Mindfulness
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Does Virtual Reality Training Increase Mindfulness in Aboriginal Out-of-Home Care Children?

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Abstract

Objectives This study aimed to address the negative impacts of adverse childhood experiences (ACEs) on Aboriginal children and young people in out-of-home care (OOHC) using mindfulness-based interventions (MBIs) delivered via virtual reality (VR). MBIs can improve emotion regulation and executive functioning, but engagement can be challenging, especially for children with other health conditions and trauma.

Method Virtual reality goggles with a head-mounted display, head tracking, and handheld controls were used. Measures included heart rate variability (HRV), the State Mindfulness Scale, the Mindful Attention Awareness Scale, and the Behaviour Rating Inventory of Executive Function 2. The procedure involved a baseline assessment of state mindfulness, a 5-min sitting baseline HRV measurement, VR orientation, exploration of the VR landscape, a mindfulness body scan, a second HRV measurement during the body scan, and completing a post-VR questionnaire.

Results No significant improvement in state mindfulness was found as measured by the State Mindfulness Scale. However, a significant improvement with moderate effect size was seen pre-to-post-intervention on the Mindful Attention Awareness Scale ($p=0.007$, $d=-0.69$). We also explored the impact of age, sex, and diagnosis on the intervention and found significant improvements in state mindfulness across subgroups. HRV did not show a significant change pre-to-post-intervention.

Conclusions Our study highlights the potential for MBI-VR to improve mindfulness in Aboriginal children and young people in OOHC who have experienced abuse and trauma. Brief mindfulness sessions were effective at enhancing state mindfulness as measured by the MAAS; the older participants and those with mental health concerns benefitted the most. Further research with more diverse samples is needed to validate the findings and examine potential interactions between demographic and clinical factors.

Preregistration This study is not preregistered.

Keywords Virtual reality · Aboriginal children · Out-of-home care · Trauma · Executive functioning · Feasibility

Exposure to adverse childhood experiences (ACEs), such as domestic violence, neglect, abuse, parental substance abuse, mental illness, or incarceration, increases morbidity and mortality rates in childhood and across the lifespan (Chen et al., 2016; Kelly-Irving et al., 2013). As of 30 June 2022, 45,400 children and young people were in out-of-home care (OOHC); approximately 19,400 (43%) were Aboriginal and Torres Strait Islanders (AIHW, 2023). Nearly half (49%) of carers of OOHC children and young people aged 4–17 years in New South Wales (NSW) reported behavioural symptoms consistent with attention-deficit hyperactivity/inattentive disorder (ADHD), anxiety, depression, post-traumatic stress disorder (PTSD), or complex developmental trauma disorder (Australian Institute of Health and Welfare 2022). Factors such as placement instability and grief at the loss of family connections negatively impact healthy attachment relationships and contribute to higher rates of mental illness (Brinser & Wissel, 2020; Mendis et al., 2015; Palmieri & La Salle, 2017). It should also be noted the national data and prevalence rates included represent both Aboriginal and Torres Strait Islander individuals. Despite the acknowledgement

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that this classification is a simplification that does not recognise the diverse social, cultural, and historical differences that exist in and within communities, it is difficult to find statistics that separates individual group data. Our sample all identify as Aboriginal. Emerging research indicates that the provision of strategies to support young people in managing stress symptoms can mitigate the negative consequences of ACEs (Wingo et al., 2010). These findings add weight to calls for early and accessible trauma-informed interventions and care.

Mindfulness-based interventions (MBIs) align well with trauma-informed approaches designed to alleviate the long-term impacts of exposure to ACEs through enhanced self-regulation, increased attentional control, and emotion regulation (Teasdale et al., 1995). Such approaches are associated with improved capacity to demonstrate executive functioning skills (Semple, 2010) and increased heart rate variability indicative of more adaptive physiological responses to stress (Shearer et al., 2016). MBIs have also been found to reduce less adaptive ADHD symptoms (Lee et al., 2022) and anxiety (Borquist-Conlon et al., 2019), and improve emotion regulation (Sibinga et al., 2014) and executive functioning (van de Weijer-Bergsma et al., 2012) as well as self-awareness, peer and familial relationships, coping skills, and focus skills (Coholic & Eys, 2016). Further, a recent review has highlighted mindfulness training to have positive effects on meta-cognitive and meta-emotional competencies among people with mental disorders, including ADHD, autism spectrum disorder (ASD), intellectual disability, and depressive disorder (Mitsea et al. 2023). While promising, the research samples discussed mainly included participants presenting with relatively isolated clinical symptoms, whereas Aboriginal children in OOHC are likely to present with multiple comorbidities (Rowland, 2023). A pilot study has indicated adapted mindfulness-based stress reduction as an effective and culturally appropriate program for use with older Aboriginal Australians (Lavrencic et al., 2021). Further study is needed to determine whether mindfulness interventions show similar positive benefits in younger populations presenting with complex issues.

