Adverse Childhood Experiences, Depressive Symptoms, Functional Dependence, and Physical Activity: A Moderated Mediation Model

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Background: Adverse childhood experiences, depressive symptoms, and functional dependence are interrelated. However, the mechanisms underlying these associations remain unclear. The authors investigated the potential of depressive symptoms to mediate the effect of adverse childhood experiences on functional dependence in older age and whether physical activity moderated this mediation. **Method**: Data from 25,775 adults aged 62 (9) years from the Survey of Health Ageing and Retirement in Europe were used in adjusted linear mixed-effects models to test whether depressive symptoms mediated the associations between adverse childhood experiences and functional dependence in activities of daily living (ADL) and instrumental ADL (IADL) and whether physical activity moderated these mediations. **Results**: The results showed a graded association between the number of adverse childhood experiences (0 vs 1 and 0 vs ≥2) and the number of functional limitations in both ADL (bs = 0.040 and 0.067) and IADL (bs = 0.046 and 0.076). These associations were mediated by depressive symptoms. Physical activity reduced the effect of adverse childhood experiences on depressive symptoms (bs = −0.179 and −0.515) and tempered the effect of depressive symptoms on functional dependence both in ADL (b = −0.073) and IADL (b = −0.100). As a result of these reductions, the effect of adverse childhood experiences and depressive symptoms on functional dependence in ADL (Ps > .081) and IADL (Ps > .528) was nonsignificant in physically active participants. **Conclusions**: These findings suggest that, after age 50, engaging in physical activity more than once a week protects functional independence from the detrimental effects of adverse childhood experiences and depression. In inactive individuals, the detrimental effects of adverse childhood experiences on functional dependence are mediated by depressive symptoms.

Keywords: activities of daily living, depression, disability, exercise, mental illness

A recent systematic review has demonstrated that adverse childhood experiences, such as neglect and household dysfunction, were associated with 23 health outcomes (eg, depressive symptoms, anxiety, physical inactivity, obesity).[1] While these results highlight the pervasive harms that adverse childhood experiences place on multiple dimensions of health, they do not reveal the nature of the relations linking adverse childhood experiences and health outcomes. Assessing whether these relations are direct or indirect (ie, explained by an intermediary variable) and whether they can be attenuated or eliminated through other factors would refine our understanding of the mechanisms underlying these relations.

Functional dependence is one of the health outcomes that has been associated with adverse childhood experiences.[2] It is typically assessed through performance in activities of daily living (ADL)[3] and instrumental ADL (IADL),[4] with ADL referring to more basic activities (eg, walking, eating, bathing) than IADL (eg, shopping, preparing meals, housekeeping). Older adults who perform these activities without limitations have life expectancies 5 years longer than those with functional limitations[5] and are more satisfied with their life.[6] New insights into the relationship linking adverse childhood experiences and functional dependence in aging could reveal new ways to increase life expectancy and well-being.

Depression, a mood disorder that causes a persistent feeling of sadness and loss of interest,[7] may be critical in understanding the relations between adverse childhood experiences and functional dependence. Indeed, etiological models for depression consider stressful experiences, such as adverse childhood events, as a factor increasing the odds of depression.[8] Recent results supported these models by showing a strong positive association between adverse childhood experiences and the probability of depressive symptoms in late adulthood,[9–11] thereby supporting the theoretical link between adverse childhood experiences and depressive symptoms. In addition, studies have shown an association between depression and functional dependence.[12–15] The mechanisms underlying this association could lie in the main symptom of depression, the "lack

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of interest to all or most things,"[16] which can potentially decrease the frequency in which an individual engages in ADL and IADL. In the long term, this decreased frequency could impact the ability to perform these activities, especially in aging, by further increasing the age-related decline of movement control, such as postural balance[17] and bimanual coordination.[18]

In sum, the data support the effect of adverse childhood experiences on functional dependence and depressive symptoms, as well as the effect of depressive symptoms on functional dependence, thereby suggesting that depressive symptoms could mediate the effect of adverse childhood experiences on functional dependence. However, to the best of our knowledge, no study has formally tested for this potential mechanism.

Understanding the mechanisms underlying the relation between adverse childhood experiences and health outcomes is important from a fundamental research perspective. Moreover, this knowledge could inform clinical and political decisions aiming at improving health. To address this point, we investigated whether protective factors could attenuate the relations linking adverse childhood experiences, depressive symptoms, and functional

Table 1 Participants' Characteristics as a Function of the Number of ACE at Baseline

