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Research Article

Effectiveness of Mindfulness-Based Stress Reduction (MBSR) Interventions on Mindfulness and Stress Symptoms for Cancer Patients: A Quantitative Assessment

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Abstract

The aim of this article is to provide a quantitative assessment of the correlation between heightened mindfulness and stress reduction among cancer patients and survivors who engaged in Mindfulness-Based Stress Reduction (MBSR) interventions. Utilizing data from eight studies, we conducted quantitative analyses to provide the effectiveness scores of MBSR interventions on mindfulness, assessed using the Mindful Attention Awareness Scale (MAAS), and stress symptoms, evaluated through standardized self-reported questionnaires. The effectiveness scores are standardized as percentages relative to baseline (pre-intervention) levels, which allows for the comparison of two variables: mindfulness and perceived stress, on a common scale, facilitating a regression analysis to generate a correlation trendline. The findings reveal that MBSR interventions yielded an average increase in mindfulness levels of 7.93%, with a standard deviation of 4.97%, while concurrently reducing stress or stress-like symptoms by an average of 22.58%, with a standard deviation of 8.77%. Subsequent linear regression analyses were performed on these effectiveness metrics to establish a correlation trendline, demonstrating a robust negative correlation between mindfulness and stress among cancer patients and survivors. In conclusion, MBSR interventions are effective in enhancing mindfulness and alleviating stress or stress-like symptoms in cancer patients and survivors. This finding suggests a causal relationship between mindfulness and stress

reduction, endorsing the integration of MBSR as a complementary therapy for cancer management.

Keywords
Cancer patients; clinical interventions; intervention effectiveness; mindfulness; mindfulness-based stress reduction; stress symptom; trendlines

1. Introduction

In the aftermath of World War II, meditation began to emerge as a prominent aspect of Western culture [1]. Among the various meditation techniques, mindfulness, originating in Asia, not only flourished in its birthplace but also found a significant following in the Western world [2, 3]. Its popularity extends beyond spiritual realms into commercial and clinical settings, making it a practice embraced in both sacred and secular contexts. It is now widely practiced in both sacred and secular worlds. Jon Kabat-Zinn defines mindfulness as a moment-to-moment, non-judgmental awareness cultivated by specific attention to the present moment, approached with non-reactivity, non-judgment, and openheartedness [4].

The exploration of mindfulness has transcended into the realm of modern therapies and interventions, revealing a diverse range of medical benefits in alleviating suffering and symptoms associated with physical, psychosomatic, and psychiatric disorders [5, 6]. Notably, Mindfulness-Based Stress Reduction (MBSR) has emerged as a prevalent and effective intervention in the West. Incorporating formal mindfulness training, MBSR has proven beneficial for both clinical and non-clinical populations [7, 8].

In MBSR interventions, participants immerse themselves in mindfulness principles and techniques to cultivate awareness, enhance emotional regulation, and mitigate maladaptive reactions to stress [9]. Across many clinical and nonclinical trials, increases in mindfulness have significantly improved psychological functioning, even during the COVID-19 pandemic environment [2, 10-12]. However, research among cancer patients yields less conclusive results. Labelle et al. [13] found no mediating role of increased mindfulness in reducing depressive symptoms following the MBSR program. More recently, Victorson et al. [14] demonstrated no association between increased mindfulness and decreased distress symptoms in cancer patients. Consequently, further evidence is needed to ascertain whether mindfulness development solely contributes to improvements in psychological health measures, especially to cancer patients. Moreover, despite its effectiveness in general populations, the mechanisms underlying how MBSR yields health improvements, particularly regarding positive psychological or physiological outcomes, especially to cancer patients, remain incompletely understood [15, 16].

Therefore, the primary objective of this study is to quantitatively assess the relationship between heightened mindfulness and health outcomes in cancer patients. With a specific focus on the widely embraced MBSR, this article examines its impact on mindfulness and health enhancements among cancer participants. Rigorous analysis and meticulous quantification of MBSR intervention effectiveness for constructing a reliable trendline connecting mindfulness with health improvements, achieved through regression analysis. True to its name, the MBSR (Mindfulness-Based Stress

Reduction) intervention centers on diminishing participants' reactivity to stress. Consequently, the pivotal metric for gauging health improvements in this study revolves around the reduction in stress or stress-like symptoms. Additionally, this paper succinctly discusses the differential effectiveness of MBSR intervention between cancer patients and healthy partners, quantitatively assessing this difference.

Eight articles, focusing on the effects of MBSR intervention on mindfulness enhancements and stress reductions among individuals diagnosed with cancer, provide foundational trial data for the present study. The Mindful Attention Awareness Scale (MAAS) is utilized to measure participants' mindfulness levels, while validated self-reported questionnaires gauge stress or stress-like symptom improvements. These MAAS mindfulness and stress improvement data, collected at pre- and post-intervention, are then utilized to calculate associated effectiveness scores.

In this article, effectiveness scores are standardized as percentages relative to pre-intervention levels. This standardization allows for the comparison of two variables: mindfulness and perceived stress, on a common scale, facilitating correlation analysis to generate a regression trendline. This trendline can predict reductions in stress-like symptoms based on levels of mindfulness enhancement. Furthermore, as shown in this study, standardized effectiveness scores enable comparisons of mindfulness strength measured by different instruments and exploration of differences in MBSR intervention effects across diverse populations, including cancer patients and healthy partners.

Finally, a Concluding Remarks section succinctly summarizes key findings and proposes avenues for future research in mindfulness-based interventions.

2. Backgrounds and Guidelines for Mindfulness and Effectiveness Evaluations

This section elucidates key concepts and guidelines crucial for understanding the assessment of intervention effectiveness, aiming to dispel potential confusion and ensure the accurate interpretation of analyzed data and the validity of obtained results.

