Prevalence and correlates of transport cycling in Chile: Results from 2014 to 2015 national surveys
Prevalencia y factores asociados al transporte en bicicleta en Chile: Resultados de encuestas nacionales de 2014 y 2015

Prevalência e fatores associados ao uso da bicicleta como transporte no Chile: resultados de pesquisas nacionais de 2014 e 2015

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ABSTRACT

Introduction: Active travel surveillance in Latin American is scarce and concentrated in a few countries. Surveillance of transport cycling in Chile is critical to document, to serve as a baseline from which to measure future planned strategies to increase transport cycling. This study aimed to document the prevalence of transport cycling in urban-dwelling Chilean adults and to examine factors associated with transport cycling in this population.

Methods: Data were collected from two cross-sectional National Environmental Surveys. Surveys were administered through a computer-assisted telephone interview system to representative samples of adult residents of the 15 regional capital cities in 2014 (n = 5057) and 2015 (n = 5664). Multivariable, multi-level logistic regression modelling was used to assess correlates of bicycling as the primary transport mode (yes, no) in the total sample and separately by sex.

Results: Transport cycling was reported by 7% of participants in 2014 and 2015. The highest prevalence estimates were found in males (9–10%), participants aged 18–24 years (12%), participants of low socioeconomic status (7%), and participants living in cities with warm summers and mild winters (8–9%). Low socioeconomic status was associated with greater likelihood of cycling in men (OR: 1.75 (95%CI 1.35–2.28), p < 0.001) but with reduced likelihood of cycling in women (OR: 0.68 (95% CI 0.52–0.91), p = 0.009). Associations between environmental factors and transport cycling were stronger in women than in men.

Conclusions: Transport cycling prevalence in Chile is low compared to other Latin American countries. Associations between environmental factors and transport cycling differed by gender. City planners should consider how environmental factors influence gender inequalities in transport cycling in their cities.

R E S U M E N

Introducción: La vigilancia del transporte activo en Latinoamérica es escasa y concentrada en pocos países. Es crítico documentar la vigilancia del transporte en bicicleta en Chile para presentar una base desde la cual se puedan medir las estrategias planificadas para incrementar esta modalidad de transporte. Este estudio está dirigido a documentar la prevalencia del transporte en bicicleta en chilenos adultos que residen en zonas urbanas y examinar los factores asociados con el transporte en bicicleta en esta población.
Métodos: Los datos fueron recolectados de dos encuestas nacionales de medioambiente de corte transversal. Las encuestas se administraron a través de un sistema de entrevistas telefónicas asistidas por computadora a muestras representativas de residentes adultos de las 15 ciudades capitales regionales en 2014 (n = 5057) y 2015 (n = 5664). Se utilizaron modelos multivariados de regresión logística multinivel para evaluar los factores asociados al uso de bicicleta como modo de transporte primario (sí, no) en la muestra total y separado por sexo.
Resultados: El 7% de los participantes reportó usar la bicicleta como transporte primario en 2014 y 2015. Las estimaciones de prevalencia más altas se encontraron en hombres (9–10%), participantes de 18 a 24 años (12%), participantes de bajo nivel socioeconómico (7%), y participantes que viven en ciudades con veranos cálidos e inviernos moderados (8–9%). El bajo nivel socioeconómico se asoció con una mayor probabilidad de usar la bicicleta en los hombres (OR: 1.75 (IC del 95%: 1.35–2.28), p < 0.001), pero con una probabilidad menor de uso de bicicleta en las mujeres (OR: 0.68 (IC del 95%: 0.52–0.91), p = 0.009). Las asociaciones entre los factores ambientales y el uso de bicicleta como transporte fueron más fuertes en las mujeres que en los hombres.
Conclusiones: La prevalencia de uso de bicicleta como medio de transporte primario es baja en comparación con otros países de América Latina. Las asociaciones entre los factores ambientales y el transporte en bicicleta difieren según sexo. Los planificadores urbanos deben considerar cómo los factores ambientales influyen en las desigualdades de sexo en el transporte en bicicleta en sus ciudades.

R E S U M O

Introdução: A vigilância do transporte ativo na América Latina é escassa e concentrada em alguns países. Desta forma, é fundamental registrar os achados relacionados ao uso de bicicletas como transporte ativo no Chile para apresentar uma base, a partir da qual, seja possível medir as estratégias planejadas para aumentar o uso deste meio de transporte. Este estudo tem como objetivo documentar a prevalência do uso de bicicletas para transporte em adultos chilenos residentes em áreas urbanas e examinar os fatores associados ao uso de bicicletas para transporte nesta população.
Métodos: Os dados são provenientes de duas pesquisas nacionais, ambientais e transversais. Os inquéritos foram administrados através de um sistema de entrevistas telefônicas assistidas por computador, em amostras representativas de residentes adultos das 15 capitais regionais em 2014 (n = 5057) e 2015 (n = 5664). Foram utilizados modelos multivariados de regressão logística multinível, para avaliar os fatores associados do uso de bicicleta como transporte primário (sim, não) na amostra total e separadamente por sexo.
Resultados: Dos participantes que relataram o uso de bicicletas como transporte primário em 2014 e 2015 totalizaram 7%. As estimativas da prevalência mais elevados foram encontrados em homens (9–10%), participantes com idades de 18 a 24 anos (12%), participantes de baixo nível socioeconômico (7%), e participantes que vivem em cidades com verões quentes e invernos moderados (8–9%). Baixo nível socioeconômico foi associado com uma maior probabilidade de ciclismo por homens (OR: 1.75 (IC 95%: 1.35–2.28), p < 0.001), mas com uma menor probabilidade de utilização da bicicleta por mulheres (OR: 0.68 (IC 95%: 0.52–0.91), p = 0.009). As associações entre fatores ambientais e o uso de bicicletas como transporte foram mais fortes em mulheres do que nos homens.
Conclusões: A prevalência do uso de bicicletas como principal meio de transporte é baixa em comparação com outros países da América Latina. As associações entre fatores ambientais e transporte de bicicleta diferem por sexo. Os planejadores urbanos devem considerar como os fatores ambientais influenciam as desigualdades de gênero no uso de bicicletas para transporte em suas cidades.

