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Preventable incidence cases from non-communicable diseases attributable to insufficient physical activity in Chile

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ABSTRACT

Objectives: Lack of sufficient physical activity (PA) has been associated with an increased risk of several non-communicable diseases (NCDs) and all-cause mortality. This study aimed to estimate the number of preventable incidence cases of NCDs attributable to insufficient PA in the Chilean population.
Study design: Comparative risk assessment modelling study.
Methods: This study examined data from 5834 participants aged ≥20 years from the Chilean National Survey (2016–2017). PA was assessed by the Global Physical Activity Questionnaire (GPAQ), and metabolic equivalent of tasks (METs) were assigned according to PA intensity. Estimated incidence cases of NCDs in Chile in 2019 were obtained from the Global Burden of Disease study. Relative risks for breast cancer, colon cancer, ischaemic heart disease, diabetes and stroke were obtained from a published meta-analysis and applied to the prevalence of insufficient PA estimates through the potential impact fraction equation.
Results: High levels of PA (≥8000 MET-min/week) could potentially avoid more than 22,000 (64.6 %) incidence NCD cases, ranging from 498 (10.1 %) preventable cases of breast cancer to 5629 (14.7 %) cases of diabetes. Other modelled scenarios also showed to reduce the incidence cases of all five NCDs but to a lesser extent; where at least PA recommendation was achieved, preventable NCDs were reduced by 6522 cases (18.7 %), and where a 10 % relative reduction in insufficient PA level in the population was achieved, preventable NCDs were reduced by 651 (1.8 %) cases.
Conclusions: The study results provide estimates for the incidence cases of preventable NCDs attributable to insufficient PA, highlighting the important role of PA in NCD prevention in Chile.

Introduction

Physical activity (PA) has been associated with a reduced risk of non-communicable diseases (NCDs), such as cardiovascular diseases, type 2 diabetes and cancer, in a dose-dependent manner, as well as other health outcomes, including all-cause and premature mortality.[1,2] In addition, PA has demonstrated benefits in cardiovascular and metabolic disease, respiratory conditions, and cognitive and mental health, as well as the improvement in quality of life and treatment outcomes in some cancers, particularly colon, prostate and breast cancers.[3] Despite these benefits of PA, one in four adults (27.5 %) worldwide do not meet the recommendations for aerobic exercise.[4] In Latin American and Caribbean countries, the prevalence of insufficient PA in adults reached 39.1 % in 2016. In Chile, the prevalence of

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insufficient PA is 31.5 % in adults, and the lack of PA represents one of the most prevalent risk factors for NCDs, surpassing other factors such as smoking (18.5 %)[5] and risky alcohol use (12.7 %).[6]

NCDs are responsible for more than 70 % of total deaths annually.[7] In terms of global premature mortality, 6.4 % is attributable to insufficient PA; however, up to 15 % of premature mortality could be avoided by meeting PA recommendations, corresponding to 3.9 million avoided deaths annually, with increased prevented fractions in lower-income countries compared with higher-income countries.[8] In Brazil, for example, PA may play an important role in reducing premature deaths from NCDs, where it could potentially avoid up to 5.75 % of premature deaths from major NCDs and 3.2 % of premature deaths from all-causes per year.[9] In addition, PA is recognised as an important modifiable risk factor for disease prevention, such as the prevention of cancers, and it can reduce the economic costs of colon and postmenopausal breast cancers attributable to lack of PA.[10] Although deaths attributable to insufficient PA have been previously studied,[11] to the best of the authors' knowledge, preventable fraction estimates of NCDs due to insufficient PA are unavailable in Chile.

The calculation of the potential impact fraction (PIF) is an epidemiological measure that is equal to the proportional reduction in the risk of a disease or mortality resulting from a specific change in the distribution of a risk factor in the population and/or in the risk associated with this factor.[12–14] PIF has been extensively used in research to measure potential gains in mortality and burden of diseases under hypothetical counterfactual scenarios of elimination or reduction of risk factors related to the outcome of interest.[15–17] This study used PIF to establish the proportion of cases that would not have occurred in the absence of an exposure either among the exposed population or the total population,[18] based on the relative risk (RR) of each NCD, extracted from a published meta-analysis.[19] Thus, this study estimated the proportion and number of preventable incidence cases from NCDs attributable to insufficient PA in Chile.

