วารสารวิทยาศาสตร์และเทคโนโลยีการกีฬา ปีที่ 15 ฉบับที่ 1, กรกฎาคม 2558

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นิพนธ์ต้นฉบับ (Original article)

สรีรวิทยาการออกกำลังกายและกีฬา (Sports and Exercise Physiology)

DOES SPORTS BRA LIMIT METABOLIC PROFILES DURING CONSTANT SPEED RUNNING?

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ABSTRACT

To investigate whether sports bra distress on metabolism during jogging or not, 15 healthy female subjects were participated in three exercise trials of no bra (NB), casual bra (CB) and sports bra (SB) conditions. Exercise condition was conducted on a motor-driven treadmill at 4 mph, 0% grade up to 80% of age-predicted maximum heart rate with randomized bra conditions at least a week apart. Anthropometric data and maximum oxygen consumption were determined under CB condition. Results revealed that there were no changes in metabolic profiles of SB at rest and during exercise when compared with that of CB and NB conditions. With the exception of respiratory exchange ratio (RER), all groups exhibited similar changing patterns of rate of oxygen consumption (VO_2), rate of carbon dioxide production (VCO_2) and energy expenditure (EE) which related to the intensity of exercise and these changes found to be declined during recovery period. Between-group comparisons showed no significant differences on metabolic variables among NB, CB and SB. However, while NB had immediate recovery, SB recovery was delayed for 1-2 min and CB showed further delayed for 3 min. In addition, this study demonstrated the critical roles of glycolytic pathway as a main energy substrate. In conclusion, sports bra does not limit metabolic profiles at rest and during exercise but may delay some recovery processes.

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KEYWORDS : sports bra, metabolic profiles, exercise

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เสื้อชั้นในกีฬามีผลต่อการเผาผลาญพลังงานของร่างกายระหว่างการวิ่งที่ความเร็วคงที่หรือไม่

ธนาชัย สหัสโชติ*, รศ.ดร. ไก้ออน ชินธเนศ, อ.ดร. เมตตา ปิ่นทอง, ผศ.ดร. สุวดี ชวนไชยะกูล**
และ รศ.พ.ต.ดร. รุ่งชัย ชวนไชยะกูล
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บทคัดย่อ

เพื่อศึกษาผลกระทบของการใส่เสื้อชั้นในกีฬาที่มีต่อระบบเผาผลาญพลังงานของร่างกายขณะวิ่ง ในการศึกษานี้ใช้อาสาสมัครเพศหญิงที่มีสุขภาพดีจำนวน 15 คน ทำการทดสอบคนละ 3 ครั้งโดยการสุ่มลำดับ (NB = ไม่สวมใส่เสื้อชั้นใน, CB = สวมเสื้อชั้นในปกติ, SB = สวมเสื้อชั้นในกีฬา) ซึ่งการทดสอบแต่ละครั้งจะห่างกันอย่างน้อย 1 สัปดาห์ ในการทดสอบจะให้ผู้เข้าร่วมการทดสอบทำการวิ่งบนลู่วิ่งกลที่ความเร็ว 4 ไมล์ต่อชั่วโมงจนกระทั่งถึง 80% ของอัตราการเต้นของหัวใจสูงสุด จากผลการศึกษาไม่พบความแตกต่างของระบบเผาผลาญพลังงานของร่างกายในกลุ่มที่สวมใส่เสื้อชั้นในกีฬาเมื่อเทียบกับกลุ่มที่สวมใส่เสื้อชั้นในปกติและกลุ่มที่ไม่สวมใส่เสื้อชั้นใน โดยทั้งสามกลุ่มแสดงให้เห็นถึงการเปลี่ยนแปลงในลักษณะเดียวกันของอัตราการใช้ออกซิเจน (VO_2), อัตราการผลิตคาร์บอนไดออกไซด์ (VCO_2) และการใช้พลังงาน (EE) ซึ่งเกิดขึ้นจากความหนักของการออกกำลังกาย และจะลดลงในช่วงการฟื้นสภาพ ยกเว้นอัตราส่วนระหว่างปริมาณการผลิตคาร์บอนไดออกไซด์กับปริมาณการใช้ออกซิเจน (RER) เมื่อเปรียบเทียมระหว่างกลุ่ม ไม่พบความแตกต่างอย่างมีนัยสำคัญทางสถิติของตัวแปรทางระบบเผาผลาญพลังงานดังกล่าวทั้งในขณะพัก, ระหว่างและหลังออกกำลังกาย เมื่อเปรียบเทียบภายในกลุ่มพบว่า กลุ่มที่ไม่สวมใส่เสื้อชั้นในกีฬาสามารถฟื้นสภาพได้ทันทีหลังจากออกกำลังกาย ในขณะที่กลุ่มที่สวมใส่เสื้อชั้นในกีฬาจะมีระยะเวลาการฟื้นสภาพหลังออกกำลังกายล่าช้ากว่าประมาณ 1-2 นาที และกลุ่มที่สวมใส่เสื้อชั้นในปกติจะมีระยะเวลาการฟื้นสภาพหลังออกกำลังกายล่าช้ากว่าประมาณ 3 นาที อย่างไรก็ตามการศึกษานี้แสดงให้เห็นถึงบทบาทที่สำคัญของกระบวนการสลายไกลโคเจนเพื่อนำมาใช้เป็นพลังงานหลัก กล่าวโดยสรุปการสวมใส่เสื้อชั้นในกีฬาไม่มีผลจำกัดการทำงานของระบบเผาผลาญพลังงานของร่างกายในขณะพักและระหว่างออกกำลังกาย แต่อาจมีผลทำให้กระบวนการฟื้นสภาพบางอย่างหลังออกกำลังกายล่าช้าลงได้

