



## Effect of physical activity on depression symptoms and perceived stress in Latinas: A mediation analysis

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### 1. Introduction

Evidence from cross-sectional, longitudinal, and experimental studies suggests that physical activity (PA), particularly moderate to vigorous PA (MVPA), plays an important role in the prevention and management of depression (Mammen & Faulkner, 2013; Teychenne, Ball, & Salmon, 2008). Moreover, results from observational and experimental studies indicate that PA has protective effects against perceived stress (Aldana, Sutton, Jacobson, & Quirk, 1996; Jonsdottir, Rodger, Hadzibajramovic, Borjesson, & Ahlberg, 2010; King, Taylor, & Haskell, 1993; VanKim & Nelson, 2013), which is an independent risk factor for depression (Kamimura et al., 2015). Despite the mental health benefits of PA interventions demonstrated among non-Hispanic Whites, their impact on perceived stress and depression among Latinas in the United States has received little attention. Latinas in the US, particularly Latina women, are more likely to report current mild, moderate, and severe symptoms of depression compared to non-Hispanic Whites, yet they are less likely to seek professional help (Pratt & Brody, 2014; Wassertheil-Smoller et al., 2014). Various factors may place Latinas at an elevated risk of stress and depression, including processes related to migration such as acculturation, language, and legal status (Fox & Kim-Godwin, 2011; Silveira, Pekow, Dole, Markenson, & Chasan-Taber, 2013); socio-economic status such as lower education/income, work-related stress (Easter et al., 2007) and less access to health care (Dunlop, Song, Lyons, Manheim, & Chang, 2003; Silveira et al., 2013); and socio-cultural factors such as discrimination (Paradies et al., 2015), caregiving responsibilities (Gallagher-Thompson et al., 2006), and complexities of social support networks (Viruell-Fuentes & Schulz, 2009). Given the existing evidence regarding the mental health benefits of MVPA, studying the effects of MVPA and MVPA interventions on depressive symptoms and perceived stress among Latinas in the US specifically is warranted.

To date, most studies that examine the effects of PA interventions on both depression and stress are short-term (Park, Han, Kang, & Park,

2013; Teychenne et al., 2008), ranging from days (Dimeo, Bauer, Varahram, Proest, & Halter, 2001) to months (Babyak et al., 2000); a limited number of studies have included follow-up periods of at least one year. Thus, little is known about the long-term impact of PA interventions on mental health. Moreover, the majority of these studies have used individual or group guided exercise programs (Park et al., 2013; Teychenne et al., 2008), which hinders our ability to differentiate between the effects of increased physical activity and the effects of increased social interaction with researchers and other participants on depression and stress. Additionally, most published studies have relied solely on subjective measures of physical activity, which is subject to recall biases. Assessing the association between depressive symptoms and PA through objective measures will address the limitations of previous studies.

This study aims to investigate 1) the effects of a 12-month mail-based PA intervention on changes in depressive symptoms and perceived stress among Latina participants; and 2) whether increases in MVPA (measured both subjectively and objectively) mediate the effects of the intervention on these mental health outcomes. We hypothesized that 1) participants in the physical activity intervention will report lower depressive symptoms and perceived stress compared to the attention control; and 2) MVPA will mediate intervention effects on depressive symptoms and perceived stress. This study thus entails several contributions to the literature. It assesses both the direct and the indirect effect of a PA intervention on mental health by using mediation models, and it focuses on Latinas living in the US. Moreover, it provides important information regarding the effects of a longer-term (12 months) PA intervention on depression and stress, using objective and subjective measures of PA, as well as a low-contact print-based intervention design.

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## 2. Method

### 2.1. Participants, intervention and procedure

Data for this study were obtained from 266 adult Latinas enrolled in the Seamos Saludables trial. Seamos Saludables was a randomized controlled trial comparing an individually-tailored, culturally-adapted PA intervention for insufficiently active Latinas with a wellness control condition. The primary purpose of the intervention was to increase MVPA levels among insufficiently active Latinas, with a goal of attaining the CDC guidelines of 150 min of MVPA/week by the end of the study. Details about the intervention implementation and main outcomes have been published previously (Marcus et al., 2013; Marcus et al., 2015; Pekmezi et al., 2012). Briefly, this 12-month intervention relied on individually tailored, mailed print materials to address some of the barriers to enrollment and participation in group-based PA interventions, such as a lack of transportation (Pekmezi et al., 2009). The intervention was culturally and linguistically adapted for Latinas through formative research (Pekmezi et al., 2012). For example, results from focus group discussions led to the addition of content discussing lack of time due to caregiving responsibilities and household chores (Pekmezi et al., 2012).