2.1 Mindfulness-Based Stress Reduction (MBSR) Intervention

Recent literature reviews highlight the widespread popularity of MBSR interventions, attributing them to clinically significant improvements in psychological functioning across diverse populations [17, 18].

Developed by Jon Kabat-Zinn in 1979 at the University of Massachusetts, MBSR is a structured eight to nine-week mindfulness program. Participants engage in weekly sessions lasting 120 to 180 minutes, with an additional all-day session typically scheduled in the sixth week [19]. These sessions incorporate three primary mindfulness techniques-sitting meditation, body scan, and mindful yoga [20]. Participants are recommended to practice mindfulness at home for at least 45 minutes daily, listening to instructional CDs. The all-day session constitutes an intensive silent mindfulness training lasting seven to eight hours.

In sitting meditation, participants engage by focusing on their breathing sensations, maintaining an awareness of the natural rhythm of their breath. The key is to refrain from attempting to control the breath, allowing it to flow naturally. Simultaneously, individuals are encouraged to observe other sensations within the body, be attuned to sounds in the environment, and remain mindful of their cognitions and emotional states. In body scan, attention is guided systematically through various

body parts, involving non-judgmental observation of sensations occurring in each area in the present moment. In mindful yoga, mindfulness practice is combined with Hatha Yoga, promoting awareness during gentle movements and stretching. The integration of mindfulness into physical activities enhances the overall experience. Additionally, MBSR incorporates "walking mindfulness" to cultivate mindfulness into daily life [20].

The out-of-class mindfulness practice is crucial, with participants recommended to practice formal mindfulness (sitting meditation, body scan, and mindful yoga) for at least 45 minutes, six days a week, over the eight-week program [19]. However, flexibility is acknowledged, recognizing that participants may adapt their practice duration and frequency based on individual needs [21].

2.2 Mindful Attention Awareness Scale (MAAS)

The Mindful Attention Awareness Scale (MAAS) is a 15-item questionnaire designed to evaluate an individual's mindfulness. This instrument assesses the frequency of maintaining an open awareness on and a receptive attention to ongoing events and experiences. While the MAAS is a single-factor measure and does not encompass various facets of mindfulness, it serves as a phenomenological counterpart to behavioral tests. Its unique focus on everyday experiences of attentional functions makes it a valuable tool in mindfulness research. The validity of the MAAS extends across general populations, as well as among cancer patients [22].

Scoring for the MAAS is done on a 6-point scale, ranging from "Almost Always" (1) to "Almost Never" (6). Lower scores on the scale indicate a less sensitive awareness, while higher scores reflect greater mindfulness. To calculate the total score, sum up the scores for each item at the end of the questionnaire and then divide the total by 15. According to Brown and Kasser, a typical MAAS score for a community sample is 4.22 ± 0.63 [23]. This benchmark provides context for interpreting individual scores and understanding the relative level of mindfulness within a given population.

2.3 Control Group

In several intervention trials discussed in this article, researchers include a control group alongside the intervention or treatment group. The control group comprises participants who do not receive the experimental intervention, undergoing routine treatment or receiving no treatment at all. The primary purpose of the control group is to establish a baseline for comparison with the intervention group that receives the target intervention or treatment [24]. This design enables investigators to isolate the genuine effects of the intervention by minimizing the influence of factors other than the target intervention, such as the MBSR intervention.

2.4 Standardization of Effectiveness of Interventions

Given that interventions considered in this article employ self-reported questionnaires or scales to quantify their impact on mindfulness and health symptoms, the score ranges associated with each questionnaire may vary. To facilitate comparisons among effects or scores obtained, intervention effectiveness is normalized as a percentage relative to the baseline (pre-intervention) score of the intervention group.

If the effectiveness is calculated by considering the score of the control group. The effectiveness of the MBSR intervention on mindfulness or target symptom is defined as the mean score change

(whether increasing or decreasing) from pre-intervention to post-intervention in the intervention group minus the mean score change in the control group during the same period [24].

Subsequently, the effectiveness is normalized as a percentage based on the pre-intervention score of the intervention group. This approach can provide a common scale to allows for a standardized and dimensionless comparison of intervention outcomes, such as efficacy, effect, and efficiency, among the datasets, making effectiveness a valuable parameter in statistical analysis and decision-making.

In this article, the standardized effectiveness would be used for the comparison between mindfulness and perceived stress, and among results measured by different instruments and effects across diverse populations.

2.5 Statistical Significance and p Value

For a robust statistical analysis, certain conditions, including statistical significance, must be met. Statistical significance is a vital metric used to determine whether observed differences or patterns in data likely represent a genuine relationship or could have arisen by chance. It aids researchers in evaluating the reliability of their findings, ensuring they are not merely a result of random variability. Thus, statistical significance assesses the likelihood that a result derived from data obtained through testing or intervention is not due to chance but can be attributed to a specific cause [25]. The associated p-value serves as a measure of the significance level, where $p \leq 0.05$ is conventionally considered statistically significant, making the analysis credible and acceptable. If $p > 0.10$, the result is statistically insignificant, while if $0.05 < p \leq 0.10$, the statistical result is marginally significant.

2.6 Effect Size: Pearson r, R^2, Cohen's d, and Hedges' g

An effect size is a value measuring the strength of the relationship between two variables in a population. Various standard measures of effect size include Pearson r, Coefficient of determination (R^2), Cohen's d, and Hedges' g [26, 27]. Conversion between different types of effect sizes is possible.

