



PHYSICAL ACTIVITY, PHYSICAL FITNESS AND SCREEN-TIME AMONG ECUADORIAN ADOLESCENTS

Dolores Susana Andrade Tenesaca

“We [the Moderns] are like dwarves perched on the shoulders of giants [the Ancients], and thus we are able to see more and farther than the latter. And this is not at all because of the acuteness of our sight or the stature of our body, but because we are carried aloft and elevated by the magnitude of the giants”

Bernard of Chartres

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Physical activity, physical fitness and screen-time among Ecuadorian adolescents

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Abbreviations

BMI: Body mass index

CI: confidence intervals

CPPE: Comprehensive Participatory Planning and Evaluation approach

CPM: counts per minute

ENSANUT: Ecuadorian National Health Survey

EUROFIT: European Tests of Physical Fitness

HDL: High-density lipoprotein cholesterol

IM: Intervention Mapping protocol

IOTF: International Obesity Task Force

IQR: interquartile range

HICs: High income countries

LDL: Low density lipoprotein cholesterol

LMICs: Low- and middle- income countries

Min: minutes

MVPA: Moderate vigorous physical activity

NCDs: non-communicable diseases

PA: Physical activity

SD: standard deviation

TC: Total cholesterol

TG: Triglycerides

TV: television

UBN: Unsatisfied basic needs

VO_{2peak}: Peak oxygen uptake

WHO: World Health Organization

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Summary

Similar to various low and middle income countries (LMICs), in Ecuador, the leading cause death is lifestyle related non-communicable disease (NCDs). Unfortunately preventive action to decrease the incidence of NCDs risk factors during adolescence is scarce. To our knowledge, there are no studies in Ecuador focused on improving the dietary intake, physical activity, physical fitness or sedentary patterns among adolescents. The present doctoral work aims to provide evidence on strategies to promote a healthy lifestyle in Ecuadorian adolescents. For this purpose, first we evaluated the current physical fitness among adolescents, and its association with dyslipidemia as the most prevalent NCD risk factor. Second, we analyzed the effect of a school-based health promotion program on physical fitness, physical activity and sedentary behaviors among adolescents. Finally, we assessed whether adolescents that are already at health risk such as overweight/obese and those with a low fitness level respond differently to the intervention program.

In order to study the current state of physical fitness among Ecuadorian adolescents, a cross sectional study in an urban (Cuenca city) and a rural (Nabón canton) area was conducted (**Chapter 2.1**). In total of 648 adolescents (52.3% boys), attending 8th, 9th and 10th grade of the secondary schools participated in this study. We found that the majority of adolescents (59%) had poor physical fitness according to the FITNESSGRAM standards. Urban participants showed better scores in the majority of EUROFIT tests compared to their rural peers. The physical fitness of the whole population was worse compared to that of adolescents from some other countries e.g. Spain, Belgium, Turkey, Poland and Mexico. These findings indicate the need for specific health promotion programs aiming to improve physical fitness among Ecuadorian adolescents. In this study we also found a weak association between physical fitness and blood lipid profile, even after adjustment for energy intake (**Chapter 3**).

A school-based health promotion program entitled “ACTIVITAL” was designed using the Intervention Mapping protocol and Comprehensive Participatory Planning and Evaluation approach. The program involved an individual and environmental component tailored to the local context and resources. The individual component included the delivery of an educational package organized at classroom level. The environmental component included (i) workshops with parents and staff in school canteens; (ii) social events at school such as an interactive session with famous young athletes and the preparation of a healthy breakfast and (iii) a walking trail that was drawn on the school playground (**Chapter 2.2**). A total of 1440 from 8th and 9th grade adolescents (intervention: n=700, 48.6%) from 20 schools (intervention: n=10, 50%) participated in the cluster-randomized pair-matched trial that lasted 28 months. Primary outcomes were dietary intake (24 recall questionnaire), physical fitness (EUROFIT battery), physical activity (accelerometers) and sedentary behaviors (screen-time self-reported questionnaire); the BMI, blood pressure, waist circumference were secondary outcomes. Results related to dietary intake, blood pressure and waist circumference were presented in a previous doctoral dissertation.

We found that the school-based health promotion program can improve physical fitness, minimize the decline in physical activity levels (**Chapter 4**) and mitigate the increase in screen-time among Ecuadorian adolescents (**Chapter 5**). Specifically, the intervention program increased the vertical jump (mean intervention effect=2.5cm; 95%CI 0.8-4.2; P=0.01). Although marginally insignificant, adolescents from the intervention group increased less time for speed shuttle run (mean intervention effect=-0.8s, 95%CI -1.58-0.07; P=0.05). The proportion of students achieving over 60 minutes of moderate-to-vigorous physical activity / day decreased over time with the change in proportion significantly less in the intervention schools (6 vs. 18 percentage points, P<0.01). Adolescents on the intervention group reported watching less television (intervention effect

=-14.8 min, 95%CI -27.4 -2.5; P=0.02) and they also showed decreased total screen-time (intervention effect =-25 min, 95%CI -47.9 -2.8; P=0.03) on a weekend day.

Our results also suggest that the school-based health promotion program might improve the speed and muscular strength fitness components among low-fit and overweight/obese adolescents (**Chapter 6**). Specifically, the intervention effect on speed shuttle run was higher in overweight (intervention effect=-1.9 s, 95%CI -3.62 -0.08; P=0.04) adolescents compared to underweight (intervention effect =-1.7 s, 95%CI -6.31 to 2.97; P=0.5) or normal weight (intervention effect =-0.4s, 95%CI -1.63 to 0.93; P=0.6) peers. The intervention effect on vertical jump was higher in adolescents with poor physical fitness (intervention effect =3.7 cm, 95%CI 1.15; 6.28; P=0.005) compared to their fit (intervention effect =1.3 cm, 95%CI -1.77 to 4.32; P=0.4) peers.

We conclude that a school-based health promotion program with relatively few intervention objectives, strategies and activities, but refined with stakeholder participation could have an effect on physical fitness, physical activity and screen-time behaviors of Ecuadorian adolescents. Future interventions should try to include the health education program as a part of the official school curriculum as well as try to identify the barriers to parents' participation in order to improve the effectiveness of the program (**Chapter 7**).

Samenvatting

In lage- en middeninkomens landen (LMIL) zijn levensstijl gerelateerde niet-overdraagbare ziekten (NOZ) de belangrijkste doodsoorzaak. Deze ziekten kunnen echter voorkomen worden door het aanpakken van de risicofactoren zoals ongezonde voeding, een gebrek aan fysieke activiteit, teveel sedentair gedrag (nl. schermtijd) en een slechte lichaamsconditie. Toch hebben slechts enkele LMIL strategieën ontwikkeld ter promotie van een gezonde levensstijl. De adolescentie is een belangrijke periode voor de preventie van NOZ. Ongezonder voedingsgedrag, fysieke inactiviteit en een slechte lichaamsconditie tijdens de vroege adolescentie zijn immers geassocieerd met de ontwikkeling van NOZ op volwassen leeftijd. Bovendien ziet men dat een ongezonde levensstijl en patronen van fysieke inactiviteit zich versterken tijdens de adolescentie en vaak aanhouden op volwassen leeftijd.

In Ecuador is de belangrijkste doodsoorzaak NOZ, maar jammer genoeg zijn de acties om een stijging van de risicofactoren van NOZ te voorkomen schaars. Voor zover wij weten, zijn er geen studies in Ecuador die focussen op het verbeteren van het voedingsgedrag, fysieke activiteit, fysieke fitheid of sedentair gedrag bij adolescenten. Dit doctoraat heeft als doel om “evidence-based” strategieën te ontwikkelen om een gezonde levensstijl te promoten bij Ecuadoriaanse adolescenten. Om tot dit doel te komen, evalueerden we eerst de fysieke conditie van adolescenten en gingen we de associatie na tussen hun fysieke conditie en de meest voorkomende risicofactor gerelateerd aan NOZ, namelijk dyslipidemie. Vervolgens werd het effect nagegaan van een gezondheidsbevorderend programma op school, op fysieke fitheid, fysieke activiteit en sedentair gedrag bij adolescenten. Tot slot evalueerden we in welke mate adolescenten die reeds een verhoogd gezondheidsrisico hadden (overgewicht/obesitas en lage fysieke fitheid) anders reageerden op het interventie programma dan adolescenten zonder een verhoogd risico.

Om de huidige fitheid bij Ecuadoriaanse adolescenten na te gaan, werd een cross-sectionele studie uitgevoerd in een stedelijk (Cuenca) en een landelijk (Nabon) gebied (**Hoofdstuk 2.1**). In totaal namen 648 adolescenten (52.3% jongens, leeftijd 11-15 jaar) uit het secundair onderwijs deel aan de studie. Uit de resultaten bleek dat de meerderheid van de adolescenten (59%) volgens de FITNESSGRAM standaard een slechte fysieke fitheid had. Hoewel adolescenten afkomstig uit een stedelijk gebied betere scores vertoonden op de meeste EUROFIT testen, was de fysieke fitheid van de gehele steekproef lager in vergelijking met adolescenten uit andere landen. Uit deze bevindingen blijkt dat er nood is aan een specifiek gezondheidsbevorderend programma met als doel het verbeteren van de fysieke fitheid bij Ecuadoriaanse adolescenten. Verder vonden we een zwak verband tussen fysieke fitheid en de cholesterol waarden, zelfs na het in rekening brengen van energie-inname (**Hoofdstuk 3**).

Een gezondheidsbevorderend programma op school, genaamd 'ACTIVITAL' werd ontwikkeld volgens een systematisch proces, gebaseerd op theorie, lokale evidentie en een "participatory approach" (**Hoofdstuk 2.2**). Een totaal van 1440 adolescenten uit de 8ste en 9de graad (interventie: n=700, 48,6%) en 20 scholen (interventie: n=10, 50%) nam gedurende 28 maanden deel aan een "cluster-gerandomiseerd pair matched" onderzoek. Het programma bevatte een individuele component en een omgevingscomponent, die beiden afgestemd waren op de lokale context en middelen. Voor de individuele component werd een educatief pakket voorzien dat georganiseerd werd op klasniveau. De omgevingscomponent hield het volgende in (i) workshops met ouders en personeel van schoolkantines; (ii) sociale evenementen op school zoals interactieve sessies met jonge bekende atleten en het bereiden van een gezond ontbijt en (iii) markering van een wandelpad op de speelplaats van de school. De primaire onderzoeksuitkomsten waren voedselinname (24 recall vragenlijst), fysieke fitheid (EUROFIT- testbatterij), fysieke

activiteit (accelerometers) en sedentair gedrag (schermtijd zelf gerapporteerde vragenlijst); de verandering in BMI, bloeddruk en buikomtrek waren secundaire uitkomsten. Resultaten gerelateerd aan voedselinname, bloeddruk en buikomtrek werden voorgesteld in een vorig doctoraal proefschrift.

We vonden dat het gezondheidsprogramma ‘ACTIVITAL’ de fysieke fitheid kan verbeteren, de achteruitgang in fysieke activiteitlevels kan minimaliseren (**Hoofdstuk 4**) en de stijging in schermtijd bij Ecuadoriaanse adolescenten kan beperken (**Hoofdstuk 5**). Meer specifiek, als resultaat van het interventie programma was de score op de verticale sprong verhoogd (gemiddeld interventie effect 2.5cm; 95%CI 0.8-4.2; p=0.01). Hoewel er slechts een trend tot significant effect was, kunnen we stellen dat adolescenten van de interventiegroep minder tijd nodig hadden voor de speed shuttle run (gemiddeld interventie effect= -0.8s, 95%CI -1.58-0.07, p=0.05). Het aantal studenten dat meer dan 60 minuten matige-tot-intense fysieke activiteit per dag bereikte daalde over de tijd significant minder in de interventie scholen dan in de controle scholen (6 vs. 18 procent, p<0.01). Adolescenten in de interventiegroep rapporteerden dat ze minder tv keken (interventie effect= -14.8min 95%CI -27.4 -2.5; p=0.02) en ze vertoonden ook een verlaging in totale schermtijd (interventie effect=-25min, 95%CI -47,9-2.8; p=0.03) op een weekend dag.

Onze resultaten suggereren ook dat ‘ACTIVITAL’ de fitheidscomponenten snelheid en spiersterkte bij adolescenten met een lage fitheid en met overgewicht/obesitas verbetert (**Hoofdstuk 6**). Meer specifiek, het interventie-effect van speed shuttle run was groter bij adolescenten met overgewicht (interventie effect= -1.9 s, 95% CI – 3.62 -0.08; p=0.04) in vergelijking met adolescenten met ondergewicht (interventie effect=-1.7s, 95%CI -6.31 - 2.97; p=0.5) of adolescenten met een normaal gewicht (interventie effect =-0.4s, 95%CI - 1.63 - 0.93; p=0.6). Het interventie-effect van de verticale sprong was groter bij adolescenten met een zwakke fysieke fitheid (interventie effect =3.7 cm, 95%CI 1.15; 6.28;

P=0.005) in vergelijking met hun fitte leeftijdsgenoten (interventie effect =1.3 cm, 95%CI -1.77 to 4.32; P=0.4).

We kunnen concluderen dat het gezondheidsbevorderend schoolprogramma 'ACTIVITAL' met relatief weinig interventie doelstellingen, strategieën en activiteiten, maar met deelname van stakeholders, een effect kan hebben op de fysieke fitheid, fysieke activiteit en schermtijd bij Ecuadoriaanse adolescenten. Het lijkt dan ook aangewezen om het programma te integreren als een deel van het officiële schoolcurriculum. Verder onderzoek kan de barrières en facilitatoren voor deelname van ouders in kaart te brengen om zo de effectiviteit van het programma nog te verbeteren (**Hoofdstuk 7**).

Resumen

Las enfermedades no transmisibles (ENT), relacionadas con el estilo de vida, son la principal causa de muerte en los países de ingreso económico medio y bajo (PIBM). Esto es lamentable, ya que estas enfermedades podrían prevenirse atacando sus factores de riesgo tales como la dieta poco saludable, la inactividad física, el sedentarismo (por ejemplo: alto tiempo dedicado a TV, computadora o video juegos) y la mala condición física. Se ha documentado que sólo unos pocos PIBM han desarrollado estrategias para promover la actividad física. La adolescencia es un período importante para la prevención de las enfermedades no transmisibles, debido a que los factores de riesgo de ENT como la dieta poco saludable, la inactividad física y la mala condición física en la adolescencia temprana están asociadas con el desarrollo de las ENT en la edad adulta. Por otra parte, los estilos de vida poco saludables y los patrones de actividad física se consolidan durante la adolescencia y persisten en la edad adulta.

En Ecuador la causa de muerte más importante son las ENT, por desgracia, son escasas las acciones para prevenir la aparición de los factores de riesgo de las ENT durante la adolescencia. Hasta donde sabemos, no existen estudios científicos en Ecuador enfocados en mejorar la ingesta alimentaria, la actividad física, la condición física o los patrones sedentarios entre los adolescentes. El presente trabajo doctoral tiene como objetivo proporcionar evidencia científica sobre estrategias para promover un estilo de vida saludable en adolescentes Ecuatorianos. Con este propósito, en primer lugar, esta tesis doctoral evalúa la condición física de los adolescentes y estudia la asociación que existe entre la condición física y la dislipidemia. Se seleccionó la dislipidemia debido a que este fue identificado como el factor de riesgo de ENT más prevalente en los adolescentes. En segundo lugar esta tesis analiza el efecto de un programa de promoción de la salud, diseñado para colegios, sobre la aptitud física, la actividad física y los hábitos sedentarios

entre los adolescentes. Por último esta tesis evalúa si los adolescentes que ya están en riesgo de salud (con sobrepeso / obesidad y con baja condición física) responden de manera diferente al del programa de intervención.

La condición física de los adolescentes Ecuatorianos fue evaluada mediante un estudio transversal llevado a cabo en una zona urbana (ciudad de Cuenca) y una zona rural (cantón Nabón) de la provincia del Azuay (**Capítulo 2.1**). En este estudio participaron un total de 648 adolescentes (52,3% varones) 8^{vo}, 9^{no} y 10^{mo} que estudiaban en colegios de Cuenca y Nabón. Los resultados mostraron que la mayoría de los adolescentes (59%) tienen una mala condición física de acuerdo a las normas FITNESSGRAM. También se encontró que, aunque los participantes urbanos mostraron mejores puntuaciones en la mayoría de las pruebas de EUROFIT, las puntuaciones de la población total estudiada fueron menores a las puntuaciones de los adolescentes de otros países. Estos resultados indicaron la necesidad de programas de promoción de salud encaminados a mejorar la condición física de los adolescentes ecuatorianos. Finalmente, se encontró una débil asociación entre la condición física y el perfil lipídico sanguíneos, incluso después de ajustar por la ingesta de calórica (**Capítulo 3**).

Basado en los resultados anteriores y siguiendo un proceso sistemático que incluyó el uso de teoría, evidencia local y un enfoque participativo se diseñó un programa de promoción de la salud para colegios titulado "ACTIVITAL" (**Capítulo 2.2**). Un total de 1.440 adolescentes de 8^{vo} y 9^{no} de Educación básica (intervención: n = 700, 48,6%) de 20 colegios (intervención: n = 10, 50%) participaron en un ensayo aleatorio controlado por clúster pareados el cual duró 28 meses. El programa de promoción de la salud incluyó un componente individual y ambiental los cuales fueron adaptados a los recursos y el contexto local. El componente individual incluyó la aplicación de un paquete educativo diseñado para ser desarrollado en las aulas de clase. El componente ambiental incluyó: (i) talleres

con los padres de familia y el personal de los bares escolares; (ii) eventos sociales en la escuela como una sesión interactiva con los jóvenes deportistas famosos y un concurso de preparación de desayunos saludables (iii) el trazado de una ruta de senderismo la cual fue dibujada en el patio de los colegios. Los resultados primarios fueron la ingesta alimenticia (recordatorio de 24 horas), condición física (batería EUROFIT), actividad física (acelerómetros) y los comportamientos sedentarios (auto-reporte del tiempo dedicado a TV, computadora y videojuegos); el índice de masa corporal, la presión arterial y la circunferencia de la cintura fueron resultados secundarios. Los resultados relacionados con la ingesta alimentaria, la presión arterial y la circunferencia de la cintura fueron presentados en una tesis doctoral anterior.

Los resultados del ensayo controlado mostraron que el programa de promoción de la salud fue capaz de mejorar la condición física, minimizar la caída de los niveles de actividad física (**Capítulo 4**) y mitigar el aumento del tiempo frente a la pantalla entre los adolescentes Ecuatorianos (**Capítulo 5**). Específicamente respecto a la condición física, el programa de intervención mejoró el salto vertical (media del efecto de la intervención=2.5cm; 95%CI 0,8 - 4,2; P = 0,01) en los adolescentes del grupo de intervención. Así también, aunque marginalmente insignificante, los adolescentes del grupo de intervención necesitaron menos tiempo para la carrera de velocidad (media del efecto de la intervención=-0.8s; 95%CI -1,58 a 0,07; P = 0,05). Respecto a la actividad física, en general la proporción de alumnos que cumplen con la recomendación de más de 60 minutos de actividad física moderada a vigorosa / día disminuyó con el tiempo. Sin embargo, este cambio fue significativamente menor en los colegios de intervención (6 vs 18 puntos porcentuales, P <0,01). Respecto a los comportamientos sedentarios, los adolescentes del grupo de intervención disminuyeron el tiempo dedicado a ver televisión (efecto de la intervención = -14,8 min; 95%IC -27,4 -2,5; P = 0,02) y también disminuyeron

el tiempo total de pantalla (efecto de la intervención = -25 min; 95%CI - 47,9 -2,8; P = 0,03) en un día de fin de semana.

Nuestros resultados también sugieren que el programa de promoción de la salud podría mejorar la velocidad y la fuerza muscular de los adolescentes que tienen baja condición física o sobrepeso / obesidad (**Capítulo 6**). En concreto, el efecto de la intervención sobre la carrera de velocidad fue mayor en los adolescentes con sobrepeso (efecto de la intervención = -1,9 s; 95%CI: -3,62 -0,08; P = 0,04) en comparación con los adolescentes con bajo peso (efecto de la intervención = -1,7 s; 95%CI: -6,31 a 2,97; P = 0,5) o con peso saludable (efecto de la intervención = -0,4s; 95%CI: -1,63 a 0,93; P = 0,6). El efecto de la intervención en el salto vertical fue mayor en adolescentes con baja condición física (efecto de la intervención = 3,7 cm; 95%CI: 1,15; 6,28; P = 0,005) en comparación con los adolescentes con buena condición física (efecto de la intervención = 1,3 cm; IC del 95%: - 1,77 a 4,32; P = 0,4).

En conclusión, un programa de promoción de la salud con relativamente pocos objetivos, estrategias y actividades; y diseñado tomando en consideración las opiniones de los interesados (adolescentes, padres de familia, profesores) podría tener un efecto sobre la condición física, la actividad física y el tiempo dedicado a TV, computadora y video juegos de los adolescentes Ecuatorianos. Intervenciones futuras deberían tratar de incluir el programa de promoción de la salud en el currículo escolar oficial, así también se deberían identificar las barreras y facilitadores para la participación de los padres en las actividades del programa de promoción con el fin de mejorar la eficacia del programa (**Capítulo 7**).

1 General introduction and aims of the research

1.1 Non-communicable diseases

Non-communicable diseases (NCDs) are chronic diseases that are not passed from person to person and are usually of long duration and slow progression (1). The five main types of NCDs are cardiovascular diseases (i.e. heart attacks and strokes), cancer, chronic respiratory diseases (chronic obstructive pulmonary disease and asthma), diabetes and neurological diseases (1, 2). Although, the origin of NCDs is complex, their main determinants can be classified into modifiable, non-modifiable and physiological risk factors (3). The modifiable risk factors are usually split into two groups: i) environmental risks factors such as urbanization, technology, migration, social/economic/political conditions, living/working conditions, physical infrastructure, education, and access to health services/essential medicines and ii) behavioral risk factors such as unhealthy diet, physical inactivity, tobacco and alcohol use. The non-modifiable risk factors include person's age, gender, ethnicity and genetic profile. The physiological risk factors consist of overweight/obesity, high total cholesterol, high fasting plasma glucose, high blood pressure (3, 4). Risk factors such as unhealthy diet and physical inactivity are linked with physiological risk factors such as high blood pressure, overweight/obesity, high blood glucose levels and high levels of blood triglycerides (4, 5). Furthermore, unhealthy diet and physical inactivity are important risk factors in and of themselves for cardiovascular diseases and cancers (3). In addition, low physical fitness has emerged as a health condition that is independently related to cardiovascular diseases, diabetes and physiological risk factors (6-8). Similarly, there is evidence suggesting that sedentary behavior (TV viewing, screen-time, sitting time and objectively measured sedentary time) is associated with all-cause mortality, fatal and non-fatal cardiovascular disease, diabetes and physiological risk factors (9).

In 2010, 34.5 million (65%) deaths were attributed to NCDs globally (10). Worldwide, the leading risk factors were high blood pressure, high body mass index, high fasting plasma glucose and high total cholesterol (11). About 80% of the global deaths secondary to NCDs occurred in low- and middle-income countries (LMICs) (12). In 2002, 80% of cardiovascular and diabetes deaths, and 66% of all cancer deaths occurred in LMICs (13). Moreover, 29% of NCDs-related deaths occurred among people under 60 years old (13). In the Latin American LMICs, 70% of total deaths in adults are attributable to NCDs (14); cardiovascular diseases, cancer, chronic respiratory diseases and diabetes were among the leading causes of death (15). In addition, the leading risks factors in Latin American LMICs are high body mass index and high blood pressure (11).

The cost related to NCDs (treatment and losses) will double from 2010 to 2030 worldwide. High income countries (HICs) carried the biggest cost related to NCDs on 2010 (15 US\$ trillion) compared to LMICs, in which the cost related to NCDs were around 8 US\$ trillions, this figure is eight times the gross domestic product/year of all low-income countries in the world. But LMICs, specifically upper-middle-income countries, will carry a much bigger cost related to NCDs compared to HICs (24 vs. 20 US\$ trillion) in 2030 (16). Therefore, an earlier investment in prevention initiatives is needed.

1.2 NCDs and adolescence

Role of adolescence on prevention of NCDs

The word “adolescence” (derived from the Latin word ‘*adolescere*’ meaning “to grow up”) was first inserted in scientific literature in 1904, by the physiologist F Stanley Hall, to refer to a period of life between childhood and adulthood. Later, around 1950, WHO defined adolescence as the period in human growth from ages 10 to 19. This period is characterized

by the presence of several biological processes that drive aspects of growth and development (puberty). In this period, there are social-role transitions: first sex, marriage, parenthood, education, employment. Particularly in this stage the process of maturation of specific brain areas (prefrontal cortex and the limbic system) has an effect on decision making, emotional wellbeing and behaviors (17) and therefore lifestyle patterns are consolidated during adolescence.

The importance of adolescence on the prevention of adult NCDs lies in the fact that during adolescence physical and psychological changes contribute to the establishment of behaviors such as dietary, physical activity and sedentary behaviors, which linger into the adulthood (18-20). Therefore, behavioral risk factors such as unhealthy diet and physical inactivity during adolescence could play a critical role on the apparition of physiological risk factors such as high blood pressure, overweight/obesity, high blood glucose levels and high fat blood levels at adulthood (21), i.e. adolescence may be a critical period for later health and disease.

In addition, the first signs of some NCDs appear during adolescence, for instance the fatty streak, the origin of atherosclerosis, has been found on the coronary arteries of adolescent corpses (22) and those signs are related with overweight, unhealthy diet and physical inactivity (23, 24).

NCDs risk factors on adolescents

In the recent decades, numerous transversal and longitudinal studies aiming at adolescent's health have been performed mainly in developed countries. Those studies have reported several detrimental health conditions during adolescence. Prevalence of overweight/obesity has increased from 16.6% in 1980 to 22.9% in 2013 among children and adolescents from HICs, and from 8.2% to 13.1% in LMICs in the same period (25). Worldwide, four out of

every five adolescents do not meet the public health physical activity recommendations per day, (26) and the prevalence of spending more than 2hours/day on screen-time behaviors among adolescents exceeds 30% in most of the countries around the world (27, 28). Available data from developed countries show that aerobic fitness has declined in magnitude by 5% per year and the anaerobic fitness (muscular strength and speed fitness) has remained relatively stable between 1980 – 2002, in adolescents (29). There is limited evidence regarding physical fitness trends in youth from LMICs. A recent systematic review reported poor physical fitness among African adolescents compared to European adolescents, but most of the studies (10 out of 13) included were carried out in the Republic of South Africa (30). A systematic review from Asia also reported temporal changes of aerobic fitness between 1964-2009, but its results were based on five studies and four of them were performed on Asian HICs (31).

The effects of adolescents' diet, physical activity, physical fitness and sedentary pursuits on adolescents' and adults' health.

Research in adolescents has shown that a healthy diet, healthy levels of physical fitness, relative higher levels of physical activity and less sedentary behavior (screen-time) have benefits on adolescent health, such as: healthier blood lipid profile (triglycerides, LDL, HDL) (32-34), lower blood pressure (33, 34), healthy body weight (measured as BMI, percent body fat or sum of skin fold or waist circumference) (32-35), improvement of a fasting insulin (32-34), healthy bone mineralization (32), higher cognitive development measure as academic scores (32, 34), high self-esteem on girls and lower risk of behavioral problems in boys (34).

In addition, longitudinal studies have reported the effects of adolescents' lifestyle on adults' health. For instance, elevated cardiorespiratory fitness during adolescence is related to

lower body fat in adulthood, muscular fitness in adolescence is related to adult bone health (32), while maintaining high activity levels from adolescence to adulthood is related to weight maintenance (preserving lean mass and reducing fat mass) (35) and the decline of screen time from adolescence to adulthood is associated with a reduced incidence of adult obesity (36).

1.3 Prevention of NCDs risk factors on schools

The World Health Organization (WHO) identified schools as target settings for the promotion of physical activity/healthy diet among children and adolescents (37). Schools are empowered to influence a large number of subjects (as the role of schools generally is to concentrate the adolescent population) and could provide continuous guidance at a relatively low cost (37). In general, primary prevention of unhealthy dietary behavior lies in the promotion of fruit, vegetables, and whole grain consumption, and the discouragement of intake of energy dense foods. Meanwhile, physical inactivity is addressed by promoting physical activity and/or physical fitness, and/or discouraging time spent in sedentary activities like watching TV or playing video games (38). Current evidence indicates that school-based interventions involving both the individual and environmental components are more effective in promoting healthy diet, physical activity and physical fitness, and discouragement of sedentary lifestyles (39-42). However, most of those programs have been performed in HICs (38-43). The school-based interventions designed for HICs are difficult to extrapolate to LMICs because their particular socio-, economic-, cultural-, technological- and environmental-conditions are different from current and past (when non-communicable diseases started to rise) conditions in HICs (44). Examples of these differences are the accelerated progress of rural out-migration associated with urbanization and high levels of urban poverty in developing countries. Furthermore, in contrast to HICs,

LMICs are facing the double burden of disease of under- and over-nutrition which drain the already limited health resources (13).

1.4 Prevention of NCDs in Latin American adolescents

In Latin America evidence on school-based interventions to promote a healthy diet and physical activity is limited to studies from Brazil, Chile, Mexico and Colombia (45-48). Most of these interventions studies (n=30) have been analyzed by systematic reviews, which report on strategies used to promote healthy diet/physical activity (45, 49, 50), and provided some key elements for researches towards health practice and policies (46-48). However, a deeper analysis of the systematic reviews showed that their findings were mainly based on studies with serious methodological limitations common for LMICs, such as small sample size (n<300), non-randomized control trial, absence of a theoretical framework to guide the interventions, and lack of objectively measured outcomes (physical activity levels and physical fitness) (51). Although all these studies focused on diet and/or physical activity only few (n=7) evaluated the change on diet or physical activity, instead those studies reported anthropometric measures, fat distribution indices and blood lipids. The majority of the studies (n=22) focused on children under 12 years and only 2 targeted a population between 12-15 years old (45-48). Furthermore, to our knowledge only a limited number of intervention studies focused on improving sedentary behaviors like screen-time (51, 52) or evaluated physical fitness with comprehensive tools among Latin American adolescents.

1.5 Context of the research

1.5.1 Justification

As is the case in the majority developing regions, NCDs in the Republic of Ecuador are the main causes of death, particularly, NCDs such as diabetes, cardiovascular disease, chronic respiratory diseases and neurological diseases (i.e. dementia, Alzheimer) (53, 54). Additionally, the leading risk factors for Ecuadorian adult morbidity are high blood pressure, high body mass index and high blood glucose (54).

Unfortunately in Ecuador actions to prevent the rise of NCDs at adolescence are scarce. For instance, at the time this study started, only one study reported on the prevalence of NCDs risk factors in adolescents, which was limited to prevalence of overweight (13.7%) and obesity (7.5%) (55). To our knowledge, there are no studies in Ecuador reporting physical fitness patterns of adolescents. Similarly, in Ecuador there are no studies reporting the effect of lifestyle intervention on dietary intake, physical activity, physical fitness or sedentary patterns in adolescents. Therefore, the present doctoral work aims to fill the knowledge gap about adolescents' health in Ecuador specifically. Specifically, this doctoral dissertation is focused on the study of physical activity, physical fitness and sedentary behaviors among Ecuadorian adolescents. The data presented here are part of a project called "Food, Nutrition and Health" (56).

1.5.2 Presentation of "Food, Nutrition and Health" Project

In 2007 the Cuenca University started the "Improvement of the Quality of Life in the Ecuadorian Austro" research program inside the framework of the Program of Institutional University Cooperation (IUC) of the Council of Flemish Universities (VLIR). The research project "Food, Nutrition and Health" was conceived as one of the seven projects in the framework of this program developed in collaboration with the Universities of Ghent and

Leuven (Belgium). The main goal of the “Food, Nutrition and Health” project was to evaluate and improve lifestyle among children and adolescents in the Southern Ecuadorian region (56).

1.5.3 Area of the study “Food, Nutrition and Health” Project

The Republic of Ecuador, with its capital Quito, is located in South America. It borders Colombia to the North, Peru to the south and east, and Pacific Ocean to the west. Due to the geographical location, there is little variation in daylight hours during the year. The country has a population of approximately 14,483,499 people (57) and an area of 283,561 km². The official language is Spanish, although the Kichwa and Shuar are the most spoken languages among indigenous populations (57).

According to The World Bank, Ecuador was classified a low income country until 2009. Thereafter, Ecuador has been classified as an upper middle income country. In 2010, the 4.6% of the population lived below the poverty line decreasing to 4.0 percent points in 2012 (58). The Human Development Index (HDI) is a summary measured for assessing long-term progress in three basic dimensions of human development: a long and healthy life, access to knowledge and a decent standard of living. In Ecuador, although the HDI slightly increased from 0.701 to 0.708 from 2010 to 2012, the index remained below to the HDI average of countries in the high human development group (0.758) and in Latin America and the Caribbean group (0.741) (58). Ecuador spent 1.3% and 3.0% of gross domestic product on health expenditures during 2000 and 2010 respectively (59), although this percentage increased, it is still under the average percentage of the Latin America and the Caribbean group which were 3.2% and 3.8% during 2000 and 2010 respectively.

Ecuador has four geographical regions: the Coast, the Highlands, the Amazon and the Insular region, including Galapagos Islands. The territory is divided into provinces and then into cantons or cities. The study was conducted in Azuay province, which is located at the Southern Ecuadorian Highlands and more specifically in the capital of the province, Cuenca, and the canton Nabón (**Figure 1.1**).



Figure 1.1 Provinces and regions of Ecuador, and the research area

Cuenca city and Nabón canton are located at 2550 and 3300 meters above sea level, respectively. The average temperature in Cuenca is 18.6 °C and in Nabón is 14 °C, and these temperatures remain more or less stable during the year (60). Cuenca is considered an urban area, as 60% of the 505,000 habitants are city dwellers; while Nabón is a rural area with approximately 90% of 15,000 inhabitants living in the surrounding rural regions. Data from the National Institute of Statistics in Ecuador indicate that the estimated

prevalence of poverty is substantially higher in Nabón compared to Cuenca (93% vs. 2% respectively) (61) Because Cuenca was the least poor area and Nabón was the poorest area of Azuay, these areas were selected in order to contrast the results of the study.

1.6 Aims of the research

The “Food, Nutrition and Health” project was planned in two phases. First, considering that there was very limited information about the current dietary behavior, physical fitness and metabolic risk factors (dyslipidemia, high blood pressure, abdominal obesity, overweight and obesity) of Ecuadorian adolescents, the project aimed to collect this information in schools from Cuenca and Nabón. Secondly, based on the results of the first phase, an intervention program was planned to improve the dietary and physical activity behavior. The intervention involved three main steps i) the process of the developing of a comprehensive, culturally-appropriate intervention package tailored to improve dietary and physical activity habits in young adolescents, ii) the implementation of the program, and iii) the evaluation of process of implementation and the impact of the intervention. Unfortunately, the second phase (the intervention program) was not conducted in Nabón because some parents were no longer willing to continue participation in the study because they were suspicious about blood sampling.

Three PhD students tackled specific issues of the research of the “Food, Nutrition and Health” project. The design of the intervention was considered during the PhD student (Verstraeten Roosmarijn), who consequently reported the process of the development of the intervention aimed to improve the dietary and physical activity behaviors in adolescents (62). The dietary aspects of the implementation and evaluation was tackled by (Ochoa-Aviles Angelica). In her work, she reported i) the prevalence of metabolic risk factor and

patterns of dietary intake among urban and rural adolescents, ii) the intervention effect on dietary intake outcomes and iii) the evaluation of the implementation of the intervention (63).

In the present doctoral dissertation, physical fitness data and results of the intervention on physical activity, physical fitness and screen-time are presented.

The overall aim of this doctoral work is to evaluate physical fitness and the improvement of physical activity, fitness and screen time behaviors of Ecuadorian adolescents through a school-based intervention program, called “ACTIVITAL”. The following specific objectives were defined:

- To document for first time the level of physical fitness among urban and rural Ecuadorian adolescents
- To examine the association of physical fitness with CVD risk factor blood lipid profiles on Ecuadorian adolescents in order to provide up-to-date evidence regarding this association.
- To assess for first time the intervention effect of a school-based program on physical activity levels, physical fitness performance and screen-time behavior on Ecuadorian adolescents.
- To investigate the effect of a school-based intervention program among groups at health risk like overweight/obese and low-fit adolescents in regards to physical activity and physical fitness.

1.7 Outline of the doctoral dissertation

The present doctoral work is based on two studies, a cross-sectional study and a pair matched randomized control trial. The cross-sectional study aimed to assess the physical

fitness and its association with blood lipid profile among Ecuadorian adolescents. The pair matched randomized control trial was an intervention study aimed to improve the dietary and physical activity behaviors in adolescents between from 8th and 9th grades.

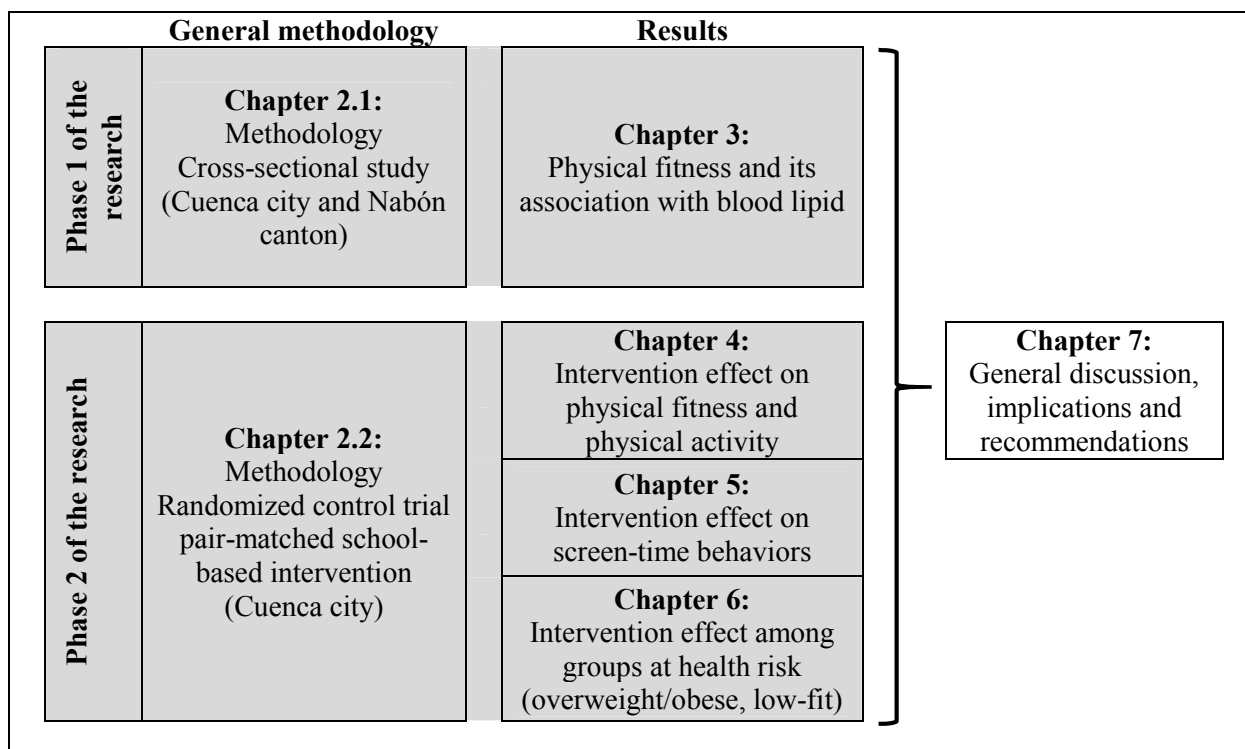


Figure 1.2 Outline of the PhD dissertation

The outline on the present doctoral dissertation is shown on **figure 1.2**. In summary, **Chapter 2** contains the methodological description (study design, the participant, ethical approvals and measurements) of both studies: the cross-sectional study and the pair matched randomized control trial.

Chapter 3 presents a description and comparison of the physical fitness and blood lipid profiles among urban and rural Ecuadorian adolescents.

Chapter 4 presents the effect of school-based intervention on physical fitness and physical activity by taking into account the measurements at baseline and after a period of 28 month is reported.

Chapter 5 contains the results of the intervention effect on screen-time behaviors by taking into account the measurement at baseline, at 18 and 28 months of follow-up.

Chapter 6 describes the different responses of adolescents who are already at health risk, i.e. adolescents who are overweight/obese or have low fitness levels, towards the school-based intervention.

Finally, **Chapter 7** presents the general discussion of the findings of this PhD work, as well as the implications and suggestions for future researches.

2 General methodology:

2.1 Cross-sectional study: Physical fitness and blood lipid profile among urban and rural Ecuadorian adolescents

2.2 Randomized control trial: Pair matched school-based intervention program among Ecuadorian adolescents

Redrafted from:

Andrade, S., Ochoa-Avilés, A., Lachat, C., Escobar, P., Verstraeten, R., Van Camp, J., Donoso, S., Rojas, R., Cardon, G., Kolsteren, P. (2014). Physical fitness among urban and rural Ecuadorian adolescents and its association with blood lipids: a cross sectional study. BMC pediatrics, 14(1), 106.

Andrade S, Lachat C, Ochoa-Aviles A, Verstraeten R, Huybregts L, Roberfroid D, Andrade D, Van Camp J, Rojas R, Donoso S, Cardon G, Kolsteren P. (2014) A school-based intervention improves physical fitness in Ecuadorian adolescents: a cluster-randomized controlled trial. International Journal Behavior Nutrition Physical Activity, 11:153.

