"Does it matter how old I feel?"

The role of subjective age in a psychosocial intervention for improving depressive

symptomatology among older adults in Brazil (PROACTIVE)

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Abstract

Depression is a prevalent mental health condition that also often affects older adults. The PROACTIVE psychosocial intervention was developed to reduce depressive symptomatology among older adults within primary care settings in Brazil. An important psychological marker that affects individuals' aging experience relates to how old people feel. Known as subjective age, this marker has been shown to be a risk factor for experiencing greater depressive symptoms if individuals report feeling older than their (chronological) age. In this study, we perform secondary analyses of the PROACTIVE cluster-randomized controlled trial (Scazufca et al., 2022) to examine the role of subjective age in a sample of 715 Brazilian older adults (74% female, M_{age} 68.6, $SD = 6.9$, age range: 60-94 years) randomized to intervention ($n = 360$, 74% female, M_{age} 68.4, $SD = 6.6$, age range: 60-89 years) or control ($n = 355$, 74% female, M_{age} 68.9, $SD = 7.2$, age range: 60-94 years) arms. Here our primary outcome was depressive symptoms at the 8-month follow-up assessed with the 9-item Patient Health Questionnaire (PHQ-9) as a continuous variable. Our previous analyses (Scazufca et al., 2022) demonstrated improved recovery from depression at follow-up in the intervention compared with the control arm. Relevant main effects and interactions in regression models for PHQ-9 presented here found that those reporting older subjective age had worse depressive symptoms at follow-up but that they benefitted more from the intervention when initial levels of depression were high. For participants who reported younger subjective ages the intervention showed positive effects that were independent of initial levels of depression. Our findings emphasize the importance of investigating possible underlying mechanisms that can help clarify the impact of mental health interventions.

Keywords: subjective age, felt age, depression, older adults, PROACTIVE psychosocial intervention

Introduction

Depression undermines quality of life (Chachamovic et al., 2008) and is the leading cause of disability (United Nations, 2017). As shown by recent meta-analyses, older adults are often affected by depression with a prevalence in the range of 13.3% (Abdoli et al., 2022) to 28.4% (Hu et al., 2022). The situation is similar in Brazil, where the highest prevalence of depression (11.8%) was found in individuals aged 60 years and older (Brito et al., 2022). At a local level, Nakamura et al. (2021) reported a prevalence of 30% of depressive symptomatology in older adults living in deprived regions of Guarulhos in the state of Sao Paulo. Depression is frequently unrecognized, leading older adults with depressive symptoms to be often untreated (Burroughs et al., 2006; Mitchell et al., 2010; Scazufca et al., 2016). This problematic situation is partly due to a shortage of mental health specialists in primary care services, including in Brazil (Datasus, 2002). Aiming to address deficiencies in the identification and treatment of depression among older adults as well as the shortage of mental health specialists, the PROACTIVE psychosocial intervention was developed to improve depressive symptomatology in primary care services, as recommended by the World Health Organization (Thomas, 2013). The intervention makes use of collaborative care models, including task sharing and stepped-care strategies (Bosanquet et al., 2017; Unützer et al., 2002). Accordingly, trained non-specialist health workers deliver the intervention making extensive use of technology (Van de Ven et al., 2019). The intervention has been shown to be highly effective in improving recovery from depression in later life, with a cluster-randomized controlled trial (Scazufca et al., 2022; see also Scazufca et al., 2019) providing evidence that PROACTIVE could help reducing the treatment gap for depression among older people in Brazil, as well as potentially in other low- and middle-income countries (LMICs).

In the context of developing and testing interventions targeting older adults, it is important to consider that individuals' aging experiences are highly heterogeneous, being shaped by biopsychosocial factors (Baltes & Smith, 2003). A core psychological indicator of the aging experience is known as *subjective age*, which indicates how old people feel in relation to their chronological age. For example, feeling younger than one's chronological age has been shown to be associated with positive outcomes such as better health, greater longevity (Kotter-Grühn et al., 2009; Westerhof et al., 2023), higher levels of subjective well-being, better cognitive functioning, and to experiencing fewer symptoms of depression (Debreczeni & Bailey, 2021; Spuling et al., 2013). Hence, in this study we are interested in investigating the role of subjective age in the PROACTIVE psychosocial intervention. This is relevant as it allows us to better understand how subjective age is associated with depressive symptoms and, specifically, whether the intervention results further depend on how old individuals subjectively feel in relation to their actual age.

The PROACTIVE Psychosocial Intervention

The PROACTIVE psychosocial intervention includes two main components to treat depressive symptomatology: (1) psychoeducation about depression, coping skills to manage depressive symptoms, and relapse prevention strategies (Donker et al., 2009); and (2) behavioral activation (Ekers et al., 2014).

We can further examine the PROACTIVE intervention components in line with the dual process theory that distinguishes two strategies of adaptive self-regulation, those being known as assimilative and accommodative (Brandtstädter & Rothermund, 2002; Rothermund & Brandtstädter, 2003). Assimilative strategies entail active attempts to shape and improve one's life. These strategies involve investing personal resources in such activities as engaging in regular exercise and healthy diet, learning new skills, and reaching out to others. These activities are highlighted in the behavioral activation component of the intervention and may

be preferred by individuals who have personal resources to intentionally engage in activating behaviors. Comparably, accommodative strategies involve adjusting personal goals to life constraints and losses. The intervention components that are mostly cognitive (e.g., psychoeducation, problem solving) may thus be preferred by individuals who do not have personal resources to actively invest in assimilative strategies.

