Does Load Position on the Trunk Affect Cardiopulmonary Responses of the Bearer during Simulated Front and Back Infant Carrying Methods?

Chidiebele Petronilla Ojukwu[1], Cyprian Ifeanyi Nnamoko[1], Adaora Justina Okemuo[1], Stephen Sunday Ede[1,2], Ijeoma Judith Ilo[3], Chioma Nneka Ikele[1], Theresa Odunayo Akinola[4]

Departments of [1]Medical Rehabilitation and [3]Nursing Sciences, Faculty of Health Sciences and Technology, College of Medicine, University of Nigeria, Enugu, [2]Physiotherapy Department, University of Benin Teaching Hospital, Benin City, [4]Department of Physiotherapy, Bowen University, Iwo, Nigeria

Abstract

Background: The position of the infant on the trunk during back and front infant carrying methods (ICMs) may be a potential factor of maternal physiological changes. Related information is necessary for the establishment of guiding principles for infant carrying tasks. Thus, this study was carried out to evaluate cardiopulmonary responses to infant-load positions on the trunk during simulated back and front ICMs. **Materials and Methods:** Twenty-three nulliparous females completed four trials while walking with a 6 kg simulated infant, being carried in four trunk positions (upper back, lower back, upper front, and lower front). Cardiopulmonary indices (systolic blood pressure, diastolic blood pressure, respiratory rate, and heart rate) and rating of perceived exertion were assessed pre- and post-trials. **Results:** All the cardiopulmonary indices did not change significantly ($P > 0.05$) as the infant load moved from upper to lower trunk positions during the back and front ICMs. However, marginal differences were observed. Participants perceived the lower back and upper front ICMs as less exerting than the upper back and lower front ICMs. **Conclusions:** Infant-load position on the trunk is not an important factor in the cardiopulmonary responses to back and front infant carrying tasks, although the lower back and upper front ICMs were perceived to be more comfortable.

Keywords: Back, cardiopulmonary indices, front, infant carrying, infant-load positions, perceived exertion

Introduction

Infant carrying is one of the major tasks of childcare. It is the act of carrying an infant close to the caregiver's body, occasionally with special devices, which aid attachment, and parenting.[1] The most popular methods of infant carrying among African women include back and front infant carrying methods (ICMs).[2] The back method requires positioning the infant on the bearer's back with or without the support of devices while the front variant is usually achieved by carrying the child on the arms or by the use of tools to support the infant on the anterior trunk.[3,4] The front ICM has become more popular among women, considering that it is fashionable and trendy.[2] Associated benefits of infant carrying include enabling close maternal-infant contact while availing the mother the opportunity to engage in other activities[5] and improved maternal-infant bonding.[6] It also promotes infant emotional,[3] physical and neural development, respiration and gastrointestinal health, improved balance[7] as well as decreased risk of sudden infant death and other structural deformities.[8]

Despite these benefits, infant carrying constitutes an energetic drain on the bearer[9-12] because of its associated biomechanical changes.[9-16] Associated gait and biomechanical responses to the infant weight on the trunk generally trigger body compensatory mechanisms to enable physiological adaptation and maintenance of stability.[17] In support, previous

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Address for correspondence: Dr. Adaora Justina Okemuo, Department of Medical Rehabilitation, Faculty of Health Sciences and Technology, College of Medicine, University of Nigeria, Enugu Campus, Enugu State, Nigeria.
E-mail: adaora.okemuo@unn.edu.ng

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studies[2,18-20] and clinical experiences have revealed incidences of infant carrying-related musculoskeletal disorders among nursing women. In a previous study,[21] cardiopulmonary and perceptual responses to the four common ICMs utilized by African women (back, front, side, and in-arms) were evaluated, and findings showed some variations in their relative responses. Its interpretation suggested that infant carrying tasks might pose cardiopulmonary responses on the bearer. It is hypothesized that these responses may be subject to the influence of several infants carrying characteristics within or between the different ICMs. Most of the available literature[2,14,21-23] were focused on infant carrying responses among different ICMs. Evaluations of infant carrying characteristics relative to specific ICMs is scarce.

