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Parents' and adolescents' perceptions towards active commuting to school and school-based interventions to promote this behaviour

Percepciones de los padres y adolescentes para el desplazamiento activo al centro educativo e intervenciones aplicadas en el centro educativo para promover este comportamiento

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A todos los que me acompañaron en esta aventura…

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Research Projects

The present Doctoral Thesis was carried out under the framework of the "Pedalea y Anda al COle: PACO" (Cycling and Walk to School) project. This project is directed by the principal investigator, Dr. Palma Chillón Garzón, from the Department of Physical Education and Sports of the University of Granada and a group of doctors and doctoral students included in the project. This project is supported by the Spanish Ministry of Economy, Industry and Competitiveness and the European Regional Development Fund (DEP2016-75598-R, MINECO/FEDER, UE).

Abbreviations

AC	Active commuting
ACS	Active commuting to/from school
DAC	Desplazamiento Activo al Colegio
EPHPP	Evaluation of public health practice projects
GPS	Global positioning system
MVPA	Moderate-to-vigorous physical activity
PA	Physical activity
PACO	Pedalea y Anda al COle
PE	Physical Education
SRTS	Safe Routes to School Program
SES	Socioeconomic status
SDG	Sustainable Development Goals
WHO	World Health Organization

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Abstract

Active commuting to school (ACS) is a routine behaviour that enables pupils to be more physical active in their day through walking or cycling to school. However, low rates of PA and levels of sedentary behaviours among youth population are increasing worldwide. So, it is necessary to analyse the factors that lead to this situation and contribute to increase physical activity domains.

Therefore, the purposes of the present Doctoral Thesis were to analyse a commuting-to-school questionnaire for families, to study the parents' and adolescents' perceived barriers towards active commuting to school and to analyse the effects of a school-based intervention to promote this behaviour.

These purposes were answered through 4 studies, whose methods are:

Study I. A total of 611 child-parents pairs from Granada, completed in two sessions separated by 14 days, the *"Family commuting-to-school behaviour" questionnaire* (completed by family), and the "*Mode and frequency of commuting to and from school" questionnaire* (completed by children. The validation between family and children's questions was assessed using the Kappa and Spearman correlation coefficients, and the test–retest reliability within the family questions was assessed using the Kappa and the weighted Kappa.

Study II. A systematic literature review was conducted through seven online databases, from the beginning of the database to March 2018. Five categories of search terms were identified: parents, barriers, school, active commuting/transport and children. Specific terms used in the search were obtained from previous reviews and experts' opinion. Also, the PRISMA guide was used to perform the review, and it was registered on PROSPERO.

Study III. A total of 401 child–parent pairs, from Granada, Jaén, Toledo and Valencia, self-reported, their mode of commuting to school and work, respectively, and the children's barriers to ACS. T-tests and chi square tests were used to analyse the differences by age for continuous and categorical variables, respectively. Binary logistic regressions were performed to study the association between ACS barriers of children and parents and ACS.

Study IV. A total of 122 adolescents from Granada, Jaén and Valencia participated in this study (cycling group, n=60; and control group, n=62). The cycling group participated in a school-based intervention to promote cycling to school within the Physical Education lessons. To analyse the changes in the dependent variables at baseline and the follow-up of the intervention, Wilcoxon, Signs and McNemar tests were conducted. The association between intervention and commuting and barriers was observed by binary logistic regression.

The main results extracted from the four studies were:

Study I) The children's modes of commuting to school (mean age: 11.44 ± 2.77 years old) were mainly passive (57.7% to school) while parents' modes of commuting to work were mainly active (71.6%). The validity of the mode of commuting questionnaire was significant with high Kappa and Spearman coefficients. The test–retest reliability presented a good agreement for the mode of commuting to school in children, distance and time to school, and the mode of commuting to work in parents, while the questions on acceptable distance to walk or cycle to school showed a moderate to good agreement.

Study II) The main parental barriers reported by parents of children (21 studies) were built environment, traffic safety, distance, crime-related safety and social support. The main parental barriers reported by parents of adolescents (6 studies) were built environment (street connectivity), distance,

traffic safety and physical and motivation barriers. The parental barriers associated with ACS were mainly related to the built environment and traffic safety.

Study III) Children and adolescents perceived higher physical and motivational barriers and social support barriers towards ACS than their parents (all $p < 0.05$). Additionally, the parents perceived higher distance, traffic safety, convenience, built environment, crime-related safety and weather as barriers towards ACS, than their children (all $p < 0.05$). Moreover, a higher perception of barriers was related to lower ACS.

Study IV) The school-based intervention might be feasible at school context. The cycling knowledge improved after the school-based intervention; the scores of cycling skills were medium-low; the adolescents' attendance, enjoyment and usefulness of the sessions were high. Concerning the effects, the rates of cycling to school and active commuting to/from school did not change after the school-based intervention, and only the *"Built environment (walk)"* barrier on the cycling group was higher on the follow-up. Also, no association was found between the participation on the school-based intervention with the rates of cycling or active commuting to school and the perception of barriers to ACS.

The main conclusions from the four studies were:

Study I) The *"Family Commuting-to-School Behaviour"* questionnaire could be a useful tool to assess the mode of commuting of children, distance and time to school for researchers and practitioners.

Study II) The results showed that it is crucial to involve parents through interventions to reduce the perception of safety and to increase awareness of the importance of ACS. In addition, these strategies should be complemented by environmental changes performed by local governments.

Study III) The outcomes of the study showed the necessity of attenuating the perceptions of children and their parents in order to increase ACS. This is relevant to develop interventions in the specific contexts of each barrier and involving both populations.

Study IV) The results manifest the necessity of developing and implementing school-based cycling interventions, and they may include families and other agents such as policy makers to create multicomponent interventions.

Resumen

El desplazamiento activo al centro educativo (DAC) es un comportamiento rutinario que permite a los alumnos ser más activos físicamente en su día desplazándose a pie o en bicicleta al centro educativo. Sin embargo, las bajas tasas de actividad física y los niveles de comportamiento sedentario entre la población joven están aumentando en todo el mundo. Por lo que es necesario analizar los factores que afectan a esta situación y contribuir al incremento de los niveles de actividad física.

Los objetivos de la presente Tesis Doctoral fueron analizar un cuestionario sobre el desplazamiento al centro educativo para las familias, estudiar las barreras percibidas por los padres y adolescentes sobre el desplazamiento activo al centro educativo y analizar los efectos de una intervención en entorno escolar para promover este comportamiento.

Estudio I. Un total de 611 padres (edad media: 43,28 ± 6,25 años) de Granada (España) completaron el cuestionario *"Comportamiento familiar para el desplazamiento al centro educativo"* en dos sesiones separadas por 14 días (2016 y 2018). La validación entre las preguntas de la familia y los niños se evaluó mediante los coeficientes de correlación Kappa y Spearman, y la fiabilidad test-retest dentro de las preguntas familiares se evaluó mediante el Kappa y el Kappa ponderado.

Estudio II. Se realizó revisión sistemática de la literatura a través de siete bases de datos electrónicas, desde el inicio de la base de datos hasta marzo de 2018. Se identificaron cinco categorías de términos de búsqueda: padres, barreras, centro educativo, desplazamiento / transporte activo y niños. Los términos específicos utilizados en la búsqueda se obtuvieron de revisiones anteriores y opiniones de expertos. Asimismo, se utilizó la guía PRISMA para realizar la revisión, y se registró en PROSPERO.

Estudio III. Un total de 401 parejas de padres e hijos, de Granada, Jaén, Toledo y Valencia, informaron por separado, de su modo de desplazarse a la escuela y al trabajo, respectivamente, y las barreras de los niños para la ACS. Se utilizaron pruebas T y pruebas de chi cuadrado para analizar las diferencias por edad para las variables continuas y categóricas, respectivamente. Se realizaron regresiones logísticas binarias para estudiar la asociación entre las barreras de ACS de niños y padres y ACS.

Estudio IV. En este estudio participaron un total de 122 adolescentes de Granada, Jaén y Valencia (grupo de ciclismo, n = 60; y grupo de control, n = 62). El grupo de ciclistas participó en una intervención escolar para promover el uso de la bicicleta en la escuela dentro de las lecciones de Educación Física. Para analizar los cambios en las variables dependientes al inicio del estudio y el seguimiento de la intervención, se realizaron las pruebas de Wilcoxon, Signs y McNemar. La asociación entre intervención y desplazamientos y barreras se observó mediante regresión logística binaria.

Los principales resultados extraídos de los cuatro estudios fueron:

Estudio I) Los modos de desplazamiento de los niños al centro educativo (edad media: 11,44 ± 2,77 años) fueron principalmente pasivos (57.7% al centro educativo) mientras que los modos de desplazamiento de los padres al trabajo fueron principalmente activos (71.6%). La validez del modo de desplazamiento del cuestionario fue significativa con altos coeficientes Kappa y Spearman. La fiabilidad test-retest presentó una buena concordancia para el modo de desplazamiento al centro educativo en los niños, la distancia y el tiempo al centro educativo, y el modo de desplazamiento al trabajo en los padres, mientras que las preguntas sobre la distancia aceptable para caminar o ir en bicicleta al centro educativo mostraron un coeficiente de moderado a buen acuerdo.

Estudio II) Las principales barreras reportadas por los padres de niños (21

estudios) fueron el entorno construido, la seguridad en el tráfico, la distancia, la seguridad relacionada con el crimen y el apoyo social. Las principales barreras reportadas por padres de adolescentes (6 estudios) fueron el entorno construido (conectividad de la calle), la distancia, la seguridad en el tráfico y las barreras físicas y de motivación. Las barreras parentales asociadas con DAC se relacionaron principalmente con el entorno construido y la seguridad del tráfico.

Estudio III) Tanto los niños como los adolescentes percibieron mayores barreras físicas y motivacionales y barreras de apoyo social hacia el DAC que sus padres ($p < 0,05$). Además, los padres percibieron una mayor la distancia, la seguridad en el tráfico, la conveniencia, el entorno construido, seguridad relacionada con el crimen y clima como barreras hacia el DAC, que sus hijos ($p < 0.05$). Además, una mayor percepción de barreras se relacionó con una menor DAC.

Estudio IV) La intervención podría ser una herramienta viable en el contexto escolar. Además, el conocimiento vial mejoró después de la intervención escolar y las puntuaciones de las habilidades ciclistas fueron medias-bajas. Respecto a la asistencia a la sesión fue alta y el grupo de ciclistas indicó que les gustaron las sesiones y fueron útiles. En cuanto a los efectos, los rangos de desplazamiento en bicicleta al centro educativo y los desplazamientos activos hacia y desde el centro educativo no cambiaron después de la intervención, y solo la barrera del "entorno construido (caminar)" en el grupo de ciclistas fue más alta tras la intervención. Además, no se encontró asociación entre la participación en la intervención con los rangos de desplazamiento en bicicleta o desplazamientos activos al centro escolar y la percepción de barreras para DAC.

Las principales conclusiones de los estudios incluidos fueron:

Estudio I) El cuestionario *"Comportamiento familiar para el desplazamiento al centro educativo"* podría ser una herramienta útil para evaluar el modo de desplazamiento de los niños, la distancia y el tiempo al centro educativo, para investigadores y profesionales.

Estudio II) Los resultados mostraron que es crucial involucrar a los padres a través de intervenciones para reducir la percepción de la barrera de seguridad y aumentar la conciencia sobre la importancia de los DAC. Además, estas estrategias deben complementarse con cambios en el entorno realizados por los gobiernos locales.

Estudio III) El estudio mostró la necesidad de atenuar las percepciones de barreras de los niños y sus padres para incrementar el DAC. Esto es relevante para desarrollar intervenciones en los contextos específicos de cada barrera e involucrando a ambas poblaciones.

Estudio IV) Los resultados manifiestan que es necesario continuar desarrollando e implementando intervenciones de ciclismo a nivel escolar, y pueden incluir a las familias y otros agentes, como políticos, para crear intervenciones multicomponentes.

1. Introduction

1. INTRODUCCTION

1.1. What is active commuting to school?

Nowadays, physical inactivity is the fourth most important global mortality risk factor (WHO, 2015), which make necessary to address this problem. Physical activity during childhood and adolescence is associated with numerous health benefits, improving the musculoskeletal health (WHO, 2010), the quality of life related to health (Jalali-Farahani et al., 2018), the social relationships (Janssen & Leblanc, 2010) and academic and cognitive performance (Conde & Sánchez, 2015). Despite, there is a great concern about the children's low PA level, as the scientific literature has shown evidence about the decrease of these levels in children and adolescents in the last decades (Ramos et al., 2016; Rhodes et al., 2017). Specifically, the study of Guthold et al. (2020) showed that in 2016 more than 80% of adolescents (aged 11-17 years) did not currents the recommendations of daily PA. Consequently, the international recommendations of physical activity (PA) propose that youth have to perform at least 60 minutes of moderate-to-vigorous PA per day in order to achieve all the benefits associated (WHO, 2020).

Consequently, an active living style is important for the health. The active living framework includes the four domains focused on active recreation, exercise, active transportation and household and occupational activities (Sallis et al., 2006). Therefore, active commuting to school is presented as a low-cost solution with high feasibility to increase the daily physical activity (Berglund et al., 2016; Owen et al., 2012).

Commuting to/from school is a behaviour that schoolchildren performed at least twice per day. This behaviour can be active (active commuting to/from school - ACS), when the child commute to school mainly walking or cycling, or passive when they use a motorized transport such as car, motorbike, bus, metro, train, etc., (Chillon et al., 2014; Herrador-Colmenero et al., 2014). Within the passive modes, a new term of semi-active modes is presented when the children use a motorised public transport (i.e. the use of the bus, train, underground...), since it involves some time of active commuting to and from the transportation stops and the house. It means that children who used public transport are significantly more active than private car commuters (Humphrey, 2005; MacDonald et al., 2010; Wener & Evans, 2007).

Currently, the global policies are focused on increasing the number of youths who are active in their daily commuting travels. The World Health Organization (WHO) launched a guide with actions to increase the levels of PA in the population, supported by the Global Action Plan on Physical Activity 2018-2030 titled *"More Active People for a Healthier World"* (WHO, 2018). In addition, the 2030 Agenda for Sustainable Development, promoted by the United Nations, proposed the Sustainable Development Goals (SDG) where active commuting is a main contributor to the development of these Goals (Macmillan et al., 2020). Actually, the WHO Global Action Plan reported that PA contributes to achieve 13 SDGs, highlighting that walking and cycling contributes specifically to 8 SDGs of them (WHO, 2018). Therefore, it is time to commit with the promotion and encouragement of active commuting and above all, of ACS, as it is a daily routine behaviour that can be acquired in childhood and maintained over time, and it can be transferred to actively commute to other destinations apart from school.

1.2. What are the benefits of active commuting to school?

Specifically, ACS provides different benefits regarding individual and social levels (**Figure 1**). Regarding to individual benefits related to the physical health, ACS contributes to increase the daily PA (included moderate, vigorous, moderate to vigorous physical activity and overall PA) (Chillon, et al., 2011; Cooper et al., 2005; Cooper et al., 2003; Roman-Vinas et al., 2016). The meta-analysis of Martin et al., (2016) found that walking to/from school provided 13 minutes of MVPA (moderate-to-vigorous physical activity) per day in high school students, a 36% of the total of daily PA that the student performed. However, different benefits have been found for walking or cycling. In relation to walking to or from school, no association has been found with improvements at the cardiorespiratory level (Larouche, Saunders, et al., 2014; Ruiz-Hermosa et al., 2020). No association was found between walking and other components of physical fitness such as muscle strength and speed-agility on some studies (Lubans et al., 2011; Ruiz-Hermosa et al., 2018). However, the associations between physical fitness and ACS need further explorations as there are not enough studies to support the improvement of muscle strength through active commuting (Ruiz-Hermosa et al., 2018; Singh et al., 2019) and there is no association between cycling and greater speed-agility (Ramirez-Velez et al., 2017; Villa-Gonzalez et al., 2015). Cycling to school is associated with greater improvements in cardiorespiratory fitness in children and adolescents (Nordengen et al., 2019; Ramirez-Velez et al., 2017). Also, the benefits of cycling to school are linked with reduced risk of cardiovascular disease, stroke, coronary disease and cancer (Blair et al., 2001). Regarding the benefits of ACS in the body composition, without specifying walking or cycling, a literature review conducted by Larouche et al. (2014) found no differences between the body mass index of actively commuting people and passively commuting people. Lee et al. (2008) showed similar results, presenting no significant association between body weight and body mass index with ACS. Therefore, the scientific literature does not show conclusive results to affirm or deny the association of active commuting with body composition. This absence of association may be due to many of the studies carried out do not separate the effects of active commuting by walking or cycling in reference to improvements in body composition in young people (Larouche et al., 2014; Lee et al., 2008; Masoumi, 2017).

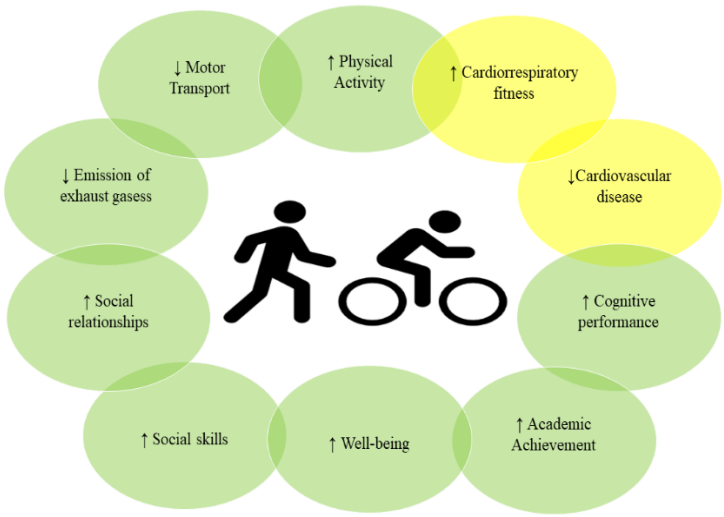

Figure 1. Health benefits of cycling (yellow) and benefits of cycling and walking (green).

The ACS also presents benefits related to the mental and social health. Regarding the mental health, the scientific literature about ACS has focused on studying variables such as cognitive performance and academic achievement (Ruiz-Hermosa et al., 2019) and well-being variables (Chillon et al., 2017; Ruiz-Ariza et al., 2015). Phansikar et al. (2019) reported that there was no evidence that ACS improved cognitive performance or the academic achievement, but Martínez-Gomez et al. (2011) concluded that cognitive performance in adolescent girls might be positively influenced by active commuting. Moreover, a study carried out in Spain suggested that active children present lower stress level than children who are less active in their way to school (Chillon et al., 2017). In this sense, a study of over 20,000 children and adolescents in China found that those who walked or cycled to school were less likely to have depressive symptoms than those who used passive transport (Sun et al., 2015). Another study conducted in Spain identified that those who spent at least 15 minutes a day actively commuting to school showed higher levels of happiness, psychological well-being and lower levels of psychological distress (Ruiz-Ariza et al., 2015). In relation to the social health variables, ACS contributes to the development of social skills and social relationships (Panter et al., 2013; Waygood et al., 2017) and promotes social interaction during travel and walking (Panter et al., 2013; Panter et al., 2008; Waygood et al., 2017). For example, the study of Kirby et al., (2012) in Scotland, showed that adolescent girls found walking as an opportunity to be with friends and socialise. Also, Westman et al., (2017) showed that children reported that engaging in a social activity while travelling was of higher quality than when they were alone or using their mobile phones.

Apart from the individual mentioned benefits, the ACS provides benefits to our society regarding environmental and economic factors. ACS reduces the emission of exhaust gases (Wilson et al., 2007), and walking only has a little or no environmental impacts and cycling does not produce emissions (Hong, 2018). In this sense, the asthma disease could be reduced due to the reduction of air pollution thanks to using active modes of commuting (McConnell et al., 2010). Consequently, ACS might improves the air quality due to avoid emissions (Dhondt et al., 2013; Grabow et al., 2012). Eliminating or reducing a portion of the buses and cars used to transport schoolchildren to school would reduce overall road congestion and its associated traffic and pollution costs (McDonald et al., 2011). In addition, the areas where active commuting is higher, fewer pedestrian and cyclist traffic accidents occur (Aertsens et al., 2010; de Geus et al., 2012; Tin et al., 2010). A study in Norway found that walking and cycling reduced the number and severity of road accidents, also, produces changes in traffic volume, in health status and even the perception of safety traffic, among others (Elvik, 2000). Also, walking does not need a big place to develop such as cycling, only a minimal space, while motorised transports need more space (not only road space, also parking space) (Hong, 2018). Consequently, building the infrastructure necessary for motorised transport has a major ecological impact on ecosystems (Hong, 2018). Finally, in relation to the economy, active commute has a lower economic cost, and it can increase expectations in terms of morbidity and mortality, thus reducing the health system expenditure (Gordon, 2018; Hafner et al., 2020).

Therefore, due to the multiple individual and social benefits derived from the ACS behaviour, it is necessary to study and promote it in today's society.

1.3. How is the trend and prevalence of active commuting to school?

The children's mode of commuting has changed as the society changes (**Figure 2**). If we compare the probability of today's children to commute walking or cycling to school against the previous generations, such as our parents or grandparents, there is a clear trend of increasing the passive commuting observed in many countries along the last decades (Larouche, 2018c).

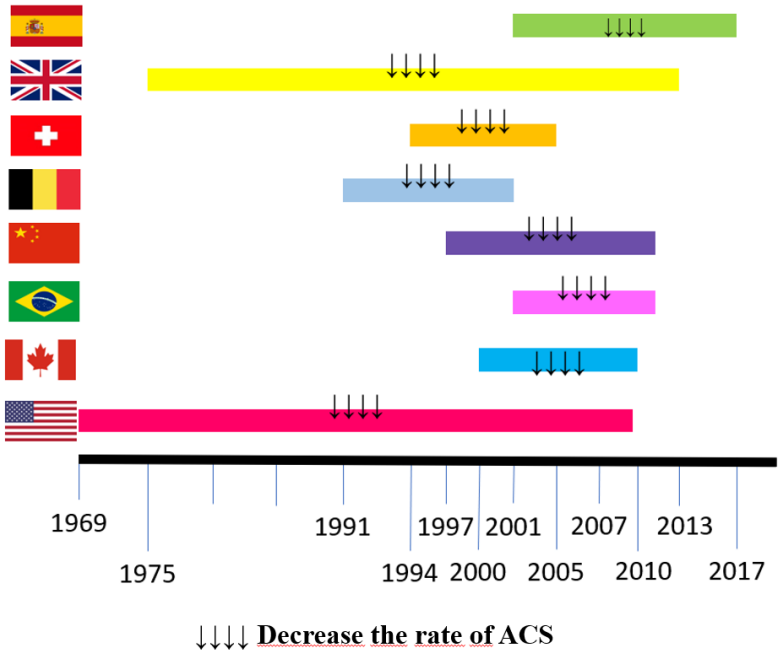

Figure 2. Worldwide trends of ACS.

In the United States, a study of McDonald, et al. (2011) compared the percentages of ACS on 2009 to 1969, 1995 and 2001, and reported that the percentage of children (5 – 12 years) decreased from 47.7% to 12.7%. This is despite the fact that the distance between the school and the American children's home was about 7km on 2009 (Larouche, 2018c; McDonald et al., 2011). In Canada, the prevalence of children who actively commuted to school from 2000 to 2010 decreased from 28% to 24% and in contrast, the percentage of motorized travel increased from 51% to 62% (Gray et al., 2014).

In Brazil, Silva et al. (2014) examined the trends in school commuting on adolescents from 2001 to 2011. The study showed that ACS declined from 56.3% to 51.3%, while the percentage of children who commuted by motorised transport was doubled (6.4% to 12.6%) (Silva et al., 2014).

Another study in China, investigated the school commuting changes from 1997 to 2011 in schoolchildren from 6 to 18 years, the ACS decreased from 95.8% to 69.3% (Yang et al., 2017). At the same time, the percentage of private motorized vehicles per house was tripled (Yang et al., 2017), whereas bicycle ownership declined from

about 80% to 60% (from 1997 to 2006) (Cui et al., 2011).

Similar data were found in other European countries. In Belgium, the study of Marique, et al. (2013), showed the changes in the commuting to school from 1991 to 2001, where the ACS decreased from 28.9% to 17%, being accompanied the increasing of car travel.

A study carried out in Switzerland reported that the prevalence of active commuting to school decreased from 78.4% to 71.4% from 1994 to 2005 (Grize et al., 2010). At the same time, the number of bicycle ownership per house decreased while the number of cars increased (Grize et al., 2010). The Department for Transport of England measured the school commuting mode during a period of 37 years (from 1975 – 2013) (Transport, 2013; Transport, 1979, 2001). The prevalence of walking declined from 63.3% to 41%, while the proportion of youth (5-16 years) driven to/from school by car was triplicate, whereas cycling accounted for less than 5% of trips at all-time points (Transport, 2013; Transport, 1979, 2001).

In the case of Spain, Chillón et al. (2013) conducted a study where they compared the prevalence of active transport in adolescents (13-17 years) from 2001 to 2007. No significant increase was found in the prevalence of active transportation among boys (from 44.4% to 49.0%), but a decrease was reported in girls, from 61% to 48% (Chillon et al., 2013). A recent study that examines the trends in the rates of ACS in Spanish children and adolescents from 2010 to 2017, showed that the rates ranged around 60% during this period, so did not change significantly in the last years (Galvez-Fernandez et al., 2021).

Due to the results presented by previous studies, which show how the prevalence of ACS has been declining in recent decades, it is necessary to analyze the reasons and the factors leading to this harmful development. The main reasons that the previous studies exposed to the decreased of ACS were the increased distance between school and home, the increase of car ownerships, the reduction of children's independent mobility, or the parental concerns about child's safety, between others (Larouche, 2018c; McDonald et al., 2011; Yang et al., 2017).

