SAGE-Hindawi Access to Research
Journal of Aging Research
Volume 2011, Article ID 420714, 10 pages
doi:10.4061/2011/420714

Research Article

The Impact of Physical Activity on Disability Incidence among Older Adults in Mexico and the United States

Kerstin Gerst,[1] Alejandra Michaels-Obregon,[2] and Rebeca Wong[2]

[1] *Institute of Gerontology, College of Public Health, University of Georgia, 255 E. Hancock Avenue, Athens, GA 30602, USA*
[2] *Sealy Center on Aging, University of Texas Medical Branch, Galveston, TX 77555, USA*

Correspondence should be addressed to Kerstin Gerst, gerstk@uga.edu

Received 31 August 2010; Revised 14 January 2011; Accepted 17 February 2011

Academic Editor: Iris Reuter

Evidence suggests that transitions among older adults towards healthy habits, such as physical activity, appear underway in developed countries such as the USA but not in developing countries such as Mexico. However, little is known about the potential benefit of physical activity in preventing disability among elders in countries at different stages of epidemiological transition. We explore the impact of physical activity on the disablement process among elders in Mexico compared to the USA. Data are from two waves of the Mexican Health and Aging Study and the Health and Retirement Study. We examine the impact of exercise on the transition from no disability to ADL limitations two years later. Findings indicate that exercise is more common in the U.S. than in Mexico. There is a positive effect of exercise on negative outcomes in both countries. However, the protective effect of exercise is stronger in the U.S. than in Mexico.

1. Introduction/Background

The United Nations [1] estimates that approximately 650 million people across the world (or 10% of the world's population) are living with a disability. Due to population aging and medical advances, this number is expected to continue to increase [1]. Research has shown that lifestyle risk factors, such as vigorous physical activity, can have a protective effect against disability. Specifically, data shows that exercise, even if not started until later in life, can result in the postponement of disability [2, 3]. In addition, researchers cite lifestyle differences as one of the contributors to health inequalities in populations [4].

The prevalence of disability varies across countries, however. Additionally, some countries are further along in adapting healthy lifestyle behaviors. Two particularly interesting countries to examine are Mexico and the United States. These countries are of interest because despite having different socioeconomic, demographic, and epidemiological profiles, they are closely linked geographically, economically, and socially. The United States population started to age earlier, and the process started under more advantageous economic conditions compared to when Mexico began to age. Additionally, the speed of aging is much faster for Mexico. Predictions show that the Mexican population over age 60 is expected to grow from 6% of the total population in 2000 to 15% in 2027. Compared to the United States and other developed countries, this 27-year pace is relatively fast. It will take the United States 70 years to reach a similar percentage in 2013 [5]. In addition to a rapid process, this is also "premature" in Mexico, due to the lack of infrastructure and lagging economic development [6]. The two countries are also in different stages of the epidemiological transition, as indicated by the current morbidity rates and mortality due to noncommunicable and communicable diseases. In Mexico, communicable diseases are more prevalent, while the relative importance of chronic conditions such as cardiovascular diseases and cancer is higher in the United States [5]. These contrasts mark different stages of transitions for the two countries that we compare.

A recent report [7] finds that the levels of disability prevalence, as measured in terms of limitations in activities of daily living (ADLs), were lower in Mexico than in the United States despite the lower level of socioeconomic development in Mexico compared to the USA. One possible explanation for this finding may be that the two countries are at different stages of the epidemiological transition. The current cohort of older adults in Mexico experienced higher infant and childhood mortality levels, and it is likely that only the "strongest" survived into old age [7]. In other words, persons surviving into old age in Mexico are relatively more robust than those surviving into old age in the USA and therefore have a lower disability rate. Furthermore, life tables appear to support this hypothesis. The numbers indicate that while life expectancy is lower in Mexico than in the USA at younger ages, beginning at age 75, the life expectancy actually becomes higher for Mexico than in the United States [8].

Little is known about how lifestyle risk factors, such as lack of physical exercise, can impact functional limitations in societies with very different demographic, epidemiological, and lifestyle behaviors profiles. It is possible that the impact of lifestyle on disability may be very different in Mexico than in the USA in part because the current cohorts of older adults in Mexico are more selected than in the United States. This paper therefore explores the impact of physical activity on disability transitions, among older adults in Mexico compared to the United States. Specifically, we postulate that since the selection of survivors among older adults is currently lower in the USA compared to Mexico overall, a healthy lifestyle (such as physical exercise) is likely to have greater beneficial effect in the USA than in Mexico. This hypothesis is of relevance for global aging because it means that lifestyle changes are likely to have differential impact on health according to the stage of the epidemiological transitions in which societies are.