A distinct infant carrying characteristic, which usually varies per individual and/or task, is the vertical position of the infant load on the trunk. Placing an infant on upper, mid, or lower trunk positions is a common practice among infant bearers. The implications of these varying infant load positions are yet to be explored for any possible effect on the bearer. Similar studies on back and front pack carrying have reported trunk-load positions as determinants of biomechanical, physiological, and perceptual responses in humans.[13,24,25] Stuempfle *et al*.[13] in their study to determine the effect of load position in an internal frame backpack on physiological and perceptual variables, reported that load placement is an important factor in the physiological and perceptual responses to load carriage. In consideration of the above, exploring responses to trunk-load positions in the context of infant carrying becomes necessary. This study was therefore designed to evaluate the cardiopulmonary and perceived exertion responses to upper and lower infant-load positions on the trunk during simulated back and front ICMs.

Materials and Methods

Participants

A repeated-measure observational study of 23 healthy non-pregnant nulliparous females (18–35 years) was conducted to achieve the study aims. Participants were conveniently selected from the undergraduate hostels of the University of Nigeria, Enugu Campus. Females who have been actively involved in infant carrying or other trunk loading tasks, for at least 6 months, were excluded from the study for the elimination of the survivor effects.[26-28] Females with cardiorespiratory disorders and musculoskeletal conditions of the spine were also excluded from the study.

Ethical approval for this study was granted by the Research and Ethics Committee, University of Nigeria Teaching Hospital, Ituku-Ozalla (NHREC/05/01/2008B-FWA00002 458-IRB00002323) and participants gave written informed consents before participation in the study.

Participants were assessed for eligibility to undergo physical tasks using the Physical Activity Readiness Questionnaire. Relevant bio-data information and anthropometric characteristics (weight in kilograms, height in meters, waist-and-hip ratios in centimeters) were investigated.

Testing conditions

This study comprised four testing conditions for each of the back and front ICMs, including:

a. Lower back ICM: For this task, the infant dummy (Jimmy) was placed at the participant's back such that its center of mass was positioned at the T12 spinal level. Jimmy was attached to the participant with a cotton wrap cloth (210 cm × 118 cm), fastened in front of the participant's torso
b. Upper back ICM: With similar protocols as in A, Jimmy's center of mass was positioned at the level of the T-12 vertebra
c. Lower front ICM: Jimmy was placed in a front baby carrier of dimension 57 cm × 38 cm and strap length of 144.5 cm while placed on the participant's anterior trunk such that its center of mass was positioned 5 inches below the umbilicus
d. Upper front ICM: With similar protocols as C, Jimmy's center of mass was positioned 5 inches above the umbilicus.

Jimmy's structural characteristics include:

- Weight = 6 kg
- Head circumference = 37 cm (Reference point: Widest point of the occiput to the forehead) using a tape measure
- Limb length = 21 cm right and left (from the anterior superior iliac spine to the medial malleolus)
- Upper limb length = 22 cm (both) from the shoulder to the tip of the middle finger.

Infant body length = 49 cm (from the occiput to the end of the calcaneum).

Procedures

To control for fatigue and carry-over effects, participants passed through the four testing conditions in a random sequence generated on a Latin square.

Before each testing condition, participants' cardiopulmonary indices (systolic blood pressure [SBP], diastolic blood pressure [DBP], respiratory rate [RR], and heart rate [HR]) were assessed.[21] For each condition, participants performed a metronome-regulated walking at the rate of 98 beats/min for 10 min, to and fro a level-surfaced walkway while carrying Jimmy in the specified trunk position, relative to that testing condition. After each trial, their cardiopulmonary indices were re-assessed as well as rates of perceived exertion (RPE), using the Borg's RPE scale.[21]

All trials were performed between 9:00 am and 12: noon daily with a testing interval of 30 min between trials. The entire study lasted 4 weeks.

Data analysis

The normality of data was tested with the Shapiro–Wilk test to isolate outliers. The results of this test suggested that the dependent variables were normally distributed.

Descriptive statistics of frequency, mean, standard deviation, frequency counts, and percentages were used to summarize data. Inferential statistics of Paired sample *t*-test was used to determine statistical differences between variables at a significant level of $P < .05$. Data were analyzed with the Statistical Package for the Social Sciences (SPSS, Version 20.0, Chicago, USA).

Results

Participants' mean age, body mass index and Waist–Hip Ratio were 21.27 ± 2.49 years, 21.73 ± 3.53 kg/m and 96.30 ± 7.60, respectively [Table 1].

