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# Tension Tamer: Delivering Meditation With Objective Heart Rate Acquisition for Adherence Monitoring Using a Smart Phone Platform

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## Abstract

***Objectives:*** This brief report demonstrates the proof of concept of the Tension Tamer (TT) smartphone application, which integrates photoplethysmograph capabilities with breathing awareness meditation (BAM), to reduce stress and measure heart rate and adherence.
***Design:*** Methods for objectively measuring heart rate and adherence to BAM were developed as part of a future randomized controlled trial.
***Setting/Location:*** The study was conducted at Jerry Zucker Middle School of Science and the Medical University of South Carolina, Charleston.
***Subjects:*** The subjects were three prehypertensive male teachers.
***Intervention:*** The method used was smartphone delivered BAM.
***Outcome measures:*** Objective measures included heart rate, adherence, and ambulatory blood pressure (BP).
***Results:*** Adherence data was successfully collected by the TT application. Increased adherence to TT coincided with increased improvements in ambulatory BP over a 3-month period.
***Conclusions:*** TT shows promise as a simple inexpensive program for administering BAM and capturing adherence data in future clinical trials.

## Introduction

Meditation is a well-studied method for reducing stress and concomitant detrimental physiological effects. Research from original studies, as well as meta-analytic reviews, have demonstrated efficacious results in reducing blood pressure from various forms of meditation exercises.[1–4] However, across these studies, a considerable amount of variability remains unexplained in determining why beneficial physiological change differs across participants. In previous work, we have examined and demonstrated that stress-related gene × environment contributions can modulate the benefit of a meditation intervention in terms of ambulatory blood pressure reduction.[5] Another potential modulator that we have not fully examined is adherence.

Less is known about adherence among meditation studies, which often includes in-class sessions and prescribed home self-practice.[6] When it is reported, adherence has been typically collected through self-report survey or phone calls. Although this is an improvement, there is no objective measure to validate accuracy. In addition, clinical trials examining meditation have reported difference in adherence across treatment groups.[7] However, whether these differences in adherence affect outcome is unknown.

In a recent study an iPod touch-based application called the iMINDr was examined as part of a proof of concept study.[8] The iMINDr is described as a custom software application to more accurately track adherence. Participants were provided with an iPod Touch (Apple Inc., Cupertino, CA) and instructed to practice meditation using the embedded iMINDr software, which included a 20-minute audio track meditation presentation. Upon returning the iMINDr, information collected from the application (date, time, action [start, stop, pause, volume change]) was provided and uploaded to a local computer server. The study showed the iMINDr was capable of collecting the described adherence information, and that participants subjectively reported greater adherence than was objectively implied by the iMINDr.

In order to better assess adherence as part of our own research, we recently developed an Android based

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smartphone application called Tension Tamer (TT). This tracks heart rate (HR) data through photoplethysmography (PPG) using the camera lens, plays an audio-delivered breathing meditation, and transmits time-stamped HRs from the session back to our servers for real-time adherence collection.[9] Among a diverse group of participants, the PPG of the TT application was previously found to provide valid heart rates compared to electrocardiograph across three different conditions (i.e., resting, oral reading under observation, challenging video game).[10] The purpose of this brief report is to demonstrate the proof of concept of the TT as a stress reduction program integrating a breathing awareness meditation (BAM) component with the PPG capabilities of the TT. Instructor-delivered BAM has been previously found to be an effective intervention for reducing resting and ambulatory blood pressure (BP) and reduction of sodium appetite (i.e., reduced urinary sodium excretion).[1]

## Materials and Methods

TT is an objective adherence-measuring program that integrates BAM and PPG to provide date, time-stamp, and physiological heart rates obtained during 10-minute sessions of the BAM protocol that is administered through an Android-based smartphone. The TT program includes graphical user interface (GUI), which allows users to see their HR and receive audio or visual instructions of the BAM protocol. While engaged in the session, an optional display allows users to see a 4-beat rolling average of their HR in real-time along with a timer that provides a count down of their session. Following the session, data are transmitted to a local server and the GUI provides a graph of the session showing average beats per minute for each minute of the session and a written description of the average beat per minute for the entire session, as well as the maximum beat per minute decrease obtained during the session. Outside of the session, the GUI allows the user to select a cumulative graph that displays their average HR per session across the current day and previous 7 days.

Three adult males (ages 26, 34, and 49 years) were recruited as part of a BP screening, which indicated they were prehypertensive based on three consecutive days of resting BP measurements (systolic BP [SBP] = 120–139 mm Hg). Participants had an initial visit that included assessment of height, weight, and waist and hip circumference; psychosocial questionnaires; and 24-hour BP monitoring with a Spacelabs Healthcare (Issaquah, WA) 90207 ambulatory monitor using previously validated settings described elsewhere.[1] Participants wore the Spacelabs 90207 24-hour BP monitor on the day of baseline testing and again at follow-up evaluations, which occurred at 1, 2, and 3 months. After the baseline evaluation, participants were given a smartphone with the TT application installed and taught how to maneuver the GUI and complete a TT session. The were instructed to use the TT twice a day for 10-minute sessions, but were not restricted to only using the program twice a day. Adherence and HR data from the TT were automatically sent from the TT application to university servers.

