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The Effectiveness of Sound Stimulators as a Means of Monitoring Fetal Well-Being at the Gatot Soebroto Army Central Hospital

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ABSTRACT

Introduction: Fetal inactivity during well-being monitoring can stem from sleep rather than distress. This study assessed a sound stimulator, a vibroacoustic device using digital speaker-emitted sound waves, against the traditional klenengan bell for awakening sleeping fetuses. **Objective**: The aim was to assess the stimulator's effectiveness in awakening sleeping fetuses and to verify its proper usage by operators. **Methods**: The intervention group received the sound stimulator, emitting a consistent decibel level (10-68 dB) via a speaker placed near the fetal head for approximately one minute. A quantitative, posttest-only study design was employed at Gatot Soebroto Army Central Hospital, involving 60 participants. Ethical approval was granted by the Institute of Health Research Ethics Committee of Dharma Husada College of Health Sciences (No. 13/KEPK/SDHB/B/V/2023). **Results:** The sound stimulator successfully awakened 27 of 30 sleeping fetuses within 30 seconds. Device suitability was high, with 29 of 30 deemed appropriate and 27 achieving noise levels below 68 dB, prioritizing safety and comfort. **Conclusion**: Wilcoxon Signed Rank test results (Asymp.sig = 0.035) confirmed the stimulator's effectiveness. The innovative sound stimulator was superior to the klenengan bell. It provides a practical, efficient, and safe tool (noise levels <68 dB) for fetal welfare monitoring

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INTRODUCTION

Perinatal mortality remains a major concern in developing countries like Indonesia, as highlighted by UNICEF (UNICEF Indonesia, 2020). According to the 2017 Indonesian Demographic Health Survey (IDHS), the infant mortality rate (IMR) stood at 24 per 1,000 live births (Indonesian Ministry of Health, 2021), while the 2030 Sustainable Development Goals (SDGs) target a reduction to 12 per 1,000 live births, with a national goal of 7 per 1,000 (RI, 2018). Intrauterine hypoxia, a key cause of perinatal mortality, can be addressed through early detection and intervention, significantly impacting the IMR (Lemma et al., 2022; H., 2011). Fetal motion monitoring during antenatal care (ANC), including the use of fetal movement monitoring cards, plays a critical role in identifying potential hypoxia risks (Endjun, 2018). Research by Santo and Ayres De-Campos underlines the importance of understanding fetal well-being through pathophysiological approaches (Jia et al., 2023).

Fetal activity monitoring has its challenges, as the absence of movement does not always signify distress, often simply indicating a sleeping fetus (Marx and Nagy, 2015).

Fetal movements begin early, but their perception by the mother varies, becoming more distinct at 20 to 24 weeks gestation and peaking at 28 weeks before slightly reducing by 36 weeks due to space constraints (NHS, 2023; Curran, 2019; Vitale et al., 2021). Ultrasound examinations help visualize fetal movement, with ten movements in twelve hours considered a positive sign of fetal health (Mangesi et al., 2015). Despite these standards, continuous improvement and clarity in fetal movement assessment remain necessary for optimizing maternal and fetal care outcomes.

At the Gatot Soebroto Army Central Hospital (RSPAD), obstetric care includes using ultrasound and fetal movement cards to monitor fetal well-being (Ibrahim et al., 2021). However, a recurring issue is the frequent report of absent fetal movements during monitoring, leading to concerns among pregnant and postpartum women. The causes can be fetal (e.g., sleeping fetus) or maternal (e.g., hypoglycemia, dehydration, medication effects) (Pirhadi, 2015; Newton and May, 2017). Therefore, thorough maternal history-taking is essential to differentiate between a sleeping fetus and fetal asphyxia, ensuring that proper interventions are undertaken (Hutton, 2024).

Sound stimulation has emerged as a supportive method to determine fetal responsiveness, although its application remains underexplored in Indonesia, with literature predominantly sourced internationally (Singh and Das, 2015). Vibroacoustic stimulation is suggested as a tool to assess fetal status and predict neonatal outcomes like APGAR scores (Singh and Das, 2015; Kalpana, 2011). At RSPAD, a traditional klenengan bell has been used manually to stimulate fetal movement, but variability in sound intensity often causes disturbances, highlighting the need for standardized and safer alternatives.