Table 1: Demographic characteristics of the participants (*n*=23)

Variables	Mean±std	Minimum	Maximum
Age (years)	21.27±2.49	18.00	26.00
Height (m)	1.69±0.06	1.61	1.83
Weight (kg)	61.57±11.29	49.00	90.00
BMI (kg/m^2)	21.73±3.53	16.92	30.78
WC (cm)	96.30±7.60	81.00	113.00
HC (cm)	76.74±9.08	67.00	101.00
WHR	0.79±0.05	0.69	0.89

BMI: Body mass index, std: Standard deviation, WC: Waist circumference, HC: Hip circumference, WHR: Waist hip ratio

Table 2 shows within-group comparisons of participants' pre- and post-test cardiopulmonary indices for each testing condition. Most of the cardiopulmonary indices increased after the infant carrying tasks. However, not all differences were statistically significant. Post-SBP values during the upper back ($P = 0.027$) and lower back ($P = 0.011$) ICMs as well as post-HR values ($P = 0.001$) during the lower back ICM increased significantly. During the lower front ICM, SBP ($P = 0.001$) and DBP ($P = 0.022$) post-test values also increased significantly.

Table 2: Paired sample *t*-test results comparing the pre and post-test cardiopulmonary responses for each infant loading positions

ILP	Variable	Pretest	Posttest	*t*	*P*
Upper back	SBP	113.26±10.93	118.91±12.55	−2.361	0.027*
	DBP	70.43±7.25	74.09±14.58	−1.104	0.288
	HR	82.35±13.84	85.30±12.80	−1.969	0.062
	RR	21.91±3.04	23.43±4.62	−1.437	0.165
Lower back	SBP	116.57±8.59	120.35±8.64	−2.784	0.011*
	DBP	71.78±10.73	73.78±8.21	−1.305	0.205
	HR	80.61±12.22	85.35±10.70	−4.06	0.001*
	RR	21.91±2.98	22.96±3.00s	−1.601	0.124
Upper front	SBP	114.30±9.07	118.83±9.19	−1.853	0.077
	DBP	71.39±8.41	75.09±8.93	−1.938	0.066
	HR	83.13±11.94	85.22±14.84	−0.643	0.527
	RR	21.39±2.21	22.22±3.59	−1.261	0.221
Lower front	SBP	112.91±8.96	118.52±10.45	−3.822	0.001*
	DBP	69.13±10.28	72.57±7.99	−2.456	0.022*
	HR	84.00±12.48	86.65±11.49	−1.985	0.060
	RR	23.04±3.61	22.91±4.01	0.223	0.825

*Significance at $P<0.05$. SBP: Systolic blood pressure, DBP: Diastolic blood pressure, HR: Heart rate, RR: Respiratory rate, ILP: Infant loading position

Comparing the mean differences of all the cardiopulmonary indices between the two back infant carrying trials yielded no significant differences ($P > 0.05$) [Table 3]. Marginal differences revealed higher responses in SBP, DBP, and RR during the upper back trial, while the lower back trial elicited higher changes in participants' HR and RPE.

Similarly, the front testing conditions revealed no significant ($P > 0.05$) differences in cardiopulmonary responses and RPE values between the upper and lower front ICMs [Table 4]. The lower front task, however, elicited marginally higher responses in the SBP, HR, and RPE of the participants while the DBP and RR were higher during the upper front ILP.

Discussion

Back and front ICMs are common among African mothers.[2] This study was designed to evaluate the effects of various infant-load positions (ILPs) on the cardiopulmonary responses (SBP, DBP, HR, RR) and perceived exertion of young women during the simulated back and front ICMs. Understanding the physiological demands of infant carrying relative to the position of the infant load on the trunk would serve as a guide for adequate implementation of infant-carrying practices.