Methods

Chilean national health survey

Sociodemographic and PA data were obtained from the Chilean National Health Survey (NHS), a cross-sectional population survey carried out from August 2016 to March 2017. The NHS enrolled 6333 participants aged ≥15 years, with Chilean or foreign nationality, who habitually resided in individual homes and belong to either urban or rural areas of the 15 regions of Chile. Adolescents and young adults were excluded as the RR used for the statistical analysis that was retrieved from the published meta-analysis[19] was only applicable to the adult population, and this population group is also in a transition period when long-term lifestyle behaviours are being established.[20] The final analytical study population included 5834 participants aged ≥20 years with complete PA data. The NHS sampling method used a random, stratified, multistage and conglomerate sample of household's representative of the national state. The multistage selection was based on counties as the primary sampling unit, households as the secondary sampling unit and, finally, one participant from selected households as the tertiary sampling unit. The 2016–2017 NHS was funded by the Chilean Ministry of Health and approved by the Ethics Committee of the School of Medicine of the Pontificia Universidad Católica de Chile. All participants provided informed consent before participating. Details on NHS 2016–2017 are available elsewhere.[21]

Sociodemographic data included sex (women and men), age (20–44 years, 45–64 years and ≥65 years), region of Chile (North, Centre and South), educational level (low <8 years, medium 8–12 years and high ≥13 years), nationality (Chilean and other) and body mass index (BMI; underweight <18.5 kg/m^2, eutrophic 18.5–24.9 kg/m^2 and overweight ≥25 kg/m^2). Urban and rural geographic areas were not considered in the current study as there were no participants from rural areas with complete data.

PA level was assessed by the Global Physical Activity Questionnaire (GPAQ v2.0),[22] considering the three domains: occupational, transportation and leisure. Participants self-reported information on weekly frequency, duration and intensity of activities in each PA domain. Metabolic equivalent of tasks (METs: 1 MET = ~3.5 ml O_2/kg/min) were assigned to weekly volume of PA (minutes/week) according to the Compendium of Physical Activities,[23] which was chosen over other MET thresholds and intensity classifications, as it is based on studies using self-report of PA and it classifies rate of energy expenditure according to specific PA considering major headings, assimilated to the three domains considered by the GPAC questionnaire. PA was then classified by domain and intensity: occupational (3.5 METs for moderate and 6METs for vigorous intensity); active transportation (5 METs e an average of walking and bicycle); and leisure (4.5METs formoderate and 6 METs for vigorous intensity). Total PA was calculated as the sum of MET-min/week across all three domains, and participants were subsequently divided into four categories of PA: ≤600 MET-min/week, 600–3999 MET-min/week, 4000–7999 MET-min/week and ≥8000 MET-min/week.[19]

NCDs: RRs and incidence

The estimated number of incidence cases of NCDs in Chile in 2019 was extracted from the Global Burden of Disease study.[19] In addition, a systematic review carried out from 1980 to September 2014 that used data from 174 cohort studies published in PubMed and Embase was used to obtain information on the dose–response association between total PA across all domains and the risk of five chronic NCDs (breast cancer, colon cancer, ischaemic heart disease, diabetes and stroke), estimating RRs of diseases for each dose of total PA in MET-min/week. Data for each disease was retrieved by sex and total population. RRs for the association of PA (≤600 MET-min/week, 600–3999 MET-min/week, 4000–7999 MET-min/week and ≥8000 MET-min/week) with breast cancer, colon cancer, ischaemic heart disease, diabetes and stroke were obtained from the published meta-analysis.[19]

Statistical analyses

Weights took into account the complex sampling design and the four levels of multistage sampling. Data analyses were performed using SPSS V26 software (SPSS Inc., IBM Corp., Armonk, Nueva York, NY, EE. UU.), where $P < 0.05$ was considered to be significant. The Kolmogorov–Smirnov test was performed to evaluate the distribution of the data, which was presented as frequency and percentage, and the Chi-squared test was used to compare the variables between PA categories.