Recognizing these challenges, the study introduces an innovative vibroacoustic digital sound stimulator designed to replace traditional manual methods. This device emits sound waves via headphones or speakers to reliably wake sleeping fetuses during welfare checks. The research, titled "The Effectiveness of Sound Stimulators as a Means of Monitoring Fetal Welfare at the Gatot Soebroto Army Central Hospital for the May-June Period in 2023," seeks to evaluate whether this new digital stimulator is more effective than the Klenengan bell in supporting fetal well-being monitoring.

METHODS

This research uses quantitative methods. The research design used in this study is a pure experiment (*true experimental design*). The pure experimental design used is *posttest-only control group design*.

This study will be conducted at Gatot Soebroto Army Central Hospital in May 2023 to June 2023. The population of this study were all pregnant women with a gestational age of 32 weeks to 44 weeks with less fetal movement at the time of ultrasound examination and fetal movement less than 10 times within 12 hours on fetal motion monitoring with a fetal motion monitoring card at the Army Central Hospital from May 2023 to June 2023 who met the research criteria as many as 60 samples.

A sample size of 60 pregnant women was chosen to provide sufficient statistical power to detect a meaningful difference in fetal response between the intervention and control groups. While a formal power analysis was not conducted a priori, a sample of 30 participants per group is generally considered adequate for detecting a moderate effect size in studies employing similar methodologies and statistical tests. Given the exploratory nature of this study, the practical constraints of the study setting (Gatot Soebroto Army Central Hospital), and available resources, a sample size of 60 was deemed to be a reasonable compromise between statistical rigor and feasibility. The limitations section acknowledges that this sample size may not be fully powered to

detect smaller effect sizes, and future research with larger sample sizes may be warranted. A post-hoc power calculation would be beneficial to better understand the power of this study, but the rationale for not doing one is outside the scope of the manuscript.

The sampling technique in this study was *incidental sampling,* which is a sampling technique based on chance, namely any pregnant woman whose gestational age is 32 weeks to 44 weeks who experiences less fetal movement during an ultrasound examination and fetal movement less than 10 times within 12 hours on monitoring with a fetal motion monitoring card.

The population was sampled as a control group and the research group was divided into 2 groups, namely the intervention group and the control group. The intervention group is mothers with odd numbers and the control group is mothers with even numbers. Group 1 or the intervention group was given treatment using an innovative sound simulator that has a constant *decibel* strength that is not influenced by the strength of the driving hand used by means of a sound source in the form of a *speaker* brought closer to the location of the mother's abdomen in the position of the fetal head which has a duration of approximately 1 minute with a strength range of 10-68 dB. Group 2 or the control group was given a sound stimulus tool with the one used at the Army Hospital, namely the traditional klenengan bell which was moved by hand. *Posttest* was conducted on both groups.

The researcher collected data with the results of collecting observations from the two groups with a *check list*. The data analysis used was univariate to describe the score of the effectiveness of the sound stimulator as a means of monitoring fetal well-being and produce a frequency distribution of each variable. Bivariate analysis in this study used the *Wilcoxon non-parametric* test. The Wilcoxon Signed Rank test was chosen as the appropriate statistical test for bivariate analysis in this study due to the nature of the data collected. Specifically, the fetal response data (awakening or not) is ordinal in nature, representing a ranked order of response rather than continuous values. Furthermore, preliminary analysis indicated that the data were not normally distributed. The Wilcoxon Signed Rank test is a non-parametric test specifically designed to analyze the significance of differences between two paired groups when the data are ordinal and not normally distributed, making it well-suited to the research design and data characteristics of this study. The basis for decision making to accept or reject Ho, Wilcoxon is if the probability (*Asymp.sig* <0.05 then the hypothesis is rejected and if the probability (*Asymp.*sig>0.05 then the hypothesis is accepted. This study has received ethical approval from the Institute of Health Research Ethics Committee of Dharma Husada College of Health Sciences with No. 13/KEPK/SDHB/B/V/2023.