The methodology of the both studies involve in this doctoral dissertation is described in the present chapter. The description is focused on aspects of physical activity, physical fitness and screen-time only, the dietary aspects were described in detail in another doctoral dissertation (63).

2.1 Methodology used on the cross-sectional study

2.1.1 Participants

The cross-sectional study involved 779 students from 8th, 9th and 10th grades of the secondary schools (**Figure 2.1**) from Cuenca city and Nabón canton. A two-stage cluster sampling of schools and classes was used to select adolescents in the urban area. Schools were grouped in six strata according to (i) their classification (public or private school) and (ii) school gender (male only, female only and co-ed schools). In the first stage of sampling, 30 schools were selected with a probability proportionate to student population. In the second stage, all students between 8th and 10th grade were listed, and out of this sample 20 adolescents were randomly selected within each school. In the rural area, all children from 8th, 9th and 10th grade attending all four schools of Nabón were invited to participate.

Adolescents (acceptance rate 85%) and their parents or guardians (participation rate 90%) provided written assent and consent respectively for the participation in the trial. Overall, adolescents were excluded from the study if they reported a concomitant chronic disease that interfered with their normal diet and physical activity, had physical disabilities or were pregnant. For the assessment of physical fitness, adolescents with chronic muscle pain or bone fractures were not able to perform any of the tests (**Figure 2.1**).

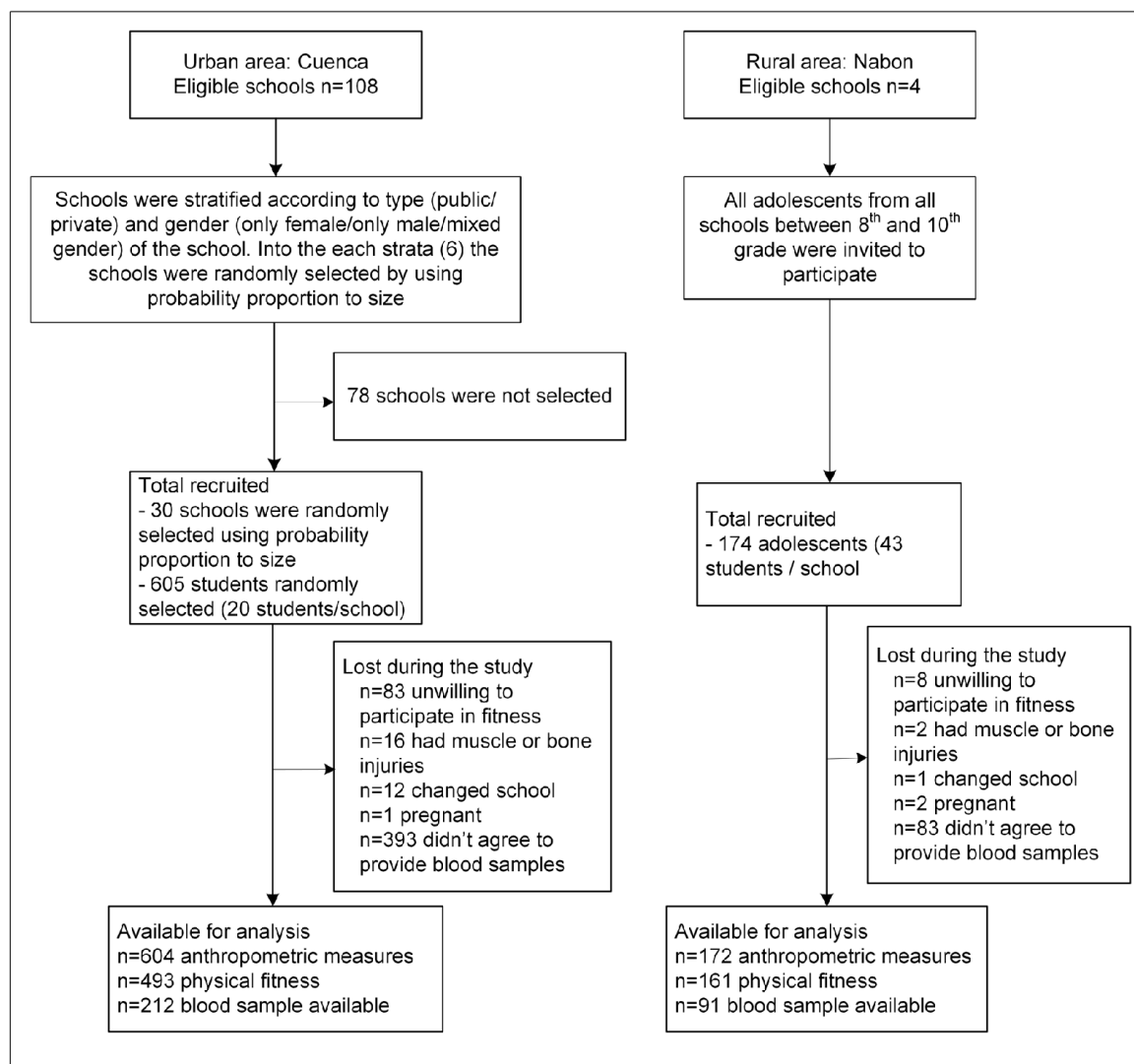


Figure 2.1 Flowchart for sample selection of study participants, Cuenca and Nabón, Ecuador 2009.

Data on physical fitness were obtained from a total of 161 rural and 493 urban adolescents, respectively. The lower participation in the fitness tests was the consequence of adolescents declining to participate in these specific tests ($n=91$), or had experiencing a bone /muscle injury ($n=18$) or leaving the schools ($n=13$) (**Figure 2.1**). There were no differences in mean age ($P=0.62$) or BMI ($P=0.36$) between adolescents with and without fitness test measurements. Post-hoc power analysis showed that the sample size ($n=654$) was sufficient to estimate the physical fitness with a precision of 11.4% and a power of 80%. A

volunteering sub-sample of 303 adolescents from both the rural (n=91) and the urban (n=212) area provided blood samples to determine biochemical parameters.

2.1.2 Ethical approval

Ethical committees from Universidad Central in Quito-Ecuador and the Ghent University Hospital Belgium approved the protocols for anthropometry, physical fitness and biochemical determinations (Nr 125 2008/462 and 2008100-97 respectively).

2.1.3 Measurements

Prior to data collection, medical doctors, nutritionists and health professionals were trained for three full days to assess outcomes: anthropometrics, physical fitness, unsatisfied basic needs and 24 hour recall questionnaires. A manual with standardized procedures was developed for the purpose of the study and used during the training. Two biochemists were in charge of collecting and analyzing blood samples.

Anthropometrics




Anthropometric variables were measured in duplicate by two independently trained staff following standardized procedures (64). The children wore light clothes, no shoes and field workers made efforts to optimize the privacy of the participants. Height was measured using a mechanical stadiometer model SECA 216 and recorded to the nearest mm. Weight was measured using a digital balance model SECA 803 and recorded to the nearest 100g. The BMI (calculated as weight / height²) was used to adjust the association between blood lipid and physical fitness parameters.

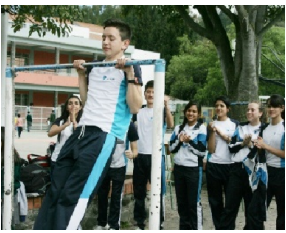





Physical fitness

Physical fitness is the capacity to perform physical activity and refers to a full range of physiological qualities i.e. it is a set of physical attributes that people can have or achieve. Normally, physical fitness is assessed by measuring each of its components, namely cardio-respiratory, speed, agility, muscular endurance, strength, flexibility and balance (65). A number of tests grouped as batteries, such as EUROFIT, AAPHERD, CAHPER and Canada Fitness Survey are used to assess the components of physical fitness (66, 67). In the present dissertation, the EUROFIT battery (68) was selected because its reliability and validity have been tested on adolescents (69-73) and in contrast to other objective methods of measurement it assesses health-related fitness (66, 67). In addition, EUROFIT tests battery has been applied in some studies on adolescents from some Latin America countries (72, 74-76), which enables some comparisons. The EUROFIT test battery is easy to apply and can be performed in large groups, and requires few materials. A potential disadvantage of EUROFIT could be that the score attained might be subjected to learning effect or changes in motivation of adolescents to perform each test.

The physical fitness dimensions assessed and the tests used in the present doctoral dissertation are described in **Table 2.1**.

Table 2.1 EUROFIT test used to measure physical fitness

Physical fitness dimension	Test	Description
Cardio-respiratory endurance	<p>20m shuttle run</p> 	<p>Two parallel lines are drawn on a flat floor, these lines are separated each other in 20m. At the sound of the beep from a recording the subjects run a distance forward where the end point is marked by a line drawn on pavement Once they reach the line (considered a complete lap), they wait until next beep sounds and run back to the initial position. The subjects continue running between the two lines as long as they can, starting each lap with the beeps of the recording. The recording contains a series of beeps which in the first minute sound each 8.47 seconds which means that adolescents have to run at least a velocity of 8.5 km/h in the first minute in order to reach the line in front before to the next beep sound. Every minute the beeps sound in a shorter time with the purpose of increase the velocity of running by 0.5 km/h every minute. The score on this test is the number of laps that the adolescent completes before He /She is not able to reach the line in front before the next beep sound. Only one attempt is allowed for this test.</p>
Strength	<p>Hand grip</p>  <p>Vertical jump</p> 	<p>Adolescent holds a dynamometer in the preferred hand and squeezes it with maximum effort during 5 seconds. The dynamometer will read the result of this test in kilogram-force. Two attempts are allowed for this test.</p> <p>First, the adolescent marks his/her standing reach on a flat wall (illustrated), afterwards standing slightly away from the wall the subject jumps up as high as possible and marks the highest point of the jump (illustrated). The result (measured in centimeter) is the distance difference between the highest point of the jump minus the standing reach. Only one attempt is allowed for this test.</p>

Muscular endurance	Bent arm hang 	The adolescent grasps a bar using an overhand grip (palms are facing away from body), with the hands shoulder width apart. The result of this test is the time (measured in seconds) that the subject keeps this position (illustrated) with the chin over the bar until the chin falls below the level of the bar. Only one attempt is allowed for this test.
	Sit-ups 	The tested result is the number of sit-ups that an adolescent can do in a 30 seconds. During the test the knees have to bent at a right angle, the hands have to be interlocked behind the head, the feet have to be flat on the floor and after each sit-up the back must return to touch the floor. Only one attempt is allowed for this test.
Speed - agility	Speed shuttle run (10x5meters) 	The adolescent is asked to run a distance of 5 m for 10 times without stopping as fast as possible. The time needed to complete the 10 runs is the results of the test measured in seconds. Only one attempt is allowed for this test.
	Plate and tapping 	The adolescent places his/her non-preferred hand on the middle of the table (rectangle). Then the subject moves the preferred hand back and forth between the discs over the hand in the middle as quickly as possible. This action is repeated for 25 full cycles (50 taps) and the time (measured in seconds) needed to do this is the result of this test. Two attempts are allowed for this test.
Flexibility	Sit and reach 	As is illustrated in the picture, the adolescent places both hands on the box and keeps the legs stretched. The subject leans forward as much as possible in order to touch as far along measuring line as possible. The tested result will be the distance (measured in centimeter) reached by the hand. Two attempts are allowed for this test.
Flamingo Balance	Flamingo Balance 	The adolescent tries to maintain balance on a beam. The result of this test is the number of falls in 60 seconds of balancing.

In the nine tests described above, high scores indicate higher levels of physical fitness, apart from the speed shuttle run 10x5 m, the plate tapping and flamingo balance, for which lower scores indicate a higher level of fitness. The vertical jump is a variation of the original item of EUROFIT (standing broad jump) and is valid for the assessment of muscular strength (77).

In each school, the physical fitness assessment lasted approximately two hours. At the end of each testing day, all forms used for data collection were taken up and revised by the supervisors. In case of missing registration forms, the researcher returned to the school to collect them.

The FITNESSGRAM standards (78) for age and gender were used to classify adolescents into those who had reached the Healthy Fitness Zone, defined as the minimum level of aerobic capacity (in ml/kg/min units of VO_{2peak}) that provides protection against health risks associated with inadequate fitness. Aerobic capacity was determined according to the results of the aerobic capacity test (20m shuttle run). For girls, standards values range from 40.2 ml/kg/min to 38.8 ml/kg/min across the developmental transition, 11 to 17 years old. For boys, values start around 40.2 ml/kg/min, rising to 44.2 ml/kg/min (78). To obtain the VO_{2peak} from the result of the 20m shuttle run, the following validated equation was used $VO_{2peak} = 41.77 + 0.49 (\text{laps}) - 0.0029 (\text{laps})^2 - 0.62 \text{ BMI} + 0.35 (\text{gender} * \text{age})$; where gender = 0 for girls, 1 for boys (79).

Unsatisfied Basic Needs (UBN)

The Integrated Social Indicator System for Ecuador was used to determine the socio-economic status per adolescent's household (80). We adopted this method to enhance comparability of our findings with national data. The method classifies a household as

“poor” when one or more deficiencies in access to education, health, nutrition, housing, urban services (electricity, potable water or waste recollection) and employment is reported. All households with no deficiencies, are classified as “better off”. A deprivation of housing facilities is defined when the roof or wall material is either cardboard, pieces of aluminum, bamboo, plastic, or any other residual material. A deprivation of urban services is considered if the household has precarious or no access to potable water or the house is not connected to a proper sewage system. There is a monetary deprivation if the ratio between household’ members with job over the total members living in the household is higher than 1:3 or when the head of the household (in the economy context) has maximum two years of primary education. There is a deprivation of education if one or more of the children at school age (between 6 to 12 year old) do not attend school. There is deprivation of physical space if the average of persons per bedroom available in the house is higher than 3 persons/room. The UBN data were provided by the parents or guardians of the adolescents. The unsatisfied basic needs data were used to adjust the analysis of associations between physical fitness and blood lipid parameters.

Energy intake

The food intake data (total energy intake in particular) were used primarily to adjust the associations of the physical fitness and blood lipid parameters. To estimate food intake two interview-administered 24h dietary recalls were taken, the first in a weekday and second on the weekend. The procedures used to assess the dietary intake were in line with the recommendations of current literature (81). Local utensils were selected in order to standardize food portion size. The Ecuadorian food composition database is considered outdated, and therefore was not used. Following food composition databases were used

instead: U.S (USDA, 2012), Mexican (INNSZ, 2012), Central America (INCAP/OPS, 2012) and Peruvian (CENAN/INS, 2008). The data were entered in Lucille, a food intake program developed by Ghent University (www.foodintake.ugent.be). The energy intake was analyzed using Stata version 11.0 (Stata Corporation, Texas, USA). The detailed description of the dietary intake (methods and results) was described in a separate doctoral dissertation (63) and article (82).

Blood lipid profile

After an overnight fast of minimum 8 hours, a blood sample of 10 ml was collected by venipuncture at the antecubital vein. The blood samples were kept on ice without anticoagulant. Subsequently, serum was separated by two centrifugations at 4000 rpm for 5 min. Serum total cholesterol (TC; CHOD-PAP kit, Human, Wiesbaden-Germany) and triglycerides (TG; GPO-PAP kit, Human, Wiesbaden-Germany) were analyzed by a calorimetric enzymatic method (83) on a Genesys 10 Thermo Scientific spectrophotometer (Madison, Wisconsin-USA). High-density lipoprotein cholesterol (HDL) was separated after sodium phosphotungstate-magnesium chloride precipitation (84). The Friedewald formula was used to calculate low-density lipoprotein cholesterol (LDL)(85).

The intra-assay and inter-assay coefficients of variation for serum total cholesterol were 3.3% and 5.3% and for triglycerides, 5.7% and 0.9% respectively. The acceptable level was for TC<170 mg/dl, TG<150 mg/dl, HDL>35 mg/dl and LDL<110 mg/dl. The acceptable levels for TC, HDL and LDL were in accordance with guidelines of the National Cholesterol Education Program(86) for children and adolescents, while the acceptable level of TG complies with the consensus definition of metabolic syndrome in children and

adolescents(87). Adolescents were classified as having dyslipidemia when at least one of the lipid profile parameters reached risk level(88).

2.1.4 Data quality

Data were entered in duplicate into EpiData (EpiData Association, Odense, Denmark) by two independent researchers and cross-checked for errors. Any discrepancy was corrected using the original forms. Data were analyzed using Stata version 11.0 (Stata Corporation, Texas, USA).

2.2 Methodology used on pair matched cluster randomized trial

ACTIVITAL was a pair-matched cluster randomized controlled trial conducted from 2009 to 2012 in Cuenca city. Cluster (school) randomization was chosen as the trial used a school-based approach. We report our findings according to the CONSORT guidelines (89).

2.2.1 Participants, sampling, allocation and blinding

Schools were eligible if they: (i) had >90 students in 8th and 9th grade, and (ii) were located in the urban area of Cuenca, Ecuador. The eligible schools were paired according to four criteria: (i) total number of students of the school, (ii) monthly school fee (as proxy for the socio-economic status of the school), (iii) gender (male/female only or mixed gender) and (iv) time schedule of classes (morning: 7:00 to 13:00 or afternoon: 12:00 to 18:00). In Ecuador, large schools might divide the students in two groups because of logistic constraints. In this case the youngest students attend classes in the afternoon and the oldest students in the morning. Schools with no matching pair were excluded. Sample size was calculated on a nutritional outcome. Ten pairs and a sample size of 65 children per school

was required to detect a reduction of 40% to 30% energy from fat using a two side significance level $\alpha=0.05$, variation in clusters means $K_m=0.15$ and a power of 80% (90). We assessed if the trial was sufficiently powered for each of the outcomes analyzed in the present dissertation i.e. fitness, screen-time and physical activity level. All outcomes had a power $>80\%$ except for bent arm hang and 20m shuttle run (65% and 64% respectively). The post-hoc power calculations were obtained using the formula for sample size calculations of pair matched trials (90) and set to detect an effect size equal to the intervention effect obtained after the intervention.

A total of 28 out of 108 schools were paired (**Figure 2.2**). We randomly selected 10 pairs in Stata (version 12.0, Stata Corporation, Texas, USA) using a random number generation with random allocation of the intervention within each pair. In each school, two 8th grades and two 9th grades were randomly selected and all students in those grades were invited to participate in the study. Pregnant adolescents and those with muscle or bone injuries or a concomitant disease were excluded at any time during the trial. In total we enrolled 1430 adolescents, including 10% of possible dropouts. After the pairs were selected and the school principal accepted to participate in the study (participation rate 100%) we obtained informed assent from adolescents (acceptance rate 85%) and written consent from caretakers (participation rate 90%). Adolescents were not informed about the existence of a counterfactual school.

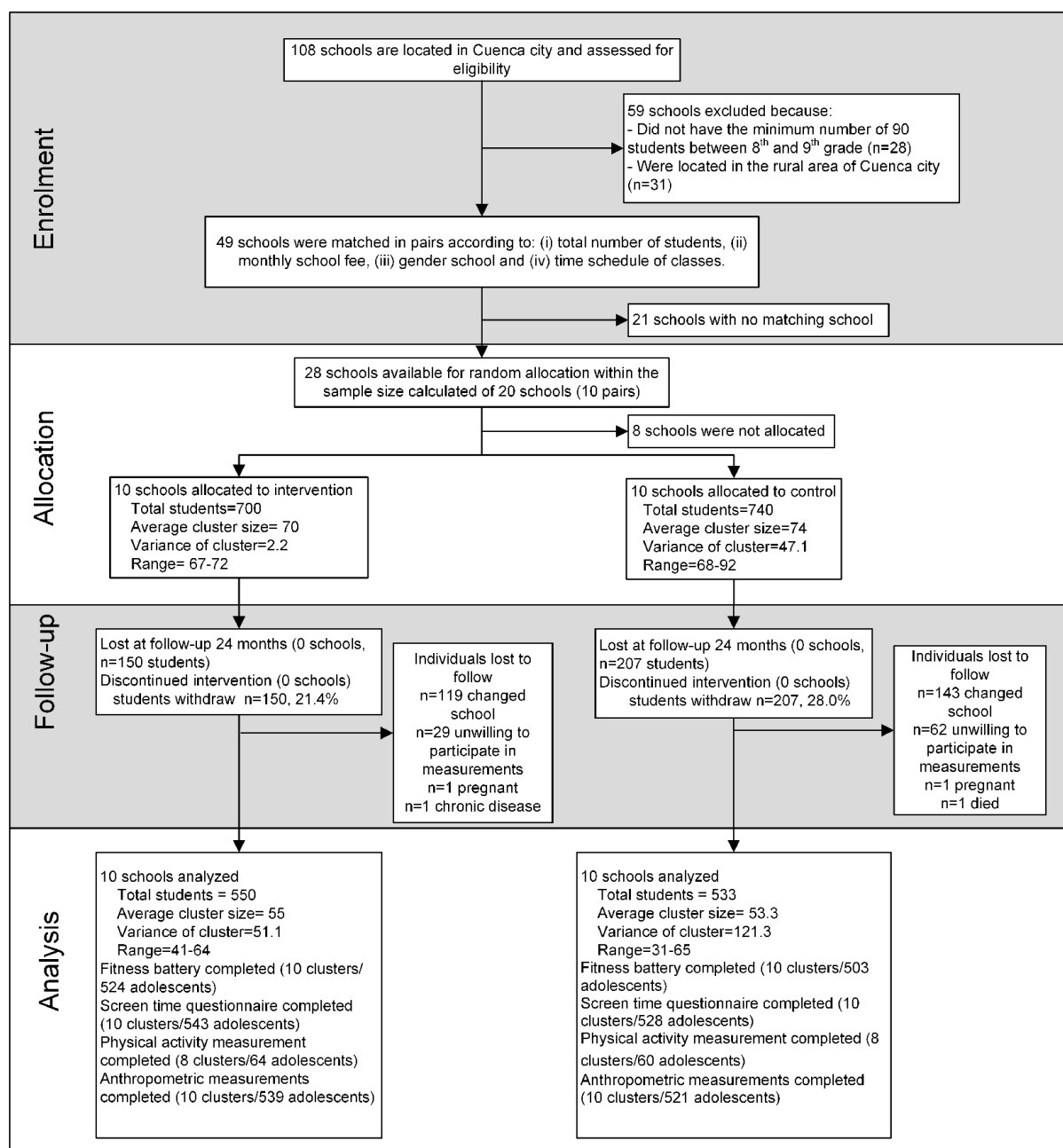


Figure 2.2 Enrolment, allocation, follow-up and analysis of Ecuadorian adolescents in a school-based health promotion intervention

2.2.2 Ethical approval

The randomized control trial was approved by two ethics committees, the “Comité de Bio-medicina de la Universidad Central” in Quito - Ecuador (CBM/cobi-001 - 2008/462) and the Ghent University Hospital - Belgium (FWA00002482). This study was registered on Clinicaltrials.gov identifier NCT01004367.

2.2.3 Intervention

The intervention program was developed using Intervention Mapping (IM) protocol (91) and the Comprehensive Participatory Planning and Evaluation (92) approach. The IM provided a framework for effective decision making in the development, implementation and evaluation of interventions considering the ways to guide the behavior change associated with the health problem (here unhealthy diet, low physical activity and sedentary behaviors). Using CPPE, workshops were performed to develop a causal model of the health problem and to identify possible intervention strategies according with the perceptions of key stakeholders (school staff and adolescents). The idea behind using these two techniques was to adapt the intervention objectives and strategies in order increase acceptability and appropriateness in the target groups. **Figure 2.3** shows the process used to design the intervention by combining both approaches.

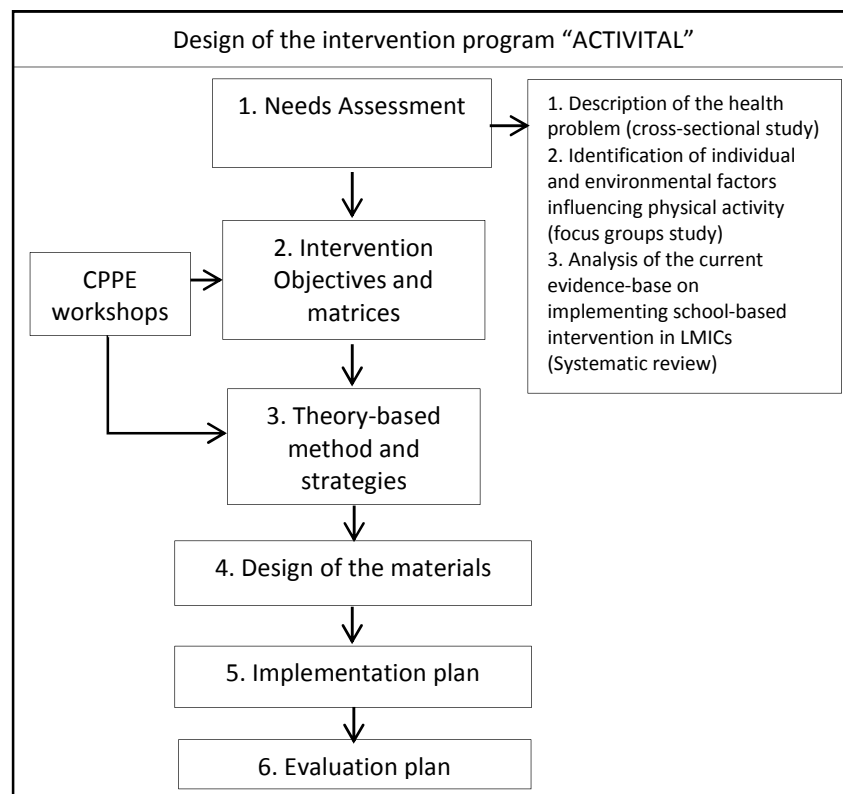


Figure 2.3 Design of the pair-matched cluster randomized controlled trial ACTIVITAL by integrating the CPPE and the IM (figure adapted from Ochoa-Aviles et.al.(63))

2.2.3.1. The needs assessment: The needs assessment involved: i) a cross-sectional data collection, ii) focus groups discussions with adolescents, parents, and school staff from Cuenca and Nabón, and iii) a systematic review of the school-based health promotion interventions implemented in LMICs.

- i) In the cross-sectional study, adolescents from grades 8th, 9th and 10th of schools located in Cuenca (urban area) and Nabón (a rural area) – Ecuador participated. Data collection included anthropometry (height, weight and waist circumference), blood pressure, dietary intake by means of two 24 hour recalls (93), physical fitness by using the full EUROFIT battery, socio-economic status and blood lipid determinations in the subsample (total cholesterol, LDL cholesterol, HDL cholesterol and triglycerides). The methodology of this study was described on the **Chapter 2.1** of the present dissertation and Ochoa-Aviles *et.al* (63, 82, 93). The cross-sectional data showed that overweight/obesity (20.1%), abdominal obesity (19.7%), high blood pressure (6.2%) and dyslipidemia (34%) were prevalent in the population (93). Adolescents consumed insufficient fiber, fruit and vegetables, and an excess of added sugar, refined cereals and processed foods during snacks (82). Moreover, an important share of the participants reported not to consume breakfast (18%)(82) and exhibited low levels of aerobic capacity (59%) (94).
- ii) The focus group discussions were performed in a convenience sample of three schools in Cuenca and two in Nabón (April - September 2008). In total twenty focus groups (N=144 participants) were conducted: 12 with adolescents from grades 8th, 9th and 10th, four with parents and four with school staff. The study aimed to develop a conceptual framework of relevant influential factors for dietary intake and physical activity among Ecuadorian adolescents (95). To structure the factors of adolescent's eating and physical activity behaviors, 'Attitude, Social influences and Self-efficacy' ASE-model

(96) and the socio-ecological model (97), covering both individual and environmental factors, were used as a theoretical framework. The ASE-model explains that the intention to engage in a certain behavior is determined by attitudes, social influences (including subjective norms, modeling and support) and self-efficacy (96). Some barriers and lack of skills however, can limit the behavior change. The socio-ecological model highlights the complex interplay between individual, relationship, community, and societal factors which affect individual health behaviors (97). To ensure the cultural appropriateness of this framework, the socio-cognitive variables from the ASE-model were nestled within the socio-cultural and physical context of adolescents' environment as elaborated by the socio-ecological model (95).

The conceptual framework (**Appendix 1**) identified the following individual and environmental factors influencing physical activity behavior in the studied population: preference for sedentary pursuits, poor knowledge regarding physical activity and its importance, time constraints and laziness were the most relevant individual factors (95). Environmental factors included lack of opportunities to be active at home and school, unsupportive parents and lack of role models. Few differences in physical activity influential factors were found by place of residence. In the urban area crime and traffic concerns were reported to be important barriers for physical activity, while in the rural area were low self-efficacy, financial constraints and that female adolescents were not allowed to perform leisure activity (95). The conceptual framework for dietary behaviors was reported in a previous PhD dissertation (62).

- iii) A systematic review was performed to address a gap of knowledge regarding the effectiveness of school-based interventions targeting the prevention of obesity through changes in dietary behavior, physical activity behavior, or both in children and adolescents 6–18 year from in LMICs (51). Additionally, the review aimed at

identifying effective pathways that alter behavior and/or BMI in school children in LMICs as well as the weak points of the already implemented strategies. The review conclude that multicomponent interventions addressing dietary and physical activity behaviors, in particular those including parents or families, attached to the school curriculum and supporting changes in the school environment were more effective. Nevertheless, high quality theory-based interventions and process evaluation are often lacking in LMICs.

Summary of the results of the needs assessment*		
<p>CROSS-SECTIONAL DATA</p> <p>Metabolic Risk Factors</p> <ol style="list-style-type: none"> 1. Overweight (18%) 2. Obesity (2%) 3. Abdominal obesity (20%) 4. Dyslipidemia (34%) 5. High blood pressure (6%) <p>Physical fitness</p> <ol style="list-style-type: none"> 1. Low levels of aerobic capacity (59%) 	<p>FOCUS GROUP / Individual and environmental factors influencing physical activity</p> <p>1 Individual factors:</p> <ul style="list-style-type: none"> - Awareness: poor knowledge - Attitudes: positive - Self-efficacy: low - Habit strength: preference of sedentary pursuits - Subjective norm: leisure physical activity inappropriate for rural girls - Perceived barriers: lack of skills/time <p>2 Environmental factors</p> <ul style="list-style-type: none"> - Family: media use, rules, lack of opportunities and role modeling - School: lack of rules, financial constrains - Socio-cultural environment: media, transport - Built environment; traffic, crime concerns 	<p>SYSTEMATIC REVIEW</p> <p>1. Effective pathways</p> <ul style="list-style-type: none"> - Target both diet and physical activity - Involve multiple stakeholders - Integrate educational activities into the school curriculum. <p>2. Weak points</p> <ul style="list-style-type: none"> - Poor design - Short follow-up - Lack of documentation of the implementation process

Figure 2.4 Summary of the result of the needs assessment for physical activity (Figure adapted from Ochoa-Aviles et.al.(63))*

2.2.3.2. Intervention objectives and strategies: In general, the output of the CPPE approach was integrated in the IM steps (2nd and 3rd) to tailor and fine-tune the objectives of the intervention, map theory-based methods to these objectives, and translate these methods into intervention strategies (62).

The CPPE was developed by means of workshops with adolescents and school staff (principals, managers of the tuck shop, PA instructors, teachers of life sciences, nutritionists and/or medical staff) in each intervention schools (62). Each group consisted of a convenience sampling of 6 to 10 participants. The workshops comprised two sections. First,

a causal model was constructed. The latter is a participatory analysis leading to a visual representation of problem at hand, broken down step by step into its perceived root causes. The second section included the evaluation of possible interventions strategies for the identified causes (92). In the first part of the causal model with the adolescent groups, a simple model that included food intake and physical activity as the causal factors for unhealthy body weigh emerged. Following this, the adolescent and school staff group built a series of sub-models to elaborate on each of the different influencing factors for food intake and physical activity in adolescents (62). The following section summarized the results of CPPE for physical activity. The CPPE outputs for dietary were reported in a previous PhD dissertations (62):

- i) All groups identified the following influencing factors for physical activity: the peer and social influence, skills, injury, and time at an individual level, and availability and accessibility at environmental level. School staff groups also added traffic and crime concerns, and opportunities available at school as important factors to the model.
- ii) The evaluation of possible interventions for influencing factors of physical activity include to increase the physical activity opportunities.

Using inputs from the needs assessment and CPPE, three intervention objectives related to physical activity and screen-time were identified:

1. Adolescents decrease daily screen time (maximum 1-2 hours/day)
2. Adolescents increase daily PA levels to reach 60 min/day (minimum)
3. The school offers more opportunities for being active

The most important and modifiable factors to reach each intervention objective were selected from the local evidence collected during the needs assessment, input received from the CPPE and existing literature. Afterwards, by crossing the expected behavior and modifiable factors, specified change objectives were developed to guide what adolescent

or environmental agents (family, school, societal and the built-environment) needed to do to reach the intervention objectives. Next, theoretical methods that have been reported as effective (91, 98) were identified and mapped against each factors. Finally, the selected theoretical methods were used together with input from CPPE to create strategies at individual and environmental level. Appendix 2 contains the matrices of the theoretical methods and the related intervention strategies used to tackle each influential factor. A detailed description of the intervention process was described on a separate PhD dissertation (62).

The intervention strategies targeting both individual and environmental level (physical and social environment at school and at home) were then integrated into two intervention components: i) the individual-based component that included the delivery of educational package organized at classroom level and ii) the environment-based component that includes a parenting and a school program. The latter comprised healthy eating and physical activity educational workshops with parents and healthy eating workshops with food-tuck shop staff, the implementation of a walking trail and social events such as the preparation of a healthy breakfast at school and an interactive session with famous young athletes. Details of the intervention program covering physical activity and screen-time are provided in **Table 2.2**, whilst for healthy dietary intake were reported in a separate PhD dissertation (63).

The persons in charge of delivering the educational package were the school teachers. These teachers received an introduction to the intervention objectives and a basic workshop on healthy eating and physical activity. If school teachers declined to participate on the program, they were replaced by the external teachers hired by the ACTIVITAL program. There was no minimum dose for the activities for each of the intervention strategies.

Table 2.2 Description of strategies related to physical activity intervention component* of the ACTIVITAL program

What	Who/where	Why	When	How
1. Individual-based strategies				
Book 1 (Curriculum) One out of five chapters addressed the physical activity and screen-time behavior. This chapter was developed to be delivered in 90 minutes (1 st year).	School teachers and trained staff/ classroom	- To create awareness regarding the importance of an adequate physical activity throughout adolescence (Book 1 and 2) - To increase knowledge and enhance decision-making skills (Book 1 and 2) - To encourage adolescents to be physically active for at least 60 min per day (Book 1 and 2)	September 2010 - February 2011 Each chapter was performed every two weeks.	Thought textbooks and pedagogic materials for teachers and students. The material contained educational objectives, clear instructions for implementation the physical and educational activities during the classes without additional training.
Book 2 (Curriculum) The book contained 8 chapters in total and one corresponded to the physical activity. Chapter 7: Physical Activity (how to remove barriers in order to be more physically active). This chapter was planned to be delivered in 90 minutes (2 nd year).	School teachers and trained staff/ classroom	- To encourage adolescents to spend maximum 2 hours per day on screen-time activities (Book 1) - To provide advice on how to be active during the day and how to deal with barriers to being physically active (Book 2).	September 2011- January 2012. Each chapter was performed every two weeks.	A second set of textbooks and pedagogic materials were developed for teachers and students. The material contained educational objectives and clear instructions for implementing the physical and educational activities.
2. Environmental-based strategies				
Parental workshops Six workshops were performed in total. Informative leaflets supporting the content of the workshop were distributed to each participant during the workshop. Two workshops focused on decreasing sedentary time and increasing physical activity (1 st year), and dealing with barriers for physical activity (2 nd year).	ACTIVITAL staff/ school meeting room	- To support healthy behavior of adolescents at home - To increase the awareness of parents regarding the importance of regular physical activity for adolescents - To provide advice how to be active during the day and how to deal with barriers to be physically active.	1 workshop from October 2010 till February 2011 1 workshop from October 2011 till January 2012	Workshops of 1 hour were delivered by the ACTIVITAL staff. Parents attendance was mandatory through a letter signed by each school principal Each leaflet included theoretical information, advises and benefits on the particular topic of the workshops
Social event -Pep talks by successful and well-known young male (n=3) and female (n=2) athletes, who were international young champions in BMX, swimming, racquetball and weightlifting (1 st year)	Young athletes/ auditorium	To encourage physical activity through the positive influence of social models	Once during the intervention	A 1-hour interactive session with young athletes was given. Athletes shared their personal sport experiences and gave advice on active lifestyles and physical activity.
Walking trail and posters - 3 posters suspended on the school walls, adjacent to the trail, with phrases like: "Do you like to talk? Walk and Talk" (1 st year). - Using line markings, a walking trail was drawn on the school's playground. The length of the trail was the perimeter of playground (2 nd year).	Physical education teachers / classroom	- To increase availability and accessibility to physical activity opportunities inside the schools - To motivate the students to walk more during the recess time	September 2011 – January 2012	The physical education teacher explained the importance of being physically active to the students about and how they could use the walking trail to be more active during recess.
Posters for classroom and food tuck shop Fiver different posters with key messages on physical activity and pictures of the young athletes (1 st year).	ACTIVITAL staff/ classroom and food tuck shop	- To encourage students to be active and eat healthy	Monthly from October 2010 to February 2011	Posters with key messages on being active were suspended on the classroom walls and in front of the food tuck shops.

* This table summarizes the physical activity component of the trial, which focus on improving both physical activity and screen-time behaviors.

2.2.3.3. Implementation and evaluation of the intervention: ACTIVITAL started in October 2009 and finished in June 2012 i.e. through the academic years 2009-2012, 2010-2011 and 2011-2012 with a total duration of 28 months. Once started it was only interrupted by the annual break (July and August). In the first academic year we started with the baseline measurements (October 2009 - February 2010) and the application of the IM protocol and CPPE (March-June 2010). In the second year we implemented a first part of the intervention (September 2010 - February 2011) and performed an intermediate follow-up (March-June 2011) in which physical fitness and physical activity was not measured. In the third year, the second part of the intervention was implemented (September 2011- January 2012) and final measurements were performed (from February 2012 - June 2012).

To assess progress, monitor potential adverse effects and coordinate the intervention activities, research staff met with schoolteachers and school managements every two to three weeks. One person in each school (mostly the medical doctor or the school supervisor) was assigned as contact point between research staff and the schools.

The control schools received the standard curriculum as determined by the Ecuadorian government. The latter is geared at increasing sports skills and schedules a mandatory 80 min of physical education per week.

The evaluation of the intervention program comprised two parts:

- i) The evaluation of effect on the intervention on primary and secondary outcomes. Diet (63), physical fitness, physical activity and screen-time were defined as primary outcomes, while anthropometric measurements (body mass indices, waist circumference (63)) and blood pressure (63) were secondary ones.
- ii) The evaluation of the implementation of the intervention. This part included monitoring dose delivery, reach, fidelity and dose receive of the intervention, and the evaluation of

the program by key stakeholders. This was done through observations, focus groups, face-to-face interactions, and questionnaires for all participant groups. This information will serve to identify facilitating factors and barriers for intervention effectiveness, and for further dissemination (62, 63). In the present dissertation we included partial information on the dose delivery and the evaluation of the stakeholders regarding to the intervention program focuses on physical activity and screen-time. A full process evaluation is reported elsewhere (63).

2.2.4 Measurements

The measurements were performed when students entered the 8th and 9th grade (12.3 and 13.3 years respectively) and after 18 and 28 months. In the intermediate follow-up, physical fitness and physical activity were not measured. Medical doctors, nutritionists and health professionals with field experience received a 40-hour training session to assess outcomes. The research team provided regular supervision.

Physical fitness

As in the cross-sectional study, the EUROFIT tests battery (68) was used to evaluate the physical fitness. Physical fitness data were used as continuous variables.

Screen time

Screen-time can be defined as the time spent on watching TV, playing video games or a using computer (99) which are the most common daily sitting activities during leisure time among adolescents (100). The self-reported questionnaires is usually used to measure the screen-time among adolescents, although, questionnaires' accuracy relies on the adolescents' recall ability and on the type of questionnaires, it is the cheapest method to

measure screen-time at a large scale. In this doctoral dissertation, a validated self-reported screen-time questionnaire was used (101-103). Adolescents reported the number of hours per typical week and weekend day that they spent watching television, playing videogames or using a computer on an eight point scale. Response categories were “zero”, “30 min”, “1 hour”, “2 hours”, “3 hours”, “4 hours”, “5 hours” and “> 6 hours”.

Physical activity and sedentary time

Physical activity is defined as any bodily movement produced by the contraction of skeletal muscles resulting in energy expenditure (65). Mainly, there are three methods to evaluate the physical activity: i) the double labelled water, which is the gold standard but unfortunately considerably more expensive than other methods for large-scale studies; ii) the use of movement sensors, like accelerometers, which is the most widely used method which can be applied at different ages; and iii) the self-reporting of activities. The latter is considered the cheapest and easiest method to assess physical activity; however its accuracy depends of the age group and the type of questionnaire (65, 104, 105). In the present doctoral dissertation accelerometers (type GT-256 and GT1M Actigraph, Florida USA) were used to assess physical activity and sedentary time since accelerometers have previously been validated in an adolescent population (26) and these provide an assessment of frequency, intensity, and duration of physical activity. The accelerometer has the inability to capture accurately the physical activity levels during the biking activities or when performing weight bearing activities.