PIF was calculated, which was defined as the proportional reduction in disease incidence that would occur if exposure to the risk factor was reduced to a give a counterfactual scenario, while other conditions remained the same.[14] PIF for each NCD by sex was calculated using the following equation:

$$PIF = \frac{\sum_{i=1}^{n} P_i RR_i - \sum_{i=1}^{n} P'_i RR_i}{\sum_{i=1}^{n} P'_i RR_i}$$

where P_i is the proportion of the population at the level i of PA, P'_i is the proportion of the population at the level i of total PA in the

proposed counterfactual scenarios, and RR_i is the relative risk of each NCD (breast cancer, colon cancer, ischaemic heart disease, diabetes and stroke) at the level i of total PA.

Three counterfactual scenarios were proposed: Scenario 1, where everyone reaches at least 8000 MET-min/week (herein considered the theoretical minimum risk exposure level); Scenario 2, where everyone reaches at least 600 MET-min/week, according to World Health Organisation (WHO) PA recommendations;[24] and Scenario 3, a 10 % relative reduction in the prevalence of insufficient PA (≤600 MET-min/week). To obtain the number of preventable incidence cases of NCDs attributable to each counterfactual scenario, PIF was applied for breast cancer, colon cancer, ischaemic heart disease, diabetes and stroke, to its respective number of incidences in 2019, using the prevalence of PA from the NHS and RR for each disease retrieved from the published meta-analysis.[19]

Results

The total number of participants was 5834 (63.6 % women; 36.4 % men), with a mean age of 51 years (SD: 18.0). Overall, 38.6 % were aged 20–44 years, 48.1 % lived in the South region, 100 % were from urban areas, 51.2 % had 8–12 years of education, 97.5 % had Chilean nationality and 78.1 % were overweight (BMI ≥25 kg/m^2). Statistically significant differences ($P < 0.05$) were observed in sex, age, region, educational level, nationality and BMI among the four groups of PA (Table 1).

This study estimated that 35.7 % of the participants did not reach the WHO PA recommendations (i.e. they scored ≤600 MET-min/week), with a higher proportion of women (40.5 %) than men (27.2 %). Results showed that 30.5 % reported 601–3999 MET-min/week, 12.6 % 4000–7999 MET-min/week and 21.2 % ≥8000 MET-min/week.

Table 2 shows the total and preventable incidence cases for each NCD in Chile in 2019. In Scenario 1, this study estimated that increasing PA to the theoretical minimum risk exposure level (≥8000 MET-min/week) could potentially avoid 22,096 (64.6 %) cases from all five NCDs considered, ranging from 498 (10.1 %) preventable incidence cases from breast cancer to 5628 (14.7 %) cases from diabetes. Preventable incidence cases from ischaemic heart disease could be reduced by 12.1 %, followed by colon cancer (13.7 %) and stroke (13.9 %). In Scenario 2, where at least the WHO PA recommendation is achieved, there was a lower proportion of preventable cases for all five conditions compared to Scenario 1. Estimates ranged from 71 (1.4 %) preventable incidence cases from breast cancer to 1110 (5.6 %) incidence cases from stroke. The proportion of preventable cases from other NCDs were 3.3 % for ischemic heart disease, 3.5 % for colon cancer and 4.9 % for diabetes. Lastly, a 10 % relative reduction in insufficient PA level could decrease the proportion of incidence cases of all NCDs, but to a lesser extent than scenarios 1 and 2, ranging from 7 (0.14 %) incidence cases from breast cancer to 111 (0.56 %) preventable incidence cases from stroke, achieving 1.87 % of total preventable cases among all five NCDs.

Discussion

The aim of this study was to estimate the proportion and number of preventable incidence cases of NCDs attributable to insufficient PA in Chile. A high prevalence of insufficient PA was observed in Chilean adults, with more than one-third (35.6 %) of adults not reaching PA recommendations (i.e. individuals scoring ≤600 MET-min/week), with a higher prevalence in women than men. These findings are in line with previous Latin American studies, where the prevalence of insufficient PA reached 40.6 % in the region and 26.9 % in Chile, with a higher proportion in women than men.[25] The current study also observed a high prevalence of overweight and obesity among the four categories of PA, including among highly active participants (4000–7999 and ≥8000 MET-min/week). A low percentage of energy expended in high-intensity PA has been associated with overweight and obesity with an inverse dose–response relationship; which is in agreement with the current study results, also seen in the categories with

Table 1
Sociodemographic and anthropometric characteristics according to physical activity (PA) categories (MET-min/week).

