

ORIGINAL RESEARCH

# The Physiological Responses to Bikram Yoga in Novice and Experienced Practitioners

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## ABSTRACT

**Context** • Bikram yoga has gained a large following, possibly because of widespread claims boasting energy expenditure of up to 1000 calories per session. However, these claims are unfounded because no scientific study has investigated the metabolic response to a complete, standardized Bikram yoga class.

**Objectives** • This study intends to determine energy expenditure, heart rate, and sweat rate in novice and experienced practitioners from a standardized Bikram yoga class.

**Setting** • Data were collected in the environmental chamber of the Exercise Physiology Laboratory at San Diego State University in California, USA.

**Participants** • Male (n=5) and female (n=19) participants between the ages of 18 and 57 y were recruited through flyers in yoga studios throughout San Diego. Participants were classified as experienced or novice practitioners, having completed  $\geq 20$  or  $< 20$  sessions, respectively.

**Interventions** • Participants were guided through a standardized 90-min yoga class performed in a hot environment using Bikram's Standard Beginning Dialogue, while expired gas was collected and heart rate was recorded.

**Outcome Measures** • Energy expenditure, calculated via

oxygen uptake, and heart rate were determined for each posture and transition period. In addition, sweat rate and core temperature were recorded for each participant.

**Results** • Mean ( $\pm$ SD) relative  $\text{VO}_2$  for the entire 90-min session was  $9.5 \pm 1.9 \text{ mL} \times \text{kg}^{-1} \times \text{min}^{-1}$ , ranging from 6.0 to  $12.9 \text{ mL} \times \text{kg}^{-1} \times \text{min}^{-1}$ . Mean absolute energy expenditure was  $286 \pm 72 \text{ kcals}$ , ranging from 179 to 478 kcals. Independent sample *t* tests revealed significant differences ( $P < .05$ ) in relative energy expenditure, heart rate, ending core temperature, and sweat rate between experience levels. Mean relative energy expenditure was  $3.7 \pm 0.5 \text{ kcal/kg}$  in novice practitioners and  $4.7 \pm 0.8 \text{ kcal/kg}$  in experienced practitioners. Percentage of predicted maximum heart rate and sweat rate were  $72.3\% \pm 10.6\%$  and  $0.6 \pm 0.2 \text{ kg/h}$  in novice practitioners and  $86.4\% \pm 5.2\%$  and  $1.1 \pm 0.5 \text{ kg/h}$  in experienced participants. All postures were classified as light-to-moderate intensity according to the American College of Sports Medicine (ACSM) standards.

**Conclusions** • Bikram yoga meets requirements for exercise of light-to-moderate intensity and, theoretically, could be used for weight maintenance or weight loss if practiced several times per week. (*Altern Ther Health Med.* 2014;20(4):12-18.)

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One of the most profound health issues in the United States is the increasing obesity rate.<sup>1</sup> Research has demonstrated that obesity leads to many health complications, such as heart disease,<sup>2</sup> diabetes,<sup>3,4</sup> cancer,<sup>3,4,5,6</sup>

hyperlipidemia,<sup>7,8</sup> and hypertension.<sup>9</sup> In an attempt to abate these health issues, the American College of Sports Medicine (ACSM) has established minimum standards that exercise programs must meet to satisfy the current recommendations for the promotion of weight maintenance and loss.<sup>10</sup>

Energy expenditure is a direct predictor of weight loss or gain.<sup>11</sup> Although the origins of yoga date back 5000 years, several forms of yoga have recently gained popularity in contemporary society,<sup>12,13</sup> which has sparked an interest in research focusing on various health outcomes associated with yoga practice.

Meta-analysis of 18 studies investigating the health benefits of yoga demonstrated the superiority of yoga over other forms of exercise for improving self-reported health status, aerobic fitness, and muscular strength in elderly

populations.<sup>14</sup> However, effect sizes and precision across studies were low and further research is needed to investigate other health-related measures. In addition, several intervention studies have demonstrated the positive effect of yoga on the blood-lipid profile of individuals presenting conditions such as hypertension, coronary artery disease, obesity, and diabetes mellitus.<sup>15,16</sup> Although these studies provide insight into some benefits of yoga, they do not evaluate the exercise intensity and/or caloric cost of yoga as a mode of physical activity or its effectiveness as a weight loss tool.

