

Pelvic belt use enhances energy expenditure and fat oxidation during light exercise

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Abstract:

Problem Statement: In an aging society, there is growing interest in maintaining health through posture improvement, not only for aesthetic reasons but also for the prevention of musculoskeletal problems. While static posture has been examined in detail, no dynamic examination has been performed on upright pelvic posture, and its effects on energy metabolism during movement remain unclear. Previous studies have suggested that wearing a pelvic belt can change trunk muscle activity and reduce the load on specific muscle groups; however, its influence on energy expenditure and fat combustion during exercise is not fully understood.

Approach: The present study investigated the effects of a posture-correcting pelvic belt (Nikko Medical Co., Ltd.) on energy metabolism during walking. Twenty healthy female university students (age 20.1 ± 0.93 years) participated. Subjects performed treadmill walking at 5 km/h for 30 minutes under two conditions: with and without the pelvic belt. Expired gas analysis was conducted in a controlled climate chamber to measure respiratory quotient (RQ), oxygen uptake (VO_2), total energy expenditure, and fat combustion. The walking order was counterbalanced to minimize bias, and diet was standardized prior to testing. **Purpose:** This study aimed to determine whether wearing a pelvic belt, which promotes an upright pelvic posture, increases energy expenditure and fat metabolism during light exercise. Results. Compared with walking without the pelvic belt, both total energy expenditure ($p = 0.0027$) and fat combustion ($p = 0.0021$) were significantly increased while wearing the belt. Moreover, fat combustion was correlated with body mass index (BMI) in both conditions, but the correlation was stronger when wearing the pelvic belt (without belt: $r = 0.662$, $p = 0.034$; with belt: $r = 0.885$, $p = 0.001$). The slope of the regression line also indicated a greater effect in individuals with higher BMI.

Conclusion: Wearing a pelvic belt during light exercise promotes fat combustion and increases total energy expenditure, because the applied load was equivalent to daily activity. These findings suggest that simply wearing a pelvic belt in everyday life may contribute to fat reduction and health promotion, particularly in individuals with a higher BMI.

Key Words: pelvic belt; posture; energy expenditure; fat combustion; treadmill walking; BMI

Introduction

In the current aging society, there is an increasing interest in maintaining and promoting health. Posture has been increasingly discussed in various media. In health promotion settings, posture is measured, and exercises are provided based on its characteristics (Terao et al., 2007). Behind this growing interest, in addition to aesthetic aspects such as the beauty of posture, there is also a trend toward preventing health problems caused by poor posture.

Research on abnormal postures has been increasing in recent years. In an examination of static posture after secondary growth, swayback, an abnormal posture, was found in 31.1% of cases, and anterior pelvic tilt posture was found in 27.2% (Dolphens et al., 2014). Thus, abnormal posture is not rare and can arise during adolescence. Moreover, a significantly higher incidence of low back pain and neck pain was identified in subjects with swayback compared in with those with an upright pelvic posture (Mitchell et al., 2008; Dankaerts et al., 2006).

In static studies, it has found that by changes in spinal and pelvic tilt significantly alter the activity of superficial and deep trunk muscles. In standing posture, by changing from upright pelvic posture to swayback posture the activity of deep muscles involved in maintaining posture (i.e., multifidus and internal oblique) decreases while the activity of superficial muscles (i.e., rectus abdominis) increases (O'Sullivan et al., 2002, 2006). In sitting posture, compared with upright pelvic posture, thoracic extension (chest-out), and slump postures, the upright pelvic posture showed the greatest increase in deep muscle activity and a reduction in superficial muscle activity. The thoracic extension posture showed increased superficial muscle activity and

decreased deep muscle activity, similar to standing. Furthermore, the passive slump posture showed a decrease in deep muscle activity, similar to swayback.

From a therapeutic perspective, in patients with chronic low back pain and neck pain, posture education emphasizing upright pelvic posture, rather than an exercise program, reduced subjective symptoms (Bonetti et al., 2010). Posture not only causes symptoms to appear when it deteriorates but can also reduce symptoms through movement and posture guidance. However, there is no evidence showing what kind of guidance is effective for such movements and posture instructions. Although static posture has been examined in healthy adults, dynamic examinations are scarce and the effects of abnormal posture on the body remain unclear.