The PROACTIVE intervention takes place over 17 weeks through home visits, delivered by trained community health workers. The intervention is divided into an initial phase (3 weeks, 3 sessions) followed by a second phase (14 weeks, either 5 or 8 sessions depending on the intensity regimen) thus totaling 8 and 11 sessions for low and high intensity regimens, respectively. The initial phase focuses on psychoeducation and coping strategies, whereas the second phase focuses on behavioral activation. For a detailed description of the PROACTIVE psychosocial intervention, see Scazufca et al. (2019; 2022).

The Role of Subjective Age in Depressive Symptomatology

Previous research has consistently shown that, in relative terms, younger subjective age increases with chronological age – in other words, the older people become, the younger they report feeling relatively (Rubin & Berntsen, 2006; although the pattern of age differences in subjective age depend on how the subjective age score is computed, see Pinquart & Wahl, 2021). This finding is interpreted as an adaptive and self-enhancing strategy that allows older individuals to distance or dissociate themselves from the pervasive negative views of aging that are often associated with growing old or with being old (Weiss & Freund, 2012; Weiss et al., 2013). Lifespan theories view this phenomenon of a younger subjective age in later life as a compensatory strategy by which individuals maintain control across the lifespan (Heckhausen & Schulz, 1998). Indeed, a recent study has shown that higher perceptions of control were associated with younger subjective ages in older but not in younger adults (Bellingtier & Neupert, 2020). It is therefore assumed that to maintain control,

self-esteem, wellbeing, and functioning, individuals are motivated to distance themselves from the highly stigmatized group of older adults, this being especially true in life domains that are dominated by negative age stereotypes such as work, finances, and health (Kornadt et al., 2018). Consequently, as shown by previous studies, those who report feeling younger than their chronological age, also report better psychological health and fewer depressive symptoms, whereas those who feel older report worse psychological health and greater depressive symptoms (Debreczeni & Bailey, 2021; Keyes & Westerhof, 2012; Westerhof et al., 2023; Wettstein et al., 2021)

Indeed, to date there is considerable evidence that subjective age is associated with late life depression. Accordingly, a younger subjective age has been found to be related to lower depressive symptoms and lower risk for major depression (Infurna et al., 2010; Keyes & Westerhof, 2002). Longitudinal studies confirm that the association between subjective age and depression can be found over time, with older subjective ages predicting future depression (Choi & DiNitto, 2014; Rippon & Steptoe, 2018) and a stronger association between depression and future physical morbidity (Segel-Karpas et al., 2018). Furthermore, when examining individuals who report either extremely younger or older subjective ages (i.e., upper and lower 5% of subjective ages), Palgi and colleagues (2018) found that, both cross-sectionally and longitudinally, only extremely older subjective ages were associated with worse adjustment (e.g., worse physical health and functioning, more depressive symptoms, higher levels of loneliness) compared with usual values of older subjective age (i.e., values at the median of subjective age). Hence, feeling much younger is not more protective than feeling averagely younger (see also Blöchl et al., 2021), but feeling much older does represent a higher risk of impaired adjustment.

Subjective Age and Initial Levels of Depression as a Possible Moderators of Intervention Effects

Considering that the PROACTIVE psychosocial intervention was developed to reduce depressive symptomatology among older adults and that subjective age has been found to be associated with psychological health, it is relevant to investigate to what extent subjective age plays a role in the effects of this intervention. Specifically, we can hypothesise that those who report older subjective ages are the ones who are at higher risk of depression and therefore may benefit most from the PROACTIVE intervention.

Previous studies also show that the initial levels of depressive symptoms are relevant for early recovery (Meyers et al., 2002) and that initial severity of depression predicted differential treatment effects (Elkin et al., 1995; Friedman et al., 2012), with some treatments being more effective for those with more severe initial depressive symptoms than those with mild symptoms. Thus, we consider initial levels of depression in our study as well.

Present Study

In this study, we are interested in examining the role of subjective age in the PROACTIVE psychosocial intervention for older adults with depressive symptomatology. We hypothesize that the effects of the intervention will depend on the interplay of initial levels of depression and participants' subjective ages. Specifically, we expect a global positive effect of the intervention that is not modified according to the initial levels of depressive symptoms for those people who feel younger than their chronological age. For those who feel older than their chronological age, however, we predict a more variable effect of the intervention, which should be particularly effective among people with high initial levels of depression. These hypotheses are based on conceptual ideas not on empirical evidence because so far there are no previous studies that tested the associations between subjective age and depressive symptom severity in the context of a randomized controlled trial targeting depression in older age. Therefore, we have to consider them as being exploratory.

