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Ergonomic Differences between Baby Carriers by Certain Wearing Positions

Background : Methods of wearing a baby carrier have suggested; however, there have been no studies suggesting ideal ways.
Objective : To investigate muscular fatigue and balance of the waist during baby carrier are worn on the front, the side, and the back of the body.
Design: Randomized controlled clinical trial (single blind)
Methods : The subjects of this study were 20 healthy men and women in their 20s, who underwent tests of muscular fatigue and balance of the waist bones based on types of wearing baby carrier. Electromyogram (EMG) patches were attached to the L2 and the L4 for testing muscular fatigue, while a device for measuring proprioceptive senses was used to assess balance ability. The measurements were performed before wearing the baby carrier and after 30 minutes of normal walking. The methods of wearing the baby carrier included wearing on the front, the side, and the back of the body.
Results : The time taken to adjust the balance was shorter than other types of wearing during the baby carrier were worn on the side, and the ratio of lumbar flexion and relaxation was shown insignificant.
Conclusions : These results suggested that wearing the carriers on the side was most effective on reducing fatigue and enhancing balance ability of the waist.

Key words: *Baby carrier; Waist; Muscular Fatigue; Balance*

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INTRODUCTION

Among a variety of childcare products, a baby carrier is an essential item used to carry a baby on the back or in the front during infancy when babies cannot walk by themselves. [1, 2] A baby carrier is a very useful product that helps users hold a baby between the age of 3 months and 36 months using waist belt and shoulder belts on both sides. [2] Among many baby products, baby carrier has the longest duration of use and it is most frequently used when people go out with babies. [1, 2] In diverse cultures around the world, commercialized childcare products aimed at reducing musculoskeletal burden of parents, such as baby carrier and sling, are being broadly used. [1, 2] In a study regarding baby carriers and slings, Wall-cheffler et al. (2007) reported that mothers consume few calories and enjoy unrestricted movement of arms when they walk by carrying a baby with a sling, compared to the case of walking by holding a baby with arms only [2]. Lee et al. (2009) argued that carrying a baby on the back or in the front with arms without using a baby carrier causes excessive tension of wrist, arm, shoulder, and lower back due to sustained loading [3]. The result, mothers experience difficulties of caring a baby for an extended amount of time and cannot perform other houseworks [3]. Use of baby carriers made a variety of daily activities, such as walking, and free use of both hands possible while carrying a baby on the back. As pointed out by Abe (2008), research on the effect of baby carrier on musculoskeletal system of child-rearing parents has been insufficient [4].

There are three methods of wearing baby carriers including front, side, and back position, among which back position is most frequently used. Yuk (2010) and Jang (2010) reported that wearing a baby carrier in front or back position increases muscle activities of erector spinae muscle and rectus abdominis muscle [5, 6]. Tyson (2006) argued that baby carriers can cause problems in basic activities and movement in daily life due to balance disorder [7]. As external weight loading affects postural alignment, baby carriers can cause musculoskeletal disease in neck, shoulder, and lower back of the users [8, 9].

Over 80% of adults experience lower back pain at least once in their life time. When the pain continues over a few months, patients not only become psychologically and socially intimidated, but also experience restriction on physical activities. Furthermore, disuse atrophy of the unused muscles can occur the result of restriction on physical activities caused by severe lower back pain. Patients with chronic lower back pain suffer from cross section reduction and myoatrophy of the muscles surrounding spinal column, which can worsen the lower back pain and induce secondary injury or recurrence of pain [10, 11].

This study examines the effect of wearing baby carriers on muscle fatigue and balance. Flexion-relaxation ratio (FRR) was used to investigate the muscle fatigue, which was measured by EMG. Lee (2015) reported that FRR is a useful method of evaluating lower back pain. Considering that people with lower back pain show different nerve root control and excessive increase of muscle activities in complete flexion interval, FRR can be a useful method of evaluating lower back pain, dysfunction, and effect of kinesiatrics [12].

It is thought that there will be a change in the muscle fatigue and balance depending on the method of attaching the baby carrier.

