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The Effects of Heat on Energy Expenditure in Experienced and Non-Experienced Hot Yoga Practitioners

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ABSTRACT

The aim of this study was to investigate the effects of heat on energy expenditure in experienced and non-experienced Hot Yoga practitioners. Forty female participants were recruited and divided into two groups: hot yoga (HY, n=20) and yoga (Y, n=20) groups. Each participant attended a 60-minute Hot Yoga session in a temperature-controlled room. The heart rate (HR), rate of oxygen consumption (VO2), rate of carbon dioxide production (VCO2), respiratory exchange ratio (RER), rated perceived exertion (RPE), thermal sensation, and discomfort scales were measured every ten minutes. Repeated two-way ANOVA was used for statistical analysis. The VO2 and VCO2 between groups were significantly different during exercise and at the end of exercise ($p < 0.05$). Within groups, the comparison was significantly different ($p < 0.001$). Furthermore, the RER's at the end of exercise in the HY group were also significantly lower ($p < 0.05$) than those in the Y group. In summary, heat stress affected non-experienced practitioners much more than experienced ones. Therefore, heat acclimatization is a mandatory pre-exercise measure for sedentary people attending Hot Yoga classes.

Keywords: *hot yoga, energy expenditure*

1. Introduction

Hot Yoga is very popular not only in America and Europe but also in Thailand. Training Yoga in a warm room helps the stretching process while it challenges the focus of the mind. This enhances the transformational experience of yoga. Heat also helps detoxification because of increasing blood flow and releasing toxins out of the body. The body's response to heat helps attain strength, detoxification, and healing to create a feeling of well-being [1]. A Hot Yoga room is typically heated up to about 37-40 °C with humidity of 50-60%, which exceeds skin temperature, and is possibly above core temperature in an exercising person. Nainate (2005) found that oxygen consumption (VO_2), respiratory rate, heart rate (HR), skin temperature (T_{sk}), and body temperature increased significantly during exercise in the heat (T = 44.19 ± 0.13 °C and RH = 58.62 ± 0.47). Rectal temperature (T_{re}), rated perceived exertion (RPE), thermal sensation, and thermal discomfort did not change at rest, but they increased gradually during exercise in the heat [2]. Danucalov, et al. (2008) suggested that in comparison with the rest state and meditation, the specific Pranayama technique (Visamavrtti Pranayama) reduces and increases metabolic rate, respectively [3]. Chaya, et al. (2006) found that the metabolic rate of Yoga practitioners was lower than that of non-Yoga group [4]. Chaya & Nagendra (2010) also found that the Yoga group showed significantly lower metabolic rates when compared to the non-Yoga group. The acute effects of Yoga practice over a period of time will have long term effects on metabolism, leading to metabolic efficiency. In general, the values of energy expenditure and intensity of exercise indicate that exercise stimulus in Yoga may not be that high to improve physical performance [5]. Therefore, Hatha Yoga practice may be more energy efficient to accrue meaningful physiological benefits for the general public as well as people who are not able to undergo high intensity exercises, as in ailing individuals [6]. In addition, a combination of Yoga postures (Shavasana and cyclic meditation) with supine rest reduces oxygen consumption (VO_2) more than resting supine (Shavasana) alone [7]. Mody (2010) found that regular practice of Surya Namaskar may maintain or improve cardiorespiratory fitness and promote weight management [8]. This is contrary to Clay, et al. (2005), who found that cardiovascular and HR responses during a 30-minute Hatha Yoga routine were lower than those from moderate walking at 3.5 km per hour [9]. This agrees with Hagins, et al. (2007), who also found that the average metabolic cost of Yoga across the entire session represented a low level of physical activity similar to walking on a treadmill at 3.2 km per hour [10]. According to Barnett (2004), Hot Yoga practitioners have better body's response to heat. However, effects of heat stress on energy expenditure of experienced and non-experienced Hot Yoga practitioners have not been fully studied. Therefore, the present study is aimed to investigate the effect of heat stress on energy expenditure in experienced and non-experienced Hot Yoga practitioners [1].

2. Materials and Methods

2.1 Participants

All of the subjects were informed verbally of the experimental protocol and possible risks involved, and agreed to the consent form before starting the experiment. The consent form was approved by the Ethical Committee of Mahidol University. Forty female participants, 28 to 45 years of age, were recruited to eliminate gender dependency and divided into two groups, Hot Yoga group (HY) of 20 participants, practicing Hot Yoga regularly for one hour per day, two to three days/week, for at least one to two years, and Yoga group (Y) of 20 participants, practicing normal Yoga regularly for one hour per day, two to three days/week, for at least one to two years. They have VO_{2peak} range from 36.7-38.5 ml.kg.min for male and 29.9-32.3 ml.kg.min for female, Bruce's protocol test (ACSM, 2013).