The Seamos Saludables trial was conducted in 2009–2012 at Brown University. Participants were recruited through advertisements in newspapers, radio, and television; flyers placed in strategic locations or distributed in churches, festivals, and other events; and other participants' referrals. Eligible participants were Latinas between the ages of 18 and 65 who reported engaging in fewer than 60 min of MVPA per week (assessed through a brief screener questionnaire that described MVPA and asked potential participants to report any MVPA performed in the past month). Participants were excluded if they had health conditions that would make PA unsafe for them, such as a history of stroke or heart disease. Exclusion criteria also included current or planned pregnancy and having plans to move from the area within 12 months. Human subjects approval was obtained from the Brown University Institutional Review Board.

Eligible participants were asked to attend an initial in-person orientation visit, in which they learned about the study details and were asked to provide written informed consent if they were still interested in participating. During a second in-person visit, questionnaires were used to collect information regarding several psychosocial constructs associated with physical activity, including stress and depression. Participants were also asked to wear an accelerometer for seven days and to return for a third in-person visit on the eighth day. During this third visit, participants were randomly assigned to the intervention or control group. Participants assigned to the intervention group were guided through a standardized protocol designed to help them set PA goals, identify potential barriers and solutions, create activity plans, and learn self-monitoring skills. The intervention was based on the Transtheoretical Model (Prochaska & Diclemente, 1983) and Social Cognitive Theory (Bandura, 1986) and consisted of regularly mailed print materials that addressed theoretical constructs. For example, strategies such as goal-setting and self-monitoring were used to promote increased self-efficacy, while materials were tailored to address needs and offer different strategies according to participants' stage of change. Participants assigned to the control group received information related to other health behaviors, such as healthy eating, sun protection, and breast cancer screening, on the same schedule as intervention participants.

For a period of 6 months after the randomization visit, intervention group participants received monthly questionnaires and individually tailored print-based materials related to MVPA, while control group participants received questionnaires and materials related to other health behaviors. At 6 months, a fourth in-person visit was conducted, in which the same measures that were conducted at baseline were repeated, and goal-setting and self-monitoring strategies were reinforced.

The last six months of the study was comprised of a tapered maintenance stage, where participants received bi-monthly questionnaires and materials. A final measurement visit was conducted at the 12-month follow up. In addition to the five in-person study visits, scheduled intervention calls occurred one week and one month after randomization. All study visits and intervention calls were conducted with participants in both study arms.

### 2.2. Measures

Two outcome variables were used in this secondary analysis: *depression symptoms* and *perceived stress*. The Spanish version of the Center for Epidemiologic Studies Short Depression Scale (CES-D) was used to measure participants' depression symptoms. This scale consists of 10 Likert-type survey items with response options weighed 0 (rarely or none of the time) to 3 (all of the time). The questionnaire asks participants about emotions they have experienced during the past week. Examples of items included, "I was bothered by things that usually don't bother me," and "I felt everything I did was an effort." This scale has also shown good reliability and validity in previous studies with Latino populations in the United States (Grzywacz, Hovey, Seligman, Arcury, & Quandt, 2006; Robison, Gruman, Gaztambide, & Blank, 2002). To measure change in depression symptoms, we subtracted baseline CES-D values from 12-month CES-D values.

The Spanish version of the Perceived Stress Scale (PSS) was used to measure participants' perceived stress (Cohen, Kamarck, & Mermelstein, 1983). This scale consists of 14 Likert-type survey items with response options weighed 0 (Never) to 4 (Very often). The PSS asks participants about their feelings and thoughts during the past month, with questions such as "In the past month, how often have you been upset because of something that happened unexpectedly?" and "In the last month, how often have you felt that you were unable to control the important things in your life?" The scale has shown good reliability and validity among different populations, including Latino populations (Campo-Arias, Bustos-Leiton, & Romero-Chaparro, 2009; Gonzalez Ramirez & Landero Hernandez, 2007; Reis, Ferreira Hino, & Rodriguez-Anez, 2010). To measure change in perceived stress, we subtracted baseline PSS data from 12-month PSS data.