Though mindfulness interventions are reported to have good longitudinal adherence and engagement in adult populations (Berghoff et al., 2017), the engagement of young people with attention and behavioural difficulties can be challenging. Rumination, worry, depression, difficulties with emotion regulation, and escape-avoidant coping, all symptoms present in an OOHC sample, can also negatively impact engagement with MBIs (Atkinson & Wade, 2012; Banerjee et al., 2018). Children and adolescents with ADHD symptoms are also less likely to engage in treatment, youth services, and family-based behaviour therapy (Johnson et al. 2008; Sayal et al. 2018). Commonly reported barriers identified are low desire and forgetfulness (Sibley et al., 2022). Recognising these challenges and using more attractive therapeutic mediums and approaches, such as video games and virtual reality, can improve engagement and adherence, especially with children and young people (Mitsea et al., 2023). Methods to increase engagement with therapeutic services are an important avenue to explore; past research indicates that clients who withdraw from MBI interventions might benefit the most (Crane & Williams, 2010).

Virtual reality (VR) has a strong attraction with children. It may improve attention difficulties associated with other mindfulness interventions and demonstrate increased positive affect while remaining easy to administer (Miller et al., 2021; Wren et al., 2021). VR is a highly participatory intervention medium that demonstrates high engagement and enables personalised treatment plans similar to traditional therapies (Valmaggia et al., 2016). Due to the engaging nature and increased therapeutic benefit, VR has the potential to be a cost-effective alternative to one-on-one in-person therapy, especially in populations where engagement is a primary concern (Corrigan et al., 2023). Using this technology as a novel psychotherapeutic intervention is a viable method to improve state mindfulness in OOHC children while reducing the attentional requirements of other MBIs (Coholic et al., 2020). This therapy encourages awareness of the present moment through non-judgemental and attentional purpose (Wielgosz et al., 2019) in a virtual space that engages participants and supports calm exploration and expression.

Virtual natural environments have demonstrated relaxation, restoration from attention fatigue, and improved cognitive performance (Browning et al. 2020; Mostajeran et al., 2021; Riches et al., 2021). By combining the experience of virtual reality with the opportunity for creative expression, using mindfulness-based therapeutic techniques, we aim to produce an engaging and effective program that supports the development of mindfulness skills during the session resulting in improvements in day-to-day functioning (Gruber & Oepen, 2018; White et al., 2018). This preliminary study assessed the feasibility and efficacy of a brief single session of VR MBI on state mindfulness and heart rate variability among Aboriginal OOHC youth.

Method

Participants

Community Engagement and Study Oversight

This research was conducted in collaboration with an Aboriginal Community Organisation based in regional NSW dedicated to improving the welfare of children and young people in OOHC. The study was initiated based on the locally identified need for targeted therapeutic support to enhance Aboriginal children and young people's well-being and placement security within the OOHC sector. A local community guidance group, established to support the project, comprising of Aboriginal clinicians, board members, and executives of the Aboriginal community-controlled organisation, and a local Elder supported and advised the study team on recruitment approaches, cultural appropriateness, community networks, and how to benefit best the children involved.

Potentially suitable participants were identified by carers and psychologists who work with Aboriginal children and young people per the inclusion and exclusion criteria. Suitability was considered based on age and frequency of attending the centre, as gauged interest collected in prior centre appointments. Participants between the ages of 7 and 17 years were considered, with children excluded if they were too physically small to use the equipment safely, were unavailable on data collection days, or had vision issues that would make wearing the VR headset difficult. Consent was obtained from the appropriate representative of the legal guardian as required for a child or young person in OOHC. The researchers then approached eligible participants to obtain consent before participation on the day they were to attend the centre to provide details on the study requirements and a trial demonstration of the VR.