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คำสำคัญ : เสื้อชั้นในกีฬา, การเผาผลาญพลังงานของร่างกาย, การออกกำลังกาย

วารสารวิทยาศาสตร์และเทคโนโลยีการกีฬา ปีที่ 15 ฉบับที่ 1, กรกฎาคม 2558
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INTRODUCTION

Well-known that benefit of physical activities on health promotion become popular for people throughout the world (ACSM, 2009). Additionally, appropriate exercises reduce risks of heart disease and diabetes (Abby King, 2003; Scott K. et al, 2009) and improve the quality of life (King et al, 1993). Numbers of female participation in sports and physical exercise increase dramatically, whereas walking and running are the popular activities (The National Statistical Office of Thailand, 2011). Despite the above benefits, exercise should be correctly done for injury prevention, in particular with breast injury from repeated excessive motions (Mason et al, 1999) and stretching of Cooper's ligament which has three-dimensional arrangement (Simonetti F. et al 2009). Previous studies showed that bra, especially, sports bra can help to support, reduce excessive breast movement and breast discomfort during exercise (Haake and Scurr, 2010; Starr et al, 2005; White et al, 2009). Few females avoid wearing sports bra during exercise (McGhee et al, 2010; Bowles et al, 2008) since they believe that it may cause furrow from straps, breast pain, too restrict on chest motion (Caro et al, 1960), breast discomfort (Bowles et al, 2005) and limit respiratory function (Bowles et al, 2008; O'Donnell et al, 2000). We hypothesize that if sports bra limits chest motion, it may affect body's metabolism. This study aimed to explore the metabolic profiles including rate of oxygen consumption (VO_2), rate of carbon dioxide production (VCO_2) and respiratory exchange ratio (RER) during constant speed running in female using sports bra.

MATERIALS AND METHOD

Fifteen healthy females with B and C cup size breasts, age ranges between 18–30 yrs, were recruited under inclusion criteria as follow: free from diseases or syndromes which may limit exercise activity, had quite regular menstruation cycle, never had thoracic or abdominal surgery, not using hormone replacement therapy and previous or current pregnancies and non-smoking and non-alcoholism. This study was approved by Human Research Ethics Committee of Mahidol University. After signing informed consent forms, subjects filled in physical activity questionnaires, personal and medical history. Their bra sizes were precisely identified by experts from THAI WACOAL PUBLIC COMPANY LIMITED. Anthropometric measurements and peak oxygen consumption (VO_{2peak}, using Bruce's protocol) were identified while subjects put on their casual bras. Subjects' instructions were provided before experimental day for regular dietary and enough water intake, avoid coffee, tea, tobacco or alcohol 48 hours before test, avoid vigorous or strenuous physical activity 48 hrs, and sleep more than 8 hrs.