Change in minutes per week of MVPA (from baseline to 12 months) was the primary goal of the study and served as a mediator variable for different models in this secondary analysis study. The Spanish version of the 7-Day Physical Activity Recall Interview (PAR) and ActiGraph GT3X accelerometers were used to measure minutes per week of MVPA at baseline, 6 months, and 12 months. The PAR is an interviewer-administered self-report measure that inquires about physical activity over the past week in at least ten-minute bouts across various contexts (leisure, occupational, etc.). It has shown good reliability, validity, and sensitivity to change over time (Sloane, Snyder, Demark-Wahnefried, Lobach, & Kraus, 2009) in both Latino and non-Hispanic White populations (Rauh, Hovell, Hofstetter, Sallis, & Gleghorn, 1992). Self-reported MVPA was the primary outcome on which the study was powered. As a second primary outcome, accelerometers were worn for 7 days, and data were processed using the ActiLife 5 software, with a cut point of 1952 to establish the minimum threshold for moderate intensity activity and minimum activity duration of 10 min. In addition to continuous MVPA, we created a dichotomous variable to differentiate between those who met CDC guidelines for MVPA at 12 months (> =150 min/week of MVPA) and those who did not.

### 2.3. Data analysis

All data analyses were conducted using RStudio Version 0.99.486. Descriptive analyses were conducted to summarize baseline data. T-tests of differences between means and Chi Squares were used to identify differences between the intervention group and the control group in sample characteristics (e.g. age, country of origin, education,

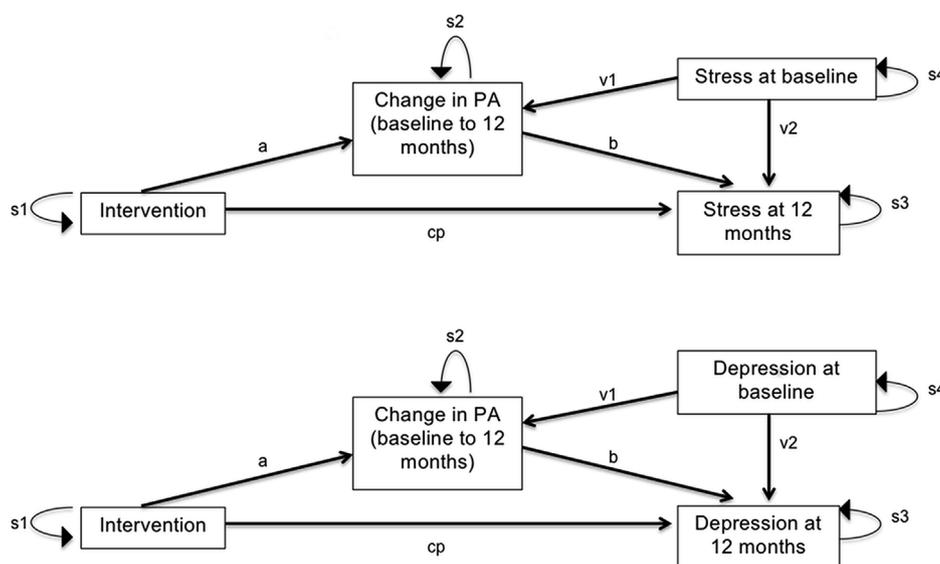


Fig. 1. Mediation models for the effect of the intervention on depression symptoms and perceived stress, mediated by PA.

income) and other study variables (i.e. baseline depression symptoms, perceived stress, and PA).

**Mediation analysis.** Analyses were conducted to determine whether the PA intervention had a significant effect on decreasing symptoms of depression and perceived stress after 12 months among participants, and whether change in MVPA (from baseline to 12 months) was the mechanism through which these decreases in depression symptoms and perceived stress occurred. Mediation models (run separately for self-reported and objectively measured MVPA outcomes) were used based on the product of coefficients approach with bootstrapped standard errors (1000 bootstrapped samples) and bias-corrected confidence intervals (Zhang & Wang, 2013). The *bmem* R package (Zhang & Wang, 2013) was used to create the mediation models, as it allows for different approaches to managing missing data including multiple imputation, which was used in this study.