1. Introduction

The association between low levels of physical activity (PA) and both chronic diseases and premature mortality are well documented in the literature (Lee et al., 2012). Physical inactivity has been described as a worldwide pandemic (Kohl et al., 2012), which suggests that strategies to increase PA levels are urgently needed in most countries. One effective strategy for increasing PA is the

support and promotion of active transport (walking and cycling to get to and from places). Studies have shown that individuals who use active modes of transport are more likely to meet PA recommendations than those who do not (Berrigan et al., 2006; Hollingworth et al., 2015; Stewart et al., 2016; Titze et al., 2014).

Previous studies have also shown direct health benefits of active transport, with more significant benefits from cycling than from walking (Fishman et al., 2015b; Hollingworth et al., 2015; Pucher et al., 2010). A recent UK study showed that commuter walking and cycling are associated with reduced risk of cardiovascular disease incidence and mortality and that commuter cycling is additionally associated with reduced risk of all-cause mortality and cancer incidence and mortality (Celis-Morales et al., 2017). The greatest benefits of active transport were seen among commuter cyclists who cycled the farthest distances. Those findings support those from an earlier study from the UK that indicated that individuals who cycle for more than the 150 min/week, as recommended in current PA guidelines (World Health Organization, 2010), have reduced risks of hypertension, obesity and hypercholesterolemia (Hollingworth et al., 2015). Studies from less developed countries also indicate associations. For example, studies in Chile suggest that individuals who report using active modes of travel have lower risks of obesity, type 2 diabetes mellitus, hypertension and metabolic syndrome (Sadarangani et al., 2018). Increasing the prevalence of transport cycling also increases the number of avoided or postponed deaths per year (Fishman et al., 2015b; Rojas-Rueda et al., 2016) and reduces carbon dioxide emissions (Rojas-Rueda et al., 2016). Health benefits can also be translated into economic outcomes: in the Netherlands health gains obtained from cycling correspond to more than 3% of its gross domestic product (Fishman et al., 2015b).

The societal and environmental benefits of active transport encouraged the United Nations (2015) to set a target of providing "safe, affordable, accessible and sustainable transport systems for all" by 2030 as one of its Sustainable Development Goals. The meeting of that goal requires that "special attention [be paid] to the needs of those in vulnerable situations," including women and older adults. The Global Action Plan on Physical Activity (GAPPA) 2018–2030 has also highlighted the promotion of active travel through the creation of active environments by strengthening the integration of urban and transport planning policies (Aguilar-Farias et al., 2018; Foster et al., 2018; World Health Organization, 2018).

To monitor a country's progress in working towards this goal requires national surveillance of active transport behaviour. However, monitoring of this behaviour is mostly being done in high-income countries, including the US, Australia, the UK, and northern Europe (Bassett et al., 2008). A wide range in prevalence estimates for transport cycling is suggested by evidence from these countries. For example, only 1% of the US population report a transport cycling trip (Nehme et al., 2016), while in the Netherlands 27% of all trips are made by cycling (Fishman et al., 2015a). Active travel surveillance in the Latin American and Caribbean (LAC) region is concentrated in a few countries. A systematic review of 45 prevalence studies conducted in five LAC countries found most studies in the literature were from Brazil with 62% (Sa et al., 2016b). Overall, the median prevalence of transport cycling in LAC was 3.2%, ranging from 1.3% in Paraná, Argentina to 16.0% in Recife, Brazil. Only one study in the review was Chilean.

Surveillance of transport cycling in Chile is critical to document, to serve as a baseline from which to measure future planned strategies to increase transport cycling in that country. Currently, about 70% of people living in Chile are exposed to concentrations of particulate material $PM_{2.5}$ that exceed the average annual national norms (Ministerio del Medio Ambiente de Chile, 2014). For both the general population and government authorities, knowledge of this health risk has contributed to raising awareness about the environmental benefits that an increase in bicycle mode share could bring to cities (Sagaris, 2010, 2015). Also, for more than two decades diverse, robust and organised pro-urban cycling advocacy groups have maintained their demands and permeated the planning system (Sagaris, 2015). As a consequence, local authorities have begun to design and implement mobility plans that support transport cycling (Ministerio de Transportes y Telecomunicaciones de Chile, 2018; Ministerio de Vivienda y Urbanismo de Chile, 2014, 2015a, b, c; Ministerio Secretaria General de Gobierno de Chile, 2014). In Chile, when the presidential period 2014–2018 started, political priority was given to a plan for building 190 km of high-quality cycle-paths and tripling the number of bicycle parking spots in 32 cities across the country (Ministerio Secretaria General de Gobierno de Chile, 2014). For this purpose, the General Ordinance of Urbanism and Construction was modified in 2014 (Ministerio de Vivienda y Urbanismo de Chile, 2014), and three new manuals for designing infrastructure according to a new standard were issued in 2015 (Ministerio de Vivienda y Urbanismo de Chile, 2015a, b, c). With these transport changes planned, surveillance of transport cycling became critical.

To further meet the United Nation's active travel goal, it is also essential to document differences in transport cycling behaviour across socio-demographic groups. Studies have shown that the prevalence of transport cycling differs across demographic characteristics of individuals, including age (Nehme et al., 2016; Reis et al., 2013; UK Department for Transport, 2017b), gender (Nehme et al., 2016; Reis et al., 2013; UK Department for Transport, 2017b), and educational level (Nehme et al., 2016; Reis et al., 2013; Veisten et al., 2011). Environmental factors have also been found to influence transport cycling. These include geographic location (Fishman et al., 2015a), population density (Nehme et al., 2016), and distance from home to urban amenities (Heesch et al., 2015). However, associations between these individual and environmental factors with transport cycling have not been explored in scientific studies conducted in Chile. Therefore, the primary aims of this study were to document the prevalence of transport cycling in a representative sample of urban-dwelling Chilean adults and to examine the associations between individual and environmental factors and transport cycling. With gender differences in cycling well established (Nehme et al., 2016; Reis et al., 2013; UK Department for Transport, 2013), a secondary aim was to examine these associations separately for men and women.

2. Methods

Data for this study were collected for two cross-sectional National Environmental Surveys (NES), which were conducted in Chile from October to December 2014 (Ministerio del Medio Ambiente de Chile, 2015) and from November to December 2015 (Ministerio del Medio Ambiente de Chile, 2016). The NES was administered through a computer-assisted telephone interview system. It collected

data on opinions, perceptions and behaviours related to environmental issues, including transport behaviours.

