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Effectiveness of HIPO Android-based application in improving hypertension self-management literacy among obese patients

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ABSTRACT

Hypertension in obese patients requires comprehensive management through enhanced health literacy. Android-based applications represent a promising innovation for improving hypertension control literacy. To analyze the effectiveness of the Android-based hypertension and obesity information system (HIPO) application in improving hypertension control literacy among obese patients. This quasi-experimental study employed a one-group pretest–posttest design without a control group, conducted at Sibela Community Health Center, Surakarta, from June to December 2025. Seventy-six respondents were selected through purposive sampling, meeting criteria of primary hypertension (≥ 140/90 mmHg) and BMI ≥ 25 kg/m². The intervention involved four weeks of HIPO application use. Data were analyzed using the Wilcoxon Signed Rank Test. Respondents were predominantly female (67.11%), aged 46–55 years (31.58%), with a genetic predisposition to hypertension (57.89%). Systolic blood pressure significantly decreased from 159.53 ± 14.19 to 144.48 ± 11.44 mmHg ($p < 0.001$), and diastolic from 95.20 ± 6.55 to 88.50 ± 4.58 mmHg ($p < 0.001$). Good knowledge increased from 35.53% to 55.26%, and good hypertension control increased from 35.53% to 61.84%. The HIPO application significantly improved blood pressure, knowledge, and hypertension control. However, the absence of a control group limits causal inference. This application may serve as a supplementary educational tool in primary healthcare chronic disease management programs.

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1. INTRODUCTION

Hypertension is one of the chronic diseases with the highest prevalence that threatens the cardiovascular and cerebrovascular health of the global population [1]. This condition has become a significant public health problem, affecting more than a quarter of the adult population in developed countries [2]. Obesity and hypertension are two non-communicable diseases that are interrelated and contribute significantly to global morbidity and mortality [3]. The long-known link between obesity and a significant increase in cardiovascular disease, including hypertension, has been well established in numerous studies [4].

The pathophysiological mechanisms underlying the relationship between obesity and hypertension involve multiple complex factors. Obesity-related hypertension is characterized by stimulation of the sympathetic nervous system, activation of the renin-angiotensin system (RAS), and sodium retention, among other abnormalities [5]. Multiple factors, including the sympathetic nervous system, the renin-angiotensin-aldosterone system, and inflammatory pathways, are intricately involved in the pathogenesis of obesity-related hypertension [6]. A new approach to the renin-angiotensin-aldosterone system (RAAS) addresses the two opposing pathways in which a state of equilibrium develops [7].

Obesity-related hypertension is a major challenge for healthcare systems due to the rapid increase in the prevalence of obesity worldwide [8], [9]. However, its treatment is still not specifically addressed by current guidelines. Weight loss per se reduces blood pressure and improves patient responsiveness to blood pressure-lowering medications. Therefore, a weight-centered approach is crucial for the treatment of obesity-related hypertension. Diet and physical activity are key components of lifestyle interventions for obesity-related hypertension, but their effectiveness in real-life settings is limited [10]. Unhealthy eating habits and inadequate physical activity are major contributors to obesity, which in turn increases the likelihood of hypertension [11]. Persistent hypertension after 6-12 months despite a healthy lifestyle requires additional treatment [12]. Primary health care stands as a strategic level for organizing care and user management in this service [13].

Despite the well-established pathophysiological link between obesity and hypertension, existing mHealth interventions have largely addressed these conditions separately rather than as comorbid entities. While mHealth applications have shown promise in improving blood pressure control, self-care behaviors, and self-efficacy among hypertensive patients [14]. Studies in Indonesia remain particularly scarce, with few Android-based interventions developed from local patient needs assessment [15]. Critically, no prior study has evaluated an application combining hypertension education with obesity-specific content to simultaneously improve health literacy, knowledge, and blood pressure outcomes in this high-risk population, highlighting a significant research gap warranting investigation.