In rehabilitation and health promotion settings, an upright pelvic posture, considered an ideal posture, has been shown in previous studies to increase deep muscle activity, such as that of the internal oblique and multifidus muscles, and reduce superficial muscle activity, such as that of the erector spinae and rectus abdominis, under static posture conditions, including sitting and standing (O'Sullivan et al., 2002; O'Sullivan et al., 2006). Furthermore, an upright pelvic posture minimizes stress on the neck muscle groups (Caneiro et al., 2010). From this, it can be considered that upright pelvic posture meets the definition of "good posture" as suggested by Kendall. Specifically, in standing, upright pelvic posture is neither swayback posture, such as reduced lumbar lordosis and posterior pelvic tilt, nor hyperlordosis with excessive anterior pelvic tilt. Rather, it is a state where the line connecting the ipsilateral anterior superior iliac spine and posterior superior iliac spine is at 8-10°, representing the most efficient state of the body with minimal stress and tension. More specifically, the spine forms a normal curve and the lower limbs are in ideal alignment against a load. As described above, the pelvis is in a moderate anterior tilt, forming good alignment with the abdomen, trunk, and lower limbs. The head is upright and in a balanced position where minimal stress is applied to the neck muscle groups (Kendall et al., 2006). However, since no dynamic examination has been done on upright pelvic posture, it is necessary to examine efficiency during movement and stress on the trunk and lower limb joints in order to confirm that the upright pelvic posture is a "good posture." Walking is the most convenient method of human locomotion. In recent years, it has been noted that, even in healthy adults, a natural trunk tilt exists during walking, and analyses of walking with forward and backward trunk tilts have been conducted domestically and internationally (Saha et al., 2008). However, in these studies, the involvement of spinal-pelvic posture and muscle activity has not been examined. In studies on posture and walking in the elderly, it has been shown that small postural changes have a large impact on the spine and lower limbs and change balance function (Rubenstein et al., 2006). Furthermore, changes in heavy trunk mass affect the lower limb joints during walking and movement (Mitnitski et al., 1998; Leteneur et al., 2009). Previous studies have also found that muscle activity changes with variations in posture (spinal and pelvic tilts). Thus, postural changes are likely to affect walking ability. However, at present, the focus is on static states, and the effects of abnormal posture on movement and lower-limb joints have not been examined. Furthermore, no dynamic studies have examined the upright pelvic posture, which is considered the ideal posture. Therefore, the effects of posture education and improvement on the body have not yet been fully elucidated. Therefore, to examine the effects of ideal and abnormal postures in the context of disease, health promotion, and sports, it is necessary to examine their effects on walking.

Previous studies have found that muscle activity changes with changes in posture (spinal and pelvic tilts) (O'Sullivan et al., 2002; O'Sullivan et al., 2006). Thus, postural changes are likely to affect walking ability. However, at present, the focus is on static states, and the effects of abnormal posture on movement and lower-limb joints have not been examined. Furthermore, no dynamic studies have examined the upright pelvic posture, which is considered the ideal posture. Therefore, the effects of posture education and improvement on the body have not yet been fully elucidated. Therefore, to examine the effects of ideal and abnormal postures in the context of disease, health promotion, and sports, it is necessary to examine their effects on walking.

It has been reported that wearing a pelvic belt is a method of creating good posture. In a study by Hyun-Gyu (2016), the use of a pelvic belt changed the trunk muscle activity and reduced the load on specific muscle groups. For example, the activities of the transverse abdominis and multifidus muscles increase and the load on the lumbar spine is reduced. Specifically, the study demonstrated the following:

- 1) improvement of lumbar stability, by compressing the lumbar spine, spinal stability, improves and correction of posture. This prevents spinal instability during daily movements and alleviates low back pain.
- 2) Muscle support: Excessive tension is prevented by supporting the muscles around the lumbar spine. In particular, the load on the multifidus and erector spinae was reduced and muscle fatigue was prevented.
- 3) Pain reduction: Compression provides appropriate support and reduces nerve compression, thereby alleviating symptoms of low back pain.