Therefore, a more useful measure of the effectiveness of yoga as an exercise mode is measurement of energy expenditure and/or caloric cost. Several studies have attempted to quantify the caloric expenditure associated with yoga. One such study measured the energy expenditure of a 30-minute hatha yoga session.<sup>17</sup> Twenty-six women participated in a taped, hatha yoga routine, during which energy expenditure data were collected each minute and then averaged to determine the response for the entire session. Results indicated that the hatha yoga routine elicited a caloric expenditure of 2.2 kcal/min or 66.9 kcal per 30-minute session. A similar study was conducted in which 40 men familiar with yoga practice for at least 6 years performed a 1-hour yoga class in a laboratory.<sup>18</sup> Between each asana, oxygen consumption was measured for each participant while in the supine position. Although certain yoga asanas required higher energy expenditure in comparison with others, results indicated that the average, total energy expenditure for the session was 55 kcal or 18% lower than the results from the previous study.

However, various studios and media sources have separated a specific style, known as Bikram, from other traditional forms of yoga. Drawing foundations from hatha yoga, Bikram Choudhury developed this style in the 1970s. A standard Bikram yoga practice is a 90-minute session in a room set to a temperature of 105°F and 40% relative humidity, during which a set of 26 specific postures, repeated twice, and 2 breathing exercises are performed.<sup>12,19</sup> This style has gained a large following, as evidenced by the \$5.7 billion revenue from class purchases in 2009 alone,<sup>20</sup> possibly because of widespread claims from Web sites and studios boasting caloric expenditures of up to 1000 calories per session.<sup>12,21</sup> However, these claims are unfounded because no scientific study has investigated the metabolic response to a complete, standardized Bikram yoga practice.

Therefore, the current study investigated energy expenditure, heart rate, sweat rate, and core body temperature that was associated with a full-length, standardized, Bikram yoga class. The research team also classified the intensity level, according to ACSM standards,<sup>22</sup> of each class component. The team hypothesized that a Bikram session would elicit greater energy expenditure than demonstrated in previous studies and that novice and experienced practitioners would differ in their physiological responses because of adaptations that would occur with increased practice.

## MATERIALS AND METHODS

### Participants

Twenty-six healthy male and female volunteers, aged 18 to 57, were recruited through flyers posted in San Diego's yoga studios. In addition, some participants were informed of the study by previous participants. Participants contacted the primary investigator, either by e-mail or a phone number posted on the recruitment flyer. When a potential participant contacted the investigator, the recruitment script was read or sent electronically to inform the individual of the study's details. Participation was voluntary, which was expressly stated to the participant. If the individual both qualified and wished to participate after receiving all details of the study, he or she was scheduled for a session in the laboratory.

Upon arrival at San Diego State University's exercise physiology laboratory, participants completed the Physical Activity Recall Questionnaire (PAR-Q) to screen for cardiovascular risks in performing moderate-intensity exercise.<sup>23</sup> Any positive responses to questions from the PAR-Q eliminated the individual from selection. The participants then signed an informed consent form, which was approved by San Diego State University's Institutional Review Board.

In addition, all women provided a urine sample, which was tested for pregnancy. Any positive responses resulted in exclusion from the study. All participants had completed at least 2 Bikram yoga classes to ensure that participants were familiar with the basic principles. Participants reported their yoga experience level by providing the total time they had practiced yoga and the average number of times per week they attended classes. Participants were classified as novice if they had completed <20 Bikram yoga sessions and experienced if they had completed ≥20 sessions.