2.2 Instrumentations

2.2.1 Portable metabolic test system (Oxycon).

2.2.2 Thermal sensation scale with 1 to 13, Gagge, et al. (1976) [11]

2.2.3 Thermal discomfort scale was quantified into 4 scales (1 to 4)

2.2.4 Rated perceived exertion (RPE), Borg (1962) [12]

2.2.5 Metabolic energy expenditure (M) from minute-average oxygen consumption (VO_2) in litres per minute and RER using equation [13]

2.2.6 The Physical activity readiness questionnaire (PAR-Q)

2.3 Experimental procedure

Participants were selected in consideration of their Hot Yoga or normal Yoga experiences with all "YES" in the Physical Activity Readiness Questionnaire (PAR-Q). The researchers explained the participants for answering the thermal discomfort scale, the thermal sensation scale, the rated perceived exertion (RPE), and the preparations before the experiment, namely no physical activity one day before testing, no caffeine at least five hours and no alcohol beverages one day before testing, six to eight hours of sleep before testing, and 24 hours before the experiment. Subjects were requested to consume their usual meals. Each participant performed two tests on consecutive weeks. On the first experiment day, VO_{2peak} and O_2 consumption of participants were measured using a Bruce's protocol with a gas analyser for classifying those participants with the same physical fitness level. The Bruce's protocol is a maximal exercise test where the participants exercise to complete exhaustion as the treadmill speeds, and the incline is increased every three minutes. Total time to completed exercise was used to estimate Vo_{2peak}. Upon arrival on the second day, participants were allowed to drink 500 ml water to control hydration status. They wore yoga suit, oxycon, and resting vital signs (heart rate and blood pressure) were measured. After that, participants entered the control room (T = 36.93 ± 0.2 ℃, humidity = 54.8 ± 2.9) and performed a 60-minutes yoga with the general yoga poses. Participants exercised by following the DVD instructions, then started with meditation and pranayamas (slow and deep breathing in-out) for ten minutes, stretching and warming up, focusing on slow movements of shoulders/arms, trunks and legs for 20 min. After that, they exercised by asana poses. The asana focused on the back bent pose, muscular strength and endurance, balance, and flexibility. Each yoga session ended with ten minutes of cooling down and relaxation. Energy expenditure and heart rate were recorded using gas analyser (Oxycon). RPE, thermal sensation and discomfort were measured every ten minutes during Yoga exercise sessions. Heart rate was measured at the end of exercise.

2.4 Statistical Analysis

Repeated two-way ANOVA was used to analyze the main effects between groups (Hot Yoga and Yoga) and within groups. The difference was considered statistically significant when $p < 0.05$.

3. Results

3.1 The general characteristics of participants

Table 1 Demographic characteristics of participants (mean ± SD)

Variables	Yoga (Y)	Hot yoga (HY)
Age (yrs.)	34.2 ± 5.9	34.6 ± 6.2
Weight (kg)	52.8 ± 1.8	50.2 ± 1.1
Height (cm)	158.4 ± 5.9	156.2 ± 4.3
VO_2 peak (ml/min^{-1}/kg^{-1})	30.17 ± 1.8	32.09 ± 2.9

3.2 Energy expenditure

3.2.1 Oxygen consumption (VO_2)

Oxygen consumption (VO_2) of the Y group at rest, the end of exercise, and the recovery were 0.22 ± 0.01, 0.80 ± 0.04 and 0.23 ± 0.01 L/min, respectively, while those in the HY group were 0.219 ± 0.01, 0.678 ± 0.03 and 0.226 ± 0.01 L/min, respectively. The result revealed that the VO_2 between groups were significantly different ($p < 0.05$) during exercise and at the end of exercise. Within group, the comparison was significantly different ($p < 0.001$). Furthermore, during exercise, the oxygen consumption was higher in the Y group than that in the HY group. Oxygen consumption (VO_2) was illustrated in figure 1.

3.2.2 Carbon dioxide production (VCO_2)

The carbon dioxide production by both groups was illustrated in figure 2. The VCO_2 of the Y group at rest, the end of exercise, and recovery were 0.19 ± 0.01, 0.80 ± 0.04, and 0.22 ± 0.01 L/min, while those of the HY group were 0.20 ± 0.01, 0.59 ± 0.03 and 0.21 ± 0.00 L/min, respectively. It was clear that the Y group released CO_2 more than the HY group did. The results illustrated that carbon dioxide production comparison between groups were significantly different ($p < 0.05$) during exercise and at the end of exercise. Within group comparison, there was a significant difference ($p < 0.001$) within each group.