Many previous studies on posture and respiration (Romei M. et al., 2010; Miller, 2005) were conducted under experimental kyphotic posture model conditions in young healthy subjects or targeted community-dwelling elderly people. These studies reported that stronger spinal kyphosis was associated with greater inspiratory function and respiratory muscle strength, as well as a significant reduction in expiratory flow rate. In other words, postural improvement may also lead to improvements in respiratory function.

Therefore, in the present study, we investigated the effects of a pelvic belt on human energy expenditure and fat metabolism by performing expired gas analysis during walking before and after wearing a pelvic belt (designed to improve posture, manufactured by Nikko Medical Co., Ltd.).

Materials and Methods

1. Subjects and Study Design

All measurements in this study were noninvasive. The study protocol was approved by the Osaka Kyoiku University ethics committee (Chairperson: Tsuyoshi Suzuki; Approval number: 25134). The study was conducted in accordance with the Declaration of Helsinki, and informed consent was obtained from all participants. The study was carried out with subjects who fully understood the content of the study and provided written informed consent.

The subjects were 20 healthy women aged 20–23 years as described in Table 1. Expired gas analysis during treadmill walking was performed over two consecutive days. The walking order under the two conditions was assigned to minimize bias: ten subjects underwent measured with the pelvic belt on the first day, and the remaining ten underwent measured without the pelvic belt on the first day. On the second day, each group underwent the experiment under the remaining condition.

Table 1 summarizes subject background (mean $\pm$ standard deviation).

Table 1. Subject Background

Number (n)	20 (female)
Age (years)	20.1 $\pm$ 0.93
Height (cm)	152.4 $\pm$ 5.9
Body weight (kg)	54.8 $\pm$ 5.3
BMI (kg/m ²)	22.2 $\pm$ 3.7

2. Pelvic Belt (Nikko Medical Co., Ltd.)

The pelvic belt used in this study had a pelvic stabilization function and included a special pad woven with elastic material to prevent slipping of the pelvic belt during multidirectional movements of the hip joint and trunk rotation. Since the same effect can be obtained during walking, the belt makes it possible to continuously maintain the effects of the pelvic belt during exercise. Therefore, it is a product that is expected to reduce or eliminate low back pain and pain near the sacroiliac joint during exercise. The procedure for wearing the belt and selecting the belt size are shown in the Figure 1 and Figure 2.



① Prepare to wear the belt ② Wrap the belt around the waist ③ Pull the auxiliary belts

Fig. 1. Wearing the Belt

① Prepare to wear the belt.

Detach all belts from the hook-and-loop fastener, firmly pull both sides of the belt, and tighten the fastener at the front of the abdomen, adjusted to the height of the hipbone.

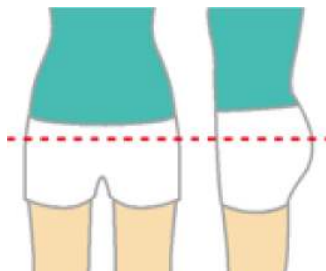
② Wrap the belt around the waist.

The auxiliary belts were held and pulled directly to the left and right sides. The participants could adjust their tightness by themselves.

③ Pull auxiliary belts.

Attach the pulled auxiliary belts to the belt surface on the abdomen to complete.

Measurement position: Around the hip



* Measurement around the highest point of the hip

M size: 80 cm, L size: 100-120 cm

Fig. 2. Selecting the Size of the Pelvic Belt

3. Exercise Load

The exercise load in the experiment was walking on an indoor treadmill (O2ROAD 2IE; Takei Scientific Instruments). The exercise load was set to assume light exercise experienced in daily life. The speed set at 5 km/h, equivalent to nearly normal walking at 70–80 m/min (slope angle 0°), and the walking time set at 30 minutes.

