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Fostering emotional self-regulation in female teachers at the public teaching network: A mindfulness-based intervention improving psychological measures and inflammatory biomarkers



David Wilson^{a,1}, Daniela Rodrigues de Oliveira^{a,b,c,d,*,1}, Fanny Palace-Berl^{b,c}, Bárbara de Mello Ponteciano^{b,e}, Luciana Fungaro Rissatti^b, Valéria Piassa Pollizi^a, Flávia Sardela de Miranda^f, Vânia D'Almeida^g, Marcelo Demarzo^{a,h}

^a Department of Preventive Medicine, Graduate Program in Collective Health, Universidade Federal de São Paulo, São Paulo, SP, Brazil

^b Department of Pathology, Graduate Program in Pathology, Universidade Federal de São Paulo, São Paulo, SP, Brazil

^c Laboratory of Medical Investigation (LIM-26), Department of Surgery, University of Sao Paulo Medical School, São Paulo, SP, Brazil

^d Department of Surgery, Medical College of Wisconsin, Milwaukee, WI, United States

^e Universidade Cidade de São Paulo, São Paulo, SP, Brazil

^f Laboratory of Immunomodulation, Department of Immunology, Instituto de Ciências Biomédicas, Universidade de São Paulo, São Paulo, SP, Brazil

^g Department of Psychobiology, Universidade Federal de São Paulo, São Paulo, SP, Brazil

^h Mente Aberta - Brazilian Center for Mindfulness and Health Promotion, Departamento de Medicina Preventiva, Universidade Federal de São Paulo, São Paulo, SP, Brazil

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ABSTRACT

Objective: To examine the effect of a mindfulness-based program specifically designed for teachers in reducing perceived stress and improving the quality of experienced emotion in female active working teachers. A second outcome evaluated is the associated change in cellular inflammatory activity, measured by peripheral blood levels of cytokines.

Method: Eighty-eight female active teachers from public schools from São Paulo Municipality were recruited, and randomly allocated to an eight-week Mindfulness-Based Health Program for Educators (MBHP-Educa) or to Neuroscience for Education Program (Neuro-Educa: active control group). The venue of both programs were several public school facilities, where many of the teachers actually worked. Both groups received activities during eight weeks in a 2 h/week regimen, totalizing 16 h. Sixty-five participants completed the program and pre- and post-interventions measures were taken from the following scales: Interpersonal Multidimensional Reactivity Scale (IRI), Positive-and-Negative Affects Scale (PANAS), Perceived Stress Scale (PSS), Connor-Davidson Resilience Scale (CD-RISC), and a primary outcome in Ryff's Psychological Well-Being Scale (PBWS). At pre- and post-intervention, blood samples were collected for the measurement of several important inflammatory biomarkers, Tumor Necrosis Factor - α (TNF- α), Interleukin 1 β (IL-1 β), Interleukin 6 (IL-6), Interleukin 8 (IL-8), Interleukin 10 (IL-10) and Interleukin 12p70 (IL-12P70) through flow cytometry assay. Intervention effects were analyzed via Generalized mixed models (GLMM).

Results: According to the GLMM, MBHP-Educa significantly reduced the scores of perceived stress ($p < 0.0001$), and negative affect ($p < 0.0001$) compared to active control group (Neuro-Educa). Conversely, an increase was observed on Psychological Well Being Scale in dimensions of Self-acceptance ($p < 0.0001$), and Autonomy ($p = 0.001$), as well as improvements in Resilience ($p < 0.0001$), and Positive Affect ($p < 0.0001$). MBHP-Educa also promoted a reduction in the levels of IL-6 ($p = 0.003$), IL-8 ($p = 0.036$), and increase in the levels of IL-10 ($p < 0.0001$) and IL-12p70 ($p < 0.044$). TNF- α , IL-1 β , and IL-10p70 showed results below theoretical limit of detection accepted for CBA kit.

* Corresponding author. Department of Preventive Medicine, Graduate Program in Collective Health, Universidade Federal de São Paulo, São Paulo, SP, Brazil.

E-mail addresses: davidwilsonbrasileiro@gmail.com (D. Wilson), danielaoliveira.phd@gmail.com, doliveira@mcw.edu (D. Rodrigues de Oliveira), fanny.palace@gmail.com (F. Palace-Berl), bmpteciano@gmail.com (B. de Mello Ponteciano), lufungaro@hotmail.com (L. Fungaro Rissatti), valerapolizzi@gmail.com (V. Piassa Pollizi), flavia.sardela@gmail.com (F. Sardela de Miranda), vaniadalmeida@icloud.com (V. D'Almeida), marcelodemarzo@gmail.com (M. Demarzo).

¹ These authors have contributed equally to this work and share first authorship.

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Conclusions: Our data suggest that mindfulness-based interventions introduced as a strategy for reducing stress, promoting well-being and improve immune function can be a useful asset in promoting psychological health among teachers in Basic Education.

1. Introduction

Teachers in elementary school are known to face several challenges, ranging from daily routine chores (personal stress) up to greater stressful events involving students and their families, educational policies, and responsibilities toward grades (professional stress). These challenges are more or less stressful according to their inherent degree of conflict or ambiguity (Papastylianou et al., 2009), and the degree to which these conflicts bring on the perception of apparent overwhelming challenges and the associated feelings of defeat. This, in association with eventual poor working conditions, unfeasibility of certain demands, and with a reduced ability to comply, build up a global scenario of great adversity (Kyriacou and Sutcliffe, 1977; von der Embse et al., 2019), which in turn can contribute to distractibility, lack of concentration, and memory failures (Allen et al., 2013; Mahoney et al., 1998; Schwabe and Wolf, 2010). More so, increased prevalence of clinical and psychiatric disorders such as depression and anxiety (Pithers and Soden, 1999; Travers and Cooper, 2018), (Ferguson et al., 2012), are also seen in teachers, which act both as cause and consequence of stress (Desouky and Allam, 2017). Professional burnout seems to be the final pathway of chronic stress for many teachers (Shin et al., 2013). Clinical conditions such as musculo-skeletal disorders (Alias et al., 2020; Erick and Smith, 2011; Ng et al., 2019), psychological distress and burn-out syndrome (Alias et al., 2020; Silva et al., 2017), anxiety and depression (Pithers and Soden, 1999; Travers and Cooper, 2018). Adverse environmental factors such as overwork, underpayment, and often conflictive educational policies (da Rocha et al., 2015; Rodrigues et al., 2020; SILVA et al., 2018) are unfortunately more frequent than desirable (Paes et al., 2014; Rodrigues et al., 2020). Several vulnerability factors can be added to these stressors and social/emotional support.