2.6.1 Pearson r

Pearson r, also known as the Pearson Correlation Coefficient, is a measure of the strength and direction of a linear relationship between two variables (two sets of data). It is the ratio between the covariance of two variables and the product of their standard deviations (SDs) [28]. It ranges from -1 (perfect negative linear relation) to 1 (perfect positive linear relation), with 0 indicating no linear relation.

2.6.2 Coefficient of Determination (R^2)

The R^2 coefficient links Pearson r by the equation $R^2 = r^2$. It also provides an intuitive interpretation of linear regression. Ranging from 0 to 1, where 0 signifies no relationship and 1 represents a perfect linear relationship.

2.6.3 Cohen's d

It is defined as the difference between two means divided by a SD. A larger Cohen's d value

indicates a more substantial difference between compared groups, with negative values decreasing the mean and positive values increasing the mean.

2.6.4 Hedges' g

Similar to Cohen's d, this parameter is defined as the difference between two means divided by a weighted SD. A g value of 1 indicates the two groups differ by 1 standard deviation, a g of 2 indicates they differ by 2 standard deviations, and so on [26]. Interpreted similarly to Cohen's d, with suggested thresholds: 0.2 for "small," 0.5 for "medium," and 0.8 for "large" effect sizes.

3. Instruments Used in Assessments of Stress and Stress-like Symptoms

This section provides background information and justification for the instruments employed to assess stress symptoms. The first three instruments (PSS-10, PSS-4, & C-SOSI) are popular questionnaires designed for direct evaluations of stress symptoms. The fourth instrument (CESD-10) is not specifically designed for stress assessment, but some of its subscales are stress-related or stress-like, and it is adopted here to measure stress-like symptoms and calculate intervention effectiveness. The rationale for adopting it is specifically discussed in this section.

3.1 Ten-Item Perceived Stress Scale (PSS-10) and 4-Item PSS (PSS-4) for Gauging Stress Symptoms

The Perceived Stress Scale (PSS), originally developed by Cohen, Kamarck and Mermelstein, is the most widely used psychological instrument for measuring the perception of stress [29]. The 10-item version (PSS-10) is the most popular, evaluating the degree to which an individual has perceived life as unpredictable, uncontrollable, and overloading over the previous month. PSS-10 scores range from 0 to 40, with higher scores indicating higher perceived stress. Scores from 0-13 are considered low stress, while scores from 27-40 are considered high perceived stress [29].

The PSS-4 is a short form consisting of 4 items, measuring psychological stress by asking about feelings and thoughts during the last month. PSS-4 scores range from 0 to 16, with higher scores correlated to more stress.

3.2 Calgary Symptoms of Stress Inventory (C-SOSI) for Quantifying Stress Symptoms

The C-SOSI is a psychological instrument designed to measure stress symptoms, consisting of a comprehensive 56-item scale. Developed by Carlson and Thomas, this instrument evaluates the frequency of stress symptoms [30]. The C-SOSI encompasses eight subscales: Depression, Anger, Muscle Tension, Cardiopulmonary Arousal, Sympathetic Arousal, Neurological/GI, Cognitive Disorganization, and Upper Respiratory Symptoms. Each subscale comprises 6-9 items. Participants rate each item on a 5-point Likert scale, ranging from 0 (never) to 4 (very frequently)**.** To calculate the total score, responses from all items are summed. A higher C-SOSI score indicates a more severe manifestation of stress symptoms.

3.3 10-Item Center for Epidemiological Studies Depression Inventory (CESD-10)

The 10-item Center for Epidemiological Studies Depression Inventory (CESD-10) is a short version of the 20-item CESD and is used to measure depression in the general population or using as a

screening tool for depression in primary care settings [31]. The CESD-10 has shown good predictive accuracy when compared to the full-length version, especially in internal consistency ($\alpha = 0.78$) [32]. The CESD-10 employs a four-point Likert scale (range: 0 to 30), where higher scores indicate more pronounced depressive symptoms. A score surpassing 10 signifies significant depressive symptoms [32].

Given that depression is a prominent symptom of stress, as highlighted in the description of C-SOSI in the preceding subsection, the CESD-10, designed to assess depressive symptoms, is deemed suitable for evaluating stress-like symptoms. Furthermore, the American Psychological Association underscores the interconnectedness of stress and depression, characterizing psychological distress as the presence of nonspecific symptoms associated with stress, anxiety, and depression [33]. This suggests that stress and depression often manifest with similar emotional symptoms. Individuals facing stress or depression may encounter challenges in concentration, decision-making, and memory, and these symptoms may coexist. Consequently, the CESD-10 is deemed suitable for adoption in the present study, considering its relevance to assessing stress-like symptoms within the same symptom category.

4. Intervention Effectiveness on Cancer Patients and Survivors

As highlighted by the American Cancer Society, mindfulness proves beneficial in managing cancer-related symptoms and side effects, particularly in reducing stress, anxiety, and depression induced by the stressful treatments associated with cancer [3]. In this section, the effectiveness of MBSR interventions on cancer patients or survivors, is studied to provide baseline information for establishing the advantages of MBSR in cancer management.

A cancer diagnosis constitutes a highly stressful event, leading to significant degradation in the quality of life compared to generally healthy individuals. Studies have indicated that these stressors contribute to increased suicides [34, 35]. Drawing on data presented by Carlson and Brown, the stress levels experienced by cancer patients are typically twice as high as those of healthy individuals, despite cancer patients exhibiting mindfulness levels only slightly lower (less than 10%) than their healthy counterparts. Evidently, cancer inflicts severe emotional stress on patients [22].