Stratified random sampling was used to ensure the representativeness of the sample regarding gender, age and socio-economic status (SES) (Ministerio del Medio Ambiente de Chile, 2015, 2016). The sampling frame was all landline and mobile phones numbers located in each of the 15 regional capital cities. Only residents aged 18 years and older were eligible. The NES 2014 and 2015 had an absolute error of ± 1.4% and ± 1.3%, respectively.

The University Human Research Ethics Committee assessed this research as meeting the conditions for exemption from HREC review and approval in accordance with section 5.1.22 of the National Statement on Ethical Conduct in Human Research (The National Health and Medical Research Council, 2007).

2.1. Study variables

To access transport cycling behaviour, interviewers asked participants, "What is your main transport mode?". Participants who responded "bicycle" were considered transport cyclists (coded 1 for analysis), and participants who reported another mode were considered not to be transport cyclists (coded 0 for analysis). The NES also captured participants' genders, ages and SES. SES was a composite variable derived from a matrix that accounted for the highest educational level of the head of household, the occupation of the head of household, and household per capita income (Asociacion Chilena de Empresas de Investigacion de Mercado, 2008). Based on this classification matrix some common characteristics among participants with low SES are complete primary or secondary education only, having a job that does not require formal training and mean household income of about USD$ 450. Most medium SES participants are characterized by having tertiary education but mostly technical degree, a job that requires formal training and a mean household income of about USD$ 2200. Participants from high SES are commonly represented by those that completed university degrees, work in places that require formal training and have a mean household income of about USD$4000.

Environmental characteristics of the cities within which participants resided were collected from publicly-available government data sources. The population size of each capital city was obtained from the 2017 National Census (Instituto Nacional de Estadísticas, 2018). Because these data were last collected in 2002, it seemed reasonable that the 2017 data would better reflect the populations in 2014 and 2015. The population size for those capital cities was calculated by accounting for the population of every district that composed each capital city. Population density was calculated as the total population size divided by the area of each capital city (Instituto Nacional de Estadísticas, 2017). City-level total summer and winter rainfall (mm) and average daily summer and winter temperatures (°C) were extracted from data produced by the Center for Climate and Resilience Research (CR^2) (2018). The rainfall data were used to categorise cities based on the distribution of seasonal rainfall across them (categories in Table 2). The temperature data were used to create a 'climate' variable that reflected average temperatures in summer and winter (categories in Table 2).

2.2. Data analysis

Stata version 15 (StataCorp. College Station, TX, USA) was used for analysis. The analysis accounted for population-level weighting of each observation by age, gender and SES, and the clustering of participants within 15 regions. For each year of collection, sample characteristics were described using categories and percentages. The prevalence of transport cycling was calculated separately for each individual and environmental factor, using the svy command in Stata. The two years of data collection were then combined to assess associations between individual and environmental factors and being a transport cyclist in the whole sample and separately for men and women. For analysis, multivariable multi-level logistic regression modelling (melogit command) was used. Participants were clustered within the region, and the year of data collection was treated as a random effect within the region. Robust standard errors were computed. Initial models (Model 1) included the individual-level factors only. Final models (Model 2) also

Table 1
Characteristics of the sample in the National Environmental Survey Ministerio del Medio Ambiente de Chile, 2014, 2015.

	2014 (n = 5057)			2015 (n = 5664)		
	n	%	Weighted[a] %	n	%	Weighted[a1] %
Sex						
Male	2029	40.1	48.9	2602	45.9	47.6
Female	3028	59.9	51.1	3062	54.1	52.4
Age group, years						
18-24	540	10.7	13.3	548	9.7	14.7
25-34	924	18.3	22.9	1216	21.5	24.9
35-44	821	16.2	16.0	1070	18.9	17.1
45-54	1066	21.1	20.8	1065	18.8	21.4
≥55	1706	33.7	27.1	1765	31.2	21.8
Socio-economic status						
High level	785	15.5	10.9	2702	47.7	24.7
Medium level	1348	26.7	18.5	1822	32.2	23.7
Low level	2924	57.8	70.6	1140	20.1	51.7

[a] Weighted by age, gender, and socio-economic status.

Table 2

Prevalence of cycling for transport in Chile by subgroup: National Environmental Survey Ministerio del Medio Ambiente de Chile, 2014 (N = 5057) and 2015 (N = 5664).

	NES2014	NES2015
	% (95% CI)[a]	% (95% CI)[a]
Overall	6.7 (5.7–7.9)	6.6 (5.4–8.0)
Sex		
Male	10.2 (8.3–12.4)	9.3 (7.2–11.9)
Female	3.3 (2.6–4.3)	4.1 (3.1–5.3)
Age group, years		
18-24	11.7 (8.2–16.4)	11.6 (7.5–17.4)
25-34	7.8 (5.9–10.3)	6.4 (4.6–8.8)
35-44	7.1 (4.6–10.8)	5.5 (3.8–7.8)
45-54	8.0 (5.5–11.5)	7.7 (4.8–12.1)
≥55	2.0 (1.3–3.1)	3.2 (1.9–5.2)
Socio-economic status		
High level	6.1 (4.1–9.1)	5.2 (3.9–6.8)
Medium level	6.2 (4.5–8.5)	7.3 (5.7–9.3)
Low level	6.9 (5.6–8.4)	6.9 (5.0–9.4)
Climate[b]		
Warm summers, mild winters	8.8 (7.2–10.7)	8.2 (6.3–10.5)
Moderate summers, mild winters	4.0 (2.8–5.7)	5.2 (3.9–6.9)
Cool summers, cool winters	3.3 (2.1–5.1)	2.6 (1.3–5.0)
Total summer rainfall (mm)[c]		
≥200	2.5 (1.5–4.2)	
100-199	6.6 (4.7–9.2)	
< 100	7.1 (5.9–8.6)	
Total winter rainfall (mm)		
≥1000	4.3 (2.8–6.6)	1.6 (0.4–5.2)
200-999	9.0 (7.4–10.9)	7.0 (5.5–8.8)
100-199	6.9 (5.0–9.5)	13.7 (8.3–21.9)
< 100	4.0 (2.9–5.4)	4.7 (3.2–6.8)
Population size		
≥1,500,000	7.4 (5.3–10.3)	7.4 (5.3–10.3)
500,000–1,000,000	3.9 (2.5–5.9)	3.9 (2.5–5.9)
200,000–499,999	7.4 (5.6–9.7)	7.4 (5.6–9.7)
< 200,000	4.9 (3.3–7.2)	4.9 (3.3–7.2)
Population density (inhabitants/km^2)		
≥1000	6.6 (5.0–8.7)	7.2 (5.3–9.8)
250-999	7.6 (5.9–9.7)	7.8 (5.2–11.4)
100-249	7.7 (6.0–9.7)	7.3 (5.0–10.6)
25-99	3.4 (2.1–5.4)	5.0 (3.0–8.2)
< 25	3.1 (2.1–4.4)	3.5 (2.2–5.6)

Note. CI = confidence interval.