Subjects visited the laboratory on the same time of the day for three randomized interventions of exercises with no bra (NB), with casual bra (CB), and with sports bra (SB). On the experimental day, subject arrived at The Sports Physiology Laboratory (College of Sports Science and Technology, Mahidol University, Salaya campus). After fifteen minutes rest, subject was randomly put on bra conditions (NB, CB, or SB) for the tests and covered with same sportswear which provided by investigators in all three conditions. Exercise protocol started with calisthenics warm up (2 minutes of static stretching and 3 minutes of 2.5 mph walking on treadmill) and then subject performed 4 mph treadmill running protocol up to 80% age-predicted maximum heart rate followed by 5 minutes recovery by sitting quietly on the chair. Testing was terminated whenever any of the following criteria were met: volitional termination, heart rate reaches age-predicted maximum range, drop in systolic blood pressure ≥10 mmHg from baseline, systolic blood pressure more than 250 mmHg and/or diastolic blood pressure more than 115 mmHg, displayed signs or symptoms such as; chest pain, shortness of breath, or wheezing and fatigue, leg cramps, or cannot sustain pace.

Oxygen consumption (VO_2), carbon dioxide production (VCO_2), respiratory exchange ratio (RER) and energy expenditure (EE) (kcal/min) were collected using Oxycon Mobile device (Germany). Heart rate was collected using Signal Morphology-based Impedance Cardiography (PhysioFlow, France). Equipment was calibrated before each experiment. All parameters were analyzed to compare for each bra conditions at 60%, 70%, and 80% of maximal heart rate. RPE and dyspnea scales were recorded every 10 minutes between the tests.

Statistical analysis

All data were presented as mean ±SEM, otherwise was stated. Normal distribution (*Kolmogorov–Smirnov test*, K–S test), one-way repeated measured ANOVA were used to evaluate significant differences analysis. Significance difference was set at $P < 0.05$. If a significant main effect was achieved, Bonferroni's *post hoc* test as applied to identify the difference couple.

RESULTS

General characteristics of subjects

The general characteristics including weight, BMI, body fat, lean body mass, waist, hip, resting heart rate, resting systolic blood pressure, resting diastolic blood pressure and resting respiratory rate–were presented in Table 1. All anthropometric and physiological data revealed the normal healthy status of subjects and were considerably in average values of Thai females at this age (Surasak *et al*, 2000). No significant differences were found for all resting variables among three conditions (p>0.05).

Table 1 General characteristics of female subjects in control no bra (NB), casual bra (CB) and sports bra (SB) trials. Values are mean ±SD.

Variables	NB (n = 15)	CB (n = 15)	SB (n = 15)
Weight (kg)	56.15 ±5.87	55.99 ±5.67	56.25 ±5.37
BMI (kg.m^{-2})	21.79 ±1.79	21.73 ±1.73	21.83 ±1.62
Body fat (%)	23.08 ±2.77	22.83 ±2.76	22.97 ±2.56
Lean body mass (%)	27.89 ±1.62	28.18 ±1.75	28.04 ±1.57
Waist (cm)	74.40 ±6.62	75.03 ±6.89	73.83 ±6.24
Hip (cm)	94.73 ±5.16	94.37 ±5.37	94.23 ±4.69
Resting HR (bpm)	71.02 ±8.58	71.69 ±9.17	71.93 ±9.36
Resting SBP (mmHg)	102.33 ±8.55	102.87 ±11.62	105.67 ±9.07
Resting DBP (mmHg)	62.07 ±6.23	63.53 ±5.94	65.93 ±5.23
Resting RR (times/min)	16.00 ±3.74	16.07 ±4.61	16.13 ±4.07

BMI (body mass index), HR (heart rate), SBP and DBP (systolic and diastolic blood pressures), RR (respiratory rate)

Metabolic profiles at rest, during and after exercises

Since data were in narrow ranges, the present study shows between group comparisons using graph and within group comparisons using a table.