2. Methodology

2.1. Data Sources. The proposed research takes advantage of the comparability of the Mexican Health and Aging Study (MHAS) and the Health and Retirement Study (HRS). To examine disability transitions across Mexico and the USA, we use two waves of the Mexican Health and Aging Study (MHAS: 2001 and 2003) and the RAND version of the Health and Retirement Study (HRS: 2000 and 2002). We examine 13,224 individuals at baseline in the HRS (2000) and 11,064 persons at baseline in the MHAS (2001). To determine transitions we observed disability outcomes both at baseline (2001 for MHAS and 2000 for the HRS) and two-year followup (2003 for MHAS and 2002 for the HRS).

The Mexican Health and Aging Study (MHAS) is a nationally representative prospective panel study of community-dwelling individuals born prior to 1951. The study was conducted by researchers at the University of Pennsylvania, University of Maryland, University of Wisconsin, and the Instituto Nacional de Estadística, Geografia e Informática (INEGI) in Mexico and funded by the National Institutes of Health/National Institute on Aging. The MHAS used a multistage cluster sampling methodology that randomly selected households with at least one individual aged 50 or older. Two waves were collected in 2001 and 2003. At baseline, approximately 15,000 eligible persons and their spouses were interviewed, with a response rate of 90.1%. A direct interview was conducted when it was possible, and proxy interviews were obtained when the subjects were in poor health or were temporarily absent (7.3% of the baseline sample were proxy interviews).

The Health and Retirement Study (HRS) is an ongoing large-scale longitudinal study nationally representative for community-dwelling adults over age 50. It is conducted by the University of Michigan with support from the National Institute on Aging (NIH/NIA). The HRS used a multistage national area probability sample of households in the United States and oversampled Blacks, Hispanics, and persons living in the state of Florida. We used the RAND version of the HRS dataset, which compiled all waves of the HRS data and used bracketing methods to minimize nonresponse in certain variables (see RAND [9] for more details). Respondents received direct interviews when possible and proxy interviews were conducted when subjects were unable to respond or were unavailable (7.5% of the baseline survey were proxy interviews).

We compare elders living in the community in Mexico to community-dwelling non-Hispanic whites who were born in and living in the United States. The MHAS survey was only conducted among elders living in the community because most long-term care is provided by families in that country. We addressed this limitation by excluding persons that were institutionalized in the USA from the analyses. This allows for a straightforward comparison by focusing on community-dwelling elders in both countries.

Additionally, only persons that identified as non-Hispanic white and who reported being born in the USA were included in the USA sample. Because both the HRS and MHAS interviewed age-eligible respondents and their spouses regardless of age, we only include persons aged 51 and older for the HRS and adults 52 years and older for MHAS, at baseline. Finally, we only included subjects with complete information on each variable in our analyses.

2.2. Variables. Because the MHAS is highly comparable to the HRS, the measures used in the analyses are very similar. The outcome of ADL limitations was measured using five components: bathing, toileting, transferring into/out of bed, walking, and eating. Each of the components in the questionnaire was coded disabled if the respondent answered "Yes" or "Cannot do" to having difficulty in performing the activity. If the respondent answered "Do not do" then the response was coded as missing. However, if they answered "Do not do" and received help performing the activity, they were coded as disabled.

2.2.1. Independent Variables. Our focal independent variable is whether or not respondents reported vigorous physical activity or exercise (note that we use the terms physical activity and exercise interchangeably throughout the remainder of the paper). The question used for this measure was similar across the two studies. Both the MHAS and the HRS asked respondents whether on average they had participated in vigorous physical activity or exercise three times a week a more. Vigorous activity or exercise was defined to include any activities such as sports, heavy housework, or a job that involve physical labor. This is a standard question and has been used extensively in the literature to operationally define self-reported physical activity (e.g., [4, 10, 11]). Research has shown support for using self-reported historical physical activity measures to assess physical activity performance. One such study found that self-reported historical walking, running, and jogging activities had reasonable validity when compared with objective measures, such as treadmill performance. Moderate Spearman's correlations between objective and self-report measures were significant for all correlations in the study ($P < .001$) [12]. There was one difference in the questions across studies. In Mexico, the question asked the respondent to reflect on the average over the last two years, whereas in the USA the respondents were asked to estimate over the past 12 months.

Because only one measure was available to capture the complex behavior of physical activity, it is important to establish validity of the focal independent variable. In order to establish construct validity (the ability of the measure to correspond to the theoretical concept under study), the physical activity measure must be related to other measures consistent with plausible hypotheses [13]. We assessed construct validity using the following two hypotheses: (1) respondents reporting problems with basic activities of daily living (walking, bathing, eating, toileting, and transferring in and out of bed) would be significantly less likely to report doing physical activity at baseline and (2) these correlations should remain significant across subgroups (e.g., gender and age). Results for both MHAS and HRS supported the hypotheses. The correlation coefficients between physical activity and the five ADL measures were consistently negative and significant. Specifically, the correlations between walking and physical activity were −0.159 in the USA and −0.099 in Mexico. For bathing and physical activity, the correlations for the USA sample were −0.168 and −0.088 in the Mexican sample, while for eating and physical activity, the correlations were −0.102 in the USA and −0.052 for Mexico. The correlations between transferring in/out of bed and physical activity were −0.123 in the USA and −0.059 in Mexico. Finally, the correlations between toileting and the physical activity measure were −0.119 in the USA and −0.062 in Mexico. Additional correlation results are available upon request. While the correlation coefficients had a lower magnitude in the Mexican sample than in the USA sample, all were significant ($P < .01$). We performed the same correlations by gender and age categories (51–59, 60–69, 60–79, 80+). The results remained significant across subgroups. Moreover, while significantly correlated at all ages, the correlations were stronger for older cohorts than for younger cohorts. This is in the expected direction and suggests robust findings.