Variable	No ACE (n = 20,256)	1 ACE (n = 4526)	≥2 ACEs (n = 986)	P value
Functional dependence in ADL (mean [range]; SD)	0.22 [0–6]; 0.74	0.28 [0–6]; 0.88	0.30 [0–5]; 0.85	<.001
Functional dependence in IADL (mean [range]; SD)	0.14 [0–7]; 0.59	0.19 [0–7]; 0.7	0.20 [0–7]; 0.65	<.001
Depressive symptoms (mean [range]; SD)	2.18 [0–12]; 2.16	2.61 [0–12]; 2.38	2.80 [0–11]; 2.42	<.001
Physical activity (n; % of physically active)	14,311; 71.0	3071; 67.9	695; 70.5	<.001
Gender (n; % of women)	11,341; 56.0	2462; 54.4	534; 54.2	.095
Years of age at baseline (mean [range]; SD)	62.4 [50–93]; 9.2	63.7 [50–89]; 8.9	64.8 [50–85]; 8.3	<.001
Country (n; %)				<.001
Belgium	2074; 10.2	466; 10.3	78; 7.9	
Austria	653; 3.2	165; 3.6	65; 6.6	
Denmark	1540; 7.6	377; 8.3	78; 7.9	
France	1659; 8.2	432; 9.5	83; 8.4	
Germany	1201; 5.9	392; 8.7	158; 16.0	
Greece	2350; 11.6	376; 8.3	50; 5.1	
Italy	1847; 9.1	462; 10.2	90; 9.1	
The Netherlands	1724; 8.5	252; 5.6	48; 4.9	
Spain	1563; 7.7	420; 9.3	112; 11.4	
Sweden	1431; 7.1	278; 6.1	66; 6.7	
Switzerland	965; 4.8	213; 4.7	50; 5.1	
Czech Republic	1364; 6.7	255; 5.6	31; 3.1	
Ireland	509; 2.5	90; 2.0	10; 1.0	
Poland	1376; 6.8	348; 7.7	67; 6.8	
Birth cohort (n; %)				<.001
After 1945	9322; 46.0	1637; 36.2	276; 28.0	
Between 1939 and 1945	4580; 22.6	1107; 24.5	273; 27.7	
Between 1929 and 1938	4360; 21.5	1342; 29.7	355; 36.0	
Between 1919 and 1928	1994; 9.8	440; 9.7	82; 8.3	
Attrition (n; % of total)				<.001
No dropout	13,956; 68.9	3319; 73.3	776; 78.7	
Dropout	4455; 22.0	804; 17.8	149; 15.1	
Death	1845; 9.1	403; 8.9	61; 6.2	
Childhood socioeconomic circumstances (n; %)				<.001
Most disadvantaged	3542; 17.5	1083; 23.9	272; 27.6	
Disadvantaged	5050; 24.9	1178; 26.0	290; 29.4	
Middle	6666; 32.9	1299; 28.7	260; 26.4	
Advantaged	3837; 18.9	723; 16.0	125; 12.7	
Most advantaged	1161; 5.7	243; 5.4	39; 4.0	
Childhood health problems (n; %)	4878; 24.1	1295; 28.6	334; 33.9	<.001

Abbreviations: ACE, adverse childhood experiences; ADL, activities of daily living; IADL, instrumental activities of daily living. Note: The baseline characteristics for adverse childhood experiences and covariates are based on the participants included in the model testing for IADL. P values are based on analysis of variance and chi-square tests for continuous and categorical variables, respectively, testing the effect of adverse childhood experiences (0 vs 1 vs ≥2) on these variables.

dependence. We focused on physical activity, a low-cost and safe factor shown to benefit healthy aging.[19] Physical activity reduces the risk of developing depressive symptoms,[20,21] attenuates the association between adverse childhood experiences and a measure of mental health that includes depression,[22,23] and decreases functional dependence.[24] Therefore, physical activity could have a protective effect on functional dependence by attenuating the association between adverse childhood experiences and depressive symptoms, and between depressive symptoms and functional dependence.

This study aimed to examine whether depressive symptoms explain the effect of adverse childhood experiences on functional dependence in older age and whether physical activity can reduce this detrimental effect of adverse childhood experiences. We hypothesized that the effect of adverse childhood experiences on functional dependence is mediated by depressive symptoms (Figure 1). We also hypothesized that this mediation is moderated by physical activity, which means that the effect of adverse childhood experiences on depressive symptoms and the effect of depressive symptoms on functional dependence are dependent on the self-reported level of physical activity.

Method

Study Population and Design

Our analyses used data from the Survey of Health, Ageing and Retirement in Europe (SHARE), a longitudinal (12 y: 2004–2015; 6 waves; data collection every 2 y), cross-national (14 European countries) study of adults aged 50 years or older.[25] Functional dependence in ADL and IADL, depressive symptoms, and physical activity were assessed at the first, second, fourth, fifth, and sixth waves. Retrospective adverse childhood experiences were assessed at the third wave. We included data from participants aged 50 to
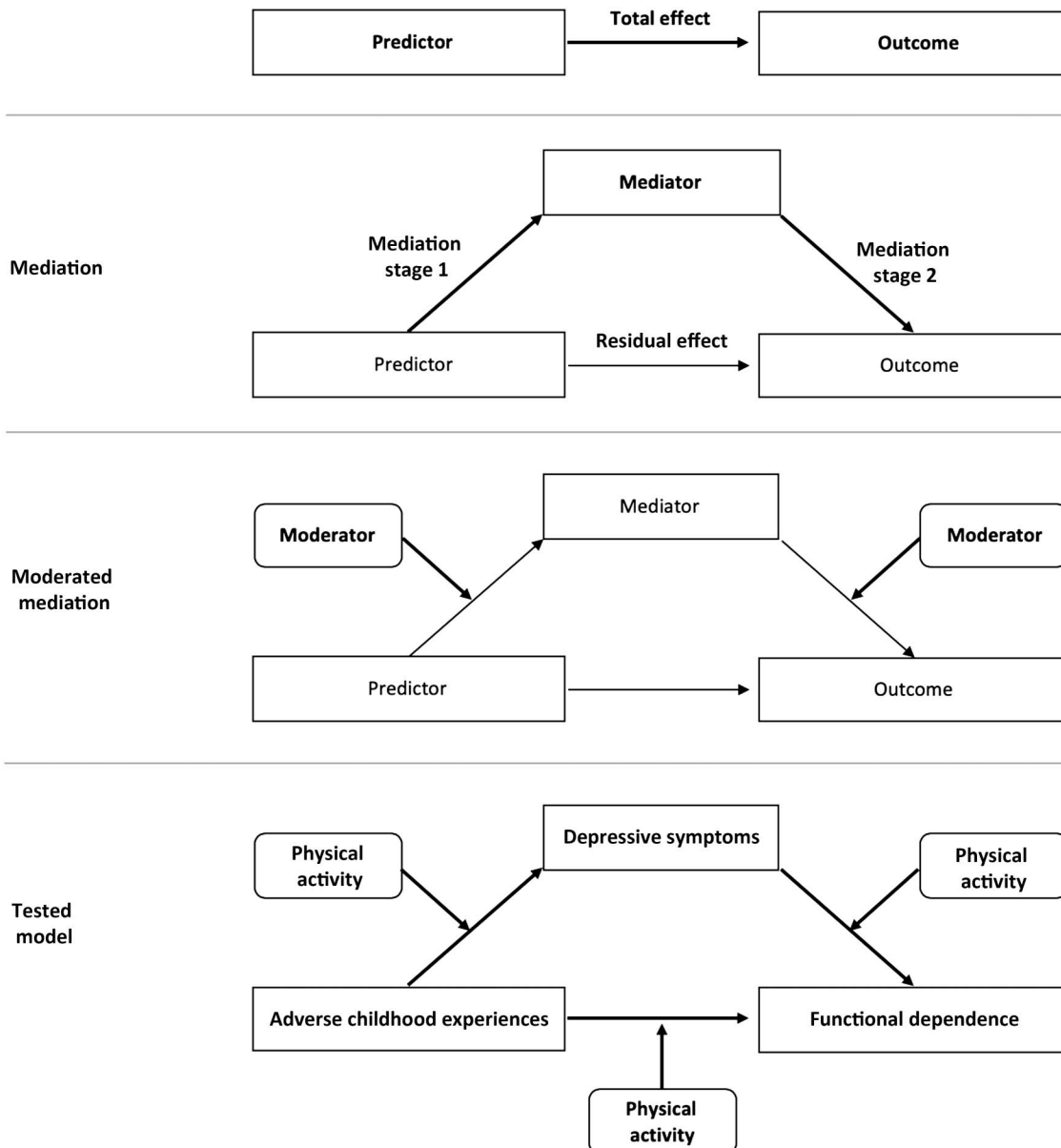