Oxygen consumption

No significant differences of resting VO_2, either in absolute (245.60 ±13.57, 246.87 ±13.15 and 250.53 ±22.45 ml/min in NB, CB and SB groups) or relative values (4.41 ±0.24, 4.41 ±0.25 and 4.48 ±0.39 ml/min/kg in NB, CB and SB groups respectively), between NB, CB and SB conditions. As exercise started, all groups showed similarly and abruptly increased from its corresponding resting absolute (Figure 1A) and relative (Figure 1B) VO_2 levels to 60% of age-predicted maximal heart rates (MHR). After that patterns of changes in absolute and relative VO_2 values were gradually increased at 70 and 80% (MHR). No significant differences of VO_2 during exercise, either in absolute (ml/min) or relative values (ml/min/kg), between NB, CB and SB conditions were detected (p<0.05). Even recovery oxygen consumptions had similar patterns of changes in all groups, however NB showed immediate non-significant difference from its resting value whereas SB showed higher than resting values VO_2 than its resting values only at 1st, and CB showed higher than resting values VO_2 than its resting values at 2nd minute (p>0.05).

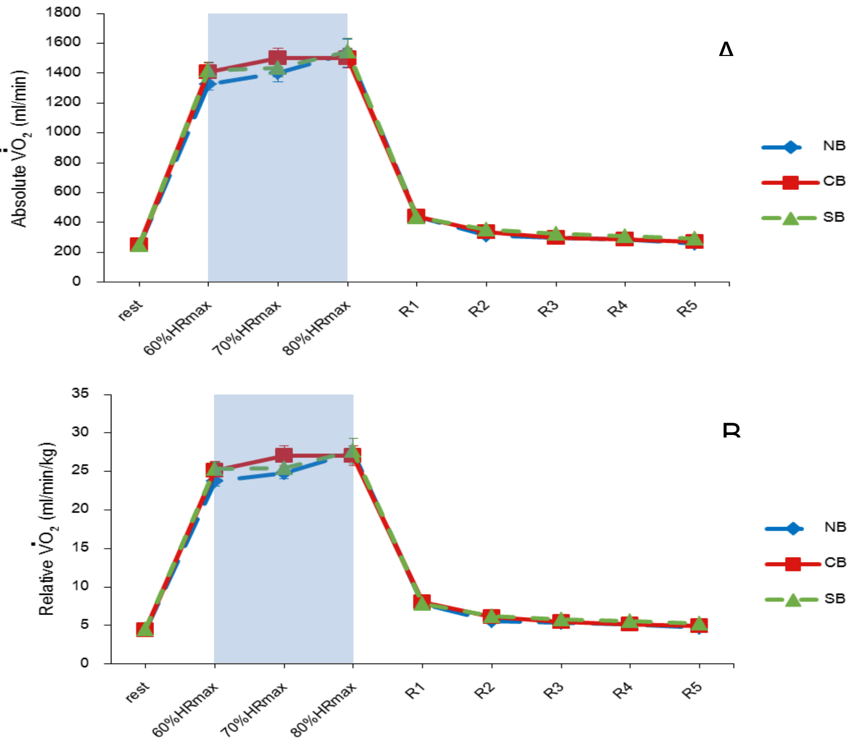

Figure 1. Between-groups comparisons of changes in absolute oxygen consumption (VO_2)(A) and relative oxygen consumption (VO_2)(B) of subjects at rest, during exercise at 60%, 70% and 80% of age-predicted maximal heart rates (shaded area), and during 5 min. recovery period(R1- R5). Abbreviations: [a] represents significant between NB-CB, [b] significant between NB-SB and [c] significant between CB-SB. All values are compared at $p<0.05$.