Twenty-two potential participants were approached; two declined to participate. The 20 remaining participants ranged between 7 and 16 years ($M = 11.4$ years; $SD = 3.3$; 65% male and 35% female), all identified as Aboriginal. A previous study of this population sample demonstrated, according to carer-reported clinical symptoms, 28% were within borderline range for total problems on the Child Behaviour Checklist (CBCL), and for self-reported clinical symptoms, 30% were within clinical range for total problems on the CBCL (Achenbach, 1999; Rowland, 2023). Further, 10% met diagnostic criteria for anxiety and depression, 5% met diagnostic criteria for oppositional defiant disorder, and 21.5% met diagnostic criteria for a combination of inattentive or hyperactive ADHD and ODD (Rowland, 2023).

Procedure

Participants were invited to a room where they completed a baseline assessment of state mindfulness in the MAAS and SMS-PA scales and a 5-min sitting baseline HRV measurement with the HRV monitor attached to their index finger. Controls for the VR were explained following safety information. Participants were fitted with the sanitised HTC VIVE Cosmo Elite headset. Participants were then oriented in the VR. After 10 min of exploring the space location (Fig. 1) in the VR environment, participants were invited to sit on the floor to engage in the mindfulness body scan.

Fig. 1 Nature Treks VR space environment

During the body scan, participants' HRV was retaken for comparison to the pre-VR HRV reading. The researcher remained in the room to ensure the safety and comfort of the participant. After completing the body scan, participants removed the headset and completed the post-VR questionnaire. Participants were then invited to choose a world to explore further if they enjoyed the VR experience or concluded the session there. No data was recorded for this part of the session; this acted as a positive reward and a gauge of interest in the VR among the participants.

Measures

Virtual Reality Apparatus During the VR sessions, participants were asked to sit for the first meditative component and stand within a 2-m radius while interacting with the VR world. Participants wore a pair of VR HTC Cosmos Elite goggles with a head-mounted display and head tracking and used handheld controls. This allowed participants to interact with the VR-generated world.

Virtual Reality Content The Nature Treks VR program was used. For the first segment of the VR experience, participants were placed just above Earth in space for 10 min, where they could create suns, planets, and blackholes and otherwise manipulate the galaxy around them (Fig. 1). The space location was chosen as it is the most basic world regarding stimuli and interaction. Participants were subsequently asked to sit down and observe the created space around them. At the same time, they listened to a 13-min mindfulness body scan delivered through a child-language-friendly recording by the primary researcher. Participants then chose a location of their preference if they continued with the VR for leisure.

Heart Rate Variability (HRV) HRV was measured using the PowerLab 26 T by AD Instruments via a single finger electrode pre-intervention and during mindfulness meditation and analysed using HRV Analysis in LabChart. HRV metrics were analysed in the time domain rather than frequency. The primary time-domain measure is the root mean square of successive differences between normal heartbeats (RMSSD), which reflects heart rate variance and measures parasympathetic activity.

State Mindfulness Scale Physical Activity (SMS-PA) SMS-PA assesses present moment mindfulness via the State Mindfulness Scale adapted for children during physical exercise (SMS; Ullrich-French et al., 2017). The SMS-PA comprises the 12 items rephrased from the original scale to be more appropriate for children. For this study, one item was modified slightly to refer to the activity being completed (e.g. "I could feel how hard my muscles were working" was changed to "I could feel the breath going in and out of my body"). With each item, participants indicated their degree of approval (1 = *not at all* to 5 = *very much*) regarding their experience during the treatment. SMS-PA has demonstrated good internal consistency reliability for the mind and body subscales ($\alpha = 0.87$ and 0.88, respectively).

Mindful Attention Awareness Scale (MAAS) MAAS, a short 5-item form of the MAAS (Brown & Ryan, 2003; Lawlor et al., 2014; Van Dam et al., 2010), was used as an alternative measure of state mindfulness. The scale utilises a 7-point Likert scale with responses ranging from *almost never* to *almost always*. Examples of items include "I was doing something without paying attention" and "I was preoccupied with the future or the past". Tense was altered pre- and post-VR to infer changes in state mindfulness, i.e. pre "I often do things without paying attention" and post "I did the VR without paying attention". Item scores were reverse-coded, so higher scores indicate greater mindfulness. As this has yet been validated in a child sample, this measure served only as a pre-post comparison measure.