Accelerometer is a small device (3.8 cm x 3.8 cm x 1.8 cm) that measures the change in velocity over a unit of time (acceleration) of the body. This device uses a system that converts an analog signal into a digital signal (*accelerometer activity count*) which is proportional to the muscular force producing motion. This system allows to record the

accelerometer activity count (min: 15 s, max: 60 s) and store these counts by a selected number of days. Based on the counts it is possible to calculate the subjects' time spent in each categories of physical activity (106). In the present dissertation, the MAH/UFFE Analyzer (version 1.9.0.3) and a syntax in Stata were used for data reduction and to compute registered time, the time spend on sedentary (≤ 100 counts/min), light (100-759 counts/min) and moderate to vigorous physical activity (≥ 760 counts/min) (107). The cut-point for MVPA were chosen in order to detect activities at moderate (non-ambulatory and ambulatory) and vigorous (ambulatory) intensity with high sensitivity and specificity (108-111). Accelerometers were worn for 5 weekdays. As recommended, the first and last day of measurement were excluded from the analyses as well as those registrations with less than 540 min of registered time per day (107). Non-wearing time was defined as 60 min of continuous zero values. Accelerometer data were adjusted for the total registered time (or wearing time). There was no minimum number of valid days that was needed per adolescent to be included in the analysis (mean valid days_{baseline} = 2.4; mean valid days_{28 months follow-up} = 2.2). The proportion of adolescents who met the recommended 60 min (33) of moderate to vigorous physical activity per day was calculated based on minutes of MVPA on an average day. Due to the high cost of the accelerometers, we assessed physical activity in a subsample (12 adolescents / school) of adolescents who were selected using a random number in Stata. Apart from sit-ups ($\beta=0.26$, $P=0.05$), there were no difference ($P_{\text{all comparisons}} > 0.05$) between adolescent who wore or not the accelerometer in terms of BMI, BMI z-score, gender, fitness and screen time.

BMI

Weight was measured using a digital calibrated balance (SECA 803, Hamburg, Germany) and recorded to the nearest 100g. Height was recorded to the nearest mm using a

mechanical stadiometer (PORTROD, Health o Meter, Illinois, USA). Students were measured with light clothing and without shoes in a separate room by a researcher of the same gender. All anthropometric measurements were done twice and average values were used. BMI indices were calculated using Anthro plus (version 3.2.2, WHO Geneva, Switzerland) and established cut-offs (112). BMI z-score was used as an outcome. Towards the end of the study, we also assessed the effect of the intervention on the proportion of adolescents with a BMI in a healthy range according to the International Obesity Task Force criteria (112). These criteria are established for age (each 0.5 years from 2 to 18 years old) and gender, and classifies adolescents as underweight, normal weigh, overweight or obese.

Adolescent's knowledge

A questionnaire was designed to assess adolescent's knowledge on recommendations and the health benefits of being physically active and/or to spend less than 2hours/day on watching TV. The questionnaire was filled by each adolescent at baseline, at 18 months follow-up and at 28 months follow-up.

Socio-economic status

As in the cross-sectional study, the socio-economic status of the adolescent's household was defined according to the Integrated Social Indicator System for Ecuador (80). The system classifies a household as "poor" when one or more deprivations related to housing facilities, basic urban services, money, education and physical space are reported otherwise the household is classified as "better-off".

School characteristics

The following school characteristics were measured prior to the intervention: (i) school size as binary variable (0=small schools; 1=large schools) with the median (n=695) of the school size as cut-off; (ii) type of school as a binary variable (0=public; 1=private); (iii) school schedule as a binary variable (0=half day; 1=full day schedule); (iv) school gender as a binary variable (0=both genders; 1=female only). The sample did not contain schools with only male students; and (v) physical activity space, expressed number of students/m² of space available for being physically active in each school. The median (4.07 students/m²) was used as a cut-off for this.

Monitoring of delivery and response of the intervention

Researchers recorded attendance and participation rates during classes, workshops, social events. After finishing classes, each workshop and social event, the participants scored the activities by means of a questionnaire with a scale from 0 to 10. Teachers in charge of a class filled out a questionnaire at the end of each class to assess their appreciation of the materials and the messages conveyed. We assessed if adolescents noticed, liked and used the walking trail using a questionnaire in a convenience sample of 2 schools. At the end of the workshop with parents, a questionnaire was administered to parents to measure satisfaction and to get general feedback of the workshops. In the **table 2.3**, we report the delivery and response of the intervention regarding the physical activity component which focused on improving both physical activity and screen-time behaviors. A full process evaluation is reported elsewhere (63).

Table 2.3 Delivery and response of the intervention*

Individual-based strategies	Environmental-based strategies			
Educational package organized at classroom	Workshops with Parent	Social event	The walking tails	The poster
<p>WD: 100% of the classes addressing physical activity component were delivered. Around 54% of the scheduled classes addressing physical activity component were delivered by the school teacher, the remaining classes (46%) were delivery by the hired teachers</p> <p>APR: The students had a 95% average attendance of classes on physical activity. Around 75% of adolescents showed an active participation in the classes.</p> <p>PS: Most (79%) of the adolescents reported this to be new knowledge. The larger majority (85%) of adolescents that attended the classes, scored the quality of classes with >8/10.</p>	<p>WD: Two workshops (100%) related to physical activity component were delivered as planned</p> <p>APR: Around 10% of the parents attended both workshops. Around 97% of the parents showed an interest in the contents of the workshops.</p> <p>PS: Around 90% scored the quality of the workshop high ($\geq 80\%$) and most (76%) considered this as new knowledge</p>	<p>WD: One pep talk was delivered in each school (100%)</p> <p>APR: Around 78% of adolescents showed an interest in the pep talks.</p>	<p>WD: The walking trail was implemented in the ten schools (100%)</p> <p>APR: Around 25% of the adolescents used the walking trail according to the results of the two schools where the walking trail was evaluated.</p> <p>PS: The majority of the adolescents had noticed the walking trail and liked it (91% and 60% respectively)</p>	<p>WD: The five posters (100%) were suspended in the classroom and food tuck shop</p>

WD: What amount of the program was delivered, APR: Attendance and participation rates, PS: Participant's score after finishing classes, each workshop and social event

*The "ACTIVITAL" trial aimed at improving diet and physical activity. This table summarizes the delivery and response of the physical activity component of the trial, which focus on promoting physical activity and decreasing screen-time behaviors

3 Physical fitness among urban and rural Ecuadorian adolescents and its association with blood lipids: a cross sectional study

Redrafted from: *Andrade, S., Ochoa-Avilés, A., Lachat, C., Escobar, P., Verstraeten, R., Van Camp, J., Donoso, S., Rojas, R., Cardon, G., Kolsteren, P. (2014). Physical fitness among urban and rural Ecuadorian adolescents and its association with blood lipids: a cross sectional study. BMC pediatrics, 14(1), 106.*

Abstract

Background: Physical fitness has been proposed as a marker for health during adolescence. Currently, little is known about physical fitness and its association with blood lipid profile in adolescents from low and middle-income countries. The aim of this chapter is therefore to assess physical fitness among urban and rural adolescents and its associations with blood lipid profile in a middle-income country.

Methods: A cross-sectional study was conducted between January 2008 and April 2009 in 648 Ecuadorian adolescents (52.3% boys), attending 8th and 9th grades of the secondary schools in Cuenca (urban n=490) and Nabón (rural n=158). Data collection included anthropometric measures, application of the EUROFIT battery, dietary intake (2-day 24h recall), socio-demographic characteristics, and blood samples from a subsample (n=301). The FITNESSGRAM standards were used to evaluate fitness. The associations of fitness and residential location with blood lipid profile were assessed by linear and logistic regression after adjusting for confounding factors.

Results: The majority (59%) of the adolescents exhibited low levels of aerobic capacity as defined by the FITNESSGRAM standards. Urban adolescents had significantly higher mean scores in five EUROFIT tests (20m shuttle, speed shuttle run, plate tapping, sit-up and vertical jump) and significantly most favorable plasma lipid profile (triglycerides and HDL) as compared to rural adolescents. There were few significant associations between blood lipid profile and physical fitness in both urban and rural adolescents, even after adjustment for confounding factors. Specifically, in the whole sample dyslipidemia was only associated with bent arm hang, and HDL / Triglyceride with plate tapping. Among urban adolescents, both cholesterol and LDL were associated with both bent arm hang and handgrip. Finally, among rural adolescents both cholesterol and LDL were associated with

the proportion of adolescents who are on the Healthy Fitness Zone defined by the FITNESSGRAM standards

Conclusions: Physical fitness, in our sample of Ecuadorian adolescents, was generally poor. Urban adolescents had better physical fitness and blood lipid profiles than rural adolescents. The differences in fitness was not associate with those in blood lipid profile between urban and rural adolescents.

3.1 Introduction

Physical fitness and physical activity are independently associated with the occurrence of both cardiovascular disease (113), and cardiovascular risk factors (114). However, in contrast to physical activity, physical fitness is stable over several months within an individual (114) and has therefore been proposed as a marker for cardiovascular risk in children and adolescents (32).

Recently, LMICs have experienced a rapid increase in the development of risk factors for non-communicable disease among young people. Ecuador is no exception. A study conducted in our sample of Ecuadorian adolescents reported that dyslipidemia, abdominal obesity and overweight were prevalent in 34.2%, 19.7% and 18.0% of the population respectively. Although dyslipidemia was the most prevalent risk factor in both urban and rural populations, it was higher in the rural group (52% vs. 27%; OR=3.3, $P<0.001$) (93). Unfavorable lipid profile has been reported associated mainly with genetic and behavioral risk factors like an inadequate diet (115), low physical activity levels, poor physical fitness (32, 113). However, a previous analysis in our sample of adolescents unexpectedly showed that dietary intake was weakly associated with plasma lipid (82). Therefore, it was hypothesized that an association of blood lipids with physical fitness is probable (32), and is a dimension of analysis that could further be explored.

There are few studies that have assessed physical fitness (72, 75, 116-118) and its association with cardiovascular risk factors in LMICs (119). In fact only a single study in adolescents has investigated a comprehensive assortment of physical fitness components such as: speed, muscular endurance/strength, cardiopulmonary and flexibility (72), and only one has assessed the association of cardiorespiratory fitness with dyslipidemia (119). To the author's knowledge no studies thus far have assessed associations of blood lipid

levels with a variety of fitness components (speed, muscular endurance and strength, cardio-respiratory endurance, flexibility and balance) according to residential location (rural vs. urban). This is surprising considering incidence of cardiovascular risk factors is known to vary along with environmental factors, such as location of residence (urban vs. rural areas)(120). Rural areas differ considerably from urban areas, i.e. in terms of available health services, medical specialists (120), sport facilities or recreational areas (121), transportation (traffic and means of transport), safety issues (122), food availability (115) and formal education, among others (120).

This chapter has three objectives: i) to assess the physical fitness in a group of Ecuadorian adolescents by residential location (urban and rural area), gender (boys and girls) and aerobic capacity (on and out of the Healthy Fitness Zone), ii) to analyze the association of physical fitness and body mass index, and iii) to analyze the associations of physical fitness and lipid profile in adolescents according to residential location.

3.2 Methods

The methodology details of this study were describe previously (**Chapter 2.1**). Briefly, this cross-sectional study involved adolescents of 8th, 9th and 10th grade of the schools from Cuenca city and Nabón canton (Azuay-Ecuador). Data on physical fitness were obtained from a total of 161 and 493 in rural and urban adolescents. And a volunteering sub-sample of 303 adolescents from both the rural (n=91) and the urban (n=212) area provided blood samples to determine biochemical parameters. In total 30 schools participated on this study.

Statistical analysis

The analysis was adjusted for the cluster sampling design by using the Stata svy command and the level of significance was set at $p < 0.05$. Normality of data was checked using the skewness and kurtosis test. When the assumption of the normality was not fulfilled, the dependent variables were log transformed before inclusion in the models. In this case, beta coefficients were back transformed and expressed as percentage differences (estimate-1*100). Prior to analysis, differences between the samples with and without blood parameters were evaluated using a t-test for numerical data and chi-square test for categorical data. The characteristics of sample and outcomes of the study are presented as mean (standard deviation) by gender and location of residence (rural/urban).

Linear regression models were used for continuous outcomes to test: (i) differences in physical fitness, blood lipid profile and anthropometric variables by gender and by residential location, all of which were adjusted by BMI or gender, when appropriate, (ii) physical fitness differences among adolescents who did, or did not, reach the Healthy Fitness Zone adjusted by BMI and gender, (iii) associations between physical fitness and BMI (model: $\text{Fitness} = \beta_0 + \beta_1 \text{residential location} + \beta_2 \text{gender} + \beta_3 \text{BMI} + \beta_4 \text{UBN} + \beta_5 \text{BMI} * \text{residence} + e$), and (iv) associations between blood lipid level with physical fitness (model: $\text{Lipids} = \beta_0 + \beta_1 \text{fitness} + \beta_2 \text{residential location} + \beta_3 \text{gender} + \beta_4 \text{BMI} + \beta_5 \text{UBN} + \beta_6 \text{energy intake per person} + \beta_7 \text{fitness} * \text{residence} + e$). Logistic regression was used to test the association of physical fitness with dyslipidemia. The associations of physical fitness with BMI and blood lipid were stratified for residential location when interaction terms were significant ($P_{\text{interaction}} < 0.1$). As this study was exploratory and not confirmatory, we did not adjust for multiple testing(123). Nevertheless, we also report our results on associations between blood lipid profiles and EUROFIT tests after applying a Bonferroni correction using an adjusted p-value of 0.005.

3.3 Results:

In this study data from 654 adolescents were analyzed. The average age was 13.6 ± 1.2 years and 52.0% of the population was male. In the rural area, more females (61.5%; $n=99$) participated ($p<0.001$) than in the urban area (43.6%; $n=215$). According to the result of the aerobic capacity test, 59% of the adolescents (55.0% urban and 73.5% rural) fell below the Healthy Fitness Zone. Physical fitness with respect to the other EUROFIT tests was lower among adolescents whose aerobic capacity was below the Healthy Fitness Zone, with significant differences in all tests ($p<0.05$) except for the plate tapping ($p=0.12$).

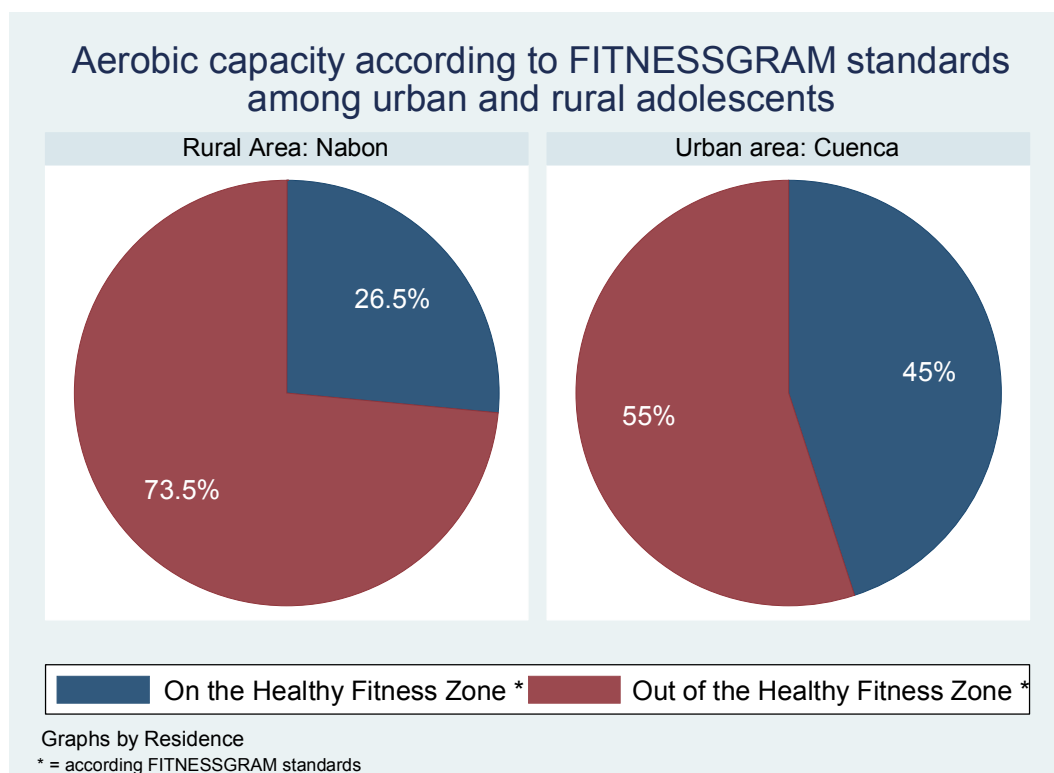


Figure 3.1 Aerobic capacity according to FITNESSGRAM standards among urban and rural adolescents

There was no significant difference in mean age ($p=0.54$), BMI ($p=0.35$), cardiopulmonary fitness ($p=0.99$), speed shuttle run ($p=0.44$), plate tapping ($p=0.71$), sit and reach test ($p=0.54$), sit-up ($p=0.30$), vertical jump ($p=0.89$), bent arm hang ($p=0.11$), handgrip ($p=0.55$) and flamingo ($p=0.09$) tests between adolescents with and without blood lipid determinations. Only the gender balance ($p=0.03$) was marginally different between

adolescent with and without blood lipid determinations (53.1% girls in the subsample versus 43.6% girls in rest of the sample).

Differences in physical fitness, anthropometric indexes and blood lipids by gender and by residence are shown in **Table 3.1**. After adjusting for BMI, boys showed higher levels of cardiorespiratory, speed, strength, endurance and balance in all EUROFIT tests compared with girls, except for the sit and reach test ($p < 0.01$). Blood lipid levels, however, showed no significant gender differences, with the exception of triglyceride levels ($p = 0.03$), which were higher in girls, after adjustment for BMI. With respect to residential location, after adjusting for gender proportion, urban adolescents had a higher mean score in the 20m shuttle test ($\beta = -0.6$ laps, 95% CI [-1.0; -0.1]), speed shuttle run ($\beta = 13.1$ s, 95% CI [6.8; 19.5]), plate tapping ($\beta = 13.3$ s, 95% CI [8.0; 18.6]), sit-up ($\beta = -2.4$, 95% CI [-3.8; -1.1]) and vertical jump ($\beta = -4.4$ cm, 95% CI [-6.3; -2.6]) (**Figure 3.2**). In terms of blood lipid profiles, mean triglycerides ($\beta = 17.2$, 95% CI [0.6; 33.9]) and HDL ($\beta = -5.0$ mg/dL, 95% CI [-7.6; -2.4]) revealed urban adolescents had a more favorable blood lipid profiles as compared to rural adolescents (**Figure 3.3**). Therefore, the proportion of the population with dyslipidemia was significantly lower in the urban area than in the rural area (28.9% vs. 46.7%, $P < 0.01$).

Table 3.1 Anthropometry, physical fitness and blood lipids of Ecuadorian adolescents stratified by gender and by residential location

	Boys		Girls		p ^b	Urban		Rural		p ^d
	n	Mean (SD)	n	Mean (SD)		n	Mean (SD)	n	Mean (SD)	
Age	334	13.6 (1.2)	306	13.6 (1.2)	0.36 ^c	487	13.7 (1.1)	153	13.5 (1.5)	0.48 ^c
Body mass index (kg/m ²)	334	19.9 (3.1)	306	20.5 (3.0)	0.02 ^c	482	20.3 (3.1)	158	20.0 (2.9)	0.39
Weight (kg)	336	45.9 (10.3)	307	45.3 (8.3)	0.76 ^c	485	46.7 (9.5)	158	42.3 (8.3)	<0.01
Height (cm)	336	151.6 (10.3)	307	149.1 (6.9)	<0.01 ^c	485	151.9 (8.7)	158	145.9 (7.9)	<0.01
Prevalence overweight (%)	329	19.8	303	20.1	0.91 ^c	479	21.3	153	15.7	0.02
Physical fitness										
<i>Cardiopulmonary fitness</i>										
20 m shuttle test (laps)	313	3.6 (1.4)	285	2.8 (0.9)	<0.01	442	3.4 (1.3)	156	2.7 (0.9)	0.01
20 m shuttle test (ml/kg/min)	303	43.0 (5.0)	279	35.4 (3.9)	<0.01	431	40.2 (6.0)	151	37.1 (5.0)	0.02
FITNESSGRAM (% who are on the Healthy Fitness Zone)	303	63.4 (48.3)	279	15.1 (35.8)	<0.01	431	45.0	151	26.5	0.19
<i>Speed-agility</i>										
Speed shuttle run (s)	338	23.3(2.0)	309	26.6 (2.7)	<0.01	489	24.4 (2.6)	158	26.3 (3.2)	<0.01
Plate tapping (s)	339	14.6 (2.1)	309	17.0 (2.5)	<0.01	490	15.3 (2.2)	158	17.2 (3.0)	<0.01
<i>Flexibility</i>										
Sit and reach (cm)	338	19.0 (6.6)	309	20.4 (7.0)	<0.01	489	19.4 (6.8)	158	20.5 (6.7)	0.52
<i>Muscle endurance and strength</i>										
Sit-up (number/30 s)	337	16.1 (3.7)	308	11.4 (3.9)	<0.01	488	14.7 (4.2)	157	11.4 (4.3)	<0.01
Vertical jump (cm)	337	29.1 (6.8)	308	23.6 (5.7)	<0.01	487	27.9 (6.5)	158	22.4 (6.2)	<0.01
Bent arm hang (s)	332	10.0 (9.1)	308	3.2 (3.0)	<0.01	483	7.3 (7.8)	157	7.1 (8.4)	0.21
Handgrip (kgf)	338	24.7 (8.0)	309	20.4 (4.8)	<0.01	489	23.2 (7.1)	158	21.2 (6.3)	0.35
<i>Balance</i>										
Flamingo (trying/1min)	322	13.8 (5.4)	285	15.4 (5.2)	0.02	464	14.5 (5.3)	143	14.7 (5.5)	0.99
Blood Lipid Profile										
Cholesterol (mg/dL)	142	144.8 (32.7)	159	147.8 (31.7)	0.65	211	144.5 (31.3)	90	159.7 (33.8)	0.53
HDL (mg/dL)	142	51.1 (12.8)	159	48.6 (11.5)	0.24	211	51.1 (11.9)	90	46.6 (12.4)	<0.01
LDL (mg/dL)	142	75.3 (30.9)	159	78.4 (26.8)	0.66	211	74.7 (28.1)	90	82.1 (30.0)	0.42
Triglyceride	142	91.9 (48.0)	159	104.2 (58.4)	0.04	211	93.6 (54.3)	90	109.5 (52.0)	0.02

^a Overweight and obese combined, ^b p-value adjusted for BMI and clustering, ^c p-value adjusted for clustering, ^d p-value adjusted for gender and clustering

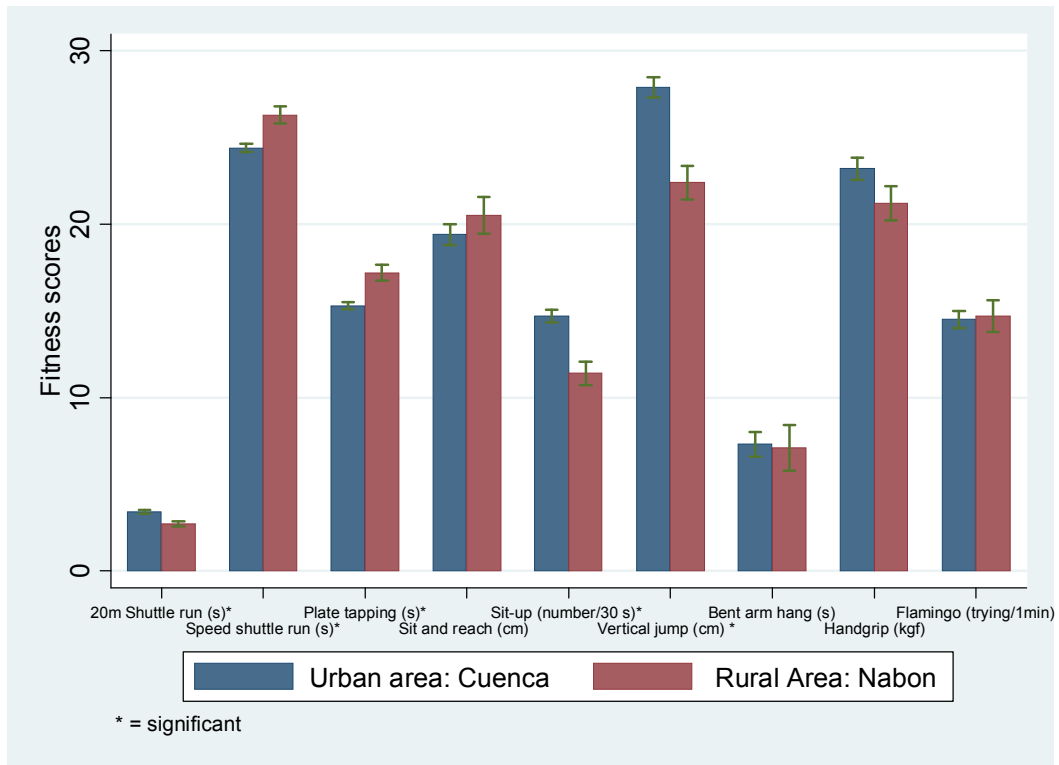


Figure 3.2 Fitness scores among urban and rural adolescents

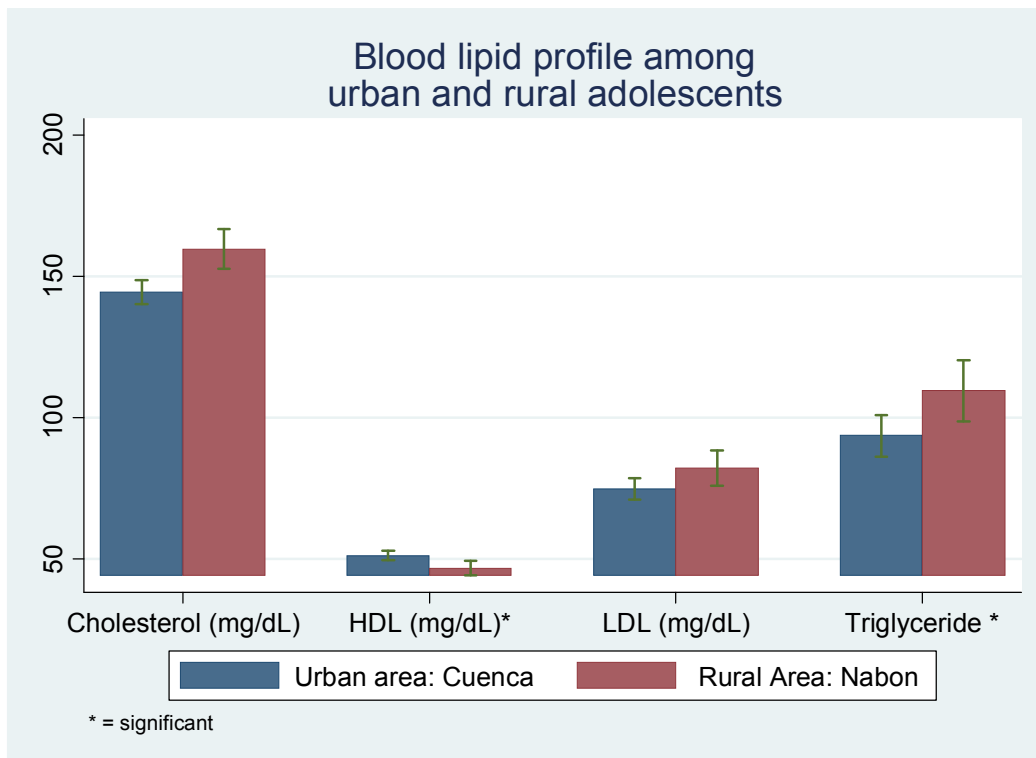


Figure 3.3 Blood lipid profile among urban and rural adolescents

The associations between fitness and BMI are shown in **table 3.2**. The interaction in terms of BMI-residence was significant for speed shuttle run, plate tapping, sit up, vertical jump,

bent arm hang and the proportion adolescents who reached the Healthy Fitness Zone. In the total sample, BMI was significantly associated with low performance on the 20m shuttle test and flamingo, and with high performance on hang grip ($p < 0.01$ for all tests). When the associations between the fitness tests and BMI were analyzed according to residential location, the results showed that the proportion of adolescents that reach the Healthy Fitness Zone in both urban and rural areas decreased significantly as mean BMI increased. However the decrease was more pronounced on urban areas ($\beta_{\text{urban}} = -6.5$ vs. $\beta_{\text{rural}} = -3.8$). In addition, in both rural and urban areas the favorable scores on the speed shuttle run and longer duration of bent arm hang were significant, and inversely associated with BMI. The magnitude of the latter associations, however, were more marked on rural areas. In both areas, the associations between BMI with plate tapping and vertical jump test were not significant. Finally, the association between the sit up test and BMI was only significant in urban and not for rural adolescents.

Table 3.2 Association between physical fitness and BMI of Ecuadorian adolescents stratified by residential location

Physical fitness	Interaction BMI & residence	All		Urban		Rural	
	p ^a	B %	p ^a	B %	p ^a	B %	p ^a
<i>Cardiopulmonary fitness</i>							
20 m shuttle test (laps)	0.24	-2.39	<0.01	-	-	-	-
FITNESSGRAM (% who are on the Healthy Fitness Zone)	0.02	-	-	-6.49	<0.01	-3.82	0.03
<i>Speed-agility</i>							
Speed shuttle run (s)	<0.01 ^b	-	-	0.47	<0.01	0.92	<0.01
Plate tapping (s)	<0.01 ^b	-	-	-0.13	0.52	0.90	0.11
<i>Flexibility</i>							
Sit and reach (cm)	0.63	-0.14	0.77	-	-	-	-
<i>Muscle endurance and strength</i>							
Sit-up (number/30 s)	0.09 ^b	-	-	-1.60	<0.01	-2.50	0.20
Vertical jump (cm)	0.06 ^b	-	-	-0.70	0.11	1.37	0.31
Bent arm hang (s)	0.06 ^b	-	-	-11.70	<0.01	-10.45	0.01
Handgrip (kgf)	0.13	3.67	<0.01	-	-	-	-
<i>Balance</i>							
Flamingo (trying/1min)	0.58	2.26	<0.01	-	-	-	-

^a Analysis adjusted for gender, socio economics status and cluster design, ^b Significant interactions

The associations between the physical fitness tests and blood lipid profile are presented in **table 3.3**. The interaction terms of residence x physical fitness were highly significant for cholesterol and LDL. In the total sample, dyslipidemia was negatively related to performance in bent arm hang. There were also significant associations between the plate-taping test with HDL and triglycerides. As time increased in seconds for the EUROFIT test, HDL decreased and triglycerides increased. When the associations between the fitness tests and blood lipid profile were analyzed according to residential location, the results showed that in the urban area there was an inverse association of bent-arm-hang and handgrip with cholesterol and LDL. Whilst, in the rural area, adolescents who reached the Healthy Fitness Zone according to the FITNESSGRAM standards had significantly lower cholesterol and LDL levels. After the Bonferroni correction however, only the association between cholesterol levels and the adolescents who reached the Healthy Fitness Zone according to the FITNESSGRAM standards remained significant.

Table 3.3 Associations of physical fitness on blood lipids among Ecuadorian adolescents, Cuenca-Nabón, Ecuador, 2009

Physical fitness	Dyslipidemia			Cholesterol				HDL			LDL				Triglyceride				
	Interaction ^a	All		Interaction ^a	Urban		Rural		Interaction ^a	All		Interaction ^a	Urban		Rural		Interaction ^a	All	
		β	p ^b		$\beta\%$	p ^c	$\beta\%$	p ^c	Interaction	$\beta\%$	p ^b		$\beta\%$	p ^c	$\beta\%$	p ^c		$\beta\%$	p ^b
<i>Cardiopulmonary fitness</i>																			
20 m shuttle test (laps)	0.30	0.85	0.20	0.17	-1.54	0.18	-2.70	0.11	0.17	-0.53	0.65	0.15	-1.72	0.34	-5.70	0.13	0.27	-0.23	0.95
FITNESSGRAM (% who are on the Healthy Fitness Zone)	0.51	0.85	0.46	<0.01	-5.25	0.14	-8.91	<0.01	0.17	-5.31	0.08	<0.01	-3.31	0.46	-11.71	0.04	0.95	-4.03	0.67
<i>Speed-agility</i>																			
Speed shuttle run (s)	0.52	1.00	0.48	0.08	0.07	0.32	0.10	0.27	0.50	0.003	0.97	0.05	0.06	0.60	0.23	0.32	0.27	0.15	0.29
Plate tapping (s)	0.09	0.99	0.99	0.20	0.04	0.60	-0.03	0.77	0.06	-0.10	0.05	0.14	0.06	0.62	-0.05	0.75	0.86	0.31	<0.01
<i>Flexibility</i>																			
Sit and reach (cm)	0.80	1.00	0.94	0.01	-0.13	0.47	-0.81	0.08	0.47	-0.25	0.26	<0.01	-0.10	0.72	-1.48	0.11	0.69	0.64	0.13
<i>Muscle endurance and strength</i>																			
Sit-up (number/30 s)	0.24	0.97	0.34	<0.01	-0.17	0.60	-0.66	0.14	0.68	-0.17	0.69	<0.01	-0.22	0.71	-1.30	0.06	0.41	0.04	0.96
Vertical jump (cm)	0.99	1.00	0.57	0.10	-0.28	0.34	-0.21	0.23	0.79	0.00	0.99	0.18	-0.50	0.25	-0.25	0.70	0.58	-0.22	0.56
Bent arm hang (s)	0.54	0.99	0.05	0.03	-0.05	0.03	-0.04	0.60	0.86	0.00	0.60	<0.01	-0.06	0.04	-0.06	0.58	0.22	0.00	0.97
Handgrip (kgf)	0.06	0.99	0.92	0.72	-0.64	0.02	-0.34	0.27	0.22	-0.28	0.19	0.23	-0.75	0.05	-0.84	0.09	0.02	-0.01	0.97
<i>Balance</i>																			
Flamingo (trying/1min)	0.99	0.99	0.63	0.64	-0.13	0.64	-0.51	0.34	0.26	0.17	0.43	0.32	-0.08	0.83	-1.19	0.17	0.22	-0.01	0.97

* Results were stratified by location when there was a consistent interaction between most of the fitness test and residence. The interaction term was significant when $P < 0.1$

^a Interaction terms of fitnessXresidence, the analysis were adjusted for gender, BMI, socio economics status, energy intake per day, residential location and cluster design

^b p-value adjusted for gender, BMI, socio economic status, energy intake per person, residential location and clustering

^c p-value adjusted for gender, BMI, socio economic status, energy intake per person and cluster design

3.4 Discussion

To our knowledge, this is the first study in a middle-income country that estimates physical fitness in urban and rural adolescents and explores its associations with blood lipid profiles. The findings show that more than half of the sample exhibits unhealthy levels of physical fitness. Furthermore, adolescents who had a low aerobic capacity as defined by the FITNESSGRAM had lower scores for physical tests, such as speed-agility, flexibility, muscle endurance / strength and balance. Our findings also show that urban adolescents were fitter than rural adolescents for five of the fitness test. Finally, our results show that there is a weak association between fitness and blood lipid profile, the latter result could implied that differences in physical fitness were not associated with those in lipid profile between urban and rural adolescents.

Two out of three Ecuadorian adolescents in our sample had early cardiovascular risk, defined by low aerobic capacity (20m shuttle run). This proportion was higher than the proportion reported in Spanish (124) and Portuguese (125) adolescents. Furthermore, the group of adolescents who had a lower aerobic capacity also showed lower scores for other physical fitness components such as muscle endurance and strength. Previous research indicates that such low fitness levels can linger on into adulthood (126) where low cardiorespiratory fitness (127) or low muscular strength (8) is associated with increased mortality risk.

In general, the absolute physical fitness of our population was worse than estimates in the majority of previous studies. Adolescents from our sample had a lower cardiopulmonary performance (3.2 ± 1.2 laps) compared with Spanish(128) (6.1 ± 2.0 laps) and Belgian(129) (6.4 ± 2.5 laps) adolescents. The estimates from the speed agility components of the physical

test (speed shuttle run 10x5m, plate taping) were also lower compared with Spanish(128), Greek(130), Polish(131) and Belgian(129) adolescents (128-131). The sit and reach scores were lower than those from Mexico (72), Spain (128), Poland (131) or Belgium (129). However, the large variation between studies, when considering the results from muscle endurance and strength tests (sit-ups, vertical jump, bent-arm hang and handgrip), renders comparison to the present study difficult. For sit-ups we obtained lower absolute values compared to estimates from Spain (128), Poland (131), Turkey (117) or Belgium (129). Also, the estimates from the handgrip test were lower than those from previous studies (72, 117, 128, 130, 131). Conversely, for the sit and reach test, we obtained a higher score compared with Greek (130) and Turkish (117) adolescents. In our results for sit-ups our adolescents averaged higher scores than adolescents in a Mexican study (72). The favorable fitness scores in European as compared to Ecuadorian adolescents may be a reflection of the favorable environmental conditions for physical activity found in Europe (26), as well as a longer tradition of health promotion programs (38), and genetic factors (132, 133). This hypothesis may be reinforced by the fact that our results were similar when compared to those from Mexican (72) and Colombian (75) studies, which have similar environmental and genetic patterns to those of Ecuador (132). However our comparisons should be treated with caution since there are some difference with available studies in terms of the altitude of area of the study and in the proportion of girls and urban subjects (**Table 3.4**).

Table 3.4 Studies used to compare our results from physical fitness

	Ecuador	Mexico (72)	Greece (130)	Turkey (117)	Spain (128)	Poland (131)	Belgium (129)
Altitude of the area of study (meters over sea)	2925	1580	115	2	243	116	694
Sample size	640	256	605	172	1501	988	2056
Female proportion (%)	47.8	50.4	40.8	50.0	48.4	50.0	50.2
Urban populations proportion (%)	76.0	47.7	51.6	43.1	67.3	53.4	N/A
Age (mean(SD))	13.6 (1.2)	11.5 (1.0)	12.3 (0.4)	9.7 (0.7)	14.5 (1.1)	12.9 (1.38)	12.7 (0.8)
Physical fitness	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
<i>Cardiopulmonary fitness</i>							
20 m shuttle test (laps)	3.2 (1.2)	N/A	N/A	12.6 (1.5)	6.1 (2.0)	N/A	6.4 (2.5)
<i>Speed-agility</i>							
Speed shuttle run (s)	24.8 (2.8)	N/A	16.9 (1.2)		21.8 (1.81)	22.4 (SD)	22.5 (1.6)
Plate tapping (s)	15.8 (2.4)					11.6 (SD)	13.2 (1.7)
<i>Flexibility</i>							
Sit and reach (cm)	19.7 (6.8)	27.3 (4.9)	16.7 (6.2)	14.1 (3.7)	21.0 (7.1)	21.6 (6.5)	21.8 (7.2)
<i>Muscle strength and endurance</i>							
Sit-up (number/30 s)	13.9 (4.2)	11.3 (4.2)		29.2 (18.1)	23.0 (3.5)	22.6 (5.8)	22.3 (4.0)
Vertical jump (cm)	26.5 (6.4)	N/A	52.5 (7.9)	18.7 (4.7)	N/A	N/A	N/A
Bent arm hang (s)	7.2 (7.9)			N/A	14.4 (9.2)	N/A	14.4 (11.0)
Handgrip (kgf)	22.7 (6.9)	34.8 (7.9)	24.4 (4.9)		29.6 (6.6)	24.5 (5.2)	29.9 (6.8)
<i>Balance</i>							
Flamingo (trying/1min)	14.5 (5.3)			N/A		8.5 (4.5)	17.1 (6.4)

SD: standard deviation

N/A: comparisons are not applicable since the test used to assess the fitness component is not similar to the test used in the present study.

Compared with rural adolescents, the urban participants in our sample had a significantly better performance for the cardiopulmonary, speed-agility, and muscle endurance and strength components of the fitness test. Although these findings are in line with measurements in Mexican (72) and Polish (131) adolescents, most literature consists of contradictory results with regard to comparison of performance between urban and rural adolescents (117, 134-136). Therefore, explaining the difference between urban and rural adolescents remains speculative. Firstly, the urban adolescents in our sample were taller and heavier than rural adolescents. It has been reported that the physical fitness is influenced by body size. Taller and heavier (not necessarily overweight or obese) children

may therefore have an advantage on strength, speed, power and endurance components (137). Secondly, urbanization and better social conditions in urban areas may mean that urban adolescents have increased access to sport facilities compared to rural adolescents (138-140). Organized sports facilities are more common in urban areas and might result in higher levels of cardio-respiratory and muscular fitness in urban adolescents (128). Thirdly, we observed that urban schools had specialized physical education teachers in their physical education programs, while these kinds of specialized teachers were virtually absent in rural areas. In addition, a lower availability of sport facilities in rural schools might result in a lower variety of sport activities. The latter was confirmed during our observations in the schools themselves. As a point of potential bias, urban adolescents are possibly more familiar with physical fitness tests than rural adolescents (72, 130). Fourthly, chronic under-nutrition during childhood instigates mechanisms of adaptation such as growth stunting and reduced muscle mass. The latter are potentially related to the physical fitness impairment during adolescence and adulthood(66). Indeed, chronic under-nutrition mainly affects children in rural areas in Ecuador (61).

To our knowledge, only a few studies have analyzed the association of blood lipid profile with multiple components of physical fitness. These studies have reported that increased cardiorespiratory fitness and muscular strength are associated with favorable lipid profiles in adolescence (32, 71, 125, 141). These associations were partially confirmed in our study. Total cholesterol and triglycerides were negatively associated with muscular strength in the urban area, whilst in the rural population these lipids were negatively associated with cardiorespiratory fitness.