Figure 1 — Framework of the moderated mediation model.

96 years, who participated in the third wave, with at least 1 observation of ADL or IADL, depressive symptoms, and physical activity. Participants without information related to their childhood life history, depressive symptoms, physical activity, or functional dependence were excluded. Relevant research ethics committees in the participating countries approved SHARE, and all participants provided written informed consent.

Variables

The following variables are detailed in the Supplemental Material (available online).

Predictor: Adverse Childhood Experiences. We combined the information of 6 indicators (child in care [living in a children's home or with a foster family], parental death [father, mother, or both], parental mental illness, parental drinking abuse, period of hunger, and property taken away) to compute a categorical variable of childhood adversity including 3 levels: 0, 1, and 2 or more adverse childhood experiences.[26] This score, combining different indicators, was used to examine the effect of an unspecific exposure to adverse childhood experiences on depressive symptoms and functional dependence. Including each indicator would have overly complicated the models and could have weakened their accuracy due to the multicollinearity of adverse childhood experiences.

Outcomes: Functional Dependence. To measure functional dependence, we used the number of functional dependencies in 6 ADL (dressing, walking, bathing, eating, getting in or out of bed, and using the toilet) and 7 IADL (using a map, preparing a hot meal, shopping for groceries, making telephone calls, taking medication, gardening or doing housework, and managing money). Higher scores were indicative of higher functional dependence.[27]

Mediator: Depressive Symptoms. Depressive symptoms were measured using the depression symptoms scale from the EURO-DEP consortium (EURO-D scale)[28,29] including 12 items: depressed mood, pessimism, wishing death, guilt, sleep, interest, irritability, appetite, fatigue, concentration, enjoyment, and tearfulness. Each item was scored as 0 (symptom absent) or 1 (symptom present), generating an ordinal scale ranging from 0 to 12, with higher scores reflecting higher depressive symptoms.

Moderator: Physical Activity. The participants who engaged in activities that require a vigorous, moderate, or low level of energy more than once a week were classified as physically active, and the other participants were classified as inactive.[30] This strategy was used to reduce potential misclassification bias whereby physically active participants would be inaccurately categorized as physically inactive. Specifically, 2 items were used to assess the usual level of physical activity over a week.[30–32] The first item assessed vigorous physical activity ("How often do you engage in vigorous physical activity, such as sports, heavy housework, or a job that involves physical labor?"). The second item assessed low to moderate physical activity ("How often do you engage in activities that require a low or moderate level of energy such as gardening, cleaning the car, or doing a walk?"). The participants answered by using a 4-point scale (1 [more than once a week]; 2 [once a week]; 3 [1 to 3 times a month]; 4 [hardly ever or never]). The participants who answered "1" to either or both items were classified as physically active. This variable was averaged over time to distinguish between physically active versus inactive participants over the whole study duration. This strategy simplified the models, as they already involved depressive symptoms as a time-varying predictor.

Covariates. We considered age at the baseline, wave, gender, country of residence, birth cohort, and participant attrition during SHARE follow-up, childhood socioeconomic circumstances, and childhood health problems as covariates. All these variables were assessed only once and were used as time-invariant predictors.

Statistical Analyses

Mediation by Depressive Symptoms. The mediation effect of depressive symptoms on the association between adverse childhood experiences and functional dependence was analyzed using linear mixed-effects models, which accounts for the nested structure of the data (eg, multiple observations within a single participant), thereby providing accurate parameter estimates with acceptable type I error rates.[33] The random structure encompassed random intercepts for the participants and random linear slopes for waves at the level of the participants. These random slopes estimated each participant's linear growth trajectory over the waves of the study (ie, 12 y). The mediation was assessed using the component approach.[34,35] In this approach, 3 models needed to be tested. Model 1 (Equation 1) tested the effect of adverse childhood experiences (time-invariant predictor) on functional dependence (time-varying outcome), adjusting for prior confounders (time-invariant predictors). This model included interaction terms between age at the baseline and time (linear and quadratic) to adjust for the influence of age on the rate of increasing dependence over the waves. The waves were centered on the first wave of SHARE to estimate the effects at the baseline assessment. Quadratic time accounted for potential accelerated rates of increasing functional dependence over the waves. Model 2 (Equation 2) tested the effect of adverse childhood experiences (time-invariant predictor) on depressive symptoms (time-varying outcome). In model 3 (Equation 3), depressive symptoms (the potential mediator, time-varying predictor) and its interaction with waves (linear and quadratic) were added to model 1.

