ERGONOMIC PORTABLE GYN- HOLDER FOR BIRTHING PROCESS

Bernadus Kristyanto ¹, Luciana Dewi ², Rustamaji ³

¹Faculty of Industrial Technology, Atma Jaya Yogyakarta University
email: b.kristyanto@mail.uajy.ac.id
²Faculty of Industrial Technology, Atma Jaya Yogyakarta University
³Faculty of Medicine, Gadjah Mada Yogyakarta University

Abstract. Birth is a natural process that always happen to mothers. Hence the mothers’ (patients’) legs have enough strength and the thigh stays open to ease the baby's way out and the doctor (midwife) in assisting the birth process, then an equipment is needed to sustain the legs’ strength (Gyn-Holder). This experiment is done through an Ergonomic approach so that a new product plan that is more optimal and can satisfy its users especially women in rural areas is available. A product plan and a tested prototype has been produced from this experiment. An improvement towards this product plan has been carried out through quantitative and qualitative result analysis.

Practitioner Summary: Portable Gyn Holder for rural area has been developed. Ergonomic approaches have been applied to analysis the feasibility of tool for helping rural women birth process. People (patient, mid wife, and doctor) who are involved in the birthing process will feel comfort and safety for using it.

Keywords: Portable Gyn-Holder, Ergonomics Approaches, Biomechanics Analysis, Birth process, Rural area

1. Introduction

Giving birth is a natural process and most women have to go through it. Hence the mothers’ (patients’) legs should have enough strength and the thigh have to stay open to ease the baby’s way out and the doctor (midwife) may have in assisting the birth process, then an equipment is needed to sustain the legs’ strength and its a Leg or Gyn-Holder. This experiment is done through an Ergonomic approach so that a new product plan that is more optimal and can satisfy its users especially women in rural areas is available. A product plan and a tested prototype has been produced from this experiment. An improvement towards this product plan needs to be done through quantitative and qualitative result analysis. Gynecologist or Midwife usually also uses the leg holder to position the cervix in the stitching process. In some part of rural areas in Indonesia, the labor process normally being done at home by calling in a midwife or gynecologist. The facilities for this kind of labor process is not yet sufficient, because the use of leg holder is supposed to be on the obstetric bed. The reality is that it is impossible to bring in the obstetric bed to the patient’s house at the time they call for labor or the time when the stitching of the cervix need to be done.

In the Kristyanto et, al., (2012) the two position of postures when delivering baby without tool was investigated by using RULA analysis. The results shown that better score results for position 1 (laying down position) than position 2 (half sitting position). Position 1 gave score 3 that has more acceptable level than position 2 with score level 6. This paper will present the development of Gyn Holder and ergonomic approaches through biomechanics analysis to reduce the risk based on position 2.

2. Methods

This research is designing the Gyn holder based on ergonomic approaches through biomechanics analysis to obtain the optimal design which is suitable to the user in a developing country such as Indonesia. Biomechanics analysis is being applied on mothers who are giving birth. The analysis was conducted in terms of normal condition of the birth process.
For designing the product, an anthropometric data from the population are needed and collected. The data were measured from the population which are pregnant woman patients in Panti Rapih Hospital in Yogyakarta, Indonesia. A data of thirty anthropometric pregnant woman were sampled to be collected. The respondents were 25 year to 35 years old with 23 to 39 weeks of pregnancy. The respondents were from a pregnant exercise community in Panti Rapih hospital. The anthropometric data of Indonesian pregnant woman from the previous research of Widhiandani and Kristyanto were collected from Batu Ampah Puskesmas (Community Health Centre) in the suburb of Dusun Tengah, Kalimantan Tengah.

The main variable which is anthropometric data from both populations that are required for designing the product were used. Dimensions of anthropometric which are involved in the design are Waist Wide (WW), Buttock to Knee (BK), Popliteal Thickness (PT), and Popliteal Circumference (PC) as shown in Table 1. These dimensions were chosen based on each of its own function in designing the portable Gyn holder.

### Table 1: Anthropometric data required for defining Gyn-Holder

<table>
<thead>
<tr>
<th>data</th>
<th>5%</th>
<th>50%</th>
<th>95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>WW</td>
<td>35,8</td>
<td>39</td>
<td>44,6</td>
</tr>
<tr>
<td>BK</td>
<td>43</td>
<td>47,25</td>
<td>52</td>
</tr>
<tr>
<td>PC</td>
<td>32</td>
<td>38</td>
<td>42</td>
</tr>
<tr>
<td>PT</td>
<td>10,2</td>
<td>12,1</td>
<td>13,4</td>
</tr>
</tbody>
</table>

Establishing function of the Ergonomic Gyn-holder as in Figure 2 has to be developed as a target of the goals.