Method

Sample and Procedures

The data for the present analyses were drawn from the pragmatic, two-arm, parallel-group, cluster-randomized controlled trial of the PROACTIVE intervention conducted in Guarulhos, São Paulo, Brazil (Scazufca et al., 2019; Scazufca et al., 2022). At baseline, the sample included 715 older adults living in deprived areas, who scored at least 10 points on the 9-item Patient Health Questionnaire (PHQ-9) measure of depressive symptoms (74% female, mean age = 68.64, range 60-94 years). Primary care clinics (clusters) were stratified by educational level and randomly allocated (1:1) to either enhanced usual care alone (control arm, $n = 355$, 74% female, mean age = 68.89, range 60-94 years) or to enhanced usual care plus the psychosocial intervention (intervention arm, $n = 360$, 74% female, mean age = 68.39, range 60-89 years). At the first follow-up (8 months after baseline), the sample included 537 older adults, with 284 in the control arm (77% retention rate) and 253 in the intervention arm (70% retention rate). Given the lack of any substantial effect of missing outcome data in the original analyses (Scazufca et al., 2022), in this study we analyzed data from participants who completed the 8-month follow-up assessment (i.e., complete data). Sensitivity analyses comparing baseline demographics and baseline measures between participants with complete data and those with missing data by trial arm at the 8-month follow-up as well as the detailed description regarding the sample selection and randomization can be found in Scazufca et al. (2022).

Measures

Patient Health Questionnaire

The assessment of depressive symptomatology was conducted with the Patient Health Questionnaire (PHQ-9, Kroenke et al., 2001; see Moreno-Agostino et al., 2022 for more information on the use of PHQ-9 in Brazil). The instrument comprises nine questions that

start with "Over the last two weeks, how often have you been bothered by any of the following problems…" (e.g., "feeling down, depressed, or hopeless", "feeling tired or having little energy"). Respondents are asked to rate each item on a 4-point rating scale ranging from 0 ("not at all") to 3 ("nearly every day"). The PHQ-9 total score is obtained by adding the score for each question, with the total score ranging from 0 to 27.

Subjective Age

Subjective age (SA) was assessed with an open question: "In general (or most of the time), how old do you feel you are?" We then computed a proportional *SA discrepancy score* [(SA-age)/age] that represents in relative terms the extent to which individuals feel younger or older than they currently are (Kotter-Grühn et al., 2016). Negative values in the proportional score indicate feeling younger than one's chronological age; positive values indicate feeling older. Following recommendations for outlier treatment by Rupprecht and Lang (2020)[1], SA discrepancy scores lower than -0.75 and higher than +0.75 were recoded to -0.75 and +0.75 ($N = 11$ or 1.56%). This procedure allows for statistical analyses that are not too heavily influenced by extreme values for samples with wide age ranges, retaining the general tendency of feeling much older/much younger without giving too much weight to its extreme magnitude. To ease the interpretation of regression coefficients, we multiplied the SA discrepancy score by 100, so that a value of 15 would indicate that an individual feels 15% older than they actually are.

Generalized Anxiety Disorder 7-Item Scale

Anxiety symptoms and screening of anxiety disorders were assessed with the seven-item Generalized Anxiety Disorder scale (GAD-7, Spitzer et al., 2006). The scale includes a list of physical or psychological anxiety symptoms (e.g., "feeling nervous, anxious or on edge", "Worrying too much about different things") and respondents are asked to give the frequency of symptoms they have experienced within the past two weeks on a 4-point rating

scale ranging from 0 ("not at all") to 3 ("nearly every day"). The GAD-7 total score is obtained by adding the score for each question, with the total score ranging from 0 to 21.

3-item UCLA Loneliness Scale

We assessed subjective feelings of loneliness as well as feelings of social isolation (e.g., lacking companionship, feeling isolated from others) with the 3-item UCLA Loneliness Scale (Hughes et al., 2004). Respondents are asked to answer each item on a 3-point rating scale ranging from 1 ("hardly ever") to 3 ("often"). The total score is calculated by summing all responses, with scores ranging from 3 to 9.

European Quality of Life Five-Level Version

Health-related quality of life was measured by the European Quality of Life Five-level version (EQ-5D-5L; Devlin & Krabbe, 2013). Five dimensions are assessed: Mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Respondents are asked to indicate their health state on a 5-level scale ranging from 1 ("no problems") to 5 ("extreme problems"). Given that no value set for the Brazilian population has been developed for this measure to date, we used the EQ-5D-5L utility values for the Uruguayan population (Augustovski et al., 2016).

Perceived Health

Perceived health was assessed with one item, "How do you see your health condition over the last month". Participants answered the item on a 5-point rating scale ranging from 1 ("very bad") to 5 ("very good").

Additional Variables

We further assessed balance problems ("Do you have any balance issues, no, yes), chronological age in years, gender (male, female), time spent in formal education in years ("None", "1-4", "5-8", and ">8"), monthly personal income ("≤1 Brazilian minimum wage", ">1-2 Brazilian minimum wage", ">2-3 Brazilian minimum wage", and ">3 Brazilian

minimum wage), and marital status ("married or living together", "divorced", "widower", "single"; categories were then recoded as "married or living together", "formerly married", "single").

Potential Confounding Variables

In all analyses, we controlled for those variables assessed at baseline for which there was evidence of an association with the outcome variable, i.e., PHQ-9 at follow-up (see Table 1 for the correlations between the continuous variables). Regarding the categorical variables, there was evidence of an association with PHQ-9 at follow-up for balance ($p < 0.001$), gender ($p = 0.022$) and marital status ($p = .006$), but not with time spent in education ($p = .697$) or personal monthly income ($p = .898$). We therefore controlled for balance, gender, marital status, perceived health, anxiety, health-related quality of life, and loneliness.

