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Perception of safety and its association with physical activity in adolescents

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Introduction: Low levels of physical activity are associated with several non-communicable diseases. In Mexico 39.5% of adolescents do not meet the physical activity guidelines from the World Health Organisation. Previous literature suggests an association between perception of safety and physical activity. The aim of this paper is to examine the association between perceived crime and pedestrian safety and physical activity in Mexican adolescents.

Methods: Cross-sectional study with data from 4,079 adolescents between 15 and 18 years old in Mexico. Physical activity was measured with the Youth Physical Activity Questionnaire and was grouped into five domains: 1) moderate-to-vigorous physical activity, 2) sport activity, 3) leisure time activity, 4) Physical Education class, and 5) active commuting to school. Perception of safety was measured as pedestrian safety and crime safety, using the Neighbourhood Environment Walkability Scale-youth (NEWS-Y). A Confirmatory Factor Analysis was performed to examine the construct validity of NEWS-Y on the Mexican population. Data was collected in 2017 and analysed in 2018. Associations between physical activity and perception of safety were examined using linear regression models.

Results: Low perception of pedestrian safety was associated with lower moderate-to-vigorous physical activity per week (coef=-0.12, 95% CI=-0.19 to -0.05) and lower sport activity per week (coef=-0.13, 95% CI=-0.23 to -0.03) in females. There was no association between perception of safety and physical activity among males.

Conclusions: Pedestrian safety was negatively associated with moderate-to-vigorous physical activity and sport participation in females. Environments with better lighting, crosswalks and walking/cycle trails could increase females' physical activity.

1 **BACKGROUND**

2 Low levels of physical activity are associated with several non-communicable diseases (NCDs).

3 In Mexico, 9.4% of adults have been diagnosed with diabetes, 25.5% with hypertension¹ and
4 approximately 16% of premature deaths of people between 30 and 70 years old is attributed to
5 NCDs.² The latest National Health and Nutrition Survey in Mexico (2016) reported that 39.5%
6 of adolescents (48.8% females, 30.1% males) do not meet the World Health Organisation's
7 (WHO) physical activity guidelines (60 minutes per day of moderate-to-vigorous physical
8 activity).¹

9

10 Mexico is a middle-income country which has experienced a fast pace of recent urbanisation.

11 Currently, 63% of the population lives in urban areas and this is expected to reach 79% by
12 2050.³ This rapid urbanisation poses a number of challenges in facilitating active lifestyles, such
13 as creating recreational public spaces, incorporating cycling trails, and guaranteeing safety.^{3,4} In
14 Mexico, the second most common barrier to performing physical activity is lack of safe spaces
15 (37.7%),¹ and the perception of safety has worsened in the last few years.⁵ In the National
16 Survey of Victimization and Public Security Perception (2018),⁶ 79.4% of Mexicans reported
17 that they perceive their city as unsafe to live in and 33.4% have stopped going out for walks as a
18 result. Regarding pedestrian safety, 62.6% Mexicans identified insufficient public lighting as an
19 issue, 49.6% perceived streets in their city to be frequently full with traffic and 38% mentioned
20 neglected parks and public spaces.⁵ Consequently, 68.6% of adults would not let their children
21 (<18 years) go out alone,⁷ possibly constraining their physical activity to indoor areas or spaces
22 considered as "safe". There is a risk that rapid and unplanned urbanization in Mexico will affect
23 crime and pedestrian safety, and therefore may reduce physical activity.