Research has shown that disability rates vary by whether persons live in rural or urban areas; thus, we added a control variable for area of residence (reference category: rural). The measurement differed across the two data countries. For the United States, the HRS dichotomous variable was created using the 1993 Beale rural-urban continuum codes (see HRS [9]). The codes were collapsed into urban area (population size 250,000 or more) and rural (population less than 250,000). For Mexico, we used the MHAS locality size measurement to code areas with 100,000 or more people as urban. All other localities were coded as rural.

This study also controlled for wealth and having access to health insurance. Wealth was measured using household's net worth of homes, businesses, rental properties, capital, vehicles, and other debts and assets. Due to high nonresponse rates in these single items, both the HRS and MHAS used unfolding brackets to recover the nonresponse (RAND; Wong & Espinoza [9, 14], resp.). Health insurance was coded as a binary variable, where respondents were classified as having health insurance if they reported having at least one health insurance, regardless of type of insurance. Finally, additional control socioeconomic and demographic variables included age (continuous), gender (reference category: male), marital status (categorical: married and union, reference category; widowed; single, separated, or divorced), and education (continuous).

2.3. Statistical Methods. We begin by comparing prevalence of self-reported disability and physical activity among all older adults across the two countries regardless of disability level. For these descriptive results, we show data from the full sample at baseline in the United States and Mexico. This allows us to estimate and compare the prevalence across countries cross-sectionally. Due to the difference in age structures across the two countries, prevalence of ADL limitations and prevalence of physical activity (Table 2) is age standardized, using the weighted average of the two countries as the standard [15]. Age-adjusted rates of disability let us compare relative differences across the USA and Mexico. We also provide cross-sectional weighted descriptive data for both countries according to the exercise variable.

In order to determine if physical activity influences the incidence of disability, we next conduct a series of separate analyses by country across time. For this portion of the analyses, we select only those respondents that did *not* report any ADL limitation at time 1 and examine their status two years later. Because our study is based on longitudinal data, we face the issue of attrition and death by the followup period two years later (unobserved respondents). The followup outcome is therefore measured by five categories: remaining nondisabled across the two years, moving from no disability to one disability, from no disability to two or more disabilities, from no disability to death and those that are lost to followup. Table 1 shows the sample distribution of the outcome by country. Because we do not have data on disability status for those lost to followup, these cases were dropped in the longitudinal analyses. Both datasets showed a 5% loss to followup over the two years. In a separate analysis (not shown here), we found similar sample characteristics of those lost to followup across both studies.

We used multinomial models to determine the likelihood of moving to one of the followup categories over two years (reference group: remaining nondisabled). We first considered each country separately. We then combined the panel surveys from the two countries and included a country indicator (reference group: United States) to identify significant differences across countries.

Table 1: Sample size for outcome at time 2 for persons with no ADL limitations at time 1.

	United States					
	Observed			Not observed		Total
	No ADL limitations	1 ADL limitation	2 or more ADL limitations	Death	Loss to followup	
Unweighted *N*	9490	501	236	514	529	11270
(% within country)	(84%)	(4%)	(2%)	(5%)	(5%)	(100%)
	Mexico					
	Observed			Not observed		Total
	No ADL limitations	1 ADL limitation	2 or more ADL limitations	Death	Loss to followup	
Unweighted *N*	8907	328	326	300	568	10429
(% within country)	(85%)	(3%)	(3%)	(3%)	(5%)	(100%)

Notes: unweighted statistics; USA data included persons age 53 and older at time 2; Mexican data included persons 54 years and older at time 2; both samples include only community-dwelling persons with no ADL limitations at baseline.

The estimators of the multinomial model indicate the relationship of the outcome variable across categories of the independent variables that are interpreted as a relative risk ratio compared to a reference category (Hilbe [16]). In order to facilitate the interpretation of results, we also present figures of the estimated probabilities of the outcome variable based on the multivariate models. We estimated the general probabilities of each outcome category at followup by exercise, and we break down these predicted probabilities by age.