The social costs of this disability are high (Coledam et al., 2019), and, despite the importance of the matter, few measures have been taken in order to specifically foster improvements in teachers perceived stress and well-being (Gorrell et al., 1985; Rey et al., 2016). Nevertheless, despite these high prevalence rates of mental discomfort, an expressive portion of teachers remain resilient, remaining relatively healthy and active, basically committed to their occupation (Borrelli et al., 2014; Guglielmi and Tatrow, 1998; Kieschke and Schaarschmidt, 2008). In fact, a great number of them carry on performing satisfactorily (Scheuch et al., 2015). This latter population, which is not disabled, is equally exposed to adversity and lacks specific interventions in order to prevent stress and improve psychological well-being (Scheuch et al., 2015), and this epidemiological observation points clearly toward a non-linear relation between adversity and stress/impooverished health.

Cellular inflammation and inflammatory biomarkers pose as an important molecular pathway taking from stressful experiences to organic and psychological impact, and have received growing attention in recent clinical research in several psychiatric and clinical conditions related to stress, such as for overweight and obesity (Fernández-Sánchez et al., 2011), coronary heart disease (Yudkin et al., 2000), high blood pressure (Savoia and Schiffrin, 2006; Tsounis et al., 2014), diabetes (Koh et al., 2005; Lontchi-Yimagou et al., 2013) and metabolic syndrome as a whole (Esposito and Giugliano, 2004; Koh et al., 2005). Psychiatric disorders and psychological states can also be prompted by inflammatory biomarkers and cytokines (Camacho, 2013; Hou and Baldwin, 2012), suggesting a big loop of positive feedback in molecular mechanisms associated to stressful states (Sternberg et al., 1992; Wijaya et al., 2020).

The association between inflammatory biomarkers and cytokines and mindfulness has also been explored, and shedding light on the intervention power posed by mindfulness, such as reduction of

proinflammatory enzymes in Mild Cognitive Impairment (Ng et al., 2020), interleukin-6 improvement in trauma-exposed women (Gallegos et al., 2015), or reduction in inflammation biomarkers such as interleukin-6 and TNF- α on clinical conditions such as breast cancer (Bower et al., 2015; Reich et al., 2017), inflammatory bowel disease (González-Moret et al., 2020; Hood and Jedel, 2017), as well as surgical conditions such as pre- and post-bariatric surgery (Chacko et al., 2016; Leahey et al., 2008), all shedding preliminary but promising results.

Several initiatives and studies have been proceeded, using several Mindfulness-based Interventions such as Cultivating Emotional Balance (CEB), Cultivating Awareness and Resilience in Education (CARE), Comprehensive Approach to Learning Mindfulness (CALM), and Mindfulness-Based Emotional Balance (MBEB), all of which showed efficacy in teachers basically by promoting stress management, thus improving psychological and physical well-being (Harris et al., 2016; Jennings et al., 2013, 2017; Kemeny et al., 2012), thus providing protective effects on the health of teachers (Abenavoli et al., 2013). Besides psychological improvement, some studies approached stress physiological and inflammatory biomarkers such as salivary cortisol (Katz et al., 2016), acting on immediate and follow-up improvements (Kuyken et al., 2016; Roeser et al., 2013, 2021; Taylor et al., 2016). Since Mindfulness training focuses mainly on bringing awareness to current experience, cultivating attention and thus decentering from the continuously changing thoughts, feelings and sensations in the conscious field from moment to moment, it is expected that it would train participants, leading them to the experience of being alert to the details of the here-and-now (Bishop et al., 2004). Mindfulness supports emotional regulation through the immediate acceptance of present experience in place of struggling to avoid or control specific emotions and perceptions as they arise and come to our awareness moment to moment (Hill and Updegraff, 2012). Research on mindfulness programs applied to healthy populations is a field in growth (Khoury et al., 2015; Sharma and Rush, 2014) and matches the idea of primary prevention and health promotion. In the school context, it is applicable both to teachers and students (van de Weijer-Bergsma et al., 2014), under the assumption that fostering attention, resilience and especially well-being in a population who is presently free of obvious health issues may have a prophylactic action for future burnout, anxiety and depression (Lawlor, 2016).

For the evaluation of changes in well-being, several facets of mental status and psychological variables (such as the presence of stressful reactions, predominance of positive and negative affects, resilience, and well-being) were measured pre- and post-intervention through a Mindfulness-based Intervention, the Mindfulness-based Health Promotion for Educators (MBHP-Educa). Such an MBI comes in accordance with previous programs and study findings previously cited, and it was specifically developed for Brazilian education context. In order to evaluate the relation of such psychometric variables and inflammatory biomarkers (Del Giudice and Gangestad, 2018; Friedman et al., 2007; Sturgeon et al., 2016), we strived to measure the variation of peripheral inflammatory enzymes, such as TNF- α , IL-1 β , IL-6, IL-8, IL-10 and IL-12p70.

With this background, the primary goals of the multi-venue randomized clinical trial was to evaluate the effects of introducing mindfulness-based activities to such groups, in order to evaluate changes in psychological well-being measures (primary outcome) in female teachers in Brazilian Public Schools. We were secondarily interested in whether the intervention would reduce perceived stress and negative affectivity and increase the resilience and positive affectivity (secondary outcome). Furthermore, we were also interested in promoting improvement on associated pro-and-anti-inflammatory interleukins (third outcome). Our study hypothesized that such measures applied to a mindfulness-based

intervention can point out a beneficial effect of mindfulness practices on perceived stress, resilience, and well-being, as well as promote an improvement on associated inflammatory biomarkers.

2. Materials and methods

2.1. Study design

A multi-venue randomized clinical trial with pre-and post-treatment measures was designed in order to evaluate changes in psychological well-being, stress as well as other psychometric variables, and associated changes in inflammatory biomarkers. There were two treatment arms:

Neuro-Educa (a psychoeducational program in Neuroscience information for Teachers which does not include a mindfulness content (awareness) or practice, and was designed by Brazilian neuroscientist and MBHP-Educa (Mindfulness-Based Health Promotion for Educators), designed by Brazilians researchers to cope with stress and increase the resilience in the educational Brazilian context (de Oliveira et al., 2021; Demarzo et al., 2020). Intention-to-treat was applied to avoid overestimation of the efficacy by excluding non-compliers. Our study follows the recommendations of the CONSORT group (Publications and on Journal, 2008) for randomized clinical trial reporting standards.