[a] Weighted by age, gender, and socio-economic status.

[b] Climate reflects summer and winter high temperatures of a city. Average summer high temperatures were for the months of January to March and October to December: in cities with the warmest summers = 25–28 °C; in cities with moderate summers = 21–24 °C; in cities with the coolest summers = 13–20 °C. Average high winter temperatures were for the months of April to September: in cities with mild winters = 15–28 °C; in cities with cool winters = 7–18 °C.

[c] The analysis included data only from 2014 because the capital cities received almost no rain in the summer of 2015 (range across cities: 0–0.5 mm).

included the environmental factors. Separate models were created for each environmental variable due to multicollinearity among the environmental variables. The significance level was set at < 0.05.

3. Results

In total, 5057 and 5664 adults were included in the NES 2014 and NES 2015, respectively. Sample characteristics are shown in Table 1. Cycling for transport was reported by 6.7% of the sample in 2014 and 6.6% in 2015 (see Table 2). The highest prevalence estimates in both years were found in males, participants aged 18–24 years, and residents of cities with warm summers/mild winters) and with moderate to high population densities (100 + people/km^2) (Table 2).

As shown in Table 3, women were less likely than men to cycle for transport (p < 0.001), and participants aged ≥25 years were less likely to cycle for transport than those aged 18–24 years (p ≤ 0.001). Participants of medium or low SES were more likely to cycle for transport than were those of high SES (p = 0.040 and p = 0.010, respectively). When genders were modeled separately, notable gender differences were seen: the dose-response relationship between age and transport cycling was more pronounced in

Table 3

Associations between socio-demographic factors and transport cycling in Chile.[a]

	Total sample	Men	Women
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Sex			
Male (ref)	1.00		
Female	0.38 (0.30–0.49)		
Age group, years			
18–24 (ref)	1.00	1.00	1.00
25-34	0.60 (0.45–0.80)	0.59 (0.37–0.95)	0.62 (0.35–1.08)
35-44	0.52 (0.38–0.72)	0.53 (0.39–0.72)	0.50 (0.27–0.94)
45-54	0.68 (0.55–0.85)	0.76 (0.60–0.96)	0.54 (0.34–0.84)
≥55	0.23 (0.15–0.36)	0.26 (0.15–0.45)	0.18 (0.09–0.36)
Trend p-value	p < 0.001	p < 0.001	p < 0.001
Socio-economic status			
High level (ref)	1.00	1.00	1.00
Medium level	1.31 (1.01–1.70)	1.39 (1.12–1.71)	1.19 (0.61–2.32)
Low level	1.30 (1.06–1.59)	1.75 (1.35–2.28)	0.68 (0.52–0.91)
Trend p-value	p = 0.007	p < 0.001	p = 0.004

Note. CI = confidence interval. OR = odds ratio.

[a] All three independent variables were included in the total sample model. Age and socio-economic status were included in the separate models of men and of women. All models accounted for weighting by sex, age and socio-economic status and for clustering within region. Year served as a random effect variable within region. For the two ordinal variables, age and socio-economic status, statistical testing for a linear trend across categories was done, and the p-values are displayed here.

women than in men, and low SES was associated with greater likelihood of cycling in men (p < 0.001) but with reduced likelihood of cycling in women (p = 0.009).

Table 4 shows that living in a city with moderate summers/mild winters or cool summers/cool winters was associated with reduced likelihood of transport cycling, compared with living in a city with warm summers/mild winters (p < 0.001). Findings were similar in men (p < 0.001) and women (p ≤ 0.001) although the dose-response was more pronounced in the women. Compared with residing in a city with the most summer rainfall (≥200 mm), residing in a city with lower levels of summer rainfall was associated with a greater likelihood of transport cycling in the men (p < 0.05) and women (p < 0.05) when modeled separately. Findings were not significant when men and women were modeled together (100–199 mm of rain: p = 0.054; < 100 mm: p = 0.71). Compared with residing in a city with the most winter rainfall (≥1000 mm), residing in a city with lower levels of summer rainfall (100–199 mm) was associated with a greater likelihood of transport cycling in the total sample, and in men and women when modeled separately (p < 0.05).

Residing in a city of 500,000–1,499,999 or < 200,000 inhabitants was associated with a decreased likelihood of transport cycling compared with residing in a city of ≥1,500,000 in the total sample (p = 0.001) and the men (p < 0.05). In the women, a reduced likelihood of transport cycling was seen only in those living in cities of < 200,000 inhabitants (p < 0.001). Last, residing in a city of < 100 inhabitants/km^2 was associated with a decreased likelihood of transport cycling compared with residing in a city ≥1000 inhabitants/km^2, both in the total sample (p < 0.05) and in men (p < 0.05). For women, residing in a city of < 25 inhabitants/km^2 was associated with a decreased likelihood of transport cycling (p < 0.001).

4. Discussion

This study is the first to assess the prevalence of transport cycling in Chile. Data from two consecutive national surveys were used. The study also examined the associations between individual and environmental factors with transport cycling. Key findings were that the prevalence of transport cycling was 7% in both survey years and that the factors associated with a reduced likelihood of transport cycling included female gender, older age, high SES and low population density. Living in a city with moderate summers and mild winters or a city with cool summers and winters was also associated with less likelihood of cycling for transport compared with living in a city with warm summers and mild winters. Men and women living in cities with the most rainfall in summer or winter were less likely to cycle for transport than those living in cities with less rainfall. Moreover, those living in the smallest cities (< 200,000 inhabitants) were less likely to cycle for transport compared to those living in the largest cities (≥1,500,000). Associations between environmental factors and transport cycling were stronger in women than in men.