Carbon dioxide production

Absolute VCO_2 at rest were 221.40 ±12.93, 220.22 ±14.18 and 217.98 ±16.09 ml/min in NB, CB and SB groups respectively which showed no significant differences among the groups. As exercise started, carbon dioxide production (VCO_2), abruptly and significantly increased from corresponding resting values (p<0.05, Figure 2) to 1,345.58 ±48.06, 1,412.60 ±63.38 and 1,412.73 ±53.65 ml/min at 60% MHR in NB, CB and SB groups respectively. After that the rates of increasing in VCO_2 were slow down to 70 and 80% MHR. No significant differences in carbon dioxide production among the groups were found during exercise. At recovery period, VCO_2 remarkably declined to 313.76 ±14.69, 323.92 ±17.47 and 334.02 ±14.67 ml/min. Groups of CB and SB showed higher than resting values VCO_2 than its resting values at 1st, 2nd and 3rd minutes (p>0.05) but VCO_2 in NB showed no significant difference from its resting value from 1st minutes. No significant differences in carbon dioxide production among the groups were found during recovery period (p<0.05).

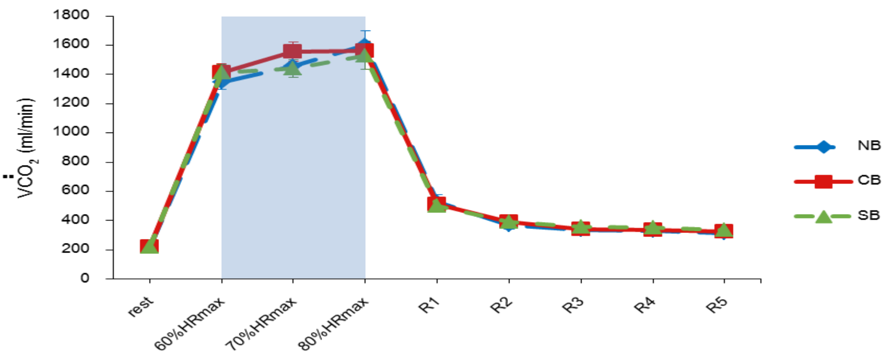

Figure 2. Between-groups comparisons of changes in carbon dioxide production(VCO_2) of subjects at rest, during exercise at 60%, 70% and 80% of age-predicted maximal heart rates (shaded area), and during 5 min. recovery period(R1- R5). Abbreviations: [a] represents significant between NB-CB, [b] significant between NB-SB and [c] significant between CB-SB. All values are compared at $p<0.05$.

Respiratory exchange ratio

Respiratory exchange ratio (RER) values at resting were 0.90 ±0.02, 0.89 ±0.02 and 0.88 ±0.02 in NB, CB and SB respectively with no significant differences between groups. As exercise started, at 60% of age-predicted maximal heart rates, RER values increased abruptly to 1.02 ±0.02, 1.01 ±0.04 and 1.00 ±0.02 in NB, CB and SB respectively (Figure 3). These were gradually declined at 70 and 80% MHR. Patterns of changes in RER during exercise in all groups showed no significant differences. During recovery periods, RER were further increased, from 80% MHR, to 1.19 ±0.03, 1.18 ±0.06 and 1.14 ±0.04 in NB, CB and SB respectively at 1st minute and nearly constant until 5th minute of recovery.