The purpose of this study was to provide fundamental data for efficient use of muscles and prevention of musculoskeletal disease. For this purpose, muscle fatigue of lumbar vertebrae based on the FRR and balance was tested by altering the method of wearing baby carrier into three types of front, side, and back position.

SUBJECTS AND METHODS

Subjects

The research was conducted during the period between May and July in 2017 using a sample consisting of 20 adult students (8 men and 12 women) enrolled in University K located in Gimhae City, Gyeongsangnam-do Province in South Korea. The students with present or past pain in neck or lower back and those with orthopedic legion were excluded from the sample. The absence of pain was based on VAS 3 or less. Research purpose and method was sufficiently explained to all research subjects before the experiment. The experiment was conducted after receiving the subjects' consent for participation in the study [6].

Research Methods

In this study, muscle fatigue of neck bone and lumbar vertebrae and balancing ability according to the method of wearing baby carrier was tested using research subjects consisting of 20 men and women students. Reference value was measured on the first day of evaluation without wearing baby carrier. Muscle fatigue and balancing ability was measured after the subjects walked on flat ground for 30 minutes while wearing a baby carrier. To reduce the potential error of each subject in the muscle fatigue and balance test, the location of wearing baby carrier was changed over three days. [13] The measurer did not know in which posture the baby carrier was put.

Intervention Methods

For the experiment, a teddy bear filled with a 14kg sand bag, which is the standard weight of a 30-month-old boy according to the child growth chart by the Ministry of Health and Welfare, was used. All subjects were told to maintain a comfortable and natural standing position as much as possible while looking straight in the front. The researcher clothed his clothes directly. In case of front position among the three types of wearing the baby carrier, the baby carrier was located in upper part of anterior superior iliac spine (ASIS) of the subject when they wore it. The baby carrier was located in upper part of iliac crest in case of side position and in upper part of posterior superior iliac spine (PSIS) in case of back position.[14]

Experiment tool

Baby carrier

As an experimental device, a commercialized baby carrier by allo & lugh (baby clothes brand by Maeil Dairies Co., Seoul, South Korea), which is composed of two shoulder belts backrest, neck rest, and lower back belt.

Electromyography

To measure the muscle fatigue, LXM3204 4-channel computerized wired electromyogram (EMG) measurement system by LAXTHA Inc. (Seoul, South Korea) was used. The device has EMG-bio feedback function and users can choose timer, sampling frequency, number of channels, and amplification. The system can easily measure EMG without causing pain because it is a non-invasive surface electromyograph where disposable electrodes are attached to the skin surface.

To remove skin resistance, the area of skin where the electrodes will be attached was carefully exfoliated with sandpaper and disinfected with alcohol. For neck bone, an active electrode was attached to both sides of erector muscle of cervical spine that is 2cm lateral from the C4 spinous process and both sides of the center of upper trapezius. Ground electrode was attached to the humerus lateral epicondyle on the left side. For lumbar vertebrae, an active electrode was attached to the area 3cm lateral from the L2 and L4 spinous process of erector spinae muscle. During the experiment, the subjects performed standardized movement of flexion-extension in three intervals as described below.

(A) Flexion interval: perform flexion for five seconds.
(B) Complete flexion interval: maintain suspended flexion for five seconds.
(C) Extension interval: perform extension for five seconds to resume the initial posture.

Guideline including restriction of knee flexion during complete flexion of lumbar vertebrae was given to the subjects. To reduce intra-measurer error and guarantee standardized test time, verbal sign from the tester was given to the participants using a timer. The subjects practiced the flexion-extension task twice before the actual measurement. To prevent fatigue from the measurement, sufficient resting time was given to the subjects between each measurement. The measurement was repeated three times and average value was computed.

Measurement of the sense of balance

A proprioceptive sense measurer (Zebris, Germany) was used to measure the balance sense index. The supporting platform (12kg, 60cm × 60cm), which is connected to a cable, sways when the device is unlocked. This kind of cyclical movement is appropriate for evaluating the subject's ability to control balance. X value means the extent of left and right sway and Y value means the extent of front and back sway. Z value means the extent of rotation. Time refers to the total evaluation time. The subjects stand on the platform while wearing a baby carrier. The device is unlocked when the subject clicks the displacement gauge. The subjects try to keep their balance once the platform starts to sway.