The prevalence of transport cycling was lower than that reported in other Latin American countries with similar economic development, such as Brazil and Colombia (Gómez et al., 2005; Reis et al., 2013; Sa et al., 2016b), and in European countries, such as the Netherlands, Belgium, Hungary and Denmark (Bassett et al., 2008; Mertens et al., 2016). However, Chile has a prevalence of transport cycling similar to that of the UK (6.0%) (UK Department for Transport, 2017b) and higher prevalence than that observed in Australia (about 2%) (Turrell et al., 2018) and the US (1.0%) (Nehme et al., 2016).

As has been shown in other low-cycling countries (Nehme et al., 2016; Reis et al., 2013; Sa et al., 2016b; Titze et al., 2014; UK Department for Transport, 2017b), women were less likely to cycle for transport than men and transport cycling decreased with

Table 4

Associations between environmental factors and bicycle use for transportation in Chile.[a]

	Total sample	Men	Women
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Climate[b]			
Warm summers, mild winters (ref)	1.00	1.00	1.00
Moderate summers, mild winters	0.40 (0.26–0.61)	0.40 (0.25–0.65)	0.34 (0.18–0.63)
Cool summers, cool winters	0.27 (0.15–0.77)	0.32 (0.19–0.54)	0.14 (0.06–0.29)
Trend p-value	p < 0.001	p < 0.001	p < 0.001
Total summer rainfall (mm)[c]			
≥200 (ref)	1.00	1.00	1.00
100-199	2.37 (0.93–6.05)	2.43(1.07–5.49)	3.82 (1.10–13.23)
< 100	2.34 (0.99–5.55)	2.36 (1.02–5.48)	3.79 (1.18–12.17)
Trend p-value	p = 0.159	p = 0.167	p = 0.193
Total winter rainfall (mm)			
≥1000 (ref)	1.00	1.00	1.00
200-999	2.38 (1.06–5.33)	2.12 (0.95–4.73)	3.06 (1.13–8.29)
100-199	3.74 1.50–9.36)	3.34 (1.39–8.02)	4.57 (1.44–14.46)
< 100	1.40 (0.65–3.00)	1.34 (0.61–2.92)	1.38 (0.48–4.01)
Trend p-value	p = 0.765	p = 0.831	p = 0.581
Population size			
≥1,500,000 (ref)	1.00	1.00	1.00
500,000–1,499,999	0.51 (0.34–0.77)	0.45 (0.24–0.85)	0.58 (0.31–1.09)
200,000–499,999	0.86 (0.52–1.43)	0.89 (0.55–1.41)	0.95 (0.45–1.99)
< 200,000	0.52 (0.35–0.76)	0.61 (0.40–0.92)	0.28 (0.18–0.45)
Trend p-value	p = 0.168	p = 0.628	p = 0.004
Population density (inhabitants/km^2)			
≥1000 (ref)	1.00	1.00	1.00
250-999	1.18 (0.62–2.26)	1.11 (0.54–2.28)	1.30 (0.60–2.81)
100-249	0.90 (0.48–1.72)	1.02 (0.55–1.87)	0.68 (0.25–1.86)
25-99	0.59 (0.39–0.91)	0.52 (0.39–0.70)	0.68 (0.22–2.08)
< 25	0.45 (0.26–0.77)	0.53 (0.30–0.93)	0.29 (0.15–0.56)
Trend p-value	p = 0.003	p = 0.011	p = 0.001

Note. CI = confidence interval. OR = odds ratio.

[a] Separate models were created for each environmental variable due to multicollinearity among the environmental variables. Each environmental variable served as an independent variable in a model, with adjustment for sex, age, and socio-economic status. Modelling accounted for weighting by sex, age and socio-economic status and for clustering within region. Year served as a random effect variable within region. Statistical testing for linear trends across categories of reach environmental variable was done, and the p-values are displayed here.

[b] Climate reflects summer and winter high temperatures of a city. Average summer high temperatures were for the months of January to March and October to December: in cities with the warmest summers = 25–28 ˚C; in cities with moderate summers = 21–24 ˚C; in cities with the coolest summers = 13–20 ˚C. Average high winter temperatures were for the months of April to September: in cities with mild winters = 15–28 ˚C; in cities with cool winters = 7–18 ˚C.

[c] The analysis included data only from 2014 because the capital cities received almost no rain in the summer of 2015 (range: 0–0.5 mm).

increasing age. The dose-response relationship with age was more pronounced for women than men. This finding may be explained by the fact that in Chile, older women are less likely than younger women to be in the workforce (Instituto Nacional de Estadísticas, 2018), and therefore, their need to ride for transport is potentially less. Another explanation is that older women may avoid cycling in traffic to get to work more than other demographic groups do. Previous research suggests that more women than men consider themselves 'beginner cyclists' (Akar et al., 2011) and fear having an accident while riding (Oja et al., 1998). This concern about cycling in traffic may become more prevalent in older age, when their cardiovascular fitness, balance and strength declines.

The likelihood of cycling for transport was higher among participants of low to medium SES than among participations of high SES, as found in other studies conducted in Latin American countries (Reis et al., 2013; Sa et al., 2016a). This contrasts with findings from other high-income countries outside of this region that showed the likelihood of cycling for transport to be greater in individuals of high SES than of lower SES (Heesch et al., 2015; UK Department for Transport, 2017a). An interesting finding of the current study was that when men and women were modeled separately, this inverse association held for men but not for women. Instead, women of low SES were found to be less likely to cycle for transport than were women of the highest SES. This difference between the genders in the association between SES and transport cycling may be explained by findings of previous studies indicating that men of lower SES are the least likely to be able to afford a car and thus may rely on the bicycle for transport (Heesch et al., 2015), while women of low SES are least likely to work outside of the home, as they are expected to maintain the traditional female roles of childcare and household duties (Instituto Nacional de Estadísticas, 2018; Stuven et al., 2013), and thus are in less need of a bicycle for transport. Also, women living in disadvantaged neighbourhoods may perceive that cycling is unsafe if they have not been given opportunities to learn to ride a bicycle, if local bicycle infrastructure (i.e., bicycle lanes or paths) is lacking or deficient, and if traffic conditions (i.e. traffic speed and congestion) are perceived to be frightening (Heesch et al., 2012; Mertens et al., 2017).