Analytic Procedure

Since the data displayed a hierarchical structure with participants (Level 1) being nested in primary care clinics (Level 2), we applied a stepwise multilevel approach to investigate our hypotheses that the effects of the psychosocial intervention are moderated by initial levels of depression and participants' subjective ages. All regression analyses used random-effects models with a random intercept to account for clustering and were controlled for stratification (above or below the median proportion of adults aged ≥60 years with no formal education).

To control for any effects of the potential Level 1 baseline confounders, in the first model, PHQ-9 scores at 8-month follow-up was regressed on gender (dummy coded), marital status (dummy coded), perceived health, health-related quality of life (EQ-5D-5L, utility scores for Uruguay), balance issues (dummy coded), anxiety (GAD-7), and subjective feelings of loneliness (3-item UCLA loneliness scale). To investigate the main effects of our Level 1 predictors of interest, Model 2 added PHQ-9 at baseline, arm (dummy coded), and

subjective age at baseline (continuous variables were grand mean centered to allow for a simultaneous interpretation of main effects and interactions; Aiken & West, 1991). Model 3 added the 2-way interactions between PHQ-9 and arm, subjective age and arm, and PHQ-9 and subjective age as well as, most importantly, the 3-way interaction of PHQ-9 at baseline × subjective age at baseline × arm.

All analyses were performed using R version 4.2.1. The following packages were used for the data analyses: haven, purr, gmodels, psych, apaTables, coin, lm.beta, interactions, sjPlot, sjmisc, ggplot2, jtools, RColorBrewer, sjmisc, Cairo, gridExtra, tidyverse, rstatix, dplyr, CTT, lme4, texreg, sjPlot, MuMIn, huxtable, broom.mixed, abricatr, reshape2, hrbrthemes, tidyr, and viridis .

Results

Descriptive Statistics

As would be expected for a randomized trial of this magnitude (albeit a cluster trial), the control and the intervention arms did not differ from each other at baseline (Table 2). On average, older adults in the control arm felt approximately 8% younger than their age, whereas those in the intervention arm felt approximately 6% younger. At baseline, 42% of the sample felt younger than their chronological age, 27% felt older than their chronological age, and 31% reported feeling the same age (with no difference between the control and intervention arms). Subjective age correlated positively with depressive symptoms (PHQ-9) at baseline (Table 1), indicating that an older subjective age (i.e., feeling older than one's actual age) was related to reporting more depressive symptoms. Similarly, reporting more depressive symptoms at baseline was related to worse perceived health and health-related quality of life, and to greater levels of anxiety and loneliness.

At follow-up, lower levels of depressive symptoms were observed in the intervention arm ($M = 8.82$, $SD = 7.23$) than the control arm ($M = 11.52$, $SD = 6.93$). Scazufca et al.

(2022) found strong evidence of an effect of the psychosocial intervention on recovery from depression (PHQ-9 score <10) at the 8-month follow-up, where 158 (62.5%) participants in the intervention group recovered from depression compared with 125 (44.0%) in the control group (adjusted odds ratio 2.16 [95% confidence interval 1.47–3.18]; $p < .0001$).

Multilevel Analysis

To investigate the relative sizes of the variances at both levels of analysis, we estimated an unconditional model of depressive symptoms at the 8-month follow-up. An intraclass correlation (ICC) of 0.047 for depressive symptoms at the 8-month follow-up indicated that 5% of the total variance in depressive symptoms at the 8-month follow-up was accounted for by the clustering (that is, primary care clinics)[2].

The results of the multilevel analysis with depressive symptoms (PHQ-9) at the 8-month follow-up as the outcome variable predicted by depressive symptoms (PHQ-9) and subjective age at baseline as well as arm, and their interactions, are shown in Table 3. The final model including all predictors and their interactions found evidence of a higher order interaction involving PHQ-9 at baseline × subjective age at baseline × arm ($p = .012$). To illustrate this interaction, we plotted the effects of PHQ-9 at baseline on PHQ-9 at follow-up at two levels of subjective age at baseline, one standard deviation below (< -28.42) and one standard deviation above the mean (>15.98), separately for the control and the intervention arms (Figure 1). To descriptively follow-up on this interaction, we used median splits of subjective age (below the median≤0, above the median>0) and depressive symptoms (PHQ-9) (below the median≤15, above the median>15) at baseline. Specifically, the effect of the PROACTIVE psychosocial intervention differed depending on the combination of subjective age and initial levels of depressive symptoms. As can be seen in Figure 1, this pattern of results indicates that those in the intervention arm who reported feeling younger than their actual age at baseline, benefitted from the intervention regardless of their initial levels of

PHQ-9 ($M_{phq\text{-}9\,FU}$ = 11.05, SD = 6.72 and $M_{phq\text{-}9\,FU}$ = 8.33, SD = 7.22, for the control and intervention arms, respectively). For those who reported feeling older than their actual age, however, there was a clear interaction between PHQ-9 at baseline and arm. Specifically, the psychosocial intervention was beneficial for those who reported higher levels of PHQ-9 at baseline ($M_{phq\text{-}9\,FU}$ = 14.92, SD = 7.60 and $M_{phq\text{-}9\,FU}$ = 10.76, SD = 7.02, for the control and intervention arms, respectively), whereas for those who started out with lower levels of PHQ-9 at baseline, there was no difference between the control and intervention arms ($M_{phq\text{-}9\,FU}$ = 9.83, SD = 4.47 and $M_{phq\text{-}9\,FU}$ = 9.09, SD = 7.39, for the control and intervention arms, respectively).