24

25 Previous literature has explored the associations between perception of safety and physical
26 activity. A recent meta-analysis including studies from low-and middle-income countries found
27 that people reporting feeling safe from crime had 27% greater odds of achieving higher levels of
28 physical activity, compared to those living in areas with higher crime rates.⁸ However, another
29 systematic review reported that only 10.1% of the papers included found a negative association
30 between physical activity and crime safety.⁹ This surprising finding could be because studies
31 were conducted in high-income countries where crime rates are significantly lower than in low-
32 and-middle income countries. Similarly, pedestrian safety, the presence of traffic lights and
33 walking tracks have been associated with greater active travel among female adolescents¹⁰ and
34 low neighbourhood safety has been found to decrease the odds of being physically active outside
35 school by 48%.¹¹ Although these studies indicate how the perception of safety is associated with
36 physical activity, information is needed about this relationship in middle-income countries
37 where a high rate of crime is experienced along with rapid urbanisation. Also, as most data
38 pertaining to perceptions of safety in Mexico is amongst adults, there is a need to better
39 understand how young people's perceptions of safety are associated with their physical activity.
40 Moreover, physical activity research in Mexico, especially in adolescents, is not as advanced as
41 in other Latin American countries (e.g., Brazil, Colombia).

42

43 The aim of this study was to examine the association between perceived crime safety (fear of
44 being hurt by a stranger), perceived pedestrian safety (how safe does walking feel in terms of
45 traffic) and five domains of physical activity (moderate-to-vigorous physical activity, sport

46 participation, leisure physical activity, Physical Education class, and Active Commuting) in a
47 sample of Mexican adolescents between 15 and 18 years old.

48

49 **METHODS**

50 **STUDY DESIGN AND SETTING**

51 The study used a cross-sectional design conducted in Mexico City and Oaxaca. These two states
52 were chosen due to their difference in criminal activity (Mexico City=49,913 per 100,000
53 habitants vs. Oaxaca=27,897) and urbanisation level (Mexico City=58.16 vs. Oaxaca=39.70, on
54 a zero to 70 scale comprising the subscales: population density, economic activity, built
55 environment, communication, education, diversity and health).^{4,12} Data were collected between
56 February and June 2017. Adolescent physical activity and perception of safety were self-
57 reported. Ethical approval was obtained by [INSTITUTION DETAILS HAVE BEEN
58 REMOVED FOR PEER-REVIEW].

59

60 **RECRUITMENT OF SCHOOLS & PARTICIPANTS**

61 A list of private and public schools of Mexico City and Oaxaca was obtained from the
62 Department of Education in Mexico. Municipalities from both states were stratified by level of
63 urbanicity (low, medium, high) according to previous research,^{4,12} and SES tertile (low,
64 medium, high) according to the Life Quality Index from the National Electoral Institute in
65 Mexico.¹³ Eighty schools of each stratum per state were randomly selected (n=1,440), from
66 which 1,319 were eligible (students' age=15-18), 517 were excluded for being in areas
67 considered as unsafe for the researcher,¹⁴ and 706 for having private contact details, leaving a

68 total of 96 eligible schools. These schools were contacted via phone number, 79 did not reply
69 and seven refused to take part in the study, resulting in 10 schools (Mexico City: n=6, Oaxaca:
70 n=4) which agreed to participate.

71

72 In each school, all students between 15 and 18 years old and present at the day of data collection
73 were included (females=2074, males=2005). A more detailed description of the recruitment
74 process and the percentage of students belonging to each school is available in Appendix 1. Data
75 was collected using printed questionnaires applied by the lead researcher during school hours.
76 Students completed the 45 minute questionnaire after reading an information sheet and
77 completing a consent form.

78

79 **ASSESSMENT OF PHYSICAL ACTIVITY**

80 The duration and frequency of physical activity in the last 7-days was measured with the Youth
81 Physical Activity Questionnaire (Y-PAQ). The Y-PAQ covers a range of activities performed
82 during school time, leisure time, weekdays and weekends giving a comprehensive measure of
83 adolescents' physical activity,¹⁵ and has demonstrated test-retest reliability (ICC=0.79, p<0.001)
84 and construct validity (r=0.46, p=0.03)¹⁶ amongst adolescents. Due to the Y-PAQ not being
85 available in Spanish, it was back-translated from English (Appendix 2). The list of activities
86 were grouped into five domains: 1) Moderate-to-vigorous physical activity (any activity with a
87 metabolic equivalent \geq 4 METS)¹⁷, 2) sports activities (e.g., football, gymnastics, swimming), 3)
88 leisure time activities (e.g., bowling, roller-skating, playing with pets), 4) Physical Education
89 (PE) class at school, and 5) active commuting to school (walking, cycling). The five domains of