RESULTS

Table 1 presents the distribution of maternal age, gestational age, and fetal response times in both the intervention and control groups. The comparison aims to explore potential differences in fetal wake-up responses following the listening intervention.

Table 1. Distribution of Maternal Age, Gestational Age (Weeks), and Fetus Wakes Up in the Intervention Group and the Control Group

Variables	Listening Time				Total
	Intervention Group (n=30)	%	Control Group (n=30)	%	
Maternal Age (Years)					
20-24	6	20.0	7	23.3	13
25-29	12	40.0	10	33.3	22
30-34	8	26.7	9	30.0	17
>35	5	16.7	4	13.3	8
Gestational Age (Weeks)					
32-34	2	6.7	3	10.0	5
35-37	8	26.7	7	23.3	15
38-40	15	50.0	14	46.7	29
41-44	5	16.7	6	20.0	11
Fetus Wakes Up					
<30 seconds	27	90.0	7	23.3	34
31-60 seconds	3	10.0	15	50.0	18
Not waking up	0	0.0	8	26.7	8
Fetus Wakes Up					
Yes	1	3.3	28	93.3	29
No	29	96.7	2	6.7	31
Fetus Wakes Up					
No (<68dB)	27	90.0	5	16.7	32
Yes (>68dB)	3	10.0	25	83.3	28

Table 1 presents a comprehensive overview of several respondent characteristics, including maternal age, gestational age, fetal response time to auditory stimuli, appropriateness of device use, and noise levels during use. In terms of maternal age, the most common age group in both the intervention and control groups was 25–29 years, accounting for 40.0% and 33.3% respectively, while the least represented group was those aged over 35 years, with 16.7% in the intervention group and 13.3% in the control group. This suggests that most participants were within the optimal reproductive age range. With regard to gestational age, the 38–40 week category was the most prevalent in both groups, making up 50.0% of the intervention group and 46.7% of the control group, whereas the 32–34 week group was the least common. In evaluating fetal response time to auditory stimuli, 90.0% of fetuses in the intervention group responded within 30 seconds after being exposed to the innovative sound stimulator, in contrast to just 23.3% in the control group who received the traditional bell sound; notably, 26.7% of fetuses in the control group did not respond at all, indicating the superior effectiveness of the innovative device. Furthermore, the appropriate use of the device was significantly higher in the intervention group, with 96.7% demonstrating correct usage, compared to only 6.7% in the control group, where 93.3% used the device incorrectly. Lastly, 90.0% of the intervention group experienced non-disruptive sound levels (≤68 dB), while 83.3% of the control group encountered higher noise levels (≥69 dB), underscoring that the innovative sound stimulator is acoustically safer and more comfortable for both the mother and the fetus.

Table 2. Impact of Usability by Users of the Noise Level of the Innovation Sound Stimulator in the Intervention Group and the Traditional Klenengan bell Sound in the Control Group

Levene Statistics	df1	df2	Sig.
6.650	1	28	0.015

Table 2 presents the results of the Levene homogeneity test, with the obtained

Significance Level. 0.015 which means that this study has unequal variants because the test results obtained *sig* value> 0.05 so that the data is not homogeneous, so the analysis is continued using the *Wilcoxon Signed Rank test*.

Table 3. Bivariate Analysis

Group	Listening Time	
	Stimulator z	Asymp.Sig.(2-tailed)
Intervention (innovation voice stimulator)	-2.111[c]	0.035
Control (traditional bell ringing)	-1.508[b]	0.132
Total	**30**	**30**

Table 7 presents the Wilcoxon test results from this study, comparing the effectiveness of the innovative sound stimulator with the traditional klenengan bell. In the control group, which used the klenengan bell, the Sig. value was 0.132. In contrast, the intervention group that received the innovative sound stimulator showed an Asymp.sig value of 0.035. According to the decision-making criteria for accepting or rejecting the null hypothesis (Ho), if the Asymp.sig probability is less than 0.05, the hypothesis is rejected; if it is greater than 0.05, the hypothesis is accepted. Therefore, the innovative sound stimulator can be considered more effective, leading to the acceptance of the null hypothesis.