Fig. 1 illustrates the hypothesized mediation models and the respective paths: the effect of the intervention on change in the MVPA mediator ( $a$  path), the effects of the change in the MVPA mediator on depression symptoms or perceived stress at 12 months ( $b$  path) and the total effect ( $c$  path) of the intervention on depression symptoms or perceived stress at 12 months. The direct effect ( $c'$  path) is the effect of treatment assigned on the outcome variables that does not go through the mediator. The indirect effect ( $ab$  path) of treatment indicates the amount of mediation, and under the Preacher and Hayes framework, is the product of path coefficients. The indirect effect of the intervention on mental health outcomes is the primary effect of interest. Following the guidelines presented in Preacher and Hayes (Preacher & Hayes, 2008), there is mediation of the intervention effect if the *indirect* effect of treatment through the mediator variable is significantly different than zero. Models adjusted for baseline values of depression symptoms or perceived stress.

Separate models were used to assess the effect of the intervention on depression symptoms or perceived stress, mediated by change in MVPA as continuous minutes/week or categorical as meeting PA guidelines.

**Additional mediation models.** Similar models were attempted using accelerometer data, wherever possible. However, because accelerometer-measured PA was not the main outcome of the trial, accelerometer data was not as complete as self-reported PA data. Thus, power for these models was diminished. Moreover, we were unable to build mediation models with accelerometer-measured meeting PA guidelines as a mediator; given the reduced sample size and the small number of participants who scored > 150 min/week of accelerometer-measured MVPA at 12 months, we did not have enough degrees of

freedom to construct such models.

In exploratory analyses, mediation models were also attempted among sub-samples of individuals who met the threshold for depression (depressed-only sample) and those who did not meet the threshold for depression (non-depressed only sample), to determine whether effects were enhanced in either group.

### 3. Results

#### 3.1. Participant characteristics

Baseline sample characteristics are presented in Table 1. Participants had an average age of  $40.6 \pm 9.9$ . Most had a high school education (74.8%) and employment (52.5%). More than half of participants were married and reported earning less than \$20,000 annually (53.5%). The majority of participants were born outside the mainland United States (93.6%) and were Spanish-language dominant (81.5%). Ethnic background was largely Dominican or Colombian (65.0%).

On average, participants scored 8 out of a maximum of 30 points on the CES-D (a score of 10 or above is indicative of depressive disorder). For perceived stress, participants scored approximately 22 of a maximum of 40 points.

#### 3.2. Mediation models

**Mediation models with self-reported PA data.** As shown in Table 2, although the PA intervention had no direct effect on changes in depressive symptoms (Path C'), it had a statistically significant indirect effect through changes in self-reported minutes/week of MVPA ( $B = -0.422$ ,  $SE = 0.174$ ,  $95\%CI = -0.812, -0.140$ ). Specifically, the intervention significantly increased changes in minutes/week of MVPA (Path A;  $B = 54.084$ ,  $SE = 13.650$ ,  $95\%CI = 26.581, 80.565$ ), and MVPA minutes/week had a significant effect on depressive symptoms such that, on average, an additional 125 min per week of MVPA resulted in a 1-point reduction in depression symptoms (Path B;  $B = -0.008$ ,  $SE = 0.002$ ,  $95\%CI = -0.012, -0.003$ ).

As shown in Table 3, the intervention also had a statistically significant indirect effect on depressive symptoms through meeting PA guidelines ( $B = 0.250$ ,  $SE = 0.140$ ,  $95\%CI = -0.649, -0.051$ ). The intervention significantly increased the likelihood of (self-reported) meeting PA guidelines (Path A;  $B = 0.156$ ,  $SE = 0.047$ ,  $95\%CI = 0.069, 0.250$ ). Additionally, meeting PA guidelines had a significant effect on decreasing depressive symptoms such that meeting