### Intervention

The intervention was a 90-minute session of Bikram yoga. Before beginning the session, each participant was given the chance to practice and review each posture. When ready to begin, participants were guided through the session using an audio recording, "Bikram's Beginning Yoga Class,"<sup>24</sup> which was played on speakers in the environmental chamber where the session took place. During the class, 26 postures, repeated twice; 2 breathing exercises; and 2 savasanas were performed. A full-length mirror was provided to enable the participants to view themselves while doing the postures. Standard water breaks occurred, with the first break taking place after the Eagle Pose,<sup>19</sup> and then water was allowed as needed by the participant.

### Procedures

Participants' baseline measures were taken prior to their entering the environmental chamber. To determine sweat rate, the weight of each participant was measured on a balance-beam scale to the nearest 0.1 kg in dry clothes before starting the yoga session. After being weighed, the participant changed into a separate set of clothes for the session. At the

conclusion of the class, the participant dried off and was reweighed in the original set of dry clothes. In addition, fluid consumption was recorded during the session. Participants were allowed to drink water without restriction, and the consumed fluid weight was then subtracted from the participant's final weight. Oral temperature was also measured prior to the participant entering the environmental chamber.

Upon entering the chamber, the participant was outfitted with a nose clip and 1-way valve (Hans-Rudolph, Shawnee, KS, USA) that was attached to a mouthpiece and secured with headgear. The headgear also allowed the participant to exert minimal effort to hold the apparatus in his or her mouth during the session. In addition, each participant wore a Polar heart rate monitor strapped across the torso that was linked to 2 watches, 1 worn by the participant and the other by an investigator.

Oxygen uptake was measured with a metabolic measurement cart (TrueOne, Parvomedics, Sandy, UT, USA). The metabolic system was calibrated with a 2-point calibration method, using both ambient air and standardized gas (16% O<sub>2</sub> and 4% CO<sub>2</sub>). In addition, the system was also physiologically calibrated by measuring a participant's VO<sub>2</sub> response to walking at 4.8 km/h on a treadmill. Values elicited from this test were referenced against predicted values to ensure that reasonable values were observed.<sup>25</sup>

Heart rate data were recorded for the entire class, with measurements taken while a participant was holding each posture and during the break following each posture. Participants were allowed to lie down and rest as needed, as well as leave the environmental chamber if they needed to cool down, as is typical in a Bikram yoga class.<sup>19</sup>

#### Data Analysis

Data were analyzed using SPSS software (IBM Corporation, Armonk, NY, USA). Independent sample *t* tests were used to compare means of novice and experienced practitioners. Significance was set at *P* ≤ .05.

**Table 1.** Relative Oxygen Consumption, METS, and Intensity Level for Each Posture<sup>a</sup>

Pose	Mean VO <sub>2</sub> (mL × kg <sup>-1</sup> × min <sup>-1</sup> )	METS	Intensity Level	Mean HR (BPM)
Standing Deep Breathing	5.85	1.67	Light	95
Half-Moon	7.79	2.23	Light	141
Awkward	9.39	2.68	Light	153
Eagle	13.00	3.71	Moderate	147
Standing Head to Knee	13.15	3.76	Moderate	160
Standing Bow	13.93	3.98	Moderate	162
Balancing Stick	13.24	3.78	Moderate	165
St. Sep. Leg Stretching	11.52	3.29	Moderate	130
Triangle	12.23	3.49	Moderate	168
St. Sep. Leg Head to Knee	11.15	3.19	Moderate	143
Tree	9.43	2.69	Light	150
Toe Stand	7.18	2.05	Light	137
Savasana	6.55	1.87	Light	105
Dead Body	7.65	2.18	Light	118
Cobra	8.47	2.42	Light	142
Locust	9.43	2.69	Light	148
Full Locust	9.59	2.74	Light	153
Bow	10.10	2.89	Light	150
Fixed Firm	9.42	2.69	Light	124
Half Tortoise	9.18	2.62	Light	119
Camel	8.95	2.56	Light	152
Rabbit	9.70	2.77	Light	145
Head to Knee	8.97	2.56	Light	139
Spine Twisting	8.28	2.37	Light	145
Blowing in Firm	8.60	2.46	Light	141
Savasana	5.71	1.63	Light	108
<b>Full Practice Average</b>	<b>9.56</b>	<b>2.73</b>	<b>Light</b>	<b>140</b>