Behaviour Rating Inventory of Executive Function 2 (BRIEF2) BRIEF2 was used to provide clinical information on the sample and determine whether the VR program under evaluation is appropriate for individuals with varying levels of executive functioning skills. The BRIEF2 contains 64 items, scored on a 3-point Likert scale (N = *never*, S = *sometimes*, O = *often*), with higher scores indicating greater levels of executive dysfunction and behavioural issues. Example items include "Makes careless errors" and "Does not notice when his/her behaviour causes negative reactions". Subscales include the behavioural rating index, emotional rating index, and cognitive rating index. This assessment has high internal consistency within a clinical sample ($\alpha = 0.80$ to 0.89; Hendrickson & McCrimmon, 2018).

Data Analyses

Descriptive statistics were used to present the sample's demographic and clinical characteristics along with pre- and post-VR results for state mindfulness (SMS-PA and MAAS) and HRV (Table 1). Normality was assessed through Shapiro–Wilk tests, and inspection of histograms and Q-Q plots. Outliers were assessed through *z*-scores and removed if appropriate. Paired-sample *t*-tests were used to assess whether there were differences in the means of SMS-PA (body and mind subscales), MAAS scores, and HRV, pre- and post-VR. Pearson's correlation analyses were used to test the relationship between state mindfulness scores MAAS and the BRIEF2.

Results

Feasibility and Acceptability

Among the 20 consenting participants, 19 completed the mindfulness-VR session and all assessments (one withdrew due to motion sickness). On questioning, 18 of the 20 participants reported that they would continue the same VR program for leisure.

Preliminary Efficacy

A paired-sample *t*-test was conducted to determine the efficacy of the short VR session on state mindfulness using the MAAS and the SMS-PA mind and body measures. The pre and post scores for SMS mind and body and MAAS are presented in Figs. 2 and 3. On average, participants improved in MAAS state mindfulness from pre-intervention ($M = 2.9$, $SD = 1.1$) to post-VR intervention ($M = 3.9$, $SD = 1.7$).

Table 1 Means, standard deviations, and correlations of Mindful Attention Awareness Scale pre-intervention with subscales of the Behaviour Rating Inventory of Executive Function 2

Variable	*M*	*SD*	1	2	3	4	5
1. MAAS, pre	2.83	1.07	-				
2. BRI	63.92	7.99	0.15	-			
3. ERI	62.50	10.86	−0.09	0.48	-		
4. CRI	62.92	9.54	0.61*	0.56	0.34	-	
5. GEC	70.08	20.65	0.56	−0.12	0.36	0.44	-

M and *SD* represent mean and standard deviation, respectively. *$p < 0.05$

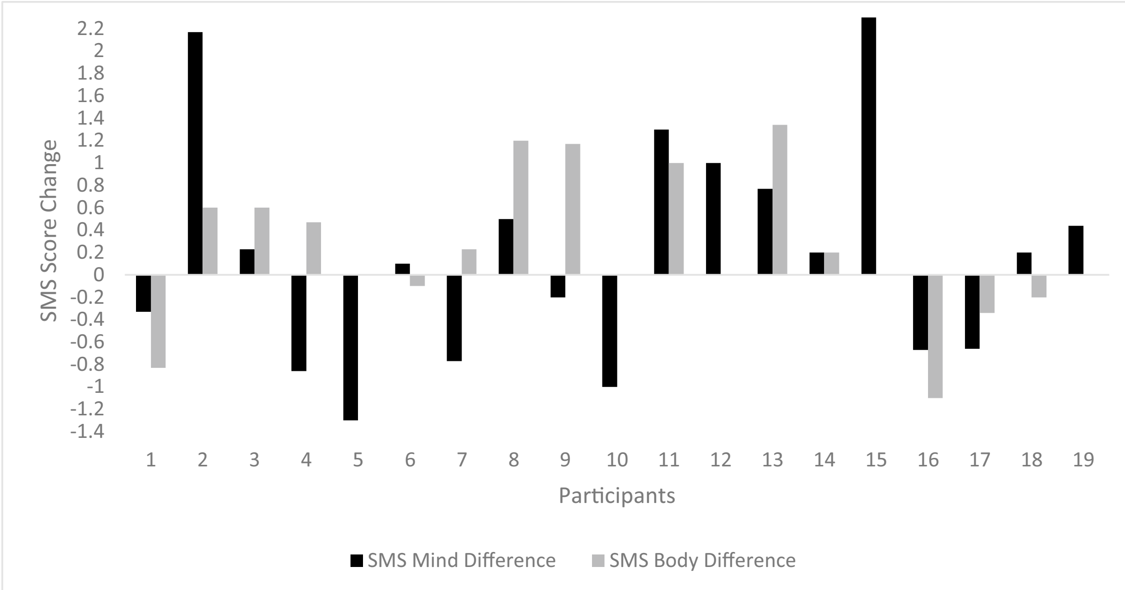

Fig. 2 Score change post mindfulness-based virtual reality interventions for State Mindfulness Scale mind and body. *Note.* Positive scores indicate improvement in state mindfulness; the absence of a column indicates no change

