Effects of Baby Carrier on Wearer's Posture Stability

Aizreena Azaman, Nurshazni Aiman Mat Isa,*
Department of Biotechnology and Medical Engineering,
Faculty of Bioscience and Medical Engineering (FBME),
Universiti Teknologi Malaysia.
** aizreena@biomedical.utm.my*

Mohd Azuwan Mat Dzahir
Department of Applied Mechanics and Design,
Faculty of Mechanical Engineering,
Universiti Teknologi Malaysia.

Khor Kang Xiang
Techcare Innovation Sdn Bhd. UTM ICC, Industry Centre,
Technovation Park, Univerisiti Teknologi Malaysia.

ABSTRACT

Design of baby carrier mostly focused on baby's needs. But less consideration have been given to wearer. The objective of this study is to investigate the effect of baby carrier on the wearer's posture stability and displacement. It was hypothesized that baby carrier would reduce loading effect caused by baby's weight on the wearer's body. Fifteen healthy young female volunteered to participate in this study. Three dimensional motion data and force distribution were collected using 3D Investigator system and force platform respectively. Subjects underwent three conditions of standing which are standing on the force plate without load (Control), standing on the force plate with load only (L) and standing on the force plate with load and wearing a baby carrier (LBC). In this study, dummy baby was used to create load effect mimicking real baby's weight. For every condition, active markers will be placed at the subject's joint and the subject is asked to standing quietly on the force plate. Then, effect of different position of baby carrier also will be analysed including front position, back position, and side position. In this investigation wrapping type of baby carrier or Mei Tai is used. Collected data were used to measure Centre of Pressure (COP) and joint displacement. The results shows that by using baby carrier there are significance change in shoulder and pelvic joint displacement. Baby carrier

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also reduced the COP sway compared to other condition, but no significance changes recorded. Even though changes in posture displacement and the COP sway were relatively small, further study is still warranted to improve function and comfort design of baby carrier.

Keywords: *Baby Carrier, Stability, Joint Displacement, Centre of Pressure, Quiet Standing*

Introduction

Practice of carrying a child using any manner of carrier is called baby wearing. In many countries, baby wearing is simply a way of life and something that has been practiced for generations. In the United States and Europe, baby waring was considered primitive until 1960s when the first baby carrying products were appeared [1]. Since then, baby carrier has evolved and presented in many way for wrapping, tying, or buckling a baby to different locations on the body. One of the most popular type of baby carrier is called Mei Tai or also known as Chinese-style carrier [1]. On the south-east Asia region, *Selendang* that is made of cloth is commonly used to carry babies [2].

In general, baby carrier has many functions. One of the function is to keep the baby close to the mother and provide the baby with comfort and security while allowing the mother to do their work at the same time. In term of child growth, the use of baby carrier can promote a positive physical and emotional, growth [3]. Besides, in psychological aspect, proximity attachment between mother and infant is important for infant's growth as recommended by Bowlby's attachment theory. Disturbance of attachment may contribute to interpersonal relationship [4]. As reported by Hunziker and Barr (1986), 43 percent of baby who are worn are less cry compared to baby who are not worn [5].

There are no specific guidance or standing in selecting baby carrier. New mother was concerned more on their child's safety, healthy, cost, lifestyle, fashion and fit [1]. These have shown that less consideration about themselves. Previously, cases on parents falling while carrying their child were reported in Injury/Potential Injury Incident File (IPII) [6, 7]. Frisbee and Hennes (2000) have raised concerns that most of the injuries related to baby carrier come from three general sources such as product appropriateness and design, product condition, and product use [6]. Hence, further study is needed to justify the crucial need of baby carrier so that it will not jeopardizing both mother and child's right and safety.

When a person carry a baby, automatically he or she is putting a load on their body. Based on previous study by Evanna Singh (2009), carrying load at front position produced postural changes similar to a pregnant women [8]. Meanwhile, carrying a load at back and side position produced changes similar to the effect of school backpack and hand lifting during work respectively [2][9]. School backpack reported to cause back pain disease by 46.1% [10]. Besides, carrying load altered gait kinematics and muscle activity. In term of posture orientation, front and back load caused a significant change in neck motion during gait [11]. Changes in range of motion and locomotion pattern has the potential to cause unpleasantly affect the individual carrying the load for long term use and may contribute to physical health problem such as back pain.