1.4. How to assess active commuting to school?

The relevance of the ACS behaviour makes necessary to research on appropriate measurement instruments (i.e, valid and reliable) that provide rigorous results. In concordance with the several factors that may affect the decision of ACS, it is crucial to determine not only the mode of commuting, but also the time and distance commuted or the perceptions to active commuting (Alton et al., 2007; Chillon et al., 2017; Nelson et al., 2008a; Tudor-Locke et al., 2003).

In order to collect this information with high rigorously and appropriately, it is necessary to use measurement instruments with the requirements of being reliable and valid, that maybe widely use as standardised instruments for assessing this behaviour.

The reliability refers to the degree of stability achieved in the results when a measurement is repeated under identical conditions (Mokkink et al., 2010), which includes four types:
1) inter-observer reliability, which refers to consistency between two different observers when they evaluate the same variable on the same individual;
2) intra-observer reliability, which aims to evaluate the degree of consistency when an observer makes a measurement on himself;
3) test-retest reliability, which indicates the extent to which an instrument provides similar results when it is applied to the same person on more than one occasion, but under identical conditions;
4) internal consistency, which is the property that defines the level of agreement or

conformity of a set of measurements with themselves (Terwee et al., 2010).
In addition, depending on the type of variable and the methods to assess the degree of agreement among evaluators or measures, different index is used (Kraemer et al., 2002). It can be used the kappa index (which is used for nominal qualitative variables), the weighted kappa index (which is used for ordinal variables), and the intraclass correlation coefficient (which is used for quantitative variables) (Kraemer et al., 2002).

Reliability is generally assessed between two or more instruments that are identical and should produce the same result in two different times. The results of a greater reliability greater must be equal or higher to 0.8, which is a common threshold for acceptable reliability (Hopkins et al., 2009).

On the other hand, an instrument is valid when it gauges what is supposed to measure (Mokkink et al., 2010). For example, an accelerometer measures the movement acceleration of a body in the space. In order to know the validity of a new instrument, it is compared with an existing instrument (concurrent validity) or a criterion measure (criterion validity) (Terwee et al., 2010). Therefore, if the measurement instrument can demonstrate a significant association, this instrument would have acceptable construct validity. The criterion validity provides the most support for a given measurement instrument (Terwee et al., 2010).

The ACS assessment has been developed through several instruments such as self-reporting questionnaire, questionnaire administered by the interviewer, diaries or the use of GPS (Global Positioning System) among others (Herrador-Colmenero et al., 2014; Larouche et al., 2014; Migueles et al., 2017; Misslin et al., 2015). A review of the scientific literature performed by Larouche et al. (2014), found that most studies used a self-reporting questionnaire to assess active commuting and to a lesser used diary, accelerometers or GPS, and similar results was confirmed by the review of Herrador-Colmenero et al. (2014). The questionnaires are subjective measurement techniques that have a low cost, are applicable to a large population and barely need personnel to carry them out, but they carry implicit errors that underestimate the results (Herrador-Colmenero et al., 2019). Despite being techniques of subjective measurement, they are the most widely used instruments to assess active commuting in children, adolescents and families in the scientific literature (Davison et al., 2008; Herrador-Colmenero et al., 2014). The questionnaires may be reported by both children and/or other family members, such as parents. In the case of the questionnaires reported by families, they usually asked about their children mode of commuting to school (D'Haese et al., 2011), their mode of commute to work or even the perceptions of allowing their children active commute to school (Bere & Bjorkelund, 2009).

Several studies have developed validated questionnaires in different contexts to assess the ACS behaviour. For example, the study of Alexander et al. (2005) assessed the means of transport to school in 103 adolescents through accelerometers and questionnaires. The results showed reliability coefficients from very good to almost perfect agreement (Alexander et al., 2005). In the same way, a study in Belgium with 33 adolescents showed that kappa values exceeded 0.70 in the variables referring to active transport to/from school (Philippaerts et al., 2006). Moreover, a study carried out in the United States within the *"Safe Routes to School Program"* (SRTS), presented a parental questionnaire about mode of commuting and frequency showing a reliability from moderate to very high (McDonald et al., 2011b). Additionally, Adams et al. (2014) obtained a moderate agreement in relation to the reliability and validity of PA measures in the transport (including an assessment of travel behaviours). In the same way, Bere et al. (2009) reported test-retest reliability of a questionnaire for Norwegian 6th grade-school children and their parents about active commuting to school and work, and test-retest correlation coefficients were high for all modes of commuting (0.85-0.92).In Spain, there is only one study in relation to

the validity or reliability of a parental questionnaire about commuting to school, but it only focused on the reliability of the parental barriers, where the study showed a good agreement for the questionnaire (Huertas-Delgado et al., 2019).

Since the parents' questionnaire reporting their children´s mode of commuting has been showed to be a gold standard (Aranda-Balboa et al., 2020; de Wit et al., 2012; Evenson et al., 2008; McDonald et al., 2011a), it is necessary to develop a Spanish questionnaire version to assess children commuting to school behaviour from their parents' responses.

In this thesis, the questionnaires used to know the ACS of Spanish children and families were compiled in two extensive questionnaires called the *"Mode and Frequency of Commuting To and From School"* questionnaire reported by children (Chillon et al., 2017; Segura-Diaz et al., 2020) and *"Family Commuting-to-School Behaviour"* questionnaire reported by parents. Both questionnaires were developed following the Delphi Method (Monfort-Panego et al., 2016) by a group of experts from University of Granada, mainly.

Therefore, the **first study** of this thesis includes the validation of the questions on the mode of commuting to/from school of children according to their parents, and the analysis of the reliability of a family questionnaire focused on commuting to school behaviours (*"Family Commuting-to-School Behaviour"* questionnaire*)*.

1.5. What correlates influence the active commuting to school?

The mode of commuting to school is influenced by many factors (Rodriguez-Lopez et al., 2013). These factors can be classified in multiple levels of influence, according to the social-ecological model that may help to determine and understand the factors associated with the active commuting in children (Larouche & Ghekiere, 2018). The socio-ecological model is built from the closest to the most distant factors from the individual. Larouche (2018a) considered five levels of influence in his model (see **Figure 3**), which will interact with each other. On the other hand, the model of Mandic et al. (2015), (see **Figure 4**), divides the factors on three levels: personal, social and environmental. Although both models have different levels, both include common factors.

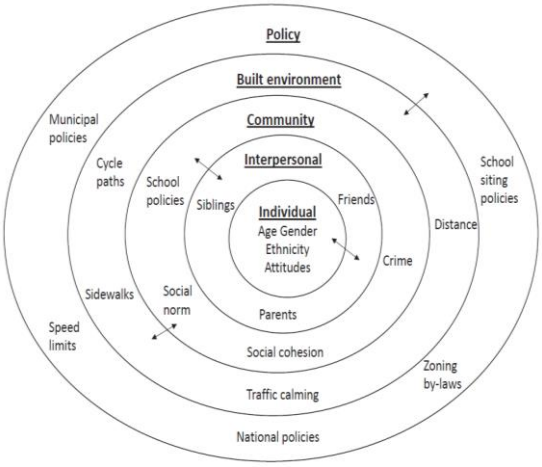

Figure 3. Social-ecological model of correlates of active commuting by Larouche (2018a).

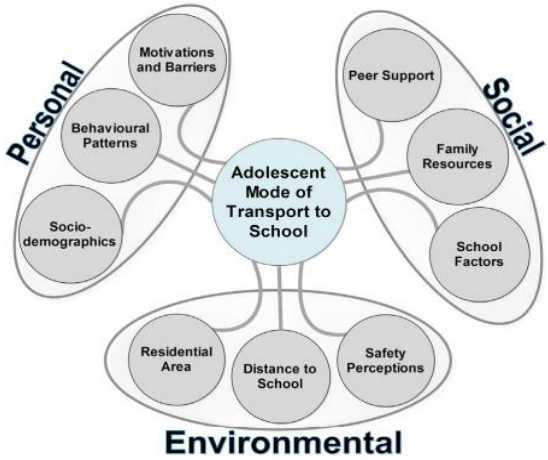

Figure 4. Conceptual framework for adolescent decision making about transport choices by Mandic et al. (2015).

Hereinafter, we will refer to the factors that influence active commuting as "correlates", which means a variable that maybe associated with our main variable (Larouche

& Ghekiere, 2018) -ACS in this case-, and we will follow the social-ecological model proposed by Larouche (2018a).

Individual correlates

As individual correlates, we can mention the age, gender and ethnicity of children and adolescents. The levels of walking and cycling to school increase as the children grow, until they reach adolescence (De Meester et al., 2014; Timperio et al., 2006; Trapp et al., 2011), and at this stage it decreases (Chillon et al., 2011; European Commission, 2014). Cooper et al. (2012), explained that the reduction of rates of ACS in adolescent is because the distance to travel is greater than when they are in primary school. Also, several studies showed the difference in relation to the gender, but there are not seemed to be conclusive results. Some studies reported that boys were more active than girls (Biddle et al., 2011; Gonzalez et al., 2020; Panter et al., 2008; Trapp et al., 2011), and other studies reported the other way around where girls were more active compared to boys (Amornsriwatanakul et al., 2015; Kokko et al., 2016; Makaza et al., 2015; Sithole, 2003).

Ethnicity is another individual correlate (DiGuiseppi et al., 1998) where there are no neither conclusive and unique results. Children from ethnic minorities were more willing to engage in active transport (Martin et al., 2007; McDonald, 2007), although the study of DiGuiseppi et al. (1998) showed that black children in London preferred to be driven to school compared to their white colleagues (DiGuiseppi et al., 1998), a possible reason might be the socioeconomic level.

Another individual correlates are psychosocial, motor development, behaviour and perception variables. Youth`s psychosocial characteristics towards ACS (e.g., attitudes, subjective norms, self-efficacy, intention, etc.) can be related to higher ACS rates (Mertens & Ghekiere, 2018). Specifically, children who reported higher levels of self-efficacy (i.e. children more confident in their ability to cycle) were more likely to cycle to school (Ghekiere et al., 2016). In addition, the motor development is a correlate to active commuting to school influenced by the ability to cycle (Barnett et al., 2016; Cools et al., 2011). The behaviours related to the mode of commuting as the independent mobility are related to the ACS. Indeed, a greater independent mobility is associated to commute actively (Ghekiere, 2016; Schoeppe et al., 2013). Also, the children's perception of personal barriers towards ACS, may influence their choice of mode of commuting; for example, their biking comfort referred to their security cycling can be associated with the choice of an active mode of commuting such as cycling (Emond & Handy, 2012), so if children ride comfortably, children are more likely to cycle.

Interpersonal

The interpersonal correlates to ACS focus on family and friends, and are diverse such as the parental licence, attitudes, socioeconomic status (SES), parent's marital status, perceptions and concerns to allow their children to actively commute, as well as their educational level and working-related issues (family correlates will be explained in more detail in the section 1.6).

The parental licence to actively commute to school depends on the sex of the child, as boys tend to have more permission to active mobility than girls, obtaining this freedom at a younger age (Carver et al., 2014; Mitra et al., 2014). In addition, older children have parental licence to actively commute to school more often than younger children (Mammen et al., 2012). Also, the study of Ducheyne et al. (2012) found that if parents reported positive attitudes about their children active mode of commuting to school, their children were more likely to go to school actively. In the same way, the neighbourhood safety concerns are directly related to the parental licence for active commuting, and they are associated to the

children´s mode of commuting (Egli et al., 2018). It should be noted that when parents know their neighbours, the percentage of active commuting of children is higher (Hume et al., 2009).

Another interpersonal correlate is the socioeconomic status (SES) (DiGuiseppi et al., 1998; Martin et al., 2007; Timperio et al., 2006; Tudor-Locke et al., 2003), where is measured using the parental educational levels, household income and/or neighbourhood income, and car ownership (Mertens & Ghekiere, 2018). Low SES is related to higher ACS behaviours. Several studies have focused the parental educational level a correlate of ACS (Mota et al., 2007; Panter et al., 2013). For example, the studies of Mota et al. (2007), or Shi et al. (2006), found an association between AC and a higher level of parental education. In contrast, other studies did not show a significant association between parental education level and AC (Fulton et al., 2005; Martin et al., 2007). Also, Panter et al. (2013) expressed that a family with a lower educational level was associated with British children start to cycle for commute at childhood. Furthermore, we cannot forget that in this society the motorised transport industry, specifically the car industry, presents us that the car as a symbol of freedom and prosperity (Parra et al., 2018), so it is not surprising that active travel is seen in a negative sense (Lorenc et al., 2008; Underwood et al., 2014), and families try to achieve more than one passive vehicle.

Also, the parents' marital status is another interpersonal correlate (Pont et al., 2009). Several studies described that children whose parents are divorced, widowed, separated or single, have lower AC rates compared to children whose parents are married or both live at home (de Bruijn et al., 2005; Martin et al., 2007). Although, other studies showed no associations between parents' marital status and AC of children (Fulton et al., 2005; Timperio et al., 2006) so further studies in this sense are needed to clarify this issue.

Community

A third level is the community, where different correlates related to active commuting have been reported, such as social or community cohesion, community concerns and deprivation, social norms, social surveillance and school's policies and practices to promote the active commuting. The social cohesion means that people of the neighbourhood know and trust on each other, which is related to higher active commuting (Aarts et al., 2013; Larouche, 2018b; Lin et al., 2017; McDonald et al., 2010). Timperio et al. (2006) showed that if parents believe that other children are walking, it is easier for them to let their children go actively. On the other side, the bullying and the crime influenced the ACS, reducing this behaviour. For instance, the children reported their fear of bullying or encountered with dangerous dogs more than encountered with a stranger danger (Buliung et al., 2014). Moreover, a study conducted in Canada with 5000 participants showed that school bus travellers were more likely to be victims of bullying than students that actively commute to school (Sampasa-Kanyinga et al., 2016). Another community correlate is the neighbourhood deprivation, where children are forced to walk or cycle to school as there are no other alternatives, despite living in dangerous areas (Rossen et al., 2011; Sarmiento et al., 2015). In this level of correlates (community) are also included the social norms that maybe be related to the culture, the context and community. In terms of context and community, it is worth noting that children in Scandinavia walk several kilometres to and from school, while few children in North America who live at 1.6 km walk actively (Tremblay et al., 2014). So, the sociocultural norms are a relevant correlate that reflect the culture and the contexts (Egli et al., 2018). In relation to these previous correlates, we can mention the social surveillance which is a way to increase the attention on neighbourhood children (O'Connor & Brown, 2013). For instance, the neighbourhood with more foot traffic

usually presents less restrictive parental licences to active commuting, and even more so, the active trips are accompanied by siblings or friends (Faulkner et al., 2010; Jago et al., 2009; Lang et al., 2011; Veitch et al., 2017). But, if there are more social surveillance, means that there are more neighbours and parents.

Within the community level, another relevant context to find correlates to ACS is the school setting. Sometimes, the schools have policies against active commuting as they are concern about children being involved in traffic accidents, and they restrict that students walk or cycle to school (Larouche, 2018b). Probably, the school staff could be frightened about parents' lawsuits in relation to the promotion active living in schools (Spengler et al., 2010; Zimmerman et al., 2013). In contrast, other schools promote active living through the identification of active safe routes for children (Larouche et al., 2014). In addition, when the schools encourage active commuting, the odds of walking to and from school increase (Trapp et al., 2012).

Built environment

The fourth level of the social-ecological model is the built environment, focusing on the urban planning and design of the environment around both the school or the neighbourhood (Timperio et al., 2018). The commuting patterns might be determined by the development of the urban areas, suburbs or infrastructures (Saelens et al., 2003). The urban design elements (residential density, connectivity of streets and land use mix) can condition the walkability, which is referred to a place or area that encourage walking because offers the necessary support (Forsyth, 2015). And even more important, the walkability is associated with active travel to school in children (D'Haese et al., 2015). The built environment determines in the majority of children the mode of commute that they choose, because the distance from home to school is the strongest predictor to ACS in youth (Davison et al., 2008; Panter et al., 2008; Pont et al., 2009; Timperio et al., 2015). In addition, the road safety is another correlate associated with active commuting (Timperio et al., 2018). Several reviews have found that active commuting in children is associated with the traffic safety that includes safe road crossing points and traffic calming to increase the ACS (D'Haese et al., 2015; Lorenc et al., 2008; Panter et al., 2008; Timperio et al., 2015). The existence of walking and cycling paths provides routes between different destinations such as school, so that they can support walking and cycling for youth (Davison et al., 2008; Ding et al., 2011; Pont et al., 2009; Timperio et al., 2015). Even the aesthetics is a correlate of the built environment, due to a pleasant and attractive surrounding might promote active commuting (Kerr et al., 2006).

In addition to the built environment, some factors of the natural environment as weather or topographical features affect ACS. Indeed, some studies found associations between the average of temperature with ACS (Gropp et al., 2012), while other studies did not find associations between ACS and seasonal climate or temperature (Chillon et al., 2014; Mitra & Faulkner, 2012). These situations might be more relevant in countries with extreme climate. On the other hand, Timperio et al. (2006), found that the 10% inclination on the route reduced children's (5-6 years old) ACS levels compared to those who did not have this inclination on their route.

Public policy

At the fifth level of the socio-ecological model (Larouche, 2018a), we find public policy as correlates of ACS. So, it is important to consider that investing on infrastructure and/or crossing guards might be facilitators to active commuting (Eyler et al., 2008), because an insufficient funding may difficult to implement local school travel plans (Mammen et al., 2014). At this

level, we find national policies and programmes to promote ACS in Denmark, Finland, Norway or the United Kingdom, designed to improve the traffic safety (i.e. educational programmes to learn how to behave in traffic situations and public transport) (Fyhri et al., 2011). However, a systematic review did not find that road safety education programmes improve safety outcomes (Duperrex et al., 2002). Another example can be found in the United States, in the well-known *"Safe Routes to School program"* (SRTS), which allocates money to create sidewalks, bike lanes, pathways and crosswalks, and the promotion of own programmes (Larouche & Saidla, 2018; Stewart, 2011). In contrast of the funding of SRTS, another programs are implemented with limited support from provincial and national governments (Faulker & Hinckson, 2018; Larouche & Saidla, 2018), so have less impact. Another successful effort by national governments was the initiative of British government that provides funding to implement school travel plans (Faulker & Hinckson, 2018). At regional level, we can find other policies as the laws related with the low-speed zones around schools which are present in 81% of the states of the United States, while others are less common such as traffic control measures or the presence of crossing guards (Chriqui et al., 2012). Regarding to this fact, Turner et al. (2013), found that schools of USA increased their walking school bus programmes if there was a law requiring crossing guards around school.

Apart from national and provincial policies, the local policies are also correlates of ACS. For example, the Danish municipalities encourage ACS on children through interventions that modified the infrastructure, discourage car travel, or manage the car traffic at schools (Jensen, 2008). On the other hand, the school board policies are responsible to offer school bus service to children for distances higher than 1.6 km in North America (Chriqui et al., 2012). In contrast, in Denmark and Finland, children walk or cycle distances greater than 1.6 km (Tammelin et al., 2016; Tremblay et al., 2016). In this point, we can highlight the possibility of choosing a school due to the school and local government policy allowing parents choosing the best school that they perceive to their children. So, some parents choose one school or another, despite the distance, because they are private or have a special study programme (Mandic et al., 2017; Torres, 2010). Concerning this fact, the study of Mandic et al. (2017), showed that adolescents who enrolled in the closest school (46.5%) tent to actively commute than who were enrolled in a school far away (8.8%). Therefore, looking at the above results, an intelligent public policy would be to consider the location of schools, in an area with walkable distances (McDonald et al., 2016).

Therefore, after examining a global picture of the correlates at individual, interpersonal, community, built environment and policy level, is important to know and understanding the factors that influence young people's active commuting to/from school, in order to be able to propose and design projects and policies to promote and implement this behaviour in young people.

1.6. How does the family influence the active commuting to school?

The ACS is influenced by multiple correlates and at different levels (individual, interpersonal, community, built environment and policy level) (Larouche, 2018a; Mandic et al., 2015), as we have seen in the previous section (see section 1.5.). Within these correlates, we have mentioned the families (parents), which are included mostly in the interpersonal level, but their perceptions and beliefs of individual, community and environmental factors should also affect to the mode of commuting. In this section, we are explaining every family correlated affecting ACS (**Figure 5**). Several studies reported parents as the main decision makers on the mode of commuting of their children (Giles-Corti et al., 2009; Henne et al., 2014), and

their decisions are influenced by different factors.

Firstly, at individual level, the gender effect of ACS maybe affected by parental decisions. Parents tend to protect more their daughters than their sons, which may be related to the traditional point of view in which girls are more vulnerable than boys to danger in the public place (Valentine, 1997). Specifically, the parental licence differs by sex of the child to restrict age or the possibility to actively commute (Carver et al., 2014; Mitra et al., 2014). Villanueva et al. (2014), showed the importance of parents having confidence on the child's ability to travel independently in order to give them license to actively commute, while for parents of girls the most important factor was the parents' perception of the safety of the neighbourhood. Also, children's age is associated with the parents' decisions to ACS, because they are more concern over children's safety than adolescent´s safety (Carlson et al., 2014). The study of Lu et al. (2015) showed that children's self-efficacy is associated with levels of active commuting, but the influence of parental self-efficacy of children's active commuting is stronger. In addition, if parents reported positive attitudes towards their children's cycling to school, the rates of cycling to school among children increased (Ducheyne et al., 2012). So, the individual characteristics of parents should be also related to the children's mode of commuting. Even the ethnicity is related to the ACS. Martin et al. (2007) showed that the engagement to ACS is higher in children from minority ethnicities. In the other hand, there are studies that did not show associations between ethnicity and ACS, as the study of Borrestad et al. (2011) between others (Fulton et al., 2005; Kerr et al., 2006). These contradictory results in the literature might be due to the specific culture of each country among other factors; so further research on this topic is needed.

In the interpersonal level, most of the family and parental factors are included. The familiar socioeconomic status can be expressed using the household income, the neighbourhood income, parental education levels or the car ownership, and they are all related to ACS (Larouche, 2018a; Mertens & Ghekiere, 2018). For instance, if the father or the mother are unemployed, the odds to have active children are higher (Rodriguez-Lopez et al., 2013), according to previous studies that affirm that ACS is associated with lower socioeconomic levels worldwide (McDonald, Dwelley, et al., 2011b; Pabayo & Gauvin, 2008; Timperio et al., 2006). Panter et al. (2013) showed that a low familiar educational level in British children was associated with a higher probability of starting to cycle to commute. However, there are also studies that find no association between SES families and active commuting in children (D'Haese et al., 2011; De Meester et al., 2012; Ghekiere et al., 2016). Besides, the parental work and daily tasks limit the opportunities to their children's active commuting (Egli et al., 2018), and increase the convenience to combine the children and parents' mode of commuting to different places such as school or work (Strazdins & Loughrey, 2008; Timperio et al., 2006). For instance, when parents work outside the neighbourhood and far from the school, the number of passive commutes increased (Black et al., 2014; Egli et al., 2018) due to it is easier and faster for parents to drive their children to school.

Another family correlate on the mode of commuting might be the parents' marital status (Pont et al., 2009). Several studies reported that the rates of ACS were lower in children with marriage parents or in a common law partner relationship (de Bruijn et al., 2005; Martin et al., 2007). Even though, other studies did not find a significant association between parental marital status and ACS (Fulton et al., 2005; Merom et al., 2006; Timperio et al., 2006); so, these associations need further analyses.

Moreover, the family behaviours and perceptions, (e.g., the perceptions of parents have about safety in different situations or context) (Kerr et al., 2006; Yeung et al., 2008), are determinant to the choice of the children mode of commuting, since parents are the main decision makers in relation to the mode of commuting of children (Giles-Corti et al., 2009). Specifically, parental concerns, such as traffic safety, play an important role in the encouragement and permission of ACS (Black et al., 2001;

Dellinger et al., 2002; Timperio et al., 2004). In this sense, the parental barriers seem to be related with the context (Heelan et al., 2008; Yeung et al., 2008). For example, some parents felt more danger in the amount of traffic than in other barriers such as maintenance of sidewalks (Oluyomi et al., 2014), so sometimes the perceptions of barriers depend on parental environment and how they perceived it. Parents also restrict the independent mobility of their children because of concerns about crime, which they think could be reduced if there were more eyes on the street (Aarts et al., 2013; Foster et al., 2015; Francis et al., 2017; McMillan, 2007). Although statistics showed that crime has been reduced in many countries (Tseloni et al., 2010), parents often believe the opposite, and in many cases, they are influenced by what they hear and see in the media (Francis et al., 2017).

At community level, in relation to the social factors, parents that allow children to actively commute feel that could be negatively judged by other parents or family members (due to social norms), so, they might change their decision to the mode of commuting of their children (Francis et al., 2017; McMillan, 2007). Consequently, the fear of other parents will be judged negatively those parents or familiar that allow their children active commuting (Francis et al., 2017), because these parents may think that the more permissive parents don't care enough about their children and let them go alone.

In addition, when children commute in group, i.e. accompany by sibling or other children, the parental prohibition the rates of active commute increases and children can be commute more actively (Faulkner et al., 2010; Timperio et al., 2006).

Although parents understand that ACS is beneficial for their children (Witten et al., 2013), parents perceive multiple barriers to allowing their children to active commute. The parental perceptions of neighbourhood safety (Egli et al., 2018), or the social cohesion of the neighbourhood (Aarts et al., 2013; Li & Zhao, 2015; McDonald et al., 2010), influence active commuting (Mitra et al., 2014). Additionally, Hume et al. (2009) showed that if parents knew their neighbours the rate of active commuting of their children was higher. In addition, the parental concerns that their children can be victims of bullying, crime or abductions affect to their mode of commuting to school (Ahlport et al., 2008; Lee et al., 2013). So, some decreases on the active commuting are associated with the parental concerns on crime (Aarts et al., 2013; Silva et al., 2014). Another correlate that influences the parental decisions is the environment which, in turn, is related to several factors that we have previously mentioned. For example, when the neighbourhood presents walking paths, sidewalks, cycling infrastructure, etc., (Carver et al., 2008; Trapp et al., 2011) and the community connections is high (Bruhn, 2005), the parental concerns are reduced. The family's fear decreases when there are connections in the community (Lang et al., 2011; Panter et al., 2010).