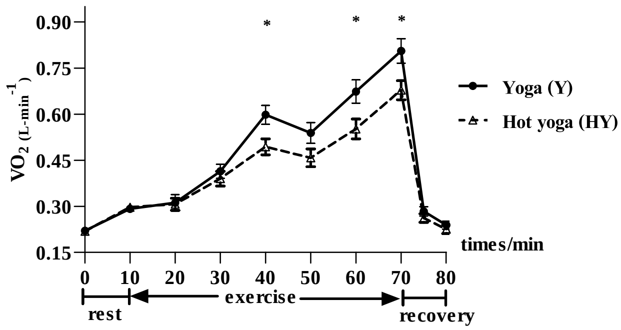

Figure 1 The oxygen consumption (VO_2) $_{(L/min)}$ between Y and HY groups

Values are mean ± SEM. ***** $p < 0.05$ significant difference between two groups

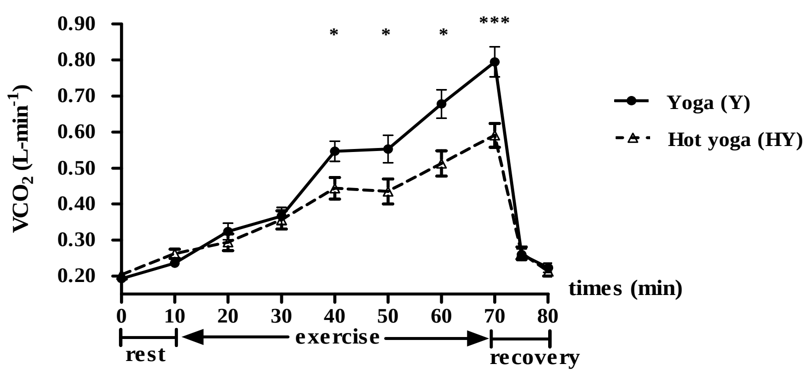

Figure 2 The Carbon dioxide production ($VCO_{2)}$ $_{(L/min)}$ between groups

Values are mean ± SEM. ***** $p < 0.05$, ******* $p < 0.001$ significant difference between groups

3.2.3 Respiratory exchange ratio (RER)

In figure 3, RER in the Y group at rest, at the end of exercise, and recovery were 0.88 ± 0.04, 0.98 ± 0.02, and 0.94 ± 0.03, while those in the HY group were 0.93 ± 0.02, 0.87 ± 0.02, and 0.95 ± 0.03, respectively. RER comparison between groups were significantly different ($p < 0.05$) at the end of exercise. Within group comparison, there was a significant difference ($p < 0.001$) in Y and HY group.