This study showed that cardiopulmonary indices increased after each infant carrying task. This corroborated a previous study,[21] which reported increased cardiopulmonary responses after infant carrying tasks. Nevertheless, these changes were expected as infant carrying with a combination of 10-min walking constitutes physical activity, which typically should elicit physiological responses. Physiological responses to trunk-loading tasks have been widely reported in previous studies.[21,29-32] This implies increased workloads to the heart and the respiratory system during infant carrying tasks. Trunk loading-related cardiopulmonary changes have been attributed to blood volume changes,[33] increased muscular activities, changes in gravitational positions, orthostatic stress,[34] and restrictive effects on pulmonary functions.[35]

Cardiopulmonary indices did not change significantly when the infant load was moved from high to low positions. However, marginal differences showed that most parameters (SBP, DBP, and RR) were higher after the upper back trial, as compared to the lower back ICM. Although Stuempfle *et al*.[13] similarly showed no significant differences in HR, RR, and respiratory exchange ratio responses between high and lower trunk-load positions, they reported marginal differences, which suggested high trunk-load positions as more efficient than low load positions. Conversely, other studies[36,37] reported that low trunk-load positions are more favorable, considering that, they elicited minimal physiological and biomechanical changes, as

Table 3: Comparisons between cardiopulmonary and perceptual responses of the participants between upper and lower back infant loading positions

Variables	Upper back[a]	Lower back[a]	*t*	*P*
SBP(mmHg)	5.65±11.48	3.78±6.52	0.605	0.551
DBP (mmHg)	3.65±15.87	2.00±7.35	0.482	0.635
HR (b/m)	2.96±7.20	4.74±5.59	−0.948	0.355
RR (c/m)	15.2±5.08	10.4±3.13	0.381	0.707
RPE	13.83±3.24	12.00±2.19	2.512	0.020*

*Significance at $P<0.05$, [a]Mean differences between post- and pre-test values. SBP: Systolic blood pressure, DBP: Diastolic blood pressure, HR: Heart rate, RR: Respiratory rate, RPE: Rate of perceived exertion

Table 4: Comparisons between cardiopulmonary and perceptual responses of the participants between upper and lower front infant loading positions

Variables	Upper front[a]	Lower front[a]	*t*	*P*
SBP(mmHg)	4.52±11.70	5.61±7.04	−0.357	0.725
DBP (mmHg)	3.69±9.15	3.43±6.71	−0.102	0.920
HR (b/m)	2.09±15.36	2.65±6.41	−0.161	0.874
RR (c/m)	0.83±3.14	−0.13±2.80	1.049	0.306
RPE	12.43±3.13	13.30±2.77	−1.099	0.284

[a]Mean differences between post- and pre-test values. SBP: Systolic blood pressure, DBP: Diastolic blood pressure, HR: Heart rate, RR: Respiratory rate, RPE: Rate of perceived exertion

compared to high load positions. Previous studies[13,24,38] that supported backpack carrying on upper trunk positions opined that these positions keep the load closer to the trunk and over the body's center of gravity, promoting antero-posterior and lateral stability as well as utilization of large muscle groups. Thus, they suggest that cardiorespiratory, metabolic variables and muscular activities are lowest in upper trunk positions.

Similarly, upper and lower front ICMs did not significantly differ in their elicited cardiopulmonary responses in the present study. However, the observed marginal differences showed that SBP and HR responses were higher during the lower front trial DBP, and RR increased higher during the upper front trial. These findings corroborate that of Legg and Mahanty,[39] which showed no differences in cardiorespiratory and metabolic responses of upper and lower front-loading tasks. Studies comparing lower and upper front-loading tasks are relatively limited.

Furthermore, the present study showed that the participants perceived lower back and upper front ICMs to be less exerting, as compared to the upper back and lower front ICMs. These suggest higher comfort levels with the former ICMs. Relative to the back ICM, these findings contradict previous studies[13,24,38] which showed preferences for upper trunk-load carriage. However, our participants' preference for upper front ICM may be attributed to the fact that the infant load was closer to the bearer's center of gravity, as posited in the previous studies.[13,24,38] Kim *et al*.[40] also reported tendencies for reduced back pain, urinary incontinence, and discomfort when the trunk is loaded in higher positions.

As much as the present study suggests that infant-load position is not an important factor of cardiopulmonary responses during infant carrying, there is a need for further studies which will factor in some of the study limitations. Involving postpartum mothers while carrying their infants in different trunk position may further highlight the cardiopulmonary responses to different infant-load positions. Simulating other daily activities or their combination with walking tasks during infant carrying should also be considered as an important factor for improving on this study. Furthermore, controlling for body anthropometric characteristics in future studies will highlight better outcomes of the statistical analyses.

Conclusions

Infant-load positions are not determinants of cardiopulmonary responses to back and front infant carrying tasks in young females. However, the upper front and lower back ICMs were reportedly perceived as less exerting ICMs.

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Conflicts of interest

There are no conflicts of interest.

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