These findings have shown that baby wearing potentially bring a bad effect to the wearer's posture. It can cause posture imbalance which can increase the risk of fall. Previously, cases on parents falling while carrying their child were reported as mentioned before which may be caused by imbalance [6]. Research have shown that increase in postural sway contributed to deterioration of balance [12-15].

Even though, baby wearing or baby carrier itself has been practise or use for generations, less studies especially in both kinetic and kinematic aspect have been made specifically on baby carrier. If the use of existing baby carrier are potentially deleterious to the wearer, further study is warranted in order to promote an ergonomic and safe design of baby carrier.

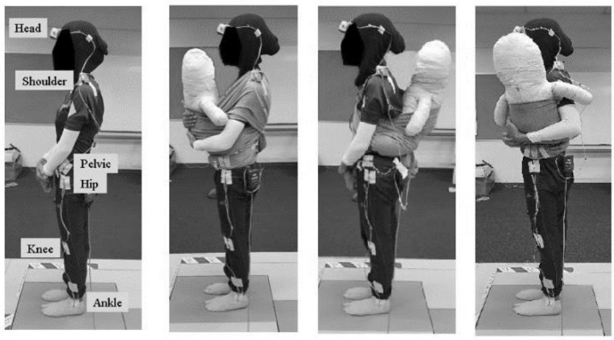
Methodology

Subject Preparation

Fifteen healthy young female adults were participated in this study (23.1 ±1.03 years old, 49.1±5.92 kg of weight and 155.3 ± 5.42 cm of height). They were recruited from a general student population in Faculty of Bioscience and Medical Engineering, Universiti Teknologi Malaysia. Each subject was fully briefed regarding to any possible risk and provided informed written consent prior participation followed the Declaration of Helsinki. Subjects were excluded from the study if they indicated any health problem or history of fall.

Experiment Set Up

Every subject need to undergo total of six conditions. First three conditions included normal standing (Control), standing with load (L) and standing with load using baby carrier (LBC-Front) in order to identify the loading and baby carrier effects. Then, the subject proceeded with other three conditions to classify the effect of different position of baby carrier such as front type (LBC-Front), back type (LBC-Back) and side type (LBC-Side) as shown in Figure 1. In this study, baby dummy with 5kg of weight and 55cm of height was used as load. The dummy was customised according to actually new born size prepared by WHO Child Growth Standards in order to mimic a real baby wearing condition. The subject need to stand on the force plate for 1 minute and 5 minutes rest between each trials. Figure 2 illustrates the experiment set up.



(a) (b) (c) (d)

Figure 1: (a) Marker's position. Different Baby carrier position (b) front type, (c) back type and (d) side type.

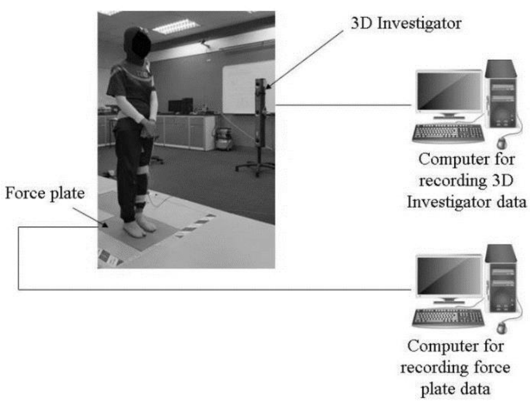


Figure 2: Experiment Set Up

Data Collection

Three dimension force and moment data from force plate (AMTI) were collected. Force and moment distribution at three different axis were used to measure centre of pressure (COP) at x-axis and y-axis using Equation (1) and (2) respectively. The thickness of force plate, d_z is 41.3 mm.

$$x = -\frac{My + Fxdz}{Fz} \qquad (1)$$

$$y = \frac{Mx + Fydz}{Fz} \qquad (2)$$

where *My* is moment at y-axis, *Mx* is moment at x-axis, *Fz* is force at x-axis (medial-lateral), *Fy* is force at y-axis and *Fz* is ground reaction force or force at z-axis. Figure 3 shows example of COP plotting at x-axis (anterior-posterior direction) and y-axis (medial-lateral direction).