Both arms were submitted to an 8-week/2-h intervention in which both programs were applied, and the outcome measures and biomarkers

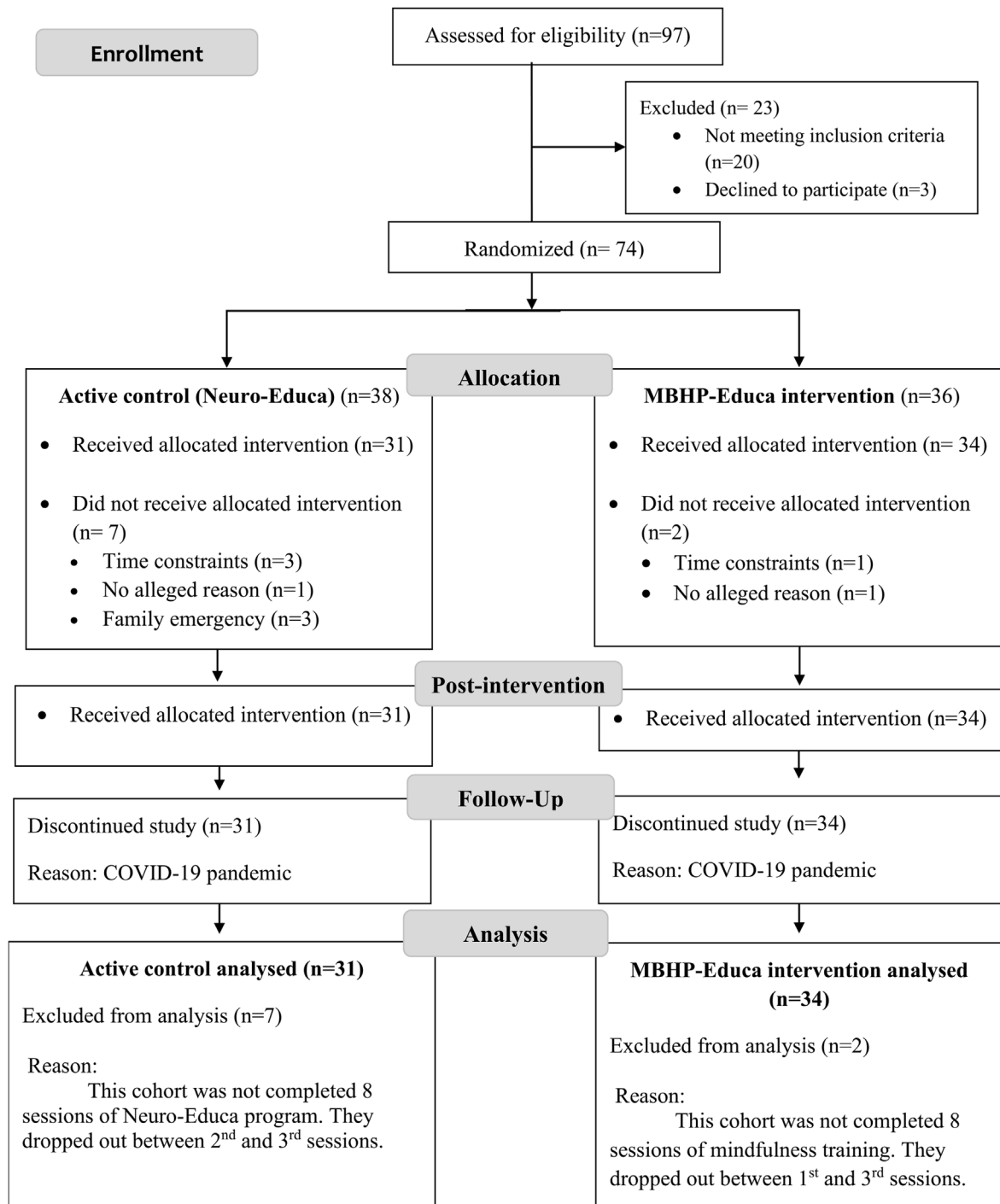


Fig. 1. Flow chart CONSORT.

were collected at similar time points: at baseline (pre-intervention) and post-intervention. Unfortunately, we were unable to carry out an initially planned 12-month follow-up of both study arms, due to the social confinement imposed by the Covid 19 pandemic.

Ethical approval was granted by the Research Ethics Committee of the Universidade Federal de São Paulo (Number: 1336/2018 (3.159.669)–CAAE: 03079918.1.0000.5505). The study design, measures, and analysis approach were registered (<https://www.clinicaltrials.gov/ct2/show/NCT05085847>) on October 01, 2019.

2.2. Participants

97 teachers actively teaching in public schools under the “Diretoria Regional de Educação de Santo Amaro – DRESA” – a southern section of the São Paulo City Hall public education secretaryship were invited to take part in the study, after a motivational lecture performed by our team. Inclusion criteria were 1) being Brazilian, 2) women, 3) age between 23 and 65 years, 4) actively teaching at the time of the study. Exclusion criteria were 1) presence of a clinical condition that prevents participation in the activities, 2) psychiatric condition which poses life-risk, 3) suicidal ideation at the moment of study, 4) previous or present involvement in meditation practices, as well as Yoga or Tai-Chi. Recruitment took place between December 2018 to February 2019 for both groups.

Twenty-three teachers were excluded from this study. The reasons were (a) declined to participate ($n = 3$), (b) current depressive disorder ($n = 15$) and (c) current yoga practices ($n = 5$). Only 74 participants were recruited and randomly allocated to the active control group (Neuro-Educa, $n = 38$) and intervention group (MBHP-Educa, $n = 36$). Nine participants dropped out of the study for not complete more of them 3 sessions. The most common reason was were competing familiar time demands and time constraints. Therefore, a total of 31 participants in the active control group (Neuro-Educa) and 34 in the intervention group (MBHP-Educa) completed the study and were included in the analysis. At the end of the study, we had a total of 65 participants (active control group – Neuro-Educa, $n = 31$ and intervention group – MBHP-Educa, $n = 34$) who had completed the intervention after 8-week sessions (see flow-chart, Fig. 1).

2.3. Assessment

Teachers were invited to a motivational lecture about the neuro-functional basis of emotional and behavioral modulation. At the end of the lecture, those who wished to participate in a study were invited to fill in for an interview. At the end of the interview, the willing participant was invited to sign an informed consent form. Sample size was performed using the G*Power 3.1 software (Faul et al., 2009) indicated that planned two-tailed test (post-test *minus* pre-test and follow-up test *minus* pre-test difference score models, i.e., GROUP x time point interaction) with α set to 0.05, power of 0.80, $N = 76$ would be required to detect moderate ($d = 0.55$) magnitude effects.