We report that differences in blood lipid profile among urban and rural adolescents are not associated with differences in physical fitness, even after adjusting for BMI and total energy intake. The association found in this study between blood lipids and fitness was adjusted for BMI and total energy intake, as these factors have previously been found associated with blood lipids (32, 115). Mean energy intake was not significantly different ($P=0.08$) between urban (1863 ± 181 kcal/day) and rural (1766 ± 153 kcal/day) adolescents (82). In our sample, the relationship of different blood lipid parameters with each of the EUROFIT tests according to residential location was generally weak and non-significant. Another possible explanation for the differences in blood lipid profile among urban and rural adolescents may be the differences in moderate to vigorous physical activity (142), or body fat distribution (143). Physical activity and fitness have been found independently associated with certain blood lipid levels among children and adolescents (114). For example, the favorable TG and HDL levels are inversely associated with moderate to vigorous physical activity, independent of time spent sedentary (142) and fitness (114). In our sample, the time spent on moderate to vigorous physical activity could be longer in urban adolescents compared to rural adolescents because of differences in the availability of sport facilities and organized group sports, detailed earlier in this discussion. In addition, qualitative research performed in adolescents from Cuenca and Nabón reported a low self-efficacy among rural adolescents in contrast to the urban adolescents (95). This fact could lead to differences in physical activity levels between urban and rural adolescents, as self-efficacy is an important determinant of physical activity in adolescence (144). On the other hand, total cholesterol, LDL, HDL and TG also have been associated with fat distribution measured by skin-fold thickness. Lean adolescents, as determined using the skin-fold system, have been found to have healthier blood lipid profiles compared to their heavier

peers (145). However, skin-fold thickness was not a parameter measured in the present study.

There are some limitations of this study. Firstly, its cross-sectional nature only allows us to establish associations and not causality. Secondly, we did not measure important variables associated with blood lipids such as physical activity, pubertal stage, sex hormone level, skin-fold thickness and family health background. Third, the blood lipid determinations were conducted only in a subsample. Nevertheless, there were no differences in physical fitness and BMI between those that did or did not provide blood samples. Fourth, the 11% of our sample of adolescents (urban n=83, rural n=8) declined to participate in the fitness tests, however there were no differences in term of BMI or age between the adolescents who participate or not on the EUROFIT tests. Finally, reliability and validity of EUROFIT were not done in our sample. Although, EUROFIT has shown good validity in previous studies performed in the region (72). We followed the EUROFIT guidelines in order to avoid source of bias, such as learning effect, or low motivation of adolescents to do their best performance during each test (68). Measurements of the 20m shuttle run could be influenced by the temperature and weather conditions during the test. In Cuenca and Nabón, however, the average temperature and weather are similar. In addition, the estimation of VO_{2peak} from the FITNESSGRAM standards of the 20m shuttle run is known to vary with the equation used. In the present study, we used the equation that shows the highest agreement between the actual VO_2 peak and the estimate VO_{2peak} from the 20m shuttle run scores (79).

The trial included adolescents from high altitude urban and rural areas of Ecuador that are characterized by mixed *mestizo* (in urban area) and *Amerindian* (in rural area) ethnicities

(133). The external validity of our findings is hence limited to urban and rural schools in the regions that share these characteristics (146).

Conclusions

The results from our study suggest that 59% of Ecuadorian adolescents have poor physical fitness. Even though urban participants showed better scores in the majority of EUROFIT tests, physical fitness of the total population was lower compared to that of adolescents from other countries. These findings call for specific health promotion programs aimed to improve physical fitness among Ecuadorian adolescents. Differences in fitness were not associated with differences in blood lipid profile between urban and rural adolescents. We only found a weak association between physical fitness and blood lipid profile, even after adjustment for energy intake. Additional studies are needed to clarify the frequent occurrence of unfavorable blood lipid profiles among rural participants. Such studies might explore associations with physical activity levels, body fat distribution, risk factors at early ages, familial hypercholesterolemia and ethnic differences.

4 The effect of the school-based intervention program “ACTIVITAL” on fitness and physical activity among Ecuadorian adolescents: randomized controlled trial

Redrafted from: *Andrade S, Lachat C, Ochoa-Aviles A, Verstraeten R, Huybregts L, Roberfroid D, Andrade D, Van Camp J, Rojas R, Donoso S, Cardon G, Kolsteren P. (2014) A school-based intervention improves physical fitness in Ecuadorian adolescents: a cluster-randomized controlled trial. International Journal Behavior Nutrition Physical Activity, 11:153.*

Abstract

Background: Effective lifestyle interventions are needed to prevent non-communicable diseases in LMICs. In this chapter, we analyzed the effects of a school-based health promotion program on physical fitness after 28 months and explored if the effect varied with important school characteristics. We also assessed effects on physical activity and BMI.

Methods and results: We performed a cluster-randomized pair matched trial in urban schools of Ecuador. The intervention was developed using the Intervention Mapping protocol and Comprehensive Participatory Planning and Evaluation. The program included an individual and environmental component. Primary outcomes included physical fitness (EUROFIT battery) and physical activity (accelerometers). The BMI was a secondary outcome. A total of 1440 grade 8 and 9 adolescents (intervention: n=700, 48.6%) and 20 schools (intervention: n=10, 50%) participated. Data of 1083 adolescents (intervention: n=550, 50.8%) from 20 schools were analyzed.

The intervention increased vertical jump (mean effect 2.5cm; 95%CI 0.8-4.2; P=0.01). Marginally insignificant, adolescents from the intervention group needed less time for speed shuttle run (intervention effect=-0.8s, 95%CI -1.58-0.07; P=0.05). The proportion of students achieving over 60 minutes of moderate-to-vigorous physical activity / day decreased over time with the change in proportion significantly less in the intervention schools (6 vs. 18 percentage points, P<0.01). The intervention effect on speed shuttle run was significant in larger schools while the effect on vertical jump was larger in mixed gender school compared to small and female schools. The proportion of schools that met the recommendations for physical activity increased with 37% in intervention schools with half-day schedule compared to the controls in the pair. No significant effects were found on BMI. Measurement of physical activity in a subsample was a limitation. No adverse

effects were reported.

Conclusions: A school-based intervention program, with an individual and environment component, could improve physical fitness and could minimize the decline in physical activity levels from childhood into adolescence in urban Ecuador.

4.1 Introduction

Although, physical inactivity (147) and poor physical fitness (32) during early adolescence are associated with the development of NCDs during adulthood (22), only a few LMICs have developed strategies, like school-based interventions, to improve physical activity or physical fitness (148).

The few school-based interventions from LMICs that aimed to promote an active lifestyle had important methodological limitations such as a weak study design or the absence of a theoretical framework to guide the interventions, or a lack of objectively measured outcomes (51). This is worrisome as adequate evidence is needed to guide allocation of scarce resources to tackle NCDs in LMICs (2).

The results of our previous studies among Ecuadorian adolescents, attending 8th, 9th and 10th grades of urban schools, showed that the prevalence of overweight/obesity was around 20% (93) and that 59% of adolescents had inadequate physical fitness levels according to the FITNESSGRAM standards (**Chapter 3**) (78). Based on the latter results we implemented a school-based health promotion intervention “ACTIVITAL” that aimed at improving diet and physical activity. ACTIVITAL was developed using the participatory approach and tailored to the Ecuadorian school context. In the present chapter, we present the effectiveness of the trial on one set of the primary outcomes, i.e. physical fitness, physical activity and the effect on body mass index (BMI) as secondary outcome. In addition, we analyzed if the effect of the intervention varied between the pairs of the school and with important school characteristics i.e. size, type, class schedule, gender composition and space for physical activity. The latter because our study was paired matched at school level and that the matching was performed based on some school characteristic (**Chapter**

2.2). Finally, this chapter reported if intervention effect on fitness and physical activity was different between boys and girls.

4.2 Methods

In this randomized controlled trial a total of 1440 adolescents from 20 urban schools were enrolled. In the present chapter we mainly used the data of the fitness which was measured by means of EUROFIT battery, physical activity measured by accelerometer, BMI measured by using the data of height and weight and socio economic status measured by means of a questionnaire. The data collected at baseline and after 28 months were used for the following analyses. Additionally, this chapter used the data collected about the characteristics of the schools (schools' type, size, schedule, etc.). The methodology details were described in **Chapter 2.2**.

Statistical analysis

Differences at baseline between intervention groups as well as differences dropout and remainders groups were assessed using a t-test for continuous variables adjusted for the pair matched allocation and χ^2 test for categorical variables. To estimate the effect of the intervention, we used a difference in differences approach.

An intention-to-treat analysis was performed to assess the intervention effect using mixed linear regression models with the pair-matching as random effect. In such models, the Beta coefficient of the intervention variable indicates the difference in means for continuous dependent variables and the difference in absolute risks for dichotomous ones (149). All models were adjusted for baseline BMI z-score, gender, adolescent socio-economic status and knowledge on recommendations and health benefits of physical activity. We adjusted

the analysis for prior knowledge on physical activity as it influences on how much the new knowledge can be assimilated (150). Akaike-Schwartz criteria (151) were used to determine the optimal covariance structure. To assess the effect of the adjusting, we also analyzed the effect of the intervention using crude models. We also tested variations of the effect by pairs of schools by a meta-analysis with visual appraisal of the forest plot and heterogeneity statistics (I^2)(152).

Next, we tested if the intervention had a different effect in boys and girls using interaction term gender x allocation group. As there was substantial heterogeneity among the pairs we explored if the intervention effect was modified by school characteristics for outcomes with a $P < 0.1$ in the main analysis. For each outcome, we first assessed the effect modification for the five school characteristics in separate models (bivariate models) by including the interaction term of the school characteristic x intervention. Secondly, a final model was constructed with all school characteristics that were significantly ($P < 0.05$) associated with the outcome in the bivariate models and all significant interaction terms ($P < 0.1$). Finally, the analysis was stratified when the interaction terms were significant ($P_{\text{interaction}} < 0.1$). In addition, we tested the effect of missing data for all outcomes with $P < 0.1$ using a multiple imputation method based on chained equations with 50 imputation runs. Age, BMI z-score, gender, physical activity knowledge and socio-economic status were used as predictors in models to impute data in the pairs. All tests were performed with a significance level of 5% and models were evaluated for collinearity using variance inflation factors. Given the small number of pairs ($n=10$), we calculated the P-values from the multilevel analyses from a t-distribution with 9 degrees of freedom. Data were analyzed using Stata.

4.3 Results

A total of 1440 adolescents (intervention group: n=700, 48.6%) and 20 schools (intervention group: n=10, 50%) participated in the trial (**Figure 2.2**). Baseline characteristics at individual and cluster level were comparable (**Table 4.1** and **4.2**). Except for 20m shuttle run, handgrip, plate tapping, sedentary time and light physical activity time, there were no significant differences in baseline characteristics.

All schools completed the trial and the sample size included in the analyses was 1083 adolescents (63.2% girls, intervention group: n=550, 50.8%). The attrition rate was higher ($P<0.001$) in the control (28%, n=207/740) compared to the intervention group (21%, n=150/700). Most of the attrition was due to adolescents changing schools (73%, 262/357). Physical activity could not be assessed in 47% (117/251) of the adolescents as accelerometers malfunctioned (n=70) or participants were lost to follow-up (n=39 left school). Six students declined to participate and 2 were pregnant. In one entire school, no accelerometer readings were available because of the malfunction of the accelerometers (n=8), adolescents changed the school (n=3) or declined to participate (n=1). Adolescents lost to follow-up had a higher baseline score in the handgrip ($P<0.001$) compared to adolescents who completed the trial, while the speed shuttle run ($P=0.01$) was better among the adolescents who completed the trial. There was no difference for all other outcomes. At the end of the intervention adolescents were on average 15.1 year \pm 0.7.

Table 4.1 Participant characteristics at baseline

	n ^a	Intervention group	Control group
		Mean (SD) ^b	Mean (SD) ^b
Age	1378	12.9 (0.8)	12.9 (0.8)
Female (%)	1440	66.4	59.3
Fitness			
<i>Cardiopulmonary fitness</i>			
20 m shuttle run (stage)	1363	2.5 (0.7)	2.7 (0.9)
20 m shuttle run (min)	1362	1.7 (0.7)	1.9 (0.9)
<i>Speed-agility</i>			
Speed shuttle run (s)	1389	24.6 (2.4)	24.5 (2.2)
Plate tapping (s)	1394	14.6 (1.9)	14.2 (2.0)
<i>Flexibility</i>			
Sit and reach (cm)	1391	20.1 (6.6)	20.5 (6.3)
<i>Muscle endurance and strength</i>			
Sit-up (number/30 s)	1389	12.0 (3.9)	12.6 (3.4)
Vertical jump (cm)	1391	25.4 (5.6)	26.0 (5.3)
Bent arm hang (s)	1390	6.0 (7.0)	6.0 (6.6)
Handgrip (kgf)	1393	18.4 (4.9)	19.2 (5.0)
<i>Balance</i>			
Flamingo (trying/min)	1389	17.8 (5.8)	18.5 (6.0)
Accelerometer data		Mean (SD)	Mean (SD)
Total PA (counts/day)	226	305226 (109950)	280819 (116144)
Total PA (CPM/day)	226	375.5 (138.0)	357.8 (141.8)
Sedentary time (min/day)	226	487.6 (126.9)	484.9 (108.3)
Light PA (min/day)	226	217.6 (58.1)	192.7 (66.7)
Moderate-Vigorous PA (min/day)	226	119.3 (42.4)	109.4 (45.0)
% who meet the PA recommendation (60 min MVPA/day)	226	95.0 (21.9)	91.5 (28.0)
Anthropometry			
Body mass index (kg/m ²)	1382	19.8 (3.4)	19.7 (2.9)
Body mass index z-score	1371	0.3 (1.1)	0.3 (1.0)
Overweight prevalence (%) ^c	1371	20.1 (40.7)	19.7 (39.8)

^a Total number of students

^b Adjusted for clustering

^c Overweight and obese combined

CPM: counts per minute; MVPA: moderate to vigorous physical activity; PA: physical activity; SD: standard deviation

Table 4.2 School characteristics at baseline

	n ^a	Intervention group	Control group
		Mean (SD)	Mean (SD)
Age	20	12.8 (0.2)	12.9 (0.3)
Female (%)	20	66.1	57.6
Physical fitness			
<i>Cardiopulmonary fitness</i>			
20 m shuttle run (stage)	20	2.5 (0.2)	2.7 (0.3)
20 m shuttle run (min)	20	1.7 (0.2)	1.9 (0.4)
<i>Speed-agility</i>			
Speed shuttle run (s)	20	24.6 (11.2)	24.5 (6.6)
Plate tapping (s)	20	14.6 (2.6)	14.2 (5.9)
<i>Flexibility</i>			
Sit and reach (cm)	20	20.1 (1.4)	20.5 (1.2)
<i>Muscle endurance and strength</i>			
Sit-up (number/30s)	20	12.0 (0.9)	12.6 (0.8)
Vertical jump (cm)	20	25.4 (1.5)	26.1 (1.1)
Bent arm hang (s)	20	6.0 (23.1)	6.1 (19.6)
Handgrip (kgf)	20	18.4 (0.7)	19.3 (0.8)
<i>Balance</i>			
Flamingo (trying/min)	20	17.9 (1.3)	18.5 (1.4)
Accelerometer data		Mean (SD)	Mean (SD)
Total PA (counts/day)	18	308630.8 (38106.2)	274071.9 (46469.4)
Total PA (CPM/day)	18	381.4 (68.6)	348.4 (71.4)
Sedentary time (min/day)	18	480.0 (78.7)	492.8 (46.4)
Light PA (min/day)	18	223.6 (21.1)	191.1 (34.5)
Moderate-vigorous PA (min/day)	18	122.7 (21.0)	106.7 (16.2)
% who meet the PA recommendation (% >60 min MVPA/day)	18	95.0 (6.9)	93.6 (7.1)
Anthropometry			
Body mass index (kg/m ²)	20	19.8 (0.5)	19.7 (0.4)
Body mass index Z-score	20	0.3 (0.2)	0.3 (0.1)
Overweight prevalence (%) ^b	20	20.8 (7.5)	19.6 (3.6)

^aTotal number of clusters

^bOverweight and obese combined

CPM: counts per minute; IQR: interquartile range; MVPA: moderate to vigorous physical activity; PA: physical activity; SD: standard deviation

Primary outcomes

Adolescents from the intervention group had a greater increase in vertical jump (intervention effect=2.5cm; 95%CI: 0.78-4.23; P=0.01). Adolescents from the intervention group decreased the time needed to perform speed shuttle run but this decrease was small and borderline statistically significant (intervention effect=-0.8s, CI:-1.58-0.07; P=0.05) compared to the control group. Adolescents from the intervention group increased the number of attempts to keep their balance for the duration of one minute in flamingo balance test (intervention effect=1.87, CI: 0.25 to -3.41; P=0.02) compared to control group (Table

4.3) i.e. the control group had a higher improvement in balance test compared to intervention group.

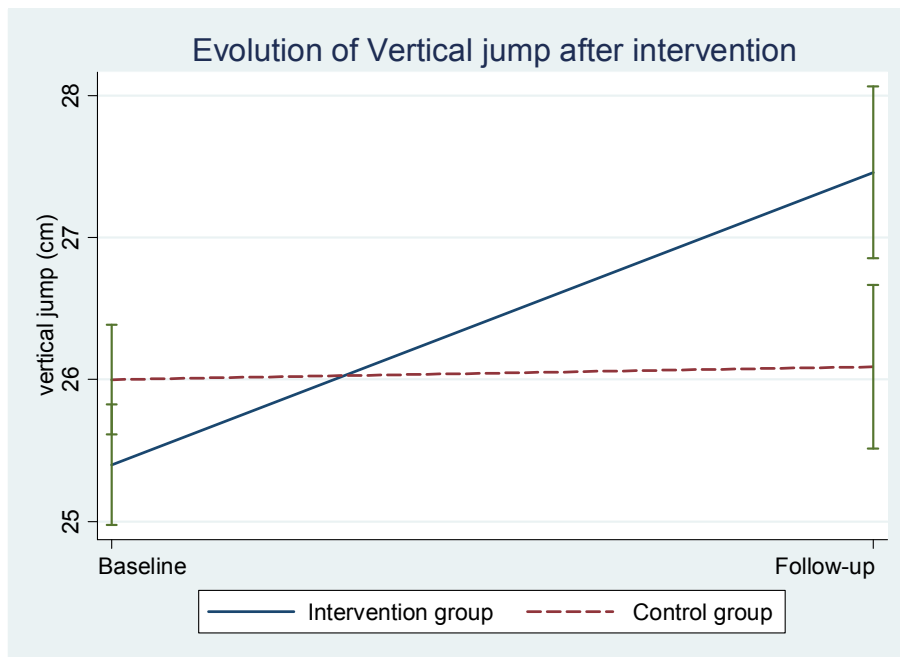


Figure 4.1 Evolution of vertical jump after on intervention and control group after 28 months

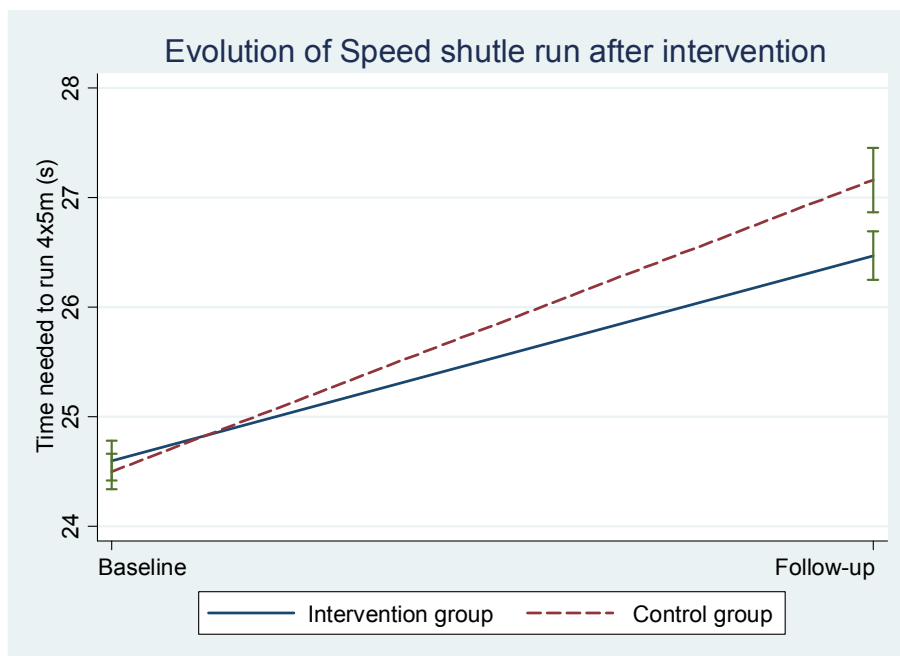


Figure 4.2 Evolution of speed shuttle run on intervention and control group after 28 months

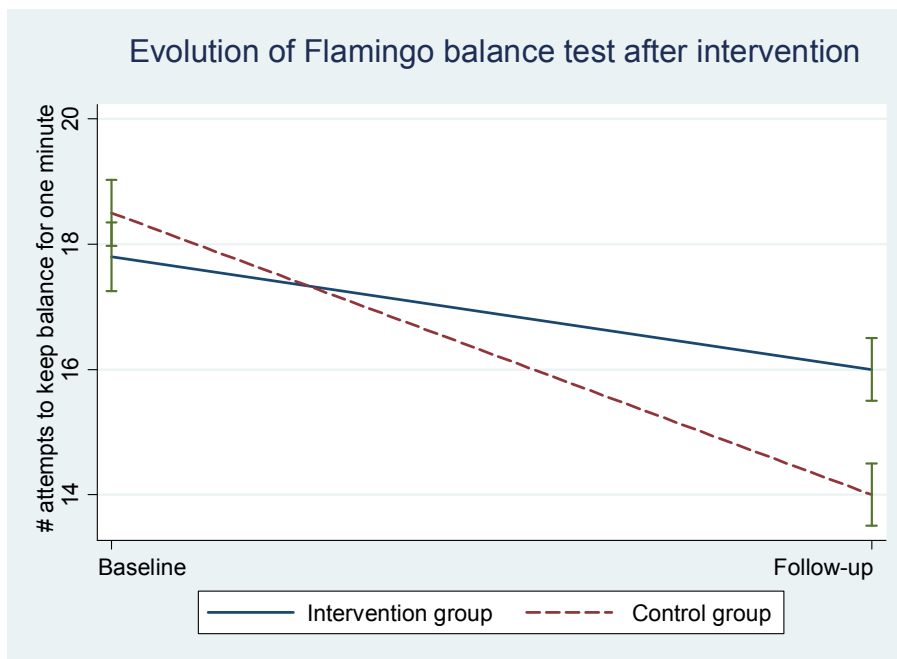
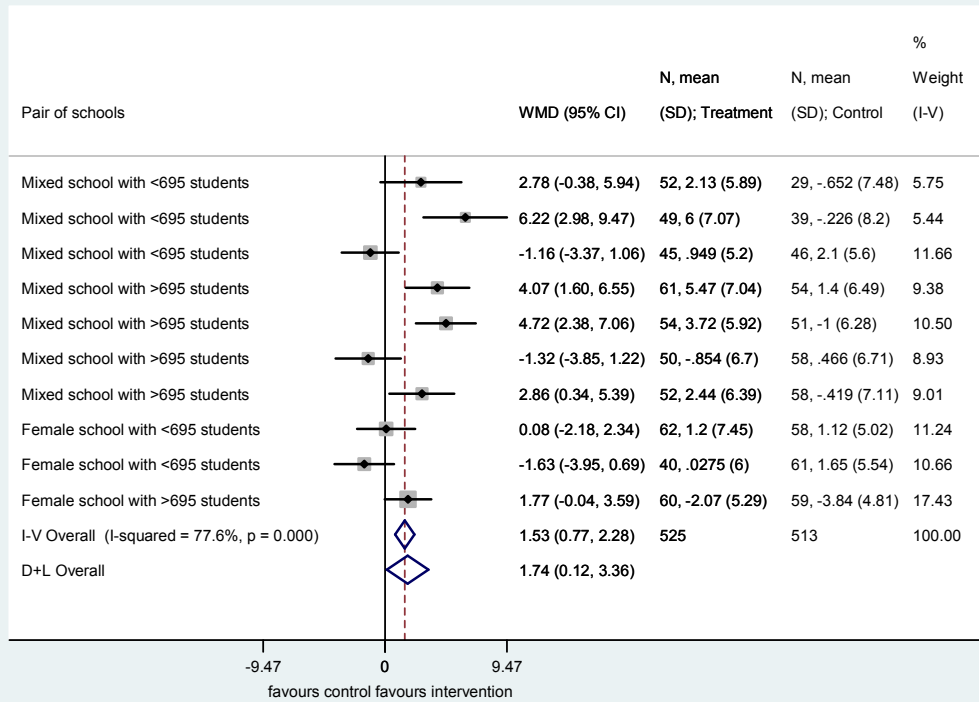


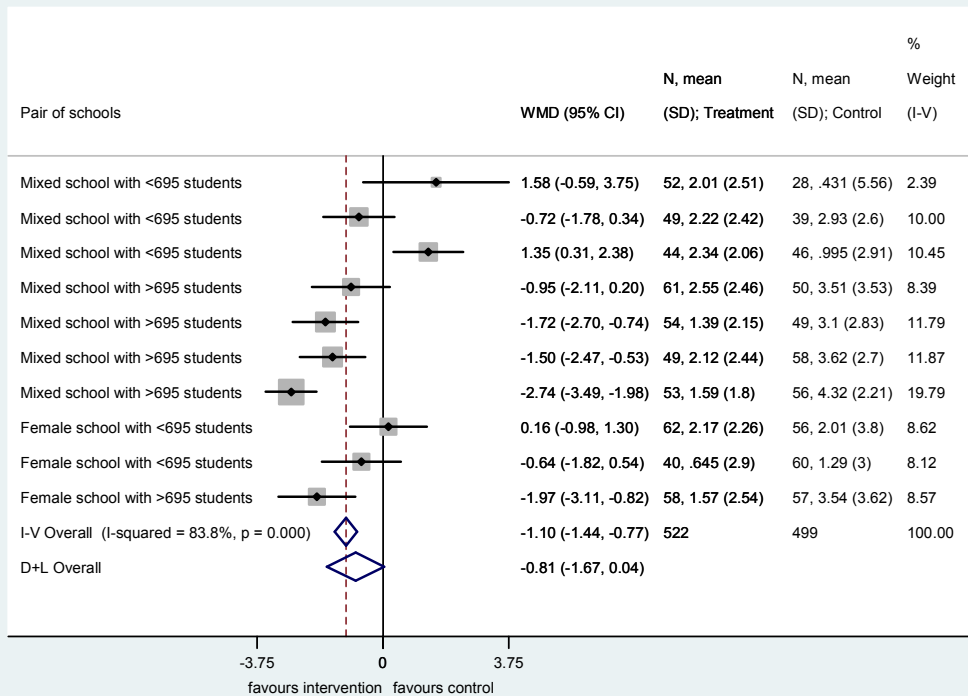
Figure 4.3 Evolution of flamingo balance test on intervention and control group after 28 months

Except for a few outcomes only a small fraction (<10%) of variance of the intervention effect was simple explained by the fact of pairing (intraclass correlation reported in **Table 4.3**). In addition, we observed a moderate to high (>25%) (152) heterogeneity in the intervention effect between pairs of schools for all but one outcome. **Figures 4.4 to 4.6** depict this effect heterogeneity amongst pairs of schools for vertical jump, speed shuttle run and the proportion of adolescents who meet the MVPA recommendation.



SD: standar deviation
 N: number of the subjects
 WMD: weighted mean difference

Figure 4.4 Forest plot for vertical jump according to size and gender of the school pairs



SD: standar deviation
 N: number of the subjects
 WMD: weighted mean difference

Figure 4.5 Forest plot for speed shuttle run according to size and gender of the school pairs

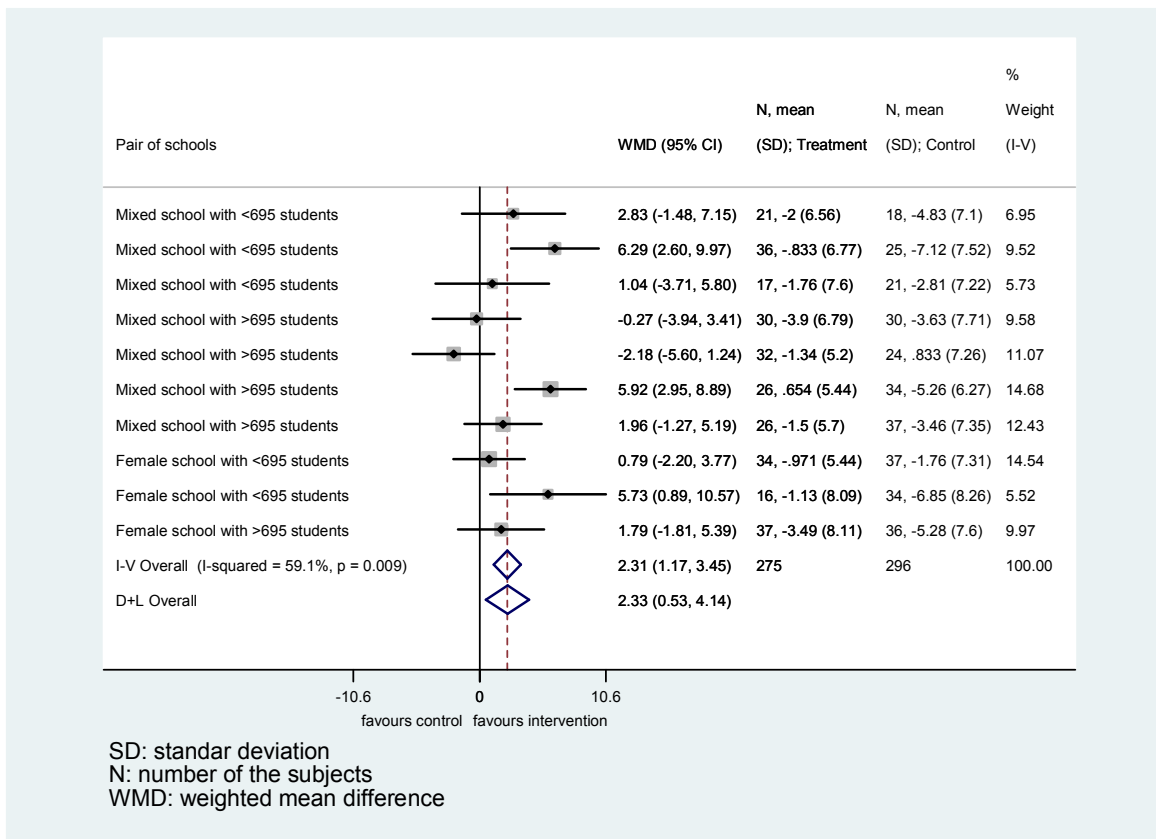


Figure 4.6 Forest plot for balance test according to size and gender of the school pairs

Total physical activity level decreased in the intervention group and control group and both groups had a similar increase in sedentary time (**Table 4.3**). At baseline, more than 90% of the adolescents had >60 min of moderate to vigorous physical activity per day. After the intervention, the proportion of adolescents that met this recommendation decreased significantly less in the intervention group compared to the control group (6 vs. 18 percentage points, $P < 0.01$).

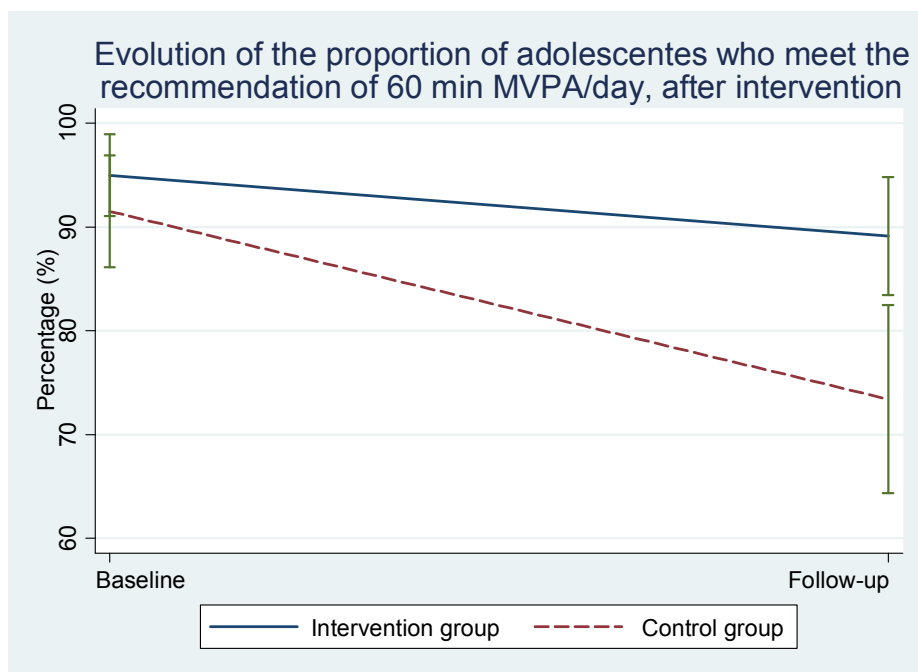


Figure 4.7 Evolution of the proportion of adolescents who reach the recommendation of 60 min of MVPA/day

Secondary outcomes

The intervention did not lead to differences in changes of BMI z-score or prevalence of overweight.

Ancillary analyses

Similar findings were obtained when analyzing the effect of the intervention with the crude models (**Table 4.3**). In addition, the intervention effect was not different among boys and girls.

Table 4.3 Group differences and mean changes in fitness, physical activity and BMI after intervention

Outcomes	n ^a (cluster)	Differences at individual level		Unadjusted effects at individual level ^c		Adjusted effects at individual level ^e				Effects in the pairs ^g		
		Δ I (SD) ^b	Δ C (SD) ^b	Beta	P ^d	Beta	P ^f	ICC	95% CI	Effect size ^h	95% CI	I ²
Physical fitness												
<i>Cardiopulmonary fitness</i>												
20 m shuttle run (min)	1003(20)	-0.17()	-0.02()	-0.18	0.18	-0.19	0.16	0.15	[-0.54 – 0.16]	-0.19	[-0.52 – 0.14]	89.3
<i>Speed-agility</i>												
Speed shuttle run (s) ⁱ	1021(20)	1.89 (2.09)	2.69 (3.44)	-0.72	0.06	-0.76	0.05	0.15	[-1.58 - 0.07]	-0.81	[-1.67 - 0.04]	83.8
Plate tapping (s) ⁱ	1043(20)	-0.18 (2.39)	0.36 (2.64)	-0.61	0.13	-0.70	0.10	0.32	[-1.70 - 0.31]	-0.64	[-1.56 - 0.34]	93.3
<i>Flexibility</i>												
Sit and reach (cm)	1040(20)	1.84 (4.93)	1.97 (4.61)	-0.13	0.37	0.11	0.39	0.06	[-0.64 - 0.86]	-0.13	[-0.96 - 0.71]	52.7
<i>Muscle endurance and strength</i>												
Sit-up (number/30 s)	1031(20)	2.45 (3.81)	2.52 (4.15)	-0.04	0.47	0.15	0.36	0.11	[-0.63 - 0.92]	-0.002	[-0.95 - 0.94]	76.3
Vertical jump (cm)	1038(20)	1.94 (6.80)	0.07 (6.45)	1.83	0.03	2.51	0.01	0.12	[0.78 - 4.23]	1.74	[0.12 - 3.36]	77.6
Bent arm hang (s)	1019(20)	-0.64()	0.005()	-0.70	0.27	-0.11	0.45	0.03	[-1.67 – 1.45]	-0.68	[-2.63 – 1.27]	82.8
Handgrip (kgf)	1032(20)	5.86 (5.42)	5.70 (6.3)	-0.03	0.48	0.59	0.12	0.06	[-0.32 - 1.50]	0.076	[-1.49 - 1.34]	81.3
<i>Balance</i>												
Flamingo (trying/min) ⁱ	571(20)	-1.69 (6.60)	-4.08 (7.60)	2.36	0.01	1.83	0.02	0.07	[0.25 - 3.41]	2.34	[0.53 - 4.14]	59.1
% able to do the flamingo test	1034(20)	5.15	5.49	-0.05	0.08	-0.37	0.13	0.03	[-0.10 – 0.02]	-0.52	[-0.12 – 0.02]	38.3
Accelerometer data												
Total PA (counts/day)	134(18)	-17503(143300)	-26291(146553)	22356 ^j	0.22	27804 ^j	0.18	0	[-29525 - 85135]	37000	[-44000 - 120000]	61.3
Total PA (CPM/day)	134(18)	-6.7(156.2)	-15.3(183.6)	18.8 ^j	0.30	30.2 ^j	0.23	0	[-46.2 - 106.6]	47.8	[-42.5 - 138.1]	64.1
Sedentary time (min/day)	134(18)	26.3(149.6)	44.1(158.9)	-14.4 ^j	0.21	-18.1 ^j	0.15	0	[-50.8 - 14.6]	-14.0	[-78.9 - 50.8]	42.8
Light PA (min/day)	134(18)	-47.9(69.2)	-47.1(70.3)	4.3 ^j	0.32	4.6 ^j	0.32	0	[-14.6 - 23.8]	-6.1	[-42.8 - 30.6]	63.7
MVPA (min/day)	134(18)	-8.8(54.0)	-14.7(55.1)	10.4 ^j	0.17	13.6 ^j	0.08	0	[-4.1 - 30.8]	15.7	[-14.1 - 45.4]	59.1

Outcomes	Differences at individual level			Unadjusted effects at individual level ^c		Adjusted effects at individual level ^e				Effects in the pairs ^g		
	n ^a (cluster)	Δ I (SD) ^b	Δ C (SD) ^b	Beta	P ^d	Beta	P ^f	ICC	95% CI	Effect size ^h	95% CI	I ²
% who meet the PA recommendation (60 min MVPA/day)	134(18)	-5.87%	-18.09%	0.16	<0.01	0.20	<0.01	0	[0.07 - 0.33]	0.06 ^k	[-0.41 - 0.53] ^k	58.1 ^k
Anthropometry												
Body mass index (z-score)	1062 (20)	-0.09 (0.58)	-0.09 (0.52)	0.02	0.34	-0.01	0.38	0.02	[-0.09 - 0.06]	-0.004	[-0.09 - 0.08]	41.1
Overweight prevalence (%) ^m	1062 (20)	-0.56	-1.62	0.03	0.15	0.02	0.31	0	[-0.05 - 0.08]	0.03	[-0.03 - 0.09]	32.5

^a Total number of students (clusters)

^b Standard deviation adjusted for clustering

^c Crude models without covariates and adjusted for clustering

^d P-value for crude models

^e Adjusted for clustering

^f Multilevel random effect models adjusted for BMI z-score, gender, socio-economic status and the physical activity knowledge at baseline. P-values were calculated with t distribution with 9 degree of freedom

^g Random effect meta-analysis with pairs as random effect

^h Pooled unstandardized mean differences

ⁱ Lower scores indicated better fitness

^j Models were adjusted for total time registered at baseline and at follow-up

^k The results were obtained from only two pairs. In all other pairs, at least one school had all students meeting the recommendation on MVPA.

^m Overweight and obese combined

Δ I: mean difference of the outcomes measured before and after the intervention in the intervention group; Δ C: mean difference of the outcomes measured before and after the intervention in the control group; CPM: counts per minute; ICC: intraclass correlation; I²: heterogeneity; PA: physical activity, MVPA: moderate to vigorous PA

School characteristics modified the intervention effect significantly for various outcomes (**Table 4.4**). In the full model the intervention effect on speed shuttle run was modified by school size ($P_{\text{interaction}} < 0.01$), the effect on vertical jump by school gender ($P_{\text{interaction}} = 0.03$), the effect on flamingo balance test by physical activity space ($P_{\text{interaction}} = 0.04$) and the effect on the proportion of adolescents that met the recommendations for physical activity by school schedule ($P_{\text{interaction}} = 0.01$). After the stratification, the speed shuttle run only showed an improvement in pairs of larger schools. The speed shuttle run showed a decrease of 1.5s ($P < 0.01$) in larger schools. The improvement in the vertical jump was only significant in pairs of schools with both male and female children. Vertical jump increased with about 3.6cm ($P < 0.01$) in intervention schools vs. control schools in pairs of schools with both male and female students. In schools with a physical activity space ≤ 4.07 students/m², control schools showed a significant ($P = 0.01$) improvement in the flamingo balance test in around 3.3 attempts less compare to the intervention schools. In pairs of schools that offer half-day class only, the proportion of adolescents that met the recommendations for physical activity increased with 37% in intervention schools. That proportion decreased with 29% in the intervention schools in pairs that provide full-day classes.

The findings were similar after imputing missing variables and produced following estimates: vertical jump: $\beta = 2.49$, $P = 0.01$ (0.4% difference), speed shuttle run: $\beta = -0.72$, $P = 0.07$ (5.5% difference), flamingo balance test $\beta = 2.26$, $P = 0.002$ (24% difference), mean moderate to vigorous physical activity time: $\beta = 12.0$, $P = 0.11$ (11.6% difference) and the proportion meeting the recommended 60 min/day of moderate to vigorous physical activity $\beta = 0.12$, $P = 0.05$ (39% difference).