$$\text{Functional Dependence}_{ij}$$
$$= \beta_0 + \beta_1\,\text{Age}_j + \beta_2\,\text{Wave}_{ij} + \beta_3(\text{Age}_j \times \text{Wave}_{ij})$$
$$+ \beta_4\,\text{Squared wave}_{ij} + \beta_5(\text{Age}_j \times \text{Squared wave}_{ij})$$
$$+ \beta_6\,\text{Gender}_j + \beta_7\,\text{Country}_j + \beta_8\,\text{Birth cohort}_j + \beta_9\,\text{Attrition}_j$$
$$+ \beta_{10}\,\text{Childhood socioeconomic circumstances}_j$$
$$+ \beta_{11}\,\text{Childhood health problems}_j$$
$$+ \beta_{12}\,\text{Adverse childhood experience}_j$$
$$+ u_{0j} + u_{1j}\,\text{Wave}_{ij} + \epsilon_{ij}, \tag{1}$$

$$\text{Depression}_{ij} = \beta_0 + \beta_1\,\text{Age}_j + \beta_2\,\text{Wave}_{ij} + \beta_3(\text{Age}_j \times \text{Wave}_{ij})$$
$$+ \beta_4\,\text{Squared wave}_{ij} + \beta_5(\text{Age}_j \times \text{Squared wave}_{ij})$$
$$+ \beta_6\,\text{Gender}_j + \beta_7\,\text{Country}_j$$
$$+ \beta_8\,\text{Birth cohort}_j + \beta_9\,\text{Attrition}_j$$
$$+ \beta_{10}\,\text{Childhood socioeconomic circumstances}_j$$
$$+ \beta_{11}\,\text{Childhood health problems}_j$$
$$+ \beta_{12}\,\text{Adverse childhood experience}_j$$
$$+ u_{0j} + u_{1j}\,\text{Wave}_{ij} + \epsilon_{ij}, \tag{2}$$

Functional Dependence$_{ij}$

$$= \beta_0 + \beta_1 \, \text{Age}_j + \beta_2 \, \text{Wave}_{ij} + \beta_3 (\text{Age}_j \times \text{Wave}_{ij})$$
$$+ \beta_4 \, \text{Squared wave}_{ij} + \beta_5 (\text{Age}_j \times \text{Squared wave}_{ij})$$
$$+ \beta_6 \, \text{Gender}_j + \beta_7 \, \text{Country}_j + \beta_8 \, \text{Birth cohort}_j + \beta_9 \, \text{Attrition}_j$$
$$+ \beta_{10} \, \text{Childhood socioeconomic circumstances}_j$$
$$+ \beta_{11} \, \text{Childhood health problems}_j$$
$$+ \beta_{12} \, \text{Adverse childhood experience}_j$$
$$+ \beta_{13} \, \text{Depressive symptoms}_{ij} + u_{0j}$$
$$+ u_{1j} \, \text{Wave}_{ij} + \epsilon_{ij,} \qquad (3)$$

where functional dependence$_{ij}$ is the jth participant's ADL or IADL dependence score on wave i, the βs are the fixed-effect coefficients, u_{0j} is the random intercept for the jth participant, u_{1j} is the random slope (varying across waves) for the jth participant, and ϵ_{ij} is the error term.

To examine whether depressive symptoms mediated the effect of adverse childhood experiences on functional dependence, 4 conditions must be met.[34,35] In Equation 1, there must be a significant effect of adverse childhood experiences on functional dependence. In Equation 2, there must be a significant effect of adverse childhood experiences on depressive symptoms (ie, first stage of the mediating process). In Equation 3, there must be an effect of depressive symptoms on functional dependence (ie, second stage of the mediating process), controlling for the effect of adverse childhood experiences. Finally, in Equation 3, the residual effect of adverse childhood experiences on functional dependence should be smaller than the effect of adverse childhood experiences in Equation 1. This component approach to the assessment of mediation was preferred over the index approach,[36] because the latter has shown a higher risk of false positives (type I errors).[34] The percentage of decrease in the effect of adverse childhood experiences on functional dependence between the models without (Equation 1) and with (Equation 3) the mediating variable was calculated as follows: $(b_{\text{model1}} - b_{\text{model3}}) \times (b_{\text{model1}})^{-1} \times 100$. These percentages provided an estimate of the proportional influence of the potential mediating variable (depressive symptoms) on the relation between adverse childhood experiences and functional dependence.

Moderation by Physical Activity.   The moderating effect of physical activity on the direct and indirect association between adverse childhood experiences (time-invariant predictor) and functional dependence (time-varying outcome) was analyzed using 3 models.[35] Adding an adverse childhood experiences × physical activity (time-invariant predictor) interaction term in Equation 1 allowed the overall effect of adverse childhood experiences on functional dependence (model 4) to be moderated by physical activity. Adding an adverse childhood experiences × physical activity interaction term in Equation 2 allowed the effect of adverse childhood experiences on depressive symptoms (time-varying outcome; model 5; ie, first stage of the mediating processes) to be moderated by physical activity. Including interaction terms between depressive symptoms (time-varying predictor) and physical activity and between adverse childhood experiences and physical activity in Equation 3 allowed the effect of depressive symptoms (ie, second stage of the mediating processes) and the residual effect of adverse childhood experiences on functional dependence (model 6) to be moderated by physical activity.