**Table 1**  
Baseline characteristics of participants in the Seamos Saludables Trial (N = 266).

	Intervention (n = 132)	Control (n = 134)
	Mean (SD)	Mean (SD)
Age	41.6 (10.1)	39.8 (9.8)
Perceived Stress Scale	21.5 (8.5)	21.9 (8.2)
CESD	7.8 (6.1)	7.6 (6.0)
7-Day PAR Physical Activity	1.9 (6.9)	3.0 (10.3)
Accelerometer Physical Activity	9.5 (33.0)	8.9 (22.2)
	N (%)	N (%)
<b>Ethnic background</b>		
Dominican	46 (34.8)	57 (42.5)
Colombian	40 (30.3)	30 (22.4)
Other	46 (34.8)	47 (35.1)
<b>Education</b>		
High School or less	58 (43.9)	62 (46.3)
Technical School or some college	43 (32.6)	44 (32.8)
College or Graduate School	31 (23.5)	28 (20.9)
<b>Employment</b>		
Unemployed	60 (45.8)	64 (48.1)
Full Time Employment	48 (36.6)	33 (24.8)
Part Time Employment	23 (17.6)	33 (24.8)
<b>Income</b>		
< 20,000	67 (52.8)	69 (54.3)
20,000–39,999	33 (26.0)	28 (22.1)
> = 40,000	17 (13.4)	11 (19.7)
<b>Marital status</b>		
Married or have partner	82 (62.1)	69 (51.9)

**Table 2**  
Mediation Model Testing the Effect of the Seamos Saludables PA Intervention on Depression Symptoms, Through Change in Minutes/Week of Self-Reported PA (N = 266).

Predictor	B	SE	95% CI
Path C Prime: Direct effect of intervention on change on depression symptoms			
PA intervention	0.520	0.705	-0.822, 1.875
Path A: effect of intervention on physical activity			
PA intervention	54.084	13.650	26.581, 80.565
Path B: effect of PA on change in depression symptoms			
Physical activity change	-0.008	0.002	-0.012, -0.003
Mediation effect			
Path A * Path B	-0.422	0.174	-0.812, -0.140

**Table 3**  
Mediation Model Testing the Effect of the Seamos Saludables PA Intervention on Depression Symptoms, Through (Self-Reported) Meeting PA Guidelines (N = 266).

Predictor	B	SE	95% CI
Path C Prime: Direct effect of intervention on change on depression symptoms			
PA intervention	0.287	0.694	-1.138, 1.633
Path A: effect of intervention on meeting PA guidelines			
PA intervention	0.156	0.047	0.069, 0.250
Path B: effect of PA on change in depression symptoms			
Meeting PA guidelines	-1.624	0.730	-3.060, -0.116
Mediation effect			
Path A * Path B	-0.250	0.140	-0.649, -0.051

guidelines was associated with a 1.6-point reduction in depressive symptoms (Path B; B = -1.624, SE = 0.730, 95%CI = -3.060, -0.116).

Similarly, as shown in Table 4, the PA intervention had no direct effect on perceived stress (Path C'), yet it had a statistically significant indirect effect through change in minutes/week of MVPA (B = -1.121,

**Table 4**  
Mediation Model Testing the Effect of the Seamos Saludables PA Intervention on Perceived Stress, Through Change in Minutes/Week of Self-Reported PA (N = 266).

Predictor	B	SE	95% CI
Path C Prime: Direct effect of intervention on change in perceived stress			
PA intervention	1.031	1.125	-1.102, 3.142
Path A: effect of intervention on physical activity			
PA intervention	56.753	14.151	30.253, 86.315
Path B: effect of PA on change in perceived stress			
Physical activity change	-0.020	0.007	-0.034, -0.009
Mediation effect			
Path A * Path B	-1.121	0.569	-2.617, -0.342

SE = 0.569, 95%CI = -2.617, -0.342). The intervention significantly increased change in minutes/week of MVPA (Path A; B = 56.753, SE = 14.151, 95%CI = 30.253, 86.315). Additionally, MVPA had a significant effect on decreasing perceived stress such that, on average, an additional 50 min per week of MVPA resulted in a 1-point reduction in perceived stress (Path B; B = -0.020, SE = 0.007, 95%CI = -0.034, -0.009).

Finally, as shown in Table 5, the intervention also had a statistically significant indirect effect on perceived stress through meeting PA guidelines (B = -0.584, SE = 0.341, 95%CI = -1.536, -0.100). The intervention significantly increased the likelihood of meeting PA guidelines (Path A; B = 0.149, SE = 0.048, 95%CI = 0.052, 0.242). Additionally, meeting PA guidelines had a significant effect on decreasing perceived stress (from baseline to 12 months) such that meeting guidelines was associated with a 3.9-point reduction in perceived stress (Path B; B = -3.931, SE = 1.570, 95%CI = -7.431, -1.199).