3. **Results and Discussion**

From the research, the anthropometric data used in the basic Gyn Holder design were presented. The prototype also developed results from evaluation or testing. The ergonomic approaches that uses RULA and REBA and Biomechanics analysis were also presented.

The Gyn Holder design is adjustable to the width and height direction. The extension can use aluminum pipe which is to be assembled or disassembled for easy carry on. The Gyn holder weight is around 6 kilos.
Using RULA sheet assessment, the posture score of patient interaction with tool was determined at the risk level as Table 2 below.

<table>
<thead>
<tr>
<th>A. Arm and Wrist Analysis</th>
<th>B. Neck, Trunk and Leg Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steps</td>
<td>Score</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Final Score</td>
<td>6</td>
</tr>
</tbody>
</table>

With similar assessment the score of REBA was also applied to determine the risk level score of patient interaction with the tool as presented in Table 3.
Table 3: REBA assessment score for half sitting position with tool

<table>
<thead>
<tr>
<th>Steps</th>
<th>Score</th>
<th>Steps</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Table score</td>
<td>7</td>
<td>1</td>
<td>Activity Score</td>
</tr>
<tr>
<td>Final Score</td>
<td>8</td>
<td>(7 + 1)</td>
<td></td>
</tr>
</tbody>
</table>

From RULA and REBA assessment scores, it can be seen that the half sitting position with the tool has a score of 6 and 8. Score 6 for RULA means that it needs further investigation and immediate improvement. Score 8 for REBA means that it is high risk and improvement and changes must be conducted.

Interview data with patients show that almost all respondents were satisfied using that tool and felt comfortable. Based on their opinion, the tool is very helpful specially for supporting the leg. As suggested by midwife when contraction begins, legs should be lifted up using the hand by pulling the thigh till close to abdomen. Using the Gyn holder will make it easier to pull it back. The problem is the pull process almost done by handled the tool onto under pedestal of leg holder supported.

According to the interview with Doctors (1 from academic, 1 from community health center, 1 from private clinics, and 1 obstetrician) it was found that the tool satisfies as a function to help re-positioning legs to keep open during the birth process and any other medical acts such as stitching, cleaning up, and placing birth control instruments. Also there are still several considerations in improving the design, such as strong construction and making steady joints, non obtrusive fasteners, and moving the bottom connecting rod.

From observation, it was also found that midwifes prefers or tend to put the Gyn holder on a bed or desk than on the floor for more comfortable work. Waist injuries and neck pain due to work process should be avoided by laying down the patient onto a higher position so bending is not necessary. If the legs keep open the sight of midwives or doctors are not obstructed and the job can be finished easily and quickly.

Based on the input information as mentioned above, it is necessary to improve the tool design as in Figure 4 below.

Based on the RULA analysis on the new Gyn holder, it was found that the score at half sitting position was 5 lower than before and need to be corrected, while REBA shows score 7 that doesn't have significant difference with the previous result.

According to the qualitative analysis, the equipment has been accepted functionally from several trials in the field by the patient and midwife. From the side of quantitative analysis, technically the equipment is still in medium risk level. When modification was done by obtaining the second prototype, feedback from midwives and patients show a level of decrease but not significantly. Meanwhile from the Ergonomic analysis through equipment and user interaction (patient, midwife/doctor) shows several behavior to optimize the function by
lowering the risk of injuries on the spine that can be done. In this case the main orientation is the comfort and the birth process could go smoothly.

A Biomechanics analysis through Catia Program Software for both positions have been applied by Kristyanto, (2013)] which is shown that The Lying down Position is a better choice compared to half seating position regarding to the forces that impact to back bone. Those are as well as RULA and REBA analysis. However, if it is concerning with the smoothness of labor process then it chooses the half seating position.