Despite extensive research on the relationship between obesity and hypertension and the development of mobile applications for hypertension management, a literature gap remains regarding the effectiveness of Android-based applications specifically designed to improve hypertension control literacy among obese patients. This study aims to evaluate the effectiveness of the hypertension and obesity information system (HIPO) application in enhancing obese patients' understanding and ability to manage their hypertension. This quasi-experimental study is expected to provide empirical evidence on the benefits of technology-based interventions in improving health literacy, potentially contributing significantly to hypertension control strategies for obesity-related hypertension both in Indonesia and globally through a patient-centered, accessible technological approach.

2. METHOD

This study uses a quasi-experimental design with a one-group pretest-posttest design approach. In this design, one group of respondents was measured for their dependent variables before the intervention (pretest), then given an intervention in the form of using the Android-based HIPO application, and then measured again after the intervention (posttest) to evaluate the changes that occurred. The one-group pretest-posttest design without a control group was chosen based on ethical and practical considerations. Ethically, conducting a health education intervention for hypertensive patients with obesity who require optimal management is considered unethical because it could harm the respondents' health. Practically, the number of hypertensive patients with obesity who met all inclusion criteria in the Sibela Community Health Center's work area was limited, so dividing the study into two groups risked reducing the study's statistical power. Furthermore, using the pretest as a baseline measurement allowed each respondent to act as their own control, thus minimizing individual differences.

This research was conducted in the working area of the Sibela Community Health Center in Surakarta, a primary healthcare facility with a chronic disease management program (*Prolanis*) for hypertension. The location was selected based on the consideration that the community health center had a sufficient number of hypertensive patients with obesity to meet the research sample requirements. The study period lasted for 7 months, starting from June to December 2025, covering the preparation phase, pretest data collection, intervention implementation, and posttest data collection.

The population in this study was all patients diagnosed with hypertension with obesity conditions who were registered and actively visiting the community health center. The target population included adult patients diagnosed with primary hypertension and a body mass index (BMI) $\geq$25 kg/m². The study sample consisted of 76 respondents selected using a purposive sampling technique. The sample size was determined using a proportion estimation formula, considering a 95% confidence level, a 10% margin of error, and population proportions based on previous research.

Inclusion criteria included: i) Patients diagnosed with primary hypertension based on JNC VIII criteria with systolic blood pressure $\geq$140 mmHg and/or diastolic $\geq$90 mmHg; ii) BMI $\geq$25 kg/m² based on the Asia-Pacific classification; iii) aged $\geq$26 years; iv) Owning an Android smartphone with at least version 5.0; v) able to operate the mobile application independently; vi) Willing to sign an informed consent; vii) able to communicate in Indonesian; and viii) Registered as an active patient at the community health center for at least 3 months. Exclusion criteria included patients with secondary hypertension, severe complications (stroke, heart failure, advanced renal failure), cognitive or psychiatric disorders, pregnancy, participation in a similar intervention program, or not having adequate internet access. Dropout criteria were set for respondents who withdrew, used the Si HIPO application for less than 80% of the intervention time, experienced worsening health conditions, or could not be contacted during the posttest measurement.

This study used three main variable categories. The independent variable was a hypertension control literacy intervention using the Android-based Si HIPO application, which is a digital educational media specifically designed to improve knowledge and ability to control hypertension in patients with obesity. The dependent variables in this study included five components, namely: i) Systolic blood pressure, which is the blood pressure when the heart contracts and is measured in millimeters of mercury (mmHg); ii) Diastolic blood pressure, which is the blood pressure when the heart relaxes and is also measured in mmHg; iii) BMI which is the ratio between body weight in kilograms and the square of body height in meters; iv) Knowledge about hypertension, including understanding the definition, causes, risk factors, complications, and management; and v) Hypertension control, which includes the ability to modify lifestyle, medication adherence, and self-monitoring.

The confounding variables identified and controlled included gender, age, genetic factors (family history of hypertension), marital status, education level, employment status, smoking habits, exercise habits, duration of hypertension, and adherence to antihypertensive medication. This study used 16 variables consisting of independent variables, dependent variables, and respondent characteristics. The independent variable was the HIPO application intervention, which provided health education on hypertension and obesity control through an Android-based application containing educational materials, medication reminders, blood pressure monitoring, and healthy lifestyle tips, measured on a nominal scale (done/not done).