Results

Descriptive Results

The data set included a total of 25,775 participants aged 62 (9) years, living in 14 European countries, with a depressive symptoms score of 2.3 (2.2), 14,342 women (55.6%), 18,080 physically active participants (70.1%), 20,263 participants without an adverse childhood experience (78.6%), 4526 with 1 adverse childhood experience (17.6%), and 986 with 2 or more childhood adverse experiences (3.8%)   (Table 1). The flow diagram is reported in Figure 2.

Effects of Adverse Childhood Experiences on Functional Dependence

Mediation by Depressive Symptoms.   ADL: Model 1 (Equation 1) showed a graded association between the number of adverse childhood experiences (0 vs 1; 0 vs ≥2) and the number of functional limitations in ADL (bs = 0.040 and 0.067; Ps = 6×10^{-6} and 1×10^{-4}; 95% confidence intervals [CIs], 0.023 to 0.057 and 0.033 to 0.101, respectively; Figure 3, left panel). Model 2 (Equation 2) showed an association between the number of adverse childhood experiences (0 vs 1; 0 vs ≥2) and the depressive symptoms score in older age (bs = 0.361 and 0.599; Ps < 2×10^{-16}; 95% CIs, 0.307 to 0.415 and 0.492 to 0.705, respectively; Figure 3, middle panel). Model 3 (Equation 3) showed that a larger depressive symptoms score was associated with a larger number of limitations in ADL (b = 0.057; $P < 2 \times 10^{-16}$; 95% CI, 0.055 to 0.060; Figure 3, right panel). Model 3 also showed that the graded association between the number of adverse childhood experiences (0 vs 1; 0 vs ≥2) and the number of functional limitations in ADL became weaker with the addition of depressive symptoms (bs = 0.019 and 0.033; Ps = .023 and .048; 95% CIs, 0.003 to 0.036 and 2×10^{-4} to 0.067, respectively; Figure 3, left panel). From model 1 to 3, these associations decreased by 51% (0 vs 1 adverse childhood experience) and 50% (0 vs ≥2 adverse childhood experiences). Taken together, these results demonstrate
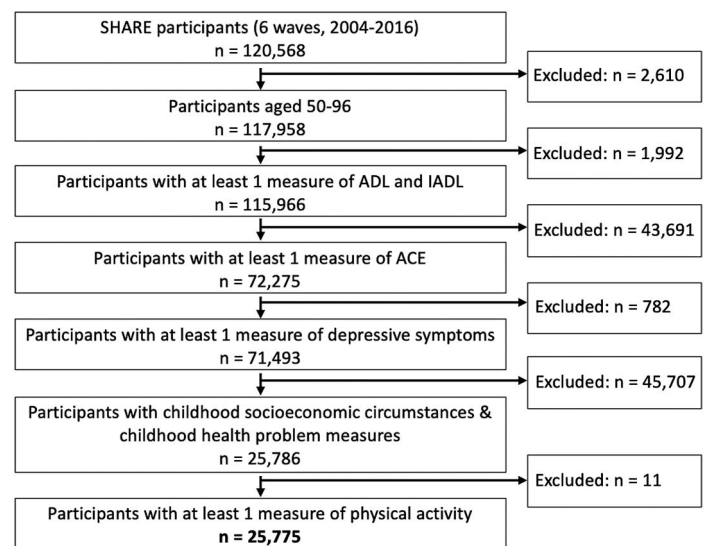

Figure 2 — Flow diagram. ACE indicates adverse childhood experiences; ADL, activities of daily living; IADL, instrumental activities of daily living; SHARE, Survey of Health, Ageing and Retirement in Europe.
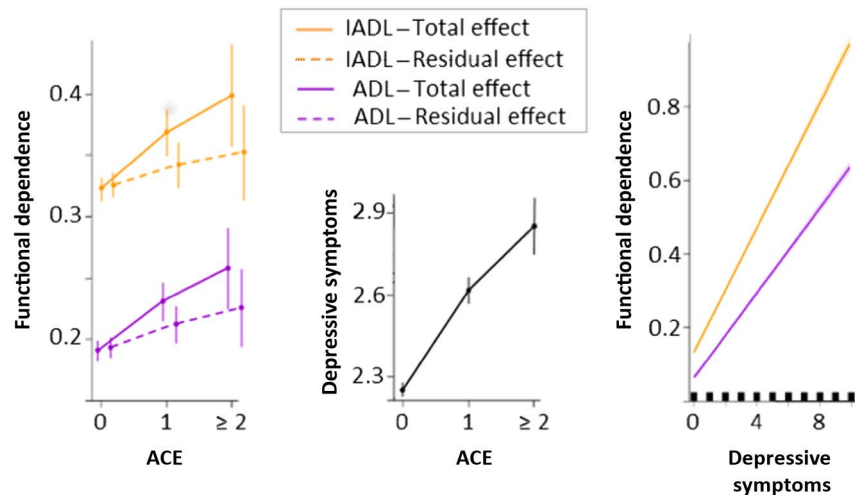
Figure 3 — Main effects and 95% CI demonstrating that depressive symptoms mediate the association between adverse childhood experiences and functional dependence in ADL (orange or light grey for hard copies) and IADL (purple or dark grey for hard copies). Solid lines illustrate the effect of adverse childhood experiences when the mediator (depressive symptoms) is not in the equation (total effect). Dashed lines illustrate the effect of adverse childhood experiences when the variable depressive symptoms is in the equation (residual effect). CI indicates confidence interval; ACE, adverse childhood experiences; ADL, activities of daily living; IADL, instrumental activities of daily living.

that depressive symptoms mediated the association between adverse childhood experiences and functional dependence in ADL.