The social quality (i.e., parental concerns regarding stranger and neighbourhood safety of the neighbourhood), influences the active commuting of children (Mitra et al., 2014). For example, a study carried out in Australia and the United Kingdom found that children tend to engage in active transportation when their parents presented many neighbourhood connections (i.e., when the parents know the neighbours and there is a relationship between them) (Hume et al., 2009; Panter et al., 2010).

Regarding the environmental level, the urban planning and design also affect the parental decision since a walkable area tend to encourage active commuting (McCormack & Shiell, 2011; Van Holle et al., 2012). The parental perception of the distance between house and school and the presence of dangerous intersections (D'Haese et al., 2011; Huertas-Delgado et al., 2017), has a clear influence on children's mode of commuting. Even the aesthetics of the neighbourhood can be affected to the parental perceptions and influence the ACS (Kerr et al., 2006).

Based on the different parental barriers to active commute to school, the **second study** of this thesis arises from the need to understand the different and classify the

parental barriers perceived to the commuting of their children to the school and study their relation with ACS. A deep systematic review is conducted based on this necessity.

In addition, there is evidence about the association of parent´s and children´s barriers with the children´s ACS. However, few studies compared the barriers between parents and children and the mode of commuting to/from school. Understanding which perceptions have greater weight in the decision to actively commute to school would be important to develop successful and effective interventions. Therefore, in this thesis a comparison of the barriers between parents and children is conducted in order to know the association between them and have a clear understanding of this relevant correlate (is the **third study** of the present thesis).

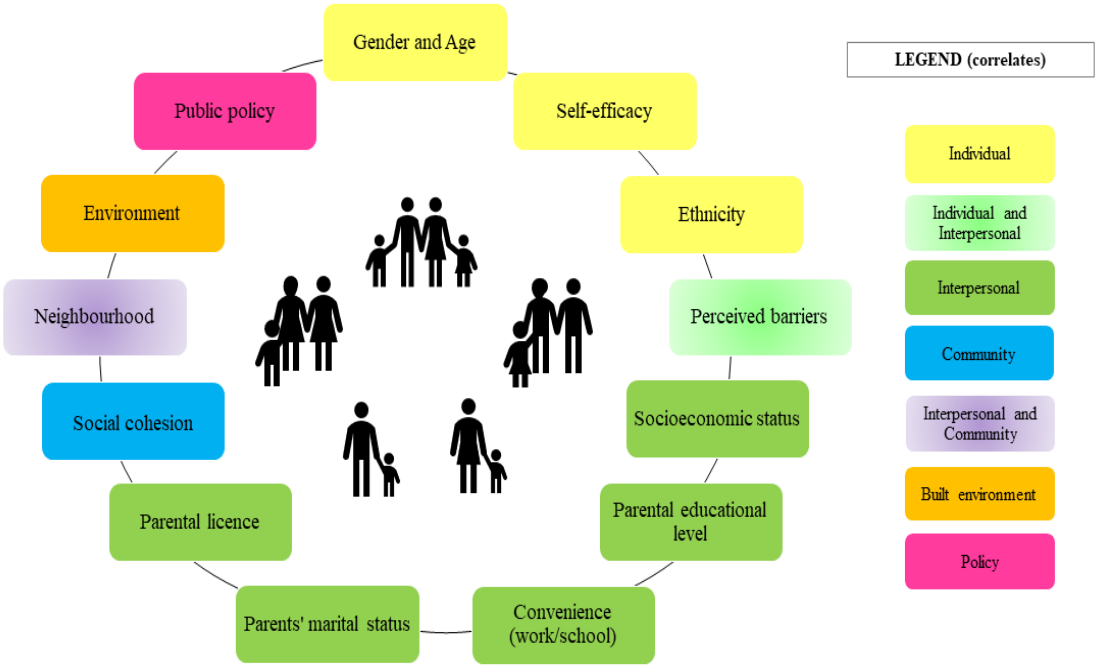

Figure 5. Family correlates of ACS.

1.7. How to promote active commuting to school?

After examining the whole range of benefits that ACS has and observing that ACS has decreased in the last decades worldwide (Chillon et al., 2011; McDonald, 2007; Van der Ploeg et al., 2008), it is necessary to try to reverse this trend to achieve higher rates of ACS in order to promote healthier and more active young people in their diary lifestyle.

Previous researching aimed to increase the ACS behaviour through the reduction of barriers and the consequently change of perceptions (Ahlport et al., 2008). However, some of the barriers are expensive and unlikely to modify, such as the infrastructure changes of building bike lanes in a city. Consequently, lower cost strategies to increase this behaviour may be focused on the promotion and encouragement of the ACS behaviour (Bungum et al., 2014). A potential feasible solution may be the design and implementation of an intervention; it may not be easy and fast, but at least might be cheap and affordable in most cases.

A systematic review about the interventions on the promotion of ACS showed the low

and poor quality of the studies published until 2011 (Chillon, et al., 2011). In 2018, an update of the systematic review of Chillón, et al. (2011) was conducted by Villa-González, et al. (2018) and, after seven years some new studies appeared; however, the conclusions of Villa-González, et al. (2018) were the same: the studies presented a low and poor quality. Consequently, researching with high quality designs using randomized study designs, greater sample size and the use of valid and reliable instruments are needed (Villa-Gonzalez et al., 2018). In addition, the reviews indicated that the interventions need to consider three factors indispensables to design and develop interventions to promote ACS (Chillon et al., 2011): the parents, the school and the neighbourhood (Chillon et al., 2011), and they have to be integrated in the interventions to try to achieve the best results.

Although the quality of the intervention studies carried out identified in the previous reviews need to be improved, we can mention how some studies have encouraged ACS in school settings. The most frequent interventions are initiatives such as the School Travel Plan programme (Mammen, 2016), Safe Routes to School (SRTS) (McDonald et al., 2014) or Walking School Bus (Smith et al., 2015).

We can mention a success story about SRTS in elementary schools of Atlanta between 2008 – 2010, where the programme got an increase on the ACS and they linked different sectors such as the family, the community and the education sector to promote this behaviour (Henderson et al., 2013). Also, the study of McDonald et al. (2014), showed the impact of the SRTS program on walking and cycling to school in USA with a sample approximately of 65000 students and 16000 parents annually. The study reported how the rates of walking and cycling to school increased every year of participation in the SRTS program. During the first year the increase was from 18% to 20%, and when school participated for four or more years the rates of ACS increase up to 30% (McDonald et al., 2014). Mendoza et al. (2011), evaluated the impact of a Walking School Bus program on 149 children of 4th - grade from 8 schools in Texas, and showed how the active commuting increased from 23.8% to 54%. Coombes et al. (2016), showed that after an intervention to promote ACS, the percentage of children from experimental group increased the frequency of ACS compared to baseline and compared to the control group. Although these results were not statistically significant, in the experimental group four children changed their mode of commuting from passive to active, while in the control group no change was reported (Coombes & Jones, 2016).

Regarding to interventions to increase cycling commuting to school, Mandic et al. (2018), observed that a cycle skill training improved children's cycling-related knowledge and perceived cycling confidence, although it was not enough impact on the cycling to school rate in children of 10-12 years in the city of Dunedin (New Zealand). This result states that interventions focused on promote cycling may be a potential way to reduce the perceived barriers towards cycling to school. Johnson et al. (2015) found that a Bikeability training in UK schoolchildren improved the frequency of cycling. Even the study of Bungum et al. (2014) with a one-day intervention in Henderson (Nevada), with children in grades K-5, showed that ACS intervention may provide an opportunity to enhance the proportion of youth who actively commute. Nevertheless, the authors reported that it is necessary a longer intervention to create the habit.

A recent intervention program that lasted 6 months was implemented in 494 Spanish children to increase ACS (Villa-Gonzalez et al., 2017). This study showed a small increase in the percentage of trips by bicycle to school and, in the follow-up test, the experimental group did not increase passive commuters as the control group (Villa-Gonzalez et al., 2017).

On the other hand, interventions aimed at increasing cycling trips to school do not always report good results. For example, the study of Ostergaard et al. (2015), in

Denmark (children from 4th to 5th grade), reported no significant differences in cycling of experimental group than control group. Another study in Belgium (Ducheyne et al., 2014), with children of 4th grade reported the effects of a cycle training course on children's cycling skills and levels of cycling to school, but no significant effects were found on cycling to school levels of children.

In this line, the present thesis includes as **fourth study** the assessment of a school-based cycling intervention in Spanish adolescents. This intervention is part of the PACO "Pedalea y Anda al Cole" study (started in January 2017), belonging to the Research Group of the University of Granada, PROFITH (PROmoting FITness and Health through physical activity). This project aimed to design instruments and interventions to promote ACS. The participants of this project were adolescents of third grade of Secondary school (13-14 years old), who participate in a 4-week programme called "Cycling and Walk to School" which aims to promote cycling to school and increase the levels of physical activity.

2. Aims

2. AIMS

The purposes of the present Doctoral Thesis were to analyse a commuting-to-school questionnaire for families, to study the parents' and adolescents' perceptions towards active commuting to school and to analyse the effects of a school-based intervention to promote this behaviour.
Therefore, the present Doctoral Thesis is organized in four studies:

Study I (Psychometric characteristics of a commuting-to-school behaviour questionnaire for families).

The objectives of this study were: 1) to describe the patterns of the modes of commuting to school (children) and to work (parents) separated by gender and age; 2) to validate the questions on the mode of commuting to/from school of children according to their parents; 3) to analyse the reliability of a family questionnaire focused on commuting to school behaviours.

Study II (Parental barriers to active transport to school: a systematic review).

The objectives of this study were: 1) to examine the parental barriers to active transport to school in the scientific literature; 2) to provide a categorization of these identified barriers based on the current literature.

Study III (Children and parental barriers to active commuting to school: a comparison study).

The objectives of this study were: 1) to compare the barriers to active commuting to and from school (ACS) between children and their parents separately for children and adolescents; 2) to analyse the association between ACS and the children's and parents' barriers, separately for children and adolescents.

Study IV (The effect of a school-based intervention on children's cylcling knowledge, mode of commuting and perceived barriers).

The objectives of this study were: 1) to assess the feasibility of a school-based cycling intervention in adolescents, 2) to assess the effectiveness of a school-based cycling intervention on the rates of cycling to school, active commuting to school and barriers to ACS from adolescents.

OBJETIVOS

Los objetivos de la presente Tesis Doctoral fueron analizar un cuestionario sobre el desplazamiento al centro educativo para las familias, estudiar las barreras percibidas por los padres y adolescentes sobre el desplazamiento activo al centro educativo y analizar los efectos de una intervención en entorno escolar para promover este comportamiento.

Por lo tanto, la presente Tesis Doctoral está organizada en cuatro estudios:

Estudio I (Características psicométricas de un cuestionario sobre el comportamiento en el desplazamiento al centro educativo para las familias).

Los objetivos de este estudio fueron: 1) describir las pautas de los modos de desplazamiento al centro educativo (niños) y al trabajo (padres) separados por sexo y edad; 2) analizar la validez de las preguntas sobre el modo de desplazamiento al centro educativo de los niños según sus padres; 3) analizar la fiabilidad de un cuestionario familiar centrado en los comportamientos de desplazamiento al centro educativo.

Estudio II (Barreras de los padres para el desplazamiento activo al centro educativo: una revisión sistemática)

Los objetivos de este estudio fueron: 1) examinar las barreras de los padres para el desplazamiento activo al centro educativo de sus hijos, presentes en la literatura científica; 2) proporcionar una categorización de estas barreras identificadas basada en la literatura actual.

Estudio III (Barreras de los niños y de los padres para el desplazamiento activo al centro educativo: un estudio de comparación)

Los objetivos de este estudio fueron: 1) comparar las barreras para el desplazamiento activo hacia y desde el centro educativo entre los niños y sus padres, separado por niños y adolescentes; 2) analizar la asociación entre el desplazamiento activo al centro educativo y las barreras de los niños y los padres, separado por niños y adolescentes.

Estudio IV (Intervención en contexto escolar para promocionar el desplazamiento en bicicleta al centro educativo).

Los objetivos de este estudio fueron: 1) evaluar la viabilidad de una intervención de bicicleta en contexto escolar en adolescentes, 2) evaluar la efectividad de una intervención de bicicleta en las ratios de desplazamiento en bicicleta y activos al centro educativo, y las barreras de los adolescentes para el desplazamiento activo al centro educativo.

3. Method

3. METHOD

The data collection in the current Doctoral Thesis was completed through questionnaires and assessment sheets throughout the four studies. The measurements within each study were taken at different times, years and cities and following specific procedures. Each study was carried out following the current Spanish legal regulations that controls human research. Prior to the beginning of the Thesis, the certification of the Ethics Committee of the University of Granada, Spain, which approved the study, design and protocol and assent procedure informed (reference162/CEIH/2016) was obtained (**Appendice I**).

Each school involved in the present thesis, as well as their families, directors and teachers at each school, were informed about the nature and purpose of the studies though an information letter. Informed consent was also completed by the parents and guardians of the students, for their participation in the studies.

Below, the method of each study is presented separately to better understanding of the procedure followed.

Study I - Psychometric characteristics of a commuting-to-school behaviour questionnaire for families

a) Study design, participants and procedure

It is a cross-sectional study and a test-retest study design. A total of 611 parents (mother mean age: 42.63±6.35 years old; father mean age: 45.19±5.57 years old) and their 611 children (girls mean age: 11.52±2.73 years old; boys mean age: 11.35±2.83 years old) participated in this study completing a family and a student questionnaire, respectively. The data collection took place in two periods, between February and May 2016 and between March and April 2018, as part of the PACO (Pedalea y Anda al COle, Spanish acronym of Cycle and Walk to School) Study. The PACO Study examines ACS in Spanish children and adolescents and aims to develop interventions to promote adolescents' ACS.

Firstly, the research team contacted with seven different schools (five public and two private) of Granada selected by convenience. Initial meetings were conducted with the staff of the schools to communicate the information about the research project. Informed consents were delivered to parents through their children and they were signed by parents after the school acceptation of the research.

The *"Family Commuting-to-School Behaviour"* questionnaire (*available at http://profith.ugr.es/pages/investigacion/recursos/cuestionario-familias-v4)* was delivered to students, and they gave it to their parents or legal tutors to complete it as soon as possible (one week). The *"Mode and Frequency of Commuting To and From School"* questionnaire (available at http://profith.ugr.es/pages/investigacion/recursos/cuestionario-alumnos-v4) was completed by the students in the classroom with a researcher. Both questionnaires were completed twice in two sessions separated by 14 days. The research team emphasized that it was important that the retest family questionnaire was filled by the same person in the family that completed the test questionnaire.

From the total of parents invited (n=695), 611 completed the questionnaire in the first administration and only 230 questionnaires were completed in the second administration by the same parent who did it in the first administration. It seems quite challenging to target parents in research, being the main reason the lack of time (Barratt et al., 2013). In addition, considering the difficulties to meet the parents, we decided to deliver it through their children. Then an additional difficulty was that parents did not understand why they had to complete it twice (Huertas-Delgado et al., 2019), so the sample is low in number.

A total of 695 students from five public schools and two private schools of Granada were invited, where 611 completed the questionnaire at school.

For the first and second objective, we included the parent sample that completed the questionnaire in the first assessment and had a corresponded child-questionnaire associated (611 parents and 611 children). For the third objective, we included a sample of 230 parents that had successfully completed the questionnaire in the two assessments by the same person (i.e. the father, mother, or legal tutor).

b) Measurements

The "Family Commuting-to-School Behaviour" questionnaire

To create the *"Family Commuting-to-School Behaviour"* questionnaire questions (**Table 1**), the Delphi Method (Monfort-Panego et al., 2016) was used. It was developed in 5 phases:

1) firstly, a deep review of the scientific literature was performed in order to find the family variables that may be associated with ACS;

2) in the second phase, a search through specialized literature was conducted and the relevant papers focused on questionnaires about mode of commuting were selected. A systematic research was conducted (Herrador-Colmenero et al., 2014) to analyse different studies which used questionnaires in children, adolescents and both. In addition, several questionnaires (de Wit et al., 2012; Forman et al., 2008; McDonald, Dwelley, et al., 2011b) were analysed to elaborate the first version of the *"Family Commuting-to-School Behaviour"* questionnaire;

3) in the next phase, independent active commuting experts were selected to evaluate the questionnaire. The experts focused mainly on the correct formulation of each item and the answers, in order to make it fully understandable. Finally, the questions were elaborated according to the experts' ideas (questions on the mode of commuting of children and parents, questions on the distance and time to school, questions on trip companion of children in the journey to school and also questions on the distance licensed to go to school on foot or by bike);

4) in this phase, a pilot administration with parents was conducted. Suggestions made by parents were registered by researchers to improve the legibility of the items;

5) the final version of the questionnaire was developed. It included nine questions divided in five categories (mode of commuting, trip companion, distance, time, and permission for ACS) (**Table 1**).

Table 1. *Questions of "Family Commuting-to-School Behaviour" questionnaire classified by categories.*

CATEGORIES	QUESTIONS	ANSWER
MODE OF COMMUTING	-How does your child usually go to school? -How does your child usually come back from school?	Walk; Bike; Car; Motorbike; Scholar Bus; Public Bus; Underground/Train/Tram; Other;
	-How do you usually go to work?	Unemployed; Work at home; Walk; Bike; Car; Motorbike; Public Bus; Underground/Train/Tram; Other;
TRIP COMPANION	-Does your child go accompanied by adults to school? -Does your child come back accompanied by adults from school?	On their own; Mother; Father; Friends; Grandmother; Grandfather; Brother/Sister; Other;
DISTANCE	-How far from the school does your child live?	Less than 0.5km; From 0.5 to 1.5km; From 1.5km to 3km; From 3km to 6km; More than 6 km;
TIME	-How long does your child get to the school, since leaving home?	Less than 5 minutes; From 5' to 15'; From 15' to 30'; From 30' to 60'; More than 60';
DISTANCE LICENSED TO ACS	-What distance do you consider acceptable for your child to commute to school walking on their own, accompanied by children under 18 (friends, siblings, neighbours ...) or accompanied by adults? -What distance do you consider acceptable for your child to commute to school by bicycle on their own, accompanied by children under 18 (friends, siblings, neighbours ...) or accompanied by adults?	None; Less than 0.5km; From 0.5 to 1.5km; From 1.5km to 3km; From 3km to 6km; More than 6 km;

The *"Family Commuting-to-School Behaviour"* questionnaire includes additionally a section with the personal data, consisting of variables such as gender, age and socioeconomic status.

The "Mode and Frequency of Commuting To and From School" questionnaire

In relation to the second objective of this study, we have used the *"Mode and Frequency of Commuting To and From School"* questionnaire (Chillon et al., 2017; Segura-Diaz et al., 2020). This questionnaire showed a good convergent validity (Chillon et al., 2017). For the objective of this study, each child was paired with his/her parent that filled in the *"Family Commuting-to-School Behaviour"* questionnaire in the same administration.

We used the questions related to ACS in the *"Mode and Frequency of Commuting To and From School"* questionnaire to complete this objective: *"How do you usually go to school?"* and *"How do you usually go home from school?"*, for which the possible answers were *walking, cycling, car, motorbike, scholar bus, public bus, metro/train, or other*; only one option could be chosen. We only used both questions to report children's mode of commuting to/from school.

c) Statistical analysis

The descriptive data of the participants are presented as frequencies (and percentages) for the categorical variables and as mean (and standard deviation) for the continuous variables. Differences between mothers and fathers were calculated using the Student's T test for continuous variables and the chi-square test for categorical variables. Reliability was analysed using the kappa (to categorical variables) and the weighted kappa (to ordinal variables) coefficients. The results of the kappa and the weighted kappa were considered as: poor agreement (0-0.20), acceptable agreement (0.21-0.40), moderate agreement (0.41-0.60), substantial/good agreement (0.61-0.80) and almost perfect / very good agreement (0.81-1.00) (Landis & Koch, 1977). As the parent is the person of authority, the children's questions on mode of commuting were validated regarding the parents' responses. The Kappa and the Spearman correlation coefficients were used to compare the parent and children's responses. The Spearman correlation coefficients were interpreted as low (< 0.30), moderate (0.30–0.50), and high (> 0.50) (Van Dyck et al., 2015). All the analyses were performed with the statistical package SPSS for Windows version 23 (SPSS Inc., Chicago, IL, USA), establishing a level of statistical significance of $p < 0.05$.

Study II - Parental barriers to active transport to school: a systematic review

a) Search strategy

A search was conducted using seven electronic databases: Pubmed, Web of Science, SportDiscus, Cinahl, Cochrane Library, PsicoINFO and National Transportation Library, in March 2018. The search included studies up to this date. Five categories of search terms were identified: parents, barriers, school, active commuting/transport and children. Specific terms used in the search were obtained from previous reviews and experts' opinion; then, they were adapted to each database (see Annex VI for more detail). The PRISMA guide was used to perform the review, and it was registered on PROSPERO (CRD42017064040).

b) Selection and review process

The search was conducted by two members of the research team independently. Once the search was finalized, the studies collected from each database were compared. Potentially relevant studies were identified based on their titles and abstracts by two researchers to determine whether they met the following inclusion criteria: (a) studies published until March of 2018; (b) original research; (c) published in English or Spanish; (d) participants: parents or relatives of schoolchildren; (e) assessment of barriers and perceptions; (f) school context; (g) transport to school. Then, a second selection was conducted reading the full texts regarding the previous inclusion criteria. Any disagreements in the inclusion process were solved by a third and independent researcher. Data were extracted from the articles, including descriptive information (i.e. sample and age; study date; design; measures), barriers of active commute and results, and the prevalence of active commute to school. The data extraction was performed by two researchers, and disagreements were solved by a third and independent researcher.

c) Quality assessment

The quality assessment was conducted using a standardized evaluation framework, the Evaluation of Public Health Practice Projects (EPHPP 1998). This tool assesses six methodological dimensions: selection bias, study design, confounders, blinding, data collection methods and withdrawals and dropouts. For the global rating, a final score was computed by summing the six dimension scores. Each dimension was rated on a three-point scale: weak, moderate or strong. Two additional methodological dimensions provided by the tool, but not involved in the global rating, are

intervention integrity and analyses. The EPHPP tool was created primarily for individual-level observational and clinical studies based on populations; consequently, rating criteria for some items were modified by the authors to improve the suitability of the tool for the interventions included in this review. These criteria are attached in Annex VII.

Study III - Children and parental barriers to active commuting to school: a comparison study

a) Study design, participants and procedure

It is a cross-sectional study with children and parental participation. The data were collected between March of 2018 and March of 2020 as part of the PACO Study. The PACO Study examines ACS in Spanish children and adolescents and aims to develop interventions to promote adolescents' ACS.

Participants were selected in two cohorts: 1) one public secondary school and one public primary school from the city of Alhendín (Granada) selected by convenience (2018); 2) ten publics secondary school from four cities, Granada, Jaén, Toledo and Valencia (2019 and 2020) randomly selected. The procedure in the 1st cohort started contacting with the schools of Alhendín and having meetings with the school board teams to inform about the project. Then, after the school accepted the participation in the project, parents signed the informed consents to participate. The procedure in the 2nd cohort started by randomly selected 10 secondary schools from the overall public secondary schools from four Spanish cities (i.e., 3 from Granada, 3 from Jaén, 1 from Toledo and 3 from Valencia). Once the school was selected, the research staff contacted with the school board team to arrange a meeting and explain the project. After the school accepted the participation, parents signed the informed consents to participate.

A total of 600 children-parents' pairs were invited to participate in this study and 401 children (girls mean age: 13.04±1.89 years old; boys mean age: 13.02±1.90 years old) and their parents (mother mean age: 43.50±5.39 years old; father mean age: 45.14±4.72 years old) completed the questionnaires –only those children-parents peers who both completed the questionnaire were included-.

b) Measurements

Sociodemographic characteristics

Parents self-reported their gender, age, educational level, and socioeconomic status. The educational level was categorized as non-university (primary school, secondary school, baccalaureate, technical training) or university (university training). The socioeconomic status was categorized as low, when the parents selected answers from none, <499 €, 500-999 €, 1000-1499 €, to 1500-1999 € or high, when parents selected answers from 2000-2499 €, 2500-2999 €, 3000-4999€, to >5000€.

Mode of commuting to/from school

The mode of commuting was extracted from the valid and reliable *"Mode and Frequency of Commuting To and From School"* questionnaire (Chillon, et al., 2017; Segura-Diaz et al., 2020), that was filled by children at school schedule under supervision of the research team. The aim of the questionnaire is to determine the mode of commuting of children to/from school. The questions were: *"How do you usually get to school?"* and *"How do you usually get home from school?"*, and the possible answers were *walking, cycling, car, motorbike, scholar bus, public bus, metro/train, or other*; only one option could be chosen. Children and adolescents were categorized as "active" if they reported walking or cycling as their mode of commuting and as "passive" if they

answered car, motorbike, scholar bus, public bus, metro/train.

Children´s perceived barriers (BATACE questionnaire)

The children perceived barriers to ACS were assessed using the questionnaire "*Barreras en el Transporte Activo al Centro Educativo"* (BATACE), which has been valid in Spanish adolescents (Forman et al., 2008; Molina-García et al., 2016). This questionnaire elicited information on barriers and perceptions of children go to/from school showing a question (*"It's hard for me to walk or bike to school because...:")* with 18 items in which children have allusion to environmental safety (e.g. *there are one or more dangerous crossings*), autonomy (e.g. *I have too much stuff to carry*) or relatedness (e.g. *other children do not walk or bike*) between others. The participants had to rate how strongly they agreed with each statement through a liker scale of 4 points (from "Strongly disagree" to "Strongly agree").