In this section, eight articles, which studied the impacts of MBSR intervention on mindfulness and stress-like disorders among participants diagnosed with cancer, were selected to investigate the associated intervention effectiveness. The 15-item MAAS was employed to assess mindfulness levels, while several questionnaires discussed earlier were utilized to evaluate stress or stress-like symptoms.

4.1 Impact on Mindfulness Level and Stress Symptoms of 19 Cancer Patients

Birnie, Garland, & Carlson conducted a study to assess the impact of an 8-week MBSR intervention on the mindfulness level and stress symptoms of 19 cancer patients and their partners at a Cancer Centre in Calgary, Canada [36]. In this subsection, only the results of the effectiveness of the cancer patients are presented. Later in Sect. 5, the results from cancer patients would compare with those from the general healthy partners to exemplify the impact difference of the MBSR intervention on two distinct populations i.e., cancer patients versus heathy adults.

The patient participants had an average age of 62.9 ± 7.37, with 52.4% being female, and an average of 24.36 ± 32.16 months since diagnosis. The MAAS measured individual differences in

mindful strength, while the C-SOSI gauged physical and psychological responses to stress. Although participants' partners were included in the intervention, their outcomes were not factored into the effectiveness calculation.

The MAAS score based on 16 intervention participants increased from 4.22 ± 0.71 measured at pre-intervention to 4.36 ± 0.65 gauged at post-intervention with p = 0.02 (Birnie, Garland, & Carlson 2010:1006). The intervention effectiveness on mindfulness can be calculated to be *3.31%* [=100% × (4.36-4.22)/4.22], indicating a small but positive improvement.

Following the MBSR intervention, the total C-SOSI score from 19 intervention participants decreased from 49.45 ± 35.40 (at pre-intervention) to 43.58 ± 32.10 with p = 0.06 (marginally statistical significance), which is resulted in an intervention effectiveness on stress of *-11.87%* [=100% × (43.58-49.45)/49.45], signifying a moderate reduction in stress symptoms.

4.2 Intervention Effects on Mindfulness and Stress in 13 Women with Breast Cancer

Dobkin investigated the effects of MBSR intervention on mindfulness changes in 13 women (mean age = 54, range: 37 to 70) who had been diagnosed with breast cancer within the past two years [37]. The participants, recruited from two university-affiliated hospitals, had completed cancer treatments within past two years and finished the MBSR intervention requirements, including answering the MAAS and the PSS-10 questionnaires at pre- and post-intervention.

After the MBSR intervention, MAAS scores increased from 3.98 ± 0.87 to 4.43 ± 0.73 with p = 0.028 and d (effective size) = -0.52. The corresponding intervention effectiveness for mindfulness was calculated as *11.31%* [=100% × (4.43-3.98)/3.98], indicating a moderate improvement in mindfulness. The corresponding PSS-10 scores decreased from 20.62 ± 5.28 (pre-intervention) to 14.46 ± 5.92 (post-intervention) with p = 0.008, yielding an intervention effectiveness on perceived stress of *-29.87%* [=100% × (14.46-20.62)/20.62-], reflecting a substantial reduction in perceived stress among women who had completed cancer treatment.

4.3 Effectiveness of MBSR Interventions on 177 Cancer Patients Using MAAS

Garland et al. explored the impact of MBSR intervention on increased mindfulness and improved stress in 268 cancer patients (age = 53.50 ± 10.59, cancer duration = 1.57 ± 2.84 years, & female = 84%) at the Tom Baker Cancer Centre in Calgary, Canada, who participated in MBSR interventions between 2000 and 2008 [38]. Of these patients, 177 completed the MAAS before and after an 8-week MBSR program.

The MAAS scores (n = 177) increased from 3.91 ± 0.83 at pre-intervention to 4.27 ± 0.76 at post-intervention ($p < 0.001$, d = 0.46), indicating a moderate improvement in mindfulness. The intervention effectiveness on mindfulness, based on MAAS scores, was *9.21%* [=100% × (4.27-3.91)/3.91]. Using the C-SOSI to measure stress symptoms, the intervention effectiveness can be calculated to be *-28.85%* [=100% × (40.71-57.22)/57.22], highlighting a significant reduction in stress symptoms.

4.4 MBSR Intervention in 77 Female-Adult Cancer Patients Using MAAS

Labelle, Campbell, & Carlson delved into the impact of MBSR intervention on mindfulness and stress-like depressive symptoms in female cancer patients [13]. The study involved 77 adult women

diagnosed with cancer (average age = 53.08 ± 8.86, months since diagnosis = 23.77 ± 32.90) recruited from the waitlist of an MBSR program at the Tom Baker Cancer Centre in Calgary, Canada. The participants were divided into 46 in the intervention group and 31 in the control group. Stress-like depressive symptoms were measured using the CESD-10, while mindfulness strength was assessed through the MAAS.

Labelle, Campbell, and Carlson reported that the MAAS score increased from 3.45 ± 0.70 pre-intervention to 3.76 ± 0.58 post-intervention for the intervention group and from 3.65 ± 0.67 to 3.58 ± 0.71 for the control group [13]. The calculated intervention effectiveness for mindfulness was *11.01%* {=100% × [(3.76-3.45) - (3.58-3.65)]/3.45}, indicating a moderate enhancement. The CESD-10 score decreased from 10.65 ± 7.06 to 7.02 ± 5.93 at post-intervention for the intervention group and from 7.55 ± 4.98 to 7.13 ± 5.33 for the control group. The corresponding intervention effectiveness on stress-like depressive symptoms was *-30.14%* {=100% × [(7.02-10.65) - (7.13-7.55)]/10.65}, demonstrating a significant reduction.