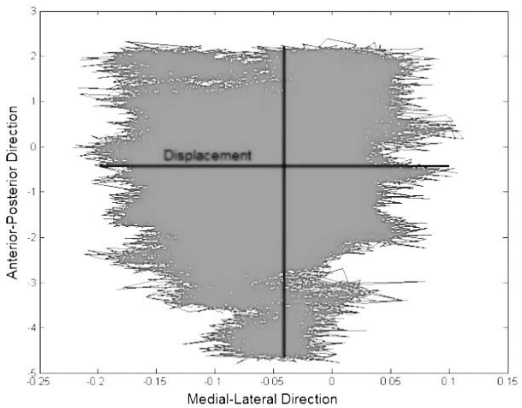


Figure 3: Example of COP plotting. COP displacement indicated range of displacement at both direction.

On the other hand, markers coordinate at three axis (x,y,z) was recorded using motion capture system (3D Investigator, Northern Digital Inc. (NDI),USA) to measure range of motion (ROM) of each body joint during trials. Active markers (Optotrack, NDI) were placed on six joints such as front head, shoulder, pelvic, hip, knee and ankle as shown in Figure 1 (a). Movement of each markers were recorded by optic camera with sampling rate of 4.6 kHz and resolution of 0.01mm. The ROMs were measure at both superior-inferior and anterior-posterior direction as shown in Figure 4 using the equation below;

$$ROM(range) = ROM(\max) - ROM(\min) \qquad (3)$$

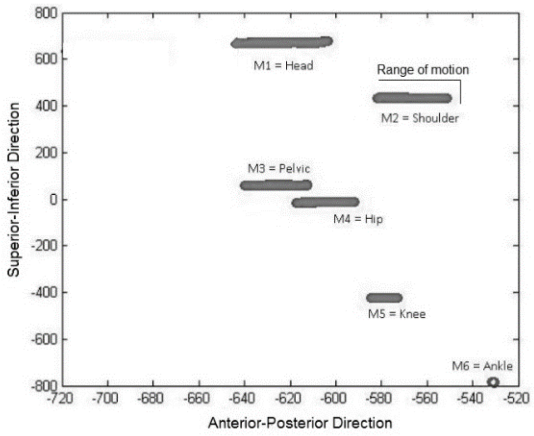


Figure 4: Example of ROM of joint plotting.

Statistical Analysis

All data then were analysed using simple statistical analysis including mean and standard deviation. Comparison between each experiment condition were analysis using simple t-test. All calculation were done using MATLAB Software.

Results

Subject Stability based on COP displacement

Based on Figure 5a, front loading (LBC-Front and L) affected COP displacement especially at anterior-posterior direction as it increased compared to Control condition. Besides, the result shows that standing with load using baby carrier (LBC-Front) caused less COP displacement at the same direction compared to standing without baby carrier (L). But no significant different found ($p>0.05$) for these results. Meanwhile, at medial-lateral direction, standing with load (L and LBC-Front) have prevented COP from deviated compared to control condition. However, no significant different found.

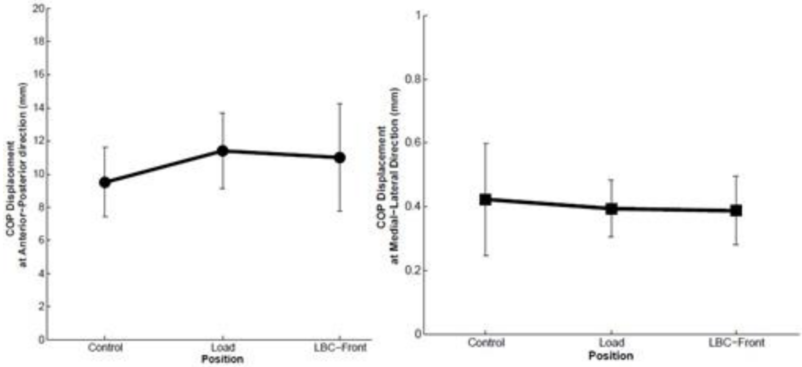


Figure 5a: COP displacement vs. load at anterior-posterior direction (left) and medial-lateral direction (right).