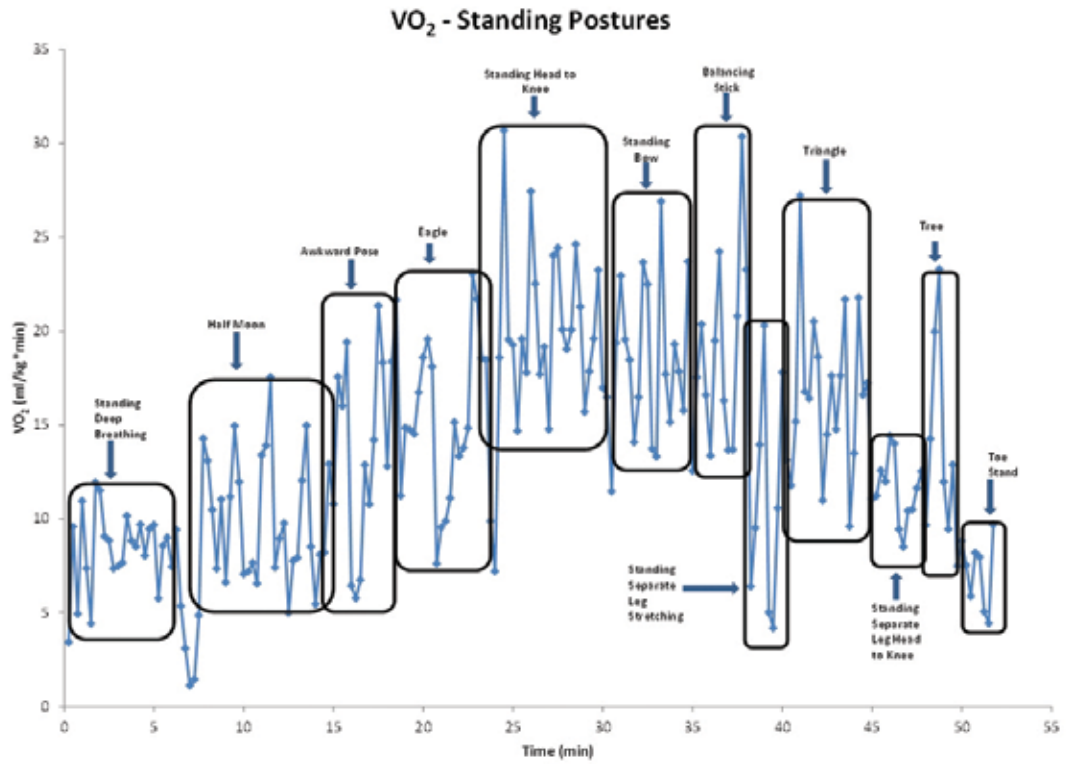
Abbreviations: VO<sub>2</sub> = oxygen uptake; BPM = beats per minute; St = standing; Sep = separate; METS = metabolic equivalent values.

<sup>a</sup>Values are expressed as means.