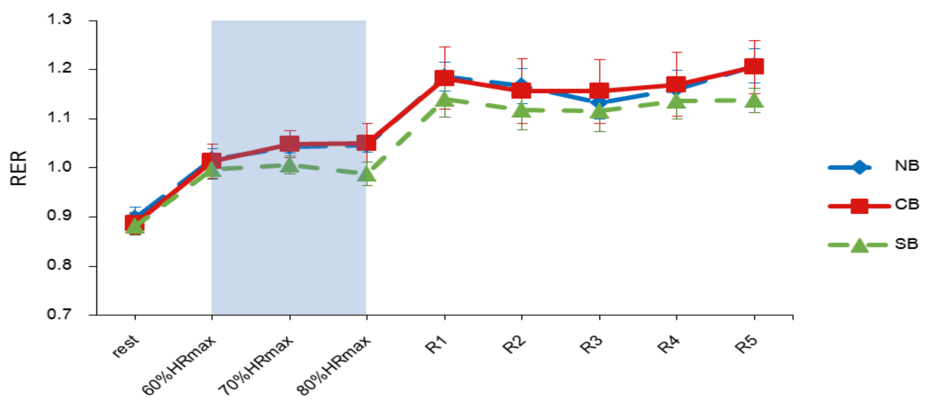

Figure 3. Between-groups comparisons of changes in respiratory exchange ratio(RER) of subjects at rest, during exercise at 60%, 70% and 80% of age-predicted maximal heart rates (shaded area), and during 5 min. recovery period(R1- R5). Abbreviations: [a] represents significant between NB-CB, [b] significant between NB-SB and [c] significant between CB-SB. All values are compared at $p<0.05$.

Energy expenditure

Resting EE were 1.20 ±0.07, 1.21 ±0.07 and 1.22 ±0.10 kcal·min^{-1} in NB, CB and SB respectively with no significant differences between groups. As exercise started, at 60% of MHR, EE values were significantly increased from corresponding resting values (p<0.05) to 6.64 ±0.19, 7.04 ±0.29 and 7.09 ±0.27 kcal·min^{-1} in NB, CB and SB respectively (Figure 4) and then slow down at 70 and 80% MHR with no significant differences between groups. EE remarkably declined, at 1st minute after exercise, and decreased gradually but no significant differences between groups. EE remained quite high even at 5th minutes of recovery period, 1.36 ±0.05, 1.41 ±0.06 and 1.51 ±0.06 kcal·min^{-1} in NB, CB and SB respectively. Recovery EE in NB group showed no significant difference at 1st minute and throughout the study, SB showed higher EE at 1st minute (p<0.05) and CB showed higher EE at 1st to 3rd minute (p<0.05).

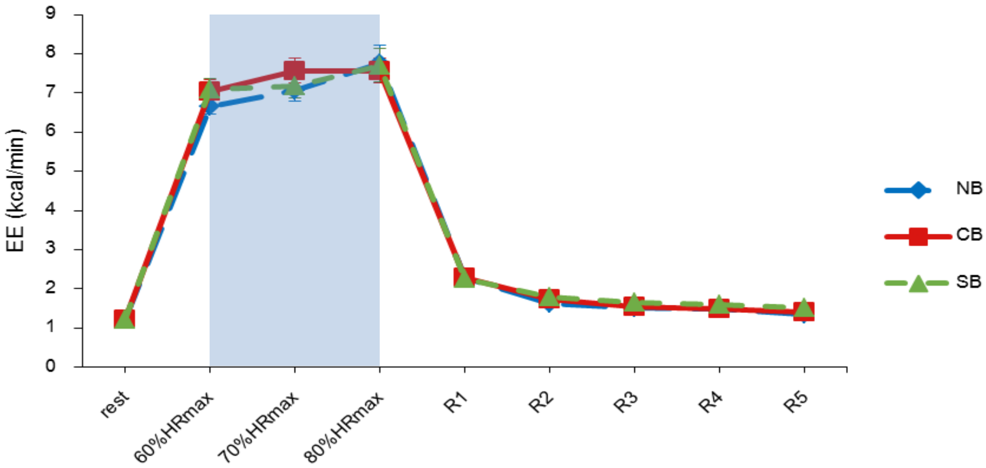

Figure 4. Between-groups comparisons of changes in energy expenditure(EE) of subjects at rest, during exercise at 60%, 70% and 80% of age-predicted maximal heart rates (shaded area), and during 5 min. recovery period(R1- R5). Abbreviations: [a] represents significant between NB-CB, [b] significant between NB-SB and [c] significant between CB-SB. All values are compared at *p<0.05*.

Table 2 Within-groups comparisons of changes in absolute oxygen consumption ($\dot{V}O2$), carbon dioxide production ($\dot{V}CO2$), respiratory exchange ratio (RER), relative oxygen consumption ($\dot{V}O2/kg$) and energy expenditure (EE) at rest, during exercise at 60%, 70% and 80% of age-predicted maximal heart rates, and during 5 minutes of recovery period (R1, R2, R3, R4 and R5) in control (no bra, NB), casual (CB) and sports (SB) bra.

