlation between WC and WtHR with physical factors in Latin-American preschool children.

	Chile		Colombia	
WC (cm) ^WHtR (ratio)	Girls *r** (*P* value)	Boys *r** (*P* value)	Girls *r** (*P* value)	Boys *r** (*P* value)
Age (y)	−0.05 (0.35) −0.05 (0.32) ^	−0.07 (0.17) −0.07 (0.15) ^	−0.15 (0.04) −0.49 (<0.001)^	0.006 (0.92) −0.31 (<0.001) ^
BMI (kg/m²)	0.15 (0.01) 0.44 (<0.001)	0.06 (0.21) 0.24 (<0.001) ^	−0.07 (0.33) 0.04 (0.59)^	0.01 (0.85) 0.24 (<0.001) ^
WtHR (WC/size)	0.71 (<0.001) −^	0.69 (<0.001) −^	0.73 (<0.001) −^	0.73 (<0.001) −^
BMI percentile	0.14 (0.019) 0.42 (<0.001) ^	0.05 (0.30) 0.22 (<0.001) ^	−0.07 (0.33) 0.05 (0.48)^	0.006 (0.92) 0.23 (0.001) ^
Fitness				
SJT (cm)	−0.01 (0.84) −0.06 (0.28) ^	−0.04 (0.37) −0.01 (0.80) ^	0.11 (0.15) 0.18 (0.01)^	0.001 (0.98) 0.02 (0.68)^
Speed 20 m (s)	0.09 (0.10) 0.13 (0.029) ^	−0.05 (0.29) −0.01 (0.80) ^	0.01 (0.86) −0.03 (0.62)^	−0.15 (0.03) −0.20 (0.004)^
Resistance 10 × 20 (s)	0.34 (<0.001) 0.27 (<0.001) ^	0.26 (<0.001) 0.22 (<0.001) ^	0.007 (0.92) −0.08 (0.28) ^	0.01 (0.87) 0.01 (0.85)^
Handgrip strength (kg)	0.09 (0.12) 0.04 (0.49) ^	−0.01 (0.83) −0.02 (0.64) ^	0.04 (0.55) 0.13 (0.07)^	0.003 (0.95) −0.02 (0.72)^
Lifestyle				
MD adherence (−5 to 11)	0.006 (0.91) −0.05 (0.34) ^	0.05 (0.27) 0.05 (0.28) ^	0.20 (0.009) 0.20 (0.008) ^	0.24 (<0.001) 0.10 (0.14)^
PA after school (h/week)	−0.15 (0.009) −0.08 (0.16) ^	−0.23 (<0.001) −0.18 (<0.001) ^	0.05 (0.46) 0.04 (0.53)^	0.007 (0.91) 0.08 (0.23)^
ST (h/day)	0.23 (<0.001) 0.14 (0.01) ^	0.24 (<0.001) 0.17 (0.001) ^	0.16 (0.03) 0.12 (0.11)^	0.14 (0.04) 0.04 (0.54)^

Data represent *r** = Pearson correlation coefficient (*P* value), $P < 0.05$ considered statistically significant. BMI = body mass index, WC = waist circumference, WtHR = waist-to-height ratio, SLJ = standing long jump test, MD = Mediterranean diet, PA = physical activity, ST = screen time.

Table 5 Association between abdominal obesity and lifestyle in Latin-American preschool children.

	Chile *n* = 611		Colombia *n* = 358	
	4–5 years old OR (CI95%) *P* value	6–7 years old OR (CI95%) *P* value	4–5 years old OR (CI95%) *P* value	6–7 years old OR (CI95%) *P* value
Bad lifestyle (PA + ST)				
EW-BMI ≥ 85th	1.73 (1.1–2.73), 0.018	1.14 (0.65–2.0), 0.63	1.83 (0.96–3.47), 0.06	1.60 (0.70–3.65), 0.25
AO by WC 90th	2.36 (1.22–4.54), 0.010	3.31 (1.05–10.4), 0.04	1.65 (0.60–4.5), 0.32	6.42 (0.77–53.2), 0.08
AO by WC 85th	1.74 (1.04–2.90), 0.032	1.69 (0.77–3.7), 0.18	1.69 (0.69–4.1), 0.25	3.53 (0.73–17.0), 0.11
AO by WtHR 90th	1.66 (0.91–3.04), 0.09	1.73 (0.55–5.37), 0.34	1.23 (0.53–2.84), 0.62	1.46 (0.25–8.26), 0.66
AO by WtHR 85th	1.75 (1.06–2.89), 0.028	0.89 (0.40–1.99), 0.78	1.21 (0.56–2.62), 0.61	3.08 (0.63–15.1), 0.16
Low MD adherence				
EW- BMI ≥85th	1.43 (1.0–2.05), 0.04	0.86 (0.56–1.30), 0.48	1.27 (0.72–2.26), 0.39	0.97 (0.48–1.97), 0.95
AO by WC 90th	1.33 (0.83–2.14), 0.22	1.17 (0.56–2.44), 0.65	0.49 (0.24–1.01), 0.056	0.53 (0.19–1.46), 0.22
AO by WC 85th	1.01 (0.69–1.46), 0.95	0.97 (0.56–1.67), 0.91	0.44 (0.23–0.84), 0.010	0.42 (0.17–1.06), 0.06
AO by WtHR 90th	1.25 (0.79–1.98), 0.33	0.57 (0.26–1.22), 0.15	0.72 (0.37–1.39), 0.33	0.61 (0.17–2.15), 0.44
AO by WtHR 85th	1.08 (0.74–1.57), 0.67	0.82 (0.45–1.49), 0.53	0.63 (0.34–1.15), 050	0.37 (0.14–0.95), 0.040

The data shown represent OR, (95%CI), *P*-value. The OR was adjusted by sex. AO = abdominal obesity, WC = waist circumference, WtHR = waist to height ratio, EW = excessive weight.

educational strategies aiming to prevent central obesity.[49] The evidence shows that Chile has the appropriate characteristics for developing MD adherence. Also, MD adherence is a key tool to protect health and is not exclusive to the countries of the Mediterranean basin. It should be a target of community based interventions to promote health.[53]

Limitations

The limitations of the present study include those inherent to its transversal character. Another limitation is the self-reporting of parents in relation to the children's PA and food habits, which could mean that these data are underestimated or overestimated. We recognize the need to investigate possible longitudinal effects and to clarify the direction of the associations and carry out interventions in children's lifestyle.

The strengths of this study are that we examined several variables that affect children's development and have contributed to a better understanding of the serious problem of bad lifestyle in Latin-American children.

Conclusion

Chilean children have a higher prevalence of AO than their Colombian peers. Moreover, AO and excess weight are associated with a poor lifestyle in children of both countries, and are related to worse CRF results. Therefore, interventions to reduce the prevalence of AO should include promoting a healthy lifestyle (i.e., increasing PA after school, reducing ST and improving CRF) in Latin-American children. Strategies for preventing and reducing children's AO, through an accessible, economical and worldwide effort, should be considered as aids in the development of healthy habits and behaviour in schoolchildren.

Authors' contributions

FC-N and PD-F contributed to the conception, organization and oversight of the study, the drafting of the analysis plan, writing the original manuscript draft and final approval of the version to be published. DJ-M, CP-V, RB-R and AR-O contributed to writing the original manuscript draft and final approval of the version to be published. IPG-G drafted the analysis plan, wrote the original manuscript draft and gave final approval of the version to be published.

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Conflicts of interest

The authors declare no conflict of interest.

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