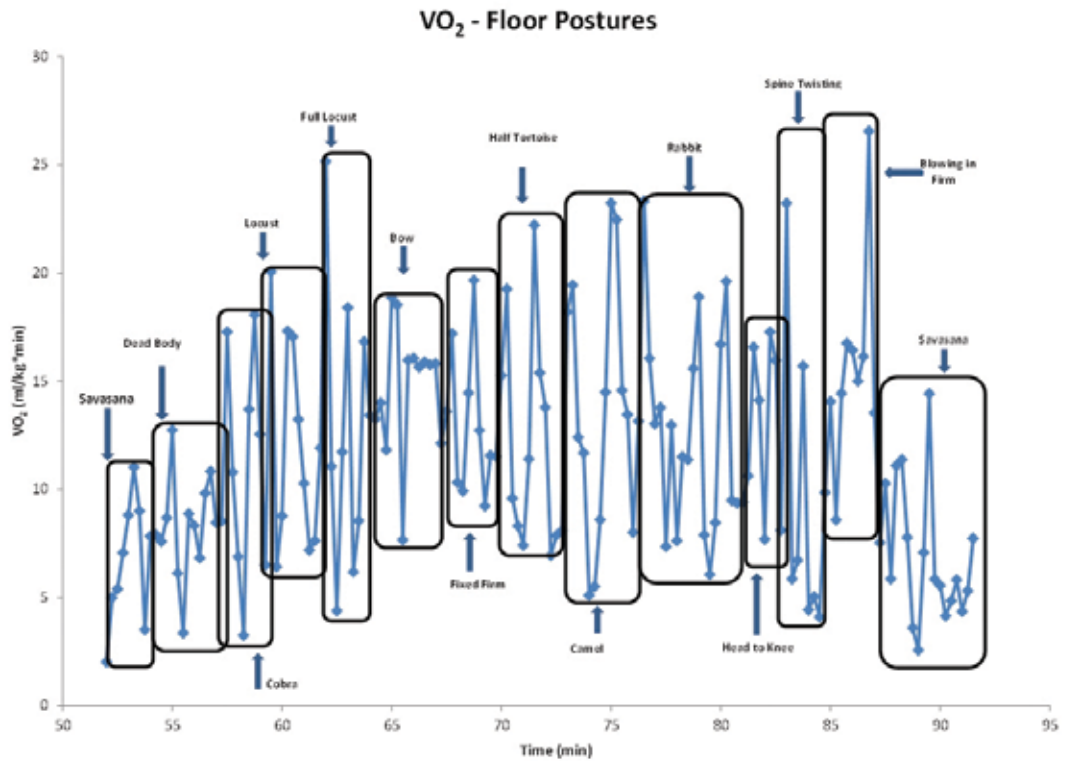
#### RESULTS

Twenty-four participants between the ages of 18 and 57 years (32.7 ± 13.3) were recruited for the study. The sample included 5 men with a mean body mass index (BMI) of 21.6 ± 2.0 kg/m<sup>2</sup> and 19 women with mean BMI of 24.7 ± 4.3 kg/m<sup>2</sup>. Mean relative VO<sub>2</sub> for the entire Bikram session for all participants was 9.5 ± 1.9 mL × kg<sup>-1</sup> × min<sup>-1</sup>, ranging from 6.0 to 12.9 mL × kg<sup>-1</sup> × min<sup>-1</sup>. According to the ACSM classification system, the intensity of postures ranged from light, <3.0 METS, to moderate, 3.0 to 6.0 METS, with the majority classified as light intensity. Intensity level of all postures can be found in Table 1.

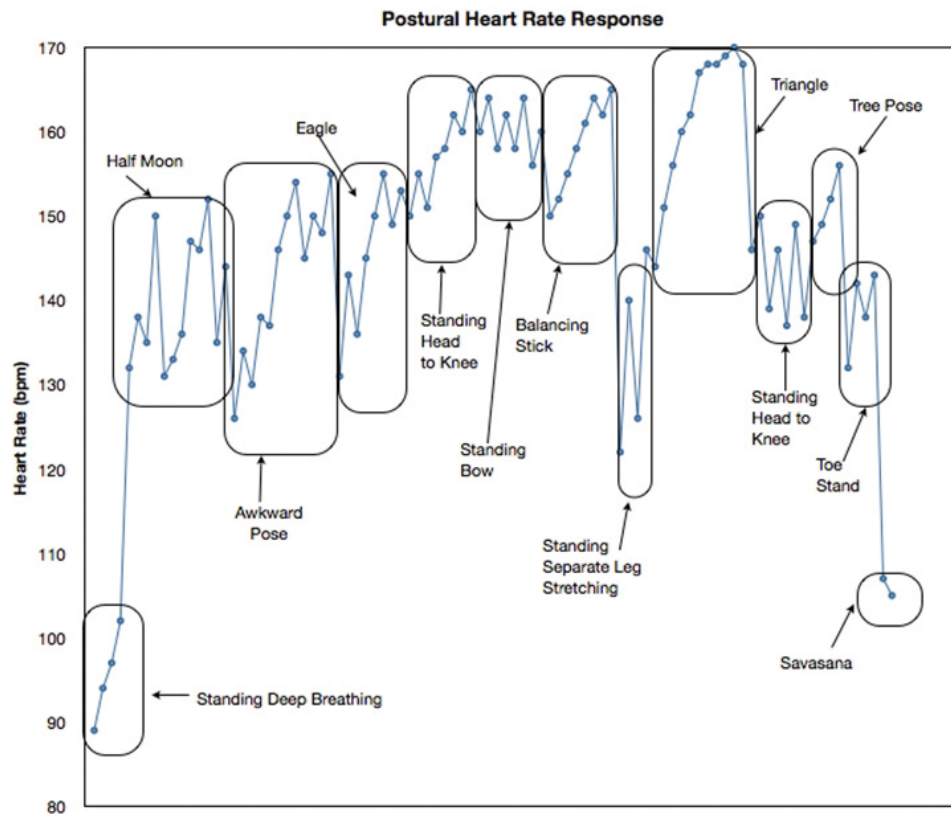
**Figure 1.** Oxygen Uptake ( $VO_2$ ) for a Representative Participant During the Standing Series of Postures