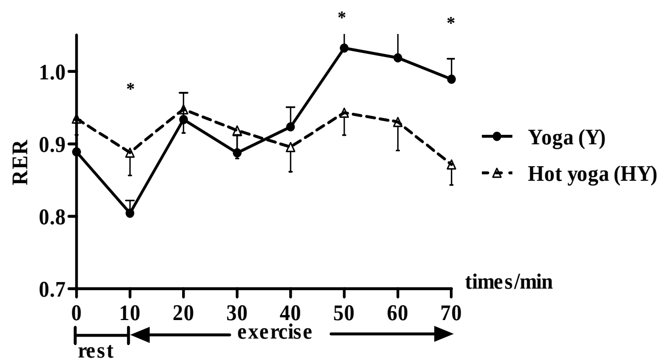

Figure 3 The Respiratory Exchange Ratio (RER) between Y and HY groups

Values are mean ± SEM. * p< 0.05 significant difference between groups

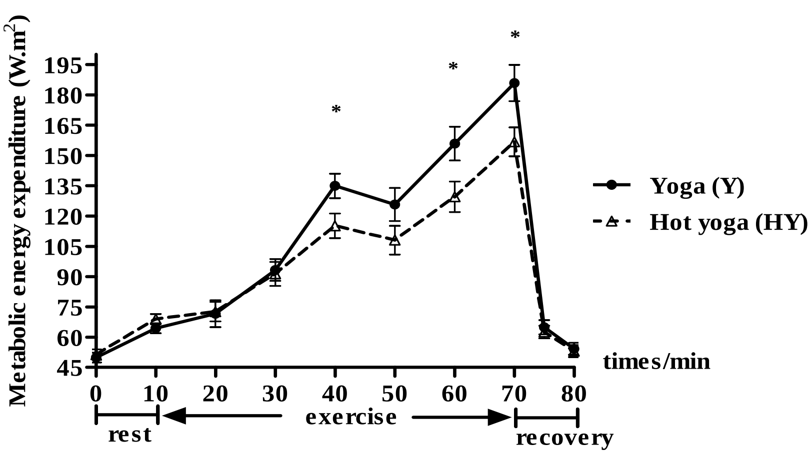

Figure 4 The Metabolic energy expenditure ($W.m^2$) between Y and HY groups

Values are mean ± SEM. * p< 0.05 significant difference between groups

Figure 4 showed the metabolic energy expenditure (M) of the two groups. The Y group expended the energy more than the HY group. The M ($W.m^2$) in the Y group at rest, the end of the exercise, and the recovery were 49.85±2.4, 185.84±8.9, and 54.25±2.9, respectively, while that in the HY group were 51.27±2.6, 156.72±7.1, and 52.99 ± 2.9, respectively. The results in this study showed that the comparison of the metabolic energy expenditure between the group were significantly different ($p < 0.05$) during the exercise and at the end of the exercise. Within the group, the comparison was significantly different ($p < 0.001$).

3.3 Subjective evaluation

3.3.1 Thermal sensation scale

The mean value of thermal sensation scale of HY group was lower than that of Y group. The thermal sensation scale in Y and HY groups at rest (in a controlled room) were 6.18 ± 0.15 and 5.21 ± 0.14, respectively. The thermal sensation from the beginning of the exercise to the end of the exercise of Y group were from 8.45 ± 0.17 to 11.29 ± 0.19, respectively, while those in HY group were from 7.79 ± 0.15 to 9.47 ± 0.16, respectively.

3.3.2 Thermal discomfort scale

The thermal discomfort from the beginning of the exercise to the end of the exercise in Y group were 1.00 ± 0.00 to 2.28 ± 0.15, respectively, while those in HY group were from 1.00 ± 0.00 to 1.28 ± 0.09, respectively. The mean value showed that the thermal discomfort in the HY group was lower than that in the Y Group.

3.3.3 Rated perceived exertion (RPE)

The RPE in Y group were 9.80 ± 0.33 to 13.70 ± 0.43 while those in HY group were 8.95 ± 0.22 to 11.65 ± 0.31, respectively. The mean value of RPE of HY group was lower than that of Y group.

4. Discussions

4.1 Energy expenditure

Prolonged exercise causes a significant increase in body temperature (both core and muscle temperatures), which is thought to have a beneficial effect by increasing the rate of metabolic reaction. The longer exercise duration under heat stress condition favoured the oxidation of carbohydrate (CHO) and caused the increase of the rate of muscle glycogenolysis, less total CHO oxidation, and high level of muscle glycogen at the point of fatigue when compared with the same exercise without the heat stress [14]. In addition, exercise in the heat could affect the circulatory system, sweat rate, and oxygen uptake leading to more energy requirement, sweat, and respiration. It was found that oxygen consumption and carbon dioxide production in both groups increased throughout exercise, yet the Y group consumed more oxygen and released more CO_2 than the HY group did. And that repeated exercise in the heat decreased oxygen uptake and carbon dioxide release. According to Lorenzo et al. (2010), physiological adaptations from heat acclimatization reduced oxygen uptake at a given power output, lowered $V0_2$ after acclimatization, and increased RER significantly from rest period. Energy expenditure in HY group was lower than that in Y group, while non-experienced individual showed tendency to utilize more carbohydrate which is the easiest available [2] than experienced one [15]. And that oxygen uptake and aerobic metabolic rate during submaximal exercise could be reduced by heat acclimatization [16].

4.2 Subjective evaluation

The RPE, thermal discomfort, and thermal sensation were higher in Y group indicated that non-experienced individuals perceived themselves working harder. Regular Yoga practice can cause a dramatic change in oxygen consumption and metabolism leading to resting metabolic rate [17]. Exercise in the heat was often accompanied with a greater 'mental effort' than that in the cool with higher RPE [18]. Therefore, external heat and internal metabolism affect the feeling of tiredness especially in non-experienced group, and these subjective discomfort [8, 19] and RPE [16, 20] would decrease after acclimatization.

5. Conclusions

During exercise, oxygen consumption (VO_2), carbon dioxide production (VCO_2), and respiratory exchange ratio (RER) in Y group increased significantly compared to those in HY. Furthermore, the metabolic energy expenditure in both groups increased from rest to the end of exercise about 49.85-185.84 and 51.27-156.72 $W.m^2$ in Y and HY groups, respectively. These indicated that non-experienced individual had tendency to utilize more CHO than experienced one. Thermoregulatory variables in both groups were significantly different. The change of time in exercise affected thermoregulatory as rectum and mean skin temperature responses in non-experienced group (Y) were faster than those of experienced group (HY). Subjective variables like RPE, thermal sensation, and discomfort scale in non-experienced group (Y) increased much faster than those in experienced group (HY). Therefore, heat acclimatization is a mandatory pre-exercise measure for sedentary people attending Hot Yoga classes.

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