Dependent variables included systolic and diastolic blood pressure measured using a calibrated digital sphygmomanometer after respondents had rested for at least 5 minutes in a sitting position, with an ordinal scale based on hypertension classification. BMI was calculated using the formula BB (kg)/TB^2 (m^2) using a digital scale and stadiometer. Hypertension knowledge and control were measured through a questionnaire with categories of good (76-100%), sufficient (56-75%), and poor (<55%). Characteristic variables included gender, age, genetic factors, marital status, education, occupation, smoking habits, exercise habits, duration of hypertension, and medication adherence, measured using the Morisky Medication Adherence Scale (MMAS-8) with categories of adherent (score $\geq$ 6) and non-adherent (score < 6).

This study used seven main instruments that had undergone a validation process to ensure the accuracy of the measurement of the research variables. The HIPO application is an Android-based mobile application specifically developed as a health literacy intervention medium by applying the principles of health literacy and user-centered design. This application has five main features: an educational module (materials on hypertension, the DASH diet, physical activity, and stress management), a monitoring feature (blood pressure and weight recording), a reminder feature (medication reminders and control schedules), interactive features (quizzes and BMI calculators), and a consultation feature. The application development went through six stages: needs analysis, design, development using Android Studio, content validation by three experts with a content validity index $\geq$ 0.80, usability testing using the system usability scale with a score of $\geq$ 68, and field trials on 15 respondents. Clinical measurements were conducted using a calibrated digital sphygmomanometer according to the European Society of Hypertension protocol with an accuracy of ±3 mmHg, a digital scale (accuracy of 0.1 kg), and a stadiometer (accuracy of 0.1 cm). The measurement procedure followed strict protocol standards to ensure the validity of the results. The questionnaire instruments included: a respondent characteristics questionnaire, a hypertension knowledge questionnaire (20 multiple-choice items), a hypertension control questionnaire (25 Likert-scale items), and the MMAS-8 for medication adherence. All questionnaires were tested for validity and reliability with a Cronbach's Alpha value of > 0.70.

The data collection procedure in this study was carried out through three main stages: preparation, implementation, and evaluation. The preparation stage included obtaining research permits, including submitting ethical clearance to the Health Research Ethics Commission, and requesting permits from the Health Office and the Head of the local community health center. Next, instrument preparation was carried out, including finalizing the Si HIPO application, calibrating measuring instruments (sphygmomanometers, scales, stadiometers), and training enumerators with a minimum D3 Nursing qualification. The implementation phase lasts seven weeks. The first week focused on respondent recruitment through an explanation of the research, signing informed consent, and conducting pretest measurements covering blood pressure, BMI, and completed questionnaires on knowledge, hypertension control, and the MMAS-8. The second week was used for the installation and orientation of the Si HIPO application to respondents. The third to sixth weeks were the intervention period, during which respondents used the application independently by reading educational materials, recording daily blood pressure, and activating medication reminders, with monitoring via the admin dashboard and technical support via WhatsApp. The seventh week included posttest measurements with the same variables and verification of data completeness.

The data collected in this study were processed through five systematic stages. The first stage was editing, which examined the completeness and accuracy of the data, including the completeness of the questionnaire, the clarity of writing, the consistency of respondents' answers, and the completeness of blood pressure and anthropometric measurement data. The second stage was coding, which assigned a numeric code to each variable to facilitate data entry, such as gender (male = 1, female = 2), genetic factors (present = 1, absent = 2), marital status, education, occupation, smoking habits, exercise habits, duration of hypertension, and medication adherence. The third stage was data entry using SPSS version 25.0 software with a double-entry method to minimize input errors. The fourth stage was cleaning, which involved data cleaning through frequency analysis to identify outliers, cross-tabulation to check consistency between variables, and correction of incorrect data by referring to the original questionnaire. The fifth stage was tabulating, which involved compiling the data in the form of frequency distribution tables and cross-tables to facilitate data analysis and interpretation.