Another finding of the current study was that transport cycling was more likely among men and women residing in cities with

better climates (warm summers and mild winters) or moderate levels of rainfall. Other researchers have shown that weather conditions play a crucial role in facilitating or hindering transport cycling (Flynn et al., 2012; Nankervis, 1999). Fishman et al. (2015a) reported that cycling appears to be more affected than walking by weather conditions. Therefore, it was not unexpected to find that in Chile, a country with a wide diversity of climates and geographical conditions, cycling prevalence differed from city to city. Variability in these associations has been observed in other developed countries (Amiri and Sadeghpour, 2015; Böcker and Thorsson, 2014; Flynn et al., 2012).

Also, in the current study, associations between rainfall and behaviour were stronger for winter rainfall than for summer rainfall and stronger for women than men. In Chile, rain is usually more prevalent in winter; therefore, it occurs when days are the shortest. Women may feel less safe than men in riding a bicycle in rain and darkness, even in cities with mild winters. Indeed, in an Australian study of cyclists, women were more likely than men to report "rainy or stormy weather" and "decreases in daylight hours during winter months" to constrain their cycling (Heesch et al., 2012). As our study is the first to document an interaction between season and rainfall, this association requires further investigation in our context, especially given that different policies to favour cycling for transport over other transport modes are being enacted in different sociodemographic groups and regions (Ministerio de Transportes y Telecomunicaciones de Chile, 2018; Ministerio de Vivienda y Urbanismo de Chile, 2015b).

Other environmental factors associated with transport cycling were population size and density. Participants residing in the smallest ($< 200,000$ inhabitants) or least dense (< 100 inhabitants/km^2) cities were less likely to cycle for transport than were those in the largest (≥ 1.5 million) or most densely populated (≥ 1000 inhabitants/km^2) cities, respectively. These findings support those of previous research suggesting that population size and density should be considered in city planning as crucial factors that can lead to behaviour and cultural change of a population (Dill, 2009; Hull and O'Holleran, 2014). For example, low population density has been associated with low cycling rates in other countries, including the US, a low-cycling country, and the Netherlands, a high-cycling country (Fishman et al., 2015a; Nehme et al., 2016; Saelens et al., 2003). Likewise, other researchers have found that greater urban density and less sprawl are associated with more active travel behaviours (Saelens et al., 2003). Recently, Hamidi et al. (2018) showed that residents of compact cities have higher life expectancies than those living in sprawling cities. Although the causal mechanisms are unclear, factors that could reduce life expectancy in sprawling cities include higher traffic speeds, longer emergency response times, lower quality and less accessible health care facilities, and less availability of healthy food in residential areas (Hamidi et al., 2018). Also, Ewing et al. (2014) have suggested that developing more compact urban and suburban areas may have positive effects on moderate-intensity PA, nutritional status, obesity, coronary heart disease, high blood pressure and diabetes. These findings highlight the complexity in the relationships among environments, behaviours and health outcomes as these relationships appear to be influenced by contextual factors, including economic development and policies, for example.

This study provides a broad understanding of cycling in Chile. To better understand cycling and its role as a travel mode, surveillance of cycling in Chile should continue and include the collection of details about this behaviour (e.g., frequency and duration of trips; use of cycling in conjunction with other modes). These data could be complemented by objective measurement of cycling behaviour, such as with bicycle counters. Chile has recently placed bicycle counters on most publicly-funded bicycle lanes (Ministerio de Vivienda y Urbanismo, 2018), as in other countries, to better understand daily and seasonal variability in cycling (Rissel et al., 2010; Sayers et al., 2012; Uttley and Fotios, 2017). Collection of these types of data is critical for documenting the influence of recent changes in policy and transport infrastructure on transport cycling. In 2014, the Chilean government began investing in cycling infrastructure and adopting cycle-friendly policies (Ministerio de Vivienda y Urbanismo de Chile, 2015b). Subsequently, a modification of the transport law was approved for implementation from November 2018 (Ministerio de Transportes y Telecomunicaciones de Chile, 2018). Highlights of this law that could affect transport cycling rates include a reduction in the maximum urban speed from 60 to 50 km/h and the requirement that motorists maintain a minimum distance of 1.5 m when passing cyclists in all speed zones. Data on cycling behaviour could be combined with other data (e.g., spatio-temporal, seasonal and infrastructural) to inform future strategies for promoting transport cycling, as has been suggested by others (Böcker and Thorsson, 2014; Uttley and Fotios, 2017).

4.1. Strengths and limitations

A key strength of this study was the combination of survey data with objective environmental data. Another major strength was the inclusion of two measurement periods to better capture the prevalence of transport cycling behaviour and the correlates of this behaviour. Also, the surveys included large representative samples from each administrative region. However, it should also be noted that the samples were drawn from capital cities, and the findings may not generalise to other, smaller communities. Another limitation was that people aged 65 + years were grouped with people aged 55–64 years because there were too few bicycle riders aged 65 + years in the sample to be able to conduct our analyses without grouping people that age with younger people. Other limitations included the use of a cross-sectional design and self-reported behavioural data although it should be noted that transport cycling behaviour is typically self-reported in studies of cycling prevalence. Another limitation was the measure of transport cycling: the question was broadly worded (about main travel mode). Details about transport cycling, including frequency and duration of trips and how these changed over time, were not available, and the validity of the item is unknown.

5. Conclusion

The prevalence of transport cycling in Chile is low. Although it is higher than in some other low-cycling, high-income countries (US and Australia), it is lower than in other Latin American and in Northern European countries. Individual-level factors associated

with transport cycling (sex, age, and SES) are the same as those found in other low-cycling countries, although the dose-response relationship for SES is not consistent across countries. Likewise, the environmental factors associated with transport cycling (climate, and population size and density) are consistent with those found in the few studies of these factors in other countries. This study adds to the literature by showing differential influences of gender on the associations between environmental factors and transport cycling with the influences of these factors appearing to be stronger in women than in men. Therefore, efforts by city planners of large cities to increase transport cycling should consider how these factors are influencing gender inequalities in transport cycling in their cities so that they can then develop strategies that address the constraints felt more strongly by women.

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References

Aguilar-Farias, N., Martino-Fuentealba, P., Infante-Grandon, G., Cortinez-O'Ryan, A., 2018. Inactividad física en Chile: debemos responder al llamado global, vol. 145 Revista medica de Chile.

Akar, G., Fischer, N., Namgung, M., 2011. Why Do Women Bicycle Less? Case Study at Ohio State University.

Amiri, M., Sadeghpour, F., 2015. Cycling characteristics in cities with cold weather. Sustain. Cities Soc. 14, 397–403.