Next, randomization identification was assigned to each participant and registered in the clinical registration form. The resulting randomization list was restricted to the research team. Participants were randomly allocated by using IBM SPSS version 25.0 (IBM Corp., Armonk, NY, USA) to Neuro-Educa or MBHP-Educa groups, with a group size of 8–12 participants each.

Patients, unaware of group allocation, filled in the questionnaires and scales, and the results were added to each participant chart and were next assessed by the questionnaires and scales above. Access to the master randomization list was restricted during the study to keep blinding.

2.4. Intervention

Neuro-Educa program (an active control group) consisted of a collection with a specific neurofunctional focus on teaching and education, and was delivered during eight weekly encounters, lasting 2 h, in

which teachers received classes about several principles involved in learning-teaching processes. Such classes were delivered by neuroscience research staff. For additional information, please see de Oliveira and collaborators (2021) (de Oliveira et al., 2021).

MBHP-Educa is a Mindfulness-Based Intervention, designed to specifically attend teachers, delivering psychoeducational material, along with mindfulness-based practices (de Oliveira et al., 2021; Demarzo et al., 2020). Both groups ran throughout the eight weeks, in different venues, all provided for free by the respective public schools. MBHP-Educa participants were encouraged to sustain a home practice during the week, and for such, were offered recorded guided practices through social media nets, which lasted between 7 and 10 min. The sessions began with a 20-min “heating-up” period, then a 20-min practice which was followed by inquiry, in which participants were trained in bodily awareness, breathing perception, and acceptance of the unfolding of experience of thoughts and feelings. Following, the next 45 min of the session were dedicated to a psychoeducational discussion involving the practice and the inquiry just performed. After that, the group underwent a 10-min practice followed by instructions for home practice during the week (de Oliveira et al., 2021; Demarzo et al., 2020).

The instructors who ran MBHP-Educa sessions were conducted by two instructors with more than 30 years’ experience in meditation practices (Zen and Tibetan Buddhist approach to mind-training) and extensive mindfulness teaching and practice (>5 years) experience. Both instructors were graduated by Mente Aberta - Brazilian Center for Mindfulness and Health Promotion, Universidade Federal de São Paulo, and were co-authors of the MBHP-Educa program (Demarzo et al., 2020). Neuro-Educa control group classes were run by two neuroscientists (2–10 years teaching experiences).

2.5. Outcomes

Our goal was to evaluate the effects of introducing mindfulness-based activities and meditation to such groups, in order to evaluate changes in well-being measures, as well as stress variables and immunoinflammatory biomarkers involved both in stress and well-being (Flook et al., 2013), specifically focusing on mechanisms such as emotional self-regulation and decentering (Emerson et al., 2017; Gawrysiak et al., 2018), attention regulation, body awareness and change in perspective on the self (Carver, 2004; Hölzel et al., 2011; Masicampo and Baumeister, 2007). This strategy is held in the hope of enhancing socio-emotional abilities and coping skills in the classroom (Gawrysiak et al., 2018; Irving et al., 2009).

For the evaluation of changes in well-being, several facets of mental status and psychological variables (such as the presence of stressful reactions, predominance of positive and negative affects, resilience, and well-being) were measured pre- and post-intervention through a Mindfulness-based Intervention, the Mindfulness-based Health Promotion for Educators (MBHP-Educa). Such an MBI comes in accordance with previous programs and study findings cited above, and it was specifically developed for Brazilian education context. In order to evaluate the relation of such variables on inflammatory biomarkers, the interaction between each other, and their effect on psychological well-being, we also strive to measure the variation of peripheral inflammatory biomarkers, such as TNF- α , IL-1 β IL-6, IL-8, IL-10, IL-12p70.

Thus, our primary outcome measure was Psychological Well-being, assessed using the 84-item Psychological Well Being Scale (PWBS) of Ryff (Springer and Hauser, 2006). It is composed of 6 psychosocial dimensions (social relationship, autonomy, environmental mastery, personal growth, purpose in life, and self-acceptance), counting 14 items per dimension, totalizing 84 items. It is derived from theories of human development, mental health and humanistic-existential psychology. It has a Cronbach's Coefficient α above 0.83 for all six domains. The Portuguese version presented acceptable psychometric performance, keeping balance relative to the 6 dimensions (Fernandes et al., 2010; Machado, 2010).

In order to follow the global evolution of variables associated with well-being other than a single-scale evaluation, other psychometric measures were used, such as the Positive-and-Negative Affects Scale (PANAS) (Zanon et al., 2013). Intended to evaluate the predominance of positive or negative affects within emotional *scenario*, the measures are distributed among 20 questions, 10 about positive affects, it and 10 about negative affects, it holds a scoring range that can go from 0 (not at all) up to 5 (extremely). Translated to Portuguese and adapted for use in Brazil, it showed a global Cronbach Coefficient $\alpha = 0.88$ (Pires et al., 2013). Since none of our study subjects reached clinical scores, the study was able to detect variations in the affective experience within the normal range of human healthy experience.

In order to measure the emotional reactivity to adversity, we used the Portuguese version of Interpersonal Multidimensional Reactivity Scale (IMRI), which measures empathy, has 21 items distributed among 3 dimensions, each one being scored between “does not describe me (1)” up to “describes me very well (5)”. All three dimensions have Cronbach Coefficient α between 0.54 up to 0.67 (Formiga, 2012).

We also chose to measure the experiencing of stress by the Perceived Stress Scale (PSS) (Siqueira Reis et al., 2010). The Perceived Stress (PSS-10) (Luft et al., 2007) was developed aiming to evaluate the degree to which one's subjectively noticed stress (composed of 10 items, 6 of which scoring positively, and 4 scoring negatively, using a Likert-kind frequency scale), with answers ranging from “Never” (0) to “Always” (4), and a proportional crescendo according to experimented stress (0–7 indicating very low stress; 8–11, low stress; 12–15 require attention, 16–20, high stress; above 21, very high stress). The Portuguese translation adapted for Brazilian use showed internal consistency (Cronbach's alpha = 0.82) when tested on a sample of 517 subjects (Luft et al., 2007).