Table 4.4 Subgroup analysis of physical fitness, physical activity according to school characteristics

Outcome	n	Control group	Intervention group	Separate model per school characteristic		Full model adjusted for school characteristics	
		Mean (SD)	Mean (SD)	Difference [95% CI] ^a	P	Difference [95% CI] ^b	P
Speed shuttle run 10x5 (s)							
School size	1021				<0.01 ^c		<0.01 ^c
≤695 students	476	1.58 (3.59)	1.93 (2.47)	0.30 [-0.55-1.14]	0.25	0.22 [-0.36 -0.80]	0.24
>695 students	545	3.63 (3.02)	1.85 (2.32)	-1.83 [-2.34 to -1.32]	<0.01	-1.49 [-2.20 to -0.78]	<0.01
Vertical jump (cm)							
School gender	1038				0.03 ^c		0.03 ^c
Male and female students	698	0.29 (6.82)	2.93 (6.70)	3.55 [1.73-5.36]	<0.01	3.57 [1.76-5.38]	<0.01
Only female students	340	-0.34 (5.67)	-0.30 (6.48)	0.14 [-2.21-2.49]	0.45	0.06 [-2.16-2.28]	0.48
Flamingo (trying/min)							
Physical activity space	571				0.04 ^c		0.04 ^c
≤4.07 (students/m ²)	237	-5.26 (7.87)	-0.82 (6.40)	3.29 [0.97 - 5.61]	0.01	3.29 [0.97 - 5.61]	0.01
>4.07 (students/m ²)	334	-3.38 (7.38)	-2.43 (6.68)	0.91 [-0.99 - 2.81]	0.19	0.91 [-0.99 - 2.81]	0.19
Proportion of adolescents who meet the recommendation (60 min of MVPA / day)							
School schedule	134				0.01 ^c		0.02 ^c
Half-day class	110	0.70 (0.46)	0.96 (0.19)	0.28 [0.14-0.42]	<0.01	0.37 [0.14 - 0.61]	0.01
Full-day class	24	1.00 (0.00)	0.77 (0.44)	-0.29 [-0.54 to -0.04]	0.02	-0.29 [-0.54 to -0.04]	0.02

^a Differences and CI were obtained from a linear mixed model adjusted for BMI z-scores, gender, socio-economic status and physical activity knowledge at baseline, including the interaction term between school characteristic and allocation group.

^b Differences and CI were obtained from linear mixed models adjusted for BMI z-scores, gender, socio-economic status and physical activity knowledge, including the interaction term between school characteristic and allocation group. Models included all school characteristics as fixed effects that were significantly associated with the outcome (P<0.05) and all significant interaction terms (P<0.1) from the separate models.

^c P for interaction (significant at P<0.10)

CI: confidence interval; SD: standard deviation

4.4 Discussion

We report how a school-based intervention had a positive effect on physical fitness parameters and recommendations for moderate to vigorous activity of adolescents in an urban area of Ecuador. The increase in muscular strength as measured by vertical jump corresponds to 10% of the average score at baseline in the intervention group. Ortega *et al.* have shown that higher muscular strength during adolescence is associated with better cardiovascular and skeletal health at adulthood (32). The intervention also resulted in an improvement of the speed shuttle run corresponding to a relative time decrease of 3% compared to the baseline values. Albeit marginally insignificant, this effect is considerable and compares to differences in speed-agility between non-obese and obese adolescents (129). The effect on the balance component of physical fitness was in favor of the control group. We attribute this counterintuitive finding to the fact that our intervention promoted physical activity and did not include specialized training for static activities needed for the balance test (153). We also observed that adolescents in the control group engaged more in static games during breaks like hacky sack and throwing coins near a target, while those in the intervention group were encouraged reach the recommendations of physical activity (60 minutes MVPA/day), engage in sports and use the walking trail.

To our knowledge, trials in our age group from high-income countries have generally resulted in mixed effect on physical fitness (154-157). Only one study in African American girls with high blood pressure led to a 1 min increase in step-test compared to children who only received physical education (158). These results are less positive than those reported in the present study. This is surprising, as we did not provide an extra hour of physical education per week, exercises during the recess or specific equipment for physical activity. Instead, we developed a comprehensive approach to improve active lifestyles and healthy

diet. The activities were tailored to the local school context and delivered through existing school structures (e.g. drawing of the walking trail on the courtyard). The frequency and intensity of the classes were kept moderate to facilitate integration of the classes in curriculum after the intervention. Notwithstanding this, we report effects on muscular strength and speed measured by EUROFIT battery, which was not reported in a previous systematic review (41). We note that our participants used more time for the speed shuttle run when getting older in both the intervention and control group. This tendency contradicts the current literature that states that (primarily European) adolescents decrease the time on speed shuttle through the transition from 12 to 15 years (128, 129). The explanation of the different findings in Ecuadorian adolescents is speculative, perhaps due to a less supportive environment for physical activity. Infrastructure including sport facilities, bike paths, well-marked traffic signs or societal aspects such as pedestrian and cyclist have preference on the street, low crime rates are found in Europe (26), differences in tradition of health promotion programs (38) and genetic factors (132, 133).

As observed in the present study, a decline in moderate to vigorous physical activity is common in early adolescence (38). ACTIVITAL led to a significantly lower decrease in the proportion of adolescents that met the daily recommended 60 min of moderate to vigorous physical activity. Besides, although the intervention effect on the moderate or vigorous activities is borderline significant in the present manuscript, it is relevant as it comprises a quarter of the daily recommendations. Furthermore, this difference was almost three times higher than that reported in a meta-analysis of physical activity interventions in children and adolescents (159) which stated a small improvement on the moderate or vigorous activities of ~4min/day as measured using accelerometers.

We found no effects of the intervention on mean BMI or prevalence of overweight. While some authors report favorable effects in girls (160, 161) or boys only (162, 163), others found no differences (157, 158, 164). Only a study from Greece reported a significant effect in both groups after one year (165). The effect size on these outcomes was possibly too small and our follow-up period was possibly too short to detect effects on BMI.

We observed a large heterogeneity in our intervention effect between the schools. School characteristics could explain the variation on intervention effects among pairs. Speed agility decreased significantly more in pairs with larger size schools. As size of secondary schools is associated with higher academic achievements (166), children from a larger sized school might have a comparative advantage and respond better to the intervention. Educational classes were an important activity in this trial and the uptake of information could have been better in larger schools. Larger sized schools also typically provide more extracurricular activities (166). In Cuenca, such extra activities are dedicated to sports and physical activity. Vertical jump on the other hand only improved significantly in school pairs that had both male and female students. Physical activity in adolescents is subjected to peer influence (167). A recent study reported that physical activity of male adolescents was associated with that of their female peers, while female physical activity was associated with physical activity of their male and female peers (168). We therefore hypothesize that physical activity as well as physical fitness in female adolescents are mainly associated with the presence of males rather than the female peers in schools. Space available for physical activity during recess did not influence the effects of our intervention on physical activity or physical fitness except for the flamingo balance test. This finding is promising for schools with limited space available. We hypothesize that the limited space in school with <4.07 students/m² triggered the adolescents to engage in static games that improve the

balance component of fitness (153). Also, our results indicate that a higher proportion of adolescents from schools with a half-day class schedule met the recommendations of 60 min physical activity per day compared to those from schools with a full day schedule. Probably, adolescents in schools with a half day schedule had more time to meet the recommendations for time spent on physical activity compared to schools with a full day schedule, as schools with a half day usually have teaching sessions of 45 min with a recess of 35 min while schools with full day schedule have classes of 35 min and a recess of 30 min. However, as the trial was not designed to analyze the moderating effects of the school characteristics on the intervention effects, the explanations for these effects are speculative. In addition, we acknowledge a large variation of the effect in the pairs that was not explained by the recorded school characteristics, which merits further consideration in future trials.

This study has important strengths. First, we delivered a comprehensive intervention aimed at promoting both diet and physical activity. A second strength is the duration of our program, which is longer than most trials on the topic. Finally, the third strength is the comprehensive assessment of physical fitness. Most studies evaluate only a few physical fitness components (41). We think the intervention was successful as it was new and responded to a latent need for activities that address healthy lifestyles. The children and parents valued the practical nature of the recommendations and simplicity of the messages.

A limitation of this study is the large and unbalanced dropout. Frequently changing school is common in Ecuador. Children who were lost to follow-up were similar to their peers at baseline and the missing data analysis showed no major differences. One school in the control group had an exceptionally high dropout rate (12%) associated with overall very

poor academic performance and drug misuse. The assessment of physical activity in a subsample is an additional limitation. Although we blinded staff that measured outcomes to the allocation of the schools, we cannot rule out that they observed elements of the interventions such as the posters or the walking trail. We could only assess the use of the walking trail in two schools due to logistical constraints. Although our results are encouraging for school interventions in LMICs, our findings are both mixed and modest. The findings were also not consistent over the outcomes. In addition, the findings for the 20m shuttle run and bent arm hang should be interpreted with caution since a post-hoc analysis showed a statistical power of 64% and 65% for these outcomes respectively.

The trial included 13% of adolescents between 8th and 9th grade from urban schools in Cuenca that is characterized by mixed *mestizo* ethnicity and its high altitude. Further generalization of our findings is hence limited to urban schools in the regions that share these characteristics (146).

Conclusion

In conclusion, a comprehensive school-based program to improve diet and physical activity can improve physical fitness in adolescents from urban area of LMICs and can minimize the decline in physical activity levels during early adolescence.

5 The effect of the school-based intervention program “ACTIVITAL” on screen-time of Ecuadorian adolescents: randomized controlled trial

Redrafted from: *Andrade, S., Verloigne, M., Cardon, G., Kolsteren, P., Ochoa-Avilés, A., Verstraeten, R., Donoso, S., Lachat, C. (2015) School-based intervention on healthy behaviour among Ecuadorian adolescents: effect of a cluster-randomized controlled trial on screen-time. BMC Public Health, 15:11.*

Abstract

Background: Effective interventions on screen-time behaviors (television, video games and computer time) are needed to prevent NCDs in LMICs. The present chapter investigates the effect of a school-based health promotion intervention on screen-time behavior among Ecuadorian adolescents. We report the effect of the trial on screen-time after the 2 stages of implementation.

Methods: We performed a cluster-randomized pair matched trial in urban schools in Cuenca-Ecuador. Participants were adolescents of grade 8 and 9 (mean age 12.8 ± 0.8 years, $n=1370$, control group $n=684$) from 20 schools (control group $n=10$). The intervention was developed using the Intervention Mapping protocol and Comprehensive Participatory Planning and Evaluation. The program included an individual and environmental component. The first intervention stage focused on diet, physical activity and screen-time behavior, while the second stage focused only on diet and physical activity. Screen-time behaviors, primary outcome, were assessed at baseline, after the first (18 months) and second stage (28 months). Mixed linear models were used to analyze the data.

Results: After the first stage (data from $n=1224$ adolescents; control group $n=608$), the intervention group had a lower increase in TV-time on a week day ($\beta = -15.7$ min; $P=0.003$) and weekend day ($\beta = -18.9$ min; $P=0.005$), in total screen-time on a weekday ($\beta = -25.9$ min; $P=0.03$) and in the proportion of adolescents that did not meet the screen-time recommendation ($\beta = -4$ percentage point; $P=0.01$), compared to the control group. After the second stage (data from $n=1078$ adolescents; control group $n=531$), the TV-time on a weekday ($\beta = 13.1$ min; $P=0.02$), and total screen-time on a weekday ($\beta = 21.4$ min; $P=0.03$) increased more in adolescents from the intervention group. No adverse effects were reported

Conclusion: A multicomponent school-based intervention led to a lower increase in adolescents' television time and total screen-time during the first stage when the intervention included specific activities to decrease screen-time. After these intervention strategies finished, adolescents increased the screen-time again. These findings suggest that including screen-time activities on interventions improves the screen time behaviors among adolescents and that focusing on physical activity alone is not enough to sustain the intervention effects.

5.1 Introduction

Adolescents who spend more than 2 hours/day in screen-time behavior (television (TV) viewing, computer use and playing video games) are more likely to have unfavorable body composition, low fitness (169) and a decreased academic achievement (34). Despite this, in Latin-America the prevalence of spending more than 2hours/day on screen-time behaviors among adolescents exceeds 50% in most of the countries (28, 170, 171).

School-based interventions have been developed to decrease screen-time (172) and resulted in a significant but small decrease in screen-time among adolescents (52). Interventions that aimed to improve either physical activity or screen-time have reported inconsistent (42, 160, 173) or marginal effects (173, 174) on screen-time. Studies that focused both on physical activity and screen-time behaviors have shown a modest effect on screen-time behaviors (161, 175-178). Most of these studies however, are conducted in high-income countries (42, 179). To our knowledge, studies on screen-time from low- and middle-income countries, including Latina American countries, are mainly observational, underpowered or with a short follow-up period (34, 52).

The previous results (**Chapter 4**) showed that the ACTIVITAL program was able to improve physical fitness and minimize the decline in physical activity. However, the interventions effect on the screen-time (television (TV) viewing, computer use and video games playing) behavior have not yet been reported. The school-based intervention program ACTIVITAL was delivered in two different stages. The first stage focused on diet, physical activity as well as screen-time behavior and the second stage only focused on diet and physical activity. Given the differences in implementation focus, we investigated the

effect on screen-time behavior after each stage. We also assess the overall intervention effect after the whole period of the intervention.

5.2 Methods

In the present chapter we used the following data: i) the screen-time behaviors which was measured by means of a questionnaire, ii) the BMI calculated by using the data of height and weight and iii) socio economic status measured by means of a questionnaire. The data of screen-time behaviors collected at baseline, after 18 and 28 months were used for the analyses. The methodology details were described previously (**Chapter 2.2**).

Screen-time outcomes

In the present chapter, we report the intervention effect for the following screen-time outcomes: i) time spend on watching TV, playing videogames and using the computer on a week- and weekend day separately, ii) the total amount of screen-time on a week- and on a weekend day which was calculated by summing the time spent watching TV, playing videogames and using computer on a week- and on a weekend day, and iii) the proportion of adolescents that spend more than two hours on an average day on screen-time behaviors (average day = $((\text{total screen-time on a week day} * 5) + (\text{total screen-time on a weekend day} * 2)) / 7$). All outcomes were considered as continuous variables. We assessed time spent watching TV, playing videogames or using the computer as these are preferred sedentary behaviors for the Ecuadorian adolescents (95). Reporting the three screen-time activities separately allows to investigate if a possible decrease in one activity is not compensated by an increase in another activity. (172). In addition, we analyzed the intervention effect on weekend days separately because young people have a different time structure during a weekday compare to a weekend day (180). Finally, we reported the total screen-time and

the proportion of adolescents who did not reach the international recommendation of screen-time (<2h/day). Using the limit of 2 hour/day for screen-time behavior is advisable since the literature showed that >2 hours/day is associated with an unfavorable body composition, low fitness (169), aggressive or violent behaviors (181) and a higher likelihood of metabolic syndrome in adolescents (101).

Statistical analysis

Data were analyzed using Stata (version 12.0, Stata Corporation, Texas, USA). The baseline characteristics were expressed as means (standard deviation) accounting for cluster design (“svy” Stata command) and in percentages.

Multilevel mixed models with a significance level of 5% were used to assess the baseline differences (crude models) and intervention effects (full models) on screen-time. Intention-to-treat analysis was performed to assess the intervention effect on the overall period of the trial and after both first and second intervention stage. The fixed part of the full mixed models included the baseline covariates BMI z-score, socio economic status and gender, while the pair matching and subject were assigned as a random part of the model. The Akaike-Schwartz criteria were used to determine the optimal covariance structure and a likelihood ratio test was used to compare the fit of the models. To assess the effect of the adjusting we also analyzed the intervention effect using crude models. The reported intervention effect corresponds to the difference in means for continuous dependent variables. For the dichotomous variables it represents the difference in absolute risks (149) after the different stages of the intervention.

The mixed model that analyzed the intervention effect after 28 months included the variable “time” and the interaction term “time X group of allocation” as covariates. The variable

“time”, measured in months, was the specific time when each observation was collected i.e. it varies from 0 to 31.6. In addition, “time” was added as a random slope at level of the measurement. The beta coefficient of interaction term “time X group of allocation” represents the intervention effect on the outcome over a unit of time (month) (182). To obtain the intervention effect, the beta coefficient was multiplied by 28 as this was the mean time of measure at second follow-up. The overall intervention effect was analyzed considering the three points of measurements. We equally analyzed the intervention effect considering only the baseline and last follow-up measurements to obtain a complete understanding of the variation of the data after 28 months.

A mixed model with spline regression was used to analyze the intervention effect by stage, this technique allows to fit multiple linear models to the data for different ranges of time (182). The knot (the point of time where the slope of the linear function change) was set at 18 months since it was the mean time of measurements at first follow-up. The Stata command “mkspline” allows performing the spline regression by means of creating two auxiliary variables, “time1” and “time2”, based on the knot and the values of variable “time”. The auxiliary variables time1 is equal to variable “time” when “time”<18 and equal 18 when “time”>18, while “time 2” is equal to zero when “time” is <18 and equal to “time”-18 when “time”>18. The variables time1, time2 were added as covariates and as a random slopes. The interaction terms “time1 X group of allocation” and “time2 X group of allocation” were added as covariates. The beta coefficient of interaction terms “time1 X group of allocation” and “time2 X group of allocation” represent respectively the intervention effect over a unit the time (months) during the first and second stage of intervention. To obtain the intervention effect after stage 1 and stage 2, the beta coefficients were multiplied by 18 or 10 respectively as these were the mean time of measures at first and second follow-up.

5.3 Results

Descriptive statistics

In total, 1370 adolescents (control group n=684) from 20 schools (control group n=10) completed the screen-time questionnaires at baseline (mean age 12.8 ± 0.8 years old, 62.4% girls, mean BMI z-score 0.31 ± 1.05). The time spent watching TV, playing videogames or using the computer and the total screen-time on a weekday and weekend day was not significantly different between the intervention and control group at baseline. At 18 and 28 months of follow-up, 1228 (mean age 14.3 ± 0.8 years old, 62.4% girls) and 1078 (mean age 15.2 ± 0.8 years old, 63.2% girls) adolescents completed the questionnaire respectively. No school left the trial. The means (SD) of all screen-time behaviors at baseline and at the two follow-ups are shown in **table 5.1**. The percentage of adolescents who spend more than 2 hours/day on screen-time behavior increased from 66% at baseline to 92% after 28 months in control groups, while in the intervention groups it increased from 69% to 90%. Mean screen-time at baseline was lower compared to that of the two follow-ups (all P-values < 0.001 data no show).

Table 5.1 Average time spent on watching television, playing videogames and computer use by week and weekend day among Ecuadorian adolescents through the implementation of ACTIVITAL program *

Screen-time	Baseline		After 18 months		After 28 months	
	Intervention (n=686)	Control (n=684)	Intervention (n=616)	Control (n=608)	Intervention (n=547)	Control (n=531)
	mean (SD)	mean (SD)	mean (SD)	mean (SD)	mean (SD)	mean (SD)
TV on a weekday (min/day)	100.10 (81.13)	98.20 (86.01)	117.61 (90.11)	128.39 (96.73)	126.36 (96.67)	122.09 (99.14)
TV on a weekend day (min/day)	162.90 (109.23)	162.06 (112.33)	179.12 (113.93)	196.57 (116.22)	181.26 (119.27)	190.00 (114.02)
Video games on a weekday (min/day)	14.13 (34.17)	15.39 (42.69)	18.46 (46.41)	20.08 (47.82)	26.93 (67.99)	20.90 (46.04)
Video games on a weekend day (min/day)	34.50 (62.74)	36.18 (67.33)	45.63 (81.02)	50.83 (83.52)	47.71 (83.80)	50.56 (81.68)
Computer on a weekday (min/day)	50.86 (53.83)	51.67 (62.95)	101.41 (86.77)	98.58 (87.58)	133.00 (107.25)	122.26 (100.95)
Computer on a weekend day (min/day)	52.17 (71.7)	55.26 (75.74)	112.94 (103.46)	118.38 (110.07)	142.82 (117.92)	142.49 (114.63)
Total screen-time on a weekday (min/day)	165.09 (115.07)	165.26 (132.45)	237.32 (151.62)	246.36 (153.15)	286.29 (184.67)	265.25 (164.85)
Total screen-time on a weekend day (min/day)	249.58(171.27)	253.51(181.98)	337.69(206.27)	365.78(209.09)	371.79 (214.91)	383.05 (211.68)
Percentage of adolescents who exceed 120 min/day on screen-time behaviors	68.9%	66.5%	86.3%	89.2%	89.6%	91.7%

* Standard deviation adjusted for clustering
TV: Television

Overall intervention effect

The overall intervention effect through the three time points of measurements was significant for TV time ($\beta=-14.8$ min, $P=0.02$) and total screen-time ($\beta=-25$ min, $P=0.03$) on a weekend day. This means that the change in TV time and total-screen time on a weekend day significantly differed between adolescents from the intervention group and adolescents from the control group (**Figure 5.1 to 5.3, Table 5.2**). To investigate this difference in the change in TV time and screen-time between adolescents from the intervention and the control group, we investigated the intervention effect between each two measurements (see below).

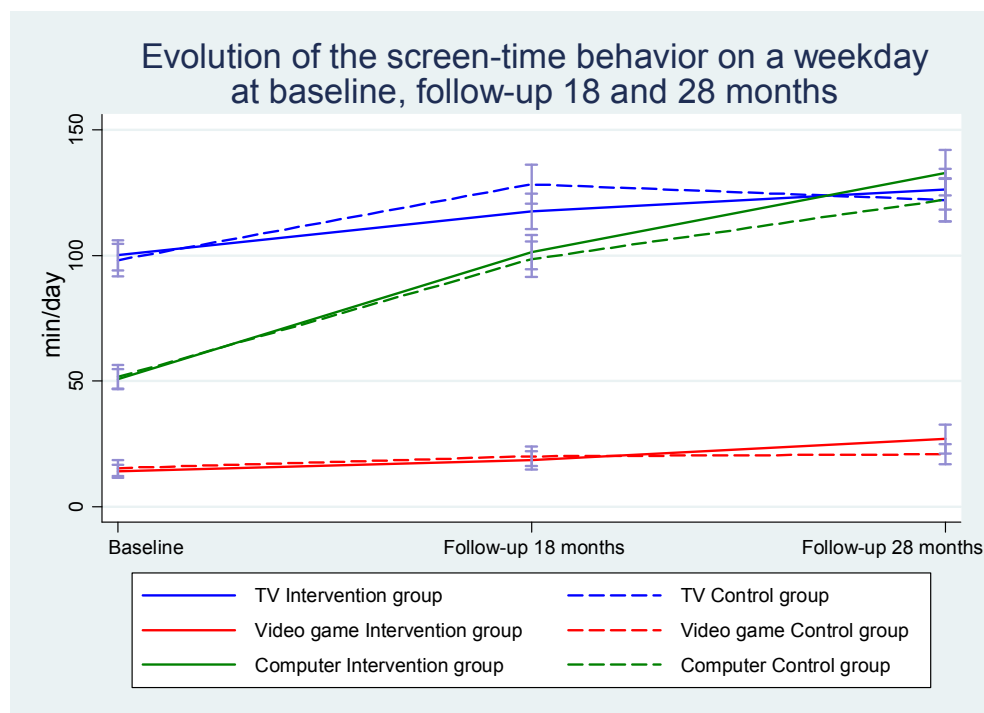


Figure 5.1 Evolution of screen-time behaviors on a week day

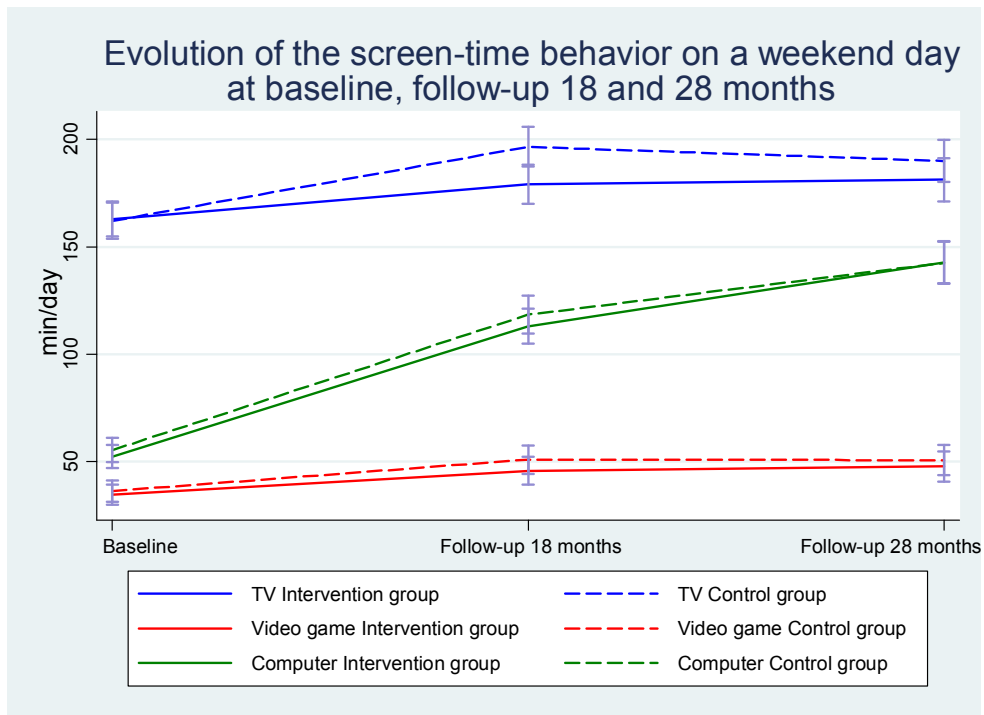


Figure 5.2 Evolution of screen-time behaviors on a weekend day

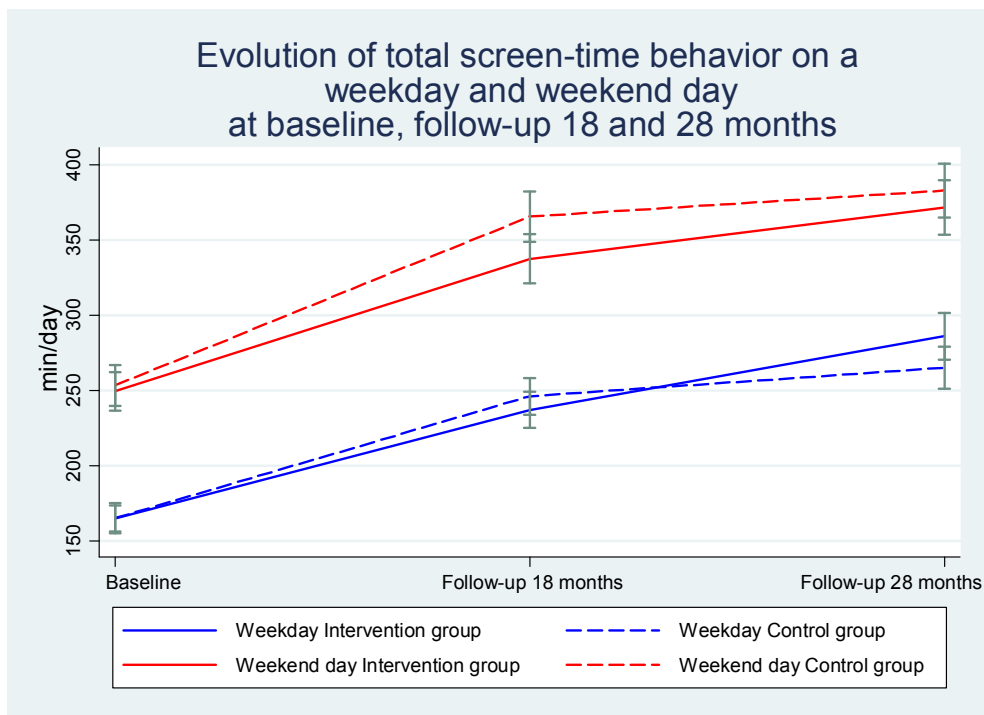


Figure 5.3 Evolution of total screen-time behaviors on a week and weekend day

Overall intervention effect

Throughout the three measurements, the change in TV time ($\beta=-14.8$ min, $P=0.02$), total screen time on a weekend day ($\beta=-25$ min, $P=0.03$) and the proportion of adolescents that did not reach the recommended screen-time ($\beta=-6$ percentage point, $P=0.01$) were significantly different between adolescents from the intervention and control group (**Table 5.2**). To further investigate these changes and directions, we report the intervention effect after stage 1 and 2 (see below).

Intervention effect between 0 and 18 months (first stage of the intervention)

TV time on a weekday ($\beta = -15.7$ min; $P=0.003$) or weekend day ($\beta = -18.9$ min; $P=0.005$), total screen-time on a weekend day ($\beta = -25.9$ min; $P=0.03$) and the proportion of adolescents that did not meet the screen-time recommendation ($\beta = -4$ percentage point; $P=0.01$) increased less in the intervention group compared to the control group after 18 months (**Table 5.2**).

Intervention effect between 18 and 28 months (second stage of the intervention)

There was a significant intervention effect for TV on a weekday ($\beta= 13.1$ min; $P=0.02$). For this outcome the intervention effect was in favor to the control schools. TV time on a weekday increased in the intervention group while it decreased in the control schools. In addition, total screen-time on a weekday ($\beta = 21.4$ min; $P=0.03$) increased more in the intervention schools compared to the control schools (**Table 5.2**).

Intervention effect between 0 and 28 months

There was no difference in the change in screen-time behavior between baseline and second follow-up between adolescents from intervention and control schools (**Table 5.2**).

Sensitivity analysis

Results from unadjusted and adjusted models differed only for one outcome, the proportion of adolescents that did not meet the screen-time recommendation. For this outcome the intervention effect on the first stage changed from significant ($\beta = -4$ percentage point; $P=0.01$) to non-significant ($\beta = -5$ percentage point; $P=0.06$) for unadjusted model. While, when baseline and second follow-up were only considered the proportion of adolescents that did not meet the screen-time recommendation changed from non-significant ($\beta = -5$ percentage point; $P=0.06$) to significant ($\beta = -6$ percentage point; $P=0.02$) for unadjusted model (**Table 5.3**).

Table 5.2 Intervention effect on screen-time per intervention stage and the whole intervention period

Screen-time	Intervention effect after first intervention stage (0 to 18 months) ^a		Intervention effect after second intervention stage (18 to 28 months) ^a		ICC ^c	Intervention effect considering baseline and last follow-up measurements ^d			Overall intervention effect considering three measurements ^e		
	β [95% CI]	P ^b	β [95% CI]	P ^b		β [95% CI]	P ^b	ICC ^c	β [95% CI]	P ^b	ICC ^c
TV on a weekday (min/day)	-15.66 [-26.1, -5.22]	0.003	13.10 [2.00, 24.20]	0.02	0.08	-2.52 [-13.44, 8.68]	0.66	0.07	-7.84 [-17.92, 2.52]	0.14	0.08
TV on a weekend (min/day)	-18.90 [-32.04, -5.58]	0.005	9.80 [-4.50, 24.10]	0.18	0.00	-10.36 [-23.8, 2.8]	0.12	0.00	-14.84 [-27.44, -2.52]	0.02	0.00
Video games on a weekday (min/day)	-0.72 [-5.94, 4.32]	0.76	5.90 [-1.00, 12.80]	0.10	0.00	5.88 [-0.84, 12.6]	0.08	0.00	3.92 [-1.68, 9.52]	0.18	0.00
Video games on a weekend day (min/day)	-1.80 [-10.44, 6.84]	0.68	0.30 [-9.20, 9.70]	0.96	0.01	-3.08 [-11.76, 5.6]	0.50	0.01	-2.80 [-10.64, 5.32]	0.52	0.01
Computer on a weekday (min/day)	1.80 [-8.64, 12.24]	0.74	3.10 [-8.10, 14.20]	0.59	0.08	3.92 [-8.4, 16.52]	0.52	0.06	4.48 [-7.84, 16.8]	0.48	0.07
Computer on a weekend day (min/day)	-3.42 [-16.38, 9.54]	0.60	0.30 [-12.70, 13.30]	0.96	0.08	-6.44 [-20.72, 7.84]	0.37	0.07	-5.04 [-19.32, 8.96]	0.48	0.07
Total screen-time on a weekday (min/day)	-14.22 [-30.78, 2.52]	0.10	21.40 [2.10, 40.70]	0.03	0.04	7.22 [-12.88, 27.44]	0.48	0.03	0.56 [-17.64, 19.04]	0.95	0.03
Total screen-time on a weekend day (min/day)	-25.92 [-48.96, -3.06]	0.03	9.60 [-14.40, 33.60]	0.43	0.02	-22.42 [-47.04, 2.24]	0.07	0.02	-25.20 [-47.88, -2.8]	0.03	0.02

^a The spline regression was used to assess the effect of intervention effect over the time. The knot was the mean time for the first follow-up (18 months)

^b The models were adjusted by adolescents' BMI z-score, socio-economic status and gender.

^c Intraclass correlation coefficient

^d The multilevel modeling included the measurements at baseline and follow-up at 28 months

^e The multilevel modeling included the measurements at baseline, follow-up at 18 months and follow-up at 28 months

TV: Television

Table 5.3 Unadjusted models for intervention effect on screen-time per intervention stage and the whole intervention period

Screen-time	Intervention effect after first intervention stage (0 to 18 months) ^a		Intervention effect after second intervention stage (18 to 28 months) ^a			Intervention effect considering baseline and last follow-up measurements ^d			Overall intervention effect considering three measurements ^e		
	β [95% CI]	P ^b	β [95% CI]	P ^b	ICC ^c	β [95% CI]	P ^b	ICC ^c	β [95% CI]	P ^b	ICC ^c
TV on a weekday (min/day)	-14.81 [-25.09, -4.52]	0.005	11.96 [1.08, 22.84]	0.03	0.08	-3.00 [-13.72, 16.35]	0.58	0.07	-7.84 [-17.95, 2.27]	0.13	0.08
TV on a weekend (min/day)	-18.32 [-31.45, -5.18]	0.006	9.93 [-6.2, 26.06]	0.23	0.00	-10.22 [-23.24, 3.44]	0.12	0.00	-15.15 [-27.33, -2.97]	0.02	0.00
Video games on a weekday (min/day)	-1.89 [-7.07, 3.28]	0.47	5.96 [-0.77, 12.68]	0.08	0.03	5.068 [-1.68, 3.95]	0.14	0.03	2.80 [-3.22, 8.79]	0.36	0.03
Video games on a weekend day (min/day)	-6.08 [-14.89, 2.72]	0.18	1.51 [-7.79, 10.81]	0.75	0.04	-5.18 [-14.28, 7.42]	0.27	0.04	-6.50 [-15.01, 2.04]	0.13	0.05
Computer on a weekday (min/day)	2.52 [-7.85, 12.89]	0.63	2.16 [-8.89, 13.21]	0.70	0.09	3.00 [-9.24, 17.67]	0.63	0.07	4.48 [-7.78, 16.74]	0.48	0.08
Computer on a weekend day (min/day)	-4.19 [-17.03, 8.64]	0.52	0.73 [-12.14, 13.6]	0.91	0.09	-6.50 [-20.72, 10.30]	0.37	0.08	-5.38 [-19.43, 8.65]	0.45	0.08
Total screen-time on a weekday (min/day)	-13.45 [-29.81, 2.92]	0.11	19.3 [0.4, 38.21]	0.05	0.04	5.15 [-14.56, 17.02]	0.61	0.03	-0.64 [-18.68, 17.39]	0.94	0.03
Total screen-time on a weekend day (min/day)	-30.42 [-53.17, -7.69]	0.01	11.97 [-11.54, 35.47]	0.32	0.02	-23.24 [-47.60, 1.74]	0.06	0.02	-28.42 [-50.74, -6.10]	0.01	0.02

^a The spline regression was used to assess the effect of intervention effect over the time. The knot was the mean time for the first follow-up (18 months)

^b The models were not adjusted.

^c Intraclass correlation coefficient

^d The multilevel modeling included the measurements at baseline and follow-up at 28 months

^e The multilevel modeling included the measurements at baseline, follow-up at 18 months and follow-up at 28 months

TV: Television

5.4 Discussion

The present chapter reported the effect of a comprehensive school-based health promotion intervention on screen-time on Ecuadorian adolescents. The results showed that the change over the three measurement periods in TV time, total screen-time and the proportion of adolescent who did not reach the screen-time recommendation differed between adolescents from the intervention and control schools. To fully understand the direction of this change and since the two intervention stages had a different focus, we specifically looked at the effect after the first and the second stage. In general the intervention effect after the first stage was in favor of the adolescents in the intervention group, while in the second stage the intervention effect was in favor of the adolescents in the control group. If we compared the screen-time behavior at baseline and the second follow-up measurement, there was no difference in the change in screen-time between the two groups.

After the first stage of the intervention, adolescents from the intervention schools had a smaller increase in TV time and total screen-time behaviors compared to the adolescents from the control schools. The proportion of adolescents that reached the screen-time recommendation decreased significantly less in the intervention group. Previous studies have shown that as adolescents get older, they spend more time in front of a screen (183). Our findings suggest that the intervention program was able to mitigate the increase in adolescents' TV and screen-time. These positive results could be a result of the program's emphasis on decreasing screen-time behavior with a particular focus on TV time during the first stage of the intervention program. Our positive results are in line with other school-based intervention programs focusing on different health behaviors including screen-time behavior (161, 176, 177), namely The Planet Health (161) and the DOiT (176) program. Both interventions aimed to improve dietary, physical activity and screen-time behaviors, and implemented an individual classroom-based intervention. The Planet Health did not

implement the environmental component in contrast to DOiT program and our intervention. Our findings hence confirm that focusing on screen-time behavior in combination with other health behaviors might result in an effect on screen-time (42).

During the second stage, we did not observe the positive effect on adolescents' screen-time anymore. Indeed, in contrast to the first stage, adolescents from the intervention schools had a higher increase in TV time and total screen-time than adolescents from the control schools in the course of the second stage. This could be attributed to two facts. Firstly, due to intervention, adolescents on the intervention group could be more aware of the time that they spend on the screen behaviors compared to the adolescents on the controls group. Second, during the second stage of the program, the intervention contained no specific strategies on the reduction of screen-time behaviors (42), and focused essentially on improving diet and physical activity. Therefore, our results might indicate that promoting physical activity does not necessarily leads to an improvement in sedentary behaviors like screen-time activities among adolescents.

The initial slower increase of screen-time for the adolescents from the intervention school after stage 1 was followed by a stronger increase of screen-time. As a result there was no difference in the intervention effect on screen-time when only the baseline and second follow-up measurement were considered. This means that there was an effect on screen-time when the intervention included activities focused on screen-time, but when the intervention is focused on other health behaviors, adolescents returned to their old behavior. This could be due to the fact that screen-time behavior has a strong habitual nature that is difficult to change (172). Therefore, a continuous focus on the reduction of screen-time behavior might be required. In Ecuadorian adolescents specifically, the topic of reducing screen-time behavior for health is new and requires continuous attention.

The positive intervention effects after the first stage of the intervention on TV time are relevant as watching TV is the preferred leisure-activity for Ecuadorian adolescents (95). In addition, TV time represents one-third of the sedentary time of a typical adolescent, and those who watch more TV are more likely to have unhealthy dietary patterns (184) and lower self-esteem (34). We did not find differences on the time spent on playing video games or a using computer between the adolescents from the intervention and control groups over the whole period. We attribute this result to the fact that the intervention program did not include specific strategies to decrease the time spent on playing video games or using computer. Also, the findings suggest that there was no compensation phenomenon i.e. the time decreased for TV time was not allocated to other screen-time behaviors.

Finally, we found that in the present study 67% of all adolescents spend more than 2 hours/day on screen-time at baseline, and that this percentage increased during the adolescents' transition from 12 to 14 years (up to 87%). After 28 months, the percentage increased up to 92%, therefore it is important to put continuous effort in developing intervention programs aiming to reduce screen-time in adolescents in Latin-America.

The present study has several strengths. First, to our knowledge this is the first study that reports the effect of a school-based health promotion intervention program on screen-time behaviors among adolescents from a low- or middle-income country. Second, the sample size is relatively large, considering that most (70%) of the similar studies have less than 500 participants (172). Third, the duration of our intervention was longer than other comparable intervention studies (172). The study has some limitations that need to be acknowledged. First, screen-time was self-reported and could be subject to social desirability. A second limitation was that the results of the present manuscript are limited

to the populations with similar characteristics to Ecuadorian adolescents i.e. mixed *mestizo* ethnicity and living in urban areas at high altitude.

Conclusion

The ACTIVITAL program, a school-based intervention aimed at promoting healthy diet, physical activity and screen-time behavior, could be able to mitigate the increase in adolescents' TV time and total screen-time. The effect was observed mainly after the first stage of the intervention, which focused on decreasing screen-time behavior. However, after the intervention strategies for reducing screen-time behavior finished, the adolescents from the intervention group increased the screen-time again.

6 The effect of the school-based intervention program “ACTIVITAL” on fitness and physical activity among Ecuadorian adolescents according to the weight and fitness status: subgroup analysis of the randomized controlled trial

Redrafted from: *Andrade S, Lachat C, Cardon G, Ochoa-Aviles A, Verstraeten R, Van Camp J, Ortiz J, Ramirez P, Donoso S, Kolsteren P. (2015) Two years of school-based intervention program could improve the physical fitness among Ecuadorian adolescents at health risk: subgroups analysis from a cluster-randomized trial. (Under 2nd revision) BMC Pediatrics.*

Abstract

Background: Adolescents with overweight and poor physical fitness have an increased likelihood of developing cardiovascular diseases during adulthood. In Ecuador, a health promotion program improved the muscular strength and speed-agility, and reduced the decline of the moderate-to-vigorous physical activity of adolescents after 28 months. We performed a sub-group analysis to assess the differential effect of this intervention in overweight and low-fit adolescents.

Methods: We performed a cluster-randomized pair matched trial in schools located in Cuenca – Ecuador. In total 20 schools (clusters) were pair matched, and 1440 adolescents of grade 8 and 9 (mean age of 12.3 and 13.3 years respectively) participated in the trial. For the purposes of the subgroup analysis, the adolescents were classified into groups according to their weight status (body mass index) and aerobic capacity (scores in the 20m shuttle run and FITNESSGRAM standards) at baseline. Primary outcomes included physical fitness (vertical jump, speed shuttle run) and physical activity (proportion of students achieving over 60 minutes of moderate-to-vigorous physical activity / day). For these primary outcomes, we stratified analysis by weight (underweight, normal BMI and overweight/obese) and fitness (fit and low fitness) groups. Mixed linear regression models were used to assess the intervention effect.