Comparison between different types of baby carrier position indicated that front type (LBC-Front) caused less COP displacement in anterior-posterior direction compared to other position type as shown in figure below. Meanwhile, the same type caused more sway at medial-lateral direction. But no significant different found at both direction (p>0.05).

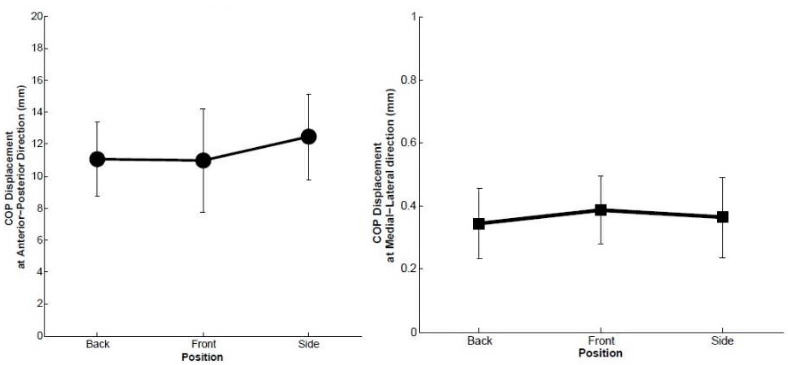


Figure 5b: COP Displacement vs. position at anterior-posterior direction (left) and medial-lateral direction (right).

Joint Displacement

Joints displacement or range of motion (ROM) were measured at both superior-inferior and anterior-posterior plane as shown in Figure 6a. The results shows that pelvic, head and shoulder joint movement were affected by the applied load at the upper body part. For control (C) condition, more joint displacement recorded at anterior-posterior direction. Interestingly, condition with baby carrier (LBC-Front) reduced the ROM of all joint compared to condition without baby carrier (L) (Figure 6a (left)). Besides, comparison between different type of baby carrier shows a significant different recorded at head, shoulder and pelvic joint movement (p<0.05) as shown in Figure 6b (left). The result also indicated that front type baby carrier (LBC-Front) produced less joint displacement than other position type.

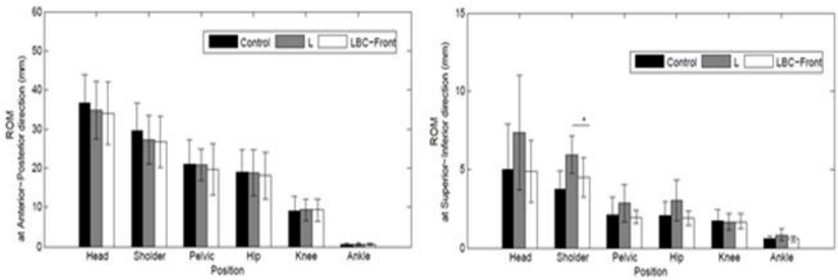


Figure 6a: ROM displacement vs. load at anterior-posterior direction (left) and superior-inferior direction (right).

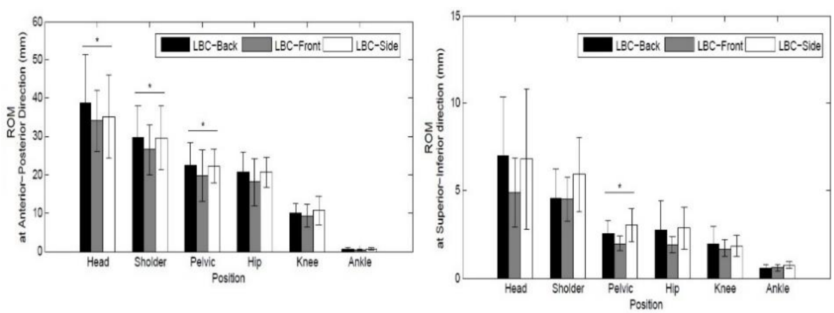


Figure 6b ROM displacement vs. load at anterior-posterior direction (left) and superior-inferior direction (right).