Based on the half seating position of the model, Biomechanical analysis are developed through the free body diagram of forces as follows:

\[ AB = 0.15 \text{ H}, AC = 0.20 \text{ H}, AD = 0.30 \text{ H}, H \text{ is the human height in cm} \]
\[ F_d \text{ is weight of upper back bone (neck and head) at D that equal 0.18 W} \]
\[ R_a, R_s \text{ are reaction forces, that are axis force and shear force at lumbosacral} \]
\[ W \text{ is the body weight times to gravity = G x g} \]
\[ F_b \text{ is weight of thorax and abdomen at B that equal 0.36 W} \]
\[ \Theta \text{ is angle between segment link of back and horizontal line} \]
\[ CD = AD-AC=0.30\text{H}-0.20\text{H}=0.1\text{H} \]

\[ F_e = F_e_1 / \cos \alpha \]
\[ F_e = F_e_2 / \sin \alpha \]
\[ F_e = F_e_{th} / \cos(\Theta+\alpha) \]
\[ F_e = F_e_{v} / \sin(\Theta+\alpha) \]
\[ F_e = F_e_{2h} / \cos(90-\Theta) \]
\[ F_e = F_e_{2v} / \sin(90-\Theta) \]
\[ R_s = R_s v / \cos(90-\Theta) \]
\[ R_s = R_s h / \sin(90-\Theta) \]
\[ R_a = R_a s \]
\[ R_a = R_a v \]
\[ R_a = F_e_1 / \cos \alpha \]
\[ \sum F_y = 0 \]
\[ R_a - R_s v - F_b - F_e_{2v} - F_e_{1v} - F_d = 0 \]
\[ R_a \sin \alpha - R_s \cos(90-\Theta) - 0.36W - F_e \sin(90-\Theta) - F_e \cos \alpha \sin(\Theta+\alpha) - 0.18W = 0 \]
\[ F_e \cos \alpha \sin \Theta - R_s \cos(90-\Theta) - 0.54W - F_e \sin(90-\Theta) - F_e \cos \alpha \sin(\Theta+\alpha) = 0 \]
\[ R_s = (F_e \cos \alpha \sin \Theta - F_e \sin(90-\Theta) - F_e \cos \alpha (\Theta+\alpha) - 0.54W) / \cos(90-\Theta) \]
\[ \sum F_x = 0 \]
\[\begin{align*}
\text{Fe2h} - \text{Fe1h} + \text{Rah} &= 0 \\
\text{Rah} &= \text{Fe1h} - \text{Fe2h} \\
\text{Rah} &= \text{Fecos}(\Theta + \alpha) - \text{Fesin}(90 - \Theta) \\
\sum \text{MA} &= 0 \\
\text{Fe1h} \cos \Theta + \text{Fe2h} \cos \Theta &= \text{Fe1h} \sin \Theta + \text{Fe2h} \sin \Theta + \text{FdAD\cos\Theta} = 0 \\
0.36W \sin \Theta + 0.15W \cos \Theta + 0.20H \cos \Theta &= \text{Fe1h} \cos ((\Theta + \alpha) \cos (\Theta + \Theta) + \text{Fesin}(90 - \Theta) \sin \Theta + 0.18W \cos \Theta = 0 \\
0.054W \cos \Theta + 0.20H \text{Fe} (\cos (\Theta + \alpha) \cos \Theta + \text{sina}(90 - \Theta) \cos \Theta - \cos \cos ((\Theta + \alpha) \sin \Theta + \text{sina}(90 - \Theta) \sin \Theta) + 0.054W \cos \Theta = 0 \\
0.02W \text{Fe} &= \{-0.108 \times \text{Wh} \cos \Theta\} / \{ \cos \sin (\Theta + \alpha) \cos \Theta + \text{sina}(90 - \Theta) \cos \Theta - \cos \cos ((\Theta + \alpha) \sin \Theta + \text{sina}(90 - \Theta) \sin \Theta\} \\
\text{Fe} &= \{-0.54W \cos \Theta\} / \{ \cos \sin (\Theta + \alpha) \cos \Theta + \text{sina}(90 - \Theta) \cos \Theta - \cos \cos ((\Theta + \alpha) \sin \Theta + \text{sina}(90 - \Theta) \sin \Theta\} \\
\text{If} \ \Theta = 300 \ \text{and} \ \alpha = 130 \\
\text{Then} \\
\text{Fe} &= \{-0.54W \times 0.1543\} / \{0.9074 \times (-0.8318) \times 0.1543 + 0.4202(-0.3048)(-0.9880) - 0.9074 \times 0.5551(-0.9880) + 0.4202(-0.9524)(-0.9880)\} \\
\text{Fe} &= -0.0833W / 0.9029 \\
\text{Fe} &= -0.0923W \\
\text{Rs} &= \{(\text{Fecos}\sin (90 - \Theta) - \text{Fesin}(90 - \Theta) - \text{Fcos}(\Theta + \alpha) - 0.54W) \times \cos (90 - \Theta)\} \\
&= \{-0.923W \times 0.9074(-0.9880) + 0.923W \times 0.4202(-0.3048) + 0.0923W \times 0.9074 (-0.8318) - 0.54W\} / (-0.9524) \\
\text{Rs} &= -0.5387 W / -0.9524 \\
&= 0.5656 W \\
\text{If} \ \text{Patient used the Gyn Holder tool which is proposed} \\
\text{AB is the length from the lower back (A) towards the central point of the backbone segment weight (B) = 0.15 H and AC is the length from the lower back (A) towards the muscle force point on the backbone (C) = 0.20 H. AD is the length from the lower back (A) with the weight point of the upper back segment (D) = 0.30 H, where H is the height of the person in cm.}
\end{align*}\]
Figure 5: Free Body diagram by using Gyn holder (Kristyanto, et.al., 2014)

