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SPECIAL ISSUE

Heart Rate Variability Biofeedback in Grandmothers Raising Grandchildren: Effects on Stress, Emotions, and Cognitions

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Over one million American grandmothers raise grandchildren, and many experience stress that may be alleviated by biofeedback. This pilot trial of 20 grandmothers used a pretest-posttest design with repeated measures to test the effects of heart rate variability (HRV) biofeedback on perceived stress, negative emotions, and depressive cognitions. Significant decreases in stress, negative emotions, and depressive cognitions were found. Biofeedback is thus potentially effective for reducing stress and depressive thoughts and feelings in grandmothers raising grandchildren, and the intervention warrants further testing.

Over the past two decades, there has been a 64% increase in the number of children living with grandparents in the United States, the majority of whom are grandmothers (Kreider & Ellis, 2011; United States Census, 2009). Research shows that grandmothers raising grandchildren are at risk for overwhelming stress and depressive symptoms (Musil et al., 2011; Musil, Warner, Zauszniewski, Wykle, & Standing, 2009). Although the need for interventions to promote their mental health is clear, intervention research with grandmothers raising grandchildren has been limited to the testing of educational programs, social service networks, parenting skills training, and support groups (e.g., Brown et al., 2000; Collins, 2011; Cox, 2002; Kelley, Whitley, & Campos, 2010; Kelley, Whitley, & Sipe, 2007), and these have shown limited effectiveness in reducing stress and depressive symptoms.

This pilot trial of 20 grandmothers raising grandchildren tested the effectiveness of biofeedback, focusing on heart rate variability (HRV) in reducing perceived stress, negative emotions, and depressive cognitions. HRV biofeedback was chosen for testing because impaired HRV has been linked with stress and depression (Prinsloo et al., 2011; Siepmann, Aykac, Unterdörfer, Petrowski, & Mueck-Weymann, 2008). HRV can be defined as the amount of moment-to-moment fluctuation in heart rate. Alternatively, HRV can be defined as the amount of variability in the "interbeat interval," the time period in milliseconds between heartbeats. HRV is believed to reflect sympathetic–parasympathetic nervous system interaction.

According to Nagai (2006), physiological (biofeedback control training) and psychological (cognitive-behavioral therapy) approaches to treating various conditions are designed to overcome the effects of stimulus events that trigger certain thought processes, including depressive cognitions. Depressive cognitions, also referred to as negative automatic thoughts, are believed to be the precursors of more serious affective and behavioral symptoms of depression (Beck, 2008). According to Nagai (2006), thoughts have direct effects on emotions and behavior. Cognitive-behavioral interventions thus work to reduce distressing emotions and negative behaviors by correcting distorted thoughts. Effects on emotions and behaviors are posited to affect bodily processes, which may include stress reduction (Nagai, 2006).

Nagai (2006) also describes biofeedback control training, which directly targets bodily processes, including the stress response. According to Nagai's (2006) theory, the ability to visualize one's bodily reactions, including the relationship of changes in breathing patterns to changes in heart rate, as in HRV biofeedback, is hypothesized to affect one's emotions and behaviors, which may ultimately affect thoughts. Research testing HRV biofeedback in samples other than grandmothers has shown this intervention to be effective in reducing stress and depressive symptoms, which include thoughts and feelings (Hallman, Olsson, von Scheele, Melin, & Lyskov, 2011; Nolan et al., 2005).

In addition, research has shown the usefulness of portable biofeedback equipment (McLay & Spira, 2009; Muench, 2008; Reiner, 2008) such as the StressEraser®—a portable, noninvasive, handheld biofeedback device manufactured by Helicor, Inc., and registered as a 510(k) exempt, Class II medical device (FDA) for use in relaxation training and stress reduction. A detailed description of this device has been published by Muench (2008). Several studies (Ebben, Kurbatov, & Pollak, 2009; Heilman, Handelman, Lewis, & Porges, 2008; Prinsloo et al., 2011) have provided evidence of the feasibility, accuracy, and effectiveness of the StressEraser®, and therefore this was the personal biofeedback device used in this study. The portability and convenience of this biofeedback device (Kennedy & Pretorius, 2008) made it possible for the grandmothers to use the device in their homes during this study.