3. Results

Table 2 shows the age-standardized prevalence of functional limitations by country in Table 2(a) as well as the prevalence of exercise according to functional limitations in Table 2(b). Table 2(a) shows the prevalence of functional limitations across the two countries at baseline. The data confirmed previous research that overall disability rates were higher in the total USA elderly population than in the Mexican elderly population. Whereas 11.5% of elders in the USA reported at least one ADL limitation, about 10.6% of persons in Mexico reported a disability. However, Mexico showed higher prevalence rate for each individual ADL limitation measured. This somewhat counterintuitive finding suggests a higher degree of overlap of ADL limitations among persons in Mexico, which is confirmed when examining the number of ADL limitations reported. The pattern appears most pronounced in the percent with five ADL limitations. Less than one percent of the sample in the USA reported problems with all ADL limitations, whereas nearly two percent reported having limitations in all five areas in Mexico.

Table 2(b) compares the prevalence of physical activity in the USA and Mexico by ADL limitation categories, age standardized. In general, the prevalence of exercise is higher in the USA than in Mexico, where approximately 46% of persons in the USA reported doing vigorous physical activity, compared to less than one-third (29%) of elders in Mexico. When prevalence of physical activity is broken down by functional limitations, this pattern is perhaps most striking for those without any ADL problems. Nearly half (44%) of elders without a disability in the USA reported exercising, compared to 27% of elders without a disability in Mexico. However, for persons with one disability or with two or more disabilities, the difference between countries becomes very small.

3.1. Descriptives Bivariate. Table 3 provides prevalence of vigorous physical activity by main characteristics of the sample separately for each country. In both countries, the propensity to exercise is higher among younger individuals. In all age categories, the percent reporting physical activity is lower in Mexico than in the United States. In both countries men are more likely to report exercising than women, although the gender gap is much larger in Mexico than in the United States. Additionally, in the USA, there appeared to be a gradient in physical activity with assets, where those with higher assets had higher rates of physical activity. Such a gradient was not found in Mexico. In fact, those with lower assets were slightly more likely to exercise. Similarly, there was a slight gradient in physical activity with educational attainment in the USA, whereas such a pattern was not found in Mexico.

While for the USA sample there were not large differences in exercise behavior by area of residence and having health insurance, these showed important differences for the Mexican sample. Persons living in an urban area were more likely to report exercising than those living in a rural area in Mexico. Those persons without health insurance in Mexico were also more likely to exercise, compared to those that were insured.

3.2. Multinomial Models. Table 4 presents results for a series of multinomial models predicting going from zero ADLs at baseline to either one ADL, two or more ADLs, or death at followup. All models used the group that remained without any limitations as the reference category. Results show that the focal independent variable, physical activity, is significantly protective for each of the negative outcomes in the USA regression model (Model 1). However, in the

Table 2

(a) Age-standardized prevalence of ADL limitations at baseline, by country

	United States (unweighted $N = 13,224$) (weighted $N = 49,603,001$) Standardized rate	Mexico (unweighted $N = 11,064$) (weighted $N = 12,836,032$) Standardized rate
Percent reporting at least one ADL limitation	11.5%	10.6%*
Percent reporting each ADL limitation:		
Walking	5.2%	7.5%*
Bathing	5.0%	5.3%*
Eating	2.1%	3.0%*
Transferring in/out of bed	4.6%	7.2%*
Toileting	4.2%	5.2%*
Total number of ADL limitations reported:		
None	88.5%	89.4%*
One	6.2%	3.2%*
Two	2.7%	2.4%*
Three	1.3%	1.7%*
Four	0.7%	1.4%*
Five	0.6%	1.9%*

(b) Age-standardized prevalence of physical activity at baseline by country and functional limitations

	United States (unweighted $N = 13,224$) (weighted $N = 49,603,001$) Standardized rate	Mexico (unweighted $N = 11,064$) (weighted $N = 12,836,032$) Standardized rate
Percent reporting physical activity	45.9%	28.6%*
By number of functional limitations (at time 1)		
0	43.9%	27.2%*
1	1.3%	0.5%*
2 or more ADL limitations	0.6%	0.5%*

Notes: Age standardized using the weighted average of the two countries as the standard; population 51 years and older in the USA and 52 years and older in Mexico; weighted statistics using community-dwelling population only; *significant differences between countries at $P = .01$.

model examining Mexico only (Model 2), physical activity is significantly protective only for the worst outcomes (2+ ADLs and death).

Model 3 combines both countries to create a panel model with a country identifier variable. These results show that the level of disability is significantly different between the United States and Mexico. Also, the propensity to go from no ADL to a worse outcome is smaller in Mexico.

Finally, Model 4 adds in an interaction variable between physical activity and country. The results indicate that engaging in physical activity prevents negative health outcomes in both Mexico and the United States, although the effect is less protective in Mexico than in the United States. This is not the case for death, however, where exercise is protective for death in both countries, and the effect is not significantly different. In other words, the effect of physical activity on death has the same protective effect in both countries.