4. Measurement of Energy Metabolism

Energy metabolism was measured using an expired gas metabolism monitor (MetaLyzer II; CORTEX). In an artificial climate chamber set to room temperature (25°C), humidity (50%), and illumination (300 lux), subjects were equipped with a heart rate measurement band (chest electrodes) and a mask for expired gas sampling were measured for respiratory quotient (RQ) and oxygen uptake per unit time (VO_2) during exercise load, both with and without the pelvic belt. At the same time, energy metabolism was measured using an expired gas analyzer ($\text{VO} 2000$, Medical Graphics Corporation).

Total energy expenditure and fat combustion were calculated from VO_2 (oxygen uptake per minute) using the following formulas. The RQ of fat combustion was set to 0.707, and the amount of heat generated by consuming 1 L of oxygen was calculated as 4.686 kcal/L in the case of carbohydrate-only combustion.

- (1) Fat metabolism ratio = $(1 - \text{RQ}) / (1 - 0.707)$
- (2) Fat combustion (kcal/min) = $4.686 \times \text{fat metabolism ratio} \times \text{VO}_2$
- (3) Total energy expenditure (kcal/min) = fat combustion + $5.047 \times (1 - \text{fat metabolism ratio}) \times \text{VO}_2$

5. Measurement Schedule

To minimize the influence of meals, breakfast on the test day was standardized according to the menu listed in Table 2. Subjects were instructed to eat breakfast by 9:00 a.m. on the test day and enter the artificial climate chamber by 10:00 a.m. After entry, body measurements were taken following the schedule shown in Figure 3. Subjects then waited in a seated position, after which expired gas was measured during 30 minutes of treadmill walking. In addition, to minimize the influence of meals, dinner on the day before the test (one bowl of udon, one piece of yogurt, and one pack of milk) and breakfast on the test day (Table 2) were standardized to the same menu. The same procedure was followed on the next day. Ten subjects who performed the test without wearing the pelvic belt on the first day performed the test while wearing the pelvic belt on the second day, and vice versa.

Table 2. Meal Composition (Dinner on the Day before Test, Breakfast on Test Day)

Commercially available nutritional balance food	56 g
Protein	10.5 g
Fat	11.5 g
Carbohydrate	22.5 g
Calories	251 kcal
Commercially available milk	200 mL
Calories	133 kcal

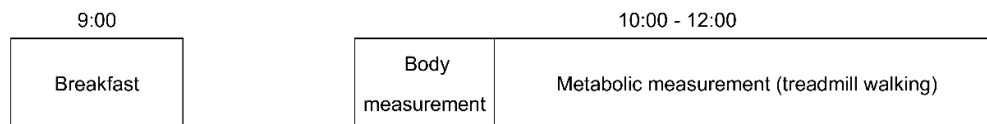


Fig. 3. Test Schedule

6. Statistical Analysis

Comparisons between the two groups were performed using paired t-tests. The relationships between two variables were calculated and tested using Pearson's correlation coefficient test. The results were expressed as means $\pm$ standard deviations.

Results

Total energy expenditure and fat combustion were calculated during the 30-minute respiratory measurement, as the measured values in the latter 15 minutes. The results are shown in Figures 4 and 5. The total energy expenditure and fat combustion during exercise with the pelvic belt were significantly higher than those without the pelvic belt, indicating the promotion of total energy expenditure ($p = 0.0027$) and fat combustion ($p = 0.0021$) by wearing the pelvic belt.

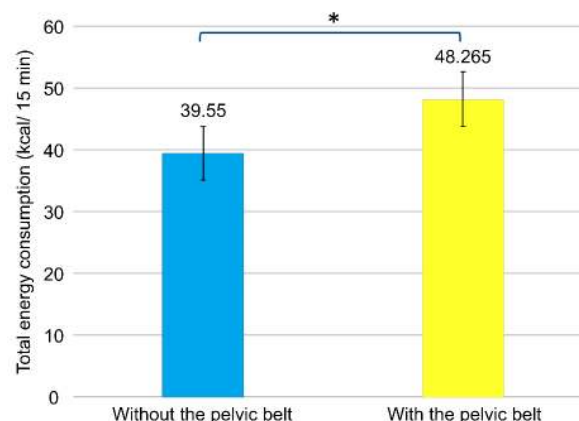


Fig. 4. Total energy expenditure during exercise with and without the pelvic belt. * $p < 0.05$