**Mediation models with accelerometer data.** Using accelerometer data for mediation models, there was a significant effect of the intervention on accelerometer-measured minutes per week of PA (Path A: B = 22.809, SE = 7.760, CI = 7.941, 37.821), a significant effect of this PA on perceived stress (Path B: B = -0.021, SE = 0.009, CI = -0.037, -0.003), and a significant mediation effect (B = -0.485, SE = 0.303 CI = -1.173,-0.054). On the other hand, we did not find change in accelerometer-measured PA to be predictive of depression symptoms at 12 months. We were unable to build mediation models with accelerometer-measured meeting PA guidelines because we did not have enough degrees of freedom to construct such models (i.e. few people met the guidelines based on accelerometer data).

**Mediation models among depressed and non-depressed subsamples.** Among the non-depressed only sample, the PA intervention had a statistically significant indirect effect on depression through change in self-reported minutes/week of MVPA (B = -0.632, SE = 0.217, 95%CI = -1.317, -0.325). The intervention significantly increased change in minutes/week of MVPA (Path A; B = 60.663, SE = 16.437, 95%CI = 26.561, 93.277). Additionally, MVPA had a significant effect on decreasing depression symptoms such that, on average, an additional 100 min per week of MVPA resulted in a 1-point

**Table 5**  
Mediation Model Testing the Effect of the Seamos Saludables PA Intervention on Perceived Stress, Through (Self-Reported) Meeting PA Guidelines (N = 266).

Predictor	B	SE	95% CI
Path C Prime: Direct effect of intervention on change in perceived stress			
PA intervention	0.526	1.060	-1.374, 2.749
Path A: effect of intervention on meeting PA guidelines			
PA intervention	0.149	0.048	0.052, 0.242
Path B: effect of PA on change in perceived stress			
Meeting PA guidelines	-3.931	1.570	-7.431, -1.199
Mediation effect			
Path A * Path B	-0.584	0.341	-1.536, -0.100

reduction in depression symptoms (Path B;  $B = -0.010$ ,  $SE = 0.003$ ,  $95\%CI = -0.016, -0.006$ ).

Similarly, the PA intervention had a statistically significant indirect effect through change in accelerometer-measured minutes/week of MVPA ( $B = -1.621$ ,  $SE = 0.709$ ,  $95\%CI = -3.115, -0.443$ ). The intervention significantly increased change in minutes/week of MVPA (Path A;  $B = 58.252$ ,  $SE = 16.501$ ,  $95\%CI = 20.912, 86.543$ ). Additionally, MVPA had a significant effect on decreasing perceived stress such that, on average, an additional 36 min per week of MVPA resulted in a 1-point reduction in perceived stress (Path B;  $B = -0.028$ ,  $SE = 0.007$ ,  $95\%CI = -0.042, -0.014$ ). However, among this sub-sample of non-depressed individuals, the intervention did not have a statistically significant indirect effect on perceived stress or depression symptoms through meeting PA guidelines. Nevertheless, it is important to note that our ability to test these models might have been compromised because only 17 out of 147 in this sub-sample met PA guidelines at 12 months, resulting in wide confidence intervals.

None of the mediation models attempted among the depressed-only sub-sample demonstrated significant direct or indirect effects of the intervention on perceived stress, nor on depression symptoms.

#### 4. Discussion

These secondary analyses evaluated the effects of a PA intervention, which was primarily designed to increase MVPA among insufficiently active Latinas, on mental health indicators. Contrary to our hypothesis, the PA intervention compared to the wellness control did not directly reduce depressive symptoms or perceived stress at 12 months. A direct effect of the intervention on the outcome variables is nevertheless not a necessary condition for mediation under currently accepted mediation procedures, particularly when, as is the case with our model, the two variables are not very proximal in time (Shrout & Bolger, 2002). Our results did support our hypothesis that the PA intervention indirectly reduced depressive symptoms and perceived stress through increases in self-reported MVPA: among women who reported increases in MVPA as a result of the intervention, there were reductions in symptoms of depression and perceived stress.