Data analysis in this study was conducted in two stages, namely univariate and bivariate analysis. Categorical data are presented in frequency distribution and percentage, while numerical data are presented with minimum, maximum, mean, standard deviation, and median values. The variables analyzed include demographic characteristics (gender, age, marital status, education, and occupation), clinical characteristics (genetic factors, smoking habits, exercise, duration of hypertension, and medication adherence), as well as blood pressure, body mass index, knowledge level, and hypertension control before and after the intervention. Bivariate analysis was conducted to examine differences in the dependent variable before and after the intervention. Data normality test using Kolmogorov-Smirnov ($n > 50$) showed that systolic and diastolic blood pressure data were not normally distributed ($p \leq 0.05$), so the Wilcoxon Signed Rank Test was used. All analyses were performed using IBM SPSS Statistics version 25.0.

3. RESULTS

Table 1 shows that the majority of respondents were female (67.11%), with the largest age group in the range of 46-55 years (31.58%). Most respondents had genetic factors for hypertension (57.89%), were married (65.79%), and had a high school education (44.74%). More than half of the respondents were unemployed (57.89%) and did not have a smoking habit (72.37%). Regarding exercise habits, the largest proportion of respondents exercised with a frequency of "often" (43.42%). From a clinical aspect, the majority of respondents had suffered from hypertension for 1-5 years (57.89%) and showed good medication compliance (67.11%).

Table 1. Frequency distribution of respondents' demographic and clinical characteristics

Characteristics	Category	N	%
Gender	Male	25	32.89
	Female	51	67.11
Age (years)	26-45	14	18.42
	46-55	24	31.58
	56-65	16	21.05
	≥66	15	19.74
Genetic factors	Exist	44	57.89
	Not exist	32	42.11
Marital status	Marry	50	65.79
	Not married	26	34.21
Education	Junior high school	20	26.32
	Senior high school	34	44.74
	University	20	26.32
Occupation	Yes	32	42.11
	No	44	57.89
Smoking habit	Yes	21	27.63
	No	55	72.37
Exercise habits	Always	22	28.95
	Often	33	43.42
	Seldom	21	27.63
Duration of hypertension	1-5 years	44	57.89
	6-10 years	16	21.05
	>11 years	15	19.74
Medication compliance	Obedient	51	67.11
	Not obey	25	32.89

Table 2 shows varying changes in the measured parameters. For systolic blood pressure, the proportion of mild hypertension decreased from 48.68% to 43.42%, but moderate and severe hypertension increased. Conversely, diastolic blood pressure showed an increase in the normal category from 11.84% to 28.95%, although the severe category also increased from 17.11% to 27.63%. Body mass index showed a slight improvement, with the proportion of obesity decreasing from 69.74% to 64.47%. Most significantly, there was a substantial increase in knowledge, with the good category increasing from 35.53% to 55.26%, and in hypertension control, with the good category increasing from 35.53% to 61.84%.

Table 2. Frequency distribution of respondents before and after the Android-based hypertension control literacy intervention for obesity

Variables	Category	Before		After	
		Frequency	%	Frequency	%
Systolic BP (mmHg)	Mild (140-159)	37	48.68	33	43.42
	Moderate (160-179)	21	27.63	24	31.58
	Severe (180-209)	18	23.68	19	25.00
Diastolic BP (mmHg)	Normal (85-89)	9	11.84	22	28.95
	Mild (90-99)	41	53.95	14	18.42
	Moderate (100-109)	13	17.11	12	15.79
	Severe (110-119)	13	17.11	21	27.63
BMI	Overweight	23	30.26	27	35.53
	Obesity	53	69.74	49	64.47
Knowledge	Good (76-100%)	27	35.53	42	55.26
	Moderate (56-75%)	31	40.79	22	28.95
	Poor (<55%)	18	23.68	12	15.79
Hypertension control	Good (76-100%)	27	35.53	47	61.84
	Moderate (56-75%)	32	42.11	17	22.37
	Poor (<55%)	17	22.37	12	15.79

Based on Table 3, the results of the Wilcoxon test showed a statistically significant decrease in blood pressure in obese patients after intervention using the Android-based HIPO application. Systolic blood pressure decreased on average from 159.53 mmHg (SD = 14.19) before the intervention to 144.48 mmHg (SD = 11.44) after the intervention, with the median value also decreasing from 154.50 mmHg to 145.50 mmHg. Similarly, diastolic blood pressure showed a decrease from an average of 95.20 mmHg (SD = 6.55) to 88.50 mmHg (SD = 4.58), with the median decreasing from 92.00 mmHg to 86.00 mmHg. Both blood pressure parameters showed a p-value of 0.000 ($p < 0.05$), which indicated that the difference before and after the intervention was highly statistically significant.