Results: The prevalence of overweight/obesity, underweight and poor physical fitness was 20.3%, 5.8% and 84.8% respectively. A higher intervention effect was observed for speed shuttle run in overweight ($\beta=-1.85$ s, $P=0.04$) adolescents compared to underweight ($\beta=-1.66$ s, $P=0.5$) or normal weight ($\beta=-0.35$ s, $P=0.6$) peers. The intervention effect on vertical jump was higher in adolescents with poor physical fitness ($\beta=3.71$ cm, $P=0.005$) compared

to their fit peers ($\beta=1.28\text{cm}$, $P=0.4$). The proportion of students achieving over 60 minutes of moderate-to-vigorous physical activity / day was not significantly different according to weight or fitness status.

Conclusion: Comprehensive school-based interventions that aim to improve of diet and physical activity could improve speed and strength aspects of physical fitness in low-fit and overweight/obese adolescents.

6.1 Introduction

Overweight and lack of physical fitness in adolescence are independent risk factors for the development of non-communicable diseases (NCDs) throughout the life course (24, 32, 185, 186). Overweight adolescents are on average 1.5 times more likely to develop type II diabetes, hypertension and an abnormal lipid profile during adulthood. Only recently, adolescents with low fitness levels are considered as a public health issue as their low fitness levels are significantly related with unhealthy cardiovascular performance, muscle mass losses, adipose tissue increase, decreased insulin response and sensitivity, and low bone mineral density in adulthood (32).

NCD prevention strategies such as school-based interventions, are particularly important since these are feasible and relatively inexpensive approaches that reach out to large populations with a wide range of BMIs or fitness abilities. School-based interventions involving both the individual and environmental components have shown small to moderate effects for the prevention of overweight and low-fitness in adolescents (38-41). However, to our knowledge little to nothing is known about the effect of these school-based interventions in groups of adolescents with a high health risk, like overweight / obese and low-fit adolescents. Current research on the topic is focused on the 6 to 12 year age group from high-income countries (159, 187-192). In LMICs the evidence on the effectiveness of school based interventions for the prevention of overweight and low-fitness is limited and specifically scarce regarding to its effect modification on high-risk groups such as overweight/obese and low-fit adolescents (32, 187-192).

The previous chapter (**Chapter 4**) reported that a multicomponent (individual combined with environmental) intervention program applied to a sample of adolescents with a wide range of BMIs and fitness abilities, was able to improve some components of physical fitness (muscular strength and agility) and minimize the decline in physical activity levels among adolescents (193). In the present chapter we assessed if the adolescents in high-risk groups, specifically those overweight/obese and low-fit, responded differently to the intervention compared to their peers in lower risk groups in terms of physical fitness (speed shuttle run and vertical jump) and physical activity (the proportion of adolescents who met the recommended 60 min of moderate to vigorous physical activity per day).

6.2 Methods

In line with the previous literature (194), in the present chapter we applied the subgroup analyses for the outcomes for which our intervention program showed an effect in favor to the intervention group, these were vertical jump, speed shuttle run and the proportion of adolescents who reach the recommendation of 60 min of MVPA (**Chapter 4**). We did not consider the outcomes of screen-time behaviors in this subgroup study since for these outcomes the overall intervention effect included 3 points of measurements in contrast to the fitness and physical activity measurements which include 2 point of measurements. However, the screen-time outcomes will be included in a posterior article which include diet outcomes measured in 3 points. In addition, this chapter uses the data of BMI, socio-economic status and 20 m shuttle run (one test of fitness battery). The details of methodology were presented on the **chapter 2.2**.

Procedure to classify adolescent into the BMI and fitness groups

For the purpose of this chapter, we classified adolescents into groups according to their BMI and aerobic capacity scores in the 20m shuttle run at baseline. The BMI groups were normal weight, underweight and overweight/obese (called “overweight”) and were defined according to IOTF criteria (112).

The fitness groups “fit” and “low fitness”, were generated based on the results from the 20m shuttle run test at baseline using the FITNESSGRAM standard. This standard was explained previously **Chapter 2.1**.

Statistical analysis

All analyses were performed on an intention-to-treat basis at individual level. The baseline characteristics by group were presented as means with standard deviation (SD) or percentage (%). In the BMI and fitness groups we tested the differences in characteristics at baseline between categories by χ^2 test and two-sample t-test, accounting for cluster design by using the STATA (command svy).

The intervention effect was analyzed using a mixed model with the pair-matching as the random factor. In such models, the Beta coefficient (β) of the intervention variable indicates the difference in means for continuous dependent variables and the difference in absolute risks for dichotomous ones (149). We assessed whether the intervention effect varied according to BMI or fitness status by including the interaction terms BMI categorical x intervention allocation or fitness categorical x intervention allocation in the model.

All models were adjusted for gender, socio economics status and the corresponding interaction terms with intervention allocation. The model for BMI was also adjusted for fitness categorical and fitness categorical x intervention allocate, while the model for fitness was also adjusted for BMI and BMI x intervention allocation. The covariates included in the models were used as they were considered confounders. The interaction terms between covariates and intervention allocation were used to check for independent of the associations between covariates (195). We stratified the analysis and compared the intervention effect within BMI or fitness status when the corresponding interaction term was significant based on a threshold of P-value of interaction (P_i) <0.1(195).

As a sensitivity analysis, we repeated all tests without adjusting for variables at the individual level. In addition, to estimate the effect of missing data on outcomes that were significant different among BMI or fitness status (P_i <0.1) we repeated the analyses after imputing missing data. Multiple imputations were done under the missing at random assumption and using the chained equation models with 50 runs of imputations. The predictors for the regression model for imputations were gender, BMI z-score, age and socio economic status at baseline since they could influence the outcome.

All statistical tests were two-sided with a statistical significance level at 5%. Stata software (version 12.0 IC, Stata Corporation, Texas, USA) was used to perform all analyses.

6.3 Results

Baseline differences

The baseline prevalence of overweight was 20.3% (including 3.4% of obese) and the underweight was 5.8%. The largest share of the sample (84.8%) of the adolescents were classified into the low-fit group. Between BMI groups, the comparable baseline characteristics were female proportion, and the proportion of adolescents who meet the PA recommendation (**Table 6.1**). Whilst for fitness groups, only age, proportion of poor and the proportion of adolescents who meet the PA recommendation were comparable (**Table 6.2**).

Table 6.1 Baseline characteristics by BMI status (normal weight, underweight and overweight) *

	P ^b	All	Normal weight			Underweight			Overweight		
			n	Control Mean (SD)	Intervention Mean (SD)	n	Control Mean (SD)	Intervention Mean (SD)	n	Control Mean (SD)	Intervention Mean (SD)
Age	0.04	1292	12.91(0.82)	12.80(0.75)	1014	13.05 (0.84)	12.89 (0.84)	79	12.77(0.78)	12.75(0.79)	278
Body mass index (kg/m ²)	<0.001	1292	18.79(1.67)	18.79(1.65)	1014	15.51 (0.83)	15.20 (0.73)	79	24.24(2.04)	24.90(2.81)	278
Body mass index Z-score	<0.001	1292	0.06(0.64)	0.07(0.68)	1014	-1.66 (0.40)	-1.80 (0.43)	79	1.73(0.43)	1.84(0.52)	278
Low socio economic status (%)	0.03	1240	34.56	32.78	971	29.41	41.46	75	26.36	25.00	269
Female proportion (%)	0.78	1292	58.30	66.73	1014	61.76	60.00	66	58.52	68.53	278
Fitness (EUROFIT)											
<i>Speed-agility</i>											
Speed shuttle run (s)	<0.001	1257	24.37(2.14)	24.44(2.28)	987	24.52 (2.82)	23.86 (2.80)	76	25.16(2.08)	25.63(2.37)	270
<i>Muscle strength and endurance</i>											
Vertical jump (cm)	<0.001	1259	26.51(5.41)	25.86(5.70)	991	25.23 (5.54)	26.19 (4.88)	76	24.21(4.96)	23.66(5.34)	268
Accelerometer data											
% who meet the PA recommendation (60 min MVPA/day)	0.29	225	91.02	96.70	169	100	85.71	11	91.30	90.90	45

^a The overweight group includes overweight and obese adolescents according to the IOTF criteria (112)

^b P-value for differences between overweight, normal-weight and underweight groups.

The analysis was adjusted for the study design

Table 6.2 Baseline characteristics by fitness status (fit and low fitness) ^a

	P ^b	All n	Fit			Low fit		
			Control Mean (SD)	Intervention Mean (SD)	n	Control Mean (SD)	Intervention Mean (SD)	n
Age	0.86	1313	12.84(0.71)	12.86(0.72)	284	12.90(0.84)	12.79(0.78)	1029
Body mass index (kg/m ²)	<0.001	1313	17.96(1.80)	17.74(1.84)	284	20.24(2.92)	20.30(3.41)	1029
Body mass index z-score	<0.001	1313	-0.22(0.84)	-0.32(1.04)	284	0.47(0.97)	0.46(1.07)	1029
Low socio economic status (%)	0.29	1260	34.39	35.90	274	31.84	31.29	986
Female proportion (%)	<0.001	1313	16.56	13.22	284	72.30	78.62	1029
Fitness (EUROFIT)								
<i>Speed-agility</i>								
Speed shuttle run (s)	<0.001	1310	23.20(1.89)	22.72(1.72)	284	24.96(2.10)	25.08(2.25)	1026
<i>Muscle strength and endurance</i>								
Vertical jump (cm)	<0.001	1304	28.22(5.67)	28.89(5.89)	284	25.29(5.06)	24.67(5.30)	1020
Accelerometer data								
% who meet the PA recommendation (60 min MVPA/day)	0.79	219	93.75	90.00	52	90.00	95.87	0.06

^a The low fit were adolescents who did not reach the health zone according to the FITNESSGRAM standards (78)

^b P-value for differences between fit and low fit groups.
The analysis was adjusted for the study design

Intervention effects by BMI status

The intervention effect according to the BMI status is presented in **Table 6.3**. There were differential intervention effects for speed shuttle run ($P_i=0.06$) between BMI groups. The intervention effect for adolescents with normal weight was $\beta=-0.35s$ [-1.63; 0.93]; $\beta=-1.66s$ [-6.31; 2.97] for underweight adolescents and $\beta=-1.85s$ [-2.59; -0.43] for overweight adolescents, i.e. the highest intervention effect was observed in the overweight group. Furthermore, this difference in intervention effect was significant only for the group of overweight adolescents ($P=0.04$), which was independent of cardiopulmonary fitness, socio economic status and gender ($P_i>0.1$ for all interaction terms) (195).

There was no evidence that the intervention effects on vertical jump ($P_i=0.59$) or in the proportion of adolescents who reached the recommendation of 60 minutes of moderate to vigorous physical activity ($P_i=0.46$) were different amongst BMI groups.

Table 6.3 Effect of the intervention according to BMI status

	All	Control	Intervention	Adjusted		Unadjusted	
	n	Mean (DS)	Mean (DS)	β [95% CI]	P^b	β [95% CI]	P^d
Fitness (EUROFIT)							
<i>Speed-agility</i>							
Speed shuttle run (s)					0.06 ^c		0.08 ^e
Normal weight	723	2.65(3.37)	1.96 (2.41)	-0.35[-1.63; 0.93]	0.59	-0.58[-1.45; 0.28]	0.19
Underweight	60	2.72 (3.79)	2.61 (1.93)	-1.66[-6.31; 2.97]	0.48	-0.20[-1.91; 1.52]	0.82
Overweight ^a	188	2.85 (3.71)	1.34 (2.40)	-1.85[-3.62; -0.08]	0.04	-1.51[-2.59; -0.43]	0.006
<i>Muscle endurance and strength</i>							
Vertical jump (cm)	987	0.07 (6.45)	1.98 (6.80)		0.59 ^c		0.85 ^e
Accelerometer data							
% who meet the PA recommendation (60 min MVPA/day)	130	-18.09	-5.87		0.46		0.57

^a The overweight group includes the obese adolescents.

^b P-value adjusted for gender, socio economic status, fitness and all interaction terms between covariates and allocation group.

^c P-value of interactions terms of BMI status (normal weight, underweight and overweight) X allocation group (control/intervention) after adjusting for gender, socio economic status, fitness and including all interactions between covariates and allocation group.

^d P-value of the unadjusted analysis.

^e P-value of the interaction term between BMI status (normal weight, underweight and overweight) X allocation group (control / intervention) from unadjusted analysis.

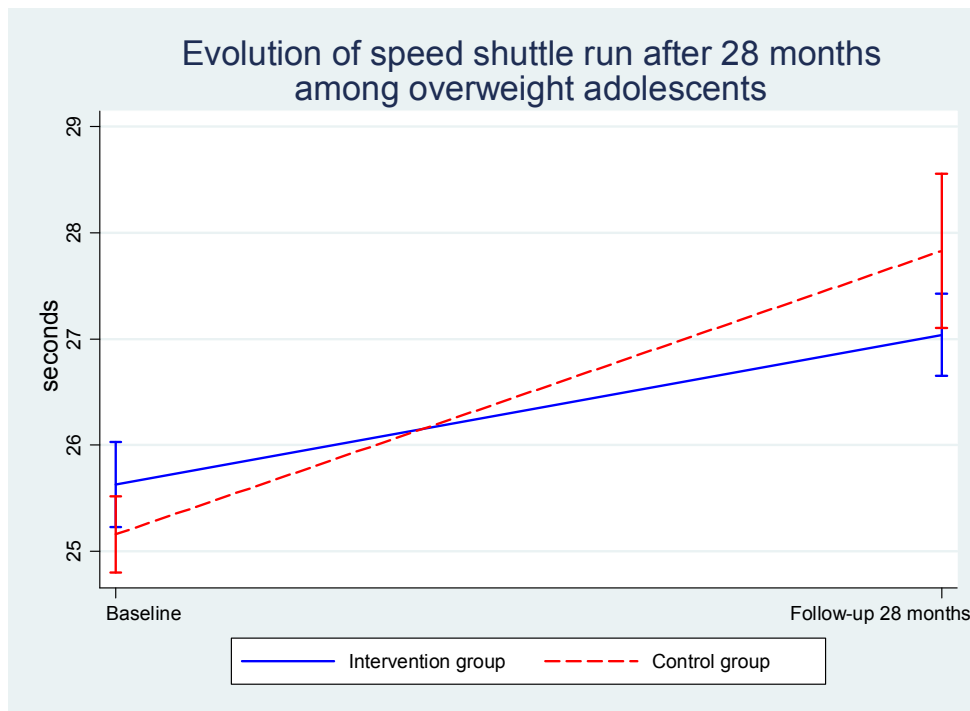


Figure 6.1 Speed shuttle run after intervention program among overweight adolescents

Intervention effects by fitness status

There were differential intervention effects for vertical jump ($P_i=0.02$) between fitness groups (**Table 6.4**). The intervention effect for fit adolescents was $\beta=1.28$ [-1.77; 4.32] cm and $\beta=3.71$ [1.15; 6.28] cm for low-fitness adolescents which was significant for the later ($P=0.005$) independently of BMI Z-score, socio economic status and gender ($P_i>0.1$ for all interaction terms) (195) No consistent differences between fit and low-fitness group were found for the intervention effect for speed shuttle run ($P_i=0.60$) and for the proportion of adolescents who reached the recommendation of 60 minutes of moderate to vigorous physical activity ($P_i=0.94$).

Table 6.4 Effect of the intervention according to fitness status

Outcomes	All	Control	Intervention	Adjusted		Unadjusted	
	n	Mean (DS)	Mean (DS)	β [95% CI]	P ^a	β [95% CI]	P ^c
Fitness (EUROFIT)							
<i>Speed-agility</i>							
Speed shuttle run (s)	971	2.69 (3.44)	1.89 (2.40)		0.60 ^b		0.39 ^d
<i>Muscle endurance and strength</i>							
Vertical jump (cm)					0.02 ^b		0.15 ^d
Fit	219	2.23(6.73)	3.69(7.19)	1.28 [-1.77; 4.32]	0.41	-	-
Low fit	768	-0.54(6.22)	1.58(6.66)	3.71 [1.15; 6.28]	0.005	-	-
Accelerometer data							
% who meet the PA recommendation (60 min MVPA/day)	130	-18.09	-5.87		0.94		0.30

^a P-value adjusted for BMI z-score, gender, socio economics status and all interaction terms between covariates and allocation group

^b P-value of the interactions terms of fitness status (fit/low fitness) X allocation group (intervention/control) after adjusting for BMI z-score, gender, socio economic status and including all interactions between covariates and allocation group.

^c P-value of the unadjusted analysis.

^d P-value of interaction term between of fitness status (fit/low fitness) X allocation group (intervention/control) from unadjusted analysis.

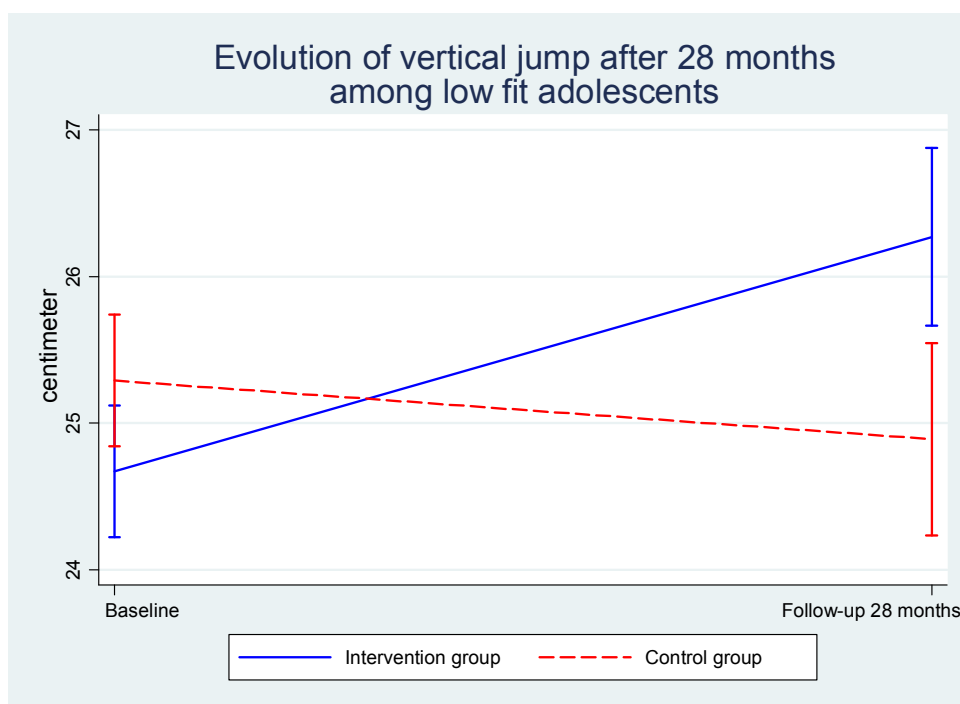


Figure 6.2 Evolution of vertical jump after intervention program among low fit adolescents

Sensitivity analysis

The unadjusted model showed that the intervention effect on vertical jump was not significant different between fit and low-fitness (P_i of the allocation group x fitness groups=0.15) in contrast to what was observed for the adjusted analysis ($P_i=0.02$). The intervention effect on speed shuttle run according to BMI groups was similar for the unadjusted and adjusted analyses. After imputing missing values, the intervention effect on vertical jump decreased by 3.8% (from $\beta=3.71$, $P=0.005$ to $\beta=3.57$, $P=0.06$) in low-fitness adolescents. For the BMI groups, the intervention effect on speed shuttle run became non-significant in overweight adolescents, changing from $P=0.04$ $\beta=-1.85$ to $P=0.09$ $\beta=-1.58$

6.4 Discussion

Our findings suggest that low-fit and overweight adolescents respond differently to ACTIVITAL program for two fitness outcomes compared to the fit and normal/underweight groups, respectively. Adolescents with poor physical fitness showed a higher improvement of muscular strength (vertical jump) compared to fit adolescents, after the intervention program. Whilst, overweight adolescents had a significantly lower increase in the time needed for speed shuttle run test compared to normal-weight and underweight adolescents i.e. although there was an overall decline in speed fitness with the time, this decline was smaller in the overweight adolescents compared to the normal-weight and underweight adolescents. These potential health benefits among adolescents at health risk (low-fit, overweight) are independent of the differences between weight and fitness groups in terms of age, socio-economic status, BMI and proportion of females. The latter is supported by the fact that our analyses were adjusted for all interaction terms between covariates and intervention allocation.

The findings of our analysis show that the intervention could provide positive effects on health (32, 196) among low-fit adolescents as they showed improvements on muscular strength. Muscular strength and cardiorespiratory fitness are independently associated with NCD risks factors and are important determinants of general health during adolescence (32).

It has been reported that overweight adolescents have a lower performance on speed shuttle run than their normal peers, diminishing their self-efficacy, enjoyment for sport participation and physical exercise (129, 197). Speed/agility is an independent predictor of bone mineral density in a young population and therefore, a persistent pattern of being slower and less agile through adolescence could compromise bone health at a later stage (32). We consider that the intervention effect reported in the present manuscript is encouraging for overweight/obese adolescents in terms of speed shuttle run with a possible positive effect on bone health. However, we acknowledge that the absence of an effect in the underweight group could be a result of its smaller sample size (194) compared to the size of overweight and normal weight groups.

To our knowledge, only one Swiss study has examined simultaneously the intervention effect by weight category and fitness levels group among preschoolers. This study showed that low-fit and overweight preschoolers had a higher decrease in waist circumference and index of skin fold compared to fit and normal weight peers. In addition, the motor fitness improved more in overweight preschoolers compared to normal-weight ones (191). Some studies have examined the variation of intervention effect only for fitness status or only for BMI status. As far as we know, only one study has analyzed the modification of intervention effect by fitness levels. This study reported the intervention effect on BMI,

body fat and waist circumference by fitness levels in a population aged from 6 to 12 years. The latter study did not find that the intervention was more effective among low-fit subjects compared to fit ones (192). On other hand, the modification of intervention effect only by weight category has been evaluated in some studies, but only in a younger population than that of the present study (187-190). In most of those studies, the intervention effect on fitness (cardiorespiratory and muscle strength) was higher in the overweight group compared to normal weight group (187-190).

Our intervention was developed using a participatory approach, i.e. participants were involved in the health research process in order to improve the quality of the research design (92). We speculate that this approach has created an environment in which the participants feel more comfortable and willing to be part of the intervention activities. In addition, our intervention used simple and positive messages that responded to a latent need for fun activities that address healthy lifestyles, in particular in the group of overweight and low-fit adolescents (198, 199). This might have induced a higher response from these groups of adolescents that commonly face discriminatory attitudes and behavior at school (200). Interventions that use high intensity physical activity or fitness sessions might have led to poor adherence in overweight/obese or low-fit adolescents due to their limited ability to carry out many of these activities (129). Another plausible explanation, for the observed intervention effect among adolescents at health risk, is the presence of a “flooring effect”. Given their poor performance on the fitness components, the group of overweight or low-fit adolescents might have had more room and could require less effort to improve the motor fitness or speed/agility fitness components compared to normal weight (201) or fit adolescents (124, 202).

The results of the present manuscript suggest that future similar programs should consider the BMI or fitness status of adolescents if they expect to improve the speed-agility or muscular strength component among adolescents. Whilst, similar approaches could have an effect of physical activity independently of the BMI or fitness status of the adolescents. Besides, while the ACTIVITAL program is potential benefit for adolescents at high risk in terms of physical fitness only, more research are needed in order to identify approaches able to improve also the physical activity among overweight or low-fit adolescents.

Our results are limited to the populations with similar characteristics to Ecuadorian adolescents i.e. mixed *mestizo* ethnicity, living in urban areas at high altitude, with an obesity/overweigh prevalence around 22%, a high proportion (>90%) of adolescents that met the physical activity recommendations and a high proportion (>60%) of adolescents with low-fitness. However, the systematic process to develop the program could be generalized to adolescent populations with different prevalence of obesity/overweight/low-fit or with low proportion of adolescents that met the physical activity recommendations, since the approach used takes into account the needs and opinions of the participants to design the intervention. And therefore, the resulted intervention program might have an increased acceptability among the target groups.

Strengths and limitations

Our study holds important strengths. First, our program uses a strong experimental design, with a sample size that is much larger than the average sample size (n=300 participants) of similar school based studies in LMICs. A second strength is the duration of our program, which is longer than most trials focusing on a similar topic. Third, we used objective and clinically relevant cut-points (FITNESSGRAM standards) to classify adolescents into the

fit and low fitness groups. Some limitations must be addressed. First, we used the 20m shuttle run as an indirect measurement of $VO_{2\text{ peak}}$. We acknowledge that the estimation of $VO_{2\text{ peak}}$ from results of 20m shuttle run can vary according to the equation used. Nevertheless, in this study we used an equation (79) that has showed the highest agreement between the actual $VO_{2\text{ peak}}$ and the estimate $VO_{2\text{ peak}}$ from the 20m shuttle run scores considering the age, gender and BMI of the subjects. Second, the dose received of the intervention could not be assessed by the weight status or the fitness status of the adolescents, as the tools used to estimate the uptake only collected general information for the entire sample (63). Third, physical activity was assessed only in a sub-sample. Fourth, although our results are encouraging for school interventions in LMICs, our findings are modest and should be combined with other strategies to improve its effectiveness. Finally, since it is a sub-group analysis the statistical power could be low and therefore the results should be considered with caution.

Conclusions

Our results suggest that comprehensive school-based interventions to improve diet and physical activity could be beneficial in low-fit and overweight/obese adolescents who are already at health risk. The overweight/obese and low-fit adolescents responded differently to the intervention program compared to their normal/underweight and fit peers for the speed component (speed shuttle run) and muscle strength component (vertical jump test) of the EUROFIT test. Future school interventions should consider the effect of their interventions strategies on the high-risk groups

7 General discussion and conclusion

7.1 Introduction

Research in the framework of the “*Food, Nutrition and Health*” project addressed knowledge gaps regarding the evaluation and prevention of NCDs risk factors in Ecuadorian adolescents. This research found that dyslipidemia was the most prevalent NCD risk factor among a sample of adolescents (93). The diet of Ecuadorian adolescents was carbohydrate-based, rich in refined cereals, added sugars and processed foods consumed mainly as a snack; and the consumption of fruit, vegetables, fish and oilseeds was very low (82). The research also provided clear and detailed insights into the development process of an intervention program aimed to encourage healthy physical activity and dietary behavior in Ecuadorian adolescents (62). The “ACTIVITAL” intervention program increased fruit and vegetable intake; decreased added sugar and processed food intake during snacks; and decreased waist circumference and blood pressure (63). The present doctoral work complements these findings with estimates on the current physical fitness of Ecuadorian adolescents and the effect of the “ACTIVITAL” intervention program on physical fitness, physical activity and screen-time behavior in adolescents.

The present chapter summarizes and discusses the main findings of this doctoral dissertation. It also sheds light on possible intervention pitfalls and future policy implications of this doctoral work. Finally, this chapter provides a list of limitations/strengths of the studies included in this PhD work and recommendations for further research.

7.2 Main findings of the PhD dissertation

- Adolescents from our sample show relatively poor physical fitness levels, and this situation is more alarming in rural (Nabón) adolescents. Additionally, in the urban

area, we observed a decrease in total physical activity levels and an increase in screen-time in the whole sample over the intervention period. These findings indicate the need for health promotion programs aiming to encourage an active lifestyle among Ecuadorian adolescents.

- The weak association observed between dyslipidemia and physical fitness in urban and rural adolescents, does not provide evidence that the higher prevalence of dyslipidemia in the rural area is associated with poor physical fitness. A parallel study on our sample found also a weak association between dyslipidemia and food intake.
- The “ACTIVITAL” intervention program, implemented in Cuenca, had a modest but encouraging effect on lowering the deterioration of Ecuadorian adolescent’s lifestyle regarding physical fitness (muscular strength and speed), physical activity (proportion of adolescents that reach the MVPA recommendations) and screen-time behaviors (TV time and total screen-time on a weekend day).
- The “ACTIVITAL” intervention program was well accepted by adolescents, teachers, and parents. However, the participation of school teachers as providers of the intervention was limited due to the fact that the intervention program was not part of the official school curriculum. Pep-talks with sports men/women had a high attendance rate, in contrast to the low use of the walking trail drawn inside the schools. In addition, parents showed a low rate of attendance to the intervention workshops, probably due to time constrains and low encouragement.

- The ACTIVITAL program, implemented in Cuenca, is potentially beneficial for overweight and low-fit adolescents, as they showed a higher improvement on their speed fitness and muscular strength components. In addition, the implementation of the intervention program in co-ed schools with more than 695 students and in schools with a half day schedule (only morning or only afternoon classes) was more beneficial towards improving the muscular strength, speed, and the proportion of adolescents that reach the recommendations of MVPA compared to the other schools.
- The improvement of the balance fitness component in adolescents from the control group, particularly among adolescents from schools with low physical activity space (≤ 4.07 students/m²), might be a reflection of Ecuadorian adolescents' preference for pursuits with low physical activity levels (games like hacky sack and throwing coins near a target); and could mean that schools with limited space for physical activity reinforce these unhealthy lifestyles tendencies.

7.3 Overall discussion

7.3.1 Physical fitness, physical activity and screen-time behavior on Ecuadorian adolescents: Evaluation

Our finding about the deterioration of Ecuadorian adolescents' lifestyle regarding physical activity and screen-time were partially confirmed by the recent Ecuadorian National Health Survey (ENSANUT 2013) (203). Similar to our findings, the ENSANUT 2013 reported that the percentage of active adolescents (those who met the recommendation of 60 minutes of MVPA during at least 5 out of 7 last day) decreased in the age group of 12 to 15 years. In contrast, the ENSANUT 2013 differed from our results by reporting that there was not major difference in the screen-time between age groups. This could be attributed to the fact

that the ENSANUT 2013 does not evaluate the time adolescents spent on computer, which is unfortunate since the evidence from the present doctoral work reveals that computer time increases more over the time than the time spent watching TV or playing videogames. We were not able to compare our results of physical fitness with those of the ENSANUT 2013, since the national survey did not report physical fitness. This is unfortunate since according to our results the proportion of Ecuadorian adolescents (59%) who are at health risk due to poor fitness is certainly higher than the proportion reported on other studies (204) (**Table 7.1**).

Table 7.1 Prevalence of adolescents (12-17 year) at health risk according to FITNESSGRAM standards for various studies ^a

Location	Year of the study	Standard	Prevalence of adolescents at health risk related to poor fitness ^c	
			Boys	Girls
Ecuador ^b	2009	FITNESSGRAM 2011	55%	74%
Argentina (205)	2012	FITNESSGRAM 2004	47%	52%
Chile	2011	FITNESSGRAM 2011	26%	55%
Chile	2011	FITNESSGRAM 2004	24%	25%
Colombia	2008	FITNESSGRAM 2004	37%	–
U.S. (California)	2013	FITNESSGRAM 2011	28%	44%
U.S. (Midwest)	2010	FITNESSGRAM 2011	26%	23%
U.S.	1999–2002	FITNESSGRAM 2004	35%	35%
England (East)	2013	FITNESSGRAM 2011	12%	25%
Pan-European	2008	FITNESSGRAM 2004	39%	43%
Portugal (125)	2008	FITNESSGRAM 2008	37%	72%
Spain	2003	FITNESSGRAM 2004	19%	17%
Sweden	2008	FITNESSGRAM 2004	9%	20%
Australia	1985–2009	FITNESSGRAM 2004	29%	23%

^a Table based on the Garber M. *et al* (204), ^b Results presented in **Chapter 3**; ^c Cut-points according to FITNESSGRAM standards

7.3.2 Physical fitness, physical activity and screen time in Ecuadorian adolescents: Improving

The “ACTIVITAL” intervention program was able to tackle the methodological limitations common for studies in LMICs. For instance, our program uses a strong experimental design (randomized controlled trial), in which the sample size is much larger than the average

sample size (n=300 participants) of studies on LMICs. Also, our study uses a theoretical framework to guide the intervention and objective tools to assess the outcomes.

In addition, the systematic process used to design the “ACTIVITAL” intervention program allowed to obtain a program that was culturally appropriate for the Ecuadorian context and able to reach the stakeholders’ needs. The latter is evidenced by the fact that most (>80%) of the stakeholders reported that the information they received during the intervention was new knowledge; and similarly, a large majority (>80%) of them scored the quality of classes/workshops with >8/10.

Although our results are modest, they are also encouraging, since most of the changes in the primary outcomes were in favor of the intervention group. We believe, that the results on physical activity and physical fitness might be related to the fact that our approach leads to adolescents maintaining their participation on activities that they “normally” give up doing between the transition of 12 to 15 years (206) such as participation in sports or playing games with high physical activity levels during the “free” time in or outside the school. Meanwhile, the effect on screen-time might be related to awareness created about the sedentary lifestyle, through the information and motivation, which are the first steps towards the behavioral change (207). Physical fitness (muscular strength and agility) among adolescents at health risk (like overweight or low-fit) improved through the intervention and could be related to the nature of the program which avoided activities that could limit the participation of these adolescents. For instance weight bearing activities (208) that could lead to teasing of adolescents by peer for their poor fitness were consciously omitted.

In summary, the “ACTIVITAL” intervention program supports the hypothesis that a school-based classroom strategy could have an effect on physical fitness, physical activity

and screen-time of Ecuadorian adolescents and in particular among those that are at health risk like adolescents with overweight or poor fitness. Therefore, interventions that use a participatory approach and are theory- and evidence-based are advisable in school settings of Ecuador.

7.3.3 Pitfalls of the study to be considered

The “ACTIVITAL” intervention program faced some issues that could have decreased the overall effect. These intervention pitfalls are summarized as following:

1. The knowledge and skills adolescents learned from our educational package were not included as learning objectives in the official school curriculum, despite the fact that they were in line with the Ecuadorian governmental school learning objectives. This is unfortunate, since the modification of school curriculum together with the use of printed materials have previously been related to a positive effect on reaching the health recommendations of MVPA, cardiopulmonary fitness and decreasing the amount of time spent on screen-time, specifically watching TV (38). Future interventions should invest time in finding an agreement of cooperation with regional or national directors of Education, Health and Sport Ministry, and not only with the teachers and school principal (as we did). This requires a substantial effort on lobbying, but given the potential benefit of intervention programs it is highly recommended to try to arrange these agreements with the ministries.
2. In the “ACTIVITAL” intervention program, the largest intervention effect on screen-time and probably on physical activity/fitness was reported in the first stage of the intervention during which a high proportion of the intervention classes were

given by school teachers (73%) employed by the school themselves. In the second stage of the intervention this number decrease to 31% and the intervention effect showed a decrease. These differences between both intervention stages could reflect the crucial role of the school teachers in such an intervention program in Ecuador. This is not a surprise, since the current literature reports that an increased participation of classroom teachers could be a favorable boots in reaching the public health recommendations of MVPA, as well as for improving cardiopulmonary fitness (38). Unfortunately, in our study some school teachers refused to collaborate since the program was not officially part of the school curriculum. Similarly to the comment given in the previous paragraph, future interventions should work in close cooperation with government institutes in order to obtain their authorization to include the health education package in the school curriculum. In this way, the delivery of the educational package does not mean extra work for the school teachers, therefore, they could be more willing to participate on the program.

3. Similar to intervention studies in HICs (209), the parents' participation in the "ACTIVITAL" workshops was fairly weak (around 10% attendance). This is regrettable since it has been reported that parental support, or family habits like watching or not TV together as family, are determinants for physical activity (38) and screen-time in youth (210). Therefore, increase in parents' participation could increase the effectiveness of interventions in terms on improvement of duration of MVPA (211) and time spent on screen-pursuits (38, 212). To our knowledge, improving the rate of participation of parents in intervention programs is a new issue for studies on LMICs. Our previous research documented the possible barriers that explain the poor attendance of parents to workshops (lack of time, work

overload, the chance that schools do not send the parents invitations on time) (63). Unfortunately, the possible motivators or facilitators to parent's participation were not assessed. Available information from developed countries suggests that adolescents could be the facilitator of the parents' participation, as they can act as intermediaries between school/intervention program and the parents. Also, informing the parents in advance about the durations of the meetings (which should be short) and their purposes could facilitate the parent's participation. Finally, parents that are confronted with negative consequences of an unhealthy lifestyle might become more interested in taking part in intervention activities (209, 213). Nevertheless, the improvement of parents' involvement on intervention programs is a topics that merits further study.

4. There were only few studies (mostly cross-sectional) in Latin America to compare our findings of physical fitness which makes it difficult to make comparisons with previous results. Furthermore, comparisons were further complicated because studies in Latin America generally do not measure all the fitness components, the most frequent being cardiorespiratory (20 m shuttle run), strength (standing jump) and muscular endurance (push-up and curls-ups). In addition, among the few studies that used 3 to 5 tests to evaluate physical fitness, 1 or 2 tests were from the EUROFIT battery (214-220). Whereas, in studies that used 1 or 2 tests, usually one of those tests was from EUROFIT (mainly 20m shuttle run) (204, 221-223).

Our results from physical fitness could not be compared to a global criterion-reference because, to date, there is no consensus about the minimal cut-off for physical fitness components that is consistent with good health (224). Furthermore, for the moment there is no unique international tool to measure the fitness

components on adolescents. Initiatives like Assessing Levels of Physical Activity (ALPHA battery), Adolescents and Surveillance System for the Obesity prevention (ASSO-FTB Fitness Test Battery), FITNESSGRAM battery and EUROFIT battery have proposed criterion-reference for fitness and/or standardized tools to measure health- and skill-related physical fitness, regrettable most of these initiatives are based on studies from USA, Europe and Australia (225, 226).

Therefore, there is a clear need for a global criterion-reference and standardized battery, which will allow obtaining relevant, comparable and health-related data of physical fitness. For this purpose, international initiatives are needed. These initiatives should start coordinating research groups involved in the assessment of physical fitness in develop and developing countries. Second, the groups should work out some methodological aspects, for example i) updating the most relevant physical fitness components related to health and skill-performance ii) selecting the field tests that have acceptable validity and reliability iii) developing a manual with the standardized procedures to apply the field tests. Third, the groups should apply the identified tests and protocols on separate samples in order to confirm the grade in which these tests are associated with current and future health/disease. Finally, the groups should apply these tests on large nationally representative samples in order to develop the global criterion-referenced. The resources needed to this research are significant but the use of a standardized battery and global reference criterion might contribute to the optimization of programs of fitness surveillance which are weak in most of the parts of the world (227). A standardized test would also be useful to generate data to guide and monitor programs to prevent the rise of NCD risk factors.

5. In the randomized controlled trial study we used the cut-point of ≥ 760 counts/min for moderate to vigorous physical activity (MVPA) suggested by Matthew *et.al* (110). Based on this cut-point we reported that the proportion of adolescents that reach the recommendation of MVPA was 94% and 84%, at baseline and at the 28 months follow-up, respectively. Matthew's cut-point was chosen in order to detect activities at moderate (non-ambulatory and ambulatory) and vigorous (ambulatory) intensity with high sensitivity and specificity (108-111). The latter was an important point since a previous study reported that Ecuadorian adolescents have mainly non-ambulatory moderate intensity activities (111)

However, our results are in dispute with other studies as there are other cut-points for MVPA that could be used instead of the Matthew's cut-point. For instance, if we had used the cut-point of ≥ 2296 suggested by Evenson *et.al* (228), our results would have shown that the proportion of adolescents that reach the recommendation of MVPA could have changed from 94% to 9.4% at baseline and from 84% to 8.4% at the 28 months follow-up. Even though there are large differences in the results obtained from Evenson's and Matthew's cut-points, both results are still acceptable since the current guidelines provide no scientific base to define the "best" cut-point which reflects the lack of consensus about the best practice for using physical activity monitors we currently face (229-231). A standardized protocol for using physical activity monitors could guide the researchers through the complex processes of decision-making related to: the choice of accelerometer, epoch length, number of axis, filtered or unfiltered data, definition of non-wearing time, minimum wearing time per day, minimum number of registration days, which data transformation will be used, which cut points will be applied, and which outcomes will be reported.

In summary, we think that the effectiveness of the “ACTIVITAL” intervention program could improve substantially if: i) the learning objectives of classroom-based health education package are part of the learning objectives of the school curriculum, and ii) motivators and barriers to the parent’s attendance on intervention activities are identified before starting the program. Additionally, in order to have an accurate and comparable assessment of physical fitness, an international initiative is needed to develop standardized tools to measure physical fitness and to obtain a global reference criterion.

7.4 Policy Implications

In Ecuador, the National Plan for Good Living states the goals of the country covering different aspects such as improvement of people’s quality of life. In the frame of this goal, the following policy regarding promotion of physical activity was included: *“To encourage active use of leisure time, devotion of free time to physical, sport and other activities contributing to improving physical, intellectual and social conditions of the populations”* and the following regarding to the prevention programs: *“To expand health prevention and promotion of services to improve living conditions and habits in the population”* (232). The 2017 goal of these policies related to populations between 5 to 18 years old is *“To reverse the trend of obesity and overweight in children ages 5 to 11 down to 26.0%”*. Based on these policies, the Ministry of Education has increased the number of mandatory sessions of physical education in schools from 2 to 5 times per week since 2014. The Minister has also included a workshop for students focused on sport, artistic, scientific or social activities with a duration of 3 school sessions per week.

We think that the actual political context in Ecuador provides possibilities for initiatives like the ACTIVITAL program. We believe that future initiatives should be designed in

order to be a useful link between national policies and their application at individual level.

