Evaluation of Baby Carriers in Indonesia: Physiological and Biomechanical Approach

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Abstract. Baby carrying is among the most performed activities during mothering and caring for children. Researches showed that baby carrying activities may increase the risk of musculoskeletal disorders among mothers. This study aimed to evaluate three types of baby carrier often used by mothers in Indonesia, namely Soft Structured Carrier (SSC), ring sling, and jarik based on the posture analysis approach, Rate of Perceived Discomfort (RPD), Activities-Specific Balanced Confidence Scale (ABC Scale) and heart rate. This research was conducted through laboratory experiments involving 12 respondents. Each respondent was asked to carry out a simulation carrying a 6 months old baby (weighing 7.3 kg) by walking on a treadmill for 10 minutes using three different types of baby carrier. Body markers for posture analysis and heart rate sensor were installed prior to the experiment to record body motion and heart rate, respectively. At the end of the experiment, respondents were asked to provide an assessment of the perceived pain using the RPD questionnaire, as well as the ABC Scale questionnaire to obtain the level of confidence in balance when carrying a baby. The results indicated that through posture analysis, all types of baby carrier produced an average value of 49° - 52° at the sagittal shoulder angle, which falls in the normal posture category. Whereas in the craniohorizontal angle, the SSC type sling provided the best change in posture. Based on the RPD questionnaire, ring sling and jarik resulted in higher pain to the left shoulder than the SSC sling. Based on the results of the ABC scale questionnaire, the SSC sling provided a higher level of trust than the jarik and ring sling. However, no significant difference found in terms of heart rate for the three types of baby carrier.

1. Introduction

Baby carrying is the most commonly performed activities during mothering and caring for children. To support the activity, the baby carrier is used, in particular when the child is 5-12 months old [1]. Researches have shown that the baby carrying activities may increase the risk of musculoskeletal disorders (MSDs) among mothers due to the baby weight. [2] reported MSDs among nurses in Nigeria in relation to baby carrying activity. [3] evaluated the different position of baby carrying with the pros and cons of each position of carrying.

There are different types of baby carrier available in the market. Soft Structured Carrier (SSC) is the most commonly suggested by the health care profession. The position of the carried baby for the SSC is in front of the mother facilitating balanced support from both shoulders. Another type of baby carrier namely ring sling is commonly used in several particular countries in Asia. Rings sling is a simple, one long piece of fabric with two rings. The cloth is worked through the rings to create a secure pouch for the child to sit in. A ring sling is worn across the torso, supported by one shoulder without any snaps,
buckles or ties. Ring slings come in multiple fabrics like cotton, linen, silk, wool and even cashmere. Similar with the ring sling, a traditional baby carrier using shawl called jarik is also commonly used in some countries such as in Indonesia. Sharing similar properties and position with the ring sling, the basic difference between jarik and ring sling is the absence of the ring. While ring sling is tied by the ring, jarik is usually tied or buckled by its own fabric.

Considering the high frequency of the use of baby carriers, coupled with the reported MSDs among mothers and child carriers, researches have been conducted to evaluate the choices and usage of baby carriers. [4] criticized the type of traditional, unstructured slings, since the safety depends solely on the wearer's use and knowledge of how to wrap an infant onto the caregiver since safety is not actively designed into the product. A more comprehensive study was conducted by [1] in relation to the use of SSC and ring sling. A study by [5] in evaluating posture in the cervical section and shoulder posture for different baby carrier types. However, there has not been studying evaluating the traditional jarik method used in Indonesia despite its large usage by mothers in Indonesia.

Thus, this study aimed to evaluate three different baby carriers that are commonly found and used in Indonesia i.e. SSC, ring sling, and the traditional shawl (jarik). Postural analysis, as well as physiological approach, were used in a laboratory study.

2. Method

Twelve female participants (range age 20-22 years) involve in this study. They were given $10 for the participation at the end of the session. Participants were instructed to carry a baby mannequin weighing 7.3 kg in a treadmill for 10 minutes each, using three different baby carrier i.e. SSC, jarik, and ring sling (Figure 1).