Fe is the muscle force on the backbone in point C with an angle $\alpha = 13^\circ$ towards the backbone line. $F_d$ is the weight segment of the upper back (neck and head) in point D which is 0.18 W. W is the weight of the person multiplied by gravitation or G x g.

$F_b$ is the weight segment of the backbone in point B which is 0.36 W and $\Theta$ is the angle of the backbone segment and the horizontal line. The length of CD is the same with AD subtracted by AC which is 0.30 H subtracted by 0.20 H, which is the same as 0.1 H. $T_p$ is the shoulder tensile force caused by the hand attraction.

$$\sum F_y = 0$$

$$-F_d - F_e - F_v + Ra_v - Rs_v = 0$$

$$-0.18W - F_e - 0.36W + Ra_v - Rs_v = 0$$

$$Ra_v = Fe_v + 54W + Rs_v Ra \sin \Theta$$

$$= (Fe_v + 54W + Rscos\Theta) / \sin \Theta$$

$$\sum F_x = 0$$

$$Fe_h - Ra_h + T_p - Rs_h = 0$$

$$Ra_h = Fe_h + T_p - Rs_h$$

$$= (Fe_h + T_p - Rs \sin \Theta) / \cos \Theta$$

$$\sum M_A = 0$$

$$-F_d AD\cos \Theta - Fe AC\cos \Theta + Fe AC\sin \Theta + Tp AD\sin \Theta - F_b AB\cos \Theta = 0$$

$$-Fe AC\cos \Theta + Fe AC\sin \Theta - FdAD \hc \cos \Theta + Tp AD \sin \Theta - F_b AB \cos \Theta = 0$$

$$-Fe 0.20H \hc (\alpha + \Theta) \cos \Theta - \cos (\alpha + \Theta) \sin \Theta - 0.18W 0.3H \cos \Theta + Tp 0.30H \sin \Theta - 0.36W 0.15H \cos \Theta = 0$$

$$Fe = [0.30H Tp \sin \Theta - 0.18W 0.30H \cos \Theta - 0.36W 0.15H \cos \Theta] / [0.20H \hc (\sin (\alpha + \Theta) \cos \Theta - \cos (\alpha + \Theta) \sin \Theta)]$$

$$Fe = [1.5Tp \sin \Theta - 0.54W \cos \Theta] / [\sin (\alpha + \Theta) \cos \Theta - \cos (\alpha + \Theta) \sin \Theta]$$

Fe or the muscle force on the back will be determined by the weight of the pregnant woman’s body (W), the angle of the force towards the back muscle (\alpha), and the slope angle of its half seated position (\Theta) and also the $T_p$, where $T_p$ is assumed to decrease the muscle force on the back.

4. Conclusion

The Gyn - Holder is needed for pregnant woman who live far away from adequate health centers. Ergonomic approaches through Biomechanics analysis can be applied in many processes of jobs including the birthing process. The analysis will help to reduce the back injury risk and also the fatigues of other part of the human body anatomy during the birth process.
From the previous analysis [2] showed that if it is respect to ergonomic analysis through biomechanical calculation the Lying down position is the choice. But if the respect is oriented to medical advices the Half Seating position is the choice. To solve the problem it is required to follow the Half Seating Position but should be completed by tools which can help to reduce the back pain or injury and the fatigue feeling of forehand and foreleg. This position makes the mother feel more comfortable. The positive side of the half seated position is that the birth passage axis that needs to be passed by the baby is shorter. By this equipment it is expected that the weakness that can cause exhaustion to the legs and complaints of backache even can be overcome. Moreover if the birth process takes longer time.

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