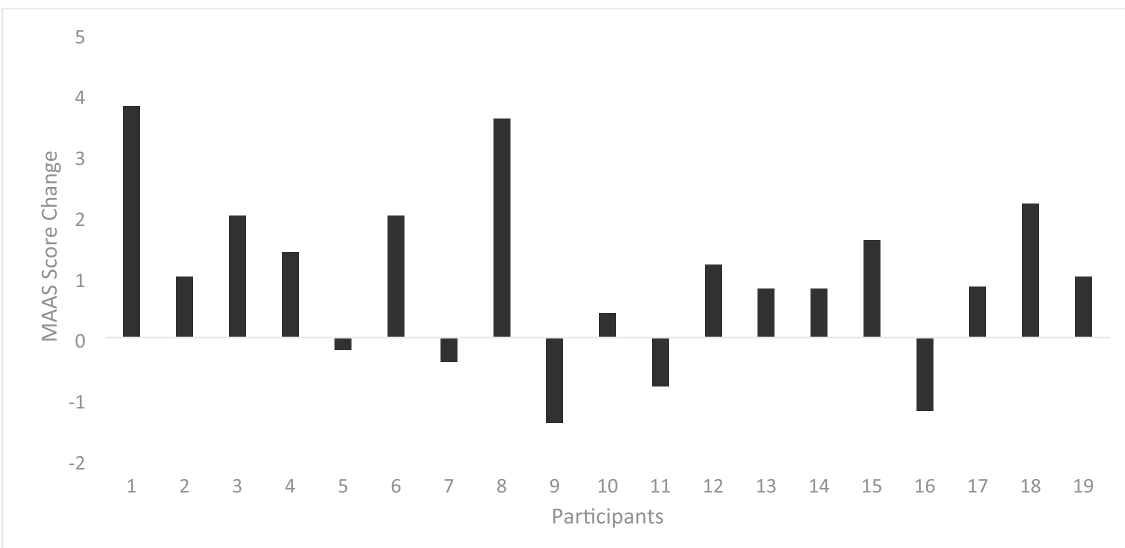

Fig. 3 Score change post mindfulness-based virtual reality interventions for the Mindful Attention Awareness Scale. *Note.* Positive scores indicate improvement in state mindfulness

This change was statistically significant (t (18) = − 3.01, p = 0.007, 95% CI [− 1.67, − 0.29]) and clinically meaningful (d = − 0.69), representing a change from "sometimes" to "often" on the Likert scale. Participants reported an increase in state mindfulness from pre-intervention (M = 2.49, SD = 0.99) to post (M = 2.67, SD = 0.79) on SMS mind, as well as an increase in state mindfulness from pre-intervention (M = 2.89, SD = 0.59) to post (M = 3.12, SD = 0.64) for SMS body. Neither SMS mind nor SMS body changes reached statistical significance: SMS mind, t (18) = − 0.778, p = 0.447, d = − 0.171; SMS body, t (18) = − 1.482, p = 0.156, d = − 0.34. Over 73% of participants recorded positive change of at least 1 point of the Likert scale in state mindfulness in MAAS and SMS body post-intervention, as opposed to 57% recording a positive change in SMS mind.

Heart Rate Variability

Normality was assessed, and through *Z*-score identification, an outlier was deleted from the data set prior to analysis. A paired-sample *t*-test was conducted to determine the efficacy of a short one-off VR session on HRV as measured by RMSSD (root mean square of successive differences). There was a non-significant decrease in RMSSD (83.36 ± 43.36 to 81.87 ± 32.78; t (16) = − 0.211, p = 0.836) with a medium effect size recorded (d = 0.051) and − 12.28 *SD* of mean difference.