90 physical activity were calculated as continuous variables by multiplying duration (minutes) by
91 frequency (times per week) of the activities listed in the YPAQ questionnaire.¹⁸

92

93 **ASSESSMENT OF PEDESTRIAN SAFETY AND CRIME SAFETY**

94 Perceptions of safety were assessed using the “Pedestrian Safety” and “Crime Safety” sub-scales
95 from the Neighbourhood Environment Walkability Scale-youth (NEWS-Y).¹⁹ This tool was
96 translated for the purpose of this research from English to Spanish in order to be used in the
97 Mexican population. The NEWS-Y is an empirically-derived measure of various aspects of the
98 built environment related to walking in adolescents²⁰, from which pedestrian and automobile
99 traffic safety and crime safety subscales had acceptable test-retest reliability (ICC=0.67 and
100 ICC=0.73 respectively) in a previous study with adolescents (12-18 years old).²¹ The pedestrian
101 safety sub-scale comprises six questions related to how safe participants feel walking around the
102 neighbourhood in terms of traffic safety (e.g., drivers go faster than the posted speed limits),
103 while the crime safety sub-scale comprises five questions related to their level of fear of being
104 hurt by someone in their neighbourhood (e.g., I am afraid of being taken/hurt by a stranger in a
105 local park). Items from both subscales are measured with a one to four scale (i.e., strongly
106 disagree, somewhat disagree, somewhat agree, strongly agree). Subscale scores were calculated
107 as the mean of the subscale items with higher scores indicating a lower perception of pedestrian
108 safety and crime safety.

109

110 **STATISTICAL ANALYSIS**

111 The five outcomes of physical activity were assessed for normality through Shapiro-Francia test
112 and skewness and kurtosis. Due to non-normality, physical activity data were log-transformed.
113 The continuous variables of pedestrian safety and crime safety had a normal distribution.

114

115 There is no existing evidence for the construct validity of the crime and pedestrian safety
116 subscales of the NEWS-Y in Mexican adolescents. As such, a Confirmatory Factor Analysis
117 (CFA) was performed to examine the construct validity of the hypothesized structure and
118 relation between the subscales. The full methods and results of this analysis are in Appendix 3.
119 The final model comprised of three items assessing pedestrian safety ($\alpha=0.583$) and five items
120 assessing crime safety ($\alpha=0.794$). Even though item 2 (Speed of traffic on most streets is usually
121 slow) did not load on either factor, it was retained and analysed as a separate item to minimise
122 the loss of information.

123

124 To increase statistical power, multiple imputation by chained equations of missing data was
125 implemented for 4,079 participants. Seventy eight percent of participants provided complete
126 data, for all other participants values were missing at random and data was imputed to create a
127 complete data set. The physical activity outcomes, the safety items resulting from the CFA and
128 participants' characteristics that were potential predictors of missingness (i.e., gender, weight,
129 height, age, school and state) were included in the imputation model. Twenty imputed datasets
130 were created using 20 cycles of regression switching and results were then averaged over these
131 datasets using Rubin's rules.²² Complete case analysis of the original dataset is available in
132 Appendix 4, showing minimal/no differences with the analysis using the imputed dataset.