Table 3. Results of the Wilcoxon test analysis of changes in blood pressure before and after the intervention

Variables	Min	Max	Mean	Elementary school	Median	p-value
Systolic						
Before	143	189	159.53	14.19	154.50	0.000
After	124	160	144.48	11.44	145.50	
Diastolic						
Before	85	110	95.20	6.55	92.00	0.000
After	81	99	88.50	4.58	86.00	

4. DISCUSSION

The present quasi-experimental study evaluated the effectiveness of the HIPO Android-based application in improving hypertension control literacy among obese patients. The findings demonstrate notable improvements across multiple outcome measures following the intervention, which aligns with the growing body of evidence supporting mobile health (mHealth) interventions for chronic disease management [16]-[18]. The study population comprised predominantly female participants (67.11%), with males representing only 32.89% of the sample. This gender distribution is noteworthy as it may reflect healthcare-seeking behaviors or the prevalence patterns of hypertension and obesity in the study setting. The age distribution revealed that the majority of participants were in the 46-55 years age group (31.58%), followed by those aged 56-65 years (21.05%) and those 66 years and above (19.74%). Only 18.42% of participants were in the younger age bracket of 26-45 years. This age profile is consistent with the epidemiological patterns of hypertension, which typically increase with advancing age [19], [20].

A significant proportion of participants (57.89%) reported having genetic factors predisposing them to hypertension, underscoring the importance of family history in cardiovascular risk assessment. The majority of participants were married (65.79%), which may have implications for social support in disease management. Educational attainment varied across the sample, with the largest proportion having completed senior high school education (44.74%), while equal proportions had junior high school and university education (26.32% each). This educational diversity is important to consider when evaluating health literacy interventions, as educational background significantly influences health information comprehension and application [21], [22].

Regarding lifestyle factors, the majority of participants were non-smokers (72.37%), which is a positive finding given the synergistic cardiovascular risks of smoking and hypertension. Exercise habits showed a relatively favorable distribution, with 28.95% reporting always exercising, 43.42% often exercising, and 27.63% rarely exercising. These lifestyle characteristics provide important context for understanding the intervention's effectiveness, as health promotion programs targeting hypertension must address multiple modifiable risk factors [20], [23].

The duration of hypertension among participants varied considerably, with the majority (57.89%) having been diagnosed for 1-5 years, followed by 6-10 years (21.05%) and more than 11 years (19.74%). This distribution suggests that the study captured patients at various stages of their disease trajectory, which is important for understanding how disease duration may influence responsiveness to educational interventions. Notably, medication compliance was relatively high, with 67.11% of participants reporting adherence to their prescribed regimens. This baseline compliance rate is encouraging, as medication adherence is a critical determinant of blood pressure control [24], [25].

The Wilcoxon test analysis revealed statistically significant reductions in both systolic and diastolic blood pressure following the intervention ($p = 0.000$ for both measures). Mean systolic blood pressure decreased from 159.53 mmHg (SD = 14.19) before the intervention to 144.48 mmHg (SD = 11.44) after the intervention, representing a clinically meaningful reduction of approximately 15 mmHg. The median systolic blood pressure also showed improvement, decreasing from 154.50 mmHg to 145.50 mmHg.

The categorical distribution of systolic blood pressure showed modest shifts, with the proportion of patients in the mild hypertension category (140-159 mmHg) decreasing from 48.68% to 43.42%. However, there were slight increases in the moderate (27.63% to 31.58%) and severe (23.68% to 25.00%) categories, which warrants careful interpretation. These seemingly contradictory findings may reflect the complexity of blood pressure management in obese patients and the need for longer intervention periods to achieve sustained improvements across all severity categories [26].