Exploratory Analysis

Exploratory analyses were conducted to examine the effect of participants' age (comparing children with adolescents: < 13 years vs ≥ 13 years), sex, and recorded behavioural or mental health diagnoses on the study findings. Among the 11 younger participants (< 13 years), 63% experienced a positive change in state mindfulness. There was a non-significant increase in MAAS (2.81 ± 1.28 to 3.47 ± 1.99; t = − 1.42, p = 0.186), representing a small to moderate effect size (d = −0.428) and *SD* of mean difference of 0.21. Among the eight older participants (≥ 13 years), 87.5% saw a positive change in state mindfulness and a significant increase in MAAS (3.03 ± 0.73 to 4.45 ± 0.93; t = − 3.38, $p < 0.05$), which represented a large effect size (d = − 1.19). The *SD* of mean difference was 0.84.

Among the female participants, 5 (83%) perceived a positive change in state mindfulness. A non-significant increase in MAAS (2.86 ± 0.87 to 4.27 ± 1.73; t = −2.02, p = 0.10) was found. This represented a large effect size (d = −0.82), with *SD* of the mean difference = − 1.24. Among the male participants, 9 (69%) reported positive changes in state mindfulness and a significant increase in MAAS (2.92 ± 1.17 to 3.71 ± 1.67; t = −2.185, $p < 0.05$). This represented a moderate effect size (d = −0.61) (Fig. 4).

Among participants with no current diagnosis, 14 (64%) reported a positive change in state mindfulness but a non-significant increase in MAAS (2.91 ± 1.01 to 3.67 ± 1.69; t = − 1.93, p = 0.07, d = −0.51). All 5 (100%) participants with a behavioural or mental health diagnosis reported a positive change in state mindfulness and a significant increase in MAAS (2.88 ± 1.33 to 4.48 ± 1.60; t = −3.09, $p < 0.005$), representing a large effect size (d = − 1.38).

Correlational Analysis

During the data collection phase, 12 participants had available BRIEF2 parent forms completed by their carers. This data was used to determine if there was a correlation between baseline state mindfulness and executive functioning.

There was a moderate, positive correlation between cognitive regulation (CRI) and MAAS pre-intervention scores, indicating higher executive functioning is related to state mindfulness (r = 0.61, $p < 0.05$). Individual items on the BRIEF that most strongly correlated with low MAAS score pre-intervention were "forgets own name" (− 0.44), "is resistant to change" (− 0.47), "has difficulty switching tasks" (− 0.35), and "has difficulty in new situations" (− 0.38). In contrast, those most strongly correlated with high MAAS score pre-intervention were "forget to bring homework home" (0.70), "struggles with finishing tasks" (0.62), "has good ideas but has difficulty getting them on paper" (0.65), "does everything at the last minute" (0.65), "needs to be told to do tasks, even the ones they enjoy" (0.55), and "underestimate time needed to complete an activity" (0.52).

Discussion

This pilot study evaluated the efficacy and feasibility of a VR mindfulness program to provide engaging therapeutic support for Aboriginal children in OOHC. The results of the current study offer preliminary evidence that a brief

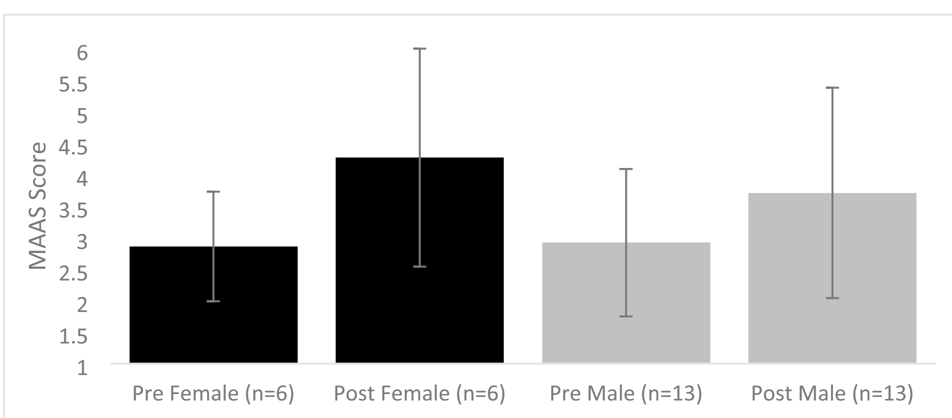

Fig. 4 Change in Mindful Attention Awareness Scale scores pre- and post-virtual reality interventions for female and male participants. *Note*. Error bars represent standard deviations

MBI-VR intervention is feasible and acceptable and has the potential to improve state mindfulness in a sample of OOHC children and young people. Notably, the study had a high degree of engagement. These findings corroborate past MBI-VR research suggesting VR can actively capture a participant's attention, support their sense of presence in mindfulness exercises, and lead to increased treatment adherence (Navarro-Haro et al., 2019; Wren et al., 2021). While this intervention was conducted with a small sample, the findings tentatively suggest that VR interventions may be appropriate in difficult-to-engage populations.

