ABSTRACT SUBMISSION
-FOR INVITED SPEAKER ONLY

TBIS

Effects of Pseudo-Abdominal Attachment on Energy Consumption

Tamaki T. Mitsuno[1]*, Naoko Okishima[2], Satoko Nakagomi[3], Akiko Haga[3], Chitaru Tokutake[3], Yuka Sato[3]
[1]*Textile technology and Science, Shinshu University, 3-15-1, Tokida, Ueda City, Nagano, 386-8567, Japan*
[2]*Education, Shinshu University, 6-Ro Nishinagano, Nagano City, Nagano, 380-8544, Japan*
[3]*Medicine, Shinshu University, 3-1-1 Asahi, Matsumoto City, Nagano, 390-8621, Japan*
*Presenter's email: mitsuno@shinshu-u.ac.jp

ABSTRACT

Background and Purpose

Japan's frequent natural disasters pose serious risks to pregnant women, who face increased vulnerability to preterm birth, low birth weight, and mental health deterioration. Common late pregnancy discomforts — fatigue, lower back pain, and edema — can further compromise evacuation. A nationwide survey in Japan found that over 90% of pregnant women experienced fatigue, which intensified in the third trimester. Maternity support garments (MSGs) are known to reduce lower back pain and provide thermal insulation, but their effect on physiological load during disaster movements is unstudied. This study quantified the effects of MSGs on energy expenditure, cardiopulmonary responses, and movement efficiency during simulated evacuations. It also identified concrete self-help strategies for pregnant women in disasters.

Methods

Seventeen healthy Japanese women in their twenties participated. An 8 kg simulated pregnancy abdomen (PA) was constructed from a silicone dummy, lead plate, and ultrasound gel, serving as a surrogate for late pregnancy. This is consistent with Japanese clinical guidelines that recommend a weight gain of 7–10 kg. The MSG configuration used a 30 cm bandage (L-MSG) wrapped from the hips to under the bust. A 15 cm bandage (S-MSG) was layered diagonally across the lower abdomen to shift the center of gravity toward the body axis. Three conditions were compared: (A) no PA or MSG (control), (B) PA only, and (C) PA plus MSGs. Participants performed four movements for one minute each: chair sit-to-stand, floor sit-to-stand, rising from a cardboard bed, and rising from the floor. Respiratory metabolism was measured breath-by-breath. Heart rate was recorded by ECG. Clothing pressure was assessed at 35 body points. Subjective perceptions of pressure and weight were evaluated using visual analog scales anchored to each participant's personal comfort reference.

Results

Wearing the 8 kg PA (protective apparel) alone significantly elevated METs (metabolic equivalents) by 15%, respiratory rate by 18%, and heart rate by 7–9%. Total energy expenditure (EE) increased 3.6-fold, with carbohydrate metabolism rising 2.7-fold. When MSGs (metabolic support garments) were added, METs decreased by 8.7%, carbohydrate metabolism was suppressed by 35.6%, and heart rate returned to near-baseline levels. Total EE was reduced by 23.8% compared to PA alone. Lipid metabolism showed no significant change, suggesting that MSGs primarily attenuate high-intensity, carbohydrate-dependent exertion, which is especially important for sustaining endurance during prolonged emergencies.

Movement efficiency also improved with MSG use. Rising from a supine position was 13–17% faster: bed, 9.5 s → 7.9 s; floor, 9.4 s → 8.2 s. Seated movements showed no significant improvement. Perceived heaviness decreased from 1.82 to 1.70, below the "heavy" threshold of 1.77, as MSGs drew the abdomen closer to the body axis. Floor-based movements imposed the greatest physiological burden. EE was about 2.4–2.5 times higher than at rest, compared with 1.8– 2.2 times for chair or bed movements.

Conclusions

Two key recommendations emerge for pregnant women in disaster situations. First, floor-based postures should be avoided whenever possible, as rising from the floor requires substantially more energy than rising from a chair or a bed. Ensuring access to bed- or chair-height surfaces in evacuation shelters may therefore help preserve physical strength. Second, wearing appropriately designed MSGs reduces per-movement EE by 13–30% and improves rising speed by 13–17%. These findings provide concrete physiological evidence to support midwifery-led disaster preparedness education and inform evacuation shelter design to better accommodate the needs of pregnant women.