Discussion

The main finding of the present study is that the effects of the intervention depended on the interplay of initial levels of depression and participants' subjective ages at baseline. Accordingly, participants who reported older subjective ages benefitted more from the intervention when initial levels of depression were relatively high as compared to when they were low. For participants who reported younger subjective ages the intervention showed positive effects that were not modified by initial levels of depression. To the best of our knowledge, this is the first study that has examined the role of subjective age on the effectiveness of psychosocial interventions for depression.

Our results indicate differential effects of the PROACTIVE intervention depending on the combination of subjective age and initial levels of depression. In line with previous research (Elkin et al., 1995; Fournier et al., 2010) showing that initial levels of symptoms can affect treatment outcome for different disorders, our findings highlight the relevance of considering initial levels of depressive symptoms as a differential predictor of response to treatment. This differential effect of initial levels of depressive symptoms was, however, conditioned by subjective age. Accordingly, only among those older adults who reported

feeling older than their chronological age the initial levels of depression played a role in response to the PROACTIVE psychosocial intervention. The pattern of results therefore indicates a synergistic effect, with those who are more psychologically vulnerable (specifically, those with older subjective ages) together with more severe initial depressive symptomatology, benefitting the most from the PROACTIVE intervention. The hypothesized interaction of PHQ-9 × Subjective Age × Arm had a small, although significant effect. We should note that our study was, however, the first to test the associations between subjective age and depressive symptom severity in the context of a randomized controlled trial targeting depression in older age. Hence, considering the exploratory nature of our main hypothesis, we consider this finding to be of high relevance.

In terms of subjective age, from a theoretical perspective the observed difference can be understood in terms of availability of resources: for those who feel younger than their age, action resources are available and hence those participants can and will use these resources to comply with the behavioral activation component of the intervention. Consequently, it is more likely that motivation for activity engagement is higher among those who report younger subjective ages. A younger subjective age may help individuals to cope with the negative implications of aging, which facilitates the maintenance of an active lifestyle. This is in line with a recent study that showed that a younger subjective age consistently predicted engagement in behaviors such as visiting with friends and family, exercising, and taking care of one's appearance (Montepare, 2020). In contrast, for those who feel older than their age, action resources may be lacking (at least according to their own evaluation), and for that reason those participants may find it more difficult to connect with the intervention components that require active engagement in activities. There is indeed evidence showing that older subjective age is related to a decline in, for example, extraversion and openness (Stephan et al., 2015). In line with that, those who feel older than their age will focus on

accommodative elements of the intervention such as psychoeducation and learning coping skills (e.g., reappraisal, acceptance, reorientation), which will help them to recover from severe depression, but will be less helpful and maybe not applicable if initial levels of depression are low.

Our study emphasizes the importance of investigating possible underlying mechanisms that can be helpful in understanding the impact of interventions of this nature. Such understanding is crucial in terms of, for example, tailoring interventions to enhance their effectiveness (Gagliardi, 2011). Our findings support the relevance of examining individual factors that can affect one's aging experience, since those can be associated with more positive outcomes in later life. As indicated by our findings, subjective age is one important marker of psychological aging (Infurna et al., 2010) that should be considered in addition to initial levels of depression. Even though asking about subjective age may seem trivial, responses to that question are very informative and provide substantial understanding about how people navigate the challenges of the aging process. Taking the PROACTIVE psychosocial intervention into account, our results suggest that initial levels of depressive symptoms and subjective age could function as proxies for availability of personal resources, which is a relevant aspect in determining which components of the intervention find more resonance among participants. For those with more severe depressive symptomatology and who report older subjective ages, accommodative components of the intervention gain relevance and replace assimilative responses that should prevail among those with less severe depression and younger subjective ages (Brandtstädter & Rothermund, 2002; Rothermund & Brandtstädter, 2003). This pattern of results offers useful insight regarding possible ways in which the PROACTIVE intervention could be adapted and tailored to individual needs and resources. Based on our findings, baseline depressive severity and subjective age might be cues as to whether the intervention should put a focus on behavioral activation (assimilation)

or on coping skills (accommodation) in order to achieve optimal results for different individuals.