Participants' background histories include neglect, physical and/or sexual abuse, exposure to drugs and/or alcohol, and placement instability. Our prior work in this sample of children has demonstrated high levels of clinically significant symptoms across a range of mental health issues such as depression, anxiety, and/or PTSD, as well as high levels of neurodivergence (ADHD and ASD and conduct disorders; Rowland, 2023). Children and young people with these clinical presentations typically have difficulty engaging in other MBI interventions (Johnson et al., 2008; Sayal et al., 2018; Sibley et al., 2022). To our knowledge, this is the first study investigating the use of MBI-VR among OOHC Aboriginal children and young people.

This study supports short one-time MBI-VR session positively impacting state mindfulness with a moderate effect size; 73% of participants reported a positive change of at least 1 point on the MAAS Likert scale. Although positive clinically meaningful changes in state mindfulness as measured by SMS-PA body and mind were observed pre- to post-intervention, these differences did not reach statistical significance likely due to the small sample size. In this instance, clinically meaningful change is represented by a change in Likert ratings, indicating a neutral to positive mindfulness experience. These results may also be due to comprehension or language issues highlighted in the previous study of SMS-PA items in a group of children. In qualitative interviews post-intervention, participants from a United States middle school revealed different interpretations of the word "feelings", potentially impacting results (Ullrich-French et al., 2017). OOHC youth often underperform academically compared to non-OOHC youth, and while comprehension was not followed up post-intervention, this was a possible limitation of employing this measure (Cheung et al., 2012).

Results from the exploratory analyses highlighted several factors' impact on the MBI-VR's effectiveness in improving state mindfulness. Participants aged 13 years and older benefitted more from the intervention, with a larger effect size and a significant increase in MAAS scores. This difference may be due to attention span, cognitive capacities, and language abilities of younger participants, as seen in previous research, calling for specific adaptations when working with this population (Burke, 2010; Napoli et al., 2005). Further, while the collection of HRV was feasible, no significant change was seen pre- and post-intervention, with the *SD* change indicating a decrease in HRV. Issues with recording HRV in the younger participants, such as restlessness and movement corrupting recordings, were limitations of using this method as a biomarker. Youth may need longer, repeated sessions of MBI-VR for significant beneficial change to be observed in HRV.

While non-significant, female participants appeared to benefit from the MBI-VR more than male participants, with 83% compared to 69% experiencing positive change in state mindfulness indicated in 1.24 *SD* of positive change, compared to 0.98 in males. In comparative literature, females have demonstrated more significant benefits from MBI than males (Bluth et al., 2017; Kang et al., 2018).

All participants with current behavioural or mental health diagnoses saw a positive change in state mindfulness. This result suggests an MBI-VR intervention may particularly benefit individuals with mental health challenges. However, Rowland (2023) highlighted that while not all participants have formal diagnoses, most reach borderline or clinically significant symptoms across the Child Behaviour Checklist subcategories, suggesting they would meet diagnostic criteria if formally assessed. While this is promising, caution should be employed when interpreting these results. Further research with more extensive and diverse samples is needed to validate these findings and examine potential interactions between demographic and clinical factors.

This study also explored the relationship between MAAS and scores on the BRIEF2. An association was identified between Global Executive Composite scores and MAAS pre-MBI-VR scores, suggesting higher executive functioning is related to state mindfulness. A significant positive correlation was found between cognitive regulation and MAAS pre-MBI-VR. In adults, cognitive mechanisms are well studied as underpinnings to mindfulness, with executive functioning and attentional control crucial in evoking a mindfulness state (Holas & Jankowski, 2013). Our findings support new research indicating that executive functioning and cognitive regulation are vital for child engagement in mindful states (cf. Geronimi et al., 2020).

Our findings support past research showing that MBIs can improve state mindfulness in child and adolescent populations (Hooker & Fodor, 2008; Ullrich-French et al., 2017). This is particularly promising as children and adolescents in OOHC are high-risk populations. Research has shown that children in OOHC who experience higher rates of psychiatric disorders are at higher risk for lower academic achievement and interaction with the judicial system, all of which can negatively impact emotional and physical functioning in adulthood (Australian Institute of Health & Welfare, 2019; Galvin et al., 2022). Aboriginal children in OOHC are at even greater risk of the abovementioned impacts (Australian

Institute of Health & Welfare, 2022). As a result, there has been an increased call for therapeutic interventions to support the psychological and physical well-being of Aboriginal children in OOHC (Raman et al., 2011).