Asociacion Chilena de Empresas de Investigacion de Mercado, 2008. Grupos Socioeconomicos.

Bassett Jr., D.R., Pucher, J., Buehler, R., Thompson, D.L., Crouter, S.E., 2008. Walking, cycling, and obesity rates in Europe, North America, and Australia. J. Phys. Act. Health 5, 795–814.

Berrigan, D., Troiano, R.P., McNeel, T., Disogra, C., Ballard-Barbash, R., 2006. Active transportation increases adherence to activity recommendations. Am. J. Prev. Med. 31, 210–216.

Böcker, L., Thorsson, S., 2014. Integrated weather effects on cycling shares, frequencies, and durations in Rotterdam, The Netherlands. Weather Clim. Soc. 6, 468–481.

Celis-Morales, C.A., Lyall, D.M., Welsh, P., Anderson, J., Steell, L., Guo, Y., Maldonado, R., Mackay, D.F., Pell, J.P., Sattar, N., Gill, J.M.R., 2017. Association between active commuting and incident cardiovascular disease, cancer, and mortality: prospective cohort study. BMJ 357, j1456.

Center for Climate and Resilience Research (CR), 2018. Explorador Climático.

Dill, J., 2009. Bicycling for transportation and health: the role of infrastructure. J. Public Health Policy 30, S95–S110.

Ewing, R., Meakins, G., Hamidi, S., Nelson, A.C., 2014. Relationship between urban sprawl and physical activity, obesity, and morbidity - update and refinement. Health Place 26, 118–126.

Fishman, E., Bocker, L., Helbich, M., 2015a. Adult active transport in The Netherlands: an analysis of its contribution to physical activity requirements. PLoS One 10, e0121871.

Fishman, E., Schepers, P., Kamphuis, C.B., 2015b. Dutch cycling: quantifying the health and related economic benefits. Am. J. Public Health 105, e13–15.

Flynn, B.S., Dana, G.S., Sears, J., Aultman-Hall, L., 2012. Weather factor impacts on commuting to work by bicycle. Prev. Med. 54, 122–124.

Foster, C., Shilton, T., Westerman, L., Varney, J., Bull, F., 2018. World Health Organisation to develop global action plan to promote physical activity: time for action. Br. J. Sports Med. 52, 484–485.

Gómez, L.F., Sarmiento, O.L., Lucumí, D.I., Espinosa, G., Forero, R., Bauman, A., 2005. Prevalence and factors associated with walking and bicycling for transport among young adults in two low-income localities of Bogotá, Colombia. J. Phys. Act. Health 2, 445–459.

Hamidi, S., Ewing, R., Tatalovich, Z., Grace, J.B., Berrigan, D., 2018. Associations between urban sprawl and life expectancy in the United States. Int. J. Environ. Res. Public Health 15.

Heesch, K.C., Sahlqvist, S., Garrard, J., 2012. Gender differences in recreational and transport cycling: a cross-sectional mixed-methods comparison of cycling patterns, motivators, and constraints. Int. J. Behav. Nutr. Phys. Act. 9, 106.

Heesch, K.C., Giles-Corti, B., Turrell, G., 2015. Cycling for transport and recreation: associations with the socio-economic, natural and built environment. Health Place 36, 152–161.

Hollingworth, M., Harper, A., Hamer, M., 2015. Dose-response associations between cycling activity and risk of hypertension in regular cyclists: the UK Cycling for Health Study. J. Hum. Hypertens. 29, 219–223.

Hull, A., O'Holleran, C., 2014. Bicycle infrastructure: can good design encourage cycling? Urban Plan. Transp. Res. 2, 369–406.

Instituto Nacional de Estadísticas, 2018. Resultados Censo 2017.

Instituto Nacional de Estadísticas, 2017. Censo 2017 Todos Contamos. Mapa de resultados censo 2017 por región, provincias y comunas del país.

Kohl 3rd, H.W., Craig, C.L., Lambert, E.V., Inoue, S., Alkandari, J.R., Leetongin, G., Kahlmeier, S., Lancet Physical Activity Series Working, G, 2012. The pandemic of physical inactivity: global action for public health. Lancet 380, 294–305.

Lee, I.M., Shiroma, E.J., Lobelo, F., Puska, P., Blair, S.N., Katzmarzyk, P.T., Lancet Phys Activity Series, W, 2012. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. Lancet 380, 219–229.

Mertens, L., Compernolle, S., Gheysen, F., Deforche, B., Brug, J., Mackenbach, J.D., Lakerveld, J., Oppert, J.M., Feuillet, T., Glonti, K., Bardos, H., De Bourdeaudhuij, I., 2016. Perceived environmental correlates of cycling for transport among adults in five regions of Europe. Obes. Rev. 17 (Suppl. 1), 53–61.

Mertens, L., Compernolle, S., Deforche, B., Mackenbach, J.D., Lakerveld, J., Brug, J., Roda, C., Feuillet, T., Oppert, J.M., Glonti, K., Rutter, H., Bardos, H., De Bourdeaudhuij, I., Van Dyck, D., 2017. Built environmental correlates of cycling for transport across Europe. Health Place 44, 35–42.

Ministerio del Medio Ambiente de Chile, 2014. Planes de descontaminación atmosférica. Estrategia 2014-2018.

Ministerio del Medio Ambiente de Chile, 2015. Informe Encuesta Nacional de Medio Ambiente 2014: opiniones, comportamientos y preocupaciones.

Ministerio del Medio Ambiente de Chile, 2016. Informe Encuesta Nacional de Medio Ambiente 2015.

Ministerio Secretaria General de Gobierno de Chile, 2014. Programa de Gobierno Presidenta Michelle Bachelet 2014-2018. 56 Medidas para los primeros 100 días. In: División de Coordinación Interministerial (Ed.).

Ministerio de Transportes y Telecomunicaciones de Chile, 2018. Modifica la ley de tránsito para incorporar disposiciones sobre convivencia de los distintos medios de transporte. In: Congreso Nacional de Chile, Ley 21088.

Ministerio de Vivienda y Urbanismo, 2018. Análisis de contadores de ciclovías: resultados preliminares. In: Comisión de Estudios Habitacionales y Urbanos + DOU (Ed.).