Analysis method

Data was analyzed using a statistical program of SPSS 18.0. One-factor repeated measure analysis of variance (ANOVA) was conducted for the analysis. Post-hoc test was implemented using Bonferroni correction. For each item, statistical significance level was set at .05.

RESULTS

General characteristics of the subjects

The age of the subjects ranged between 19 and 21, with an average age of 19.95±.39. Average height was 164.95±8.31cm and average weight was 63.55±14.69kg (Table 1).

Table 2. General characteristic of subjects

General characteristics	Subject (n=20)
Gender (male/female)	8/12
Age (years)	19.95±0.39
Height (cm)	164.95±8.31
Weight (kg)	63.55±14.69

Evaluation of balance

In a comparison of dynamic balance among the cases of wearing the baby carrier in front, side, and back position, Pos X showed a significant difference when the subjects wore the baby carrier in front and back position. A significant difference of the total evaluation time was observed in case of front and side position ($p<.05$).

FRR

(A) FRR of L2

Table 3. presents the FRR value of L2 of each subject. FRR showed a significant difference among the cases of wearing the baby carrier in three different

positions. FRR of right and left side was 2.07±1.37 and 1.32±0.69, respectively, when wearing the baby carrier in front position. FRR of right and left side was 1.74±1.26 and 1.70±1.08, respectively, in case of side position and 1.63±.71 and 1.29±0.60, respectively, in case of back position.

(B) FRR of L4

Table 3 presents the FRR value of L4 of each subject. FRR showed a significant difference among the cases of wearing the baby carrier in three different positions. FRR of right and left side was 1.91±1.06 and 2.06±1.99, respectively, when wearing the baby carrier in front position. FRR of right and left side was 1.91±1.43 and 2.34±2.04, respectively, in case of side position and 1.54±0.56 and 1.70±0.71, respectively, in case of back position.

Table 2. Differences in dynamic balance based on types of wearing baby carriers (N=20)

Dynamic balance	Reference value	Front	Side	Back	f	p
Pos X	−40.27±27.26	−49.69±2.8	−49.4±2.24	−51.52±2.78	4.09	.023*
Time	11.76±4.2	13.13±7.53	7.54±4.17	12.9±8.67	4.3	.020*

* p <0.05

Table 3. Ratio of flexion and relaxation based on types of wearing baby carriers (N=20)

		Reference value	Front	Side	Back	f	p
L2	Right	0.90±0.25	2.07±1.37	1.74±1.26	1.63±0.71	6.863	.003*
	Left	1.16±0.25	1.32±0.69	1.70±1.08	1.29±0.60	6.049	.005*
L4	Right	1.18±0.45	1.91±1.06	1.91±1.44	1.54±0.56	5.78	.007*
	Left	1.24±0.32	2.06±1.00	2.34±2.04	1.71±0.71	7.27	.002*

* p <0.05

DISCUSSION

In this study, the effect of wearing a baby carrier in front, side, and back position on the muscle fatigue of lower back and sense of balance was investigated. The time to maintain balance against the external disturbance showed a significant difference when the subjects wore the baby carrier in side position. This measures the time starting from the moment the platform is unlocked until the sway disappears. The average vertical distance from the ground to the hip of the doll was 98.3cm in case of wearing the baby carrier in front position, 85.4cm in case of side position, and 102.8cm in case of back position. When the subjects wore the baby carrier in side position, vertical distance from the ground to the baby carrier was 13% and 17%, respectively, shorter than the case of wearing the baby carrier in front position and back position. Peggy et al. (2012) argued that body stability increases under the following conditions: low gravitational center, broad supporting basal area, line of gravity located at the center of the basal area, and heavy body weight [15]. This study result implies that lower position of the baby carrier improves the sense of balance as body stability increases because of the lower gravitational center.

In this study, the balance measurement of Pos X value showed a significant difference when the subjects wore the baby carrier in side and back position. Pos X value indicates the extent of left and right sway that occurs from the moment the platform is unlocked until the sway disappears. When the subjects tried to keep balance against left and right sway while wearing the baby carrier in side position, Pos X value was lower, compared to the case of back position. It implies that the subjects adapted themselves to the posture of side wearing while they walked by wearing the baby carrier in side position for 30 minutes.