To measure another biopsychological variable associated to stress, we collected scores taken from the Connor-Davidson Resilience Scale (CD-RISC) (Anjos et al., 2019). The CD-RISC consists of a 25-item measure of different aspects of resilience, with each item ranging from 0 (“not true at all”) up to 4 (“true nearly all the time”). In the final scores (obtained by the sum of each item value), elevated values correspond to higher levels of resilience. Its translation into Portuguese for adaptation for Brazilian use, a sample of 463 subjects in which it was tested revealed adequate adjustment, showing good internal consistency (Cronbach's alpha = 0.82) (Lopes and Martins, 2011).

2.6. Blood sample collection and inflammatory cytokine assays

Serum samples were collected through peripheral blood samples in tubes TUBE BRAND without anti-coagulants (BD Vacutainer®). The samples were then centrifuged after coagulation. The resulting aliquots were stocked at -80°C until the moment of analysis, which were performed within 6 months from collecting. The levels of cytokines Interleukin-8 (IL-8), Interleukin-6 (IL-6), Interleukin-10 (IL-10), Interleukin-1 β (IL-1 β), Tumor Necrosis Factor (TNF- α) and Interleukin-12p70 (IL-12p70) were determined by Cytometric Bead Array (CBA) Human Inflammatory Cytokines Kit (BD Biosciences, San Jose, CA). The Acquisition Analysis was obtained by FCAP Array TM Software (Soft Flow Hungary Ltd., Pécs, HU). Further details on material and methods are elsewhere in our previous paper (de Oliveira et al., 2021). Cytokines TNF- α , IL-12p70 e IL-1 β (3.7, 1.9 and 7.2 pg/mL respectively) yielded results below theoretical limit of detection accepted for CBA Human Inflammatory Cytokines Kit, and so, were excluded from the statistical analysis.

2.7. Statistical analysis

Demographic, clinical, lifestyle, and physical characteristics of participants at baseline were described using means and standard deviations (SD), frequencies, or percentages (%), according to their nature. Also, group comparisons of these variables were performed using Student's independent *t*-test for continuous variables and Chi-Square (χ^2) test

(Fisher's test was used when adequate) for categorical data. Descriptive data were calculated in SPSS (version 22) (Ibm, 2017). Hedges' *g* values were calculated in Microsoft Excel and pooled weighted standard deviations were used to account for pre- and post-intervention treatment group size (Hedges, 1981).

Generalized mixed models (GLMM) were conducted to determine whether the intervention group changed on the outcome measures relative to the control group. The GLMMs were implemented through SPSS (version 22) GENLINMIXED procedure. One nominal random effect (participants), one nominal fixed effect (group: intervention, MBHP-Educa, versus active control, Neuro-Educa), one ordinal fixed effect (time: pre-test versus post-test), and Group \times Time interaction were established. Confidence level of 95% was applied. Violations of sphericity were addressed by establishing the first-order autoregressive (AR1) covariance matrix. The GLMM ‘robust statistics’ option was examined to assess for violations of normality and homogeneity of variance. Log-likelihood function convergence criterion was selected. GLMM analysis was conducted separately for each outcome to optimize the chances of convergence. Bonferroni adjusted alpha-levels were calculated accordingly to each outcome (see Supplementary Table 1).

3. Results

3.1. Socio-demographic, clinical, lifestyle, and physical characteristics

Data revealed no significant differences between groups ($p > 0.05$) in any socio-demographic, clinical, and physical variables (Table 1).

3.2. Baseline data investigation

No differences between pre-intervention active control group (Neuro-Educa) and pre-intervention group (MBHP-Educa) were found through the *t*-test performed with the variables: psychological well-being scale (PWBS) of autonomy, environmental mastery, personal growth, relations with others, purpose in life, and self-acceptance, as well as, perceived stress scale (PSS), resilience scale (RISC), negative affect subscale (PANAS-N), positive affect subscale (PANAS-P), and Inflammatory cytokines (IL) (Table 2).

Descriptive data (adjusted means, standard deviations, and N values) comparing treatment and control conditions at pre- and post-intervention on each outcome were performed. These data revealed an increase in mean values for resilience scale (RISC) and positive affect subscale (PANAS-P) between pre- and post-intervention of the intervention group (MBHP-Educa). Also, the Hedges' *g* values demonstrate a large effect size when comparing these two groups, which means that they are substantially different (Δ and Hedges' *g* in Table 3). On the other hand, the perceived stress scale (PSS) and negative affect subscale (PANAS-N) showed the opposite behavior. Considering interleukins, most tend to decrease their mean values between pre- and post-intervention of the treatment group and only interleukins 6 and 10 differ substantially in Hedges' *g* values.

3.3. Mindfulness meditation enhanced psychological well-being

The psychological well-being scale (PWBS) of autonomy, environmental mastery, personal growth, relations with others, purpose in life, and self-acceptance were investigated under mindfulness meditation effects (Table 4, see Supplementary material 2: Q-Q plot primary outcome). Results on this primary outcome indicated that the intervention group significantly increased from pre- to post-test on the autonomy subscale of PWBS (main effect of Group*Time: $F = 17.83$, $p < 0.0001$) (Tables 3 and 4). Similar behavior was observed on the self-acceptance subscale, from pre- to post-test (main effect of Group*Time: $F = 26.251$, $p < 0.0001$).

Table 1
Socio-demographic and clinical characteristics of participants at baseline.

Characteristics	Active control (Neuro-Educa)	MBHP- Educa	Group Comparisons
	(n = 38)	(n = 36)	
Socio-demographic			
Age, mean (SD)	44.87 (7.75)	43.19 (6.84)	$t(72) = 0.983, p = 0.329$
Ethnicity, n (%)			
White	24 (63.2)	22 (61.1)	$\chi^2 = 5.303, p = 0.151$
Black	3 (7.9)	7 (19.4)	
Indian Brazilian	9 (23.7)	3 (8.3)	
Pardo Brazilian	–	–	
Asian Brazilian	2 (5.3)	4 (11.1)	
Relationship status, n (%)			
Single	6 (15.8)	10 (27.8)	$\chi^2 = 4.544, p = 0.208$
In a relationship	22 (57.9)	21 (58.3)	
Married	10 (26.3)	4 (11.1)	
Divorced	–	1 (2.8)	
Children, n (%)			
1 child	17 (44.7)	21 (58.3)	$\chi^2 = 6.943, p = 0.074$
2 children	10 (26.3)	10 (27.8)	
3 children	11 (28.9)	3 (8.3)	
4 children	–	2 (5.6)	
Individual Income (R\$ 954.00), n (%)			
954.00–1908.00	10 (26.3)	11 (30.6)	$\chi^2 = 1.748, p = 0.782$
1908.00–4770.00	24 (63.2)	22 (61.1)	
4770.00–9540.00	2 (5.3)	1 (2.8)	
>9540.00	2 (5.3)	1 (2.8)	
Not informed	–	1 (2.8)	
Working hours, n (%)			
<20	1 (2.6)	–	$\chi^2 = 4.534, p = 0.209$
20–29	–	3 (8.3)	
30–39	2 (5.3)	3 (8.3)	
>40	35 (92.1)	30 (83.3)	
Clinical Characteristics			
Psychological health			
BDI score, mean (SD)	11.24 (5.53)	12.72 (5.10)	$t(72) = -1.199, p = 0.234$
BAI score, mean (SD)	11.79 (6.59)	13.36 (6.21)	$t(72) = -1.055, p = 0.295$
Pathology, n (%)			
Not diagnostic	33 (86.8)	24 (66.7)	$\chi^2 = 4.259, p = 0.119$
Metabolic syndrome	3 (7.9)	7 (19.4)	
Musculoskeletal disorders	2 (5.3)	5 (13.9)	
BMI, mean (SD)	22.82 (2.03)	23.78 (2.49)	$t(72) = -1.830, p = 0.071$