This pilot study of grandmothers raising grandchildren examined the effects of a four-week biofeedback intervention using the StressEraser® on perceived stress, negative emotions, and depressive cognitions in grandmothers raising grandchildren at 2 weeks, 8 weeks, and 14 weeks postintervention.

Methods

Design and Sample

A pretest-posttest design with repeated measures was used to examine the effects of biofeedback over time. The study was approved by the Case Western University Institutional Review Board. Grandmothers were recruited from the community through flyers posted in health centers, churches, and places of business (e.g., grocery stores, department stores, restaurants, coffee houses, bookstores, libraries, etc.) or distributed to support groups for grandmothers raising grandchildren. Grandmothers had to have grandchildren younger than 18 years of age who had lived with them for at least six months. Ages of the grandmothers ranged from 42 to 68 with an average of 58 years. Ten grandmothers were married while the other ten were single, divorced, separated, or widowed. Ten were African American and ten were Caucasian. Ten reported having less than a college education while ten were college-degreed. Eleven grandmothers reported an annual income less than \$50,000, while nine reported incomes greater than \$50,000.

Intervention

Immediately following a baseline (T1) interview, a research assistant taught the grandmother the breathing protocol developed by Helicor, Inc., for use of the StressEraser®. Grandmothers were instructed to: (1) insert their left index finger into the sensor clip that detects their pulse rate located at the top of the device; (2) inhale slowly and gently while observing the waves on the screen; (3) exhale slowly and gently while counting slowly from one to five when a new triangle appeared above the wave; and (4) begin to inhale when the next wave started to rise. The grandmothers practiced with the device while the research assistant was present until they felt confident in using it. Each grandmother was given a StressEraser® for use for four weeks. The detailed protocol for use of the StressEraser® is provided in the owner's manual (Helicor, 2007).

Variables and Their Measurement

Data were collected during four face-to-face, structured interviews with a trained research assistant. The data collection interviews occurred approximately six weeks apart. The StressEraser® was retrieved by the research assistant at the time of the second (T2) data collection. The third (T3) and fourth (T4) data collection interviews followed at six-week intervals afterwards.

At baseline (T1), grandmothers completed a self-report demographic questionnaire to assess age, race/ethnicity, marital status, education, and annual income and measures of perceived stress, negative emotions, and depressive cognitions. Changes in mean scores on measures of stress, negative emotions, and depressive cognitions were examined for the presence of downward trends over time.

Perceived stress was measured by the 14-item Perceived Stress Scale (PSS; Cohen, Kamarck, & Mermelstein, 1983) on which items are rated on a five-point Likert scale from never to very often. Higher scores, after reversing scores on seven items phrased in the opposite direction, indicate greater perceived stress. Cronbach's α ranging from .84 to .87 (Cohen et al., 1983; Cohen & Williamson, 1988) indicate internal consistency. Construct validity has been supported by associations with self-assessed health, health service use, health behaviors, help-seeking behavior, and salivary cortisol (Schwartz & Dunphy, 2003; Wright et al., 2004).

Negative emotions were measured by the 10-item Emotional Symptom Checklist (ESC; Zauszniewski, Morris, Preechawong, & Chang, 2004), which assesses the presence of 10 negative emotions over the past two weeks that may be risk factors for more serious depressive symptoms and are not fully captured by standard measures. The emotions assessed are anxiousness, nervousness, tension, worry, anger, restlessness, irritability, sadness, loneliness, and unhappiness. Respondents score one point for each symptom experienced and no points for those they do not

Table 1. Mean scores and standard deviations on perceived stress, negative emotions, and depressive cognitions across four data points in grandmothers ($N = 20$)