Additional models (results available upon request) examined a variety of potentially interesting interactions. In order to determine if the effect of physical activity is different across various characteristics, we ran Interactions between physical activity and gender, physical activity and age, and physical activity and education. None of these interactions were significant in the models. Finally, in order to test whether physical exercise was more beneficial across groups within countries, we ran interactions for country and education as well as country and area of residence. None of the interactions were significant in the models.

3.3. Predicted Probabilities. Figures 1 and 2 show the predicted probabilities of the outcome at time 2 by country and various demographic groups. Figure 1 visually charts the previous models predicting the probability of going from no

Table 3: Prevalence of physical activity at time 1 according to main characteristics, by country.

United States		Mexico		P-value across countries
Age*		Age*		
51–59	49.6%	52–59	39.4%	.000
60–69	50.0%	60–69	32.7%	.000
70–79	43.0%	70–79	22.9%	.000
80+	28.9%	80+	14.2%	.000
Sex*		Sex*		
Male	50.8%	Male	42.7%	.000
Female	41.3%	Female	23.1%	.000
Marital status*		Marital Status*		
Married, union	49.1%	Married, union	29.3%	.000
Single, divorced, separated	43.0%	Single, divorced, separated	35.8%	.000
Widowed	34.7%	Widowed	21.9%	.000
Education*		Education**		
<12 years	41.9%	0 years	31.4%	Na
12 years	47.4%	1–5 years	35.1%	Na
>12 years	52.6%	6 years	29.4%	Na
		7+ years	30.4%	Na
Assets*		Assets***		
Low	37.3%	Low	33.2%	.001
Medium	44.6%	Medium	31.7%	.000
High	51.4%	High	31.5%	.000
Location***		Location*		
Urban	46.8%	Urban	39.1%	.000
Rural	45.1%	Rural	24.3%	.000
Health insurance		Health Insurance*		
Uninsured	47.2%	Uninsured	38.6%	.000
Insured	45.6%	Insured	27.0%	.000
	5,965		**3,667**	
Total sample ($n = 13,224$)	45.10%	Total sample ($n = 11,064$)	33.10%	

Notes: Percentages are weighted statistics; sample sizes may vary due to missing values; data may not add to 100% due to rounding; HRS included persons age 51 and older at time 1; MHAS included 52 years and older at time 1; HRS and MHAS data includes only community-dwelling populations. Statistical comparisons based on unweighted data. Statistical test of the difference across categories for each variable *within* each country is reflected by embedded asterisks: $^*P < .001$, $^{**}P < .05$, $^{***}P < .1$. Statistical test of the difference *between* the two countries is reported in the final column (P value). Difference in education is not tested between countries because of the difference in educational categories.

ADL limitation at time 1 to one ADL limitation, 2 or more limitation, or to death at time 2, by physical activity and by country. The figure indicates that those who exercise have a lower probability of transitioning to a worse disability status or to death in both countries. The differences appear to be most dramatic for the United States.

Figure 2 presents predicted probabilities of outcome at time 2 by age. As expected, the probability of disability or death increased with age in each country, regardless of physical activity. However, the probability curve for transitioning to one ADL is nearly the same in Mexico for exercisers and nonexercisers. On the other hand, for the United States, there is a clear advantage for those who exercise, with a lower probability of transitioning to one ADL, especially at the older ages.

A protective effect appears for Mexico as well as for the USA when examining the probability of transitioning to two or more ADLs at time 2. Those who exercise in the USA have similar probability of transition to two or more ADLs as those who exercise in Mexico. The probability curve is lower for those who do not exercise in the United States than for those who do not exercise in the United States.

The final graph in Figure 2 shows the probability of death at time 2 by age, physical activity, and country. The results

Table 4: Multinomial models for outcome at time 2 for persons without ADL limitations at Time 1, united states and mexico.