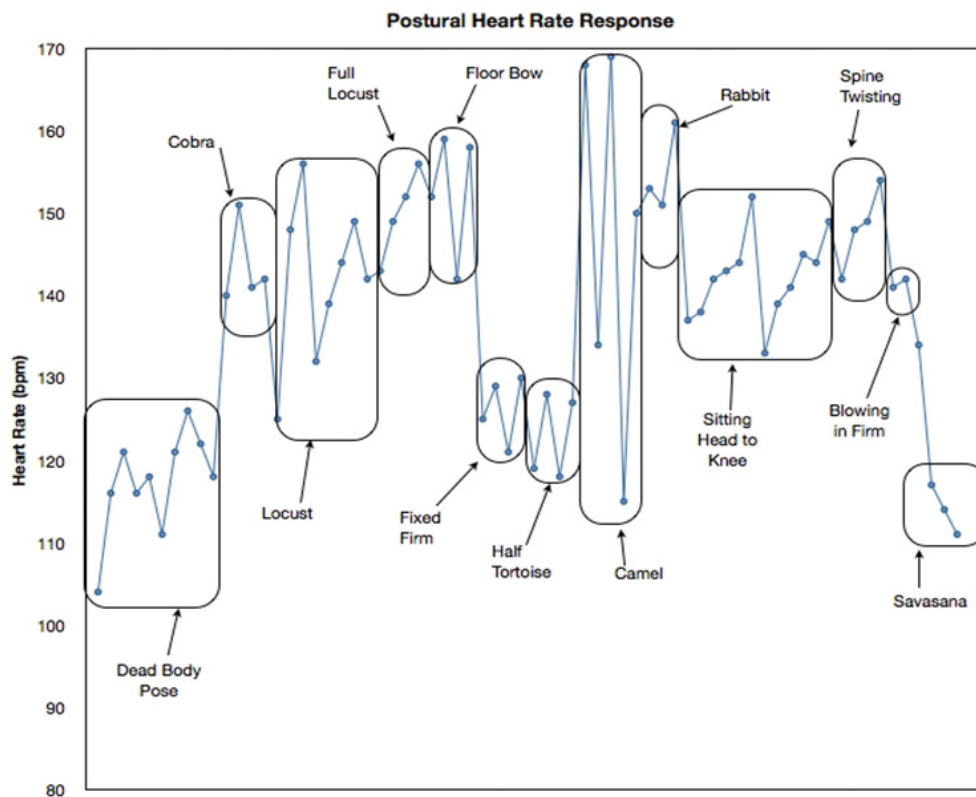
**Figure 2.** Oxygen Uptake ( $VO_2$ ) for a Representative Participant During the Floor Series of Postures