DISCUSSION

Innovative Sound Stimulator is More Effective than Traditional Klenengan Sound for Waking Sleeping Fetuses during Fetal Wellbeing Monitoring

The results showed that the innovative sound stimulator was more effective than the traditional klenengan bell sound. The innovation sound stimulator in the manufacturing process looks at various aspects, namely the sound produced, the sound waves produced, the practicality of the tool, and the noise level produced. The innovation sound stimulator tool is stored in the form of a *softcopy* document and is easily *downloaded* on electronic media and the sound can be emitted through *headphones* or digital *speakers* which are more practical and flexible because they are easily *downloaded* on electronic media such as *bluetooth speakers*, *headphones*, or other digital *speakers*.

The innovative sound stimulator maintains a consistent decibel level, as its performance is not affected by the force applied by the user. This digital sound stimulator operates by positioning a speaker near the mother's abdomen, specifically at the location of the fetal head, for a duration of approximately one minute. The sound output ranges from 10 to 68 dB.

Based on the results of data analysis, it was found that the fetus whose sleeping condition at the time of monitoring fetal welfare was given an innovative sound stimulator, the fetus woke up with a time of <30 seconds, only 7 out of 30 traditional bell klenengan users could wake up the fetus with a time of <30 seconds so it can be concluded that the use of innovative sound stimulators can wake up the fetus more effectively judging by the time played compared to the traditional bell klenengan sound.

Measuring effectiveness can be done by looking at the results of the work achieved. Effectiveness can be measured through the success or failure of a goal. If it succeeds in achieving the goal then the process can be said to have run effectively. Effectiveness is the achievement of goals through the efficient use of resources, in terms of inputs, processes, and *outputs.* (More et al., 2024). In this case, the *output*

includes the use of the innovation sound stimulator as a means of monitoring the welfare of the fetus. (Maeda and M., 2017). Based on this theory and the results of research showing that with a time of <30 seconds the use of an innovative sound stimulator is able to wake the fetus, the innovation sound stimulator can be said to be more effective than the traditional klenengan bell sound.

An innovative sound stimulator that is more appropriate for use as a sound stimulator to awaken sleeping fetuses during fetal well-being monitoring compared to traditional Klenengan sounds.

The findings indicate that the innovative sound stimulator is highly effective, incorporating technology that is well-suited to the environment at Gatot Soebroto Army Hospital Center. Users find the device easy to operate. Data analysis revealed that the innovative sound stimulator was used correctly in 29 out of 30 instances, whereas the traditional klenengan bell was considered effective in only 1 out of 30 cases. The appropriate use of these tools was determined by their ability to awaken a sleeping fetus during fetal well-being monitoring.

In this case, the use of innovative sound stimulator tools has the right value of usability by developing the provision of sound stimuli to wake the sleeping fetus manually with a traditional bell to digital *technology* that applies the requirements of *the technology acceptance model*, such as: resources that already exist in the environment: appropriate, suitable and acceptable; tools can be operated easily; able to solve existing problems; and can be learned which are easy to use, practical according to the user.

Acceptable Innovation Sound Stimulator (Does not cause noise)

The study results indicate that the sound produced by the innovative sound stimulator is more acceptable, as it does not generate disruptive noise, with levels below 68 dB. When comparing the sound power of the innovative stimulator to the traditional klenengan bell, it was found that 25 out of 30 innovative stimulators operated at noise levels under 68 dB. In contrast, only 5 out of 30 traditional klenengan bells maintained noise levels at or below 68 dB.

The innovation sound stimulus has a power of 10-68 dB with a safe noise range (Mangesi et al., 2015). Sound with a power range of 10-68 dB is safe for the fetus because the fetus has amniotic fluid that functions as a protector including sound. The innovative sound stimulator with a power of 68 dB sound can wake the sleeping fetus so that monitoring of fetal welfare can be done optimally or optimally.

This is in line with research at the University Hospital of Barcelona in 2015 found that sound stimulation causes the fetus to make or increase the frequency of movements, this suggests that sound stimulus may have a beneficial effect on the fetus and that stimulation can be used as a method to improve fetal well-being. (Pirhadi., 2015; Vitale, F. M., Chirico, G., & Lentini, C.,2021) It can be said that the innovative sound stimulator noise level is acceptable which is less than 68 dB or in other words does not cause noise.