Characteristic	PA level				*P*-value
	≤600 MET-min/week (n = 2082)	601-3999 MET-min/week (n = 1778)	4000-7999 MET-min/week (n = 738)	≥8000 MET-min/week (n = 1236)	
	[n (%)]	[n (%)]	[n (%)]	[n (%)]	
Sex					<0.001[a]
Women	1503 (72.2)	1157 (65.1)	449 (60.8)	600 (48.5)	
Men	579 (27.8)	621 (34.9)	289 (39.2)	636 (51.5)	
Age group					<0.001[a]
20–44 years	657 (31.6)	737 (41.5)	311 (42.1)	548 (44.3)	
45–64 years	696 (33.4)	574 (32.3)	269 (36.4)	525 (42.5)	
≥65 years	729 (35.0)	467 (26.2)	158 (21.5)	163 (13.2)	
Region					<0.001[a]
North	584 (28.0)	468 (26.3)	196 (26.6)	309 (25.0)	
Centre	450 (21.6)	510 (28.7)	197 (26.7)	316 (25.6)	
South	1048 (50.4)	800 (45.0)	345 (46.7)	611 (49.4)	
Educational level					<0.001[a]
Low	678 (33.0)	393 (22.4)	142 (19.4)	250 (20.3)	
Medium	969 (47.1)	907 (51.6)	389 (53.2)	722 (58.7)	
High	410 (19.9)	457 (26.0)	200 (27.4)	258 (21.0)	
Nationality					<0.001[a]
Chilean	2033 (97.6)	1737 (97.7)	717 (97.2)	1204 (97.4)	
Foreign	49 (2.4)	41 (2.3)	21 (2.8)	32 (2.6)	
BMI (kg/m^2)					<0.001[a]
Underweight	19 (1.0)	4 (0.3)	7 (1.1)	7 (0.6)	
Eutrophic	353 (19.5)	352 (22.5)	144 (22.1)	237 (21.7)	
Overweight/Obesity	1439 (79.5)	1206 (77.2)	500 (76.8)	850 (77.7)	

[a] Significance value for Chi-squared test.

Table 2
Total incidence cases, potential impact fraction (PIF) and preventable incidence cases from cancer (breast and colon), ischaemic heart disease, diabetes and stroke according to physical activity (PA) scenarios in a Chilean population, according to sex and total population.

NCD	Total incidence cases (n)	PA scenario					
		Scenario 1: ≥8000 MET-min/week achieved		Scenario 2: at least 600 MET-min/week achieved		Scenario 3: 10 % reduction in insufficient PA achieved (<600 MET-min/week)	
		PIF	Preventable incidence cases (n)	PIF	Preventable incidence cases (n)	PIF	Preventable incidence cases (n)
Breast cancer							
Women	4904	10.16	498	1.45	71	0.14	7
Colon cancer							
Women	30,398	15.17	4614	4.12	1253	0.41	125
Men	29,594	12.15	3596	2.87	852	0.28	85
Total	59,992	14.10	8210	3.67	2105	0.36	210
Ischaemic heart disease							
Women	14,119	14.21	2007	4.16	589	0.41	59
Men	26,978	11.18	3016	2.90	785	0.29	78
Total	41,097	13.14	5023	3.72	1374	0.37	137
Diabetes							
Women	3651	18.17	663	6.62	242	0.66	24
Men	34,627	14.33	4965	4.67	1620	0.46	162
Total	38,278	16.82	5628	5.93	1862	0.59	186
Stroke							
Women	10,762	15.32	1650	6.51	701	0.65	70
Men	8963	12.09	1084	4.55	409	0.45	41
Total	19,725	14.18	2734	5.82	1110	0.58	111

NCD, non-communicable disease; PIF, potential impact fraction.