133

134 Descriptive statistics were calculated for variables in the imputed data, Body Mass Index (BMI)
135 was computed by using the BMI Index Cut-Offs for children (five to 19 years old) from the
136 WHO.²³ The associations between the three perception of safety variables (i.e., high speed of
137 traffic, pedestrian safety, crime safety) and the five physical activity outcomes were examined
138 using linear regression models. During exploratory analysis, the Wald test showed that by
139 including gender in the models, the fit would be improved ($p < 0.05$), therefore, separate models
140 for females and males are presented. Five linear regression models were run with physical
141 activity outcome variables (MVPA, sport activity, leisure activities, PE class, active commuting)
142 and exposures of perception of safety (i.e., high speed of traffic, pedestrian safety, crime safety)
143 for males and females separately. Due to the log transformation of physical activity variables,
144 the linear regressions must be interpreted as: $\ln Y_i = \alpha + \beta x_i + \varepsilon$, where a unit increase in x_i
145 results in an expected increase in $\ln Y_i$ of β . According to Benoit (2011), by performing a Taylor
146 series expansion, $e^\beta \approx 1 + \beta$ for $\beta \ll 1$, and therefore the interpretation of $\exp(\beta)$ is as a
147 percentage, meaning the expected percentage change in Y for a unit increase in x .²⁴

148

149 All models were adjusted for parents' education level, participant age, BMI and state. Robust
150 standard errors were used in all models to account for the clustering (non-independence) of
151 children in schools. All analyses were performed in STATA (Version 13), College Station, TX.

152

153 **RESULTS**

154 The results of the CFA are shown in Table 1. Factor loadings for pedestrian safety showed a
155 strong association to the underlying factor (ranged from 0.44-0.68) as well as factor loadings for
156 crime safety (0.46-0.75). Pedestrian safety and crime safety showed mean values greater than 2
157 (1 being safe and 4 unsafe), being greater among females than males.

158

159 Descriptive statistics of participants' physical activity are shown in Table 2. In all the physical
160 activity outcomes, except for leisure physical activity, males reported more minutes per week
161 than females. The prevalence of overweight and obesity was higher among males (26.71% and
162 6.13%, respectively) compared to females (20.46% and 2.85%, respectively).

163

164 The adjusted associations between perceived safety and physical activity outcomes are shown in
165 Table 3. In females, every unit increase of pedestrian safety (i.e., feeling less safe) was
166 associated with 12% lower MVPA per week (Coef. -0.12, 95% CI=-0.19 to -0.05), and 13% less
167 sport activity per week (Coef. -0.13, 95% CI=-0.23 to -0.03). Crime safety and high speed of
168 traffic were not associated with physical activity participation in females. There were no
169 associations between either crime, pedestrian safety nor high speed of traffic and any physical
170 activity variables amongst males.

171

172 **DISCUSSION**

173 In this study, the perception of lower pedestrian safety was associated with lower MVPA and
174 sport participation amongst females. Considering the mean MVPA of 671.61 minutes per week
175 amongst the females in the sample, the observed association would imply a difference of 241.77

176 minutes per week (671.61 min per week of MVPA x 0.12 x 3 units of difference of pedestrian
177 safety) of MVPA between a female perceiving high pedestrian safety (score 1 in the scale) and a
178 female perceiving low pedestrian safety (score 4 in the scale). Similarly, a mean of 450.17
179 minutes per week of sport-related physical activity would imply a difference of 175.57 minutes
180 per week of sport activity between a female perceiving high pedestrian safety and a female
181 perceiving low pedestrian safety. Findings suggest that, this increment of MVPA and sport
182 participation might be the difference between meeting and not meeting the WHO's physical
183 activity guidelines for some Mexican females.

184

185 As in many studies in Mexico and in other countries,²⁵⁻²⁷ females reported less physical activity
186 than males, and the data reported here suggest that pedestrian safety might be a contributing
187 factor for this. It is feasible that the lack of lighting in public spaces generates uneasiness and a
188 feeling of being a target of crime among females. It has previously been shown that the presence
189 of traffic lights is associated with greater active transport among female adolescents.¹⁰ Evidence
190 suggests that accessibility (i.e., how easy it is to get to...) to sport facilities (basketball courts,
191 parks, swimming pools...) is positively associated with the MVPA of female adolescents,^{28,29}
192 further, the total length of walking trails has been associated with greater active transport among
193 this population.¹⁰ Another explanation why perception of low pedestrian safety affects females
194 might be previous negative experiences in the neighbourhood and a sense of risk. As such, it
195 may be the case that the lack of cycling/walking trails and crosswalks in areas with heavy traffic
196 might be discouraging for females' MVPA and sport involvement.¹¹