Recent research on the effectiveness of sound stimulators as a means of monitoring fetal well-being has highlighted their potential in improving prenatal care, but incorporating more recent studies strengthens these findings and addresses existing gaps. Vibroacoustic stimulation (VAS) remains a cornerstone in this field, as demonstrated by the Cochrane Review, which evaluated its use in 6822 participants. (Movalled, K., Sani, A., Nikniaz, L., & Ghojazadeh, M., 2023). VAS has been shown to reduce non-reactive cardiotocography (CTG) results and shorten test durations,

making it a practical tool for antenatal monitoring. However, limitations such as insufficient data on safety and optimal application parameters indicate the need for further exploration. (Hussain, N. M., O'Halloran, M., McDermott, B., & Elahi, M. A., 2024).

Complementing these findings, newer studies have delved into the broader implications of sound stimulation. For instance, music interventions during pregnancy have been shown to influence fetal heart rate (FHR) stability and maternal-fetal bonding. Research using Doppler fetal monitoring revealed that irregular singing elicited stronger fetal movement responses compared to fixed melodies, suggesting that variability in auditory stimuli may enhance fetal responsiveness and emotional connections between mother and child. (Lee, L., Chang, Y. H., Liang, W. J., & Huang, Y. C., 2022). This aligns with earlier findings that maternal perception of fetal movements after sound stimulation can serve as a reliable screening method for fetal well-being. (Yetkin, A. K., Güneş, B., & Erbaş, O., 2023).

Moreover, systematic reviews on the impact of sound stimulation during pregnancy have expanded the understanding of fetal learning. These studies underline how repeated exposure to specific auditory stimuli, such as music or speech, can create prenatal memory traces, which may influence neonatal behavior and cognitive development post-birth. (Movalled, K., Sani, A., Nikniaz, L., & Ghojazadeh, M., 2023). This reinforces the importance of designing sound-based interventions not only for monitoring but also for fostering developmental outcomes.

Despite these advancements, challenges remain in standardizing methodologies across studies. For example, while VAS has proven effective in labor settings with non-reassuring FHR patterns, there is insufficient evidence from randomized controlled trials to recommend its routine use during labor. Similarly, although sound stimulation shows promise in high-risk pregnancies by predicting adverse outcomes through impaired FHR responses, its predictive value needs further validation. (Zbelo, M. G., 2024; Toker, E., & Gökduman Keleş, M., 2024).

While the study's strengths are evident, particularly in the controlled stimulation environment and immediate clinical applicability, potential confounding factors related to maternal health, such as hypoglycemia, dehydration, or the influence of medications, should be carefully considered, as they can significantly affect fetal responsiveness to sound stimulation. Recognizing and managing these maternal conditions are crucial to ensuring accurate interpretation of fetal responses during monitoring. Expanding the application of this innovative sound stimulator into standard clinical protocols could greatly enhance fetal monitoring practices by providing a reliable method to differentiate between normal fetal sleep and potential fetal distress, thereby improving early intervention strategies and elevating the overall quality of obstetric care.

Incorporating these recent insights into clinical practice could significantly enhance prenatal monitoring protocols. Future research should focus on integrating diverse auditory stimuli into structured interventions while addressing safety concerns and long-term developmental impacts. By bridging these gaps, sound stimulators could evolve from diagnostic tools into holistic aids for maternal and fetal health.

CONCLUSIONS

The innovative sound stimulator proved more effective than the traditional klenengan bell in awakening sleeping fetuses during monitoring at Gatot Soebroto Army Central Hospital. Its safe noise level supports its use in clinical settings such as hospitals, health centers, and midwifery clinics for fetal well-being assessments. While

the device offers a practical solution for early detection of fetal conditions, future research should broaden its evaluation across diverse populations, including high-risk pregnancies, and explore its effects on fetal neurodevelopment. Further advancements, such as integrating noise-filtering algorithms and wireless monitoring technology, could optimize its performance and expand its application in modern prenatal care.

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