In this study, FRR was highest when the subjects wore the baby carrier in side position. Higher FRR means that the posture is more similar to the normal range. This can be attributed to the minimized use of body trunk muscles muscle in case of side position because the center of weight is lowered as the 14kg teddy bear is closer to the ground.

As suggested by the result of this study, wearing the baby carrier in side position can reduce musculoskeletal disease and pain. This will help child-rearing parents learn correct way of using the baby carrier.

This study has the following limitations. First, babies' dynamic movement could not be reproduced as the experiment was conducted using a teddy bear, instead of real baby. Second, the study could not explain every part of body mechanics because muscle fatigue and balance was analyzed using the subjects consisting of healthy men and women in their twenties. Third, the small number of the experiment subjects makes generalization of this study difficult. Also, the time of wearing baby carrier was relatively short at 30 minutes. Further studies will be required in the future using the subjects consisting of caregivers who actually raise babies and sufficiently long period of intervention.

CONCLUSION

These results suggested that wearing the carriers on the side was most effective on reducing fatigue and enhancing balance ability of the waist.

REFERENCES

1. Lee HR, Lee YJ. A survey on the purchase and use of baby carriers. Korean Journal of Human Ecology 2017; 26(3): 213-25
2. Wall-Scheffler CM, Geiger K, Steudel-Numbers KI. Infant carrying: the role of increased locomotory costs in early tool development. AM J PHYS ANTHROPOL 2007; 133(2): 841-6
3. Lee SY, Bae SS. The studies on the foot stability and kinesiology by direction of carry a load during gait. J Kor Phys Ther 2009; 21(2): 97-101
4. Abe D, Muraki S, Yasukouchi A. Ergonomic effects of load carriage on energy cost of gradient walking. Appl Ergon 2008; 39(2): 144-9
5. Yuk GC, Park RJ, Lee HY et al. The effects of baby carrier and sling in muscle activation of trunk, low extremity and foot pressure. J Kor Phys Ther 2010; 5(2): 223-31
6. Chang JS, Lee SY, Kim MH et al. The effects of EMG activation of neck, lumbar and low limb by using baby carrier with arms during walking. J Korean Soc Phys Med 2010; 5(3): 323-30
7. Tyson, S. F, Hanley, M. Chillala, J.Selley, A&Tallis. Balance disability after stroke. PEDIATR PHYS THER 2006; 86(1): 30-8
8. Lee IH. Effect of the deep neck flexor muscular strength exercise on cervical spine alignment, muscular fitness and pain. Woosuk University. Dissertation of Master's Degree. 2016
9. Murphy BA, Marshall PW, Taylor HH. The Cervical Flexion-Relaxation Ratio: Reproducibility and Comparison Between Chronic Neck Pain Patients and Control. Spine 2010; 35(24): 2103-8
10. Lee SC, Lee DC. Effects of exercise therapy on lower back pain patients. Asian J Kinesiol 2007; 9(2): 69-78
11. Deyo RA, Martin DC, Shoenfeld LS et al. A controlled trial of transcutaneous electrical nerve stimulation (TENS) and exercise for chronic low back pain. NEW ENGL J MED 1990; 322(20): 1627-34
12. Lee HM. Immediate effects of diagonal neck pattern combined with hold-relax technique on the cervical range of motion, neck pain, and cervical flexion-relaxation ratio in individuals with video display terminal syndrome. Kyungnam University. Dissertation of Master's Degree. 2015
13. Lee HR, Hong KH. Evaluation of muscle fatigue and subjective fatigue depending on the hip seat and waist support band of baby carrier. Fashion & Text. Res. J. 2017; 19(4): 504-14.
14. Kim K, Yun KH. The effects of body posture by using baby carrier in different ways. J Korean Soc Phys Med 2013; 8(2): 193-200.
15. Peggy A. Houglum, Dolores B. Bertoti. Brunnstrom`s Clinical kinesiology 6th Ed. 2012; 62