This scale showed a good internal consistency for the subscale of environment/security barriers and for the planning/psychosocial barriers. In the same way, ACS was related with the total scale, environment/security barriers and planning/psychosocial barriers (Molina-García et al., 2016).

Parent´s perceived barriers (PABACS questionnaire)

The parental perceived barriers to ACS were assessed using the *"Parental Perception of Barriers Towards Active Commuting to School"* (PABACS) questionnaire, which has been validated in Spanish children and adolescents (Huertas-Delgado et al., 2019). The question was formulated in this way: *"Here are some situations that might occur on a day-to-day basis. For each situation, please indicate how much you agree or disagree that it might affect your decision not to allow your child to walk/bike to or from school. (Please check only one option for each question.)"*. The scale includes 23 different items categorized in general barriers -including those common to both walking and cycling to school (e.g. *There is a long distance from home to school*)-, walking barriers -including those referring to walking (e.g. *there are no sidewalks or they are in poor condition*)-, and cycling barriers -including those referring to cycling (e.g. *there is no bike path or it is in poor condition*). The scale asked the participants to rate how strongly they agreed with each statement through a Likert scale of 4 points (from *"nothing"* to *"substantially"*).

This scale showed a good internal consistency for the overall question and for the three scales. The Intra-Class Correlation values were moderate. The overall scale and the general and walking barriers scales showed a moderate to high validity to predict active modes of commuting (Huertas-Delgado et al., 2019).

Comparison procedure of Children and Parent´s barriers

In order to be able to compare the children and parent´s barriers coming from the BATACE and PABACS questionnaires respectively, the barriers to ACS have been clustered into categories. These categories have been proposed according to the scientific literature in a recent previous systematic review (Aranda-Balboa et al., 2020).

Following this categorization, we have set 13 common barriers (i.e., categories) for both children and parents (see **Table 1**) to offer a common framework and be able to compare them. These 13 common barriers are grouped on the basis of general situations, walking situations and cycling situations.

Table 2. *Categorization of the barriers presented in the BATACE and PABACS scales.*

BATACE	CATEGORIES	PABACS
General situations		
13.It is very far	Distance	1.There is a long distance from home to school
17.There are too much traffic	Safety Traffic	2.There is a lot of traffic on the way to the school 4.The cars go very fast on the route to the school
9.It is easier to drive or to be taken 10.Too much advance planning is necessary	Convenience	12.It is more convenient to drive than to walk 18.It is more convenient to drive than to ride a bike
4.There are one or more dangerous crossings	Built environment	6.Lack of security at intersections and crossings
12.There are stray dogs 14.You would have to Walk/ cycle in places that would be unsafe due to crime or other crime related things (i.e. vandalism, graffiti, people drinking alcohol in public places) 3. The way does not have good lighting	Crime-related safety	7.There are no guards or police at crossings 8.There is violence and/or crime in the area
5. I get too hot and sweaty, or it always rains	Weather	9.It is very cold / hot 10.There is a lot of rain / snow
8. I have too much stuff to carry	Physical and motivational barrier	11. Your child carries a lot of weight in the backpack
Walking barriers		
1. There are no sidewalks or bike lanes 16.There are too many hills	Built environment (walk)	14. There are no sidewalks or they are in poor condition
6. Other children do not walk or bike	Social support (walk)	15. There are no other children to walk with 13.No other adults are walking the route from home to the school 17.No other parents are walking the children
2. The road is boring	Physical and motivational barriers (walk)	16. It is boring for your child to walk
Cycling barriers		
1. There are no sidewalks or bike lanes 18.Cycle lanes are occupied by people walking 11. There are no places to safely leave the bike	Built environment (bike)	20. There is no bike path or it is in poor condition 21. There is no place in the school to leave the bicycle
6. Other children do not walk or bike	Social support (bike)	19. There are no other adults who bike along the route from home to the school 22. There are no other children with whom to ride a bicycle 24.No other parents ride the children on a bicycle
2. The road is boring	Physical and motivational barriers (bike)	23. It is boring for your child to ride a bike

c) Statistical analysis

The descriptive data of the participants are presented as frequencies (and percentages) for categorical variables and mean and standard deviation for continuous variables. Differences between gender (mother/father; girl/boy) and age (child/adolescent) were calculated using the Student's T-test for continuous variables and chi-square test for categorical variables. The Kolmogorov-Smirnov test was conducted to analyse the distribution and the results followed the normal distribution. To analyse the mean difference between children and their parents, and between adolescents and their parents, a T-Test for independent samples was conducted. To establish the association between the commuting to school and the barriers, binary logistic regressions were performed. The ACS was established as the dependent variable and each barrier was established as the independent variable, being developed one model for each barrier. All the analyses were performed with the statistical package SPSS for Windows version 23 (SPSS Inc., Chicago, IL, USA), establishing a level of statistical significance of $p < 0.05$.

Study IV - The effect of a school-based intervention on children's cycling knowledge, mode of commuting and perceived barriers

a) Design study and sample

A random sample of six public secondary schools from three cities (Granada, Jaén and Valencia) in Spain was selected to participate in this study. In each city there was an intervention group (hereinafter called cycling group) and a control group. The data were collected between 2019 and 2020 as part of the PACO (Pedalea y Anda al Cole / Cycling and Walk to School) Study. The PACO Study examines ACS in Spanish children and adolescents and aims to develop interventions to promote adolescents' ACS. The complete information of the recruitment, randomization process and procedure has been published elsewhere (Chillón et al., 2021). The PACO study has been approved by the Review Committee for Research Involving Human Subjects at the University of Granada (Reference: 162/CEIH/2016).

The sample initially recruited was 150 adolescents who were included in the intent-to-treat analysis. After application of the inclusion criteria, the final sample included 122 adolescents in the per-protocol analyses (cycling group, n=60; and control group, n=62) in the three cities. The cycling group participated in a school-based intervention to promote cycling to school within the Physical Education lessons. In the current study, the inclusion criteria were (a) adolescents from 3rd grade of secondary school (b) present completed data in both baseline and follow-up intervention questionnaire, and (c) attend to at least 70% (3 sessions of 4) of the entire intervention (i.e., cycling group).

b) School-based intervention

The content of the school-based intervention have been published (Chillon et al., 2021; Salto et al., 2019), and it is available online in the Spanish language (http://profith.ugr.es/pages/investigacion/recursos/manualbici/). However, a briefly explanation is presented in the section *"description of the school-based intervention"*.

Pilot phase of the school-based intervention

Firstly, a pilot phase was undertaken in the city of Granada, within the PE sessions in a small sample of 14 students from 3rd grade of secondary school in a private secondary school. This pilot phase studied the adoption and the implementation of the intervention using different measures regarding the feasibility and the perceptions of the students: 1) observations of the research

staff during the sessions, 2) an interview with the PE teacher after the pilot intervention, 3) a focus-group with the students performed after the pilot intervention, and 4) the self-reported enjoyment, usefulness, and potential improvements of the students after each session.

The students answered that the third session (urban circuit session) was the most liked one, although they were afraid of the last activity (e.g., how to crossed safety a roundabout). The PE teacher reported that he would like to incorporate the intervention into his programme and that the sessions worked well. He also recommended adding more sessions to teach cycling to students who are less experienced in the use of bike. Both, students and PE teacher recommended that the fourth session (bicycle's party) could be better organized regarding the planning of activities and their timing.

Description of the school-based intervention

This school-based intervention is based in the Bikeability methodology (Goodman et al., 2015). The intervention was conducted in 4 sessions at Physical Education (PE) class during a month (1 class per week).

- First session, theoretical session (60 min): The contents of the session include awareness about the benefits and usefulness of cycling as a mode of commuting in the city, and learning basic road safety rules to cycle, the cycling safety equipment for both the rider and the bike and cycling hand signalling in urban context.
- Second session, closed circuit session (120 min): This session occurs at the playground of the school in a free traffic space. The contents of the session include correct helmet fitting, bicycle safety check before starting to ride, and the fundamental cycling skills of starting off and pedalling, breaking safely, changing gears and hand signalling to change directions.
- Third session, urban circuit session (120 min): The participants practice the knowledge and the skills learned on previous sessions in real traffic context. The specific contents of the session include starting from side of road (kerb), stopping on side of road (kerb), overtaking a parked or slower-moving vehicle, lane changing, turning right and left and crossing a roundabout.
- Fourth session, bicycle's party (120 min): The students have the opportunity to demonstrate what they learned in previous sessions by teaching it to a group of 1st grade of secondary education. The specific contents of the session include a circuit with several exercises based on knowledge and fundamental cycling skills learnt in the previous lessons about urban cycling.

c) Measures

Several measures were used to answer the objectives of the current study. They were implemented at baseline, at follow-up and during the intervention. The complete information has been described in detail else-where (Salto et al., 2019).

The measures used to answer the **feasibility** of the school-based intervention were cycling knowledge, cycling skills, enjoyment, usefulness and improvements.

-Cycling knowledge: A self-reported questionnaire completed by participants in the classroom at baseline and follow-up. The questions were about route safety rules, cycling hand signalling, and circulation. It was a 20-item questionnaire with multiple-choice answers with 3 options with 1 correct answer (Salto et al., 2019). A final score was obtained representing the number of correct answers.

-**Cycling skills on traffic-free**: A cycling ad-hoc observational checklist in a traffic-free situation completed by participants once during the intervention. The test was about cycling skills on bike and signalling safety. It was a 18-items checklist with dichotomy answer (yes/no), ranging from 0 points (lowest score indicating *"It does not have the capacity to carry out the urban circuit"*) to 18 points (highest score indicating *"Unbeatable capabilities for the street circuit"*). The observational checklists are available elsewhere (Salto et al., 2019).

-**Cycling skills on-road**: A cycling ad-hoc observational checklist on road traffic situation completed by participants, once during the intervention. The tests were about cycling skills on bike and signalling safety. It was a 22-items checklist with dichotomy answer (yes/no), ranging from 0 points (lowest score indicating *"Low Cycling Capabilities"*) to 22 points (highest score indicating *"Expert Cyclist"*).

-**Enjoyment, usefulness and improvements**: A short questionnaire completed by participants at the end of the 4 sessions during the intervention. There were 2 questions about enjoyment and usefulness with a Liker scale of 5 points (5, *"Totally agree"*; 1, *"Totally disagree"*), and 1 question with open answer.

The measures used to analyse the **effect** of the intervention were cycling and active commuting to/from school and perceived barriers to ACS, that were reported at baseline and follow-up of the intervention:

-**Cycling and active commuting to/from school**: A self-reported questionnaire (*"Mode and Frequency of Commuting To and From School"* questionnaire (Chillon et al., 2017; Segura-Diaz et al., 2020)) completed by participants in the classroom at baseline and follow-up. The questions were about the latest weekly patterns of commuting to and from school. The possible answers were *walking, cycling, car, motorbike, scholar bus, public bus, metro/train or other*; and only one option could be chosen. The participants were categorized as *"active"* if they reported walking or cycling as their usual mode of commuting and as *"passive"* if they answered car, motorbike, scholar bus, public bus, metro/train.

-**Perceived barriers to ACS:** A self-reported BATACE's questionnaire (Forman et al., 2008; Molina-García et al., 2016) completed by participants in the classroom at baseline and follow-up. The questions were about the barriers perceived to active commute to and from school. The possible answers were a Likert scale of 4 points to answer (4, *"Totally agree"* -high perception of the barrier-; 1, *"Totally disagree"* -low perception of the barrier-).

d) Statistical analysis

The descriptive data of the participants are presented as frequencies (and percentages) for categorical variables and mean and standard deviation for continuous variables.

The normality was studied using the Kolmogorov-Smirnov; since the results showed that the age and cycling knowledge did not follow the normal distribution, these two variables were analysed using non-parametrics' tests.

Differences between groups were calculated using the Student's T test and U-Mann Whitney test for continuous variables (parametrics and no parametrics test) and the chi-square test for categorical variables.

To analyse the changes in the dependent variables at baseline and the follow-up of the intervention, the differences were observed through the comparison test of related samples such as the t-student and non-parametric tests in those variables with free distribution (Wilcoxon, Signs and McNemar), both separately in the control group and in the cycling group. To establish the association between the dependent variables and the intervention, a binary logistic regression equation was performed. Difference at baseline and follow-up intervention were established as dependent

variables and the intervention group variable was established as the independent variable for the analysis.

All the analyses were performed with the statistical package SPSS for Windows version 23 (SPSS Inc., Chicago, IL, USA), establishing a level of statistical significance of $p < 0.05$.

4. *Results*

4. RESULTS

Study I - Psychometric characteristics of a commuting-to-school behaviour questionnaire for families

The descriptive data of participants and the differences between the father and the mother are presented in **Table 3** from the *"Family commuting-to-school behaviour"* questionnaire. The children's mode of commuting to/from school was mostly passive (57.7% and 56.4% respectively) and the trip companion to/from school was mainly independent (76.3% and 73.0%, respectively). In addition, the distance and time from home to school were less than 2 km and less than 15 minutes (55.5%, and 57.1%, respectively). The parents' mode of commuting was mainly passive to work (89.2%) and 43 parents did not commute to work (i.e. work at home or unemployed). The mean age of children was 11.44±2.77 years old and, separated by gender, the mean age of girls was 11.52±2.73 years old and in the case of boys it was 11.35±2.83 years old.

Table 3. *Descriptive data of the "Family Commuting-to-School Behaviour" questionnaire and sociodemographic characteristics of the parent's sample according to gender.*

	All n (%)	**Mothers** n (%)	**Fathers** n (%)	**p**
Parents age (n=417) M± (SD)	43.28 ± 6.25	42.63 ± 6.35	45.19 ± 5.57	<0.001*
Study level (n=207)				
Non-University	143 (69.1)	111 (71.6)	32(61.5)	0.174
University	64 (30.9)	44 (28.4)	20 (38.5)	
Income (n=190)				
Low (<1999€)	127 (66.8)	96 (69.1)	31 (60.8)	0.283
High (>1999€)	63 (33.2)	43 (30.9)	20 (39.2)	
Commuting to/from school behaviours of children				
Mode of commuting to school (n=582)				0.740
Active	246 (42.3)	186 (42.7)	60 (41.1)	
Passive	336 (57.7)	250 (57.3)	86 (58.9)	
Mode of commuting from school (n=582)				0.760
Active	254 (43.6)	191 (44)	63 (42.6)	
Passive	328 (56.4)	243 (56)	85 (57.4)	
Accompaniment to school (n=392)				0.909
Yes	76 (19.4)	56 (19.2)	20 (20)	
No	299 (76.3)	224 (76.7)	75 (75)	
Sometimes	17 (4.3)	12 (4.1)	5 (5)	
Accompaniment from school (n=392)				0.425
Yes	86 (21.9)	61 (21)	25 (24.8)	
No	286 (73)	213 (73.2)	73 (72.3)	
Sometimes	20 (5.1)	17 (5.8)	3 (3)	
Distance to school (n=598)				0.030*
<2km	332 (55.5)	258 (58.1)	74 (48.1)	
>2km	266 (44.5)	186 (41.9)	80 (51.9)	
Time to school (n=602)				0.014*
<15 minutes	344 (57.1)	269 (60)	75 (48.7)	
>15 minutes	258 (42.9)	179 (40)	79 (51.3)	
Parent´s mode of commuting to work (n=194)				0.001*
Active	139 (71.6)	95 (65.5)	44 (89.8)	
Passive	55 (28.4)	50 (34.5)	5 (10.2)	
Acceptable distance to walk to school (n=580)				
On their own				N/A
<2km	186 (95.9)	136 (94.4)	50 (100.0)	
>2km	8 (4.1)	8 (5.6)	0	
With children <18years old				N/A
<2km	175 (91.6)	129 (90.8)	46 (93.9)	
>2km	16 (8.4)	13 (9.2)	3 (6.1)	
With an adult				0.948
<2km	140 (71.8)	105 (71.9)	35 (71.4)	
>2km	55 (28.2)	41 (28.1)	14 (28.6)	
Acceptable distance to cycle to school (n=570)				
On their own				0.753
<2km	161 (84.3)	119 (83.8)	42 (85.7)	
>2km	30 (15.7)	23 (16.2)	7 (14.3)	
With children < 18years old				0.073
<2km	145 (77.5)	113 (80.7)	32 (68.1)	
>2km	42 (22.5)	27 (19.3)	15 (31.9)	
With an adult				0.066
<2km	(106) 55.2	(85) 59	21 (43.8)	
>2km	(86) 44.8	(59) 41	27 (56.3)	

*N/A= Not applicable; * = p-value < 0.05; M±SD: Mean ± standard deviation; n (%):sample (percentage).*

Table 3 shows children's mode of commuting separated by age (i.e., children vs. adolescents). Both groups of age presented mainly passive modes of commuting to school (children = 57.7% and adolescents = 53.1%). However, the adolescents showed a higher percentage of active vs passive mode of commuting from school, being significantly higher than children (p = 0.005). There were no differences between boys and girls in the mode of commuting.

Table 4. *Validation of the mode of commuting questions between parents and children.*

	Complete sample (n=563)					
		Kappa	Rho			
Mode of commuting to school		0.865	0.882*			
Mode of commuting from school		0.839	0.860*			
	Children (n=311)			**Adolescents** (n=252)		
	n	Kappa	Rho	n	Kappa	Rho
Mode of commuting to school	309	0.864	0.862*	250	0.863	0.904*
Mode of commuting from school	304	0.806	0.839*	248	0.867	0.879*
	Girls (n=298)			**Boys** (n=264)		
	n	Kappa	Rho	n	Kappa	Rho
Mode of commuting to school	295	0.881	0.911*	263	0.846	0.847*
Mode of commuting from school	292	0.870	0.908*	259	0.799	0.798*

*Notes: * P value <0.001.*

The agreement of the children's responses in relation to the parental response is presented in **Table 4**. The results showed a very good or almost perfect agreement (kappa coefficients range between 0.810 – 1.00) for the mode of commuting to/from school, even when they were separated by children and adolescents (children to school k=0.864; adolescent to school k=0.863), except for the mode of commuting from school in children that presented a good agreement (k=0.806). In addition, there were high correlation coefficients for the mode of commuting to/from school for the total sample (to school, rho=0.882; from school, rho=0.860) and separated by age (children to and from school, rho=0.862; rho=0.839, respectively; adolescents to and from school, rho=0.904; rho=0.879, respectively). In relation to gender, the results showed a very good or almost perfect agreement in girls and boys for commuting to school (k=0.881 and k=0.846, respectively), a very good or almost perfect agreement for girls for commuting from school (k=0.870) and a good agreement for boys for commuting from school (k=0.799). Moreover, high Spearman coefficients were observed in both gender to/from school although they were higher in girls than boys: girls commuting to school, rho=0.911; girls commuting from school, rho=0.908; boys commuting to school, rho=0.847; boys commuting from school, rho=0.798.

***Table 5**. Test-retest reliability coefficients on modes of commuting to school of children and fathers/mothers' mode of commuting to work.*

	All participants			Mothers			Fathers		
	n	Kappa	p	n	Kappa	p	n	Kappa	p
Commuting to/from school behaviours of children									
To school	130	0.951	<**0.001**	104	0.939	<**0.001**	26	1.000	<**0.001**
From school	221	0.930	<**0.001**	175	0.929	<**0.001**	46	0.931	<**0.001**
Accompaniment to school	137	0.780	<**0.001**	110	0.724	<**0.001**	27	1.000	<**0.001**
Accompaniment from school	137	0.793	<**0.001**	109	0.753	<**0.001**	28	1.000	<**0.001**
Distance to school *	224	0.893	<**0.001**	177	0.889	<**0.001**	47	0.912	<**0.001**
Time to school *	227	0.850	<**0.001**	180	0.822	<**0.001**	47	0.777	<**0.001**
Parents' mode of commuting									
To work	88	0.814	<**0.001**	69	0.812	<**0.001**	19	0.779	<**0.001**
Acceptable distance to walk to school*									
On their own	74	0.771	<**0.001**	58	0.856	<**0.001**	16	0.478	0.103
With children <18years old	70	0.577	<**0.001**	54	0.610	<**0.001**	16	0.488	**0.003**
Adult	77	0.538	<**0.001**	60	0.532	<**0.001**	17	0.547	**0.005**
Acceptable distance to cycle to school*									
On their own	73	0.692	<**0.001**	57	0.733	<**0.001**	16	0.558	0.008
With children <18years old	65	0.565	<**0.001**	50	0.526	<**0.001**	15	0.582	0.432
Adult	71	0.490	<**0.001**	55	0.455	<**0.001**	16	0.595	0.017

*Notes: * Weighted Kappa; Data in bold = p-value < 0.001.*

The test-retest reliability analyses are shown in **Table 5**. Overall, the children's mode of commuting, distance, and time to school, and the parents' mode of commuting showed a good or almost perfect agreement (k= 0.951; k=0.893; k=0.850; k=0.814, all p<0.001), while the distance licensed to walk or cycle on their own showed a good or moderate agreement (k=0.771 and k=0.692, respectively; all p<0.001). In addition, the distance licensed showed higher values of reliability for mothers than fathers.

Study II - Parental barriers to active transport to school: a systematic review

Study selection

The electronic search produced 977 studies among the seven databases: 17 from Pubmed, 194 from Web of Science, 44 from SportDiscus, 7 from Cochrane Library, 376 from National Transportation Library, 66 from Cinahl and 273 from Psycinfo. After discarding 143 duplicates, 834 papers remained. From those, 797 studies were excluded because they failed to meet the inclusion criteria. From the remaining 37 studies, the full texts were read and 12 papers were still removed according to the inclusion criteria. Based on forward and

backward screening of the included primary studies, two additional studies that met the inclusion criteria were added. Thus, 27 studies were included in this review.

Study population and measurement

The 27 studies took place in four continents (America, Oceania, Asia and Europe). Twenty-one studies were conducted in the USA, four studies in Australia (Hume et al., 2009; Salmon et al., 2007; Timperio et al., 2006; Yeung et al., 2008), two studies in Iran (Shokoohi et al., 2012a; Shokoohi et al., 2012b) and one study in Canada (Guliani et al., 2015), in Netherlands (Van Kann et al., 2016) and in Belgium (De Meester et al., 2014). All studies aimed to analyse the parental barriers related to active transport to school of children and adolescents (from 5 to 18 years old). Specifically, twenty-one studies focused on children, five on children and adolescents (DeWeese et al., 2013; Forman et al., 2008; Kerr et al., 2006; Yeung et al., 2008; Zhu & Lee, 2009) and one on adolescents (Carlson et al., 2014). Five studies focused on both adolescents and children (DeWeese et al., 2013; Forman et al., 2008; Hume et al., 2009; Kerr et al., 2006; Rosenberg et al., 2009).

Fifteen studies had additional criteria to include the participants in the sample of the study. Five studies included the distance between home and school as participants' requirement (Carlson et al., 2014; Heelan et al., 2008; W. Lu et al., 2014; Napier et al., 2011; Oluyomi et al., 2014), where students had to live within 2 miles (3.22 km) from school. Four studies included just schools or families that were involved in a programme which promotes active transport to school (A. Eyler et al., 2008; Gustat et al., 2015; Hume et al., 2009; Yeung et al., 2008). One study involved parents of children who had no access to bus services (Ahlport et al., 2008), and one study only included parents of students who lived more than 2 miles from school and had access to bus service (Zhu & Lee, 2009). Finally, two studies analysed children from low-income families (Greves et al., 2007; Zhu et al., 2008) and one of them added as inclusion criteria to be Hispanic (Zhu et al., 2008). The analysed studies used different tools to measure the parental barriers, using in some studies more than one tool. The main tool to collect data was the self-report survey, used in sixteen studies, followed by the use of a questionnaire in seven studies, a focus group in two studies (Ahlport et al., 2008; Greves et al., 2007), a telephone interview in two studies (DeWeese et al., 2013; A. Eyler et al., 2008), an in person interview in one study (A. Eyler et al., 2008) and a telephone survey in one study (Salmon et al., 2007).

Categorization of barriers

We found a wide variety of barriers reported by parents in the studies identified in this review. These barriers have been classified regarding common concepts through consensus among experts, and 14 categories of barriers were developed. These categories have been structured keeping in mind the ecological framework developed by Mandic et al. (2015). Thus, the parental barriers have been classified in three categories of factors: personal, social and environmental. These categories are defined in **Table 6**, including literally the barrier name, its definition, and several examples of parental barriers shown in the studies included in this review.

Parental barriers to active transport to school

The reported parental barriers and the association of these barriers with active transport to school of children are shown in **Table 7**, using the barrier names presented in the previous **Table 6**. The **Table 7** provides information about: author and place of the studies and the main barriers associated with active transport to school. In addition, the **Appendix 2** displays the full information extracted in this review including: author and place of the studies, sample and age of the participants, date and measures of the study, the parental barriers

associated and not associated with active transport to school and the prevalence of active transport to school. The identified studies are organized in **Table 7** and **Appendix 2** according to the children's age: children, adolescents and all (i.e. children and adolescents).

The main parental barriers reported by the parents of children (21 studies) were built environment (18 studies), traffic safety (16 studies), distance (13 studies), crime-related safety (12 studies) and social support (11 studies). The main parental barriers reported by the parents of adolescents (1 study) were built environment (street connectivity), distance, traffic safety and physical and motivation barriers. The main parental barriers reported by the parents of children and adolescents (5 studies) were built environment (5 studies), traffic safety (3 studies), crime-related safety (3 studies) and social support (1 studies).

The main parental barriers associated with active transport to school with a higher frequency were built environment in 24 studies (see **Table 7**). Particularly, the subcategory walkability was the most reported built environment barrier in 22 studies (see T**able 7**). Additionally, traffic safety was associated with active transport to school in 20 studies (see **Table 7**), where the subcategory high amount of traffic was the most reported (14 times) by parents, while crime-related safety was associated with active transport to school 15 times, being the subcategories bullying and abductions the most commonly reported. Distance appeared in 15 studies, being the barrier with the strongest associations with active transport to school. Finally, social support was a barrier associated with active transport to school in 12 studies (see **Table 7**).