	Model 1 United States			Model 2 Mexico			Model 3 Panel model			Model 4 Panel model with interaction		
	One ADL	2 ADLs +	Death	One ADL	2 ADLs +	Death	One ADL	2 ADLs +	Death	One ADL	2 ADLs +	Death
Age	1.06***	1.07***	1.09***	1.05***	1.07***	1.07***	1.05***	1.07***	1.08***	1.05***	1.07***	1.08***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)
Female	1.08	1.23	0.50***	1.40**	1.46**	0.59***	1.20*	1.36**	0.55***	1.23**	1.38**	0.55***
	(0.11)	(0.18)	(0.05)	(0.18)	(0.20)	(0.08)	(0.09)	(0.13)	(0.04)	(0.10)	(0.14)	(0.04)
Single	0.60***	0.93	0.63**	1.03	1.16	1.47	0.74**	0.95	0.96	0.77*	0.96	0.97
	(0.09)	(0.24)	(0.10)	(0.20)	(0.22)	(0.30)	(0.08)	(0.13)	(0.11)	(0.08)	(0.13)	(0.11)
Widowed	0.85	1.24	0.84	1.12	0.95	1.72***	1.04	1.06	1.35*	1.06	1.07	1.36*
	(0.14)	(0.34)	(0.15)	(0.17)	(0.15)	(0.27)	(0.12)	(0.14)	(0.16)	(0.12)	(0.14)	(0.16)
Education	0.96*	0.93**	0.95**	0.95**	0.90***	0.98	0.95***	0.91***	0.97*	0.95***	0.91***	0.97*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Wealth med	0.77*	0.94	0.64***	0.85	0.93	0.97	0.80*	0.94	0.74**	0.80*	0.94	0.74**
	(0.09)	(0.16)	(0.08)	(0.12)	(0.13)	(0.15)	(0.07)	(0.10)	(0.07)	(0.07)	(0.10)	(0.07)
Wealth high	0.59***	0.66*	0.53***	0.88	0.83	0.75	0.68***	0.74*	0.60***	0.68***	0.75*	0.60***
	(0.07)	(0.12)	(0.07)	(0.13)	(0.13)	(0.12)	(0.06)	(0.09)	(0.06)	(0.07)	(0.09)	(0.06)
Urban	0.85	0.85	1.08	0.84	1.00	1.30	0.86*	0.93	1.17	0.86	0.93	1.18
	(0.08)	(0.12)	(0.11)	(0.11)	(0.13)	(0.18)	(0.07)	(0.09)	(0.10)	(0.07)	(0.09)	(0.10)
Insurance	0.86	0.93	1.22	1.23	1.22	0.86	1.13	1.19	0.94	1.16	1.20	0.95
	(0.24)	(0.44)	(0.45)	(0.16)	(0.16)	(0.12)	(0.13)	(0.15)	(0.12)	(0.14)	(0.15)	(0.12)
Exercise	0.35***	0.36***	0.43***	0.89	0.55***	0.52***	0.48***	0.44***	0.45***	0.35***	0.35***	0.42***
	(0.04)	(0.06)	(0.04)	(0.12)	(0.09)	(0.08)	(0.04)	(0.05)	(0.04)	(0.04)	(0.06)	(0.04)
Country							0.42***	0.72	0.51***	0.35***	0.66*	0.49***
							(0.06)	(0.14)	(0.08)	(0.05)	(0.13)	(0.08)
Country* exercise										2.51***	1.55*	1.20
										(0.42)	(0.34)	(0.23)
Number of obs	10,683			9,184			19,867			19,867		
Pseudo-*R*-square	0.0969			0.0637			0.0827			0.0845		
LR chi2	994.01			484.73			1484.9			1517.06		
Prob>chi2	0.000			0.000			0.000			0.000		

Notes: HRS included persons age 51 and older at time 1; MHAS included 52 years and older at time 1; ADL: activities of daily living; cells indicate relative risk ratios, standard Errors in parentheses, reference category; no ADL limitations at time 2.
*** P-value < .001, ** P-value < .01, * P-value < .05.

indicate that exercise has a buffering effect on death for both countries. While the probability of death is higher for the USA than in Mexico regardless of exercise, the impact of exercise appears to be similar across both countries.

It is interesting to note that in each of the figures the differences appear especially pronounced at older ages.

4. Discussion and Conclusions

This paper compared the impact of physical activity on the incidence of disability among older persons in two countries at different stages of the epidemiologic transition, Mexico and the United States. To our knowledge, this is the first paper to examine the importance of physical activity on predicting transitions in disability using a comparative approach across two countries.

Results showed that physical activity was more prevalent in the USA than in Mexico. This supports recent evidence that transitions among older adults towards healthy lifestyle habits, such as avoiding tobacco and binge alcohol drinking, or exercising, appear to be underway in the USA but not yet in Mexico [4]. There are several potential explanations

	1 ADL		2 + ADLs		Death		No ADLs	
	Exercise	No exercise	Exercise	No exercise	Exercise	No exercise	Exercise	No exercise
U.S.	0.058	0.022	0.0244	0.0094	0.0465	0.0216	0.8711	0.947
Mexico	0.0305	0.0279	0.0279	0.0159	0.0270	0.0143	0.9147	0.9419