lower levels of PA. However, little or no association of moderate-intensity PA with either overweight or obesity was demonstrated, which could explain why the more active categories still showed a high prevalence of overweight.[26]

In terms of preventable cases of the five selected NCDs (breast cancer, colon cancer, ischaemic heart disease, diabetes and stroke), the most significant reduction is observed in Scenario 1, concluding that high levels of PA among the population could avoid up to 22,000 (64.6 %) incidence cases of these NCDs. Similarly, a study carried out in Brazil demonstrated a potential reduction of up to 16,700 (5.75 %) premature deaths from NCDs, reinforcing the important impact that PA can have in reducing premature deaths.[27] Previous studies have also shown an association between higher PA level and lower mortality, where the reduction due to increased habitual exercise was steeper at lower compared with higher exercise levels.[28] However, the current study showed that if the WHO-recommended PA levels were met by the population, only a relatively small impact would be seen on the preventable incidence cases of NCDs. Sizable reductions in the number of cases of NCDs would be observed only if a higher proportion of the population reached the most active PA levels (4000–7999 and ≥8000 MET-min/week), which may be unfeasible for the majority of the Chilean adult population. The prevalence of low levels of PA (Scenario 2) also showed a reduction of 6522 cases (18.7 %) in the incidence of NCDs, although to a lesser extent than Scenario 1. Finally, the scenario with a 10 % relative reduction in the prevalence of insufficient PA showed the lowest reduction in incidence compared with scenarios 1 and 2, with only 651 cases of NCDs (1.8 %). This reinforces the premise that although PA has consistently been associated with decreased mortality rates, the ideal combination of PA of different intensities remains unknown.[29] Regarding the potential impact of PA for each NCD, diabetes showed the highest incidence reduction at the highest level of PA (≥8000 MET-min/week), while stroke showed the greatest effect at WHO PA recommendations (≥600 MET-min/week) and 10 % relative reduction in insufficient PA prevalence compared to other NCDs. In the Latin American context, previous modelling studies have used comparative risk assessments to evaluate the potential impact of PA changes in cases of NCDs, concluding that sufficient PA levels could potentially avoid up to 16,700 premature deaths from NCDs in Brazil,[27] reinforcing the importance of PA in reducing NCDs prevalence and mortality among the population.

Strengths and limitations

This study has several strengths that should be noted. Firstly, this study used data from an extensive representative survey to estimate the PA levels of Chilean adults. In addition, to the best of the authors' knowledge, this was the first study in Chile to estimate preventable incidence cases of NCDs attributable to insufficient PA, which may provide useful findings for NCD prevention and control in the country.

This study also has some limitations. These are mostly related to the comparative risk assessment modelling design, which cannot analyse behaviour over a period of time or establish a cause-and-effect relationship. PA was self-reported via a questionnaire and thus susceptible to measurement error. RR estimates were used from a meta-analysis[19] and applied to the Chilean population, assuming transportability of the RR due to lack of long-term cohort studies in Chilean adults.

Conclusions

This study estimated the preventable cases of NCDs attributable to insufficient PA in Chilean adults, considering different counterfactual scenarios of PA level. In the theoretical minimum risk exposure level scenario, results estimated that 10.1 % of breast cancer and 14.7 % of cases of diabetes per year were attributable to insufficient PA in Chile in 2019. Increasing PA to low levels and reducing insufficient levels of PA in the population could have

a moderate and low impacts, respectively, on preventable cases of NCDs.

Author statements

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Ethical approval

The protocol was approved by the Ethics and Research Committee of the Universidad de Santiago de Chile (USACH) (records no. 224/2022). The protocol of each wave of the National Healthy Survey from Chile was approved by the Ethics Committee of the Pontificia Universidad Católica de Chile (Pontifical Catholic University of Chile – (records no. 16–019), institution in charge of the studies. Participants signed an informed consent to take part in the study.

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Competing interests

None declared.

Author contributions

P.F-H. and G.F. designed and conceptualised the study. G.F. and L.R. had a major role in the acquisition, analysis or interpretation of the data. P.F-H., C.F-V., A.C-P., C.C.-M., K.P.S. and D.G.D.C. wrote the first draft of the manuscript. All authors contributed to the interpretation of the data and commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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