Concerning active transport to school prevalence, 20 studies reported rates of walking to school ranging from 18 to 88% and rates of cycling to school ranging from 0 to 50% (see **Appendix 2**).

Regarding the association between objectively and subjectively measured parental barriers, only 1 study found a positive association (Zhu et al., 2008). In addition, parents of children presented more barriers, such as built environment (walkability), traffic safety or social support for active transport to school, than parents of adolescents (Forman et al., 2008; Kerr et al., 2006). Finally, parents provided several ways to promote active transport to school and improve this behaviour (i.e. someone accompanies my children to school).

Table 6. *Categorization of parental barriers to active transport to school and their definitions.*

BARRIERS' NAME	DEFINITIONS
ENVIRONMENTAL FACTORS	
Distance	***Long distance from home to school.*** Examples: *"My child's school is too far to walk to"; "Distance too far".*
Traffic safety	***Circulation of motorized vehicles.*** **-High amount of traffic.** Examples: *"Too much traffic at school"; "Heavy traffic".* **-High speed of traffic.** Examples: *"Lack of speed control for cars"; "Cars exceeding speed limits in nearby streets".* **-Dangerous behaviours of vehicles.** Examples: *"Drunk drivers and drivers not obeying traffic signals"; "Distracted motorists".* **-Lack of Parking.** Example: *"Car parking is difficult at my child's school".*
Crime-related safety	***Presence of illegal actions that constitutes an offense that may be prosecuted on the way from home to sc*** Examples: *"Bullying from teenage gangs, homeless people, or drug dealers"; "I'm concerned my child mig* *way to school".*
Built environment	***Built configuration of the ground that hinder walking and/or cycling to school.*** **-Walkability (low):** difficulties to be able to walk to school. Examples: *"There are many cul-de-sacs, courts, or not-through roads near where I live"; "There are no fo* **-Bikeability (low):** difficulties to use cycling as mode of commuting. Examples: *"Nowhere to leave bike safely"; "Bike lanes/paths or trails well maintained".* **-Land- use mix:** low variety of land uses. Examples: *"Presence of land uses en route to school: convenience store, bakery, restaurant, office building* **-Residential density (low):** low concentration of population. Example: *"Residential density".* **-Street connectivity (low):** Lack of connection between streets. Example: *"Street connectivity".* **- Aesthetics:** Low maintenance of the environment. Examples: *"Attractive buildings and natural things to see"; "Neighbourhood aesthetics".*
Natural environment	***Natural configuration of the ground that hinder walking and/or cycling to school.*** Examples: *"The streets in my local neighbourhood are hilly"; "Terrain".*

Weather	***Inappropriate climatic conditions.*** Examples: *"Rain, darkness and cold, especially in winter months"; "Insufficient daylight in the morning".*
PERSONAL FACTORS	
Time constraints	***Lack of time to walk or cycle to school.*** Examples: *"I have no time to walk with my child to/from school"; "Not enough time".*
Schedules	***Parent´s and children´s schedules before or after school activities that hinder walk to school.*** Examples: *"Inflexible work schedules"; "Child's before or after school activities".*
Convenience	***Suitability of driving children to school because of work and/or familiar issues.*** Examples: *"More convenient to drop children off on way to work". "Walking to school involves too much*
Children's preferences	***Children's liking that hinder walking and/or cycling to school.*** Examples: *"Child doesn't want to, or like to, walk or bicycle to school"; "My child prefers to be driven to*
Children's competences	***Children's capability and skills that hinder walking and/or cycling to school safely.*** Examples: *"Immature judgment on the part of the child"; "My child may get lost".*
Physical and motivation barriers	***Corporeal and psychological reasons that hinder walking and cycling to school.*** Examples: *"My child's school bag is too heavy to carry"; "Not having the energy, strength, or motivation"*
SOCIAL FACTORS	
Social support	***Absence of children or adults in the way from home to school or neighbourhood.*** **-Absence of children**. Examples: *"Other kids walk quite often in their daily routines"; "There are no other children for my child* **-Absence of adults**. Examples: *"There are no adults for my child to walk to school with"; "I don't trust the people in our neigh*
School policy	***School´s norms and actions that hinder walking and cycling to school.*** Examples: *"My child's school does not encourage the children to walk to school"; "Lack of storage space*

When appears "to school", it refers to "to and from school".

Social support: can be positive or negative.

Table 7. *Author and place of the studies, and the main barriers associated with active transport to school.*

Author Locality, (country)	Associated barriers	Author Locality, (country)	
Timperio et al., (2006) Melbourne, (Australia).	- Social support (absence of children). - Built environment (walkability: No lights or crossings).	De Meester et al., (2014) Flanders, (Belgium).	- Built envi access; resi - Distance.
Greves et al., (2007) Seattle, Washington (USA).	- Crime-related safety (violence from strangers; bullying; unsupervised children). - Social support. - Distance. - Time constraints. - Schedule. - Physical and motivation barriers. - Traffic safety (High speed traffic; danger behaviour). - Built environment (Walkability: Crossings unsafe, lack of crossing guards, safe walking routes). - Natural environment (hills). - Weather.	Lu et al., (2014) Texas, (USA).	- Children' - Built envi crossings); - Crime-rel - Traffic sa traffic). - Distance. - Weather. - Social sup - Convenie - Time con - Children'
Salmon et al., (2007) (Australia).	Decreased likelihood of active commuting. - Time constraints. - Children's preferences. - Social support (absence of children and adults). - Traffic safety (danger behaviour). - Built environment (walkability: no direct route, footpaths). - Distance. - Physical and motivation barriers.	Oluyomi et al., (2014) Texas, (USA).	- Built envi safety inter - Natural en - Traffic sa traffic). - Social sup - Crime-rel
Ahlport et al., (2008) North Carolina, (USA).	- Crime-related safety (abducted; bullying). - Children's competences. - Convenience. - Schedule. - Physical and motivation barriers. - Built environment (walkability: sidewalks, crossing guards). - Natural environment. - Weather. - Distance. - Traffic safety (high amount of traffic; danger behaviour). - School policy.	Guliani et al., (2015) Toronto, (Canada).	- Distance. - Built envi crossings) (- Traffic sa

Author Locality, (country)	Associated barriers	Author Locality, (country)	
Eyler et al., (2008) Missouri, Massachusetts, South Carolina, North Carolina, Columbia (USA).	- Crime-related safety (abductions). - Traffic safety (high amount of traffic; danger behaviour). - Built environment (walkability: sidewalks, crosswalks and crossing guards).	Gustat et al., (2015) Lousiana, (USA).	- Distance. - Time. - Children' - School po - Social sup - Traffic sa
Heelan et al., (2008) Nebraska, (USA).	- Traffic safety (high amount of traffic). - Time constraints. - Built environment (walkability: crosswalks).	Van Kann et al., (2016) Southern Limburg, (Netherlands).	- Built envi
Yeung et al., (2008) Queensland, (Australia).	- Distance.	Yu et al., (2016) Austin, Texas, (USA).	- Social sup - Children' - Children' - Crime-rel dogs). - Distance. - Built envi overall wal - Traffic sa - Time con
Zhu et al., (2008) Austin, Texas, (USA).	- Physical and Motivation. - Traffic safety (high amount of traffic; danger behaviour). - Social support (absence of adults and children). - Distance. - Built environment (walkability: highway/freeway); (land use – mix: stores and office buildings). - Convenience. - Time constraints. - Crime-related safety. - School policy.	Carlson et al., (2014) Baltimore, Maryland-Washington, DC and Seattle-King County, Washington metropolitan areas, (USA).	- Built envi - Traffic sa - Distance. - Physical a
Zhu et al., (2009) Austin, Texas, (USA).	- Distance. - Built environment (walkability: highways/freeways); (land use mix: stores and office buildings). - Time constraints. - Convenience. - School policy (bus service). - Physical and motivation barriers. - Social support.	De Weese et al., (2013) New Jersey, (USA).	- Built envi

Author Locality, (country)	Associated barriers	Author Locality, (country)	
	- Traffic safety (danger behaviour). - Crime-related safety. - Children's preferences.		
Napier et al., (2011) (USA).	- Crime-related safety. - Distance. - Built environment (walkability). - Traffic safety.	Kerr et al., (2006) Seattle, (USA).	- Crime-rel - Traffic sa traffic). - Built envi mix (stores - Schedule. - Convenie
Shokoohi et al., (2012) Tehran, (Iran).	- Crime-related safety. - Social support (absence of children and adults).	Forman et al., (2008) San Diego, Boston, Cincinnati, (USA).	- Built envi (bikeability - Natural e - Weather (- Distance. - Physical a - Traffic sa - Crime-rel
Shokoohi et al., (2012) Tehran, (Iran).	- Traffic safety (high speed of traffic; high amount of traffic). - Built environment (walkability: cross road with more than four lanes; narrow streets; crosswalks; traffic signs).	Hume et al., (2009) Melbourne, (Australia).	- Social sup - Traffic sa - Crime-rel - Built envi pedestrian cross
Lee et al., (2013) Austin, Texas, (USA).	- Traffic safety (high amount of traffic). - Crime-related safety (abduction). - Distance. - Convenience. - Built environment (walkability: sidewalks; overall walking environments).	Rosenberg et al., (2009) Boston, Cincinnati and San Diego, (USA).	*Children:* - Built envi density). *Adolescent* - Built envi environmer
Chillón et al., (2014) Florida, North Carolina, Texas, Colorado, California, Alaska, Minnesota, Pennsylvania and New Jersey, (USA).	- Children's preferences. - Crime-related safety (attacked by dogs). - Weather. - Traffic safety (high amount of traffic). - Built environment (walkability). - Social support.		

Quality assessment

The quality of all included studies was evaluated as weak in the global rating. The analysis of the individual items was included in **Appendix 3**. Regarding the selection bias, only one study included a representative sample, classified as strong (Shokoohi et al., 2012a). Three studies were classified as moderate (see **Appendix 3**), whereas the rest of the studies were classified as weak. Taking into account the study designs, one study was rated as moderate because case–control designs were used (Eyler et al., 2008), and the other study designs were rated weak, based on using cross-sectional designs. Concerning the control of confounders, one study was rated as strong (Lee et al., 2013), one as moderate (Van Kann et al., 2016), two as not applicable (Ahlport et al., 2008; Greves et al., 2007) and twenty-three as weak. In most of the studies, blinding was assessed as moderate, and only one was assessed as weak (Yu & Zhu, 2016). Regarding the assessment method for data collection, ten studies were rated as strong, four as moderate and the rest of studies were rated as weak (see **Appendix 3**). The studies did not present information about dropout criteria and withdrawals as they only included a one-time assessment. The unit of intervention allocation in most of the studies was the organization/institution (i.e. school), except for four studies where it was the individual (DeWeese et al., 2013; Greves et al., 2007) and the community (Carlson et al., 2014; Kerr et al., 2006). The unit of analysis was individual in all the studies. Finally, all the studies used appropriate statistical methods for the study design.

Study III - Children and parental barriers to active commuting to school: a comparison study

The descriptive data of participants and the differences between children and adolescents are presented in **Table 8**. The mean age of children was 13.26± 1.78 years old and the mean age of parent was 44.35 ± 5.54 years old. The children's mode of commuting to/from school was mostly active (67.6%), and the parents' mode of commuting to work was mainly passive (74.8%). Also, the educational level of parents was mainly non-university (62.6%) and the socioeconomic status was low (61.2%).

Table 8. *Descriptive data of participants.*

	All	**Children**	**Adolescents**	**p**
Children's age M±SD	13.26 ± 1.789	10.71 ± 0.713	14.06 ± 1.164	<0.001*
Commuting to/from school of children n (%)				
Active	265 (67.6)	59 (63.4)	206 (68.9)	0.326
Passive	127 (32.4)	34 (36.6)	93 (31.1)	
	All	**Parents of children**	**Parents of adolescents**	**p**
Parents' age M±SD	44.34 ± 5.54	40.60 ± 5.147	45.44 ± 5.165	<0.001*
Commuting to work n (%)				
Active	90 (25.2)	22 (25.9)	68 (25.0)	0.870
Passive	267 (74.8)	63 (74.1)	204 (75.0)	
Educational level n (%)				
Non-University	244 (62.6)	62 (67.4)	182 (61.1)	0.274
University	146 (37.4)	30 (32.6)	116 (38.9)	
Socioeconomic status n (%)				
Low (<1999€)	219 (61.2)	51 (62.2)	168 (60.9)	0.829
High (>1999€)	139 (38.8)	31 (37.8)	108 (39.1)	

** = p-value < 0.05.*
M±SD: Mean ± standard deviation.
n (%):sample (percentage).

The **Table 9** shows the parental barriers differences between children and parents by age group. The perception of barriers was different between children/adolescents and parents except for social support (walking) for both of them and physical and motivational barriers (bike) in children (all $p<0.05$). The parents reported higher importance for distance, traffic, convenience, built environment, crime-related safety and weather (all $p<0.05$) than children and adolescents. Whereas the children/adolescents reported higher importance to physical and motivational barriers and social support (all $p<0.05$) than parents

.

***Table 9**. Comparison of children and parents' barriers for children and adolescents.*

BARRIERS' CATEGORIES M±SD	**Children**	**Parents of children**	**Mean difference**	**p**
Distance general	1.83 ± 1.11	2.51 ± 1.04	0,67	**<0.001**
Safety Traffic general	1.72 ± 1.04	2.76 ± 0.87	1,04	**<0.001**
Convenience general	1.76 ± 0.81	2.21 ± 1.05	0,45	**<0.001**
Built environment general	2.14 ± 1.26	2.69 ± 0.99	0,54	**<0.001**
Crime-related safety general	1.84 ± 0.87	2.12 ± 0.95	0,28	**0.037**
Weather general	1.46 ± 0.76	2.30 ± 0.76	0,84	**<0.001**
Physical and motivational barrier general	1.63 ± 1.03	1.33 ± 0.75	-0,30	**0.026**
Built environment (walk)	1.82 ± 0.90	2.33 ± 1.10	0,50	**0.001**
Social support (walk)	2.26 ± 1.25	2.15 ± 0.92	-0,10	0.507
Physical and motivational barriers (walk)	1.63 ± 1.03	1.33 ± 0.75	-0,30	**0.026**
Built environment (bike)	1.83 ± 0.77	2.34 ± 0.97	0,51	**<0.001**
Social support (bike)	2.26 ± 1.25	1.85 ± 1.04	-0,40	**0.019**
Physical and motivational barriers (bike)	1.63 ± 1.03	1.47 ± 0.85	-0,16	0.252
BARRIERS' CATEGORIES M±SD	**Adolescents**	**Parents of adolescents**	**Mean difference**	**p**
Distance general	2.02 ± 1.26	2.62 ± 1.06	0,60	**<0.001**
Safety Traffic general	1.89 ± 1.06	2.66 ± 0.94	0,76	**<0.001**
Convenience general	1.98 ± 0.91	2.16 ± 1.06	0,17	**0.030**
Built environment general	2.03 ± 1.10	2.67 ± 1.09	0,63	**<0.001**
Crime-related safety general	1.58 ± 0.64	2.12 ± 0.97	0,53	**<0.001**
Weather general	1.54 ± 0.82	2.10 ± 0.73	0,56	**<0.001**
Physical and motivational barrier general	1.85 ± 1.01	1.48 ± 0.77	-0,36	**<0.001**
Built environment (walk)	1.80 ± 0.89	2.30 ± 1.07	0,49	**<0.001**
Social support (walk)	2.11 ± 1.26	2.04 ± 0.77	-0,06	0.438
Physical and motivational barriers (walk)	1.85 ±1.01	1.48 ± 0.77	-0,36	**<0.001**
Built environment (bike)	1.82 ± 0.80	2.35 ± 0.95	0,53	**<0.001**
Social support (bike)	2.11 ± 1.26	1.72 ± 0.82	-0,39	**<0.001**
Physical and motivational barriers (bike)	1.85 ± 1.01	1.66 ± 0.91	-0,18	**0.018**

Data in bold = Significant changes; p-value < 0.05.
M±SD: Mean ± standard deviation.

The results of **Table 10** present the association between the ACS and the barriers. In children, when they reported higher importance to the distance home-school (OR=0.411, 0.265-0.638), safety traffic (OR=0.492, 0.319-0.759), convenience (OR=0.518, 0.301-0.891) and built environment (general) (OR=0.661, 0.471-0.928), the odds to actively commute to school were lower. In relation to the parents of children, when they reported higher importance to distance (OR=0.591, 0.380-0.920), safety traffic (OR=0.464, 0.262-0.920) and convenience (OR=0.389, 0.237-0.640), the odds to actively commute to school were lower. In adolescents, the odds to actively commute to school were lower when they reported higher importance to distance (OR=0.264, 0.202-0.346), safety traffic (OR=0.638, 0.507-0.802), convenience (OR=0.305, 0.220-0.422), built environment (general) (OR=0.666, 0.533-0.831), crime-related safety (OR=0.402, 0.270-0.598), weather (OR=0.737, 0.554-0.981), built environment (walkability) (OR=0.436, 0.488-0.587), and built environment (bike) (OR=0.641, 0.473-0.868). In relation to the parents of adolescents, the odds to actively commute to school were lower when they reported higher importance to distance (OR=0.476, 0.364-0.623), safety traffic (OR=0.635, 0.481-0.838), convenience (OR=0.327, 0.244-0.438), built environment (general) (OR=0.690, 0.544-0.876), physical and motivational (general) (OR=0.615, 0.451-0.838) and physical and motivational (walk) (OR=0.615, 0.451-0.838).

***Table 10**. Associations between ACS and the barriers separated by children and adolescents.*

	Children			Parents of children		
BARRIERS' CATEGORIES	**Odd ratio**	**CI 95%**	**p**	**Odd ratio**	**CI 95%**	**p**
Distance general	**0.411**	**0.265 – 0.638**	**<0.001**	**0.591**	**0.380 – 0.920**	**0.020**
Safety Traffic general	**0.492**	**0.319 – 0.759**	**0.001**	**0.464**	**0.262 – 0.824**	**0.009**
Convenience general	**0.518**	**0.301 – 0.891**	**0.018**	**0.389**	**0.237 – 0.640**	**<0.001**
Built environment general	**0.661**	**0.471 – 0.928**	**0.017**	0.804	0.514 – 1.256	0.338
Crime-related safety general	1.043	0.640 – 1.698	0.867	1.056	0.660 – 1.689	0.820
Weather general	1.076	0.613 – 1.888	0.799	0.993	0.554 – 1.781	0.981
Physical and motivational barrier general	0.757	0.506 – 1.132	0.175	0.633	0.355 – 1.128	0.121
Built environment (walk)	0.794	0.499 – 1.263	0.329	0.910	0.610 – 1.359	0.646
Social support (walk)	1.284	0.907 – 1.816	0.158	0.781	0.485 – 1.258	0.309
Physical and motivational barriers (walk)	0.757	0.506 – 1.132	0.175	0.633	0.355 – 1.128	0.121
Built environment (bike)	0.672	0.390 – 1.156	0.151	1.074	0.682 – 1.691	0.758
Social support (bike)	1.284	0.907 – 1.816	0.158	0.796	0.525 – 1.209	0.284
Physical and motivational barriers (bike)	0.757	0.506 – 1.132	0.175	1.045	0.622 – 1.756	0.869
	Adolescents			**Parents of adolescents**		
BARRIERS' CATEGORIES	**Odd ratio**	**IC 95%**	**p**	**Odd ratio**	**IC 95%**	**p**
Distance general	**0.264**	**0.202 – 0.346**	**<0.001**	**0.476**	**0.364 – 0.623**	**<0.001**
Safety Traffic general	**0.638**	**0.507 – 0.802**	**<0.001**	**0.635**	**0.481 – 0.838**	**0.001**
Convenience general	**0.305**	**0.220 – 0.422**	**<0.001**	**0.327**	**0.244 – 0.438**	**<0.001**
Built environment general	**0.666**	**0.533 – 0.831**	**<0.001**	**0.690**	**0.544 – 0.876**	**0.002**
Crime-related safety general	**0.402**	**0.270 – 0.598**	**<0.001**	1.087	0.841 – 1.406	0.522
Weather general	**0.737**	**0.554 – 0.981**	**0.037**	0.881	0.629 – 1.232	0.458
Physical and motivational barrier general	0.801	0.631 – 1.018	0.069	**0.615**	**0.451 – 0.838**	**0.002**
Built environment (walkability)	**0.436**	**0.488 – 0.587**	**<0.001**	0.951	0.755 – 1.198	0.670
Social support (walk)	1.069	0.876 – 1.303	0.512	1.022	0.740 – 1.410	0.896
Physical and motivational barriers (walk)	0.801	0.631 – 1.018	0.069	**0.615**	**0.451 – 0.838**	**0.002**
Built environment (bike)	**0.641**	**0.473 – 0.868**	**0.004**	1.198	0.913 – 1.572	0.191
Social support (bike)	1.069	0.876 – 1.303	0.512	0.828	0.612 – 1.121	0.223
Physical and motivational barriers (bike)	0.801	0.631 – 1.018	0.069	0.987	0.747 – 1.303	0.926

Data in bold = p-value < 0.05.

Study IV - The effect of a school-based intervention on children's cycling knowledge, mode of commuting and perceived barriers

The descriptive data of the participants are presented in **Table 11**. The sample included 122 students, 49.5% boys, 50.5% girls) and their mean age was 14.26 ± 0.44 years old. A total of 66.3% of the students owned a bike and the 96.8% of them did not cycle to/from school. The children's mode of commuting to/from school was mostly active, and a percentage of 81.6% and 47.7% were active in the cycling and control group respectively (p=0.002).

Table 11. *Descriptive data of the participants from both cycling and control group at baseline (intention to treat data).*

	All *(n=122)*	***Cycling group*** *(n= 60)*	***Control group*** *(n= 62)*	***p***
Children's age *M±SD*	14.26 ± 0.44	14.20 ± 0.40	14.32 ± 0.47	0.209
Children's gender *n (%)*				
Boy	48 (49.5)	28 (54.9)	20 (43.5)	0.261
Girl	49 (50.5)	23 (45.1)	26 (56.5)	
Own bike *n (%)*	63 (66.3)	28 (57.1)	35 (76.1)	0.008*
Commuting to/from school of children *n (%)*				
Active	63 (67.7)	40 (81.6)	23 (52.3)	0.002*
Passive	30 (32.3)	9 (18.4)	21 (47.7)	
Cycling to/from school *n (%)*				
Cycling	3 (3.2)	3 (6.1)	-	0.950
Do not cycling	90 (96.8)	46 (93.9)	44 (100)	

** = Significant changes; p-value < 0.05.*
M±SD: Mean ± standard deviation.
n (%):sample (percentage).

The **Table 12** presents the differences in the perceived barriers between the cycling group and the control group at baseline. The results showed that cycling group perceived less barriers than control group, although there were no significance differences on the perceived barriers between both groups (p>0.05).

***Table 12**. Descriptive data of perceived barriers by intervention group at baseline.*

Perceived barriers to ACS *n (%)*	***Cycling group***				***Control group***				
	Totally disagree	***Disagree***	***Agree***	***Totally agree***	***Totally disagree***	***Disagree***	***Agree***	***Totally agree***	***p***
Distance	27 (58.7)	8 (17.4)	3 (6.5)	8 (17.4)	19 (41.3)	7 (15.2)	8 (17.4)	12 (26.1)	0.210
Safety Traffic	20 (40.8)	12 (24.5)	9 (18.4)	8 (16.3)	18 (39.1)	13 (28.3)	9 (19.6)	6 (13)	0.953
Convenience	19 (38.8)	13 (26.5)	11 (22.4)	6 (12.2)	10 (21.7)	14 (30.4)	14 (30.4)	8 (17.4)	0.336
Built Environment	16 (32.7)	15 (30.6)	12 (24.5)	6 (12.2)	22 (48.9)	8 (17.8)	8 (17.8)	7 (15.6)	0.285
Crime Related Safety	21 (42.9)	18 (36.7)	8 (16.3)	2 (4.1)	17 (37)	24 (52.2)	5 (10.9)	-	0.275
Weather	37 (75.5)	5 (10.2)	4 (8.2)	3 (6.1)	30 (65.2)	7 (15.2)	7 (15.2)	2 (4.3)	0.574
Physical and Motivational Barriers	6 (12.2)	13 (26.5)	12 (24.5)	18 (36.7)	9 (19.6)	11 (23.9)	10 (21.7)	16 (34.8)	0.808
Built Environment (Walk)	27 (55.1)	12 (24.5)	8 (16.3)	2 (4.1)	22 (47.8)	14 (30.4)	9 (19.6)	1 (2.2)	0.810
Social Support (Walk)	26 (54.2)	4 (8.3)	7 (14.6)	11 (22.9)	18 (40)	8 (17.8)	7 (15.6)	12 (26.7)	0.434
Physical and Motivational Barriers (Walk)	22 (44.9)	17 (34.7)	5 (10.2)	5 (10.2)	23 (50)	10 (21.7)	6 (13)	7 (15.2)	0.538
Built Environment (Bike)	11 (22.4)	25 (51)	11 (22.4)	2 (4.1)	16 (34.8)	18 (39.1)	12 (26.1)	-	0.260
Social Support (Bike)	26 (54.2)	4 (8.3)	7 (14.6)	11 (22.9)	18 (40)	8 (17.8)	7 (15.6)	12 (26.7)	0.434
Physical and Motivational Barriers (Bike)	22 (44.9)	17 (34.7)	5 (10.2)	5 (10.2)	23 (50)	10 (21.7)	6 (13)	7 (15.2)	0.538
Sum of BATACE scale	1 (2.2)	25 (55.6)	17 (37.8)	2 (4.4)	3 (6.8)	18 (40.9)	21 (47.7)	2 (4.5)	0.466

n (%):sample (percentage).

The **Figure 6** presents the results of the cycling knowledge, showing improvements of 2.02 points at follow-up compared to baseline in the cycling group (44 students) ($p<0.001$).