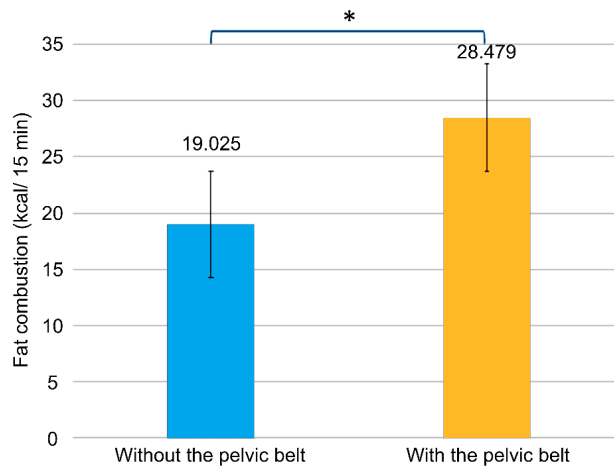


Fig. 5. Fat Combustion during Exercise with and without the Pelvic Belt. * $p < 0.05$

Next, the relationship between BMI and fat combustion with and without the pelvic belt was examined (Figures 6 and 7). In both groups, fat combustion was correlated with BMI, but the correlation was stronger when wearing the pelvic belt (without pelvic belt: $r = 0.662$, $p = 0.034$; pelvic belt: $r = 0.885$, $p = 0.001$). Since the slope was also greater, the effect of the pelvic belt on fat combustion was more pronounced in subjects with higher BMI.

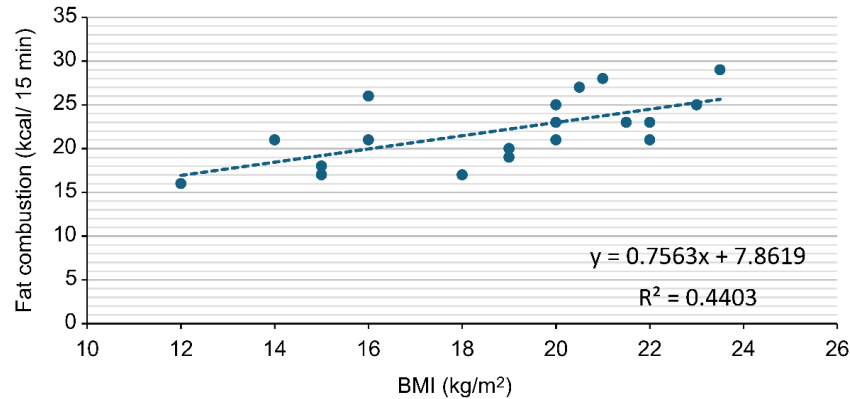


Fig. 6. Relationship between BMI and Fat Combustion (without pelvic belt). $r=0.662$.

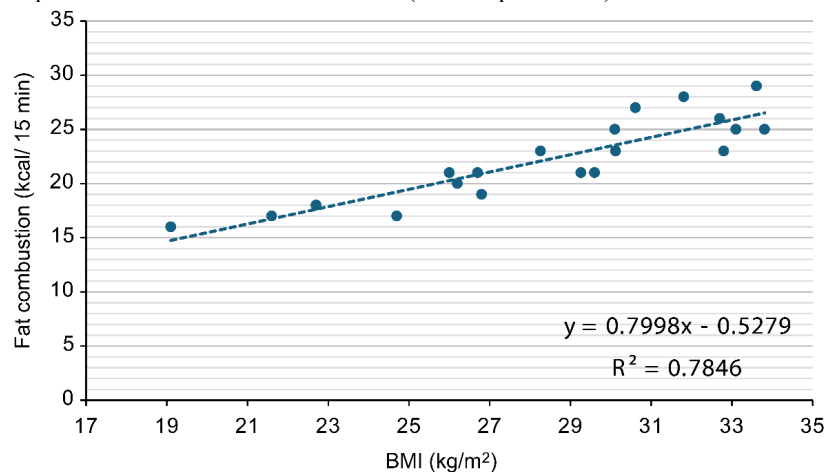


Fig. 7. Relationship between BMI and Fat Combustion (with pelvic belt). $r=0.885$.