For instance:

- The intervention programs aimed to promote healthy lifestyles on youngsters should be conducted on schools using their existing structures (regular school classes, regular parent-teacher meeting, and physical infrastructure of the space in schools) and keeping moderate intensity and frequency of the intervention activities.

- The intervention programs should help to fulfill requirements created by the governmental policies. For instance, the recent increase in number of physical education sessions per week obliges physical educators to incorporate more activities into their classes. The textbooks designed for the intervention programs could address these needs since the subject of physical education does not have a workbook for teachers or students in contrast to other subjects.

We also think that even though the actual Ecuadorian political context is favorable to promote a healthy lifestyle, these policies could be complemented with the following points:

1. In most of the schools, particularly in the rural areas, the teacher in charge of physical education classes is a person with no formal education in this area, as we observed during the field work in Nabón. According to the governmental data in Ecuador, there is a deficit of 3535 physical education teachers with proper formal education in this area in the national school system. Currently other non-formally educated teachers provide physical education lessons. To fill this gap, considering that only 7 universities offer this career in Ecuador, at least 10 years will be needed. Therefore, we suggest to include printed education material with a detailed

description of possible routines per class and of the sports for teachers and students, so that every teacher is able to apply these physical education programs without major instructions. In addition, this printed education material should provide knowledge and methodological techniques to teachers in order to develop a pedagogical model for health-based physical education (233). As we mentioned before, similar textbooks are available for other subjects in the Ecuadorian school system.

2. The school curriculum in physical education has remained mostly unchanged since 1996. This means that during the first years of formal education (1st to 7th) the motor skills are developed through playful activities that involve running, walking, jumping and dancing. During 8th to 10th grade sport (mainly basket, volley, soccer, athletic) and dancing skills are developed. Dancing is the most recent addition to the school curricula (April 2014). This “classic” curriculum might be a factor that contributes to the fact that Ecuadorian adolescents had the worst performance on cardiopulmonary, speed-agility, muscular strength and flexibility fitness components compared to adolescents from other countries.

We think that future government and research initiatives should focus on improving the curriculum of physical education classes. We have some suggestions to improve the quality of physical education classes. First, we think that in addition to the sports regularly taught on Ecuadorian school (basket, volley, soccer, athleticism) other sports should be included in the school curriculum, in order to make the classes more interesting and entertaining, for instance: i) fistball (<http://www.ifa-fistball.com>), ii) netball (<http://www.netball.org/americas-region>), iii) kinball (<http://www.kin-ball.com>), iv) chirunning (<http://www.chirunning.com>). Although,

Ecuadorian traditional games could be included in the school curriculum, to our knowledge most of the Ecuadorian traditional games require low physical activity levels. Second, the new structure of physical education classes should focus on improving those physical fitness components for which Ecuadorian adolescents showed the worst performance (cardiopulmonary, speed-agility, muscular strength and flexibility fitness components). These fitness components are related to health (in high or low grade) (32, 234) and could be improved by means of structured aerobic or anaerobic training (235, 236) or including different stretching exercises (seated L, seated toe touch, hip flexor and standing quadriceps) (237) as a part of the routine of the physical education session. Finally, considering the heterogeneity of adolescent groups in the schools, such as differences in weight status and fitness levels between students, we suggest that the structure of classes includes activities that are fun and enjoyable for all adolescents (208). For this purpose it is highly recommended that adolescents are involved in the process of improving the curriculum of physical education.

3. The high prevalence of adolescents that spent more than 2 hour/day on screen-time calls on national policies to found mechanisms that address this situation. We think that National policies should:
 - Stipulate that practitioners in the National Health System receive and provide information about the health risks associated with spending more than 2 hours / day on screen pursuits or having an inactive lifestyle, as a part of the standard procedures during the medical consultation.
 - Stipulate that media education must be part of the school curriculum i.e. include in the school curriculum an educational package focusing on

creating awareness about the health risks of sedentary lifestyle as well as focus on teaching adolescents to engage critically with media messages about health (238). It has been reported that TV series, TV ads, internet information, and digital social-networks might distort adolescent's perception of an active lifestyle (239), if they do not have the ability to deconstruct media messages and be more critical about them. For instance, it has been reported that TV series created for adolescents project the image that physical education classes are boring, with little educational value; and that the physical educators have poor formal training together with a high concern about their external appearance (239). This kind of message could be deconstructed by media criticism in the media about of the accuracy, validity and truthfulness of the messages and the persons behind (media owners) and in front (setting, images, actors) of TV series or ads. In other words, through media education it is possible to bring about deeper understanding of media content and information (240).

- Regulate the media content on TV/radio that cause under-valorization of the effect of regular physical activity on the health. To date the Ecuadorian "Media Law" (241) stipulates that media content related to food and nutrition on TV or radio must be authorized by the Ministry of Health. Unfortunately, the law does not include explicit regulation about the content related to physical activity, fitness or sedentary behaviors. For instance, some TV ads about weight control, weight loss and lowering risk for develop NCD, attributed this effect to special diet supplements. Therefore, these ads could cause a misunderstanding about the importance of a lifestyle with regular physical activity.

4. Physical inactivity is not considered a health problem by some key institutes of health in Ecuador. For instance, the Ministry of Health in Ecuador aims to optimize the use of resources for research, and improve research quality, has elaborated a document entitled: "Health Research Priorities 2013-2017" (242). This document lists the priority research lines based on a series of pathologies and its determinants that impact on the Ecuadorian population's health. There are 19 lines of research and 9 out of them are related to NCDs (CVD, mental health, chronic respiratory diseases, endocrine) and only one research line is related to nutrition. Surprisingly, this list does not yet include physical inactivity as determinant of NCDs. This situation is regrettable since it could affect the financial support for future research and intervention in physical activity, physical fitness or sedentary behavior. We suggest the inclusion of physical inactivity and sedentary behaviors in this list of risk considering that a decrease in or removal of these unhealthy behaviors could substantially improve health (243)

7.5 Limitations and strengths

There are extra strengths and limitations in addition to those previously mentioned in this doctoral dissertation. The first strength is the age group studied, as this period involves important physiological, emotional and behavioral changes/transitions. Only a few studies have been conducted in the populations between 12 to 15 years old. The second strength is that the characteristics of "ACTIVITAL" intervention program (high quality design, larger sample size, and objective measurements) and its encouraging effects make it a study of high methodological quality with promising effect. To our knowledge this is a quite unique intervention program within Latin American countries.

Although, the “Food, Nutrition and Health Project” was able to collect an important volume of information which needed several work hours / manpower and financial resources, there were still other parameters that could not be measured due to limited resources. These parameters that could not be measured are the main limitations of the present study. A first limitation is that it was not possible to perform the intermediate measurement (18 months follow-up) on physical fitness and physical activity. This did not allow us to evaluate the effect of the intervention during the first 18 months, which might have been higher than the measurement at 28 months follow-up. A second limitation, is that we did not measure body fat which is more closely related to fitness, rather we only measure BMI. Third, we did not perform a follow-up after the ACTIVITAL activities were finalized. This limited our understanding about the sustainability of the intervention effect. However, the length of the intervention (28 months) could be considered sufficient time range for measuring the intervention's sustainability. Fourth, the use and appreciation of the walking trail were assessed only in two of the intervention schools, which limits our understanding about whether walking trail is a good strategy for Ecuadorian adolescents. Fifth, we could not assess the blood lipids profile which is an important determinant for health in adolescents and helps to determine how intervention programs aiming to improve the dietary and physical activity behaviors could influence the blood lipids

7.6 Recommendations for further research

- We observed that the health status related to physical fitness and blood lipid profile were worse for rural adolescents compared to their urban peers. Given these health risks and considering that rural areas are quite different from urban areas because of

the social, economic and cultural context, it is recommended to design and implement intervention programs that fit the regional context. For instance, it has been reported that in the rural areas (Nabón) of the Ecuadorian highland, the economic situation, self-efficacy and farming or household chores have an impact on physical activity (95). Parents and school staff in rural area argue that the low economic status limits the acquisition of sport equipment or limit the access to the proper infrastructure for sport activities. Adolescents reported to have low self-efficacy to do sport or exercise, fear injuries and to be limited by subjective norms which do not allow that girls can play or use their leisure-time on physically active pursuits like playing/training a sport. Rural parents reported to encourage their children to be active, although they found it difficult due to assistance required from their children in farming or household activities. Except for the socio-economic constrains, intervention programs should be effective in influencing the factors that alter the physical activity of rural adolescents. For instance, the intervention program should be focused on improving the knowledge about physical activity, stressing that farming or household chores are also physical activities, which could lead improvement on of adolescent's physical capacity and therefore could improve their self-efficacy. The subjective norms are an aspect that should be treated with caution since the rural population is sensitive to changes in their cultural believes. It is highly recommended that future studies on rural areas collaborate with local authorities and assure an active participation of the rural stakeholders, in order to design an intervention program suitable for the rural context.

- Sedentary behavior in general has been poorly studied in adolescents from LMICs. Given the high prevalence of adolescents that spend more than 2 hours/day on screen-

time pursuits, it is clear that there is a need for more studies that tackle this issue in LMICs. Future studies should be extended to broader sedentary behaviors (beyond the watching TV, using computer or playing videogame) and add the assessment of other sitting pursuits (chatting, doing homework, working, passive transport, attending classes in school, overuse of smart phone) which is also associated with health outcomes. In addition, these studies should assess not only the total sedentary time but also the duration of the periods without break on sedentary pursuits (prolonged sitting), since the prolonged sitting could be associated with different health risks. Additionally, the future studies should assess whether programs focused on improvements of one or more specific sedentary behaviors could have side effects on other sedentary pursuits. Finally, future studies should use mixed methods to measure sedentary time e.g. self-reported questionnaires, and accelerometer with inclinometers.

- Although, the school based intervention program had several advantages, other types of interventions like community or built interventions (45) should be further tested. We assessed the physical activity environment in schools, but our results were limited to close areas (100 m around) to the schools. Assessing how the physical environment could affect the lifestyles, is an aspect that should be targeted with a wider methodological approaches in future researches in Ecuador and other Latin American countries.
- Including the educational package in the school curriculum and improving the parents' participation in the intervention could be useful for future intervention studies and should also be considered when replicating the present program in order to confirm our results. In addition, we have some methodological suggestions for

future studies: i) to analyze the effect of intervention on groups at health risk (overweight/obese or low-fit adolescents). This is important because, first, intervention programs focused on the promotion of healthy lifestyles on overweight/obese or low-fit adolescents are sparse in LMICs; second, it could give an insight of an additional advantage of intervention program designed for adolescents independently of their weight or fitness status; and third, it could help to guide future intervention programs among adolescents with overweight/obesity or poor fitness. ii) to analyze the variation of intervention effect according to the school characteristics since these characteristics might modify the intervention effect in the schools. This suggestion is highly recommended for studies developed in countries with a high heterogeneity between schools, like in Ecuador, and iii) to include measurements about the self-esteem, which is an important determinant for physical and mental health on adolescents and could be influenced by the intervention programs aiming to improve the dietary and physical activity behaviors. These three suggestions have been studied in few interventions programs in HICs and LMICs.

7.7 Conclusions

Ecuadorian adolescents are at health risk due to the low levels of physical fitness / physical activity, and high screen-time. This situation could compromise their health in the future.

Our findings support the fact that a comprehensive school-based program, aimed to promote a healthy diet and adequate levels of physical activity, could improve physical fitness, minimize the decline in physical activity levels and mitigate the increase in screen-time on adolescents from urban area of a LMIC. However, our study should be replicated, taking into account the limitations mentioned, in order to confirm its effectiveness.

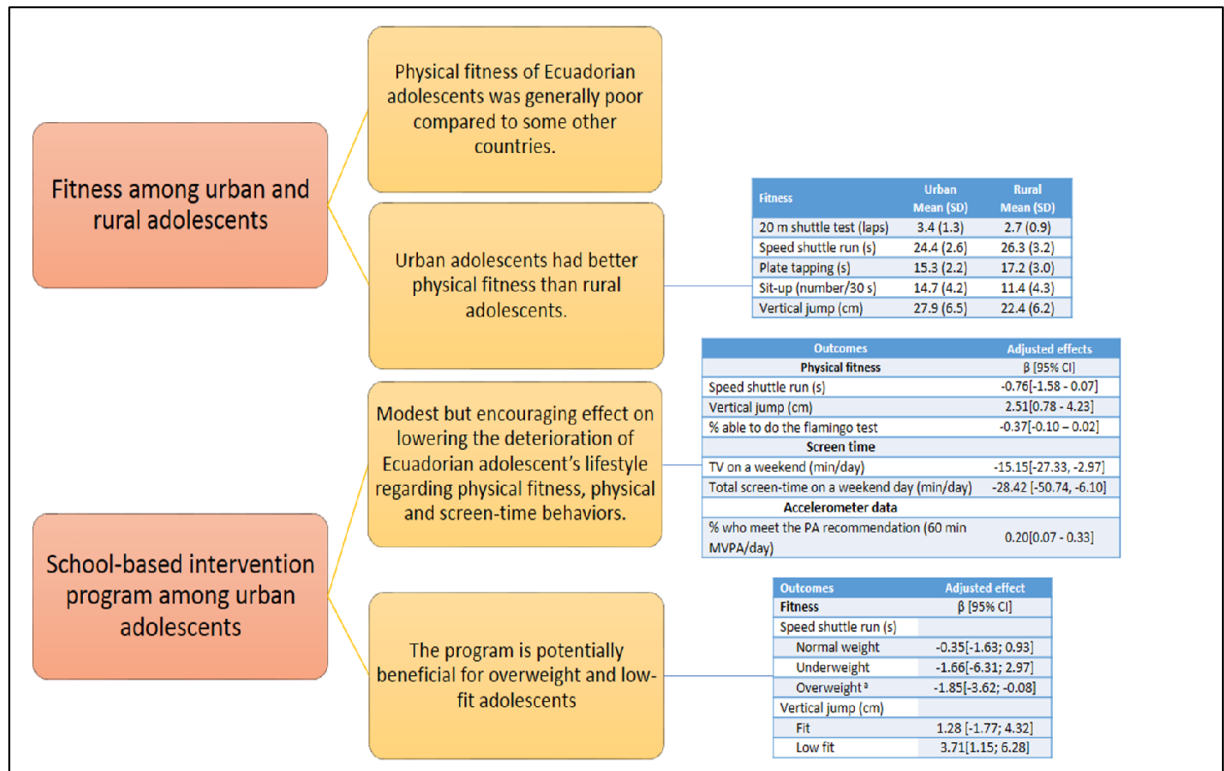


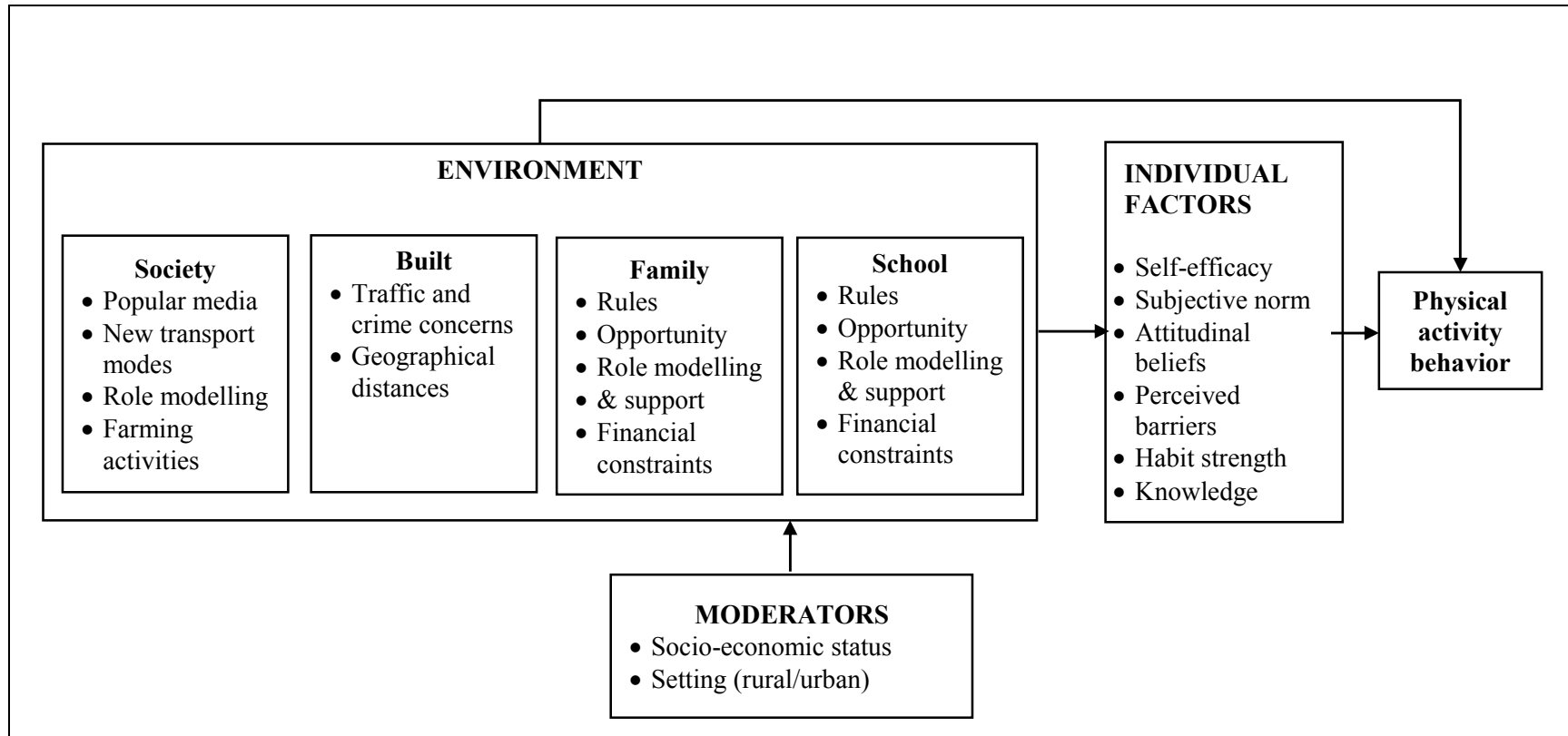
Figure 7.1 Main findings of the research

In Ecuador there are policies aimed to promote healthy lifestyle among youngsters. These policies could be complemented by including changes in the school curriculum, especially for the program of physical education classes, by establishing policies related to media education on the schools and by regulating the media content on TV/radio related to physical activity. Physical inactivity should also be included in the national research priorities.

Our conclusion beyond the Ecuadorian context is that there is a need for a global criterion-reference for fitness and standardized methods to measure physical fitness. International cooperation should address this need.

Appendices

Appendix 1 Conceptual framework for physical activity behaviors*



*Figure adapted from Verstraeten *et.al* (62)

*Appendix 2 Matrix: theoretical methods and related intervention strategies mapped towards behavioral and environmental factors**

Factors	Theoretical methods	Intervention strategies
Adolescents		
Knowledge/awareness	Active learning (IMB model)	The ACTIVITAL toolkit: providing information, facts about a healthy breakfast through an interactive session (games, visual exercises, etc.)
	Using imagery (theories of information processing)	Images are used as analogy to create awareness on health benefits or risks
	Goal setting (CT)	Current habits are discussed (quiz) and new goals are set
	Rehearsal	Throughout the intervention, knowledge is repeated and evaluated
	Self-evaluation (TTM) Prompt barrier identification (SCogT)	They identify barriers, get feedback (group discussion) which is followed by problem-solving and teaching them skills (breakfast event/athletes sharing their experiences) on how to overcome these
Attitudinal beliefs	Self-evaluation (TTM) Prompt barrier identification (SCogT)	They identify barriers, get feedback (group discussion) which is followed by problem-solving and teaching them skills (breakfast event/athletes sharing their experiences) on how to overcome these
	Persuasive communication	Guided towards adoption of a positive attitude towards a healthy breakfast
	Modelling (SCogT)	Famous young athletes share their experiences on breakfast, attention, remembrance and show them how they can improve
Skills/Self-control	Guided practice (SCogT)	A session in which a “real life game” is played in which they get money to buy a healthy breakfast and evaluate what they bought for a limited amount of money
	Planning coping responses	Providing them with alternatives in case they are confronted with limitations
	Active learning (IMB) Direct experience	Events, workshops in which they prepare a healthy breakfast and share experiences and receive practical tips
Subjective norm	Shifting the focus (TPB) Information about other’s approval (TPB)	Focusing on e.g. better performance at school, a healthy skin, rather than on healthy weight, etc.
	Modelling Prompt identification as role models (SCogT)	Famous athletes share their experience, and increase acceptance of eating a healthy breakfast. Workshops
	Plan social support and change (social support theories)	Workshops
Parents		
Knowledge/Awareness	Active learning (IMB model)	Workshops providing information, facts about a healthy breakfast through an interactive session

Factors	Theoretical methods	Intervention strategies
	Using imagery (theories of information processing)	Images are used as analogy to create awareness on health benefits or risks
Attitude	Goal setting (CT)	Current habits are discussed (quiz) and new goals are set
	Self-evaluation (TTM) Prompt barrier identification (SCogT)	They identify barriers, get feedback (group discussion) which is followed by problem-solving and skills training on how to overcome these (breakfast recipes)
	Prompt identification as role models (SCogT)	Their exemplary role for their children is discussed in an interactive session
Skills/Self-control	Persuasive communication	Guided towards adoption of a positive attitude towards a healthy breakfast
	Planning coping responses	Providing them with alternatives in case they are confronted with limitations
	Active learning (IMB) Direct experience (Theories of learning)	Workshops in which they receive breakfast recipes for different budgets, share experiences and receive practical tips
School staff		
Knowledge/Awareness	Active learning (IMB model)	The ACTIVITAL toolkit: providing information, facts about a healthy breakfast through an interactive session (games, visual exercises, etc.). Each chapter provides details on how to deliver sessions within the toolkit
Attitude	Using imagery (theories of information processing)	Images are used as analogy to create awareness on health benefits or risks
	Prompt identification as role models (SCogT)	They are encouraged to be an exemplary role for the adolescents throughout the ACTIVITAL toolkit, use of leaflets, and informal meetings
	Persuasive communication	Guided towards adoption of a positive attitude towards a healthy breakfast
Skills/Self-control	Guided practice (SCogT)	A session in which a “real life game” is played in which they get money to buy a healthy breakfast and evaluate what they bought for a limited amount of money. The teachers first models the good behavior and then the adolescents are asked to play the game themselves.
	Planning coping responses	Providing them with alternatives in case they are confronted with limitations
Outcome expectations	Enactive mastery experience (SCogT)	Participatory development and problem-solving: including recommendations in the toolkit, technical assistance in problems in

Factors	Theoretical methods	Intervention strategies
	Persuasive communication	implementing the toolkit, generating solutions, and obtaining feedback after implementation Benefits of protecting children from diseases by having a healthy breakfast
Tuck shops		
Knowledge/Awareness	Active learning (IMB model)	Workshops providing information, facts about a healthy breakfast, food safety issues, planning healthy breakfasts through interactive session
	Using imagery (theories of information processing)	Images are used as analogy to create awareness on health benefits or risks
	Goal setting (CT)	Current practices are discussed (quiz) and new goals are set
Skills/Self-control	Planning coping responses	Providing them with alternatives in case they are confronted with limitations
	Active learning (IMB) Direct experience (Theories of learning)	Workshops in which they receive breakfast recipes for different budgets, share experiences and receive practical tips
Attitude	Self-evaluation (TTM) Prompt barrier identification (SCogT)	They identify barriers, get feedback (group discussion) which is followed by problem-solving and teaching them skills on how to overcome these
	Persuasive communication	Guided towards adoption of a positive attitude towards a healthy breakfast
	Direct experience (Theories of learning)	Sharing experiences
Outcome expectations	Structural redesign (organizational development theory)	Trainings with manager or employees of tuck shops on providing healthy breakfasts
	Guided practice (SCogT)	Tuck shops with positive experiences on healthy recipes shared these with the other tuck shops
	Enactive mastery experience (SCogT)	Participatory problem-solving: including technical assistance in diagnosing problem, generating solutions, developing priorities, making action plan, obtaining feedback after implementation

*SCogT, Social Cognitive Theory; CTh, Control Theory; TTM, Trans Theoretical Model; IMB, Information-Motivation Behavioural skills model; TPB, Theory of Planned Behaviour. *Table adapted from Verstraeten et al (62)*

References

1. McKenna M, Taylor W, Marks J, Koplan J. Current issues and challenges in chronic disease control. *Chro Dise Epide Cont*. 1998;2:1-26.
2. Abegunde D, Vita-Finzi L. Preventing chronic diseases: a vital investment 2005.
3. Jamison DT, Summers LH, Alleyne G, Arrow KJ, Berkley S, Binagwaho A, et al. Global health 2035: a world converging within a generation. *Lancet*. 2013;382(9908):1898-1955.
4. Mendis S. Global status report of non noncommunicable diseases 2014. Switzerland: WHO Library Cataloguing-in-Publication Data; 2014 2014.
5. WHO. Four noncommunicable diseases, four shared risk factors. 2015. Available from: <http://www.who.int/ncdnet/about/4diseases/en/>.
6. Blair SN, Kampert JB, Kohl HW, 3rd, Barlow CE, Macera CA, Paffenbarger RS, Jr., et al. Influences of cardiorespiratory fitness and other precursors on cardiovascular disease and all-cause mortality in men and women. *JAMA*. 1996;276(3):205-210.
7. Wei M, Gibbons LW, Kampert JB, Nichaman MZ, Blair SN. Low cardiorespiratory fitness and physical inactivity as predictors of mortality in men with type 2 diabetes. *Ann Inter Med*. 2000;132(8):605-+.
8. FitzGerald SJ, Barlow CE, Kampert JB, Morrow J, Jackson AW, Blair SN. Muscular fitness and all-cause mortality: prospective observations. *J Phys Activ & Healt*. 2004;1:7-18.
9. de Rezende LF, Rodrigues Lopes M, Rey-Lopez JP, Matsudo VK, Luiz Odo C. Sedentary behavior and health outcomes: an overview of systematic reviews. *PLoS One*. 2014;9(8):e105620.
10. Lozano R, Naghavi M, Foreman K, Lim S, Shibuya K, Aboyans V, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*. 2012;380(9859):2095-2128.
11. Lim SS, Vos T, Flaxman AD, Danaei G, Shibuya K, Adair-Rohani H, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*. 2012;380(9859):2224-2260.
12. Abegunde DO, Mathers CD, Adam T, Ortegón M, Strong K. The burden and costs of chronic diseases in low-income and middle-income countries. *Lancet*. 2007;370(9603):1929-1938.
13. Wagner KH, Brath H. A global view on the development of non communicable diseases. *Prev Med*. 2012;54 Suppl:S38-41.
14. Baldwin W. KT, Amato L., Nolan L. Noncommunicable Disease in Latin America and the Caribbean: Youth Are Key to Prevention Data Sheet. Population Reference Bureau, 2013.
15. McDonald M. PF. The Global Burden of Noncommunicable Diseases: pfizer; 2011 [cited 2014 January 28]. Available from: <https://www.pfizer.pt/Files/Billeder/Pfizer%20P%C3%BAblico/Not%C3%ADcias/Globa%20Burden%20of%20Noncommunicable%20Diseases.pdf>.

16. Bloom DE, Cafiero E, Jané-Llopis E, Abrahams-Gessel S, Bloom LR, Fathima S, et al. The global economic burden of noncommunicable diseases. Program on the Global Demography of Aging, 2012.
17. Sawyer SM, Afifi RA, Bearinger LH, Blakemore SJ, Dick B, Ezech AC, et al. Adolescence: a foundation for future health. *Lancet*. 2012;379(9826):1630-1640.
18. Catalano RF, Fagan AA, Gavin LE, Greenberg MT, Irwin CE, Jr., Ross DA, et al. Worldwide application of prevention science in adolescent health. *Lancet*. 2012;379(9826):1653-1664.
19. Viner RM, Ozer EM, Denny S, Marmot M, Resnick M, Fatusi A, et al. Adolescence and the social determinants of health. *Lancet*. 2012;379(9826):1641-1652.
20. Hancox RJ, Milne BJ, Poulton R. Association between child and adolescent television viewing and adult health: a longitudinal birth cohort study. *Lancet*. 2004;364(9430):257-262.
21. Viner RM, Ross D, Hardy R, Kuh D, Power C, Johnson A, et al. Life course epidemiology: recognising the importance of adolescence. *J Epidemiol Community Health*. 2015.
22. McGill HC, Jr., McMahan CA, Herderick EE, Malcom GT, Tracy RE, Strong JP. Origin of atherosclerosis in childhood and adolescence. *Am J Clin Nutr*. 2000;72(5 Suppl):1307S-1315S.
23. Patton GC, Coffey C, Cappa C, Currie D, Riley L, Gore F, et al. Health of the world's adolescents: a synthesis of internationally comparable data. *Lancet*. 2012;379(9826):1665-1675.
24. Juonala M, Magnussen CG, Berenson GS, Venn A, Burns TL, Sabin MA, et al. Childhood adiposity, adult adiposity, and cardiovascular risk factors. *N Engl J Med*. 2011;365(20):1876-1885.
25. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet*. 2014;384(9945):766-781.
26. Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U, et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet*. 2012;380(9838):247-257.
27. Currie C. Inequalities in young people's health: HBSC international report from the 2005/2006 Survey. World Health Organization Copenhagen; 2008.
28. Guthold R, Cowan MJ, Autenrieth CS, Kann L, Riley LM. Physical activity and sedentary behavior among schoolchildren: a 34-country comparison. *J Pediatr*. 2010;157(1):43-49 e41.
29. Tomkinson GR, Olds T. Pediatric fitness: secular trends and geographic variability: Karger Medical and Scientific Publishers; 2007.
30. Muthuri SK, Wachira LJ, Leblanc AG, Francis CE, Sampson M, Onywera VO, et al. Temporal trends and correlates of physical activity, sedentary behaviour, and physical

- fitness among school-aged children in Sub-Saharan Africa: a systematic review. *Int J Environ Res Public Health*. 2014;11(3):3327-3359.
31. Tomkinson GR, Macfarlane D, Noi S, Kim DY, Wang Z, Hong R. Temporal changes in long-distance running performance of Asian children between 1964 and 2009. *Sports Med*. 2012;42(4):267-279.
 32. Ortega FB, Ruiz JR, Castillo MJ, Sjostrom M. Physical fitness in childhood and adolescence: a powerful marker of health. *Int J Obes (Lond)*. 2008;32(1):1-11.
 33. Janssen I, Leblanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int J Behav Nutr Phys Act*. 2010;7:40.
 34. Tremblay MS, LeBlanc AG, Kho ME, Saunders TJ, Larouche R, Colley RC, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *Int J Behav Nutr Phys Act*. 2011;8:98.
 35. Blair SN, Archer E, Hand GA. Commentary: Luke and Cooper are wrong: physical activity has a crucial role in weight management and determinants of obesity. *Int J Epidemiol*. 2013;42(6):1836-1838.
 36. Boone JE, Gordon-Larsen P, Adair LS, Popkin BM. Screen time and physical activity during adolescence: longitudinal effects on obesity in young adulthood. *Int J Behav Nutr Phys Act*. 2007;4:26.
 37. Waxman A, World Health A. WHO global strategy on diet, physical activity and health. *Food Nutr Bull*. 2004;25(3):292-302.
 38. Dobbins M, Husson H, DeCorby K, LaRocca RL. School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6 to 18. *Cochrane Database Syst Rev*. 2013;2:CD007651.
 39. Khambalia AZ, Dickinson S, Hardy LL, Gill T, Baur LA. A synthesis of existing systematic reviews and meta-analyses of school-based behavioural interventions for controlling and preventing obesity. *Obes Rev*. 2012;13(3):214-233.
 40. Dobbins M, De Corby K, Robeson P, Husson H, Tirilis D. School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6-18. *Cochrane Database Syst Rev*. 2009(1):CD007651.
 41. Kriemler S, Meyer U, Martin E, van Sluijs EMF, Andersen LB, Martin BW. Effect of school-based interventions on physical activity and fitness in children and adolescents: a review of reviews and systematic update. *Br J Sports Med*. 2011;45(11):923-930.
 42. Leung MM, Agaronov A, Grytsenko K, Yeh MC. Intervening to Reduce Sedentary Behaviors and Childhood Obesity among School-Age Youth: A Systematic Review of Randomized Trials. *J Obes*. 2012;2012:685430.
 43. Van Cauwenberghe E, Maes L, Spittaels H, van Lenthe FJ, Brug J, Oppert J-M, et al. Effectiveness of school-based interventions in Europe to promote healthy nutrition in children and adolescents: systematic review of published and 'grey' literature. *Br J Nutr*. 2010;103(06):781-797.
 44. Miranda JJ, Kinra S, Casas JP, Davey Smith G, Ebrahim S. Non-communicable diseases in low- and middle-income countries: context, determinants and health policy. *Trop Med Int Health*. 2008;13(10):1225-1234.

45. Hoehner CM, Ribeiro IC, Parra DC, Reis RS, Azevedo MR, Hino AA, et al. Physical activity interventions in Latin America: expanding and classifying the evidence. *Am J Prev Med.* 2013;44(3):e31-40.
46. Lobelo F, Garcia de Quevedo I, Holub CK, Nagle BJ, Arredondo EM, Barquera S, et al. School-based programs aimed at the prevention and treatment of obesity: evidence-based interventions for youth in Latin America. *J Sch Health.* 2013;83(9):668-677.
47. Galaviz KI, Harden SM, Smith E, Blackman KC, Berrey LM, Mama SK, et al. Physical activity promotion in Latin American populations: a systematic review on issues of internal and external validity. *Int J Behav Nutr Phys Act.* 2014;11:77.
48. Mancipe Navarrete JA, Garcia Villamil SS, Correa Bautista JE, Meneses-Echavez JF, Gonzalez-Jimenez E, Schmidt Rio-Valle J. Effectiveness of educational interventions conducted in latin america for the prevention of overweight and obesity in scholar children from 6-17 years old; a systematic review. *Nutr Hosp.* 2015;31(1):102-114.
49. Hoehner CM, Soares J, Parra Perez D, Ribeiro IC, Joshu CE, Pratt M, et al. Physical activity interventions in Latin America: a systematic review. *Am J Prev Med.* 2008;34(3):224-233.
50. Ribeiro IC, Parra DC, Hoehner CM, Soares J, Torres A, Pratt M, et al. School-based physical education programs: evidence-based physical activity interventions for youth in Latin America. *Glob Health Promot.* 2010;17(2):5-15.
51. Verstraeten R, Roberfroid D, Lachat C, Leroy JL, Holdsworth M, Maes L, et al. Effectiveness of preventive school-based obesity interventions in low- and middle-income countries: a systematic review. *Am J Clin Nutr.* 2012;96(2):415-438.
52. Friedrich RR, Polet JP, Schuch I, Wagner MB. Effect of intervention programs in schools to reduce screen time: a meta-analysis. *J Pediatr (Rio J).* 2014;90(3):232-241.
53. INEC. Anuario de estadísticas vitales: nacimientos y defunciones Ecuador Instituto Nacional de Estadísticas y Censos; 2011 [cited 2015 January 28]. Available from: <http://www.ecuadorencifras.gob.ec/nacimientos-defunciones/>.
54. WHO. Ecuador: health profile 2014 [cited 2015 January 28]. Available from: <http://www.who.int/gho/countries/ecu.pdf?ua=1>.
55. Yopez R, Carrasco F, Baldeon ME. [Prevalence of overweight and obesity in Ecuadorian adolescent students in the urban area]. *Arch Latinoam Nutr.* 2008;58(2):139-143.
56. Universidad-de-Cuenca. "Food, Nutrition and Health" project Ecuador2015 [cited 2015 June 6]. Available from: <http://ucuenca.edu.ec/la-investigacion/unidades-de-investigaci%C3%B3n/vlir-uos/programas/nuthealth>.
57. INEC. Censo 2010 [14 January 2014]. Available from: <http://www.ecuadorencifras.gob.ec/resultados/>.
58. The-World-Bank. [cited 2015 14 January 2015]. Available from: <http://data.worldbank.org/country/ecuador>.
59. Malik K. Human development report 2013. The rise of the South: Human progress in a diverse world. 2013.

60. INAMHI. Instituto Nacional de Meteorología e Hidrología del Ecuador [cited 2015 14 January 2015]. Available from: <http://www.serviciometeorologico.gob.ec/wp-content/uploads/downloads/2014/12/ATLAS-ESTUDIANTIL2.pdf>.
61. INEC. Censo de Población y vivienda 2010 Quito, Ecuador 2010 [June 6]. Available from: <http://157.100.121.12/cgi-bin/RpWebEngine.exe/PortalAction?&MODE=MAIN&BASE=CPV2010&MAIN=WebServerMain.inl>.
62. Verstraeten R. Development of a school-based health promotion intervention in Ecuadorian adolescents and its cluster randomised-controlled evaluation design: Ghent University; 2014.
63. Ochoa Avilés AM. Cardiovascular risk factors among Ecuadorian adolescents: a school-based health promotion intervention: Ghent University; 2015.
64. Cogill B. Anthropometric indicators measurement guide. 2003.
65. Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Rep.* 1985;100(2):126-131.
66. Malina RM, Katzmarzyk PT. Physical activity and fitness in an international growth standard for preadolescent and adolescent children. *Food Nutr Bull.* 2006;27(4 Suppl Growth Standard):S295-313.
67. Vanhees L, Lefevre J, Philippaerts R, Martens M, Huygens W, Troosters T, et al. How to assess physical activity? How to assess physical fitness? *Euro Cardio Preve Rehab.* 2005;12(2):102-114.
68. Adam C, Klissouras V, Ravazzolo M, Renson R, Tuxworth W. Eurofit: European test of physical fitness. Rome, Council of Europe, Committee for the Development of Sport. 1988.
69. Castro-Pinero J, Artero EG, España-Romero V, Ortega FB, Sjostrom M, Suni J, et al. Criterion-related validity of field-based fitness tests in youth: a systematic review. *Br J Sports Med.* 2010;44(13):934-943.
70. Castro-Pinero J, Chillón P, Ortega FB, Montesinos JL, Sjostrom M, Ruiz JR. Criterion-related validity of sit-and-reach and modified sit-and-reach test for estimating hamstring flexibility in children and adolescents aged 6-17 years. *Int J Sports Med.* 2009;30(9):658-662.
71. Ruiz J, Ortega F, Gutierrez A, Meusel D, Sjöström M, Castillo M. Health-related fitness assessment in childhood and adolescence: a European approach based on the AVENA, EYHS and HELENA studies. *J Publi Healt.* 2006;14(5):269-277.
72. Pena Reyes ME, Tan SK, Malina RM. Urban-rural contrasts in the physical fitness of school children in Oaxaca, Mexico. *Am J Hum Biol.* 2003;15(6):800-813.
73. Mac Donncha C, Watson AW, McSweeney T, O'Donovan DJ. Reliability of Eurofit physical fitness items for adolescent males with and without mental retardation. *Adapt Phys Act Q.* 1999;16:86-95.
74. Kain B J, Uauy D R, Leyton D B, Cerda R R, Olivares C S, Vio D F. Efectividad de una intervención en educación alimentaria y actividad física para prevenir obesidad en

- escolares de la ciudad de Casablanca, Chile (2003-2004). *Rev Med Chile*. 2008;136(1):22-30.
75. Mojica GT, Poveda JG, Pinilla MI, Lobelo F. Sobrepeso, inactividad física y baja condición física en un colegio de Bogotá, Colombia. *Arch Latinoam Nutr*. 2008;58(3):265-273.
76. Barbieri CO. Programa de evaluación, diagnóstico e investigación de la aptitud física y la salud, PEDIAF yS: Instituto Bonaerense del Deporte; 1996.
77. Castro-Pinero J, Ortega FB, Artero EG, Girela-Rejon MJ, Mora J, Sjostrom M, et al. Assessing muscular strength in youth: usefulness of standing long jump as a general index of muscular fitness. *J Strength Cond Res*. 2010;24(7):1810-1817.
78. The-Cooper-Institute. FITNESSGRAM Performance Standards California, USA2011 [cited 2012 September 1]. Available from: <http://www.cvesd.org/COMMUNITY/Documents/2012%20HFZ%20Chart.pdf>.
79. Boiarskaia EA, Boscolo MS, Zhu W, Mahar MT. Cross-validation of an equating method linking aerobic FITNESSGRAM(R) field tests. *Am J Prev Med*. 2011;41(4 Suppl 2):S124-130.
80. SIISE. Sistema Integrado de Indicadores Sociales del Ecuador Quito2013 [cited 2013 July]. Indicadores del SIISE. Available from: http://www.siise.gob.ec/siiseweb/PageWebs/POBREZA/ficpob_P05.htm.
81. Gibson RS, Ferguson EL. An interactive 24-hour recall for assessing the adequacy of iron and zinc intakes in developing countries. Washington, DC: International Life Sciences Institute. 2008.
82. Ochoa-Aviles A, Verstraeten R, Lachat C, Andrade S, Van Camp J, Donoso S, et al. Dietary intake practices associated with cardiovascular risk in urban and rural Ecuadorian adolescents: a cross-sectional study. *BMC Public Health*. 2014;14:939.
83. Trinder P. Enzymatic method of triglycerides. *Ann Clin Biochem*. 1969;6:24-27.
84. Gordon T, Castelli WP, Hjortland MC, Kannel WB, Dawber TR. High density lipoprotein as a protective factor against coronary heart disease: the Framingham Study. *Amer Jour Med*. 1977;62(5):707-714.
85. DeLong DM, DeLong ER, Wood PD, Lippel K, Rifkind BM. A comparison of methods for the estimation of plasma low- and very low-density lipoprotein cholesterol. The Lipid Research Clinics Prevalence Study. *JAMA*. 1986;256(17):2372-2377.
86. Lauer R, Barness L, Clark R, Deckelbaum R, Finberg L, Kwiterovich P, et al. National Cholesterol Education-Program (Ncep)-Highlights Of The Report Of The Expert Panel On Blood Cholesterol Levels In Children And Adolescents. *Amer Acad Pediatrics*; 1992.
87. Zimmet P, Alberti KG, Kaufman F, Tajima N, Silink M, Arslanian S, et al. The metabolic syndrome in children and adolescents - an IDF consensus report. *Pediatr Diabetes*. 2007;8(5):299-306.
88. Pediatrics AAo. American Academy of Pediatrics. Committee on Nutrition. Cholesterol in childhood. *Pediatrics*. 1998;101(1 Pt 1):141.