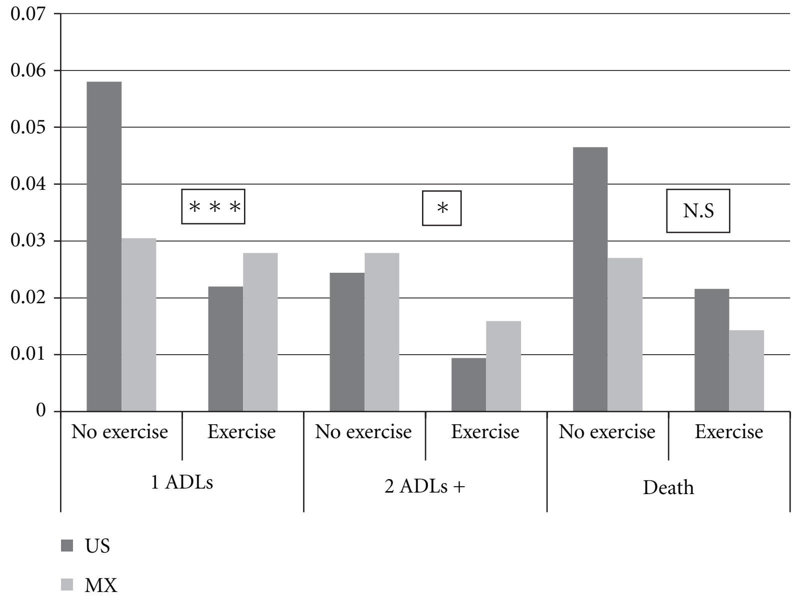

Figure 1: Probabilities of outcome at time 2, by country and exercise at time 1, for persons without ADL limitations at time 1. Notes: *P value < .05, **P value < .01, ***P value < .001; across country significance, N.S: not statistically significant across countries.

for this finding. One is that the survey questions were asked in a slightly different way across the two countries, and because physical activity was self-reported, it is possible that the interpretation of the question may have been different across the two samples. Another more plausible explanation was posited by Wong et al. [4] that the two countries are at different stages of a "lifestyle transition," where transitions to healthier lifestyles have progressed further in the USA than in Mexico. Social and policy changes impacting healthier lifestyle choices have occurred earlier in the USA and have been more extensive [4], which may in part explain this disparity in levels of exercise between the two countries.

We also found differences in physical activity across groups, including gender, which echoed findings by Wong et al. [4]. Men had nearly twice the prevalence rate of physical activity than women in Mexico (43% versus 23%, resp.). While the gender gap was not as large in the USA, men were still more likely to exercise than women. Although there were no large differences in physical activity prevalence by area of residence and health insurance status in the USA, there were notable differences by these groups in Mexico. It is possible that those uninsured or those living in an urban environment in Mexico may be employed in more physically demanding labor, which would be categorized as vigorous exercise in the surveys. It may also be possible that the logistics of exercising (e.g., accessing a gym) are easier in urban areas or that a culture of exercise has been adapted to a greater extent in urban areas of Mexico compared to rural areas of the country.

The results also show that not only is the level of disability different across the USA and Mexico, but that the effect of physical activity on disability is significantly different across the two countries. Overall, we found a beneficial effect of physical activity against onset of disability or death at followup in both countries. However, we also found that the protective effect of physical activity on disability is stronger in the USA than in Mexico. This supports our initial hypothesis that physical activity is less protective among the Mexican older population since they represent a more selected group of survivors than in the US. In other words, we speculate that older adults in the USA are more disabled at older ages and therefore are more likely to benefit from a lifestyle intervention. This result has important implications for aging in developing countries that are lagging in the epidemiological transition. We should expect that policies that are implemented in the countries towards healthy lifestyles should have lower impact while the countries are in early stages of the transition compared to the likely impact that similar policies may have later on.

One limitation of this study is the question used to determine physical activity in the surveys. Physical activity is a complex behavior and can be difficult to describe [17]. The question determining physical activity asked about exercise broadly, including everything from sports to physical