Limitations

The present study is not without limitations. First, our data set does not allow us to examine bidirectional, reciprocal relationships between subjective age and depression, mainly because the PROACTIVE intervention aimed at reducing depression symptoms over time. Thus, it is not possible to assert whether feeling older leads to depression in the future or the other way around (i.e., feeling older would be a symptom of depression, see e.g., Dutt & Wahl, 2017). However, longitudinal evidence is consistent in showing that subjective age predicts physical and mental health as well as its longevity over time (see Westerhof et al. 2023 for a recent and updated meta-analysis). The rationale behind this is that the way individuals perceive themselves and their own aging process operates as self-fulfilling prophecies that in turn affect development in old age (Wurm et al, 2013). Future studies could track the independent and intercorrelated developmental trajectories of depression and subjective age. Beyond that it would have been of interest to examine whether the PROACTIVE intervention had an effect on subjective age, such that the intervention would have made individuals feel younger and therefore report less depressive symptoms. In this study, however, subjective age was only assessed at baseline, which precludes us from examining possible effects of the intervention on subjective age at follow-up. Future studies could examine whether interventions targeting mental health would have an effect on subjective age.

It should also be noted that the PROACTIVE psychosocial intervention was investigated among depressed older adults in socioeconomically deprived areas of Brazil, which could limit the representativeness of our results. One question for future studies,

therefore, is whether our findings would differ depending on socioeconomic and cultural context.

Furthermore, we assessed depressive symptomatology solely with the PHQ-9, which is a self-report screening instrument. Previous validation studies of the PHQ-9, however, have shown that the instrument is a rapid and reliable tool that incorporates DSM-IV depression criteria with other leading major depressive symptoms into a brief self-report instrument to screen and evaluate the severity of depression in primary care settings (Gilbody et al., 2007; Kroenke et al., 2001). For example, in a diagnostic meta-analysis, Gilbody and colleagues (2007) indicated that fourteen studies (5,026 participants) validated the PHQ-9 against Major Depressive Disorder showing a sensitivity = 0.80 (95% CI 0.71–0.87) and a specificity = 0.92 (95% CI 0.88–0.95). Accordingly, even though we did not carry out formal psychiatric diagnostics, we are confident that the instrument that we used is reliable and acceptable to screen depressive symptomatology in primary care settings.

At last, we should note that the reliability of the PHQ-9 measure at baseline was low. This was because, at baseline, the range in depressive symptoms was restricted as the sample only included "depressed individuals" at this time point. Indeed, the distribution of item responses (i.e., the percentage of participants who gave each response to each of the items), showed that for more than half of the scale items, participants gave the same responses. As the variances of these items were quite low, this has led to the scale low reliability at baseline.

Conclusions

Depression is highly prevalent in old age and represents a major challenge to health systems worldwide. The PROACTIVE psychosocial intervention was developed to treat depression in older adults, with previous findings showing that the intervention is effective. In this study, we were interested in further examining the effects of the PROACTIVE

intervention by taking an important psychological marker of the individual aging experience into account – that is, subjective age. Findings indicated the importance of considering subjective age in terms of recovery from depressive symptoms, with different effects of the PROACTIVE intervention being found among those who feel younger and those who feel older than their chronological age – in particular, an effect on the benefits from the intervention across different levels of baseline depressive symptoms. Specifically, positive effects of the intervention were obtained irrespective of initial levels of depressive symptoms for people with a younger subjective age. For people feeling older than they are, however, positive effects of the intervention were limited to participants with high initial levels of depressive symptoms.

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Footnotes

1. We also carried out the analyses applying the traditional approach to treat outliers for subjective age (i.e., to exclude scores that are more than +- 3 SD apart from the mean) and the pattern of results remained the same.

2. The PROACTIVE is a *cluster-randomized controlled trial*, and therefore we used multilevel analysis despite the low ICC. Furthermore, it is not just the ICC but also the cluster sizes that contribute to any impacts of the cluster design on the valid estimates of precision in such a trial.

Tables

Table 1

Means, Standard Deviations, and Correlation Coefficients with 95% Confidence Intervals for the Continuous Variables

Variables	M	SD	Cronbach's alpha	1	2	3	4	5	6	7
1. PHQ-9	16.19 (10 – 27)	4.63	.48	-						
2. PHQ-9 (8-month FU)	10.25 (0 – 27)	7.19	.84	.32** [.25, .40]						
3. Subjective Age	-6.96 (-75 – 75)	22.02	-	.07 [-.02, .15]	.13** [.06, .20]					
4. Age	68.64 (60 – 94)	6.89	-	.03 [-.05, .11]	-.04 [-.11, .03]	-.06 [-.13, .02]				
5. Perceived Health	2.77 (1 – 5)	0.85	-	-.22** [-.30, -.14]	-.26** [-.33, -.19]	-.14** [-.21, -.07]	.03 [-.04, .11]			
6. EQ-5D-5L	0.76 (-.19 – 1)	0.20	.72	-.24** [-.32, -.16]	-.31** [-.38, -.24]	-.13** [-.20, -.05]	-.10** [-.17, -.03]	.42** [.36, .48]		
7. Anxiety	9.80 (0 – 21)	6.12	.83	.30** [.22, .37]	.43** [.37, .49]	.13** [.05, .20]	-.21** [-.28, -.14]	-.25** [-.32, -.18]	-.30** [-.37, -.23]	

| 8. Loneliness | 5.44 (3 – 9) | 1.99 | .74 | .24** [.16, .32] | .26** [.19, .33] | .04 [-.03, .11] | -.06 [-.13, .02] | -.09* [-.17, -.02] | -.19** [-.26, -.11] | .37** [.30, .43] |

Note. Except for PHQ-9 (8-month FU), all variables were assessed at baseline. *M* and *SD* are used to represent mean and standard deviation, respectively. Values in parenthesis indicate the range for the variable. Values in square brackets indicate the 95% confidence interval for each correlation coefficient. PHQ-9 = Depressive symptoms. EQ-5D-5L = Health-related quality of life; Anxiety = Generalized anxiety disorder (GDA-7); Loneliness = Subjective feelings of loneliness (3-item UCLA loneliness scale). * indicates $p < .05$. ** indicates $p < .01$.