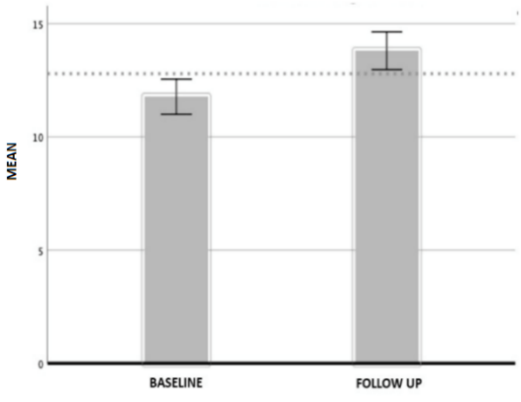

***Figure 6**. Changes on the cycling knowledge between baseline and follow-up on the cycling group.*

The **Figure 7** presents the descriptive data of the cycling skills including scores for both tests, the cycling skills on traffic-free (12.52 ± 3.537) and the cycling skills on-road- (10.94 ± 6.894).

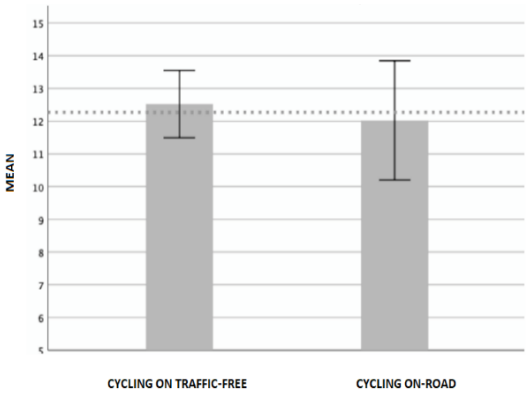

***Figure 7**. Descriptive data of the cycling skills in the cycling group.*

The **Figure 8** shows the sessions' attendance, and the **Figure 9** presents the enjoyment and usefulness of every session, within the cycling group. The mean of attendance to the sessions was 47.5 participants from the total of 60 adolescents of cycling group. The mean of enjoyment was 4.60, and the mean of usefulness of the sessions was 4.78, both from a scale of 5 points.

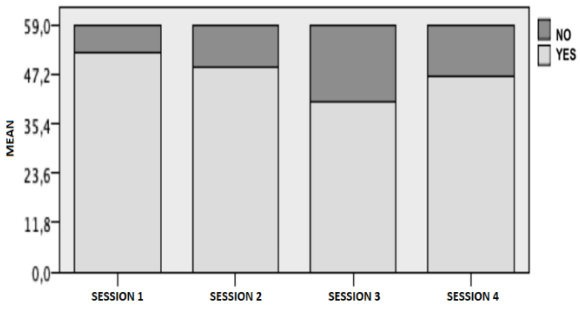

***Figure 8**. Attendance of the cycling intervention.*

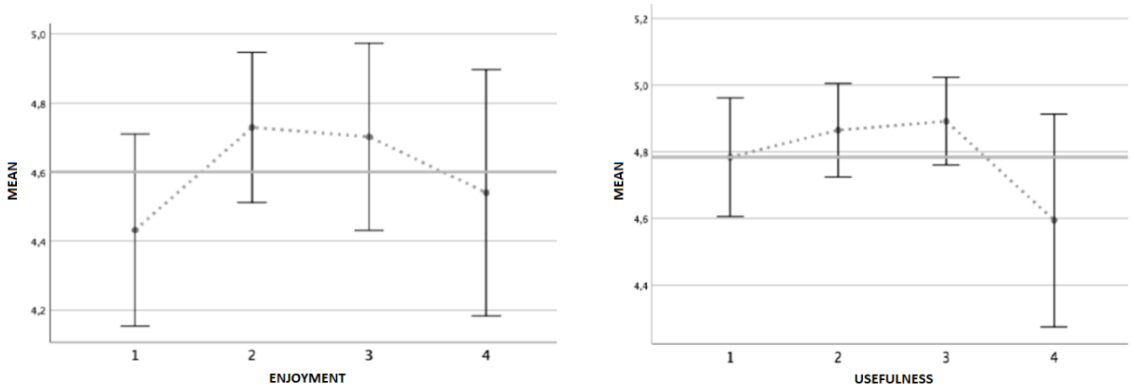

***Figure 9**. Enjoyment and usefulness of the cycling intervention.*

The **Table 13** presents the changes in the mode of commuting to/from school and children's perceived barriers to ACS at baseline and follow-up of the school-based intervention for both groups (i.e., control and cycling). The ranks table provides data on the comparison of participants at baseline and follow-up. The results, stratified by group, showed the *negative ranks* when the perceived barriers after the program was higher than before the program, the perception of barriers decreases. The *positive ranks* indicated that the sample reduced the perception of each barrier or mode of commuting, and a *tie* showed that there were no changes at follow-up. There were no significant differences ($p>0.05$) in the changes of the mode of commuting between the follow-up and baseline. Regarding to the barriers, the baseline – follow-up change of each barrier was calculated, but only the cycling group presented a change in the built environment (walk) barrier ($p=0.002$), with a positive rank of 4, negative rank of 17 and tie of 19. There were not significant differences in the change of barriers within the control group.

***Table 13**. Changes in the mode of commuting to/from school and children's perceived barriers to ACS at baseline and at follow-up of the school-based intervention for both groups (per protocol data).*

MODE OF COMMUTING	**Cycling group**				**Control group**			
	Positive Ranks	**Negative Ranks**	**Ties**	***p***	**Positive Ranks**	**Negative Ranks**	**Ties**	***p***
Active commuting to/from school	13	19	28	0.377	10	19	33	0.137
Cycling to/from school	3	1	56	0.625	2	2	58	1.000

	Cycling group				**Control group**			
PERCEPTION OF BARRIERS TO ACS	**Positive Ranks**	**Negative Ranks**	**Ties**	***p***	**Positive Ranks**	**Negative Ranks**	**Ties**	***p***
Distance	8	10	19	0.821	13	12	17	0.501
Safety Traffic	16	12	12	0.907	13	14	15	0.861
Convenience	11	11	18	0.573	15	13	15	0.674
Built Environment	11	11	18	0.813	10	12	19	0.892
Crime Related Safety	9	16	15	0.252	8	12	23	0.437
Weather	6	19	14	0.086	9	12	21	0.387
Physical and Motivational Barriers	17	9	13	0.100	12	10	20	0.829
Built Environment (Walk)	4	17	19	0.002*	9	15	19	0.178
Social Support (Walk)	11	10	17	0.685	17	14	10	0.530
Physical and Motivational Barriers (Walk)	11	15	14	0.302	12	14	17	0.784
Built Environment (Bike)	8	17	15	0.066	9	14	20	0.263
Social Support (Bike)	11	10	17	0.685	17	14	10	0.530
Physical and Motivational Barriers (Bike)	11	15	14	0.302	12	14	17	0.784
Sum of BATACE scale	6	14	20	0.061	4	10	29	0.225

** = Significant changes; p-value < 0.05.*

The **table 14** shows 3 logistic regression models to observe the relationship between the intervention on the dependent variables. The changes on the mode of commuting (active/passive) at baseline and follow-up did not present association with the school-based intervention (OR=0.6, 0.13 -2.70). Regarding to perceived barriers to ACS, the variable created with the scores' differences baseline and follow-up (sum of BATACE scale) and the differences at baseline and follow-up of the item *"Built environment (walk)"*, no significant association was showed (p>0.05).

Table 14*. Logistic regression of the differences of active commuting and perceived barriers baseline and follow-up regarding the group.*

	Model 1: DV. Differences of baseline – follow-up of active commuting to/from school	**Model 2:** DV. Differences of baseline -follow-up of the sum of BATACE scale	**Model 3:** DV. Differences of baseline – follow-up of *"Built environment (walk)"*
	Odd Ratio (IC 95%)	**Odd Ratio (IC 95%)**	**Odd Ratio (IC 95%)**
Cycling group*	0.6 (0.13 -2.71) **	0,56 (0,21-1,47) **	0.42 (0.12-1.49) **

**Reference's category: Control group*
*** p>0.05*
DV= Dependent Variable

5. Discussion

5. DISCUSSION

Study I - Psychometric characteristics of a commuting-to-school behaviour questionnaire for families

The main findings of the current study were that children's mode of commuting to/from school was mainly passive. Simultaneously, parents' modes of commuting to work were predominantly passive, being fathers more active than mothers. The validation of the questions on the mode of commuting to/from school, reported by both parents and children, presented a very good or almost perfect agreement and high correlation coefficients. Regarding the reliability of the family questionnaire, results showed an almost perfect agreement in relation to the mode of commuting, including questions about distance and time, and a good agreement in questions of trip companion of children to school; and the questions about distance licensed to go to school on foot or cycling showed a moderate agreement.

In our results, children mainly used passive modes of commuting, similar to the study results from Herrador-Colmenero et al. (2018) among Spanish population. Surprisingly, the parents in this study presented very high rates of passive commuting to work, being fathers more active than mothers. These results about commuting to work are lower than the study of Velde et al., (2017) where 5.7% of the parents cycled and 18.2% walked to work at least 4 days per week. In relation to gender, no other studies presented these differences (Bjorkelund et al., 2016) between the percentages of parents' mode of commuting to work. The parental results may be confirmed by future studies focused on parents, where the parents' perceptions of their own mode of commuting could be reported.

The validation of the questions about the mode of commuting to school was studied using parents and children's responses to the same questions. The questions about the mode of commuting to/from school presented very good or perfect agreement and high values of correlation. Similar results were obtained in other studies carried out in other cities such as in Charlotte (McDonald, Dwelley, et al., 2011b), in the region of Auckland, (de Wit et al., 2012), or a study in the region of North Carolina (Evenson et al., 2008). In the study in Charlotte, the validity of the student-report travel mode was assessed by comparison with the parent-report one; in consonance with our study, a kappa coefficient with a good agreement for both modes was obtained as a result (McDonald et al., 2011b). In Auckland, the validity of the questions on children's mode of commuting regarding parents was assessed with a similar sample to the one in our study; they obtained a kappa coefficient between 0.85 – 0.98, a very good or almost perfect kappa coefficient (de Wit et al., 2012). The study in the region of North Carolina showed a substantial agreement between parental and child reports for the mode of commuting (k= 0.80) (Evenson et al., 2008). After analysing the results obtained in this study and reviewing several articles, it is possible to affirm that we can obtain the mode of commuting through the *"Family Commuting-to-School Behaviour"* questionnaire and the *"Mode and Frequency of Commuting To and From School"* questionnaire, both being valid.

In relation to the reliability of the family questionnaire, our results showed a very good or almost perfect agreement in the questions on the mode of commuting to/from school and work, as well as the distance and time. In the study of McDonald et al., (2011a), with a sample of 262 parents-students, they obtained results from moderate to very high agreement for the questions about travel mode and journey. On the other hand, in a study carried out in England in 2004, 103 adolescents were assessed on the means of transport to school; values of similar reliability coefficients were

obtained (very good or almost perfect agreement) (Alexander et al., 2005). Finally, a study in Belgium with 33 adolescents showed kappa values changing from 0.44 and 1.00 in the variables referring to active transport to/from school (Philippaerts et al., 2006), which showed lower values than our results.

While the studies that involve families are scarce, there are numerous studies on this topic that directly involve children through completing questionnaires or hands-up surveys. A research carried out in Norway, where the purpose was to study the test-retest reliability of a questionnaire on active transport to school and work according to the seasons of the year, showed high results for all modes of commuting with high Spearman correlation coefficients in children (Bere & Bjorkelund, 2009). The fact that the questionnaire is completed either by the child or by the mother/father can influence the reliability of the questionnaire. According to the previously mentioned studies (Alexander et al., 2005; McDonald et al., 2011b; Philippaerts et al., 2006), we hypothesize that the reliability of the questionnaires on the mode of commuting to/from school completed by the children obtained a huge range of kappa coefficients. Meanwhile in our study, the one completed by fathers and mothers obtained kappa coefficients with a very good or almost perfect agreement for the same variables. Therefore, those questionnaires completed by parents seem more reliable.

In addition to the reliability, the results of this study showed a high agreement between all studied items except *"acceptable distance to walk/cycle to school"* where kappa values with moderate to good agreement were obtained. These differences could be presented because the questions about the acceptable distance on foot or bike are related to perceptions. McDonald et al., (2011b) found a low test-retest reliability when they asked to parents if they would allow children to walk or cycle and, as well, about the barriers for allowing them to walk and cycle. Moreover, Forman et al., (2008) developed a similar instrument for parents. He asked parents the importance of different factors in their decisions to allow their children to walk/cycle and the results showed test-retest reliability from moderate to good agreement (Forman et al., 2008). In our study, the results were strong enough to use the questions.

Study II - Parental barriers to active transport to school: a systematic review

A total number of 27 studies reporting the parental barriers to their children's active transport to school were identified in this study. The barriers reported in these studies were used to provide a categorization of parental barriers. The main barriers associated to active transport to school were distance, traffic safety, crime-related safety, social support, and built environment.

The categorization extracted 14 different barriers from the scientific literature. All these barriers referred to the parental perception of different factors that affect their children's active transport to school and they can be classified as personal (e.g. children's preferences, convenience), social (e.g. social support, school policy) or environmental barriers (e.g. distance, built environment) (Mandic et al., 2015). This categorization provides researchers and practitioners with a useful tool in order to name each barrier using the same terminology and making the communication between experts easier and more direct.

The identified studies mainly focused on parents of children and focused less on parents of adolescents. A previous study suggested that the perception of barriers by parents decreases as children grow (Forman et al., 2008). Furthermore, parents of adolescents reported a less amount barriers than parents of children (Yeung et al., 2008). When children grow up, their involvement in the decision-making process and their autonomy increase (Panter et al., 2008;

Valentine, 1997). Besides, in the studies identified in this review, both parents of children and parents of adolescents reported barriers to active transport to school, although parents of children had more concerns than parents of adolescents (Kerr et al., 2006). Moreover, the main reported barriers of the parents of children were built environment, traffic safety, distance, crime-related safety and social support. the parental barriers of the adolescents' parents were built environment, distance, and traffic safety. Generalization is however not possible with only a single study focusing solely on adolescents (Carlson et al., 2014). In addition, parents of children who passively commute to school reported a high number of barriers or higher scores of barriers than parents of children who use active transport to school (Lee et al., 2013). When children grow, they get a greater degree of autonomy to perform better any type of task and the parental concerns are reduced to some extent (Forman et al., 2008). In terms of physical activity, when parents are physically active, they tend to encourage their children to set these behaviours and attitudes (Mitchell et al., 2012; Rodriguez-Lopez et al., 2013). Accordingly, parental barriers might be more important for parents of children than for parents of adolescents and for inactive parents than for active parents. It is necessary to continue examining both populations separately to know accurately what the barriers of parents of both children and adolescents are, in order to create and develop strategies to reduce them.

The barrier distance was highly reported in the 15 studies and it was found to be associated with active transport to school in 14 studies, while only 1 study did not report association (Heelan et al., 2008). Therefore, this barrier is perceived by parents as the main predictor to active transport to school (Weigand & McDonald, 2011). When the distance is shorter, the rates of active transport to school are higher (D'Haese et al., 2011; Mandic et al., 2015). The threshold distance that young Spanish people are willing to actively transport to school is 875 m in children, and 1350 m in adolescents (Rodriguez-Rodriguez et al., 2017). Also, Timperio et al. (2006) found a negative association between the distance to school and the mode of transport in children from Australia. However, real distances from home to school may be higher because of different reasons such as parents preferring to enrol their children in a particular school rather than in the local school; or them wanting a specific type of school; or the lack of available place at the local school, among others (Carver et al., 2005). These findings are important for policy makers in order to build schools with available walking distance for the students (Huertas-Delgado et al., 2017; Mandic et al., 2015) or implement drop-off spots close to school (Vanwolleghem et al., 2014).

Regarding the traffic safety barrier, most of the studies that found an association with active transport to school, referred to the high amount of traffic as the main reason (13 studies), and dangerous behaviour of drivers (9 studies); and a lower number of studies mentioned high speed traffic (5 studies) as a barrier. The traffic barriers referred to the areas around school, in the neighbourhood and on the route to and from school. Traffic may be caused by school and work schedules and is related to the increased traffic in peak-times in urban areas. Furthermore, the parents' fear of traffic may reverse to paradoxically increase the traffic, since parents may think that the best way of avoiding traffic accidents is driving their children (Fyhri et al., 2011). For this reason, it is important to reduce traffic in school surroundings and promote active transport to school as a safe behaviour.

Regarding crime-related safety, parents reported that they are afraid of bullying by other children or strangers, and the possibility of abduction of their children (Ahlport et al., 2008; Lee et al., 2013). These reasons may be emphasized by social media that may make parents wonder if it is safe to let their children go to school walking or cycling and taking these risks. These risks

are not totally real, as sometimes parents are influenced by media, which focuses too much on the problem and causes (Lorenc et al., 2008), where the truth is that it is more probable that a child will be abducted by a relative or an acquaintance than by a stranger (Shutt et al., 2004).

According to the built environment category, the studies mentioned walkability as a barrier based mainly on two elements: sidewalks (i.e. lack of sidewalk and maintenance of this) and street crossings (i.e. lack of crossings). The built environment might improve through infrastructure modifications around the school and in the route from home to school, supported by governments and politicians. Examples of environmental policies to increase active transport to school are to increase the facilities for walking or cycling to the school, such as reducing the speed of traffic to 30 km / h or to build bicycle lines; or to decline the architectural barrier for people with specific needs (Kerr et al., 2006; Lee et al., 2013; Napier et al., 2011).

The social support barrier is the presence or absence of other children. If children are accompanied by adults or other children, the rates of active transport to school increase (Greves et al., 2007; Gustat et al., 2015; Kerr et al., 2006). Moreover, parents' accompaniment of their children when walking or cycling to school can be an opportunity to teach them how to handle different situations, avoid road hazards and improve their skills (Ghekiere et al., 2016). This knowledge could increase the confidence of parents in their children and the child's autonomy and independence for going with their friends or others acquaintance. Since this barrier has been improved in previous intervention programs in USA such as school walking (Mendoza et al., 2009), further intervention programs should address it.

These findings suggest that future interventions should aim to improve the perceptions of parents and to improve some barriers in the built environment (Greves et al., 2007), such as providing adequate crosswalks, sidewalks and crossing guards (Ahlport et al., 2008). In addition, the social support should be increased to get parents less worried about their children while they go to and from school (Hume et al., 2009).

Study III - Children and parental barriers to active commuting to school: a comparison study

The main findings of this study were: 1) the most perceived barriers to ACS for children and adolescents were physical and motivational and social support barriers. By contrast, the most perceived barriers to their children´s ACS by parents are the distance home-school, safety traffic, convenience, built environment, crime-related safety and weather. 2) The ACS rates were lower when the children/adolescents and their parents reported higher perceived barriers to ACS.

The children and adolescents perceived more importance to the physical and motivational and social support barriers than their parents. The findings suggested that these groups of populations need a physical or motivational encouragement to walk or cycle to school. Similarly, a study carried out in Australia found that different factors such as social support may influence children's ACS (Timperio et al., 2006). Another study in USA with adolescents, reported that the absence of other children to walk with was related to ACS (Forman et al., 2008). Consequently, the findings showed that it is more important for children and adolescents to have somebody with to walk or cycle to school than for the parents. Timperio et al. (2006) highlights that having other children nearby may be important in all the strategies for increasing ACS. It is especially important when the children grow because they become the decision maker of their mode of commuting. Finally, this higher importance for the children may be related to a greater the importance of the socialization

for children and adolescents (Perez-Felkner & L, 2013).

The parents showed greater concerns than children in barriers of distance, safety traffic, convenience, built environment, crime-related safety and weather. In this sense, Greves et al. (2007) found that parents and grandparents of children from 6 to 13y present crime related-safety, distance, built environment and weather as barriers to ACS of their children. Same results were found in the studies of Carlson et al. (2014) and Hume et al. (2009), where the barriers of safety traffic and built environment were perceived by parents of children and adolescents (Huertas-Delgado et al., 2017). Parents would be more realistic with the barriers related to the natural and built environment as well as the traffic and the safety issues due to their greater experience because the ACS is a habit which is a representation of stimulus–response links and are in a sense directly elicited by the environmental states or stimuli or contexts (Robbins & Costa, 2017).

There are several children/adolescents and parental barriers associated to the ACS. According to the results of our study the barriers of distance, safety traffic, convenience and built environment are associated with the ACS, both for children and adolescents and their parents. Several studies confirm that the barriers as distance, safety traffic, convenience or built environment are associated with ACS (Aranda-Balboa et al., 2020). The barrier of distance is the main barrier associated with the ACS (Easton & Ferrari, 2015), also is a predictor of the mode choice among adolescents (Nelson et al., 2008b). Regarding to convenience's barrier, a study carried out in Texas with 857 parents of children declared the convenience as a barrier to ACS of their children (Lu et al., 2014). Also, the study of Timperio et al. (2006) found the physical neighbourhood environment as a factor of influence on the ACS, so, the improving of urban design could be a strategy for increase the ACS. Finally, the safety traffic barrier is associated with ACS, because of the speed of traffic on the route to school; the amount of traffic; the safety at intersections; the crossing problems; or the availability of crossing guards concern this population on the way to and from school (Oluyomi et al., 2014).

In addition to the barriers mentioned in the previous paragraph when the adolescents perceived crime-related safety and weather as barriers the ACS was lower. The crime-related safety is a barrier for adolescents, even more for boys than girls in their neighbourhood (Esteban-Cornejo et al., 2016). Our study presented similar results to the study of Forman et al. (2008) carried out in USA, where the barrier of crime-related safety was associated with the ACS (e.g. *"It is unsafe because of crime to walk or bike"* or *"I get bullied, teased, harassed along the way"*) or the weather's barrier (e.g. *"It is not considered cool to walk or bike"*). Regarding to the weather barrier, it could be affected by the place. For example, in Spain the main problem may be the heat as Herrador-Colmenero et al., reported (2018) where the participants of these studies perceived the weather as a barrier to commuting. While in other areas such as the northern United States or Canada, extreme winter conditions (excess snow) are one of the main barriers associated with ACS (Kerr et al., 2006).

The results of our study showed the necessity of working with the perceptions of schoolchildren and parents in order to increase ACS. It is very important to develop interventions related to the specific contexts as barriers for parents of children and parents of adolescents are similar but not the same (Huertas-Delgado et al., 2017), consequently, interventions in school and high-school may differ. In addition, strategies to improve the built environment infrastructure are necessaries to encourage the behaviour change. The perception of barriers of children and adolescents are susceptible to change as the mode of commuting to school (Davison et al., 2008). Consequently, the design of interventions and programs to promote the ACS must be

done with the objective of increase the awareness in youth and their parents increasing the support to this behaviour due to both (parents and children) perceived similar barriers.

So, to reduce the perception of barriers will be necessary to design practical strategies such as to impart educational sessions where students learn what type of backpacks are best and least harmful for carrying weight or educational session about this behaviour where students can be knowing the short- and long-term benefits of commute actively. Also, another strategy could be the design and implementation of road safety education courses for students to learn how to get around safely by walking and cycling, so that parents may reduce their perception of barriers.

Study IV - The effect of a school-based intervention on children's cycling knowledge, mode of commuting and perceived barriers

The main findings of this study showed that: 1) the school-based intervention might be feasible at school context; the cycling knowledge improved after the school-based intervention; the scores of cycling skills were medium-low; the adolescents' attendance, enjoyment and usefulness of the sessions were high; 2) concerning the effects, the rates of cycling to school and active commuting to/from school did not change after the school-based intervention, and only the *"Built environment (walk)"* barrier on the cycling group was higher perceived on the follow-up. Also, no association was found between the participation on the school-based intervention with the rates of cycling or active commuting to school and the perception of barriers to ACS.

The collected information may indicate that the proposed school-based intervention is feasible in the school context to be used by other teachers and researchers. Actually, the cycling knowledge improved on the cycling group after the school-based intervention. Previous studies (Groesz, 2007; Hatfield et al., 2019; Van Lierop et al., 2016) showed similar results, were children improved their cycling knowledge scores after a cycle education program. In fact, another intervention study on USA (Lachapelle et al., 2013) found that a cycling program might improve up to 4 points from a maximum of 13 points on average in terms of cycling knowledge. It is necessary to emphasize that the fact of improving cycling knowledge does not imply that cycling skills are practiced more (Van Lierop et al., 2016), although it could be an incentive to cycle to school. In addition, the participants in the current study concluded that they liked the sessions and found them useful. The student´s enjoyment increases their learning improvements, so it is crucial to develop intervention highly satisfactory and enjoyable (Van Lierop et al., 2016). Furthermore, a useful cycling program, like the one used in this study which has been considered useful by the students, may be an opportunity to increase cycling to school (Sersli et al., 2019). Also, we must mention that in the current school-based intervention there was only one data measurement for cycling skills (one for cycling skills on free traffic and another on road traffic, but not comparable to each other), so we cannot know if there was an improvement in the cycling skills at follow-up of the intervention as others studies reported indicating cycling skills improvements after the school-based interventions (Jones, 2017; Montenegro, 2015; Van Lierop et al., 2016). In addition, we must highlight that few participants in the current study used their own bicycle, because they did not have, or it was not in conditions of using. So, this might affect to cycling skills, due to when a child uses a bike that is not yours, he can obtain a worse score than if it were, according to the researchers' observations (Ducheyne et al., 2013).