4.5 Interventions Effectiveness in 136 Cancer Patients Using MAAS

Labelle et al. explored the effects of an 8-week MBSR intervention on mindfulness and psychological functioning in 75 cancer patients (age = 54.8 ± 9.9, female = 89.3%, months since diagnosis = 25.2 ± 41.9) in the intervention group and 61 cancer patients (age = 54.4 ± 10.3, female = 80.3%, months since diagnosis = 25.3 ± 57.1) in the control group [39]. In the terminology used by Labelle et al. [39], the 8-week MBSR intervention is known as the 8-week Mindfulness-Based Cancer Recovery (MBCR) program [40].

The MAAS was used to measure the status of mindfulness status, while the C-SOSI was applied to gauge stress symptoms. Scores were measured at pre-intervention (baseline), middle-intervention (the end of the 4-week of the intervention), and post-intervention (the end of the 8-week of the intervention).

The MAAS increased from 3.63 ± 0.77 at pre-intervention to 3.78 ± 0.64 at mid-intervention and to 4.04 ± 0.62 at post intervention for the intervention group while the score changed from 3.57 ± 0.76 at pre-intervention to 3.60 ± 0.71 at mid-intervention, and to 3.60 ± 0.76 at post-intervention for the control group. The corresponding intervention effectiveness on mindfulness for cancer patients can be found to be 3.31% {=100% × (3.78-3.63) - (3.60-3.57)]/3.63} at mid-intervention and *10.47%* {=100% × (4.04-3.63) - (3.60-3.57)]/3.63} at post-intervention, which represents a moderate 10.47% mindfulness increase.

The total C-SOSI score decreased from 55.48 ± 29.37 at pre-intervention to 46.65 ± 23.31 at med-intervention, and to 40.05 ± 23.40 at post-intervention for the intervention group, while the CSSI score varied from 60.98 ± 26.15 at pre-intervention to 55.36 ± 30.58 at mid-intervention, and to 58.75 ± 28.77 at post-intervention for the control group. The corresponding intervention effectiveness on stress reduction for cancer patients can be found to be -5.79% {=100% × (46.65-55.48) - (55.36-60.98)]/55.48} at mid-intervention and *-23.79%* {=100% × (40.05-55.48) - (58.75-60.98)]/55.48} at post-intervention, representing a significant reduction in stress symptoms.

4.6 MBSR Intervention on Stress Reductions in 57 Breast-Cancer Survivors

Matousek & Lã Dobkin conducted an MBSR intervention to investigate its impact on stress symptoms and mindfulness levels in women after breast cancer treatment [41]. From 2006 to 2009,

fifty-nine adult women (age = 56.4 ± 10.2, months since completion of treatment = 28.9 ± 58.8), without concurrent psychiatric disorders, and having completed medical treatment for breast cancer, recruited. Fifty-seven participants successfully completed all requirements of the intervention. The MAAS was used to quantify changes in mindfulness, while the PSS-10 measured perceived stress as the health outcome.

The MAAS score increased from 3.91 ± 0.82 pre-intervention to 4.35 ± 0.68 post-intervention with d = -0.77 and p = 0.0001, while the PSS-10 score decreased from 17.95 ± 6.05 pre-intervention to 14.07 ± 6.17 post-intervention with d = 0.64 and p = 0.0001. The corresponding intervention effectiveness on mindfulness can be computed to be 11.25% [=100% × (4.35-3.91)/3.91], representing a moderate improvement in mindfulness. The effectiveness on perceived stress became -21.62% [=100% × (14.07-17.95)/17.95], indicating a substantial reduction in perceived stress after the intervention for breast cancer survivors.

4.7 Effects of MBSR Interventions Ion 69 Breast Cancer Survivors

Schellekens et al. implemented an 8-week MBSR intervention with slight modifications to assess its effects on 69 breast cancer survivors using the MAAS and the C-SOSI to measure the changes of the mindfulness status and the symptoms of stress, respectively [42]. Among 271 participants recruited from Canada, sixty-nine (age = 54.9 ± 9.2 & months since diagnosis = 24.5 ± 18.0) completed all intervention requirements.

Following the intervention, the MAAS score changed from 3.81 ± 0.86 pre-intervention to 4.16 ± 0.98 with p = 0.872 (statistically insignificant) and Cohen's d = 0.28. The associated total C-SOSI score decreased from 67.98 ± 28.21 to 48.77 ± 27.83 with p = 0.003 and d = 0.35 (Schellekens et al., 2017: 418). The corresponding intervention effectiveness was *9.19%* [=100% × (4.16-3.81)/3.81] for mindfulness enhancement and *-28.26%* [=100% × (48.77-67.98)/67.98] for stress reduction, As shown, the intervention had a moderate impact on mindfulness enhancement and a significant effect on reducing perceived stress for breast cancer survivors.

4.8 Intervention Effectiveness on Mindfulness and Stress of 76 Young Adults with Cancer

Victorson et al. investigated the impact of an MBSR intervention on changes in mindfulness and perceived stress in young adults with cancer [14]. One-hundred twenty-six young adults diagnosed with cancer (mean year since diagnosis = 2.06) were recruited from a large cancer center in the Midwestern USA to participate in the MBSR program. They were randomly assigned to either an MBSR intervention group (n = 67, age = 33.01 ± 4.42 & female = 80.6%) or a waitlist control group (n = 59, age = 32.56 ± 5.14, female = 76.3%). Thirty-five participants in the MBSR intervention group completed all intervention requirements, while forty-one participants in the control group reported all required assessments. The MAAS was used to assess changes in mindfulness, while the PSS-4 was applied to gauge changes of perceived stress at pre-intervention, immediate post-intervention, and 8-week after post-intervention.