IADL: Model 1 showed a graded association between the number of adverse childhood experiences (0 vs 1; 0 vs ≥2) and the number of functional limitations in ADL ($bs = 0.046$ and 0.076; $Ps = 2 \times 10^{-5}$ and 4×10^{-4}; 95% CIs, 0.025 to 0.067 and 0.034 to 0.117, respectively; Figure 3, left panel). Model 2 was the same as for ADL (Figure 3, middle panel). Model 3 showed that a larger depressive symptoms score was associated with a larger number of limitations in IADL ($b = 0.085$; $P < 2 \times 10^{-16}$; 95% CI, 0.082 to 0.087; Figure 3, right panel). Model 3 also showed that the graded association between the number of adverse childhood experiences (0 vs 1; 0 vs ≥2) and the number of functional limitations in IADL became nonsignificant with the addition of depressive symptoms ($bs = 0.016$ and 0.027; $Ps = .119$ and $.184$; 95% CIs, −0.004 to 0.036 and −0.013 to 0.067, respectively; Figure 3, left panel). From model 1 to 3, these associations decreased by 65% (0 vs 1 adverse childhood experience) and 64% (0 vs ≥2 adverse childhood experiences). Taken together, these results demonstrate that depressive symptoms mediated the association between adverse childhood experiences and functional dependence in IADL.

Moderation by Physical Activity. ADL: Model 4 showed a graded moderation of the association between adverse childhood experiences (0 vs 1; 0 vs ≥2) and functional dependence in ADL by physical activity ($bs = -0.060$ and -0.135; $Ps = .001$ and 2×10^{-4}; 95% CIs, −0.096 to −0.024 and −0.207 to −0.063, respectively; Figure 4, upper-left panel). Model 5 showed a graded moderation of the association between adverse childhood experiences (0 vs 1; 0 vs ≥2) and depressive symptoms by physical activity ($bs = -0.179$ and -0.515; $Ps = .002$ and 9×10^{-6}; 95% CIs, −0.292 to −0.065 and −0.742 to −0.288, respectively; Figure 4, upper-right panel). Model 6 showed a moderation of the association between depressive symptoms and functional dependence in ADL by physical activity ($b = -0.073$; $P < 2 \times 10^{-16}$; 95% CI, −0.077 to −0.069; Figure 4, lower-right panel). Figure 4 illustrates that the effects of adverse childhood experiences (upper-left panel) and

depressive symptoms (lower-right panel) on functional dependence in ADL (purple in the figure or dark grey for hard copies) were not significant in physically active participants ($Ps > .081$) as the 95% CI crossed the 0 dashed line. Model 6 also showed that the graded moderation of the association between adverse childhood experiences (0 vs 1; 0 vs ≥2) and functional dependence in ADL by physical activity became nonsignificant ($bs = -0.018$ and -0.055; $Ps = .306$ and $.116$; 95% CIs, −0.053 to 0.016 and −0.124 to 0.014, respectively; Figure 4, lower-left panel and Figure 5A). From model 4 to 6, these associations decreased by 70% (0 vs 1 adverse childhood experience) and 59% (0 vs ≥2 adverse childhood experiences). Taken together, these results demonstrate a moderated mediation (Figure 5A).[35]