## Results

Three participants used the TT for a 3-month period. Due to the small number of participants valid statistical tests were not possible. Figure 1 displays the baseline and ambulatory 24-hour SBP data change collected by the Spacelabs 90207 over the 3-month period along with the HR in average beats per minute and adherence rate (AR) collected by the TT over each month (calculated as two 10-minute sessions per day).

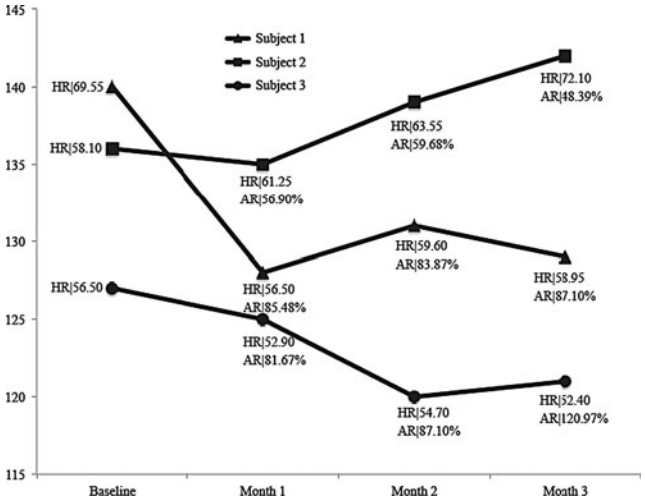


**FIG. 1.** Twenty-four-hour systolic blood pressure at baseline and across 3 months with Tension Tamer heart rate (HR) and adherence rate (AR).

## Conclusions

Although preliminary, our data suggested that AR impacted the amount of benefit received by using the TT application. Subject 2 had poorer adherence than subjects 1 and 3 and in general did not benefit from its use. Subject 1 exhibited a continued reduction of 24-hour SBP across the 2-month period and maintained generally stable adherence rates across those periods with an average of 85.48%. Subject 3 displayed reductions across months 1 and 2 and displayed a slight increase in month 3 (i.e., +1 mm Hg). Subject 3 also increased adherence during month 3 and was completing more than two 10-minute sessions a day with 120.97% adherence. HR collected by the TT seemed to follow the same overall pattern coinciding with AR and SBP reductions. A future version of the TT will establish criteria to determine meditation session quality, an important component that many previous meditation studies have ignored. It is currently unknown as to whether HR is sensitive enough to adequately assess the quality of the meditation session. However, it may be possible for TT algorithms to be updated to capture HR variability and estimated respiratory rate using the acquired PPG signal; these measures could provide a more sensitive and useful meditation quality assessment. Future studies will examine these possibilities.

In conclusion, the TT shows promise as a simple, easy-to-use program for administering BAM and capturing adherence data. However, future clinical trials implementing its use remain to be conducted.

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### Disclosure Statement

No competing financial interests exist.

### References

1. Gregoski MJ, Barnes VA, Tingen MS, et al. Breathing awareness meditation and LifeSkills Training programs influence upon ambulatory blood pressure and sodium excretion among African American adolescents. J Adolesc Health 2011;48:59–64.
2. Rainforth MV, Schneider RH, Nidich SI, et al. Stress reduction programs in patients with elevated blood pressure: a systematic review and meta-analysis. Curr Hypertens Rep 2007;9:520–528.
3. Schneider RH, Alexander CN, Staggers F, et al. Long-term effects of stress reduction on mortality in persons >/=55 years of age with systemic hypertension. Am J Cardiol 2005;95:1060–1064.
4. Black DS, Milam J, Sussman S. Sitting-meditation interventions among youth: a review of treatment efficacy. Pediatrics 2009;124:e532–541.
5. Gregoski M, Barnes V, Tingen M, et al. Differential impact of stress reduction programs upon ambulatory blood pressure among African American adolescents: influences of endothelin-1 gene and chronic stress exposure. Int J Hypertens 2012;2012:510291.
6. Caspi O, Burleson KO. Methodological challenges in meditation research. Adv Mind Body Med 2005;21(1):4–11.
7. Schneider RH, Alexander CN, Staggers F, et al. A randomized controlled trial of stress reduction in African Americans treated for hypertension for over one year. Am J Hypertens 2005;18:88–98.
8. Wahbeh H, Zwickey H, Oken B. One method for objective adherence measurement in mind-body medicine. J Altern Complement Med 2011;17:175–177.
9. Gregoski M, Vertegel A, Treiber F. Photoplethysmograph (PPG) derived heart rate (hr) acquisition using an Android smart phone. Proceedings of the 2nd Conference on Wireless Health. San Diego, California: ACM; 2011, pp. 1–2.
10. Gregoski M, Mueller M, Vertegel A, et al. Development and validation of a smart phone heart rate acquisition application for health promotion and mind-body telehealth applications. Int J Telemed Appl 2012;2012:696324.

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