Table 2

Summary Statistics for Baseline Characteristics of Participants, Reported for the Control and Intervention

Arms Separately

Variables	Control (N = 355, 49.65%)	Intervention (N = 360, 50.35%)	Effect Size [a]
PHQ-9, *M (SD)*	16.34 (4.69)	16.04 (4.58)	0.06
Subjective Age, *M (SD)*	-8.12 (22.30)	-5.81 (21.72)	0.10
Age, *M (SD)*	68.89 (7.19)	68.39 (6.58)	0.07
Gender (Female)	262 (74%)	268 (74%)	0.00
Time spent in formal education, years			0.02
None	65 (18%)	72 (20%)	
1-4	180 (51%)	173 (48%)	
5-8	71 (20%)	70 (19%)	
>8	38 (11%)	44 (12%)	
Monthly personal income, minimum wage			0.05
≤1 ($266)	255 (76%)	263 (76%)	
>1 to 2 ($266-$532)	55 (16%)	61 (17%)	
>2 to 3 ($532-$798)	15 (4%)	9 (3%)	
>3 ($798)	12 (4%)	13 (4%)	
Marital Status			0.21
Married, living together	173 (51%)	185 (52%)	
Formerly married	129 (38%)	146 (41%)	
Single	38 (11%)	22 (6%)	
Perceived Health	2.72 (.86)	2.83 (.84)	0.13
Anxiety, *M (SD)*	9.43 (6.16)	10.16 (6.06)	0.12

Loneliness, *M (SD)*	5.26 (1.97)	5.61 (1.99)	0.18
EQ-5D-5L, *M (SD)*	0.75 (.20)	0.76 (.21)	0.05
Balance Issues (Yes)	235 (66%)	227 (63%)	0.03

Note. PHQ-9 = Depressive symptoms; Monthly personal income (in Brazilian Reais), 1 minimum wage = R$1,320 in 2023 or approximately $266 US dollars; Anxiety = Generalized anxiety disorder (GAD-7); Loneliness = Subjective feelings of loneliness (3-item UCLA Loneliness Scale); EQ-5D-5L = Health-related quality of life. a. Effect size: Cohen's d for continuous variables, Phi coefficient for two level categorical variables (Gender and Balance), and Cramer's V for categorical variables that have more than two levels (Monthly personal income, Marital status, and Time spent in education).

Table 3

Multilevel Analysis of Predictors of Depressive Symptoms at 8-Month Follow-Up

	Model 1	p	Model 2	p	Model 3	p
Gender (female)	.163	.837	-.027	.969	.019	.978
Marital Status		.003		.004		.005
Formerly married	1.556		1.529		1.459	
Single	-1.991		-1.822		-1.910	
Perceived Health	-.735	.071	-.546	.168	-.556	.157
EQ-5D-5L	-3.891	.023	-3.094	.078	-3.175	.069
Balance Issues (Yes)	.913	.168	.863	.169	.913	.144
Anxiety	.237	<.001	.175	.002	.182	.001
Loneliness	.461	.003	.372	.019	.312	.049
Stratification Educational Level (primary care clinic above the median proportion with no formal education)	.670	.521	.569	.400	.590	.383
PHQ-9			.255	<.001	.366	<.001
Subjective Age			.008	.551	.006	.732
Arm (Intervention)			-3.087	<.001	-2.965	<.001
PHQ-9 × Subjective Age					.006	.074
PHQ-9 × Arm					-.211	.083
Subjective Age × Arm					-.001	.971
PHQ-9 × Subjective Age × Arm					-.013	.012
AIC	3340.122		3317.686		3315.660	

|			
BIC	3390.816	3381.054	3395.927
Marginal R^2/Conditional R^2	.172/.236	.232/.246	.247/.261
Random Effects			
σ Primary Care Clinics (Level 2)	3.332	.688	.719
σ Residual	39.799	38.774	37.981
ICC Primary Care Clinics	0.077	0.017	0.019

Note. Predictor variables assessed at baseline, Gender is dummy coded (male is the reference category); Marital Status is dummy code (married or living together is the reference category); EQ-5D-5L = Health-related quality of life; Balance is dummy coded (not having balance issues is the reference category); Anxiety = Generalized anxiety disorder (GDA-7); Loneliness = Subjective feelings of loneliness (3-item UCLA loneliness scale); Stratification by Educational Level is dummy coded (primary care clinic below the median proportion of adults aged ≥60 years with no formal education is the reference category); PHQ-9 = Depressive symptoms; Arm is dummy coded (control arm is the reference category). All continuous predictors are centered. AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; Marginal R^2 is concerned with variance explained by fixed factors, and conditional R^2 is concerned with variance explained by both fixed and random factors; ICC Primary Care Clinics = intraclass correlation coefficient [(σ Primary Care Clinics (Level 2)/ σ Residual)], large values indicate a lot of the variance is due to clustering (Level 2), whereas small values indicate that not much of the variance is due to clustering (Level 2). Model fit increased significantly after adding the main effects of Subjective Age, PHQ-9 at baseline, and Arm in Model 2, ΔChi²(3) = 28.436, $p < .001$, and after adding all the interactions among them in Model 3, ΔChi²(4) = 10.025, $p = .04$. The proportion of variance, computed by using the Marginal R^2 for fixed effects ($f^2 = R^2/1-R^2$), in PHQ-9 at follow-up that is explained by