Note: Means with standard deviations (SD), and number of cases with percentages (%).

3.4. Mindfulness meditation enhances resilience to stress and reduces negative affectivity

Considering the perceived stress scale (PSS), a significant reduction was observed in the intervention group pre-to post-test (main effect of Group*Time: $F = 51.344, p < 0.0001$) (Tables 3 and 4, see Supplementary material 2: Q-Q plot secondary outcomes). Conversely, the intervention group showed a substantial increase from pre to post-test on resilience scale (RISC) (main effect of Group*Time: $F = 63.387, p < 0.0001$). Similarly, the intervention group presented a decrease on negative affect subscale (PANAS-N) from pre-to-post-test (main effect of Group*Time: $F = 24.696, p < 0.0001$), and a opposite behavior on positive affect subscale (PANAS-P) (main effect of Group*Time: $F = 55.536, p < 0.0001$).

3.5. Mindfulness meditation alters inflammatory biomarkers

Interleukins were investigated on the intervention group and revealed lower the serum of IL-6, and IL-10 from pre-to post-test. IL-6 effect of Group*Time: $F = 9.297, p = 0.003$, and IL-10 effect of

Table 2
Active control (Neuro-Educa) and intervention group (MBHP-Educa) comparison at baseline.

PWBS: Autonomy	$t(72) = 2.388, p = 0.931$
PWBS: Environmental Mastery	$t(72) = 0.443, p = 0.128$
PWBS: Personal Growth	$t(72) = -0.203, p = 0.913$
PWBS: Positive Relations with Others	$t(72) = -0.035, p = 0.978$
PWBS: Purpose in life	$t(72) = -0.902, p = 0.162$
PWBS: Self-Acceptance	$t(72) = -0.482, p = 0.082$
PSS	$t(72) = -2.034, p = 0.900$
RISC	$t(72) = 3.263, p = 0.077$
PANAS-P	$t(72) = 2.415, p = 0.552$
PANAS-N	$t(72) = -1.032, p = 0.347$
IL-6 (pg/mL)	$t(70) = 0.445, p = 0.600$
IL-8 (pg/mL)	$t(70) = -0.455, p = 0.251$
IL-10 (pg/mL)	$t(70) = 2.017, p = 0.379$
IL-12p70 (pg/mL)	$t(70) = -0.460, p = 0.303$

Note: No differences between pre-intervention active control group (Neuro-Educa) and pre-intervention group (MBHP-Educa). T-test performed with IC = 95%.

Group*Time: $F = 43.023, p < 0.0001$ (Tables 3 and 4, see Supplementary material 2: Q-Q plot third outcome).

4. Discussion

The reduction in perceived stress, as identified by PSS, contributes decisively to well-being, and is consonant with the larger picture and previous studies where mindfulness is an effective instrument in reducing stress and its associated reactivity (Lee, 2012), especially with aging (Stawski et al., 2008), both strong factors for the development of associated anxiety and depression (de Rooij et al., 2010).

A similar pattern was accomplished concerning interpersonal reactivity, yielding evidence of an ameliorated empathic sensibility, which in turn is a factor of general improvement in the stressful nature of interpersonal relations with significant pairs (Hampes, 2010). This improvement is of great importance for the intricate and often tricky emotional interaction between teacher and child students. Our finding is in accordance with previous findings and theorizations (Haydon et al., 2019; Jennings et al., 2013; Kemeny et al., 2012), where mindfulness promotes an improvement in classroom environment due to the mitigation of stressful reactions of teachers, in congruence with the enhancement of their ability to cope with inherent adversity and unpredictability (Doyle, 1977; Haydon et al., 2019).

The effect yielded by the improvement of balance between positive and negative affect, with a reduction of negative affect and a simultaneous increase in positive affect, are, *per se*, criteria for improved quality of life and enhanced stamina (Kuechler and Stedham, 2018), promoting health in itself through neuroendocrine and inflammatory mechanisms throughout the organism (Ambrona and López-Pérez, 2014; Spangelo and Gorospe, 1995), and consequently enhancing job satisfaction and teaching efficiency (Collie et al., 2012).

Our study also found an increase in the score of resilience, as measured by Connor-Davidson's Resilience scale, which is in accordance with other measures found in our study as well as in others (Harker et al., 2016). Psychological resilience is a learnable process of positive adaptation to stress, frequently considered a protective factor against burnout (Kaplan et al., 2017), and can easily be understood as another factor which, by being enhanced via mindfulness practice, contributes decisively for the amelioration of global stamina and health.

These findings, taken altogether, contribute for the enhancement of well-being, pointing out to the fact that a mindfulness-based program offered to healthy individuals yielded improved psychological well-being as seen by PWBS autonomy and self-acceptance scores. Such a result sheds light on how people see and treat themselves, as can be seen through the observed increase in the self-acceptance dimension of the Psychological Well-being Scale. It is long known that a poor opinion of

Table 3
Descriptive data of intervention and active control groups.