Regarding the effects of the school-based intervention, it must be remarked that the

rates of cycling and active mode of commuting to/from school at baseline and follow-up of the intervention did not change in both cycling and control groups. A previous school-based intervention of 4 sessions per week did not find changes on the children's cycling to school after an intervention about cycling skills (Ducheyne et al., 2014). Similar results were found on the study of Groesz et al. (2007) from Texas, which included 15 sessions on the PE lessons, where there was not found an increased cycling to school but showed an increased in recreational cycling. However, the studies of Hatfield et al. (2019) (8 sessions), Jones et al. (2017) (5 sessions) and Montenegro et al. (2015) (8 sessions), presented increases on cycling to school after a school-based intervention. In addition, the study of Groesz et al. (2007), found that cycling to school did not increase even having improved the children's confidence on cycling. A potential explanation of these results may be that it is important to involve the families on the interventions. It has been shown that family involvement on this type of interventions can be effective in promoting children's physical activity (Lin et al., 2017). The children's cycling to school is determinate by parental attitudes and household travel schedules (Ahern et al., 2017; Mammen et al., 2012). However, there is a previous study that did not increase the rates of cycling to school even when parents were involved (Ducheyne et al., 2014), indicating that there are a broad range of factors (i.e., environmental) than may underlay the changes of the mode of commuting, such as the lack of cycle's parking at schools (De Meester et al., 2014; Lu et al., 2014). It is highly evidenced the difficulty of changing behaviours in our lifestyles (Kwasnicka et al., 2016), which maybe even more complex in potential new and danger situations as cycling in urban context. In addition, starting to cycle to school may require specific characteristics such as both adolescents' and parents' consents, a bikeable distance between school and home, safety routes and an available bicycle, among others.

Concerning to the change of perceived barriers to ACS, the results showed that there is a significant change in the cycling group in terms of the built environment for walking. Consequently, the cycling group increased the perception of built environment (walk) as a barrier to actively commute. Regarding the other perceived barriers, there were no differences. A potential reason might be that the school-based intervention did not focus on the change of the perception of barriers directly. It was more focused on the cycling knowledge, cycling skills and cycling behaviour, and improving the barriers maybe require another approach (Ducheyne et al., 2014). Despite this, it was expected that the perceived barriers would be reduced as the participants tested real situations in the school-based intervention (i.e., stay and manage traffic situations perceiving risks). However, the perception as the built environment as a barrier to walk to school increased. It may be caused because of the increase of the awareness and the importance of a good built environment to safety commute to school (Broberg, A., & Sarjala, S., 2015). It seems necessary to design interventions that focus attention on reducing barriers to active commuting. If we review the literature, we can find that adolescents perceive different barriers than their parents (Aranda-Balboa et al., 2021), and parents are the main decision makers of commuting of their children (Giles-Corti et al., 2009). In the case of parents, they reported as barriers to active commuting the distance between home and school, built environment, traffic safety, crime-related safety, social support and physical and motivation barriers (Aranda-Balboa et al., 2020). On the other hand, the children reported convenience, built environment, traffic safety, crime-related safety, physical and motivation barriers and social support (Lu et al., 2014).

Thus, it is important to continue implementing new cycling interventions (i.e. environmental, social, personal) to promote active commuting in adolescents. Also, it is

necessary to attend the context and culture (Shoveller et al., 2016) where the interventions are developed. It may be easier to develop school-based interventions on countries where exists a "bicycle culture" or attitudes toward using bicycles (Aldred & Jungnickel, 2014; Klinger et al., 2013). For instance, other countries have specific programs or organization to learn to cycle safely such in Belgium (verkeersveiligheid, 2009), UK (Sustrans, 2013) and Ireland (Travel, 2011), which is very common cycling training in elementary schools. Consequently, interventions in countries where the cycling to school rates are low may focus on increasing knowledge, skills and students and parents' barriers towards active commuting to schools. The interventions must be attractive to youth, since enjoyable interventions can be useful for participants to learn skills (Van Lierop et al., 2016) and to increase the rate of cycling to school (Sersli et al., 2019).

6. Limitations and Strengths

6. LIMITATIONS AND STRENGTHS

Study I - Psychometric characteristics of a commuting-to-school behaviour questionnaire for families

In this study, some limitations can be pointed out. Firstly, the sample of the study is a convenience sample and the minimum sample size was not calculating. Secondly, the questionnaire was delivered by children to their home, and the sample of parents was low. Another limitation was the potential confusion that there might be between the behaviour variability (i.e. variability in scores associated with changes in behaviour from one week to the other) and the technical variability (i.e. variability in scores associated with the questionnaire design). A potential solution to increase the sample might be meeting the parents on a specific day to fill out the questionnaire using a similar procedure to the one used with the children in the classroom or deliver an incentive to motivate families as several studies reported. In order to highlight the strengths of the study, it must be considered that it is a pioneer questionnaire in Spain, as well as being the first reliability and validity study with Spanish families that contributes to propose a questionnaire about the patterns of children commuting to school to be used for the society.

Study II - Parental barriers to active transport to school: a systematic review

The current review has some limitations that merit to be mentioned. On the one hand, the classification of the category of barriers has been prepared according to the ecological general framework for active transport to school but there is not a specific framework for parental barriers. In addition, there is only one study that solely reports barriers of parents of adolescents. Therefore, conducting more studies in this population is necessary. Besides, the vast majority of the studies included in this review are from USA (18) and only 9 of the studies included are from Europe (2), Asia (2) and Oceania (5). Studying parental barriers in other regions should be encouraged, as they are very context related. Moreover, due to the different tools used in the studies (self-report survey, questionnaire, focus group, telephone and in-person interview), and the different terms used to specify the barriers, it is difficult to compare the different studies. Also, EPHPP identify that the quality of primary research is weak overall. Therefore, more high-quality research is needed. On the other hand, some strengths must be highlighted. To our knowledge, this review might be the first systematic review about parental barriers to active transport to school of their children and adolescents. Moreover, we provide a categorization that includes all parental barriers in the literature according to a theoretical framework. Furthermore, every process in the selection and extracting data were conducted by two researchers to assure the quality of the results. Another strength is the inclusion of a quality assessment.

Study III - Children and parental barriers to active commuting to school: a comparison study

Firstly, although in this study there is a great geographic diversity (i.e., four cities) within the same country, we cannot generalize the results findings because the sample was recruitment only in Spain. It is necessary highlight as strengths of this study, that the sample of the study is a mixed of convenience and randomization sample and it was taken in two cohorts. Also, it has been used validated and reliable tools. In addition, a large population of children and parents

paired have participated in this study. Finally, it is the first study that compared the children/adolescents and parental barriers under our knowledge.

Study IV - The effect of a school-based intervention on children's cycling knowledge, mode of commuting and perceived barriers

Several limitations must be pointed out. Firstly, the sample of the study was relatively small, although it was a randomized design. In addition, we must mention the short duration of the school-based intervention, the lack of family involvement in the intervention, and the lack of assessment of cycling skills more than one time. Regarding to the strengths of the study, it is necessary to remark the design of the school-based intervention adapted to the PE sessions including cycling skills in two different contexts (free traffic and on road traffic situations), including of experienced instructors to implement the intervention and providing the PE teacher a basic guide to teach how to safety circulate by cycling.

7. Future Research Directions

7. FUTURE RESEARCH DIRECTIONS

In view of the results extracted the future research directions might be:

Study I Psychometric characteristics of a commuting-to-school behaviour questionnaire for families

-Due to the modes of commuting to school and to work were mainly passive, there is a need to promote this behaviour through strategies that include parents and children working together to raise awareness of active commute.

- Since the *"Family Commuting-to-School Behaviour"* questionnaire is a valid and reliable tool for Spanish parents, the next step would be the translation of the questionnaire into other languages and its subsequent validation.

Study II Parental barriers to active transport to school: a systematic review

Knowing the main barriers perceived by parents, the main aim will be the reduction of these barriers to active commuting to school through programmes focused on increasing the safety and improving the social support. These programmes should be based on two strategies:

- Develop public health policies to improve the built environment and the traffic problems in the route to school and,

- Develop educational interventions to improve the negative parent's perceptions of their children's active transport to school.

Study III - Children and parental barriers to active commuting to school: a comparison study

-Since both children and adolescents present barriers associated with ACS, it is necessary to design and develop of school-based interventions to improve the negative perceptions of these populations.

-Also, the school-based intervention will be designed including parents to reduce their perceptions associated to ACS of their children.

Study IV The effect of a school-based intervention on children's cycling knowledge, mode of commuting and perceived barriers

- It is necessary to continue developing and implementing school-based cycling interventions, and they may include families and other agents such as policy makers to create multicomponent interventions.

- A future effective and universal initiative maybe including the promotion of cycling to school as a compulsory content in the curricula of Physical Education within the educational law.

8. Conclusions

8. CONCLUSIONS

The results of the current Doctoral Thesis suggest that:

Study I Psychometric characteristics of a commuting-to-school behaviour questionnaire for families

-Children's mode of commuting to/from school was mainly passive. In the same way, the mode of commuting to work was predominantly passive.

-The validity of the questions on parents and children's mode of commuting to/from school was high, thus using either the parents' or the children's questions will be recommended to assess children's mode of commuting.

-The *"Family Commuting-to-School Behaviour"* questionnaire is a valid and reliable tool to explore the Spanish parents' opinions about their children's mode of commuting to/from school behaviour.

Study II Parental barriers to active transport to school: a systematic review

-The main parental barriers to ACS were distance, traffic safety, crime-related safety, built environment and social support.

-The categorization of barriers provided an useful tool for administration and researches.

Study III Children and parental barriers to active commuting to school: a comparison study

-The children and adolescents perceived higher physical, motivational and social support barriers to ACS than their parents. On the other hand, parents perceived higher barriers of distance, safety traffic, convenience, built environment, crime-related safety and weather than their children/adolescents.

-Distance home-school, convenience, safety traffic, crime-related safety and built environment barriers were associated with lower ACS to children, adolescents and parents. Also, when adolescents perceived crime- related safety and weather the ACS was lower too.

Study IV The effect of a school-based intervention on children's cycling knowledge, mode of commuting and perceived barriers

-The proposed school-based intervention has been showed to be feasible within the PE sessions in the school context, improving the cycling knowledge of the adolescents and, at the same time, reporting that the sessions were enjoyable and useful.

-The school-based intervention did not change the cycling and active commuting to school behaviour and the perceived barriers to ACS. Although the *"Built environment (walk)"* barrier was perceived to a greater extent in the cycling group.

CONCLUSIONES

Los resultados de la actual Tesis Doctoral sugieren que:

Estudio I Características psicométricas de un cuestionario sobre el comportamiento en el desplazamiento al centro educativo para las familias

-El modo de desplazamiento al colegio de los niños fue principalmente pasivo. En la misma línea, el modo de desplazamiento al trabajo de los padres fue predominantemente pasivo.

-La validez de las preguntas sobre el modo de desplazamiento de los padres y de los hijos al/del colegio fue alta, por lo que se recomienda utilizar ambas preguntas (padres o hijos) para evaluar el modo de desplazamiento de los niños.

-El cuestionario *"Comportamiento familiar en los desplazamientos al centro educativo"* es una herramienta válida y fiable para explorar las opiniones de los padres españoles sobre el comportamiento de sus hijos en los desplazamientos al centro escolar.

Estudio II Barreras de los padres para el desplazamiento activo al centro educativo: una revisión sistemática

-Las principales barreras de los padres para el DAC fueron la distancia, la seguridad en el tráfico, la seguridad relacionada con el crimen, el entorno construido y el apoyo social.

-La categorización de barreras proporciona una herramienta útil para las administraciones e investigadores.

Estudio III Barreras de los niños y de los padres para el desplazamiento activo al centro educativo: un estudio de comparación

-Los niños y adolescents percibieron en mayor proporción las barreras físicas, motivacionales y de apoyo social como barreras para el desplazamiento activo al colegio frente a sus padres. Mientras que los padres percibieron como principales barreras la distancia, la seguridad en el tráfico, la conveniencia, el entorno construido, la seguridad relacionada con el crimen y el clima frente a sus hijos.

-Las barreras de distancia entre casa y centro educativo, la conveniencia, la seguridad en el tráfico, la seguridad relacionada con el crimen y el entorno construido se asociaron con un menor DAC para niños, adolescentes y padres. Además, respecto a los adolescentes, si percibían la seguridad relacionada con el crimen y el clima como barreras, el DAC fue más bajo.

Estudio IV Intervención en contexto escolar para promocionar el desplazamiento en bicicleta al centro educativo

-La intervención en contexto escolar diseñada mostró que es viable para las clases de Educación Física, mejorando el conocimiento de circulación vial de los adolescents.

-La intervención no cambió el modo de desplazamiento tanto en Bicicleta como activo de los adolescents ni las barreras percibidas para el DAC. Aunque la barrera *"Entorno construido (andando)"* fue percibida en mayor medida por el grupo de bici.

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10. Curriculum Vitae

10.CURRICULUM VITAE

María Jesús Aranda Balboa
Date of birth: 29/08/1993
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Affiliation: PROFITH CTS-977 Research group "PROmoting FITness and Health through physical activity". Department of Physical Education and Sport, Faculty of Sport Sciences, University of Granada, Spain.

ACADEMIC BACKGROUND

2017/2021 - Ph.D. student at Education Doctoral Program.
University of Granada, Spain.

2016/2017 - Master's Degree in Physical Activity and Sport Research.
Faculty of Sport Sciences, University of Granada, Spain.

2015/2016 - Master's Degree in Education and Teaching in High School and Bachelor (Specialization: Physical Education).
Faculty of Sport Sciences, University of Granada, Spain.

2011/2015 - Bachelor's Degree in Physical Activity Sciences and Sport.
Faculty of Sport Sciences, University of Granada, Spain.

PREVIOUS FUNDING

2020 - Full time (3-moths) contract linked to the PACO project. (Ref: DEP2016-75598-R). University of Granada, Granada, Spain.

2019 - International mobility of students on doctoral programmes University of Granada. Academic Year 2018/2019. Postgraduate school. University of Granada, Spain.

2018/2019 - Full time (1year and 6 moths) research staff contract, within the framework of the Spanish National Youth Guarantee" funded by the Junta de Andalucía and the European Social Fund. University of Granada, Spain.

2018 - Grant of the attendance to national or international congress 2018. University of Granada.

2016/2017 – Full time (9-moths) internship contract linked to Granada City Council. Training, information and road safety centre. University of Granada, Spain.

VISITING RESEARCH

2020 February – University of Valencia. Department of Didactics of Musical and Artistic Expression and Body Language. Supervisor: Professor Javier Molina García.

2019 June-September – Cardiff Metropolitan University. Department of Sport and Health Sciences. Supervisor: Professor Robyn Jones.

PROJECTS PARTICIPATION

2016/2021 “The PACO project "Pedalea y Anda al COlegio": retrospective analysis of commuting to school in Spain and implemention of interventions to promote active commuting among young people”. (Estudio PACO: “Análisis retrospectivo de la movilidad al centro educativo en España e implementación de intervenciones que fomenten la movilidad activa en jóvenes”). Ministry of the Economy, Industry and Competitiveness, national plan I+D+I (Ref. DEP2016-75598-R).

2017/2020 “Support service for the advice and dynamization of the STARS project in the province of Granada”. Provincial council of Granada and University of Granada. Spain.

2016/2017 “Support service for the advice and dynamization of the STARS project in the city of Granada”. Granada City Council. Training, information and road safety centre. Spain.

2015 Project “Active mobility: courses of bike driving”. (Proyecto “Movilidad Activa: Cursos de Conducción en Bicicleta”). Company Auguria, Taller de Urbanismo, S.L;

COURSES AND EXTRACURRICULAR ACTIVITIES

2020 - Qualitative research course with the help of nvivo software (session I) (3h). International graduate school. University of Granada, Spain.

2020 - Introduction to variance analysis (ANOVA): practical application with the spss and r statistical programmes (1h). International graduate school. University of Granada, Spain.

2020 - Introduction to living potentialities to assist qualitative research: content analysis, social networks and bibliographic management (1.5h). International graduate school. University of Granada, Spain.

2019 - Course "qualitative research design using nvivo software (16h). International graduate school. University of Granada, Spain.

2019 - Seminar "basic theoretical and practical aspects of multilevel analysis in SPSS” (6h). International graduate school. University of Granada, Spain.

2018 - Seminar "basic theoretical and practical aspects of multilevel analysis in SPSS” (5h). International graduate school. University of Granada, Spain.

2017 - Course on analysis of data in qualitative research (20h). Escuela Andaluza de Salud Pública, Spain.

2017 - Assessing the built environment in relation to health: maps global tool course(15h). Faculty of Sport Sciences, University of Granada, Spain.
2015 - Training course for trainers on cycling in the city called "bikeability (10h). Faculty of Sport Sciences, University of Granada, Spain.

PUBLICATIONS

1. Gálvez-Fernández P, Saucedo-Araujo RG, Campos-Garzón P, **Aranda-Balboa MJ**, Molina-Soberanes D, Segura-Díaz JM, Herrador-Colmenero M, Huertas-Delgado FJ, Villa-González E, Barranco-Ruiz Y, Chillón P. El desplazamiento activo al centro educativo e indicadores de salud asociados: protocolo de evaluación del estudio PACO “Pedalea y Anda al Colegio” y

su aplicación en educación secundaria. **Retos. Nuevas Tendencias en Educación Física, Deporte y Recreación** 2020, 39: 649-657. Advance Online Publication.

2. **Aranda-Balboa MJ**, Fernández M, Villa-Gonzalez E, Murillo-Pardo B, Segura-Díaz JM, Saucedo-Araujo RG, Barranco-Ruiz Y, Herrador-Colmenero M, Huertas-Delgado FJ, Chillón P. Psychometric characteristics of a commuting-to-school behaviour questionnaire for families. **International Journal of Enviromental Research and Public Health** 2020, 17 (22): 8584. doi: 10.3390/ijerph17228584.

3. Segura-Díaz JM, Barranco-Ruiz Y, Saucedo-Araujo RG, **Aranda-Balboa MJ**, Cadenas-Sánchez C, Migueles JH, Saint-Maurice PF, Ortega FB, Welk G, Herrador-Colmnero M, Chillón P, Villa-González E. Feasibility and reliability of the Spanish version of the Youth Activity Profile questionnaire (YAP-Spain) in children and adolescents. **Journal of Sport Sciences 2020**. https://doi.org/10.1080/02640414.2020.1847488.

4. Rodríguez-Rodríguez F, Huertas-Delgado FJ, Barranco-Ruiz Y, **Aranda-Balboa MJ**, Chillón P. Are the parents´and their children´s physical activity and mode of commuting associated? Analysis by gender and age group. **International Journal of Enviromental Research and Public Health** 2020, 17 (18): 6864. doi: 19.3390/ijerph17186864

5. Segura-Díaz JM, Rojas-Jiménez A, Barranco-Ruiz Y, Murillo-Pardo B, Saucedo-Araujo RG, **Aranda-Balboa MJ**, Herrador-Colmenero M, Villa-González E, Chillón P. Feasibility and reliability of a questionnaire to assess the mode, frequency, distance and time of commuting to and from school; the PACO Study. **International Journal of Enviromental Research and Public Health** 2020, 17(7): 5039. doi: 10.3390/ijerph17145039

6. **Aranda-Balboa MJ**, Huertas-Delgado FJ, Herrador-Colmenero M, Cardon G, Chillón P. Parental barriers to active transport to school: a systematic review. **International Journal of Public Health** 2019.

7. Salto C, **Aranda-Balboa MJ**, Gálvez-Fernández P, Herrador-Colmenero M, Chillón P. Proyecto de innovación educativa para la ESO: "Manual de intervención Bikeability". **Habilidad Motriz** [Internet] 2019; 52: 12–38. Available from: https://docs.wixstatic.com/ugd/28d333_aab6253debf54d1480fa4d69e9f53f08.pdf

8. Huertas-Delgado FJ, Herrador-Colmenero M, Villa-González E, **Aranda-Balboa MJ**, Cáceres MV, Mandic S, Chillón P. Parental perceptions of barriers to active commuting to school in Spanish children and adolescents. **European Journal of Public Health** 2017, 27(3): 416-421.

PUBLICATIONS OF CONGRESS

1. Gálvez-Fernández P, Herrador-Colmenero M, **Aranda-Balboa MJ**, Saucedo RG, Molina-Soberanes D, Campos-Garzón P, Chillón P. ¿Conoces al auténtico PACO? Un proyecto a descubrir. En: Camacho S, Sanabrias D, Sánchez M, Cachón J, Lara AJ (Eds.). Estrategias de intervención en el aula de Educación Física. Material para docentes 2020, pp.67-72. ISBN: 978-84-939866-1-2. Asociación Didáctica Andalucía.

2. Saucedo RG, **Aranda-Balboa MJ**, Gálvez-Fernández P, Molina- Soberanes D, Campos-Garzón P, Lara-Sánchez A, Pérez-López I, Chillón P, Herrador-Colmenero M. La

gamificación para promover el desplazamiento activo: The Mystic School". En: Camacho S, Sanabrias D, Sánchez M, Cachón J, Lara AJ (Eds.). Estrategias de intervención en el aula de Educación Física. Material para docentes 2020, pp. 29-40. ISBN: 978-84-939866-1-2. Asociación Didáctica Andalucía.

3. Campos-Garzón P, Gálvez-Fernández P, Saucedo RG, **Aranda-Balboa MJ**, Villa-González E, Herrador-Colmenero M., Lara- Sánchez A, Chillón P, Barranco-Ruíz Y. ¿Qué gasto energético se deriva de desplazarse de forma activa? En: Camacho S, Sanabrias D, Sánchez M, Cachón J, Lara AJ (Eds.). Estrategias de intervención en el aula de Educación Física. Material para docentes 2020, pp. 11-28. ISBN: 978-84-939866-1-2. Asociación Didáctica Andalucía.

4. Gálvez-Fernández P, **Aranda-Balboa MJ**, Saucedo RG, Chillón P. Estudio PACO "Pedalea y Anda al COlegio": un ensayo controlado aleatorizado por grupos para promover el desplazamiento activo hacia y desde el centro educativo y los niveles de actividad física en adolescentes españoles. En: Zurita Ortega F, Ubago Jiménez JL, González Valero G, Chacón Cuberos R, Ramírez Granizo IA (Eds.) Educación Física: pasado, presente y futuro 2019, pp. 579-596. ISSN: 978-84-09-11660-7. Granada: Asociación de Docentes e Investigadores Jóvenes en Educación y Salud – ADDIJES.

5. Herrador M, Gálvez P, **Aranda-Balboa MJ**, Chillón P. PROYECTO PACO (Pedalea y anda al cole): una alternativa para el fomento del desplazamiento activo al colegio. En: Frutos de Miguel J, Pérez-Brunicardi D (Eds.), Actas del II Congreso Estatal sobre Educación Física en el Medio Natural 2019, pp. 59-61. Valsaín: Red Estatal de Educación Física en la Naturaleza.

6. Herrador-Colmenero M, Montalbán-Navas A, Tatay-Puchades J, Gálvez-Fernández P, **Aranda-Balboa MJ**, Martín-Matillas M, Tercedor P, Chillón P. A clase en bici, experiencia Bikeability. En: Vergara-Román L (Coord.), Actas del XIV Congreso Ibérico La Bicicleta y la Ciudad, 2017, pp. 247-266. Zaragoza, España, 27-30 abril. ISBN: 978-84-697-7154-9. **Asociación Colectivo Pedalea.**

7. Chillón P, Huertas-Delgado FJ, Villa-González E, Barranco-Ruiz Y, Pérez-López I, Martín-Matillas M, Esteban-Cornejo I, Fernández-Luna JM, Santiago-Zaragoza JM, **Aranda-Balboa MJ**, Gálvez-Fernández P, Segura-Díaz JM, Rodríguez-López C, Gisele-Saucedo R, Rosado-López S, Belmonte-Parra I, Camiletti-Moirón D, Molina-García J, Queralt A, Lara-Sánchez AJ, Rodríguez-Rodríguez F, Mandic S, Herrador-Colmenero M. The PACO Study: Design, Planning and Preliminary Results. En: Mandic S, Ergler C, Moore A (Eds.), actas del Symposium Active Living and Environment 2017, pp. 21. Dunedin, New Zealand. ISBN: 978-0-473-40996-8. **University of Otago.**

CONGRESS COMUNICATIONS

1. Rodríguez-Rodríguez F, Solís-Urra P, Mota J, **Aranda-Balboa MJ**, Barranco-Ruiz Y, Chillón P. Predictores parentales del desplazamiento activo al colegio en niños y adolescentes. En: **II Congreso Internacional "Actividad física, educación y salud pública"**. Talca, Chile, 5-6 noviembre 2020. **Premio a la mejor exposición oral de la mesa "epidemiología A".**

2. Campos-Garzón P, Gálvez-Fernández P, Saucedo RG, **Aranda-Balboa MJ**, Villa-González E, Herrador-Colmenero M, Lara-Sánchez A, Chillón P, Barranco-Ruiz Y. The adolescents that active commute to school had higher total physical activity levels and energy expenditure. On: **International Workshop: a focus on statistical methods to analyse accelerometer-measured physical activity**. Granada, Spain, 21 October 2019.