The categorical analysis of diastolic blood pressure revealed notable improvements, with the proportion of patients in the normal range (85-89 mmHg) increasing substantially from 11.84% to 28.95%. Correspondingly, the proportion in the mild hypertension category (90-99 mmHg) decreased dramatically from 53.95% to 18.42%. The intervention demonstrated modest effects on BMI, with the proportion of participants classified as obese decreasing from 69.74% to 64.47%, while those classified as overweight increased from 30.26% to 35.53%.

One of the most striking findings of this study was the substantial improvement in knowledge levels following the intervention. The proportion of participants with good knowledge (76-100%) increased from 35.53% to 55.26%, representing a nearly 20 percentage point improvement. Concurrently, the proportion with moderate knowledge (56-75%) decreased from 40.79% to 28.95%, and those with poor knowledge (<55%) decreased from 23.68% to 15.79%. These improvements in knowledge are consistent with findings from other studies evaluating educational interventions for hypertension [27]-[29].

Online health education significantly influences knowledge, attitudes, and practices regarding hypertension awareness in productive-age populations, supporting the effectiveness of digital educational approaches. Health education programs effectively improved knowledge and perception about hypertension among university students, although their study focused on pregnancy-induced hypertension [28]. The family mentoring model evaluated by Ibnu *et al.* [27] also showed effectiveness in improving knowledge, attitudes, and behaviors related to hypertension treatment, highlighting the importance of educational interventions in chronic disease management.

The improvements in hypertension control literacy were even more pronounced than knowledge gains alone. The proportion of participants demonstrating good hypertension control (76-100%) increased substantially from 35.53% to 61.84%, representing a 26%-point improvement. The proportion with moderate control (56-75%) decreased from 42.11% to 22.37%, and those with poor control (<55%) decreased from 22.37% to 15.79%. These findings suggest that the HIPO application was particularly effective in translating knowledge into practical hypertension control behaviors.

The improvements observed in this study suggest that the Android-based application format may be particularly effective in enhancing health literacy, possibly due to its accessibility, interactivity, and ability to provide personalized information [30]. The ability of mHealth interventions to provide continuous access to health information and support self-management behaviors is particularly valuable for chronic conditions like hypertension [31], [32]. Mobile-based educational interventions effectively improved media health literacy among adults, suggesting that the mobile platform itself may confer advantages for health education delivery.

The accessibility and convenience of smartphone applications may facilitate more frequent engagement with health information compared to traditional clinic-based education [33], [34].

5. CONCLUSION

This quasi-experimental study demonstrates that the HIPO Android-based application is effective in improving hypertension control literacy and achieving clinically meaningful reductions in blood pressure among obese patients. The significant improvements in knowledge (from 35.53% to 55.26% with good knowledge) and hypertension control (from 35.53% to 61.84% with good control) highlight the potential of mobile health interventions for chronic disease management. The statistically significant reductions in both systolic (159.53 to 144.48 mmHg) and diastolic (95.20 to 88.50 mmHg) blood pressure further support the clinical utility of this intervention. The findings align with the growing body of evidence supporting technology-based health education interventions for hypertension management.

Future research should explore mediating and moderating variables, such as application usage adherence, family support, dietary patterns, and physical activity levels, to better understand the mechanisms underlying the intervention's effectiveness. Furthermore, integrating additional features into the application, including real-time teleconsultation and personalized lifestyle modification programs, warrants investigation. Finally, cost-effectiveness analyses are essential to assess the feasibility of scaling the HIPO application within primary healthcare systems. This study has several limitations, including that the 80% app usage threshold for dropout does not account for qualitative differences in user engagement with specific app features. Finally, the lack of follow-up assessments beyond the post-test period precludes evaluating the long-term sustainability of the intervention.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Author state that no conflict of interest.

ETHICAL APPROVAL

This research has received ethical approval from the Surakarta Ministry of Health Polytechnic with the number: Etik/LH/2203/Poltekkes Kemenkes Surakarta/2025.

DATA AVAILABILITY

The data that supports the findings of this study are available from the corresponding author upon reasonable request.

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