Variables	Active control group (Neuro-Educa)					Intervention group (MBHP-Educa)						
	Pre-intervention (N = 38)a		Post-intervention (N = 31)b		Δ	Hedges' g	Pre-intervention (N = 36)c		Post-intervention (N = 34)d		Δ	Hedges' g
	Mean	SD	Mean	SD			Mean	SD	Mean	SD		
PWBS: Autonomy	55	5.963	50	10.339	-5	0.590	49.5	10	57	6.790	8	-0.863
PWBS: Environmental Mastery	54	4.339	50	4.795	-4	0.866	51	5.761	53	7.986	2	-0.285
PWBS: Personal Growth	48	5.705	48	4.859	0	0.000	48	6.207	47	9.625	-1	0.123
PWBS: Positive Relations with Others	43	5.236	45	4.621	2	-0.400	44	5.653	43	3.698	-1	0.206
PWBS: Purpose in life	58	9.051	52	8.769	-6	0.666	64	11.751	68	10.753	4	-0.351
PWBS: Self-Acceptance	50	10.617	51	9.925	1	-0.096	55	14.634	63	12.137	8	-0.587
PSS	31	7.167	36	7.310	5	-0.683	38	6.730	28	8.649	-10	1.281
RISC	56	9.541	52	10.632	-4	-2.383	53	12.772	72	14.988	19	-3.569
PANAS-P	31	6.403	28	7.371	-3	0.125	30	7.166	37.5	6.300	8	-1.509
PANAS-N	29	8.351	24	6.268	-5	3.898	26.5	7.969	17	7.463	-10	3.379
IL-6 (pg/mL)	3,77	0,76	3,453	0,169	-0,316	0,561	3,422	0,910	2,783	0,432	-0,638	0,878
IL-8 (pg/mL)	7,82	3,12	6,407	2,712	-1,412	0,476	6,845	3,704	5,978	2,828	-0,867	0,259
IL-10 (pg/mL)	5,91	0,49	5,847	0,547	-0,058	0,111	5,680	0,522	4,599	0,609	-1,081	1,890
IL-12p70 (pg/mL)	2,714	1,006	3,892	1,043	1,178	-1,135	2,330	0,500	2,610	0,780	0,280	-0,227

Note: SD: Standard deviations; a: N = 28 for IL-12p70 (pg/mL); b: N = 22 for IL-12p70 (pg/mL); c: N = 29 for IL-12p70 (pg/mL); N = 26 for IL-12p70 (pg/mL); Δ: difference between post- and pre-intervention; Hedges' g calculated between pre- and post-intervention.

Table 4
Generalized linear mixed models results for each outcome.

Outcomes	Variables	Numerator df	Denominator df	F- value	P-value
<i>Primary outcome</i>					
PWBS: Autonomy	Group	1	135	0.016	0.899
	Time	1	135	2.463	0.119
	Group*Time	1	135	17.830	<0.0001*
PWBS: Environmental Mastery	Group	1	135	1.523	0.219
	Time	1	135	2.712	0.102
	Group*Time	1	135	4.333	0.039
PWBS: Personal Growth	Group	1	135	0.132	0.717
	Time	1	135	0.428	0.514
	Group*Time	1	135	0.557	0.457
PWBS: Positive Relations with Others	Group	1	135	0.465	0.497
	Time	1	135	0.026	0.871
	Group*Time	1	135	0.708	0.402
PWBS: Purpose in life	Group	1	135	6.923	0.009
	Time	1	135	0.109	0.742
	Group*Time	1	135	6.272	0.013
PWBS: Self-Acceptance	Group	1	135	6.316	0.013
	Time	1	135	15.497	<0.0001*
	Group*Time	1	135	26.251	<0.0001*
<i>Secondary outcome</i>					
PSS	Group	1	135	1.487	0.225
	Time	1	135	11.511	0.001**
	Group*Time	1	135	51.344	<0.0001**
RISC	Group	1	135	0.048	0.827
	Time	1	135	42.634	<0.0001***
	Group*Time	1	135	63.387	<0.0001***
PANAS-Positive	Group	1	135	0.456	0.501
	Time	1	135	12.821	<0.0001**
	Group*Time	1	135	55.536	<0.0001**
PANAS-Negative	Group	1	135	1.614	0.206
	Time	1	135	19.706	<0.0001**
	Group*Time	1	135	24.696	<0.0001**
<i>Third outcome</i>					
IL-6 (pg/mL)	Group	1	132	8.710	0.004****
	Time	1	132	33.429	<0.0001****
	Group*Time	1	132	9.297	0.003****
IL-8 (pg/mL)	Group	1	132	0.696	0.405
	Time	1	132	4.510	0.036****
	Group*Time	1	132	1.875	0.173
IL-10 (pg/mL)	Group	1	132	46.144	<0.0001****
	Time	1	132	45.863	<0.0001****
	Group*Time	1	132	43.023	<0.0001****
IL-12p70 (pg/mL)	Group	1	132	6.484	0.012****
	Time	1	132	8.790	0.004****
	Group*Time	1	132	4.157	0.044****

Note: *p < Bonferroni correct alpha-level of 0.008 (PWBS outcomes); **p < Bonferroni correct alpha-level of 0.005 (PSS, PANAS-P and PANAS-N outcomes, separately); ***p < Bonferroni correct alpha-level of 0.002 (RISC outcome); ****p < 0.05 (IC = 95%); df: estimated denominator degrees of freedom; Results of omnibus maximum likelihood mixed effects linear regressions; Poisson distribution for primary and secondary outcomes; Gamma distribution for third outcome; PWBS: Psychological Well-Being Scale; PSS: Perceived stress; RISC: Resilience; IL: Interleukins; Neuro-Educa – active control group (Pre-n = 38 and Post-n = 31); MBHP-Educa – intervention group (Pre-n = 36 and Post-n = 34).

oneself and self-criticism, which are opposite to self-acceptance and autonomy, are both major factors for social and psychological vulnerability to pressure and adversity (Trzesniewski et al., 2006), whereas a more compassionate attitude toward oneself has beneficial effects on health and social interactions (Chamberlain and Haaga, 2001; Järklström, 2018). Similarly, the autonomy dimension of Psychological Well-being also stands for a relevant aspect of improved health. The experience of a reduction in an everlasting need for appreciation and opinions, renders a larger scope of action and feeling, which is congruent with the decentering experience of mindfulness (Josefsson et al., 2014). Since teacher's profession is one constantly under pressure coming from several different demands as previously seen (Lopes et al., 2004), autonomy becomes a long-sought ability. Worrying less about "other people's opinion" can harvest a great deal of relief and strengthen teacher's stamina and efficacy both pedagogically and emotionally. Perceived autonomy has a positive association with adaptability in the classroom environment, which in turn, can improve teacher's organizational commitment (Collie and Martin, 2017), and thus produces better learning environment in the long term, shedding well-being in both teachers and students.