IADL: Model 4 showed a graded moderation of the association between adverse childhood experiences (0 vs 1; 0 vs ≥2) and functional dependence in IADL by physical activity ($bs = -0.109$ and -0.227; $Ps = 1 \times 10^{-6}$ and 4×10^{-7}; 95% CIs, −0.153 to −0.065 and −0.315 to −0.140, respectively; Figure 4, upper-left panel). Model 5 was the same as for ADL (Figure 4, upper-right panel). Model 6 showed a moderation of the association between depressive symptoms and functional dependence in IADL by physical activity ($b = -0.100$; $P < 2 \times 10^{-16}$; 95% CI, −0.106 to −0.095; Figure 4, lower-right panel). Figure 4 illustrates that the effects of adverse childhood experiences (upper-left panel) and depressive symptoms (lower-right panel) on functional dependence in IADL (orange in the figure or light grey for hard copies) were not significant in physically active participants ($ps > .528$). Model 6 also showed that the graded moderation of the association between adverse childhood experiences (0 vs 1; 0 vs ≥2) and functional dependence in IADL by physical activity became weaker ($bs = -0.052$ and -0.114; $Ps = .014$ and $.007$; 95% CIs, −0.197 to −0.010 and −0.093 to −0.032, respectively; Figure 4, lower-left panel and Figure 5B). From model 4 to 6, these associations decreased by 53% (0 vs 1 adverse childhood experience) and 50% (0 vs ≥2 adverse childhood experiences). Taken together, these results demonstrate a moderated mediation (Figure 5B).[35]
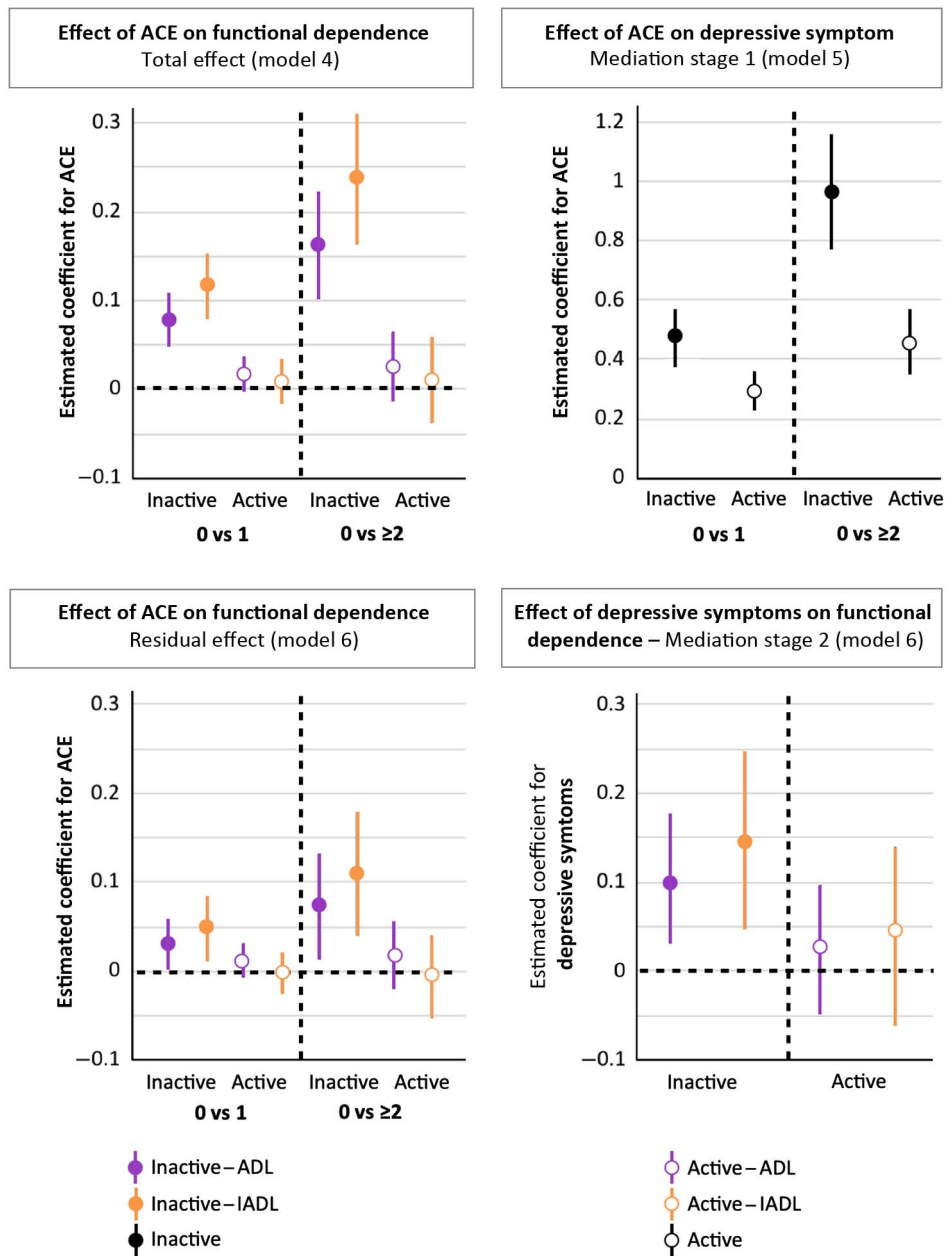
Figure 4 — Conditional b coefficients and 95% CI as a function of physical activity. The upper-left panel illustrates how physical activity moderates the total effect of adverse childhood experiences (0 vs 1 and 0 vs ≥2 ACEs) on functional dependence. The upper-right panel illustrates how physical activity moderates the first stage of the mediation by depressive symptoms. The lower-left panel illustrates the absence of moderation by physical activity on the residual effect of adverse childhood experiences on ADL and the moderation effect on this effect on IADL. The lower-right panel illustrates how physical activity moderates the second stage of the mediation. Functional dependence in ADL and IADL are in orange (or light grey for hard copies) and purple (or dark grey for hard copies), respectively. Physically inactive and active participants are illustrated by filled and empty circles, respectively. Of note, the effects of adverse childhood experiences (upper-left panel) and depressive symptoms (lower-right panel) on functional dependence are not significant in physically active participants, as the 95% CI crossed the 0 dashed line. CI indicates confidence interval; ACE, adverse childhood experiences; ADL, activities of daily living; IADL, instrumental activities of daily living.

Discussion

Main Findings

We consistently showed the same pattern of results based on sophisticated statistical analyses suited to examine a potential mechanism of moderated mediation between adverse childhood experiences, depressive symptoms, functional dependence, and physical activity.