These preliminary findings indicate that MBI-VR is a novel therapeutic intervention that should be further explored in more extensive randomised controlled trials (RCTs). Most MBIs have been delivered in person by mental health providers or in individual and group therapy settings. However, using VR, brief MBIs could be given to children by various providers on multidisciplinary OOHC teams with psychologist oversight. This increased access to brief MBI-VRs could support youth care teams in providing children and adolescents with improved state mindfulness, which may assist in managing mental health symptoms (e.g. anxiety, depression) in therapeutic settings providing more holistic care (Hofmann & Gómez, 2017). Additionally, due to the rural nature of many OOHC organisations, behavioural health interventions that can be delivered remotely are increasingly important. MBI-VR allow for remote exposure to mindfulness training in an engaging format that can be easily used in a home setting. Past research has supported VR use at home with various devices, including self-guided app-based VR interventions that use smartphones and low-cost cardboard VR goggles (Donker et al., 2019).

Limitations and Future Directions

While the study's preliminary results are promising, it is important to consider limitations, such as lack of random assignment and control condition. At the time of the study, inviting Aboriginal children to participate in a control group sample during the height of the COVID-19 pandemic was deemed high risk. The decision was made in conjunction with the guiding Aboriginal organisation to proceed with the pilot utilising a pre-post within subject design. While the decision to simplify the study was made in the interest of safety, the implications for the study results are meaningful. Due to the lack of a control group, interpretation of the results needs to be conducted with care as the risk of covariates or extraneous variables was not appropriately accounted for.

In addition, the study included a diverse array of Aboriginal children and young people in OOHC, who varied in terms of presenting clinical symptoms, diagnoses, age, and literacy level. To further assess the study's external validity, future studies should recruit a larger sample and conduct appropriate stratified analyses across groups to evaluate the efficacy of MBI-VR among sub-populations of youth within OOHC. The current feasibility study delivered MBI-VR before or after psychologist appointments based on centre flow and participant availability. It is possible that baseline mindfulness scores were impacted by appointment-related stress for those who received the intervention before their psychology appointment or from being removed from school. Finally, while an objective biophysiological data marker was used (HRV), difficulties interpreting results due to recording issues limited the interpretation of findings. Future research should build on the current study and further assess the efficacy of MBI-VR among children and adolescents in OOHC. A larger RCT that includes a VR control condition, in-centre-treatment and at-home-treatment comparisons, and additional data sources (e.g. biophysiological outcomes) is needed to determine intervention efficacy. A longitudinal study, including follow-up assessments, would provide important information on the stability of improving state mindfulness, practice effects, and maintenance of state mindfulness in children and young people.

Conclusions

This pilot study demonstrated the feasibility and efficacy of using MBI-VR to improve mindfulness in a high-risk population of Aboriginal children in OOHC with a history of abuse and trauma. The brief MBI-VR sessions were engaging and acceptable and led to significant improvements in state mindfulness as measured by MAAS, though the difference was not statistically significant when measured by SMS-PA. Participants aged 13 years and older and those with existing mental health concerns benefited most from the intervention. Although no significant correlation was found between the BRIEF and MAAS scores, the study showed that executive functioning and cognitive regulation were crucial for child engagement in mindful states. Further research with more extensive and diverse samples is needed to validate these findings and examine potential interactions between demographic and clinical factors.

Author Contribution Georgia Rowland: conceptualization, methodology, data analysis, manuscript preparation. Emily Hindman: conceptualization, data analysis, reviewing, and editing. Peter Hassmen: reviewing and editing. Julie Jomeen: reviewing and editing.

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Data Availability Due to the sensitive content of the data, it is not available upon request.

Declarations

Ethics Approval Ethics approval was obtained from the Aboriginal Health and Medical Research Council (1696/20) and Southern Cross University Human Research Ethics Committee (2021/054).

Consent to Participate Participants involved in this study provided consent, as all were under 18 years of age, and informed assent was provided by appropriate guardians.

Conflict of Interest The authors declare no competing interests.

Use of Artificial Intelligence AI was not used.

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