![Figure 1. Participants using three different baby carriers simulating baby carrying activity.](image)

Activities during the experiment were recorded for posture analysis purpose. Posture analysis is a method used to analyze whether the posture that resulted from doing an activity is appropriate. This study involved measurement of craniohorizontal, craniovertebral, and sagittal angles (Figure 2: [6]). Craniohorizontal angle is the angle formed at the intersection of a horizontal line through the tragus of the ear and a line joining the tragus of the ear and the external canthus of the eye. It provides an estimation of head on neck angle or position of the upper cervical spine [7]. Craniovertebral is the angle termed at the intersection of a horizontal line through the spinous process of C7 and a line to the tragus of the ear. The craniovertebral angle provides an estimation of the neck on upper trunk positioning with small angle indicating more forward head posture. Sagittal shoulder angle measured the angle formed by the intersection of a horizontal line through C7 and a line between the mid-point of the greater tuberosity of humerus and posterior aspect of the acromion. It provides a measurement of forwarding shoulder position with a smaller angle indicates that the condition called protracted shoulder.
Heart rate was recorded during the session. At the end of each session, the participants were instructed to rate the Borg rate of Perceive discomfort (RPD) and Activities-Specific Balanced Confidence (ABC Scale) to subjectively evaluate each type of baby carrier. The RPD is used to evaluate the intensity of physical activity (Figure 3 [8]). The ABC Scale was a method to assess self-confidence during daily activities, in particular for the balance condition, which was originally used to assess the elderly in their daily activities. The scale was rated by the respondents to evaluate how confident they were to not lose their balance during activities [9].

| Borg CR10 Scale (1982) | Borg CR10 Scale° (2010) |
|------------------------|-------------------------|
| 0 Nothing at all       | 0 Nothing at all         |
| 0.5 Extremely weak (just noticeable) | 0.3 Extremely weak Just noticeable |
| 1 Very weak            | 0.5 Extremely weak Just noticeable |
| 2 Weak (light)         | 0.7 Very weak            |
| 3 Moderate             | 1 Very weak              |
| 4 Somewhat strong      | 1.5 Weak                 |
| 5 Strong (heavy)       | 2 Light                  |
| 6                       | 2.5                      |
| 7 Very strong          | 3 Moderate               |
| 8                       | 4                        |
| 9                       | 5 Strong                  |
| 10 Extremely strong (almost max) | 6 Heavy                  |
| Maximal                | 7 Very strong            |
|                        | 8                        |
|                        | 9                        |
|                        | 10 Extremely strong      |
|                        | “Maximal”               |
|                        | 11                       |
|                        | Absolute maximum        |
|                        | Highest possible        |

Figure 3. The RPD scale.

3. Result and Analysis
All parameters of biomechanical and physiological analysis of baby carrying using three different baby carriers and non-baby carrying activity can be seen in Table 1.
Table 1. Biomechanical and physiological parameter as a function of baby carriers

| Parameter | Without carrying baby | Baby carrier | Sig |
|-----------|-----------------------|--------------|-----|
|           | SSC                  | Ring Sling   | Traditional Searf (jarik) |
| Heart Rate (%HR) | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Angle     | Craniohorizontal     | 26.57 (4.65) | 31.95 (5.57) | 38.09 (8.26) | 35.25 (8.21) | * F(3.47) = 7.099, p<0.05, MSE = 2846.2 |
|           | Craniovertebral      | 42.42 (4.29) | 46.5 (3.81) | 9.82 (9.82) | 44.27 (5.71) | NS |
|           | Sagittal             | 38.48 (7.74) | 49.17 (9.01) | 8.94 (8.94) | 49.92 (7.13) | * F(3.47) = 3.4, p<0.05, MSE = 1066.9 |
|           | Trunk                | 22.91 (4.39) | 23.3 (3.37) | 4.81 (4.81) | 22.64 (4.09) | NS |
| RPD       | Sway                 | 1.88 (1.26)  | 7.47 (2.05) | 2.10 (2.10) | 6.11 (1.55) | * F(3.47) = 45.330, p<0.05, MSE = 321.8 |
|           | Right shoulder       | - - 4.11 (1.90) | 1.76 (1.76) | 2.67 (1.12) | NS |
|           | Left shoulder        | - - 4.37 (1.60) | 1.85 (1.85) | 5.67 (1.97) | * F(3.28) = 5.186, p<0.05, MSE = 145.9 |
|           | Neck                 | - - 3.6 (1.84) | 1.36 (1.36) | 3.8 (1.62) | NS |
|           | Back                 | - - 3.5 (1.35) | 1.97 (1.97) | 4.73 (2.15) | NS |
|           | Waist                | - - 2.95 (1.34) | 1.95 (1.95) | 2.73 (1.79) | NS |
| ABC       | - - 8                | 7.5 | 6.5 | * F(3.35) = 3.587, p<0.05, MSE = 84.3 |