Variable	$\dot{V}O_2$ (ml/min)			$\dot{V}CO_2$ (ml/min)			RER			$\dot{V}O_2/Kg$ (ml/kg/min)			EE (kcal/min)		
Condition	NB	CB	SB	NB	CB	SB	NB	CB	SB	NB	CB	SB	NB	CB	SB
Rest	245.60 ±13.57	246.87 ±13.15	250.53 ±22.45	221.4 ±12.93	220.22 ±14.18	217.98 ±16.09	0.90 ±0.02	0.89 ±0.02	0.88 ±0.02	4.41 ±0.24	4.41 ±0.25	4.48 ±0.39	1.20 ±0.07	1.21 ±0.07	1.22 ±0.10
60%MHR	1323.78 ±37.30*¶	1405.44 ±60.72*¶	1419.69 ±54.67*¶	1345.58 ±48.06*¶	1412.60 ±63.38*¶	1412.73 ±53.65*¶	1.02 ±0.02	1.01 ±0.04	1.00 ±0.02	23.72 ±0.62*¶	25.16 ±1.10*¶	25.32 ±0.86*¶	6.64 ±0.19*¶	7.04 ±0.29*¶	7.09 ±0.27*¶
70%MHR	1399.25 ±56.11*	1502.03 ±64.89*	1435.36 ±61.72*	1457.03 ±54.71*	1555.28 ±65.51*	1439.79 ±59.16*	1.04 ±0.01*	1.05 ±0.03	1.01 ±0.02*	24.76 ±0.65*	27.03 ±1.31*	25.47 ±1.06*	7.06 ±0.28*	7.57 ±0.32*	7.18 ±0.30*
80%MHR	1532.38 ±93.97*	1500.93 ±63.89*	1545.00 ±85.01*	1602.33 ±96.56*	1560.63 ±68.41*	1528.26 ±94.29*	1.05 ±0.01*	1.05 ±0.04	0.99 ±0.02*	27.45 ±0.87*	27.04 ±1.26*	27.64 ±1.63*	7.74 ±0.47*	7.57 ±0.31*	7.71 ±0.43*
R1	439.31 ±32.39¶	439.57 ±26.70*¶	435.80 ±21.32*¶	528.42 ±50.46¶	513.60 ±34.98*¶	499.69 ±32.79*¶	1.19 ±0.03*	1.18 ±0.06	1.14 ±0.04*	7.85 ±0.52¶	7.98 ±0.54*¶	7.80 ±0.41*¶	2.29 ±018¶	2.28 ±0.14*¶	2.25 ±0.12*¶
R2	312.98 ±19.55	337.82 ±14.08*¶	350.73 ±15.19¶	369.24 ±30.38	390.74 ±26.84*¶	393.13 ±23.01*¶	1.17 ±0.04	1.16 ±0.07	1.12 ±0.04*	5.61 ±0.33	6.08 ±0.33*¶	6.27 ±0.26¶	1.63 ±0.11	1.75 ±0.08*¶	1.80 ±0.08¶
R3	296.49 ±12.02	299.13 ±15.96	322.35 ±14.64	337.78 ±19.78	343.00 ±21.33*	358.38 ±18.40*	1.13 ±0.03	1.16 ±0.06	1.12 ±0.04*	5.32 ±0.21	5.42 ±0.37	5.77 ±0.26	1.53 ±0.07	1.54 ±0.08*	1.65 ±0.07
R4	285.98 ±9.21	286.72 ±13.38	311.04 ±15.92	332.89 ±17.67	337.26 ±26.22	353.64 ±21.17	1.16 ±0.04	1.17 ±0.07	1.14 ±0.04*	5.12 ±0.15	5.17 ±0.32	5.55 ±0.27	1.48 ±0.05	1.49 ±0.08	1.60 ±0.08
R5	260.98 ±10.55	270.15 ±11.93	293.96 ±12.31	313.76 ±14.69	323.92 ±17.47	334.02 ±14.67	1.21 ±0.03*	1.20 ±0.05*	1.14 ±0.02*	4.68 ±0.19	4.89 ±0.31	5.24 ±0.20	1.36 ±0.05	1.41 ±0.06	1.51 ±0.06

Abbreviations * represents from initial (resting) values and ¶ significant from previous value at $p<0.05$

To investigate the effect of sports bra at rest, during and after exercise on metabolic profiles, this study enlisted fifteen healthy female subjects for the tests. All subjects have normal ranges of anthropometric variables, their VO_{2peak} values are considerably in average ranges of Thai female population (Surasak *et al*, 2000).