Discussion

The present study examined how wearing a pelvic belt, which has been shown to improve posture and reduce lower back pain in prior research (Cha et al., 2016) affects energy metabolism during exercise. Healthy women were recruited, and total energy expenditure as well as fat metabolism (fat combustion) were measured during exercise with and without the pelvic belt using the indirect method of expired gas analysis. Compared with exercising without the pelvic belt, both total energy expenditure and fat combustion were significantly increased when wearing the pelvic belt during 15–30 minutes (the latter 15 min) of exercise load after the start of the experiment. This suggests that the pelvic belt promoted fat combustion. In other words,

wearing a pelvic belt is effective in correcting posture and facilitating breathing, which resulted in increased oxygen intake. This, in turn, made aerobic exercise easier to perform, resulting in fat being more easily consumed. These results are consistent with previous research showing that wearing a pelvic belt improves posture (Cha et al., 2016) and that good posture improves respiratory efficiency (Romei M. et al., 2010; Miller, 2005).

Both total energy expenditure and fat combustion during exercise were significantly correlated with BMI. Even at the same walking speed (5 km/h), if the body weight differed, the required energy amount also differed; therefore, individuals with higher body weight and BMI showed higher total energy expenditure and fat combustion during exercise. When wearing the pelvic belt, these correlations became stronger, and the slope increased. In other words, individuals with a higher BMI are likely to experience greater increases in total energy expenditure and fat oxidation when wearing the pelvic belt.

Overall, both total energy expenditure and fat oxidation indicated a clear fat-burning effect of the pelvic belt. As the exercise load applied in this study was mild and comparable to the physical activity encountered in daily life, it is reasonable to expect that simply wearing a pelvic belt during everyday activities could also promote fat burning.

In clinical and health-promotion settings, an upright pelvic posture is often recommended as an ideal postural condition (O'Sullivan et al., 2006; 2013). However, the definition of "good posture" remains vague, with no clear description of its range. Kendall (2006) suggested that good posture is characterized by an upright pelvis and proper alignment of the abdomen, trunk, and lower limbs. From the perspective of muscle balance, posture can also be described in terms of ideal skeletal alignment. Such an alignment reflects sound scientific principles and represents the body's most efficient state with minimal stress and strain. In the present study, wearing a pelvic belt appeared to stabilize the pelvis without inducing trunk inclination or minimizing pelvic sway during walking. As walking involves alternating periods of single-leg support, pelvic instability can place considerable strain on the trunk and lower limb joints. By stabilizing the pelvis, the belt helped promote an ideal posture that reduced stress on the joints and supported a smoother gait.

Accordingly, pelvic belt use may be considered an appropriate intervention for correcting abnormal posture. Moreover, by reducing joint strain during walking, it may also serve as a useful postural aid for patients with lower back pain, hip or knee joint pain in the context of health promotion.

This study has some limitations. The sample size was small ($n=20$), which may have limited the generalizability of the findings. In addition, the participants were recruited from a specific region of Japan, which may limit the generalizability of the findings to a broader population. Moreover, the study design was nonrandomized, and there was a potential for selection bias in participant recruitment. In future research, which would incorporate more data, we will recruit people who would like to reduce their weight, patients, training coaches, and medical professionals based on the findings obtained from this study.

Conclusion

In this study, the effects of pelvic belts on energy metabolism were investigated in healthy women. When light exercise was performed while wearing the pelvic belt, both total energy expenditure and fat combustion significantly increased compared with light exercise without the pelvic belt. This suggests that the effect may be more prominent in individuals with a higher BMI, and that this contributes to a reduction in body fat percentage. These findings suggest that simply wearing a pelvic belt in everyday life may contribute to not only fat reduction but also health promotion, rehabilitation, and exercise program, particularly in individuals with a higher BMI.

Declaration of generative AI and AI-assisted technologies in the writing process- Not Applicable

Conflicts of interest – The authors declare no conflicts of interest.

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