Through posture analysis, SSC sling, ring sling, and jarik produced an average value of 49° - 52° at the sagittal shoulder angle which still falls under the normal category. In term of %HR, the three types of baby carrier did not result in a significant difference. This shows that differences in the types of baby carriers between SSC, ring sling and jarik did not have a different physiological effect. This is consistent with the results of a study conducted by [1] regarding the evaluation of different types of baby carriers.

The type of baby carrier that resulted in the most pain to the left shoulder was ring sling. This may be caused by the shape of the product, the sling rings having a ring to strengthen the sling pressured on the shoulder, particularly because the ring is made of circular metal. Based on the ABC scale questionnaire it can be seen that respondents were more confident that they would not fall/lose balance when pulling the fabric on the sling. From the results of the questionnaire, it can be seen that for a number of activities such as cuddling babies, breastfeeding and feeding babies, SSC cannot support housewives to carry out the other activities. From the economic aspect, jarik is the cheapest. Based on the biggest online shopping in Indonesia, the price of jarik is between IDR 29.000 – 65.000, whereas the price of ring sling at IDR 35.000 - 100.000 and IDR 50.000 – 300.000 for SSC. Whereas from the view of the social aspect, jarik is usually used by rural people, and ring sling, as well as SSC, are usually used by urban people they are traveling and show high social status.

4. Conclusion
In conclusion, one of the most important advantages of traditional baby carrier namely jarik was the comfort it provides to mother due to its flexibility to be used while performing other activities while carrying the baby. The jarik was also more comfortable compared to the ring sling because of the absence of the metal ring. These advantages come with a cost of higher pain in the left shoulder compared to SSC carrier. The jarik was also found to be less supportive of the perceived balance while carrying the baby compared to the other two types. These findings are interesting because in fact many
Indonesians still use this traditional carrier. There shall be some other factors that influence Indonesian mothers, which may better explain the decision. Education, culture, economics and other factors may be of interest in the matter.

References
[1] Wu C, Huang H and Wang M. 2017 Ergonomics 60, 111-117
[2] Ojukwu CP, Anyanwu GE, Anekwu EM, Chukwu SC and Fab-Agbo C. 2017 J Obstet Gynaecol 37, 855-60
[3] Rajalakshmi J and Lagesse K. 2014 J Nurs Health Sci 3, 47-51
[4] Deppa SW and Allen ED. 2014 Proceedings of the Human Factors and Ergonomics Society Annual Meeting 58, 534-8
[5] Ruivo RM, Pezarat-Correia P and Carita Al. 2014 Braz J Phys Ther 18, 364-71.
[6] Mohan M, Singh U and Quddus N. 2007 Indian J Physiother Occup Ther 11, 4-6.
[7] Raine S and Twomey L. 1994 Australian J Physiother 40, 25-32
[8] Borg G. 1998. Borg's Perceived Exertion and Pain Scales Stockjol University: Human Kinetics
[9] Powel L and Myers A. 1995 J Gerontol A Biol Sci Med Sc 4, 28-35.