Our study suggests that wearing sports bra had no effect on metabolic profiles of either oxygen consumption or carbon dioxide production. Resting values of absolute and relative VO_2, VCO_2, RER and EE values are in normal ranges (Exercise Physiology, 2012) and no significant differences were found among NB, CB and SB conditions. During exercise, dynamic metabolic profiles showed similar patterns in all three conditions. It is noted that as exercise was intervened, metabolic profile was subsequently increased. This result supports the study of Prado D. M. et al. that metabolic profiles are an intensity-dependent response. For example at light exercise intensity, metabolic profiles are enhanced minimally, at moderate exercise intensity metabolic profiles are further stimulated and at heavy exercise intensity metabolic profiles are possibly augmented up to the peak (Prado D. M. et al). In our study metabolic profiles confirm the same principle of intensity-dependent (Figure 1-4). With this intensity-dependent pattern, no matter which type of sports bra were put on, effects of exercise intervention seems likely override effects of bra types.

Interestingly, RER in the present study indicated that subjects most likely utilized glycolytic processes as main energy substrate. During exercise, increasing in RER values demonstrated shifting from mix diet into more carbohydrate utilization (1.02 ±0.02, 1.01 ±0.04 and 1.00 ±0.02 in NB, CB and SB respectively). At recovery period, increasing in RER in all groups was most likely due to the interferences of anaerobic processes. Previous study indicated that even though exercise intervention had been ceased, metabolism remained work since biochemical processes remained in activation stage (Sedlock et al, 2010). Even no bra condition exhibits full recovery immediately after exercise, this is not recommended for safety since excessive breast motion was indicated in female athletes (Mason et al, 1999; Gefen and Dilomoney, 2007). CB condition showed higher absolute and relative VO_2 at 2rd minute recovery *($p<0.05$)* and higher VCO_2 and EE at 3nd minute recovery *($p<0.05$)* whereas SB condition showed higher absolute and relative VO_2 and EE at 1rd minute recovery *($p<0.05$)* and higher VCO_2 at 3nd minute recovery *($p<0.05$).* Thus, wearing sports bra expresses full recovery within the 3 minutes post-exercise which was in an acceptable range. Despite, all changed above were probably effect of exercise rather than effect of wearing bra, it seems to be corresponded with previous studies showed that there was no significant difference in respiratory function when exercise with sports bra.
(Bowles K. A, 2005)

Chest strapping may reduce metabolic profiles in some circumstances, for example in chest strapping with lungs diseases (O'Donnell D.E. et al, 1998) and severe thoracic limitation. The latter example was on the severe chest wall restriction model when external restriction pressure was progressively increased from 20 to 60 mmHg, there was reduction of maximum oxygen uptake from 41.9 ±1.3 to 39.4 ±1.3 ml/kg/min (Coast J.R. et al, 2004). In the present study sports bra covers about 0.15-0.16 m^2 of chest wall area (Yuen-Jong, L, 2009). Sports bra used in this study showed no limit chest motion for two reasons: a) area covered by sports bra is minimal and b) elastic recoil of bra's garment is not strong enough.

CONCLUSION

This study indicates that there was no limitation of sports bra on metabolic profiles during constant speed running since there was no changed in either oxygen consumption or carbon dioxide production. Additionally, the present study indicates that the body utilized mostly glycolysis as main energy substrate during constant speed running at 4 miles per hour. In addition, this running speed seems likely that intensities used in this study were at moderate to high levels. The study presents that sports bra can be put on safely and effectively during constant speed running. There was no limitation in body metabolism for progressive workloads from 60-80% age-predicted maximum heart rate.

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