To our knowledge, there are no published studies examining the impact of PA interventions on symptoms of depression and perceived stress among Latinas in the US. Studies among other populations have reported that MVPA and MVPA interventions have a positive effect on levels of depression symptoms (Stanton & Reaburn, 2014; Teychenne et al., 2008) and perceived stress (Park et al., 2013). However, most studies examining the effects of PA interventions on depression and stress employ short-term, (individual or group-guided) structured PA sessions (Park et al., 2013; Teychenne et al., 2008). Our intervention spanned 12 months and aimed to motivate people to adopt PA on their own. Thus, our study provides new information regarding the effects of a longer PA intervention on mental health. Additionally, because this intervention entailed limited interaction between participants and interventionists, and very little or no interaction among participants, we are better able to attribute the mental health outcomes to increases in MVPA, as opposed to increases in social interaction with other participants and/or study staff.

Nevertheless, these same features of the intervention may also have made it more susceptible to non-compliance and, therefore, lower doses of the intervention received. This may partially account for the small effect sizes observed in our results, which are nevertheless comparable to the small decreases on depression and stress scales reported in previous studies (King et al., 1993; Roth & Holmes, 1987). Effect sizes were particularly small when change in accelerometer-measured (versus self-reported) MVPA was used as the mediator variable, which resulted in a non-significant indirect effect for the depression symptoms model; missing data and a narrow range in the accelerometer-measured MVPA mediator variable may also partially account for these results. Additionally, it is important to note that participants in the Seamos

Saludables trial scored relatively low on depressive symptomology at baseline, so the room for improvements in depressive symptoms was relatively small and thus power was diminished, as suggested in previous research (Teychenne et al., 2008).

The issue of statistical versus practical significance must be considered: while our models revealed statistical significance, the amount of MVPA required to obtain decreases in depression symptoms and perceived stress may or may not have clinical relevance. In this appraisal, it is important to consider that while our PA intervention promoted both moderate and vigorous intensity PA, most participants chose to walk at moderate intensity, while few engaged in vigorous intensity PA. Future research might thus study the mediation effect of vigorous intensity PA specifically, as research suggests that higher intensities may have a stronger effect on mental health (Gerber et al., 2014). However, compliance often becomes a major barrier when vigorous exercise is prescribed among individuals with very low fitness levels such as those in this study. Future research would also benefit from investigating the moderating effect of different types of PA (e.g. leisure-time, occupational, transportation) and different settings for PA (e.g. indoors, outdoors) on similar mediation models. Previous research suggests that physical activity performed outdoors in rural environments, for example, might have increased mental health benefits compared to activities performed in urban environments (Marselle, Irvine, & Warber, 2013) and that leisure-time PA might have increased mental health benefits than occupational and other PA (Asztalos et al., 2009).

This study is not without limitations. First, our sample consisted predominately of Caribbean, immigrant, and Spanish-speaking Latinas in the Northeastern US, which may not be representative of other Latino subgroups. Second, poor accelerometer compliance was an obstacle to further explore mediation models using this objective PA measure. Additionally, the main outcome variables contained missing data. Although our mediation models used imputation techniques that did not assume missing at random, it is important to mention that participants who did not complete these outcome measures reported significantly higher depressive symptoms at baseline. Therefore, due to missing data from individuals with higher baseline depression scores, our analytic sample may have provided low power to test the effect of PA among these generally non-depressed adults. Future studies must investigate how to better retain individuals with higher depression scores in MVPA interventions from which they might benefit.

Overall, these findings suggest that increases in MVPA resulting from participation in a 12-month, print-based, low-contact PA program for insufficiently active Latinas resulted in modest improvements in depressive symptoms and perceived stress. These small but statistically significant results are encouraging considering that mental health was not intentionally targeted in the study design, suggesting that results may have been larger if targeted mental health intervention components were added to supplement PA. These findings thus represent a promising approach to improving mental health among Latinas in the US, which is particularly important given that Latinos are less likely to seek professional help for mental health compared to other ethnic groups (Pratt & Brody, 2014). Future studies should further elucidate the MVPA dose and the intensity of MVPA interventions required to improve perceived stress and depressive symptoms, as well as potential interactions between PA and unique stressors experienced by Latinas. Additionally, further research is warranted to understand whether improving perceived stress and depressive symptoms among this population would lead to higher levels of PA; previous research has found that increased depression symptoms might result in decreased MVPA, thus suggesting a need to address depression to achieve successful MVPA promotion results (Scarapicchia et al., 2014).

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### Availability of data

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

### Declarations of interest

None.

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### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.mhpa.2019.03.001>.

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