Outcome (Possible Range)	Baseline (T1) Pre-Biofeedback	Immediate (T2) 1–2 wks Post-Biofeedback	Lagged (T3) 7–8 wks Post-Biofeedback	Extended (T4) 13–14 wks Post-Biofeedback
Perceived stress (0–56)	$M = 23.05$	$M = 17.85$	$M = 18.15$	$M = 18.30$
	$SD = 6.82$	$SD = 8.20$	$SD = 9.17$	$SD = 10.05$
Negative emotions (0–10)	$M = 6.30$	$M = 5.20$	$M = 4.50$	$M = 4.50$
	$SD = 3.37$	$SD = 3.47$	$SD = 3.80$	$SD = 3.04$
Depressive cognitions (0–40)	$M = 6.20$	$M = 5.05$	$M = 4.55$	$M = 4.00$
	$SD = 3.90$	$SD = 3.84$	$SD = 3.84$	$SD = 3.29$

experience; higher scores indicate more negative emotions. Cronbach's α of .73 and .76 have been reported in studies of elders (Zauszniewski, Bekhet, Lai, McDonald, & Musil, 2007; Zauszniewski, Eggenshwiler, et al., 2004; Zauszniewski, Morris, et al., 2004). Construct validity has been supported by significant correlations with established measures of anxiety and depression (Zauszniewski, Eggenshwiler, et al., 2004).

Depressive cognitions were measured by the eight-item Depressive Cognition Scale (DCS; Zauszniewski, 1995) on which responses are rated on a six-point Likert scale, from strongly agree to strongly disagree, to indicate the degree to which each item describes one depressive cognition (e.g., hopelessness, worthlessness, etc.). Since the items are phrased positively, strong disagreement with an item indicates the presence of a depressive cognition. Thus, item scores must be reversed so that higher scores indicate more depressive cognitions. Cronbach's α ranging between .75 and .88 have been reported in various populations (Zauszniewski & Bekhet, 2012). Construct validity has been supported by significant correlations in the expected direction with measures of psychosocial development, adaptive functioning, depressive symptoms, life satisfaction, resourcefulness, and health practices (Zauszniewski & Bekhet, 2012).

Results

Given the pilot nature of this study and the small sample of grandmothers who took part, the data analysis was limited to examination of descriptive statistics, specifically the mean scores on measures of stress, negative emotions, and depressive cognitions, to see whether there were decreasing trends following biofeedback training using StressEraser® (see Muench, 2008), and to identify effect sizes.

The mean scores and standard deviations for perceived stress, negative emotions, and depressive cognitions are displayed in Table 1. As shown in Table 1, the means (M) and standard deviations (SD) on perceived stress and negative emotions suggest that grandmothers' scores on these measures were normally distributed at baseline. Although the M and SD on the DCS, which is the measure of depressive cognitions, suggested that the distribution was skewed in the direction of lower depressive cognitions, a cut score of seven on this measure has been determined as the point at which a risk for serious depressive thinking exists (Zauszniewski & Bekhet, 2012). Examination of the distribution of scores on the DCS revealed that 40% of the grandmothers ($n = 8$) had scores above seven, indicating potential risk for serious depressive symptoms.

The impact of the changes in mean scores for perceived stress, negative emotions, and depressive cognitions following biofeedback was examined in a series of paired t tests; the results are shown in Table 2. Despite the small sample of grandmothers in the study, changes in all three outcomes were found to be significant at 2 weeks postbiofeedback, and at 8 and 14 weeks thereafter. In a further analysis, we computed effect sizes for the three outcomes using the standard formula (Thalheimer & Cook, 2002):

$$\mathrm{d} = \frac{M_1 - M_2}{\sqrt{\frac{S_1^2 + S_2^2}{2}}}$$

The effect sizes for perceived stress, negative emotions, and depressive cognitions are shown in Table 3.