3. Herrador-Colmenero M, **Aranda-Balboa MJ**, Saucedo RG, Salto C, Chillón P. Feasibility of a cycle training course in physical education lessons for Spanish adolescents: the PACO Project. On: ISBNPA 2019 Annual Meeting**,** pp. 463, **Symposium oral presentation**. Prague, Czech Republic, 4-7 June. ISBN: 1479-5868. **International Society for Behavioral nutrition and Physical activity.**

4. Huertas-Delgado FJ, **Aranda-Balboa MJ**, García-Ruiz MM, Chillón P. A school-based intervention to promote active commuting to school focused on families: the PACO Study. On: ISBNPA 2019 Annual Meeting**,** pp. 558. Prague, Czech Republic, 4-7 June. ISBN: 1479-5868. **International Society for Behavioral nutrition and Physical activity.**

5. Chillón P, Gálvez-Fernández P, Huertas-Delgado FJ, Villa-González E, Barranco-Ruiz Y, **Aranda-Balboa MJ**, Gisele-Saucedo R, Segura-Díaz JM, Pérez-López IP, Martín-Matillas M, Santiago-Zaragoza JM, Molina-García J, Queralt, Lara-Sánchez A, Aznar S, Rodríguez-Rodríguez F, Mandic S, Herrador-Colmenero M. A cluster-randomized controlled trial to promote active commuting to and from school and physical activity: The PACO Study. On: ISBNPA 2019 Annual Meeting**,** pp. 842. Prague, Czech Republic, 4-7 June. ISBN: 1479-5868. **International Society for Behavioral nutrition and Physical activity.**

6. **Aranda-Balboa MJ**, Herrador-Colmenero M, Huertas-Delgado FJ, Cardon G, Chillón P. What are the main parental barriers to active commuting to school of their children? **Journal of Physical Activity and Health 2018 October;** 15 (Suppl 1): S174. ISSN: 1543-3080. **7th International Society for Physical Activity and Health Congress, 15-17 October 2018, London, United Kindong.**

7. **Aranda-Balboa MJ**, Fernández M, Esteban-Cornejo I, Villa-González E, Murillo-Pardo B, Segura-Díaz JM, Saucedo RG, Barranco-Ruiz Y, Herrador-Colmenero M, Huertas-Delgado FJ, Chillón P. Reliability of a parents' questionnaire to assess the behaviour of commuting to and from school: The PACO project. **Journal of Physical Activity and Health 2018 October;** 15 (Suppl 1): S217-S218. ISSN: 1543-3080. **7th International Society for Physical Activity and Health Congress, 15-17 October 2018, London, United Kindong.**

8. **Segura-Díaz JM, Barranco-Ruiz Y, Saucedo RG, Aranda-Balboa MJ, Cadenas-Sánchez C, Migueles JH, Herrador-Colmenero M, Chillón P, Villa-González E. Feasibility and reliability of the Spanish version of the Youth Activity Profile questionnaire (YAP-Spain) in children and adolescents. Journal of Physical Activity and Health 2018 October;** 15 (Suppl 1): S135. ISSN: 1543-3080. **7th International Society for Physical Activity and Health Congress, 15-17 October 2018, London, United Kindong.**

9. **Segura-Díaz JM, Rojas-Jiménez A, Esteban-Cornejo I, Villa-González E, Barranco-Ruiz Y, Herrador-Colmenero M, Murillo-Pardo B, Saucedo RG, Aranda-Balboa MJ, Chillón P. Reliability of a questionnaire to assess the mode and frequency of commuting to and from school: the PACO project. Journal of Physical Activity and Health 2018 October;** 15 (Suppl 1): S141. ISSN: 1543-3080. **7th International Society for Physical Activity and Health Congress, 15-17 October 2018, London, United Kindong.**

10. Huertas-Delgado FJ, Herrador-Colmenero M, Villa-González E, **Aranda-Balboa MJ**, Cáceres MV, Mandic S, Chillón P. Are parental barriers related to youths´gender and mode of commuting

to school? **Medicine and Science in Sports and Exercise** 2017 May; 49 (5S): 894. **64th Annual Meeting of the American College of Sports Medicine,** 30 may-3 june 2017, Denver, Colorado, United States.

11. **Aranda-Balboa MJ**, Herrador-Colmenero M, Fernández-Luna JM, Chillón P, Huertas-Delgado FJ. ¿Rutas seguras?: plataforma para diseñar recorridos sguros para el desplazamiento activo al colegio, ¿qué piensan los padres? En: **Symposium Exernet** – Red Española de Investigación en Ejercicio Física y Salud-. Cádiz, España, 14-15 octubre 2016.

12. Gálvez-Fernández P, **Aranda-Balboa MJ**, Chillón P, Herrador-Colmenero M. Efectos de un curso de conducción de bicicleta en ciudad sobre las percepciones del entorno en adultos. En: **Symposium Exernet** – Red Española de Investigación en Ejercicio Física y Salud-. Cádiz, España, 14-15 octubre 2016.

ATTENDANCE TO CONFERENCES/SEMINARS

1. Attendance to **"the PACO study"** seminar. 16th September 2019, organized by the Physical Health Education for Lifelong Learning (PHELL) research group. Cardiff Metropolitan University, School of Sport and Health Sciences, Cyncoed Campus, United Kindong.

2. Attendance to **"IV Meeting PACO**". 17-18 June 2019, organized by Faculty of Sport Sciences. University of Granada, Spain.

3. Attendance to **7th ISPAH Congress** 2018, London, United Kindong, 15-17 October. International Society for Physical activity and Health.

4. Attendance to "**Taller de Investigación** Evaluación del ambiente construido en relación a la salud: MAPS Global tool". 10-11 July 2017, organized by Faculty of Sport Sciences. University of Granada, Spain.

5. Attendance to **IV Seminario "desplazamiento activo y entorno**". 6 July 2017, organized by Faculty of Sport Sciences and PROFITH. University of Granada, Spain.

6. Attendance to **"III Seminario Internacional de desplazamiento activo: experiencias a 10.515 km".** 30 March 2017, organized by Department of Sport and Physical Education. University of Granada, Spain.

7. Attendance to **Symposium Exernet** – Red Española de Investigación en Ejercicio Física y Salud-. 7-8 November 2016, organized by University of Granada, Spain.

8. Attendance to **II International Workshop Desplazamiento Activo: investigaciones y experiencias de transferencia**. 18 December 2015, organized by Faculty of Sport Sciences and PROFITH. University of Granada, Spain.

9. Attendance to **"Workshop Desplazamiento activo:** investigaciones y experiencias de transferencia". 1 July 2015, organized by Department of Sport and Physical Education. University of Granada, Spain.

TEACHING EXPERIENCE

2020 – Instructor in the course "Conducción y manejo de la bicicleta para la ciudad". Instituto Andaluz del Deporte, Málaga, Spain. (10h).

2019/2020 – Mentoring of a Final Degree project, "Propuesta de U.D.: ¡Desplázate por el mundo! University of Granada, Spain.

2019/ 2020 – Mentoring of external internships on "PACO project". University of Granada, Spain.

2018/2019 – Mentoring of a Final Degree project, "Propuesta de entrenamiento para cicloturismo dentro del proyecto "BiciConecta la UGR". University of Granada, Spain.

2018/2019 – Mentoring of external internships on "PACO project". University of Granada, Spain.

2018 – Instructor in the course "Bikeability: conduce seguro", at "IES María Zambrano" in Alcázar de San Juan, Ciudad Real, Spain. (3.5h).

2015 - Instructor in training courses for learning to ride a bicycle. Granada City Council. Granada, Spain. (April to May).

OTHER MERITS

2020 – First Certificate in English, University of Cambridge (B2).

2019-2020 - Journal reviewer of:

- Health & Place (Q1)
- International Journal of Environmental Research and Public (Q1)
- Preventive Medicine (Q1)
- Journal of Transport & Health (Q2)
- Journal of Sport and Health Research

2017 – Director of Cycling Sport Level II. Royal Spanish Cycling Federation. Spain.

2014 – Director of Cycling Sport Level I. Royal Spanish Cycling Federation. Spain.

11. Appendices

11. APPENDICES

Appendix 1

ugr Universidad de Granada — Vicerrectorado de Investigación y Transferencia

COMITE DE ETICA EN INVESTIGACION
DE LA UNIVERSIDAD DE GRANADA

La Comisión de Ética en Investigación de la Universidad de Granada, analizado el informe preliminar del Presidente del Comité en Investigación Humana, emite informe favorable a la metodología en la investigación titulada 'PACO (PEDALEA Y ANDA AL COLEGIO). ANáLISIS, DISEñO E INTERVENCIóN SOBRE EL DESPLAZAMIENTO ACTIVO EN ESCOLARES ESPAñOLES.' que dirige D./Dña. PALMA CHILLÓN GARZÓN, con NIF 74.637.361-S, quedando registrada con el nº: 162/CEIH/2016.

Granada, a 22 de Noviembre de 2016.

UNIVERSIDAD DE GRANADA

EL PRESIDENTE
Fdo: Enrique Herrera Viedma

EL SECRETARIO
Fdo: Fernando Cornet Sánchez del Águila

Gran Vía de Colón 48, 2 Planta. 18071 GRANADA
http://investigacion.ugr.es

Appendix 2

Table 15*. Descriptive data of the studies, parental barriers to commuting to school and other results related to parenta*

Author Locality, (country)	Sample and age. Study date Design Measures	Barriers of parents to active commuting to school		Prevalenc commutin
		Associated	Not associated	
Timperio et al., (2006) Melbourne, (Australia).	235 parents of children (from 5 to 6y). 677 parents of children (from 10 to 12y). From July to December 2001. Cross-sectional study. Barrier outcome measure: questionnaires.	- Social support (absence of children). - Built environment (walkability: No lights or crossings).	- Traffic safety (High amount of traffic; danger behaviour). - Crime-related safety (violence from strangers). - Built environment (walkability: Cross road). - Physical and motivation barrier. - Limited public transport. - Children preferences.	47.8% walked from school (a 60.4% walked school (aged 1 6.6% cycled to from school (a 6.3% cycled to school (aged 1
Greves et al., (2007) Seattle, Washington (USA).	53 parents and grandparents of children from low income neighbourhoods. Summer 2006. Cross-sectional study. Barrier outcome measure: focus group.	- Crime-related safety (violence from strangers; bullying; unsupervised children). - Social support. - Distance. - Time constraints. - Schedule. - Physical and motivation barriers. - Traffic safety (High speed traffic; danger behaviour).		13% walked to

Author Locality, (country)	Sample and age. Study date Design Measures	Barriers of parents to active commuting to school		Prevalenc commutin
		Associated	Not associated	
		- Built environment (Walkability: Crossings unsafe, lack of crossing guards, safe walking routes). - Natural environment (hills). - Weather.		
Salmon et al., (2007) (Australia).	720 parents of children (from 4 to 13y). April of 2004. Cross-sectional study. Barrier outcome measure: anonymous telephone survey (CLASS questionnaire).	Decreased likelihood of active commuting. - Time constraints. - Children's preferences. - Social support (absence of children and adults). - Traffic safety (danger behaviour). - Built environment (walkability: no direct route, footpaths). - Distance. - Physical and motivation barriers.	- Physical and motivation barriers. - Crime-related safety (bullying; neighbourhood). - Social support (absence of Adults-neighbourhood). - School policy. - Children preferences. - Children´s competences. - Built environment (walkability: crossing). - Traffic safety (speed of traffic; high amount of traffic; lack of parking).	41% actively c school at least week.
Ahlport et al., (2008) North Carolina, (USA).	37 parents of children (aged 9-11 y). From May and June 2003. Cross-sectional study.	- Crime-related safety (abducted; bullying). - Children's competences. - Convenience. - Schedule. - Physical and motivation barriers.		

Author Locality, (country)	Sample and age. Study date Design Measures	Barriers of parents to active commuting to school		Prevalenc commutin
		Associated	Not associated	
	Barrier outcome measure: focus group.	- Built environment (walkability: sidewalks, crossing guards). - Natural environment. - Weather. - Distance. - Traffic safety (high amount of traffic; danger behaviour). - School policy.		
Eyler et al., (2008) Missouri, Massachusetts, South Carolina, North Carolina, Columbia (USA).	69 parents of children of elementary schools. October 2005 to March 2006. Case study. Barrier outcome measure: phone interview and in-person interview.	- Crime-related safety (abductions). - Traffic safety (high amount of traffic; danger behaviour). - Built environment (walkability: sidewalks, crosswalks and crossing guards).		
Heelan et al., (2008) Nebraska, (USA).	150 families (school aged children). Cross-sectional study. Barrier outcome measure: questionnaire.	- Traffic safety (high amount of traffic). - Time constraints. - Built environment (walkability: crosswalks).	- Weather. - Distance. - Built environment (walkability: sidewalks); (bikeability: bike access). - Crime-related safety.	

Author Locality, (country)	Sample and age. Study date Design Measures	Barriers of parents to active commuting to school		Prevalenc commutin
		Associated	Not associated	
Yeung et al., (2008) Queensland, (Australia).	318 parents of children (aged from 4 to 12y). Cross-sectional. Barrier outcome measure: questionnaire.	- Distance.		33% commute school.
Zhu et al., (2008) Austin, Texas, (USA).	1281 parents of elementary school children. April of 2007. Cross – sectional study. Barrier outcome measure: survey.	- Physical and Motivation. - Traffic safety (high amount of traffic; danger behaviour). - Social support (absence of adults and children). - Distance. - Built environment (walkability: highway/freeway); (land use – mix: stores and office buildings). - Convenience. - Time constraints. - Crime-related safety. - School policy.	- Physical and Motivation. - Built environment (aesthetic).	28% walked to 34% walked fr
Zhu et al., (2009) Austin, Texas, (USA).	2695 parents or guardians of children (full school age range). November 2007. Cross-sectional study.	- Distance. - Built environment (walkability: highways/freeways); (land use mix: stores and office buildings). - Time constraints. - Convenience.	- Built environment (walkability; aesthetics).	27.8% of child actively to sch 31.5% of child actively from s

Author Locality, (country)	Sample and age. Study date Design Measures	Barriers of parents to active commuting to school		Prevalenc commutin
		Associated	Not associated	
	Barrier outcome measure: questionnaire.	- School policy (bus service). - Physical and motivation barriers. - Social support. - Traffic safety (danger behaviour). - Crime-related safety. - Children's preferences.		
Napier et al., (2011) (USA).	177 parents of children (aged 10 – 11y). Spring 2007. Cross-sectional study. Barrier outcome measure: survey.	- Crime-related safety. - Distance. - Built environment (walkability). - Traffic safety.		88% walked to sometimes in v community. 60% walked to sometimes in n walkable comn 17% walked to sometimes in l community.
Shokoohi et al., (2012a) Tehran, (Iran).	561 parents of children (from grades 3 to 5). From January to February of 2009. Cross-sectional study. Barrier outcome measure: survey.	- Crime-related safety. - Social support (absence of children and adults).		48% of childre school. 56.3% of child from school.
Shokoohi et al., (2012b) Tehran, (Iran).	561 parents of children (from grades 3 to 5).	- Traffic safety (high speed of traffic; high amount of traffic).		42% walked to

Author Locality, (country)	Sample and age. Study date Design Measures	Barriers of parents to active commuting to school		Prevalenc commutin
		Associated	Not associated	
	From January to February of 2009. Cross-sectional study. Barrier outcome measure: survey.	- Built environment (walkability: cross road with more than four lanes; narrow streets; crosswalks; traffic signs).		58 % used pas commuting.
Lee et al., (2013) Austin, Texas, (USA).	601 walker–driver child pairs (aged 4 – 14y). 2007 and 2010. Cross-sectional Barrier outcome measure: survey.	- Traffic safety (high amount of traffic). - Crime-related safety (abduction). - Distance. - Convenience. - Built environment (walkability: sidewalks; overall walking environments).	- Crime-related safety (bullying; attacked by dogs). - Traffic safety (danger behaviour).	50% walked to 50% was drive
Chillón et al., (2014) Florida, North Carolina, Texas, Colorado, California, Alaska, Minnesota, Pennsylvania and New Jersey, (USA).	1007 parents of children (from grade 4th to 5th). Fall 2003. Cross-sectional study. Barrier outcome measure: survey.	- Children's preferences. - Crime-related safety (attacked by dogs). - Weather. - Traffic safety (high amount of traffic). - Built environment (walkability). - Social support.	- Physical and motivation barriers.	35.5% of child active commut
De Meester et al., (2014) Flanders, (Belgium).	701 parents of children (aged 10 – 12y).	- Built environment (land use mix diversity; land use mix access; residential	- Traffic safety (high speed of traffic). - Safety or crime (strangers).	10.2% reporte transport to an

Author Locality, (country)	Sample and age. Study date Design Measures	Barriers of parents to active commuting to school		Prevalenc commutin
		Associated	Not associated	
	September 2010 and June 2011. Cross-sectional study. Barrier outcome measure: questionnaire.	density; walkability; bikeability). - Distance.	- Convenience.	
Lu et al., (2014) Texas, (USA).	857 parents of children (aged 4 – 14y) 2009. Cross-sectional. Barrier outcome measure: survey.	- Children's preferences (cues to action). - Built environment (walkability: sidewalks; footpaths; crossings); (bikeability: facilities) (aesthetics). - Crime-related safety (bullying). - Traffic safety (high amount of traffic; high speed of traffic). - Distance. - Weather. - Social support (absence of children and adults). - Convenience. - Time constraints. - Children's competences.		18.1% walked school. 78.8% used pa school.
Oluyomi et al., (2014) Texas, (USA).	830 parents of children (aged 9 – 10y). 2009.	- Built environment (walkability: sidewalks, crossings; safety intersections; crossing guards).		18.7% walked 1.8% biked to

Author Locality, (country)	Sample and age. Study date Design Measures	Barriers of parents to active commuting to school		Prevalenc commutin
		Associated	Not associated	
	Cross-sectional study. Barrier outcome measure: survey (T-COPPE survey).	- Natural environments (trees). - Traffic safety (high speed of traffic; high amount of traffic). - Social support. - Crime-related safety (violence; attacked by animals).		
Guliani et al., (2015) Toronto, (Canada).	720 parents/adult caregivers of children (aged 10 -11y). From April 2010 to June 2010. Barrier outcome measure: survey. Other outcome measures: Geographic Information System (GIS)	- Distance. - Built environment (walkability: intersection density; crossings) (aesthetics). - Traffic safety (high amount of traffic).	- Traffic safety (high speed of traffic). - Built environment (walkability: sidewalks).	73% of childre school.
Gustat et al., (2015) Lousiana, (USA).	844 parent of children (aged 4 – 14y). From April to May 2009.	- Distance. - Time. - Children's preferences (permission).		2.4%-17.4% w school. 0.3%-4.5% bik

Author Locality, (country)	Sample and age. Study date Design Measures	Barriers of parents to active commuting to school		Prevalenc commutin
		Associated	Not associated	
	Cross-sectional study. Barrier outcome measure: survey.	- School policy. - Social support (absence of adults and children). - Traffic safety (high speed of traffic).		
Van Kann et al., (2016) Southern Limburg, (Netherlands).	722 parents of children (aged 8 to 12y). Fall of 2012. Cross-sectional study. Barrier outcome measure: questionnaire.	- Built environment (walkability: light).	- Built environment (aesthetics). - Crime-related safety (strangers). - Traffic safety (high amount of traffic).	
Yu et al., (2016) Austin, Texas, (USA).	2597 parents of children (aged 4 – 14y). 2007. Cross-sectional study. Barrier outcome measure: survey.	- Social support (absence of children and adults). - Children's competences. - Children's preferences. - Crime-related safety (strangers; bullying; attacked by dogs). - Distance. - Built environment (walkability: intersection; sidewalks; overall walkability). - Traffic safety (high amount of traffic; danger behaviour). - Time constraints.	- Convenience. - Physical and motivation barriers (heavy bag). - Weather. - Time constraints.	32% students v from school a day.

Author Locality, (country)	Sample and age. Study date Design Measures	Barriers of parents to active commuting to school		Prevalenc commutin
		Associated	Not associated	
Carlson et al., (2014) Baltimore, Maryland-Washington, DC and Seattle-King County, Washington metropolitan areas, (USA).	294 parents of adolescents (aged 12 to 16y). 2009 – 2011. Cross-sectional study. Barrier outcome measure: Subset of the Neighbourhood Environment Walkability Scale for Youth (NEWS-Y).	- Built environment (Street connectivity). - Traffic safety (high amount of traffic). - Distance. - Physical and motivation barriers.	- Built environment (land use mix); (walkability: facilities); (aesthetics) (residential density). - Traffic safety. - Crime-related safety.	36% no active 25% reported week to/from s 39% reported 5 week to/from s
De Weese et al., (2013) New Jersey, (USA).	901 parents of children and adolescent (aged 3 – 18y). 2009-2010. Cross-sectional study. Barrier outcome measure: telephone interview.	- Built environment (walkability: sidewalk); (bikeability).	- Traffic safety. - Crime-related safety.	54% reported a commuting to than 1 day per
Kerr et al., (2006) Seattle, (USA).	259 parents from 20 to 65 years old of children and adolescent (aged 5-18y). Cross-sectional study. Barrier outcome measure: survey (NEWS) and GIS.	- Crime-related safety (strangers; bullying). - Traffic safety (High amount of traffic; high speed of traffic). - Built environment (Walkability, Bikeability, Land use-mix (stores) and Aesthetics). - Schedule.	- Built environment (Residential density, Land use mix – diversity and access, street connectivity).	18.1% of the c walked or bike school 5 days 25.1% of the c walked or bike a week.

Author Locality, (country)	Sample and age. Study date Design Measures	Barriers of parents to active commuting to school		Prevalenc commutin
		Associated	Not associated	
		- Convenience.		
Forman et al., (2008) San Diego, Boston, Cincinnati, (USA).	287 parents of children (aged 5-18y). 2005. Test-retest study. Barrier outcome measure: survey.	- Built environment (walkability: sidewalks, crossings); (bikeability: facilities). - Natural environment (hills). - Weather (bad lighting). - Distance. - Physical and motivation barriers (boring). - Traffic safety (high amount of traffic). - Crime-related safety (bullying; attacked by dogs).	- Convenience.	
Hume et al., (2009) Melbourne, (Australia).	121 parents of children (aged 8-9y) and 188 parents of adolescents (aged 13-15y). 2004 and 2006. Longitudinal. Barrier outcome measure: survey.	- Social support (absence of children). - Traffic safety (danger behaviour). - Crime-related safety (stranger danger). - Built environment (walkability: lights or crossings and pedestrian crossings); (aesthetics).	- Weather. - Physical and motivation barriers (lack of energy and boring). - Social support (absence of adults). - Traffic safety (parking; danger behaviour). - Natural environment (hills). - Built environment (walkability: cul-de-sacs).	In 2004: childr 2.9 walking an trips/week and reported 2.9 w cycling trips/w In 2006: childr 3.6 walking an trips/week and reported 3.5 w cycling trips/w

Author Locality, (country)	Sample and age. Study date Design Measures	Barriers of parents to active commuting to school		Prevalenc commutin
		Associated	Not associated	
Rosenberg et al., (2009) Boston, Cincinnati and San Diego, (USA).	116 parents of children (aged 5-11y) 171parents of adolescents (aged 12-18y) Date: 2005. Cross – sectional study. Barrier outcome measure: survey (NEWS-Y).	*Children:* - Built environment (land use – mix diversity); (residential density). *Adolescents:* - Built environment (walkability and overall environment); (Bikeability); (others: recreation facilities).	*Children:* - Built environment (aesthetics); (street connectivity). - Crime-related safety (strangers). - Traffic safety (high amount of traffic; speed of traffic). *Adolescents:* - Built environment (aesthetics, street connectivity, residential density, land use mix-diversity). - Crime-related safety (strangers). - Traffic safety (high amount of traffic; speed of traffic).	24.1% of the c walked to scho 18.7% of the a walked to scho

Appendix 3

Table 16*. Quality assessment of studies includes in the systematic review (study II).*

Author and locality (country)	Quality assessment				
	Selection bias	**Study design**	**Control for confounders**	**Blinding**	**Data collect**
Timperio et al., (2006) Melbourne, (Australia).	*	*	*	**	*
Greves et al., (2007) Seattle, Washington (USA).	*	*	NA	**	*
Salmon et al., (2007) (Australia).	*	*	*	**	*
Ahlport et al., (2008) North Carolina, (USA).	*	*	NA	**	*
Eyler et al., (2008) Missouri, Massachusetts, South Carolina, North Carolina, Columbia (USA).	*	**	*	**	*
Heelan et al., (2008) Nebraska, (USA).	*	*	*	**	*
Yeung et al., (2008) Queensland, (Australia).	*	*	*	**	*
Zhu et al., (2008) Austin, Texas, (USA).	*	*	*	**	**

Author and locality (country)	Quality assessment				
	Selection bias	**Study design**	**Control for confounders**	**Blinding**	**Data collect**
Zhu et al., (2009) Austin, Texas, (USA).	*	*	*	**	**
Napier et al., (2011) (USA).	*	*	*	**	**
Shokoohi et al., (2012a) Tehran, (Iran).	*	*	*	**	*
Shokoohi et al., (2012b) Tehran, (Iran).	***	*	*	**	*
Lee et al., (2013) Austin, Texas, (USA).	*	*	***	**	*
Chillón et al., (2014) Florida, North Carolina, Texas, Colorado, California, Alaska, Minnesota, Pennsylvania and New Jersey, (USA).	*	*	*	**	*
De Meester et al., (2014) East and West Flanders, (Belgium).	**	*	*	**	***
Lu et al., (2014) Texas, (USA).	*	*	*	**	*
Oluyomi et al., (2014) Texas, (USA).	*	*	*	**	***

Author and locality (country)	Quality assessment				
	Selection bias	**Study design**	**Control for confounders**	**Blinding**	**Data collect**
Guliani et al., (2015) Toronto, (Canada).	*	*	*	**	***
Gustat et al., (2015) Lousiana, (USA).	*	*	*	**	***
Van Kann et al., (2016) Southern Limburg, (Netherlands).	*	*	**	**	***
Yu et al., (2016) Austin, Texas, (USA).	*	*	*	*	*
Carlson et al., (2014) Baltimore, Maryland-Washington, DC and Seattle-King County, Washington metropolitan areas, (USA).	*	*	*	**	***
De Weese et al., (2013) New Jersey, (USA).	**	*	*	**	***
Kerr et al., (2006) Seattle, (USA).	*	*	*	**	**
Forman et al., (2008) San Diego, Boston, Cincinnati, (USA).	*	*	*	**	***
Hume et al., (2009) Melbourne, (Australia).	*	*	*	**	***

Author and locality (country)	Quality assessment				
	Selection bias	**Study design**	**Control for confounders**	**Blinding**	**Data collect**
Rosenberg et al., (2009) Boston, Cincinnati and San Diego, (USA).	**	*	*	**	***

NA=not applicable;

Quality assessment tool for quantitative studies (Mc Master University): Effective public health practice project (EPHP

confounders" was not applicable (NA) when the study had no a control group. The assessment of "with drawl and drop

the study had only 1 measure (pre or post). When the assessment of a component was not indicated in the tool, the lowe

set*=weak; **=moderate; ***=strong.