197

198 In this study there was no association between active commuting and the perception of safety.
199 This lack of an association could be because in Mexico adolescents have to walk or cycle to
200 school in spite of safety perceptions as their family does not own a private vehicle. Previous
201 research in adults has shown that physical activity in Mexico is strongly driven by necessity
202 (i.e., active commuting to work) rather than by leisure.³⁰ Even though this study did not measure
203 how many adolescents had a car in their family, it is known that in Mexico the percentage
204 family car ownership is low (23%)¹ and therefore 75% of trips to school are done through active
205 commuting.³¹ It could be said that active transport in Mexico is a necessity and not choice, so
206 the influence of environmental factors might not be so relevant.

207

208 A positive association between increased safety and leisure physical activity was expected.
209 However, it is possible that part of adolescents' recreational activities are carried out within
210 school facilities and the YPAQ did not capture these activities. Moreover, participation in PE
211 class is usually performed inside school or on external school facilities in which cases transport
212 is provided.

213

214 In this study a Spanish version of the NEWS-Y scale was used to assess pedestrian safety and
215 Crime Safety. While testing the hypothesised factor structure, three items from the pedestrian
216 safety subscale, showed weak associations with other items of the same latent variable and also
217 cross-loaded with crime safety. Cross-loading could be explained by the order in which the
218 questions were asked (i.e., one item belonging to crime safety is placed in the middle of the

219 pedestrian safety items) and participants could have followed a pattern of answers without fully
220 reading the individual items. Future research should test new arrangements of items.

221

222 **STRENGTHS AND LIMITATIONS**

223 This study is the first study in Mexico that studies the association between perception of safety
224 and physical activity in the adolescent population, therefore it contributes to the dearth of
225 evidence in this population in Latin America. Among the strengths of the study is the use of a
226 large dataset with complete physical activity information for 4,079 adolescents. In addition,
227 support for the validity of the NEWS-Y measures of pedestrian and crime safety among
228 Mexican adolescents was provided. Another strength is the assessment of perceived safety
229 opposed to an objective measure of safety. This is important because perceived measures
230 acknowledge how people feel in their neighbourhood and surroundings and how these influence
231 their behaviour, compared to objective measures (i.e., crime statistics) provided by the
232 government.³² The study is limited by the cross-sectional design that prevents drawing
233 conclusions pertaining to the causality of the perception of the safety-physical activity
234 relationship. Also, the use of self-reported measure to assess physical activity might be
235 responsible for the high levels of physical activity (over-reporting). Schools were excluded if
236 they were in a very unsafe area, which could mean not covering the “full range” of safety as the
237 physical activity-perception of safety relationship was only observed at the higher end of the
238 scale (highest safety). This might lead to an overestimation of the perceptions of safety and to
239 not be generalizable to unsafe areas. Moreover, it is important to mention that the exclusion of
240 schools in unsafe areas and schools without contact details may limit the extent to which the
241 sample is representative of the adolescent population of Mexico City and Oaxaca. In the case of

242 the perception of safety measurement, although the NEWS-Y items were back-translated, no
243 examination of the clarity of the questions in Spanish was piloted and these steps are needed to
244 develop a more robust measure of perception of safety.

245

246 **CONCLUSIONS**

247 Perception of pedestrian safety was negatively associated with MVPA and sport participation in
248 females, there was no association among males. Results from this study suggest that
249 environments with better lighting, crosswalks, walking trails and signals on busy streets could
250 increase females' MVPA and sport participation. Future research should examine the association
251 between perception of safety and physical activity in a representative sample from all areas of
252 the security spectrum, also physical activity should be measured objectively (i.e. accelerometer).
253 Moreover, an examination of the clarity of the questions of the NEWS-Y in Spanish should be
254 performed.

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