89. Campbell MK, Piaggio G, Elbourne DR, Altman DG, Group C. Consort 2010 statement: extension to cluster randomised trials. *BMJ*. 2012;345:e5661.
90. Hayes RJ, Bennett S. Simple sample size calculation for cluster-randomized trials. *Int J Epidemiol*. 1999;28(2):319-326.
91. Bartholomew LK, Parcel GS, Kok G, Gottlieb NH, Fernandez ME. Planning health promotion programs: an intervention mapping approach. United States of America: John Wiley & Sons; 2011.
92. Lefevre P, Kolsteren P, De Wael M, Byekwaso F, Beghin I. Comprehensive participatory planning and evaluation (CPPE). 2001.
93. Ochoa-Avilés A, Andrade S, Huynh T, Verstraeten R, Lachat C, Rojas R, et al. Prevalence and socioeconomic differences of risk factors of cardiovascular disease in Ecuadorian adolescents. *Pediatric obesity*. 2012;7(4):274-283.
94. Andrade S, Ochoa-Aviles A, Lachat C, Escobar P, Verstraeten R, Van Camp J, et al. Physical fitness among urban and rural Ecuadorian adolescents and its association with blood lipids: a cross sectional study. *BMC Pediatr*. 2014;14:106.
95. Van Royen K, Verstraeten R, Andrade S, Ochoa-Aviles A, Donoso S, Maes L, et al. Factors affecting physical activity in ecuadorian adolescents: a focus group study. *J Phys Act Health*. 2015;12(3):340-348.
96. de Vries H, Dijkstra M, Kuhlman P. Self-efficacy: the third factor besides attitude and subjective norm as a predictor of behavioural intentions. *Health Educ Res*. 1988;3(3):273-282.
97. Green LW, Richard L, Potvin L. Ecological foundations of health promotion. *Am J Health Promot*. 1996;10(4):270-281.
98. Abraham C, Michie S. A taxonomy of behavior change techniques used in interventions. *Health Psychol*. 2008;27(3):379-387.
99. Pate RR, O'Neill JR, Lobelo F. The evolving definition of "sedentary". *Exerc Sport Sci Rev*. 2008;36(4):173-178.
100. Pate RR, Mitchell JA, Byun W, Dowda M. Sedentary behaviour in youth. *Br J Sports Med*. 2011;45(11):906-913.
101. Mark AE, Janssen I. Relationship between screen time and metabolic syndrome in adolescents. *J Public Health (Oxf)*. 2008;30(2):153-160.
102. National-Health-and-Nutrition-Examination-Survey. Questionnaire Physical activity and physical fitness 2004. Available from: http://www.cdc.gov/nchs/data/nhanes/nhanes_03_04/sp_paq_c.pdf.
103. Schmitz KH, Harnack L, Fulton JE, Jacobs DR, Jr., Gao S, Lytle LA, et al. Reliability and validity of a brief questionnaire to assess television viewing and computer use by middle school children. *J Sch Health*. 2004;74(9):370-377.
104. Corder K, van Sluijs EM, Wright A, Whincup P, Wareham NJ, Ekelund U. Is it possible to assess free-living physical activity and energy expenditure in young people by self-report? *Am J Clin Nutr*. 2009;89(3):862-870.

105. Neilson HK, Robson PJ, Friedenreich CM, Csizmadi I. Estimating activity energy expenditure: how valid are physical activity questionnaires? *Am J Clin Nutr.* 2008;87(2):279-291.
106. Mattocks C, Tilling K, Ness A, Riddoch C. Improvements in the measurement of physical activity in childhood obesity research; lessons from large studies of accelerometers. *Clin Med: Pediatrics.* 2008;2:27-36.
107. Trost SG, Loprinzi PD, Moore R, Pfeiffer KA. Comparison of accelerometer cut points for predicting activity intensity in youth. *Med Sci Sports Exerc.* 2011;43(7):1360-1368.
108. Matthews CE, Chen KY, Freedson PS, Buchowski MS, Beech BM, Pate RR, et al. Amount of time spent in sedentary behaviors in the United States, 2003-2004. *Am J Epidemiol.* 2008;167(7):875-881.
109. Freedson P, Pober D, Janz KF. Calibration of accelerometer output for children. *Med Sci Sports Exerc.* 2005;37(11 Suppl):S523-530.
110. Matthews CE. Calibration of accelerometer output for adults. *Med Sci Sports Exerc.* 2005;37(11 Suppl):S512-522.
111. Verstraeten R, Lachat C, Ochoa-Aviles A, Hagstromer M, Huybregts L, Andrade S, et al. Predictors of validity and reliability of a physical activity record in adolescents. *BMC Public Health.* 2013;13:1109.
112. Cole TJ, Flegal KM, Nicholls D, Jackson AA. Body mass index cut offs to define thinness in children and adolescents: international survey. *BMJ.* 2007;335(7612):194.
113. Williams PT. Physical fitness and activity as separate heart disease risk factors: a meta-analysis. *Med Sci Sports Exerc.* 2001;33(5):754-761.
114. Ekelund U, Anderssen SA, Froberg K, Sardinha LB, Andersen LB, Brage S, et al. Independent associations of physical activity and cardiorespiratory fitness with metabolic risk factors in children: the European youth heart study. *Diabetologia.* 2007;50(9):1832-1840.
115. Perichart-Perera O, Balas-Nakash M, Rodriguez-Cano A, Munoz-Manrique C, Monge-Urrea A, Vadillo-Ortega F. Correlates of dietary energy sources with cardiovascular disease risk markers in Mexican school-age children. *J Am Diet Assoc.* 2010;110(2):253-260.
116. Karkera A, Swaminathan N, Pais SM, Vishal K, Rai BS. Physical Fitness and Activity Levels among Urban School Children and their Rural Counterparts. *Indian J Pediatr.* 2013;81(4):356-361.
117. Ozdirenc M, Ozcan A, Akin F, Gelecek N. Physical fitness in rural children compared with urban children in Turkey. *Pediatr Int.* 2005;47(1):26-31.
118. Wang JH, Wu MC, Chang HH. Urban-rural disparity in physical fitness of elementary schoolchildren in Taiwan. *Pediatr Int.* 2013;55(3):346-354.
119. Campos H, Bailey SM, Gussak LS, Siles X, Ordovas JM, Schaefer EJ. Relations of body habitus, fitness level, and cardiovascular risk factors including lipoproteins and apolipoproteins in a rural and urban Costa Rican population. *Arterioscler Thromb.* 1991;11(4):1077-1088.

120. Hartley D. Rural health disparities, population health, and rural culture. *Am J Public Health*. 2004;94(10):1675-1678.
121. Moore JB, Jilcott SB, Shores KA, Evenson KR, Brownson RC, Novick LF. A qualitative examination of perceived barriers and facilitators of physical activity for urban and rural youth. *Health Educ Res*. 2010;25(2):355-367.
122. Moore JB, Brinkley J, Crawford TW, Evenson KR, Brownson RC. Association of the built environment with physical activity and adiposity in rural and urban youth. *Prev Med*. 2013;56(2):145-148.
123. Streiner DL, Norman GR. Correction for multiple testing: is there a resolution? *Chest*. 2011;140(1):16-18.
124. Ortega FB, Ruiz JR, Castillo MJ, Moreno LA, Gonzalez-Gross M, Warnberg J, et al. Low level of physical fitness in Spanish adolescents. Relevance for future cardiovascular health (AVENA study). *Rev Esp Cardiol*. 2005;58(8):898-909.
125. Moreira C, Santos R, de Farias Junior JC, Vale S, Santos PC, Soares-Miranda L, et al. Metabolic risk factors, physical activity and physical fitness in Azorean adolescents: a cross-sectional study. *BMC Public Health*. 2011;11:214.
126. Janz KF, Dawson JD, Mahoney LT. Tracking physical fitness and physical activity from childhood to adolescence: the muscatine study. *Med Sci Sports Exerc*. 2000;32(7):1250-1257.
127. Blair SN, Kohl H, Barlow CE, Paffenbarger R, Gibbons LW, Macera CA. Changes in physical fitness and all-cause mortality. *JAMA*. 1995;273(14):1093-1098.
128. Chillón P, Ortega FB, Ferrando JA, Casajus JA. Physical fitness in rural and urban children and adolescents from Spain. *J Sci Med Sport*. 2011;14(5):417-423.
129. Deforche B, Lefevre J, De Bourdeaudhuij I, Hills AP, Duquet W, Bouckaert J. Physical fitness and physical activity in obese and nonobese Flemish youth. *Obes Res*. 2003;11(3):434-441.
130. Tsimeas PD, Tsiokanos AL, Koutedakis Y, Tsigilis N, Kellis S. Does living in urban or rural settings affect aspects of physical fitness in children? An allometric approach. *Br J Sports Med*. 2005;39(9):671-674.
131. Wilczewski A SM, Krawczyk B. Physical development and fitness of children from urban and rural areas as determined by EUROFIT test battery. *Biology Sport*. 1996;13:113-126.
132. Costa AM, Breitenfeld L, Silva AJ, Pereira A, Izquierdo M, Marques MC. Genetic inheritance effects on endurance and muscle strength: an update. *Sports Med*. 2012;42(6):449-458.
133. Gonzalez-Andrade F, Sanchez D, Gonzalez-Solorzano J, Gascon S, Martinez-Jarreta B. Sex-specific genetic admixture of Mestizos, Amerindian Kichwas, and Afro-Ecuadorans from Ecuador. *Hum Biol*. 2007;79(1):51-77.
134. Adamo KB, Sheel AW, Onywera V, Waudu J, Boit M, Tremblay MS. Child obesity and fitness levels among Kenyan and Canadian children from urban and rural environments: a KIDS-CAN Research Alliance Study. *Int J Pediatr Obes*. 2011;6(2-2):e225-232.

135. Tambalis KD, Panagiotakos DB, Sidossis LS. Greek children living in rural areas are heavier but fitter compared to their urban counterparts: a comparative, time-series (1997-2008) analysis. *J Rural Health*. 2011;27(3):270-277.
136. Albarwani S, Al-Hashmi K, Al-Abri M, Jaju D, Hassan MO. Effects of overweight and leisure-time activities on aerobic fitness in urban and rural adolescents. *Metab Syndr Relat Disord*. 2009;7(4):369-374.
137. Malina RM, Bouchard C, Bar-Or O. Growth, maturation, and physical activity: *Human Kinetics*; 2004.
138. Papas MA, Alberg AJ, Ewing R, Helzlsouer KJ, Gary TL, Klassen AC. The built environment and obesity. *Epidemiol Rev*. 2007;29:129-143.
139. Davison KK, Lawson CT. Do attributes in the physical environment influence children's physical activity? A review of the literature. *Int J Behav Nutr Phys Act*. 2006;3:19.
140. Gordon-Larsen P, Nelson MC, Page P, Popkin BM. Inequality in the built environment underlies key health disparities in physical activity and obesity. *Pediatrics*. 2006;117(2):417-424.
141. García-Artero E, Ortega FB, Ruiz JR, Mesa JL, Delgado M, González-Gross M, et al. Lipid and Metabolic Profiles in Adolescents Are Affected More by Physical Fitness Than Physical Activity (AVENA Study) (spanish). *Rev Esp Cardiol*. 2007;60(6):581-588.
142. Ekelund U, Luan J, Sherar LB, Esliger DW, Griew P, Cooper A, et al. Moderate to vigorous physical activity and sedentary time and cardiometabolic risk factors in children and adolescents. *JAMA*. 2012;307(7):704-712.
143. Browning LM, Hsieh SD, Ashwell M. A systematic review of waist-to-height ratio as a screening tool for the prediction of cardiovascular disease and diabetes: 0.5 could be a suitable global boundary value. *Nutr Res Rev*. 2010;23(2):247-269.
144. Craggs C, Corder K, van Sluijs EM, Griffin SJ. Determinants of change in physical activity in children and adolescents: a systematic review. *Am J Prev Med*. 2011;40(6):645-658.
145. Tresaco B, Moreno LA, Ruiz JR, Ortega FB, Bueno G, Gonzalez-Gross M, et al. Truncal and abdominal fat as determinants of high triglycerides and low HDL-cholesterol in adolescents. *Obesity (Silver Spring)*. 2009;17(5):1086-1091.
146. Wang S, Ray N, Rojas W, Parra MV, Bedoya G, Gallo C, et al. Geographic patterns of genome admixture in Latin American Mestizos. *PLoS Genet*. 2008;4(3):e1000037.
147. Andersen LB, Riddoch C, Kriemler S, Hills AP. Physical activity and cardiovascular risk factors in children. *Br J Sports Med*. 2011;45(11):871-876.
148. Lachat C, Otchere S, Roberfroid D, Abdulai A, Seret FM, Milesevic J, et al. Diet and physical activity for the prevention of noncommunicable diseases in low- and middle-income countries: a systematic policy review. *PLoS Med*. 2013;10(6):e1001465.
149. Hellevik O. Linear versus logistic regression when the dependent variable is a dichotomy. *Quality & Quantity*. 2009;43(1):59-74.
150. Andersson P, Harris J. Re-theorising the recognition of prior learning. 2006.

151. Díaz FFC. Selección de modelos mediante criterios de información en análisis factorial: aspectos teóricos y computacionales: Editorial de la Universidad de Granada; 2011.
152. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ*. 2003;327(7414):557-560.
153. DiStefano LJ, Clark MA, Padua DA. Evidence supporting balance training in healthy individuals: a systemic review. *J Strength Cond Res*. 2009;23(9):2718-2731.
154. Verstraete SJ, Cardon GM, De Clercq DL, De Bourdeaudhuij IM. A comprehensive physical activity promotion programme at elementary school: the effects on physical activity, physical fitness and psychosocial correlates of physical activity. *Public Health Nutr*. 2007;10(5):477-484.
155. Baquet G, Berthoin S, Gerbeaux M, Van Praagh E. High-intensity aerobic training during a 10 week one-hour physical education cycle: effects on physical fitness of adolescents aged 11 to 16. *Int J Sports Med*. 2001;22(4):295-300.
156. Weeks BK, Beck BR. Twice-weekly, in-school jumping improves lean mass, particularly in adolescent boys. *Pediatr Obes*. 2012;7(3):196-204.
157. Singh AS, Chin APMJ, Brug J, van Mechelen W. Short-term effects of school-based weight gain prevention among adolescents. *Arch Pediatr Adolesc Med*. 2007;161(6):565-571.
158. Ewart CK, Young DR, Hagberg JM. Effects of school-based aerobic exercise on blood pressure in adolescent girls at risk for hypertension. *Am J Public Health*. 1998;88(6):949-951.
159. Metcalf B, Henley W, Wilkin T. Effectiveness of intervention on physical activity of children: systematic review and meta-analysis of controlled trials with objectively measured outcomes (EarlyBird 54). *BMJ*. 2012;345:e5888.
160. Haerens L, Deforche B, Maes L, Cardon G, Stevens V, De Bourdeaudhuij I. Evaluation of a 2-year physical activity and healthy eating intervention in middle school children. *Health Educ Res*. 2006;21(6):911-921.
161. Gortmaker SL, Peterson K, Wiecha J, Sobol AM, Dixit S, Fox MK, et al. Reducing obesity via a school-based interdisciplinary intervention among youth: Planet Health. *Arch Pediatr Adolesc Med*. 1999;153(4):409-418.
162. Burke V, Milligan RA, Thompson C, Taggart AC, Dunbar DL, Spencer MJ, et al. A controlled trial of health promotion programs in 11-year-olds using physical activity "enrichment" for higher risk children. *J Pediatr*. 1998;132(5):840-848.
163. Sallis JF, McKenzie TL, Conway TL, Elder JP, Prochaska JJ, Brown M, et al. Environmental interventions for eating and physical activity: a randomized controlled trial in middle schools. *Am J Prev Med*. 2003;24(3):209-217.
164. Alexandrov AA, Maslennikova GY, Kulikov SM, Propirnij GA, Perova NV. Primary prevention of cardiovascular disease: 3-year intervention results in boys of 12 years of age. *Prev Med*. 1992;21(1):53-62.

165. Lionis C, Kafatos A, Vlachonikolis J, Vakaki M, Tzortzi M, Petraki A. The effects of a health education intervention program among Cretan adolescents. *Prev Med.* 1991;20(6):685-699.
166. Newman M, Garrett Z, Elbourne D, Bradley S, Noden P, Taylor J, et al. Does secondary school size make a difference?: A systematic review. *Educ Res Rev.* 2006;1(1):41-60.
167. Maturo CC, Cunningham SA. Influence of friends on children's physical activity: a review. *Am J Public Health.* 2013;103(7):e23-38.
168. Sirard JR, Bruening M, Wall MM, Eisenberg ME, Kim SK, Neumark-Sztainer D. Physical activity and screen time in adolescents and their friends. *Am J Prev Med.* 2013;44(1):48-55.
169. Chinapaw MJ, Proper KI, Brug J, van Mechelen W, Singh AS. Relationship between young peoples' sedentary behaviour and biomedical health indicators: a systematic review of prospective studies. *Obes Rev.* 2011;12(7):e621-632.
170. Lopes AS, Silva KS, Barbosa Filho VC, Bezerra J, de Oliveira ES, Nahas MV. Trends in screen time on week and weekend days in a representative sample of Southern Brazil students. *J Public Health (Oxf).* 2014;36(4):608-614.
171. Janssen I, Medina C, Pedroza A, Barquera S. Screen time in Mexican children: findings from the 2012 National Health and Nutrition Survey (ENSANUT 2012). *Salud Publica Mex.* 2013;55(5):484-491.
172. Biddle SJ, O'Connell S, Braithwaite RE. Sedentary behaviour interventions in young people: a meta-analysis. *Br J Sports Med.* 2011;45(11):937-942.
173. Slootmaker SM, Chinapaw MJ, Seidell JC, van Mechelen W, Schuit AJ. Accelerometers and Internet for physical activity promotion in youth? Feasibility and effectiveness of a minimal intervention [ISRCTN93896459]. *Prev Med.* 2010;51(1):31-36.
174. Jones D, Hoelscher DM, Kelder SH, Hergenroeder A, Sharma SV. Increasing physical activity and decreasing sedentary activity in adolescent girls--the Incorporating More Physical Activity and Calcium in Teens (IMPACT) study. *Int J Behav Nutr Phys Act.* 2008;5:42.
175. Ezendam NP, Brug J, Oenema A. Evaluation of the Web-based computer-tailored FATaintPHAT intervention to promote energy balance among adolescents: results from a school cluster randomized trial. *Arch Pediatr Adolesc Med.* 2012;166(3):248-255.
176. Singh AS, Chin APMJ, Brug J, van Mechelen W. Dutch obesity intervention in teenagers: effectiveness of a school-based program on body composition and behavior. *Arch Pediatr Adolesc Med.* 2009;163(4):309-317.
177. Spruijt-Metz D, Nguyen-Michel ST, Goran MI, Chou CP, Huang TT. Reducing sedentary behavior in minority girls via a theory-based, tailored classroom media intervention. *Int J Pediatr Obes.* 2008;3(4):240-248.
178. Lubans DR, Morgan PJ, Callister R, Collins CE. Effects of integrating pedometers, parental materials, and E-mail support within an extracurricular school sport intervention. *J Adolesc Health.* 2009;44(2):176-183.

179. Biddle SJ, Petrolini I, Pearson N. Interventions designed to reduce sedentary behaviours in young people: a review of reviews. *Br J Sports Med.* 2014;48(3):182-186.
180. Vandewater EA, Bickham DS, Lee JH. Time well spent? Relating television use to children's free-time activities. *Pediatrics.* 2006;117(2):e181-191.
181. Pediatrics AAO. American Academy of Pediatrics: Children, adolescents, and television. *Pediatrics.* 2001;107(2):423.
182. Fitzmaurice GM, Laird NM, Ware JH. *Applied Longitudinal Analysis*: Wiley; 2011.
183. Must A, Tybor DJ. Physical activity and sedentary behavior: a review of longitudinal studies of weight and adiposity in youth. *Int J Obes (Lond).* 2005;29 Suppl 2:S84-96.
184. Chaput JP, Klingenberg L, Astrup A, Sjodin AM. Modern sedentary activities promote overconsumption of food in our current obesogenic environment. *Obes Rev.* 2011;12(5):e12-20.
185. Rauner A, Mess F, Woll A. The relationship between physical activity, physical fitness and overweight in adolescents: a systematic review of studies published in or after 2000. *BMC Pediatr.* 2013;13:19.
186. Eisenmann JC, Katzmarzyk P, Perusse L, Tremblay A, Despres J, Bouchard C. Aerobic fitness, body mass index, and CVD risk factors among adolescents: the Quebec family study. *Int J Obesity.* 2005;29(9):1077-1083.
187. Korsten-Reck U, Kaspar T, Korsten K, Kromeyer-Hauschild K, Bos K, Berg A, et al. Motor abilities and aerobic fitness of obese children. *Int J Sports Med.* 2007;28(9):762-767.
188. Thivel D, Isacco L, Lazaar N, Aucouturier J, Ratel S, Dore E, et al. Effect of a 6-month school-based physical activity program on body composition and physical fitness in lean and obese schoolchildren. *Eur J Pediatr.* 2011;170(11):1435-1443.
189. D'Hondt E, Gentier I, Deforche B, Tanghe A, Bourdeaudhuij I, Lenoir M. Weight loss and improved gross motor coordination in children as a result of multidisciplinary residential obesity treatment. *Obesity.* 2011;19(10):1999-2005.
190. Jago R, McMurray RG, Drews KL, Moe EL, Murray T, Pham TH, et al. HEALTHY intervention: fitness, physical activity, and metabolic syndrome results. *Med Sci Sports Exerc.* 2011;43(8):1513-1522.
191. Niederer I, Burgi F, Ebenegger V, Marques-Vidal P, Schindler C, Nydegger A, et al. Effects of a Lifestyle Intervention on Adiposity and Fitness in Overweight or Low Fit Preschoolers (Ballabeina). *Obesity.* 2013;21(3):E287-E293.
192. Magnusson KT, Hrafinkelsson H, Sigurgeirsson I, Johannsson E, Sveinsson T. Limited effects of a 2-year school-based physical activity intervention on body composition and cardiorespiratory fitness in 7-year-old children. *Health Educ Res.* 2012;27(3):484-494.
193. Andrade S, Lachat C, Ochoa-Aviles A, Verstraeten R, Huybregts L, Roberfroid D, et al. A school-based intervention improves physical fitness in Ecuadorian adolescents: a cluster-randomized controlled trial. *Int J Behav Nutr Phys Act.* 2014;11(1):153.

194. Assmann SF, Pocock SJ, Enos LE, Kasten LE. Subgroup analysis and other (mis)uses of baseline data in clinical trials. *The Lancet*. 2000;355(9209):1064-1069.
195. Sun X, Briel M, Walter SD, Guyatt GH. Is a subgroup effect believable? Updating criteria to evaluate the credibility of subgroup analyses. *BMJ*. 2010;340.
196. Smith JJ, Eather N, Morgan PJ, Plotnikoff RC, Faigenbaum AD, Lubans DR. The health benefits of muscular fitness for children and adolescents: a systematic review and meta-analysis. *Sports Med*. 2014;44(9):1209-1223.
197. Casajus JA, Leiva MT, Villarroya A, Legaz A, Moreno LA. Physical performance and school physical education in overweight Spanish children. *Ann Nutr Metab*. 2007;51(3):288-296.
198. Tsiros MD, Olds T, Buckley JD, Grimshaw P, Brennan L, Walkley J, et al. Health-related quality of life in obese children and adolescents. *Int J Obes (Lond)*. 2009;33(4):387-400.
199. Smith KL, Straker LM, McManus A, Fenner AA. Barriers and enablers for participation in healthy lifestyle programs by adolescents who are overweight: a qualitative study of the opinions of adolescents, their parents and community stakeholders. *BMC Pediatr*. 2014;14:53.
200. Puhl R, Brownell KD. Bias, discrimination, and obesity. *Obes Res*. 2001;9(12):788-805.
201. Bovet P, Auguste R, Burdette H. Strong inverse association between physical fitness and overweight in adolescents: a large school-based survey. *Int J Behav Nutr Phys Act*. 2007;4(1):24.
202. Rhea MR, Alvar BA, Burkett LN, Ball SD. A meta-analysis to determine the dose response for strength development. 2003.
203. Freire W. RM, Belmont P., Mendieta MJ., Silva MK., Romero N., Sáenz K., Piñeiros P., Gómez LF., Monge R. Encuesta Nacional de Salud y Nutrición del Ecuador. ENSANUT-ECU 2011-2013. In: *Censos. MdSPINdEy*, editor. Quito Ecuador 2013. p. 112.
204. Garber MD, Sajuria M, Lobelo F. Geographical variation in health-related physical fitness and body composition among Chilean 8th graders: a nationally representative cross-sectional study. *PLoS One*. 2014;9(9):e108053.
205. Secchi JD, Garcia GC, Espana-Romero V, Castro-Pinero J. Physical fitness and future cardiovascular risk in Argentine children and adolescents: an introduction to the ALPHA test battery. *Arch Argent Pediatr*. 2014;112(2):132-140.
206. Aaron DJ, Storti KL, Robertson RJ, Kriska AM, LaPorte RE. Longitudinal study of the number and choice of leisure time physical activities from mid to late adolescence: implications for school curricula and community recreation programs. *Arch Pediatr Adolesc Med*. 2002;156(11):1075-1080.
207. Fisher WA, Fisher JD, Harman J. The information-motivation-behavioral skills model: A general social psychological approach to understanding and promoting health behavior. *Social psychological foundations of health and illness*. 2003:82-106.

208. Council on Sports M, Fitness, Council on School H. Active healthy living: prevention of childhood obesity through increased physical activity. *Pediatrics*. 2006;117(5):1834-1842.
209. Van Lippevelde W. The role of parents in childhood obesity prevention: Ghent University; 2012.
210. Stierlin AS, De Lepeleere S, Cardon G, Dargent-Molina P, Hoffmann B, Murphy MH, et al. A systematic review of determinants of sedentary behaviour in youth: a DEDIPAC-study. *Int J Behav Nutr Phys Act*. 2015;12:133.
211. Van Lippevelde W, Verloigne M, De Bourdeaudhuij I, Brug J, Bjelland M, Lien N, et al. Does parental involvement make a difference in school-based nutrition and physical activity interventions? A systematic review of randomized controlled trials. *International journal of public health*. 2012;57(4):673-678.
212. van Grieken A, Ezendam NP, Paulis WD, van der Wouden JC, Raat H. Primary prevention of overweight in children and adolescents: a meta-analysis of the effectiveness of interventions aiming to decrease sedentary behaviour. *Int J Behav Nutr Phys Act*. 2012;9:61.
213. Van Lippevelde W, Verloigne M, De Bourdeaudhuij I, Bjelland M, Lien N, Fernández-Alvira JM, et al. What do parents think about parental participation in school-based interventions on energy balance-related behaviours? A qualitative study in 4 countries. *BMC Public Health*. 2011;11(1):881.
214. Guedes D, Neto J, Silva A. Desempenho motor em uma amostra de escolares brasileiros Motor performance in. 2011.
215. Jochims S, Zeni AE, Nunes HMB, Borfe L, Burgos MS. APTIDÃO FÍSICA RELACIONADA AO DESEMPENHO MOTOR DE ESCOLARES: estudo comparativo dos hemisférios Norte-Sul-Leste-Oeste, da zona rural de Santa Cruz do Sul-RS. *Cinergis*. 2014;14(2).
216. Aguilar AC, Pradilla A, Mosquera M, Gracia AB, Ortega JG, Leiva JH, et al. Percentiles de condición física de niños y adolescentes de Santiago de Cali, Colombia. *Biomedica*. 2011;31(2):242-249.
217. Cruz AG, Suárez JF, Ciro JO, Chavarro NR, Villegas JG, editors. Asociación entre el estado nutricional y las capacidades físicas en niños de 6 a 18 años de Medellín (Colombia). *An Pediatr*; 2014: Elsevier.
218. Cossio-Bolaños MA, Arruda M. Propuesta de valores normativos para la evaluación de la aptitud física en niños de 6 a 12 años de Arequipa, Perú. *Rev Med Herediana*. 2009;20(4):206-212.
219. Kain J, Olivares S, Romo M, Leyton B, Vio F, Cerda R, et al. Nutritional status and aerobic capacity among children attending public elementary schools in Chile. *Rev Med Chil*. 2004;132(11):1395-1402.
220. Escola-de-Educação-Física-da-UFRGS. Projeto Esporte Brasil 2015. Available from: <http://www.proesp.ufrgs.br/>.
221. Constantino-Coledam DH, Ferraiol PF, Arruda GAd, Pires-Júnior R, Teixeira M, Greca JPdA, et al. The association between socioeconomic indicators and adolescents' physical activity and health-related fitness. *Rev Saude Publ*. 2013;15(6):810-815.

222. Cohen DD, Gomez-Arbelaez D, Camacho PA, Pinzon S, Hormiga C, Trejos-Suarez J, et al. Low muscle strength is associated with metabolic risk factors in Colombian children: the ACFIES study. *PLoS One*. 2014;9(4):e93150.
223. Arango CM, Parra DC, Gomez LF, Lema L, Lobelo F, Ekelund U. Screen time, cardiorespiratory fitness and adiposity among school-age children from Monteria, Colombia. *J Sci Med Sport*. 2014;17(5):491-495.
224. Cureton KJ, Warren GL. Criterion-referenced standards for youth health-related fitness tests: a tutorial. *Res Q Exerc Sport*. 1990;61(1):7-19.
225. Bianco A, Jemni M, Thomas E, Patti A, Paoli A, Roque JR, et al. A systematic review to determine reliability and usefulness of the field-based test batteries for the assessment of physical fitness in adolescents—the ASSO project. *Int J Occup Med Env*. 2015;28(3).
226. Ruiz JR, Castro-Pinero J, Espana-Romero V, Artero EG, Ortega FB, Cuenca MM, et al. Field-based fitness assessment in young people: the ALPHA health-related fitness test battery for children and adolescents. *Br J Sports Med*. 2011;45(6):518-524.
227. Olds T, Tomkinson G, Leger L, Cazorla G. Worldwide variation in the performance of children and adolescents: an analysis of 109 studies of the 20-m shuttle run test in 37 countries. *J Sports Sci*. 2006;24(10):1025-1038.
228. Evenson KR, Catellier DJ, Gill K, Ondrak KS, McMurray RG. Calibration of two objective measures of physical activity for children. *J Sports Sci*. 2008;26(14):1557-1565.
229. Matthews CE, Hagstromer M, Pober DM, Bowles HR. Best practices for using physical activity monitors in population-based research. *Med Sci Sports Exerc*. 2012;44(1 Suppl 1):S68-76.
230. Ward DS, Evenson KR, Vaughn A, Rodgers AB, Troiano RP. Accelerometer use in physical activity: best practices and research recommendations. *Med Sci Sports Exerc*. 2005;37(11 Suppl):S582-588.
231. Van Cauwenberghe E. Measuring, understanding, and changing physical activity and sedentary behavior in young children: Ghent University; 2012.
232. SENPLADES. National development plan / National plan for Good living, 2013-2017. Summarized Version 2013.
233. Haerens L, Kirk D, Cardon G, De Bourdeaudhuij I. Toward the development of a pedagogical model for health-based physical education. *Quest*. 2011;63(3):321-338.
234. Mikkelsen LO, Nupponen H, Kaprio J, Kautiainen H, Mikkelsen M, Kujala UM. Adolescent flexibility, endurance strength, and physical activity as predictors of adult tension neck, low back pain, and knee injury: a 25 year follow up study. *Br J Sports Med*. 2006;40(2):107-113.
235. Lee WASS, Shabeshan A, Rengasamy L, Subramaniam A, Raju L. The Effectiveness Of An Additional Stretching Exercise Program In Improving Flexibility Level Among Preschool Boys. *Malay Onl J Edu Sci*. 53.
236. Sainz de Baranda P. El trabajo de la flexibilidad en educación física: Programa de intervención. (Flexibility training in physical education: Intervention program). CCD. *Cultura_Ciencia_Deporte*. 文化-科技-体育 doi: 10.12800/ccd. 2009;4(10):33-38.

-
237. Baquet G, van Praagh E, Berthoin S. Endurance training and aerobic fitness in young people. *Sports Med.* 2003;33(15):1127-1143.
238. Strasburger VC, Jordan AB, Donnerstein E. Children, adolescents, and the media: health effects. *Pediatr Clin North Am.* 2012;59(3):533-587, vii.
239. García ER, López IP, Cervantes CT. Imaginario social de la Educación Física construido desde las “teen series” de televisión españolas. *Movimiento.* 2014;20(3):853-873.
240. Buckingham D. *Media education: Literacy, learning and contemporary culture*: John Wiley & Sons; 2013.
241. *Ley Organica de Comunicacion* In: Nacional A, editor. Quito: Registro Oficial; 2013.
242. *Prioridades de investigación en salud 2013-2017.* In: Ecuador MdSPd, editor. Quito Ministerio de Salud Publica del Ecuador; 2013.
243. Lee IM, Shiroma EJ, Lobelo F, Puska P, Blair SN, Katzmarzyk PT, et al. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet.* 2012;380(9838):219-229.

Curriculum vitae of the author

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Studies

2010-2015	PhD student at Ghent University, Department of Food safety and food Quality. “Physical fitness, physical activity and screen time among Ecuadorian adolescents”.
2007-2010	Master in Management Technology. Chemistry Faculty, Cuenca University
2000-2007	Chemical Engineer. Chemistry Faculty, Cuenca University
1994-2000	Mathematics - Physic, secondary school Asunción High School.

Peer review publications with scientific citation index (A1):

Andrade, S., Verloigne, M., Cardon, G., Kolsteren, P., Ochoa-Avilés, A., Verstraeten, R., Donoso, S., & Lachat, C. (2015). School-based intervention on healthy behaviour among Ecuadorian adolescents: effect of a cluster-randomized controlled trial on screen-time BMC PUBLIC HEALTH, <http://dx.doi.org/10.1186/s12889-015-2274-4>

Collaboration NCDRF. (2015). Effects of diabetes definition on global surveillance of diabetes prevalence and diagnosis: a pooled analysis of 96 population-based studies with 331 288 participants. *LANCET DIABETES & ENDOCRINOLOGY*, [http://dx.doi.org/10.1016/S2213-8587\(15\)00129-1](http://dx.doi.org/10.1016/S2213-8587(15)00129-1)

Andrade, S., Lachat, C., Ochoa Aviles, A.M., Verstraeten, R., Huybregts, L., Roberfroid, D., Andrade, D., Van Camp, J., Rojas, R., Donoso, S., Cardon, G. & Kolsteren, P. (2014). A school-based intervention improves physical fitness in Ecuadorian adolescents: a cluster-randomized controlled trial. *INTERNATIONAL JOURNAL OF BEHAVIORAL NUTRITION AND PHYSICAL ACTIVITY*, 11. <http://dx.doi.org/10.1186/s12966-014-0153-5>

Andrade, S., Ochoa Avilés, A.M., Lachat, C., Escobar, P., Verstraeten, R., Van Camp, J., Donoso, S., Rojas, R., Cardon, G. & Kolsteren, P. (2014). Physical fitness among urban and rural Ecuadorian adolescents and its association with blood lipids: a cross sectional study. *BMC PEDIATRICS*, 14. <http://dx.doi.org/10.1186/1471-2431-14-106>

Ochoa Avilés, A.M., Verstraeten, R., Lachat, C., **Andrade, S.,** Van Camp, J., Donoso, S. & Kolsteren, P. (2014). Dietary intake practices associated with cardiovascular risk in

urban and rural Ecuadorian adolescents: a cross-sectional study. *BMC PUBLIC HEALTH*, 14(1). <http://dx.doi.org/10.1186/1471-2458-14-939>.

Van Royen, K., Verstraeten, R., **Andrade, S.**, Ochoa Avilés, A.M., Donoso, S., Maes, L. & Kolsteren, P. (2014). Factors affecting physical activity in Ecuadorian adolescents: a focus group study. *JOURNAL OF PHYSICAL ACTIVITY & HEALTH*. <http://dx.doi.org/10.1123/jpah.2013-0288>.

Verstraeten, R., Lachat, C., Ochoa Avilés, A.M., Hagströmer, M., Huybregts, L., **Andrade, S.**, Donoso, S., Van Camp, J., Maes, L. & Kolsteren, P. (2013). Predictors of validity and reliability of a physical activity record in adolescents. *BMC PUBLIC HEALTH*, 13. <http://dx.doi.org/10.1186/1471-2458-13-1109>.

Ochoa Avilés, A.M., **Andrade, S.**, Huynh, T.T.T., Verstraeten, R., Lachat, C., Rojas, R., Donoso, S., Manuel-y-Keenoy, B. & Kolsteren, P. (2012). Prevalence and socioeconomic differences of risk factors of cardiovascular disease in Ecuadorian adolescents. *PEDIATRIC OBESITY*, 7(4) 274-283. <http://dx.doi.org/10.1111/j.2047-6310.2012.00061.x>.

Ochoa A, **Andrade S**, Ortiz J, Donoso S. (2014). “Resultados de la Investigación del Programa “Alimentación Nutrición y Salud” efectuado en Nabón en los años 2008-2009. *REVISTA DE LA FACULTAD DE CIENCIAS QUÍMICAS*. 8 (19-23)

Chapter in books (b1)

Andrade S, Ochoa-Avilés A, Ortiz J, Rojas R, García JL, Donoso S. “Asociación entre el sobrepeso y obesidad con la aptitud física (EUROFIT) y el nivel socioeconómico en alumnos de 8° a 10° grado de educación básica. Cuenca- Ecuador (2008-2009)”. *EXPOMOTRICIDAD. Libro: Algunas consideraciones sobre actividad física en personas con sobrepeso y obesidad. Medellín-Colombia: Funámbulos Editores, 2010.*

Abstracts (c1)

Ochoa-Avilés A, Lachat C, Verstraeten R, **Andrade S**, Donoso S, Kolsteren P. “Validity of physical activity diary in assessing sedentary activity among Ecuadorian adolescents”. *Libro II world congress of Public Health Nutrition. Oporto-Portugal, (2010).*

Ortiz J, Ochoa-Avilés A, **Andrade S**, Abril V, Escobar P, Astudillo G, Donoso S: “Pilot study to develop a food composition database for a Southern region of Ecuador”. *In 9th International Food Data Conference; Norwich, England. 2011*

Andrade S, Lachat C, Ochoa A, Verstraeten R, Donoso S, Cardon G, Kolsteren P. “Effects of a school based health promotion intervention on physical activity and physical fitness in Ecuadorian adolescents: a cluster randomized controlled trial” *International Society for Behavioral Nutrition and Physical Activity. Mayo 2013. Gent- Belgium (Oral presentation)*

Andrade S, Lachat C, Ochoa A, Donoso S, Cardon G, Kolsteren P. “Physical fitness performance in adolescents from an urban and a rural area of Ecuador”. *International Society for Behavioral Nutrition and Physical Activity*. Mayo 2013. Gent- Belgium

Andrade S, Ochoa A, Lachat C, Donoso S, Cardon G, Kolsteren P “Effect of ACIVITAL 2-year-intervention program on screen time, physical activity and fitness according to weight status and fitness levels in adolescents”. *International Society for Behavioral Nutrition and Physical Activity*. Mayo 2014. San Diego-EEUU

Andrade S, Ochoa A, Verstraeten R, Lachat C. “Process evaluation of a school-based intervention in Ecuadorian adolescents from the perspective of parents” *International Society for Behavioral Nutrition and Physical Activity*. June 2015. Edinburgh- Scotland. (Oral presentation)

Educational Materials

Guía de alimentación y actividad física para profesores de 9no y 10mo año de educación básica. Universidad de Cuenca. Cuenca-Ecuador, (2010 y 2011).

Guía de alimentación y actividad física para estudiantes de 9no y 10mo año de educación básica. Universidad de Cuenca. Cuenca-Ecuador, (2010 y 2011)

Recetas Saludables, desayunos y refrigerios. Universidad de Cuenca. Cuenca-Ecuador, (2011).

Working experiences

2015-currently: Researcher of the Bioscience research Department of Cuenca University

2009-currently: Researcher of the project “Food, Nutrition and Health” VLIR-IUC Cuenca University

2012-2015: Researcher of the project “Food allergy among adolescents from Cuenca and Santa Isabel, Ecuador”

2014-2015: Researcher of the project “Fortalecimiento tecnológico de la planta de piloto de lácteos de la Facultad de Ciencias Químicas y desarrollo de nuevos productos lácteos” Cuenca University.

2010-2014: Professor of Chemistry Faculty on the following subjects: Statistic, Calculus, Food Chemistry and Structural Chemistry.

Training

2010 Introduction to STATA

2011 Applied Statistics

2011 Nutrition Disorders

2011 Analysis of Variance

2011 Effective Scientific Communication

2011 Intermediate Academic English

2011 Personal Effectiveness

2012 Creative thinking

2012 Diet and physical activity in research studies

2012 Health in number: Quantitative Methods in Clinical & Public Health Research

2014 Practical English 3

2015 Data mining