For the intervention group, the MASS score changed from 3.88 ± 0.88 at pre-intervention to 3.65 ± 0.82 at post-intervention, and to 3.91 ± 0.93 at 8-week after post-intervention with p = 0.403 (statistical insignificance) [14]. The MASS score for the control group varied from 4.12 ± 0.82 at pre-intervention to 3.98 ± 0.76 at post-intervention, and to 4.00 ± 1.04 at 8-week after intervention with p = 0.554 (statistical insignificance).

The corresponding intervention effectiveness on mindfulness can be found as -2.32% {=100% × [(3.65-3.88) - (3.98-4.12)]/3.88} at post-intervention and as 3.87% {=100% × [(3.91-3.88) - (4.00-4.12)]/3.88} mindfulness at 8-week after post-intervention. It was surprised to find that a negative effectiveness (a decline) on mindfulness by the MBSR intervention. Also, it was found that the increase of mindfulness during the 8-week follow-up period is much larger than the mindfulness reduction during the intervention (the follow-up period *is helpful* to enhance mindfulness).

The PSS-4 score for perceived stress changed from 7.00 ± 2.46 pre-intervention to 5.86 ± 2.79 post-intervention and to 5.82 ± 2.52 at 8 weeks after post-intervention with p = 0.147 (statistical insignificance). For the control group, the corresponding score varied from 7.31 ± 2.79 to 6.65 ± 2.83 and to 6.55 ± 2.82 with p = 0.026 (statistically significant). The intervention effectiveness on perceived stress was *-6.86%* {=100% × [(5.86-7.00) - (6.65-7.31)]/7.00} at post-intervention and -6.00% {=100% × [(5.82-7.00) - (6.55-7.31)]/7.00} at 8 weeks after post-intervention. These results indicate a 6.86% reduction in perceived stress immediately after intervention and a 6.00% reduction at 8 weeks after post-intervention, highlighting the effectiveness on stress symptoms increases 0.86% [=-6.00 - (-6.86)] during the 8-week follow-up period (the follow-up period *is unhelpful* to reduce stress symptoms).

5. Comparisons of MBSR Intervention on Two Distinct Populations and Mindfulness Measured by Two Instruments

This section presents two comparisons. The first examines the effectiveness differences of MBSR intervention on two distinct populations: cancer patients and general healthy partners. The second compares mindfulness measurements using two different instruments: MAAS and the Five Facet Mindfulness Questionnaire (FFMQ).

5.1 Comparison of Mindfulness and Stress between Cancer Patients and Their Partners

As presented in Sect. 4.1, the effectiveness of MBSR intervention on cancer patients was studied. In this subsection, the trial data reported by Birnie, Garland, & Carlson [36], is further studied to calculate the effectiveness of MBSR intervention on the partners of the cancer patients for comparing with those from the cancer patients.

Since none of the partners had prior cancer diagnoses or major health issues, they were considered generally healthy adults. In the study by Birnie, Garland, & Carlson [36], the 21 cancer patients and their partners were all in heterosexual relationships, with 20 couples married and one common-law. Partners had an average age of 62.8 ± 9.34 years, with ten (47.6%) being female, while cancer patients had an average age of 62.9 ± 7.37. Of the 21 partners, 16 completed the MAAS for mindfulness assessments, while 19 filled out the C-SOSI for stress evaluation.

The MAAS score for 16 healthy partners increased from 4.18 ± 0.74 at pre-intervention to 4.53 ± 0.60 at post-intervention (p = 0.02), indicating an intervention effectiveness on mindfulness of 8.37% [=100% × (4.53-4.18)/4.18] [36]. Comparatively, the effectiveness of the intervention on mindfulness for 16 cancer patients was 3.31% at post-intervention. Thus, the mindfulness advancement for healthy partners was 253% (=100% × 8.37%/3.31%) higher than that for cancer patients.

Following the MBSR intervention, the total C-SOSI score from the 19 healthy partners decreased from 38.80 ± 29.27at pre-intervention to 29.68 ± 16.19 at post-intervention (p = 0.06), signifying a significant reduction in stress symptoms. The corresponding effectiveness on stress reduction for

the 19 cancer patients was -11.87%. Comparing these effectiveness results, stress symptom reduction in healthy adult partners was 200% higher than that in cancer patients. This comparison study indicates that the impact of MBSR intervention on healthy adults is much more effective (200% to 250% improvement) than on cancer patients.

5.2 Comparison of Mindfulness Levels Measured by MAAS and FFMQ

Garland et al. [38] utilized both MAAS and FFMQ to measure mindfulness changes in 268 cancer patients through MBSR intervention. While their MAAS-based results are presented in Sect. 4.3, here we utilize the FFMQ data reported by Garland et al. to estimate corresponding effectiveness and study differences in mindfulness measurement by MAAS and FFMQ.

FFMQ is a 39-item self-administered questionnaire measuring five facets of mindfulness: Observing, Describing, Nonjudging, Nonreactivity, and Acting with awareness [43]. Scores closer to 5 indicate more mindfulness, while scores closer to 1 indicate less mindfulness. Combining facet scores produces an overall mindfulness score, divided by the number of items for an average category score. Both MAAS and FFMQ are widely validated and popular measures of mindfulness [39, 43].

Among the 268 cancer participants, 177 completed MAAS and 91 completed FFMQ before and after an 8-week MBSR intervention. Garland et al. reported FFMQ scores for each facet of mindfulness. Here, the total FFMQ score, which was obtained by adding each of the five-facet scores, increased from 123.91 ± 25.87 at pre-intervention to 138.87 ± 24.54 at post-intervention, reflecting an effectiveness on mindfulness of 12.07% [=100% × (138.87-123.91)/123.91].