Ministerio de Vivienda y Urbanismo de Chile, 2014. Modificación decreto supremo N° 47 de vivienda y urbanismo, de 1992, ordenanza general de urbanismo y

construcciones en materia de ciclovías y estacionamientos para bicicletas. In: División de desarrollo urbano. División Jurídica Ministerio de Vivienda y Urbanismo. Gobierno de Chile (Ed.).

Ministerio de Vivienda y Urbanismo de Chile, 2015a. Espacios públicos Urbanos. Construcción de ciclovías. Estándar técnico. Versión Mayo 2015.

Ministerio de Vivienda y Urbanismo de Chile, 2015b. Espacios públicos Urbanos. Vialidad ciclo-inclusiva. Recomendaciones de diseño. Versión 1 abril 2015.

Ministerio de Vivienda y Urbanismo de Chile, 2015c. Movilidad urbana. Vol.1 Biciestacionamientos en el espacio público. In: División de Desarrollo Urbano. Dirección de Proyectos de Ciudad (Ed.).

Nankervis, M., 1999. The effect of weather and climate on bicycle commuting. Transp. Res. A Policy Pract. 33, 417–431.

Nehme, E.K., Perez, A., Ranjit, N., Amick 3rd, B.C., Kohl 3rd, H.W., 2016. Sociodemographic factors, population density, and bicycling for transportation in the United States. J. Phys. Act. Health 13, 36–43.

Oja, P., Vuori, I., Paronen, O., 1998. Daily walking and cycling to work: their utility as health-enhancing physical activity. Patient Educ. Couns. 33, S87–S94.

Pucher, J., Buehler, R., Bassett, D.R., Dannenberg, A.L., 2010. Walking and cycling to health: a comparative analysis of city, state, and international data. Am. J. Public Health 100, 1986–1992.

Reis, R.S., Hino, A.A., Parra, D.C., Hallal, P.C., Brownson, R.C., 2013. Bicycling and walking for transportation in three Brazilian cities. Am. J. Prev. Med. 44, e9–17.

Rissel, C.E., New, C., Wen, L.M., Merom, D., Bauman, A.E., Garrard, J., 2010. The effectiveness of community-based cycling promotion: findings from the Cycling Connecting Communities project in Sydney, Australia. Int. J. Behav. Nutr. Phys. Act. 7, 8.

Rojas-Rueda, D., de Nazelle, A., Andersen, Z.J., Braun-Fahrlander, C., Bruha, J., Bruhova-Foltynova, H., Desqueyroux, H., Praznoczy, C., Ragettli, M.S., Tainio, M., Nieuwenhuijsen, M.J., 2016. Health impacts of active transportation in Europe. PLoS One 11, e0149990.

Sa, T.H., Duran, A.C., Tainio, M., Monteiro, C.A., Woodcock, J., 2016a. Cycling in Sao Paulo, Brazil (1997-2012): correlates, time trends and health consequences. Prev. Med. Rep. 4, 540–545.

Sa, T.H., Rezende, L., Borges, M.C., Nakamura, P.M., Anapolsky, S., Parra, D.C., Adami, F., Monteiro, C.A., 2016b. Prevalence of active transportation among adults in Latin America and Caribbean: systematic review of population-based studies. Rev. Panam. Salud Públic 41, e35.

Sadarangani, K.P., Von Oetinger, A., Cristi-Montero, C., Cortinez-O'Ryan, A., Aguilar-Farias, N., Martinez-Gomez, D., 2018. Beneficial association between active travel and metabolic syndrome in Latin-America: a cross-sectional analysis from the Chilean National Health Survey 2009-2010. Prev. Med. 107, 8–13.

Saelens, B.E., Sallis, J.F., Frank, L.D., 2003. Environmental correlates of walking and cycling: findings from the transportation, urban design, and planning literatures. Ann. Behav. Med. : Publ. Soc. Behav. Med. 25, 80–91.

Sagaris, L., 2010. From sustainable transport development to active citizenship and participatory democracy: the experience of Living City in Chile. Nat. Resour. Forum 34, 275–288.

Sagaris, L., 2015. Lessons from 40 years of planning for cycle-inclusion: reflections from Santiago, Chile. Nat. Resour. Forum 39, 64–81.

Sayers, S.P., LeMaster, J.W., Thomas, I.M., Petroski, G.F., Ge, B., 2012. Bike, walk, and wheel: a way of life in Columbia, Missouri, revisited. Am. J. Prev. Med. 43, S379–S383.

Stewart, G., Anokye, N.K., Pokhrel, S., 2016. Quantifying the contribution of utility cycling to population levels of physical activity: an analysis of the Active People Survey. J. Public Health 38, 644–652.

Stuven, A.M., Cabello, T., Crisostomo, B., Lozier, M., 2013. La mujer ayer y hoy: un recorrido de incorporación social y política. Centro de Políticas Públicas UC.

The National Health and Medical Research Council, t.A.R.C.a.U.A., 2007. National Statement on Ethical Conduct in Human Research 2007 (Updated 2018). National Health and Medical Research Council, Commonwealth of Australia, Canberra.

Titze, S., Merom, D., Rissel, C., Bauman, A., 2014. Epidemiology of cycling for exercise, recreation or sport in Australia and its contribution to health-enhancing physical activity. J. Sci. Med. Sport/Sports Med. Aust. 17, 485–490.

Turrell, G., Hewitt, B.A., Rachele, J.N., Giles-Corti, B., Brown, W.J., 2018. Prospective trends in body mass index by main transport mode, 2007–2013. J. Transport. Health 8, 183–192.

UK Department for Transport, 2013. National Travel Survey 2013.

UK Department for Transport, 2017a. British Social Attitudes Survey 2015: Public Attitudes towards Transport.

UK Department for Transport, 2017b. National Travel Survey 2016.

United Nations, 2015. Transforming Our World: the 2030 Agenda for Sustainable Development.

Uttley, J., Fotios, S., 2017. Using the daylight savings clock change to show ambient light conditions significantly influence active travel. J. Environ. Psychol. 53, 1–10.

Veisten, K., Flugel, S., Ramjerdi, F., Minken, H., 2011. Cycling and walking for transport: estimating net health effects from comparison of different transport mode users' self-reported physical activity. Health Econ. Rev. 1, 3.

World Health Organization, 2010. Global Recommendations on Physical Activity for Health. World Health Organization, Geneva, Switzerland.

World Health Organization, 2018. Global Action Plan on Physical Activity 2018–2030: More Active People for a Healthier World. World Health Organization, Geneva.