These effect sizes suggest that the effect of the biofeedback on perceived stress, beginning at two weeks post-biofeedback training, was moderate to large (Cohen,

Table 2. Paired t tests from baseline to 2, 8, and 14 weeks post-biofeedback in grandmothers ($N = 20$)			
Outcome	T1 to T2 (2 wks)	T1 to T3 (8 wks)	T1 to T4 (14 wks)
Perceived stress	$t = 3.43$	$t = 2.55$	$t = 2.77$
	$p = .003$	$p = .019$	$p = .012$
Negative emotions	$t = 2.53$	$t = 2.78$	$t = 2.45$
	$p = .013$	$p = .018$	$p = .024$
Depressive cognitions	$t = 3.29$	$t = 2.28$	$t = 2.99$
	$p = .004$	$p = .034$	$p = .007$

1992). There were small to moderate effects (Cohen, 1992) on negative emotions and depressive cognitions at two weeks after completing biofeedback training. These effects improved to a moderate level by 8 weeks and continued to improve by 14 weeks.

Conclusions

Although persons with chronic stress or depressive symptoms, which may include depressive thoughts and feelings, are believed to have low heart rate variability and dysregulation of the autonomic nervous system (Schubert et al., 2009; Wheat & Larkin, 2010), it is beyond the capability of the StressEraser® to maintain a recording of the user's physiological responses over time, including recording of the beat to beat variation in heart rate (Nunan, Sandercock, & Brodie, 2010). However, although changes in the heart rate variability of grandmothers who participated in the study are unknown, their scores on measures of perceived stress, negative emotions, and depressive cognitions improved over time, and improvements on these measures may reflect an increase in heart rate variability and better mental health.

The lower stress and fewer negative emotions and depressive cognitions observed in these grandmothers after they received biofeedback training are consistent with other studies of the effects of HRV biofeedback on measures of stress (Hallman et al., 2011; Kennedy & Pretorius, 2008; Nolan et al., 2005; Prinsloo et al., 2011; Schubert et al., 2009), negative affect (Bradley et al., 2010), and depressive symptoms (Karavidas et al., 2007; Nolan et al., 2005; Siepmann et al., 2008). However, except for the study conducted by Bradley and colleagues (2010), which measured negative effect as an outcome, studies of the effects of HRV biofeedback have not examined separately the effects on negative emotions or depressive cognitions, both of which are included in measures of depressive symptoms. Nevertheless, taken together, the findings from all of the studies, including the one reported here, support Nagai's (2006) theoretical model that describes the mechanisms and hypothesized effects of biofeedback training on stress, cognitions, and emotions.

There were several limitations to this pilot study, including the small sample size and the convenience sampling method used to recruit grandmothers, which limit the generalizability of the findings. Further, the lack of a control group makes it impossible to compare the effects of HRV biofeedback training with the spontaneous adaptation of coping skills that may occur as grandmothers become more accustomed to their care-giving role and responsibilities (Musil et al., 2011; Standing, Musil &

Table 3. Effect sizes of biofeedback on perceived stress, negative emotions, and depressive cognitions in grandmothers over time.			
Outcome	Effect at 2 wks	Effect at 8 wks	Effect at 14 wks
Perceived stress	ES = .69	ES = .61	ES = .56
Negative emotions	ES = .32	ES = .50	ES = .56
Depressive cognitions	ES = .30	ES = .43	ES = .61
Note. ES = effect size.			

Warner, 2007). It is also possible that the novelty of using a biofeedback device itself may have magnified its effects on outcome measures (Zucker, Samuelson, Muench, Greenberg, & Gevirtz, 2009). Finally, this study did not include measures of other potentially confounding variables that have known associations with HRV, including exercise and caffeine intake (Zucker et al., 2009).

Despite these limitations, this study of biofeedback in grandmothers raising grandchildren demonstrates the potential effectiveness of HRV biofeedback for reducing stress and depressive thoughts and feelings in grandmothers raising grandchildren (Kelley et al., 2010). A logical next step would be to test the comparative effectiveness of biofeedback and other cognitive-behavioral and physiologic methods in a larger clinical trial with grandmothers raising grandchildren and other samples of family caregivers. Once established, such interventions will be useful in promoting optimal, healthy functioning among caregivers who provide care for family members on a daily basis.

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