Comparatively, effectiveness on mindfulness based on MAAS scores was 9.21%. Thus, effectiveness on mindfulness measured by FFMQ is 31.05% [=100% × (12.07%-9.21%)/9.21%] higher than that measured by MAAS, likely due to FFMQ's broader coverage of mindfulness facets. Note that MAAS is a single-factor scale that quantifies the frequency of experiencing mindful states over time, whereas FFMQ is composed of five different domains thought to encompass various components of mindfulness.

Let's consider another study by Labelle et al. that used both MAAS and FFMQ to study mindfulness effects of an 8-week MBSR intervention in 136 cancer participants [39]. While the MAAS-based results were presented in Sect. 4.5, here we continue with studying mindfulness changes using FFMQ. Of these 136 patients, 75 were in the intervention group, and 61 participated in the control group.

Labelle et al. [39] reported that the total FFMQ score (by adding each of the five-facet scores) increased from 125.00 ± 26.76 at pre-intervention to 140.11 ± 24.78 at post-intervention for the intervention group, while for the control group, it varied from 123.05 ± 27.72 at pre-intervention to 122.30 ± 28.81 at post-intervention. The associated intervention effectiveness on mindfulness enhancement was 12.69% {=100% × (140.11-125.00) - (122.30-123.05)]/125.00}. Comparatively, the effectiveness based on MAAS scores was 10.47%. Thus, the effectiveness measured by FFMQ was 21.20% higher than that by MAAS, consistent with the earlier comparison findings.

In summary, both MAAS and FFMQ scores showed significant increases in mindfulness after MBSR intervention. FFMQ tended to yield 20-30% higher scores, suggesting it provides higher scale resolution for measuring mindfulness.

6. Data Summary, Linear Regression, and Trendlines

The investigation into the effectiveness of MBSR interventions on cancer patients and survivors is encapsulated in the synthesis of findings from eight articles, summarized in Table 1. The range of effectiveness on mindfulness, as measured by the MAAS, spans from -2.32% to 11.31%. The mean and SD of 7.93 ± 4.90, coupled with a coefficient of variance (CV) of 61.79%, showcase the variability in mindfulness outcomes. Correspondingly, stress or stress-like changes exhibit a range from -6.86% to -30.14%, with a mean and SD of -22.58 ± 8.77 and a CV of 38.84%, indicating variability in stress responses.

Table 1 Effectiveness of MBSR Intervention on mindfulness and cancer-related symptoms.

First author [Reference]	Participants (number)	Age [year] Mean ± SD	Using control group data	Effectiveness on mindfulness [%]	Stress or stress like Effectiveness [%]
Birnie et al. [36]	Cancer patients (19)	62.9 ± 7.37	No	3.31	-11.87 (stress by C-SOSI)
Dobkin [37]	Breast cancer patients (13)	37 to 70 (mean = 54)	No	11.31	-29.87 (stress by PSS-10)
Garland et al. [38]	Cancer patients (177)	53.50 ± 10.59	No	9.21	-28.85 (stress by C-SOSI)
Labelle et al. [13]	Women with cancer (77)	53.08 ± 8.86	Yes	11.01	-30.14 (stress-like by CESD-10)
Labelle et al. [39]	Cancer patients (136)	54.63 ± 10.04	Yes	10.47	-23.79 (stress by C-SOSI)
Matousek et al. [41]	Breast cancer patients (57)	56.4 ± 10.2	No	11.25	-21.62 (stress by PSS-10)
Schellekens et al. [42]	Breast cancer patients (69)	54.9 ± 9.2	No	9.19	-28.26 (stress by C-SOSI)
Victorson et al. [14]	Young adults with cancer (76)	33.01 ± 4.42	Yes	-2.32	-6.86 (stress by PSS-4)
Mean ± Std deviation	-	-	-	7.93 ± 4.90 (CV = 61.79%)	-22.58 ± 8.77 (CV = 38.84%)

The statistical significance of the data sets for mindfulness and stress groups was evaluated through a t-test using the Excel package. The resulting p-value, less than 0.0004, establishes the statistical significance of the observed differences, underscoring the effectiveness of MBSR interventions.

To further explore the relationship between mindfulness enhancement and stress reduction, a linear regression analysis was conducted using Excel. Figure 1 visually represents the best-fit linear regression trendline, equations, and the associated coefficient of determination (R-squared value or R^2), where the eight solid diamonds correspond to the eight data pairs reported in Table 1. As shown, the dashed trendline equation, Stress [%] = -1.6239 × Mindfulness [%] - 9.7074, exhibits an R^2 of 0.8221. The proximity of R^2 to the perfect score of 1.0 suggests the dashed trendline is a reliable and strong correlation, making this trendline a valuable tool for predicting stress reduction based on mindfulness enhancements.

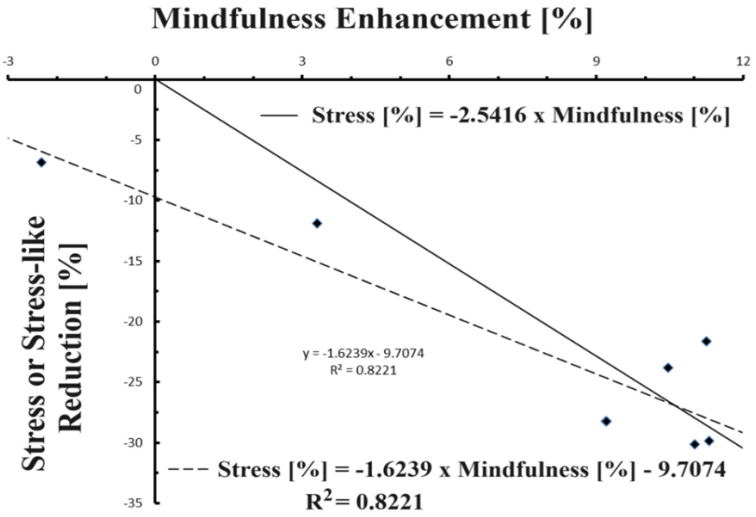

Figure 1 Trendline between mindfulness enhancement and stress or stress-like reduction for cancer patients and survivors.