This study uncovered 3 main findings. For the first time, we show that depressive symptoms mediate the effect of adverse childhood experiences on functional dependence (ADL and IADL) in aging. Second, the results showed that physical activity reduced the effect of adverse childhood experiences on depressive symptoms and on the residual effect on IADL. Third, the results revealed that adverse childhood experiences were not (directly or indirectly) associated with functional dependence in physically active individuals.
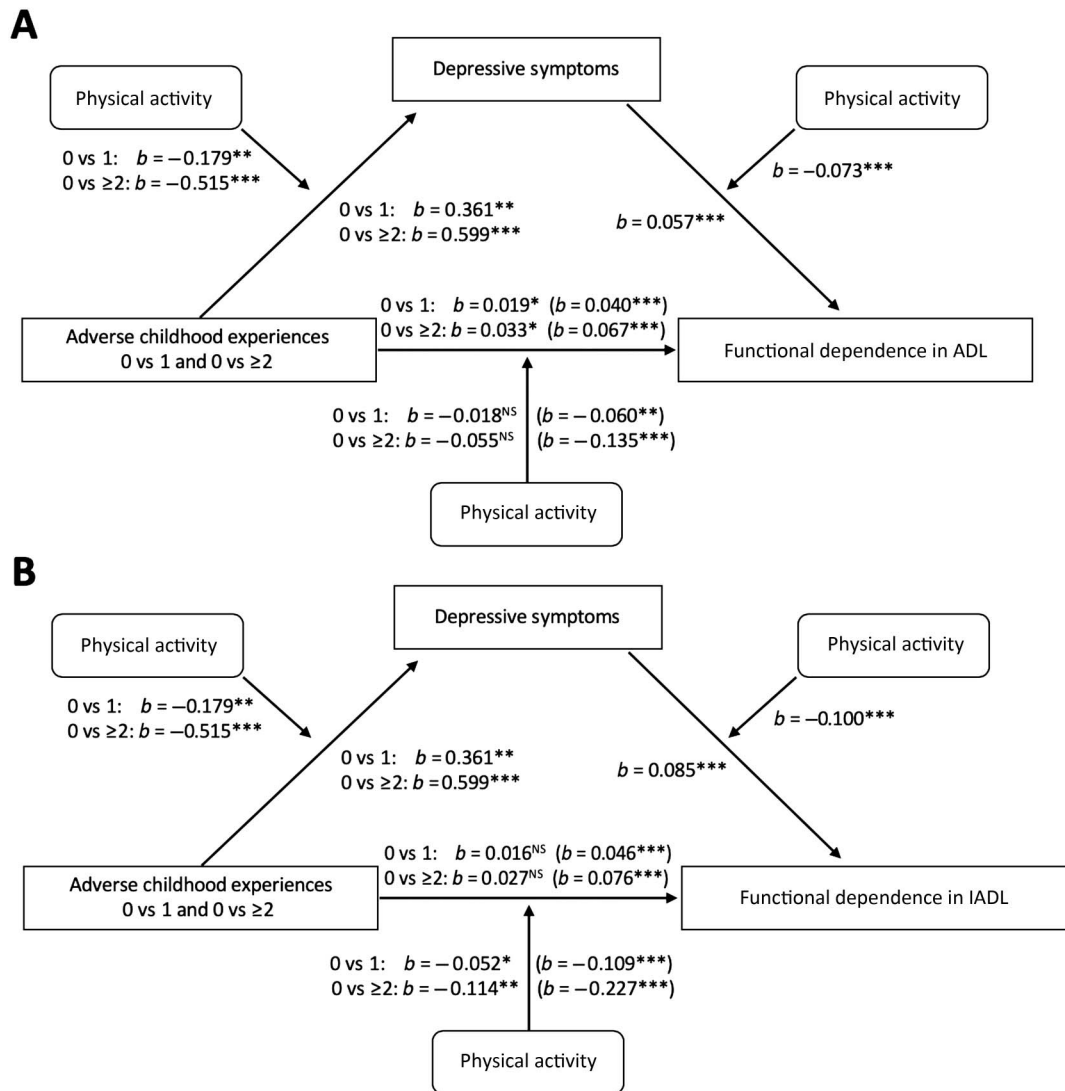
Figure 5 — Moderated mediation of the effect of adverse childhood experiences on functional dependence in ADL (A) and instrumental ADL (B). The b values in brackets are the coefficients when the mediator is not in the equation (total effect). The *b*s not in brackets are the coefficients when the mediator (depressive symptoms) is in the equation (residual effect). *$P < .05$; **$P < .01$; ***$P < .001$; Non significant $P \geq .05$. ADL indicates activities of daily living; IADL, instrumental activities of daily living.

Comparison With Previous Studies

Our results showing that adverse childhood experiences are associated with functional dependence are consistent with previous literature.[2,37] The effect of adverse childhood experiences is consistent with etiological models for depressive symptoms considering stressful experiences as factors increasing the odds of depressive symptoms[8,38] and with previous results showing an association between adverse childhood experiences and the probability of depressive symptoms.[9–11] The effect of depressive symptoms on functional dependence supports previous studies showing an association between depressive symptoms and functional dependence.[12–15] The protective effect of physical activity is in line with multiple studies, especially those showing that physical activity reduces the risk of developing depressive symptoms[20,21]; attenuates the relation between adverse childhood experiences and mental health[22,23]; and decreases functional dependence.[24] Our results demonstrate that all these effects can be included in a single and meaningful moderated mediation framework.

Strengths and Limitations

This study has many strengths. The sample is large and includes noninstitutionalized older adults from multiple European countries. Moreover, we used validated measures of depressive symptoms (EURO-D)[28] and functional dependence. However, potential limitations should be noted. First, our results were based on self-reported measures of physical activity, which creates the potential for misclassification bias.[39] However, the potential inaccuracy of these self-reports is unlikely to explain the associations observed in this study. Moreover, the scale lacked granularity, which prevented the assessment of specific physical activity levels that are associated with health benefits, such as the 30 minutes of moderate to vigorous physical activity intensity 5 times per week. Second, there is the potential for recall bias, as adverse childhood experiences were based on self-reports. Yet, the validity of these self-reports has been demonstrated.[40] Third, although 2 widely validated measures of functional dependence were used and revealed consistent results, these measures were self-reported. Future

studies should investigate whether our results apply to objective indicators of functional dependence (eg, walking speed, chair stand, balance). Fourth, the adverse childhood experiences reflected poverty and parental dysfunction, but did not include maltreatment or witnessing maltreatment. Fifth, other prominent factors in the pathways, from adverse childhood experiences to depressive symptoms and to functional dependence, such as adulthood poverty, isolation, or adversities, stand as other potential hypotheses that were not tested here. Sixth, the dichotomized measure of physical activity provided in SHARE may have provided relatively low statistical power for the analysis, that is, limited ability to discern differences among groups. Seventh, the score used to assess adversity during childhood combined different adverse childhood experiences. Future studies should examine how each type of childhood adversity is related to functional independence and depressive symptoms. When comparing the strength of these specific associations, the prevalence of each adverse childhood experience should be controlled for to avoid reporting spurious associations resulting from statistical power differences rather than true differences.

Conclusions

The first result of this study suggests that the relation between adverse childhood experiences and functional dependence at an older age is explained by depressive symptoms. Therefore, public policies aiming to improve functional dependence in older adults should not only focus on the physical factors (eg, muscle strength, joint range of motion, cardiovascular fitness). Psychological factors, such as depressive disorders, deserve as much focus as the physical factors, as they are as likely to increase functional dependence. The second result suggests that physical activity tempers the strength of the mediated relation and that older adults engaging in physical activity more than once a week are protected from the detrimental effects of adverse childhood experiences and depression on their functional independence. These results support previous results demonstrating the importance of physical activity in alleviating depressive disorders[19,22] and in improving functional independence.[21] Therefore, actions from public policies aiming to increase engagement in physical activity over the lifespan should be further supported.

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