Such findings are convergent with previous studies and meta-analyses which showed improvement in several psychometric measures (such as anxiety, depression and distress scores) in the normal healthy (Chiesa and Serretti, 2009; Eberth and Sedlmeier, 2012; Khoury et al., 2015; Sharma and Rush, 2014), and goes further assessing its effectiveness and feasibility as a supporting strategy in preventing evolution toward depression, anxiety and burn-out (Hernandez et al., 2018).

Another relevant finding in our study is the mediating effects of inflammatory enzymes IL-6, IL-8 and IL-10 on Psychological Well-being, and not the opposite, as would be intuitively suspected in the first hand. This finding cements the previous findings that inflammation can cause stress, as seen in cancer patients (Bartsch and Nair, 2004) and in inflammatory diseases (Chatterjee, 2016). Since our study investigates psychological stress, we found an effect in a much milder context than in cancerous or inflammatory diseases. These results with IL-6, IL-8 and IL-10 mediating the dimensions of Autonomy and Self-acceptance corroborate previous observations of the intimate relation between inflammation and stress as seen in severe clinical inflammation (Harth and Nielson, 2019; Sewitch et al., 2001). The complexity of inflammatory signaling, which involves several different molecular pathways, our result, albeit thrilling, cautions us to strive for further and more specific studies, in order to clarify the effects of mindfulness in the molecular mechanisms here discussed. This approach strengthens the idea that many of the psychological improvements seen in MBIs may be secondary to primary physical benefits derived from the practices, meaning mindfulness is not merely a "psychological practice", but in the same proportion, a bodily one, which may, in turn, benefit emotional and cognitive dimensions of human experience. Other inflammatory biomarkers, TNF- α , IL-12p70 and IL-1 β all generated results below detection limits for the adopted assay kit. Since all participants were healthy and declared not to have chronic serious diseases, low levels below detection were expected as a possibility (de Oliveira et al., 2021; Kleiner et al., 2013).

Since the study was multivenued, the number of peripheral blood samples was smaller after the intervention, due to an incomplete collection of blood for logistic reasons, but not due to any contraindication for puncture. Consequently, the MBHP-Educa sample consisted of 34 individuals, against 31 of Neuro-Educa active control group.

Besides, these subclinical pictures, albeit not sufficiently intense or long-lasting to fulfill criteria for a psychiatric disorder, can be understood as a result of the wear-and-tear of emotional and cognitive usage in a daily task fashion, and thus, still able to bring expressive distress and cognitive impairment at critical points in healthy populations (Ng et al., 2012). The fact that heightened subclinical inflammatory activity can pose an important effect on the well-being and quality of life of these populations (Kiecolt-Glaser et al., 2010; Suinn, 2001).

This study has limitations that deserve mention. The sample size was small for the inflammatory biomarker's appreciation, with an uneven

distribution of genders, when 100% of our sample was constituted of women. In the one hand, this may contribute to a more even population, pre and post, as well as intergroup. On the other hand, we do not have a clue about the biological and psychological effects of our intervention in men. Nevertheless, this imbalance is in line with the general distribution of teachers in elementary school, which verges 100%.

Also, the study was not able to evaluate the long-term effects of the intervention due to the social confinement imposed by the COVID-19 pandemic. Since the intervention was performed in a present-fashion way, and the pandemic posed especially harsh conditions for teachers, the researchers were unable to carry on the study, due to logistic factors, and the overwhelming stress brought on by social isolation and life-threatening news.

Our study has the strength of not having borne any waiting lists, which are known to have a noxious effect on groups that "have to wait" while others are receiving the program (Elliott and Brown, 2002). Our active control (Neuro-Educa) group was attended at the same time by MBHP-Educa received intervention. The immediate absorption of both arms of the study at the same time, besides giving a more accurate "time panel" to our findings, can also contribute to a better adherence to the procedures and instructions, which can be decisive for the success of treatment (Forbes et al., 2018; Segal et al., 2002).

Our study is pioneering in the fact that it takes female teachers, presently active, nested in similar schools and institutions, without evident psychopathology detected in our evaluations and screenings, and deals with the idea of "mindfulness for the healthy". Aligned with previous research, it brings new insights to mindfulness mechanisms, since it detected a mediating effect of peripheral biomarkers on Psychological Well-being dimensions, and not the opposite (e.g. psychological variables influencing peripheral biomarkers, which is the first intuition).

Taken as a whole, our results point in the direction of a general improvement in psychological and organic measures, which promote well-being, and all of them relevant both to a protective effect as well as to the promotion of health and resilience in teachers. These improvements can, in turn, contribute for global improvement in health and personal spheres. Such an endeavor is in accordance with the idea of Primary Prevention, which is commonly overseen in research and interventions. Although modest in its effects when compared to genetic and epigenetic factors, Primary Prevention is nevertheless relevant for disorders such as anxiety (Garcia-Campayo et al., 2015), depression (de Pablo et al., 2021) and adjustment disorders (Strain, 2015), all bearing strong genetic vulnerability factors, making behavioral approaches such as an MBI important assets in preventing psychopathology (van de Weijer-Bergsma et al., 2014).

Some limitations in this study are not worthy. To begin with, the study was under-powered because of the drop-outs of 7 participants in control group (attrition of 18%) and 2 participants in treatment group (attrition of 5%). Further studies with larger populations are warranted. Future research should include a follow-up phase (our study was severely handicapped in this aspect, due to the Covid 19 Pandemic) in order to assess mid-range and long-range effects of the intervention, as well as to follow home adherence in the months after the program, which should have direct effects in the more distant outcomes of the participants. Nevertheless, results showed that the inclusion of an MBI in the teachers' curriculum has the potential to improve quality of life and psychological resilience as well as to reduce the prevalence of negative affect and general beneficial changes. Our study supports the call (Khoury et al., 2015) for careful practice and research into how MBIs can be efficacious and effective in enhancing health in people who are submitted to daily stress.

Author contributions

DRO contributed to the study design. DRO and DW contributed the acquisition of data, analysis, and interpretation of data, and drafting/revising of the manuscript for content. DRO contributed to designing the

Neuro-Educa program. DW contributed to conducting the MBHP-Educa program for teachers. FPB contributed with statistical modelling and review. DRO, MD, VPP are authors of the MBHP-Educa program. BPM collected blood samples from research subjects. BPM, LFR were involved in the application of all scales and questionnaires. BPM, FSM, and DRO analyzed and interpreted data regarding the inflammatory biomarkers. DRO, MD and VD'A contributed to supervising the study and revising the manuscript content. All authors critically reviewed the manuscript. The authors read and approved the final manuscript.

Declaration of competing interest

The authors declare that they have no conflict of interest.

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Appendix A. Supplementary data

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