At superior-inferior direction, the highest displacement of joint was recorded during load (L) condition and significance difference was found at shoulder (p<0.05) (Figure 6a (right)). Comparison between different position type in Figure 6b (right) have shown that front type (LBC-Front) reduced more displacement of joint compared to the other position and significance difference was found at pelvic (p<0.05).

Based on the results obtained above, sagittal plane plotting was done in order to portray an average joint reaction toward applied load. Based on Figure 7, changes were clearly observed on upper part of the body. Front type baby carrier (LBC-Front) have shown a positive effect in keeping body sway as close to Control condition. In other words, it shows similar response to normal standing.

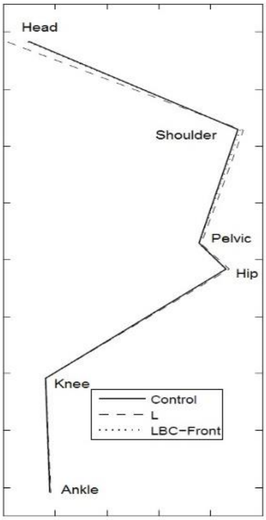


Figure 7: Sagittal plane plot on average posture movement pattern

Discussion

As mentioned before, less biomechanics consideration have been made in designing baby carrier especially its effect to the wearer's stability and postural changes. In this study, a common and basic baby carrier has been used in order to identify those effects.

Measurement of COP displacement can give initial prediction of posture stability. COP affects by both external and internal stimuli. The results on COP displacement have shown that 5kg of load did not give much effects on subject's stability. It was reported that load which more than 10% of individual weight can give a significant effect to individual's stability [16]. Despite of that, the used of baby carrier might increase stability as it reduce COP displacement especially at anterior-posterior direction as the results showed reduction at around 5 percent of anterior-posterior sway. But, it is still relatively small. Negrini et al (2002) reported a strong correlation between back pain and backpack carrying only can be seen as duration spent for carrying increased [10]. Besides, it was suggested that duration of carrying load which is less than 45 min may prevented a noting of postural changes due to load effect [11]. One minute standing was set for this study in order to observe a prompt effect of baby carried without take into account any effect of muscle fatigue and tiredness.

Baby carrier allow the baby to be attached on the wearer body closer as possible. This allow the baby's load to be transfer to the wearer's body. Based on the results, load applied affected mostly on posture orientation especially at the upper body. The increase of joint displacement especially at the upper body part indicated adaptive response of human body towards additional load applied at the particular body region. Front load reduced anterior-posture sway of head and shoulder and resulted more upright posture when standing. In contrast, back load increased more at anterior-posterior sway especially at head and shoulder. These results consistent with findings reported by Fiolkowski (2006) on walking activities [11]. Based on these findings, it can be assumed that posture alteration pattern might similar for both static and dynamic movement. Besides, front type baby carrier causes less postural sway.

Many studies has been done to identify relation between posture alteration and physical health condition. Sheir-Neiss et al (2003) reported that the use of backpack truly associated with back pain disease [17]. Back load can give compressive forces on the neck that can cause increase forward movement of the head. Mc Gill et al (2000), has been noted that increase shear force on spine that caused by forward head movement contributed to injuries [18]. However, less study on side pack or side load position. On the other hand, in term of risk of slips and falls, front load carriage reported contributes less like hood of falls and slips as it altered less biomechanical parameters such as trunk angle and range of motion [16].

Even in static experiment condition, the use of baby carrier have showed a positive effect on reducing postural changes for about five percent compare to the other condition. It not only can be considered as a way of baby wearing but technically a weight-bearing assistance mechanism. The present result suggested that the use of baby carrier may give a positive effect on stability while carrying a load. Besides, backpack and side type is less preferred for baby carrier as it can lead to injuries and back pain disease at long term use.

Conclusion

As a conclusion, baby carrier gives a positive effect on the wearer's posture orientation. Even though changes in posture displacement and the COP sway were relatively small, further study is still warranted to improve function and comfort design of baby carrier.

Acknowledgment

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