the covariates (Model 1) is 21%. The proportion of variance in PHQ-9 at follow-up explained

by adding the main effects of Subjective Age, PHQ-9 at baseline, and Arm (Model 2) is 30%.

The proportion of variance in PHQ-9 at follow-up explained by adding the interactions among

them (Model 3) is 33%.

Figures

Figure 1

Interaction of Depressive Symptoms at Baseline, Arm, and Subjective Age at Baseline on Depressive Symptoms at the 8-Month Follow-Up
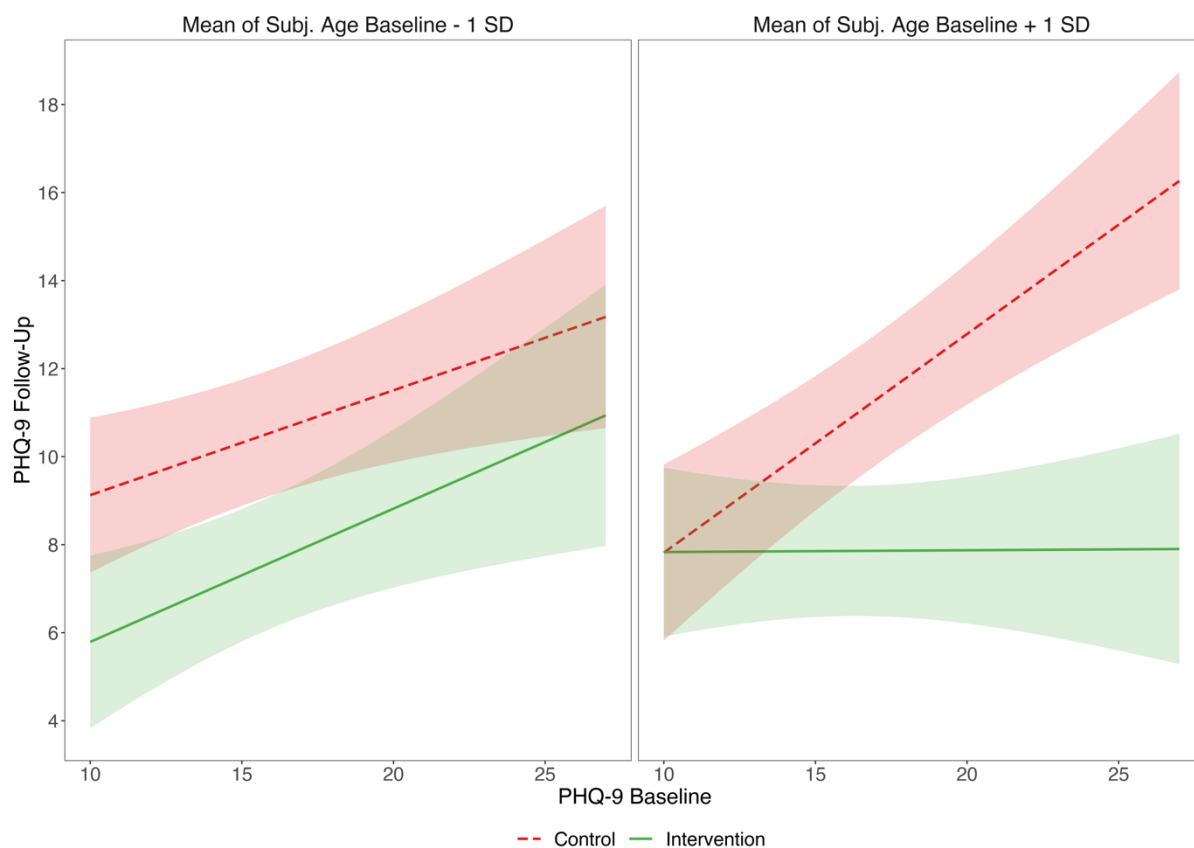
Note. PHQ-9 = Depressive Symptoms; Subj. Age Baseline: values 1 SD below the mean of Subjective Age at baseline (< -28.42) represent younger subjective ages; values 1 SD above the mean of Subjective Age at baseline (> 15.98) represent older subjective ages. The figure indicates that for younger subjective ages, positive effects of the intervention were obtained irrespective of initial levels of depressive symptoms (i.e., as compared to the control arm, the intervention arm showed lower levels of depressive symptoms at follow-up independently of initial levels of depressive symptoms). For older subjective ages, however, benefits from the intervention can be observed when initial levels of depression were relatively high as compared to when they were low (i.e., as compared to the control arm, the intervention arm

only showed lower levels of depressive symptoms at follow-up when initial levels of depressive symptoms were high).