Acknowledging the importance of baseline conditions, the analysis considers the pre-intervention state, where both mindfulness and stress exhibit zero change. Imposing the constraint of setting the intercept to zero in Excel, a solid trendline equation is derived: Stress [%] = -2.5416 × Mindfulness [%]. This solid trendline is particularly useful for predicting stress reduction, when mindfulness enhancement values are relatively small, saying below 3%.

However, caution is warranted when forcing the intercept to zero in regression analysis. The algorithm adopted by Excel, as illustrated by Cross Validated, may not consistently compute R^2 values. Hence, R^2 is not presented for the intercept-constrained trendline [44]. The R^2 of the unconstrained trendline (dashed line) can serve as a benchmark, offering insight into the accuracy of the regression trendline.

The above discussion emphasizes the importance of considering baseline conditions and highlights potential limitations when imposing constraints in regression analysis.

7. Further Discussions of Results

Within the two effectiveness data sets outlined in Table 1, a notable observation is the Coefficient of Variation (CV) for the effectiveness on mindfulness in the cancer population, which stands at a very high value, i.e., CV = 61.79%. This value is approximately 60% higher than that of the effectiveness on stress reduction. Such a substantial difference highlights the relatively high variability in the mindfulness data for the cancer population.

The CV serves as a metric to evaluate the relative variability of data, offering a means to compare the risk or volatility of different datasets. A CV exceeding 50%, particularly as seen here, suggests a wide range of observations and may indicate the presence of uncontrolled variables or factors influencing outcomes. These uncontrolled variables could stem from measurement errors or inconsistencies in data collection methods. Inappropriate instruments or questionnaires, lack of specificity in measurement tools, or the inclusion of too many types of cancers in data collection (resulting in high variability) could contribute to this. Consequently, the high CV specifically raises concerns about the suitability of the MAAS questionnaire, used to quantify mindfulness levels for the cancer population.

Moreover, as reported in Table 1, the intervention data reported by Victorson et al. [14] reveals a unique scenario where mindfulness enhancement is negative at -2.32% (indicating a decrease in mindfulness level), while stress symptoms simultaneously reduce by 6.86%. This outlier contradicts the remaining seven observations, where MBSR interventions are expected to increase mindfulness levels, subsequently reducing stress or stress-like symptoms. The negative effectiveness data reported by Victorson et al. [14] also raises doubts about the appropriateness of using the MAAS to gauge mindfulness levels in the cancer population. Furthermore, the p-value associated with Victorson et al.'s analysis is notably larger than 0.05, indicating that the reported data lacks statistical significance.

8. Concluding Remarks

In this comprehensive assessment of eight MBSR intervention studies, our focus has been on understanding the impact of MBSR on mindfulness strength and stress (or stress-like) symptoms in individuals diagnosed with cancer. The results overwhelmingly support the positive effects of MBSR interventions, revealing increased mindfulness levels as measured by MAAS and a concurrent reduction in perceived stress, assessed through validated questionnaires. The strong correlation between the rise in mindfulness and the decline in perceived stress, as evidenced by linear regression trendlines, emphasizes the major finding that cancer patients experience psychological benefits by reducing stress-related symptoms following participation in the MBSR intervention, and that increases in mindfulness were related to improvements in psychological functioning, particularly in reducing stress.

Moreover, the estimated effectiveness of MBSR interventions on two different populations, i.e., cancer patients and healthy partners, reveals that the impact of the MBSR intervention on healthy adults is significantly more pronounced than that on cancer patients, with stress reduction in healthy partners being 200% more than that of cancer patients, and the mindfulness advancement for healthy partners being 250% higher than that of cancer patients.

However, notable concerns arise regarding the reliability of the mindfulness data set for the cancer population, evidenced by a relatively high Coefficient of Variation (CV) of 61.79%, particularly

in the data used for quantifying stress or stress-like symptoms. This inconsistence in data may stem from the absence of a control group in five of the eight cases studied, potentially compromising causal attributions regarding observed changes in mindfulness and stress. Thus, future intervention trials should prioritize the inclusion of control groups to bolster methodological robustness.

Looking ahead, while the MAAS remains the gold standard for mindfulness assessment, we suggest for exploring alternative measures such as the Five Facet Mindfulness Questionnaire (FFMQ). Known for its comprehensive evaluation of mindfulness components, FFMQ offers valuable insights into how various facets of mindfulness correlate with stress alleviation and mood outcomes. Our findings indicated that FFMQ scores may provide a 20-30% higher scale resolution than MAAS, highlighting its potential for more nuanced mindfulness assessment.

Furthermore, it is crucial to acknowledge a limitation of the present study: the inclusion of only participants who completed both pre- and post-intervention assessments, potentially biasing outcomes toward those who initially began the intervention. This limitation, coupled with variations in participant numbers between variables, hinders generalizability to the broader population and may not fully reflect the experiences of those who opt out of such interventions. Thus, future intervention studies should employ diverse approaches to enhance measurement control and methodologies, as outlined by Tseng [45].

In summary, this study offers valuable insights into the effectiveness of MBSR interventions in the context of cancer while identifying avenues for further research and improvement.

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Author Contributions

AAT is the sole author.

Competing Interests

The author has declared that no competing interests exist.

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