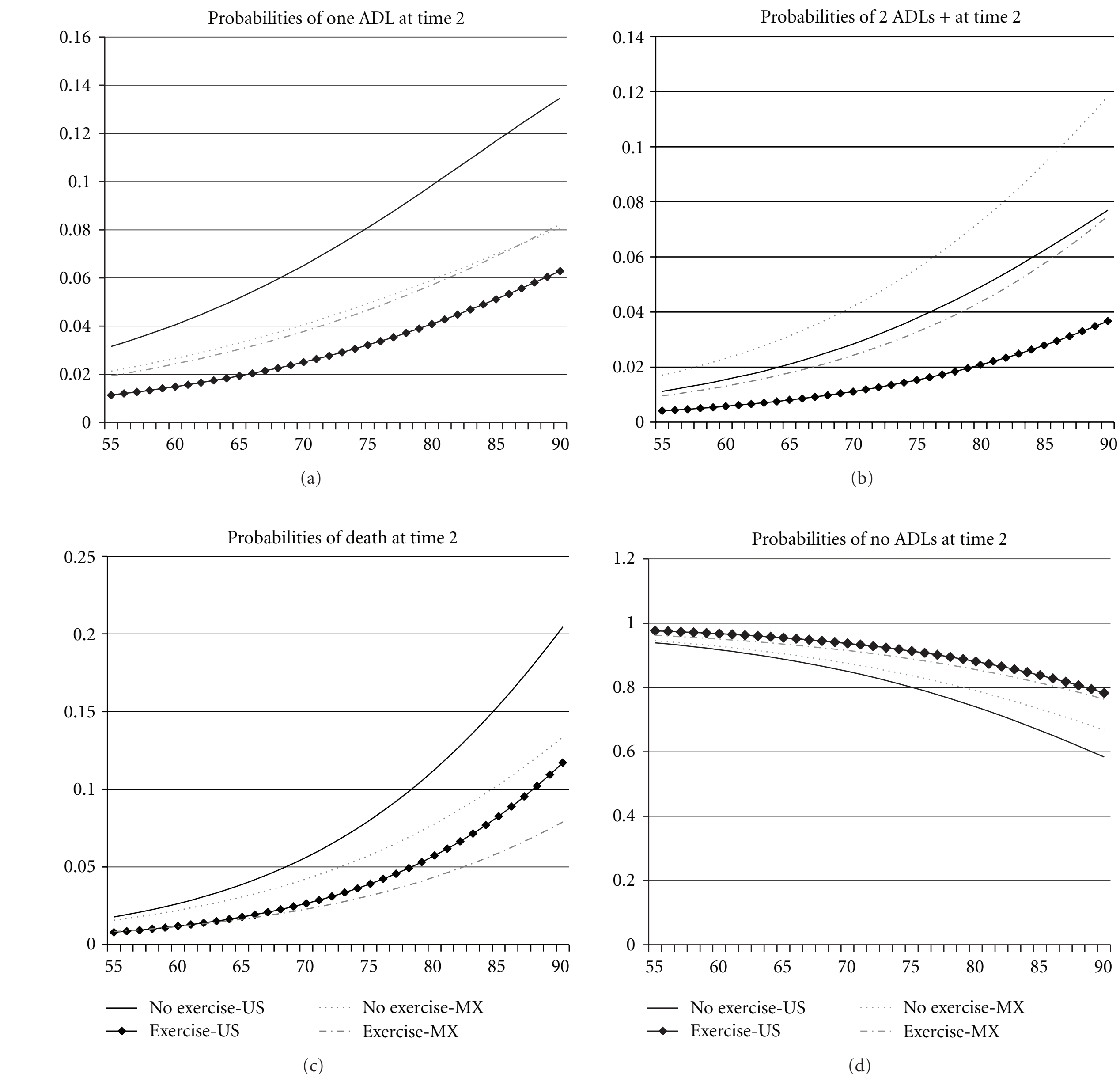

Figure 2: Probabilities of outcome at time 2, by country, exercise, and age for persons without ADL limitations at time 1.

labor. We are therefore unable to differentiate between those who exercise because of daily occupation-related physical labor and those that train at a gym, for example. It is likely that the various types of exercise may have different impacts on health. For instance, those working dangerous and physically demanding jobs may not see a benefit from their regular physical exertion, whereas those training in a gym may see the benefits of an exercise routine. This may be particularly the case when comparing these two countries with different cultures and at different lifestyle transitions. In rural Mexican communities, outdoor sports may be more prevalent, whereas gyms with modern fitness equipment may be more prevalent in urban USA areas. Similarly, recommendations by the Centers for Disease Control and Prevention and American College of Sports Medicine (CDC/ACSM) include an emphasis on the value of moderately intense activity, which we were unable to capture [18]. It was not possible to control for the type of activity or for the intensity of the activity in these surveys, and it is not clear how shorter or more moderate bouts of activity may impact functional limitations. More objective data would allow for a more precise measurement of physical activity. Future research should consider including measures such as metabolic equivalent task (MET) values, which allows the researcher to determine both the intensity and rate of exercise.

Finally, the wording of the activity question was identical across the two surveys except for the different time frames the respondents are asked to reflect on. Respondents in Mexico were asked about their average exercise in the last two years, whereas those in the USA were asked about their average over the past year. This is a limitation when comparing physical activity rates across countries, and the results should be interpreted with caution. However, the issue of timing is less of a concern when comparing the effects of physical activity on disability *within* each country, which is the main focus of this study.

As the epidemiological and demographic transitions continue to run their course in developing countries such as Mexico, it is likely that the levels of old age disability will increase. As the results of this study confirm, lifestyle changes such as exercise can help in the avoidance of chronic and disabling conditions. This is particularly important in the design of policies for older adults, since our work has shown that the beneficial effects of physical activity extend to these age cohorts in a developing country such as Mexico. However, our work has shown also that the positive effect of physical exercise may be dependent on the stage of the transition that societies are undergoing. This is informative, not only to expect lower impact of exercise on health overall compared to more developed countries, but also to motivate the search for modified or alternative exercise interventions to achieve a higher impact in countries that are early in the epidemiologic transition. Nevertheless, policies aimed to encourage physical activity in Mexico may play particularly important roles in preventing negative health outcomes. Our work has also indicated avenues of further work for future population-based studies, in order to better capture the concept of physical exercise among older adults.

Acknowledgments

This research was partially supported by NIA/NIH grant no. 5T32 AG 000270-10 while K. Gerst was a postdoctoral fellow at the UTMB Sealy Center on Aging, and by Grants nos. R01AG25533 and R01HD051764 for R. Wong and A. Michaels-Obregon.

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