**Figure 3.** Heart Rate for a Representative Participant During the Standing Series of Postures



**Figure 4.** Heart Rate for a Representative Participant During the Floor Series of Postures





Mean absolute energy expenditure per session was  $286 \pm 72$  kcal, ranging from 179 to 478 kcal. The Pearson correlation coefficient revealed a relationship of  $r = 0.601$  between body weight and energy expenditure; total expenditure was divided by body weight to standardize values. Relative mean kcal/kg were  $3.7 \pm 0.5$  kcal/kg in novice practitioners and  $4.7 \pm 0.8$  kcal/kg in experienced practitioners. A representative, oxygen-uptake response for both standing- and floor-series postures is depicted in Figures 1 and 2.

Sweat rate for the class was calculated via the following formula: sweat rate (kg/h) =  $(BW_i - [BW_p - (F_i - F_p)]) / \text{time}$ , where  $BW_i$  was body weight prior to the session,  $BW_p$  was body weight following the session,  $F_i$  was fluid weight prior to the session,  $F_p$  was fluid weight following the session, and time was equal to 1.5 hours.

Mean heart rate was highly variable across postures. In general, higher heart rate responses were observed during standing postures. A representative heart rate response for both standing- and floor-series postures is depicted in Figures 3 and 4. Mean postural heart rates are found in Table 1. Percentage of predicted maximum heart rate (%PMHR) was calculated using the formula  $\text{PMHR} = 220 - \text{the participant's age}$ . Maximum heart rate for the session was then divided by this value to obtain the %PMHR.

The independent samples  $t$  test ( $\alpha = .05$ ) revealed significant differences in relative energy expenditure ( $P < .002$ ), %PMHR ( $P < .001$ ), and sweat rate ( $P < .006$ ) between experience levels. Means and standard deviations can be found in Table 2. All parameters met Levene's assumption for the homogeneity of variance.

## DISCUSSION

The major finding of the current study was that the energy cost of a complete, standardized Bikram class was found to be substantially lower than commonly advertised values.<sup>12,21</sup> The majority of postures only met requirements for light-intensity exercise as established by ACSM.<sup>22</sup> Postures meeting moderate-intensity requirements were standing, balancing postures—eagle, standing head to knee, standing bow, balancing stick, standing separate leg stretching, triangle, and standing separate head to knee. This finding is likely because of the increased number of muscle groups required to perform the poses correctly. Average intensity of the entire session was 2.9 METS, categorizing Bikram yoga as a light-intensity exercise modality.

Oxygen consumption, or energy expenditure, is directly dependent on the work required to perform an activity. Work has been defined as the product of force and the distance through which the force is moved.<sup>26</sup> Force in the session was dependent upon both body weight and the force of contraction of the engaged musculature. Absolute expenditure values were divided by body weight to standardize energy expenditure as a relative value, removing any effect of body weight. The remaining variability depended on how forcefully participants contracted their muscles and the total number

of muscles engaged. In yoga terms, *full expression* of a posture requires maximum contraction of several different muscle groups, depending on the pose.

For example, the balancing stick posture requires engagement of both the standing and the airborne leg, the abdominal muscles, the spinal muscles, and the arms. The significant differences found between novice and experienced practitioners likely depended on the degree to which full expression was reached. Experienced individuals likely had a higher level of muscle engagement than novice practitioners, who were not as proficient in the poses. Future research should measure the exact engagement of the musculature to provide further insight into these differences.

The distance component of the work performed also depended on how far the participant moved in each posture or what their ability to reach full expression was (ie, the maximum range of motion within the posture). Experienced participants were able to lift their limbs higher in many of the postures, thus increasing the workload of the session.

The significant differences found in energy expenditure between experience levels were substantiated by the concurrent significant differences found between experience levels in sweat rate, %PMHR, and change in oral temperature, because increases in all of these variables indicated increased exercise intensity.

Scientific literature has demonstrated the possible effect of body composition on energy expenditure<sup>27</sup>; however, no significant differences in BMI were found between the novice and experienced practitioners, suggesting that the differences were not because of discrepancies in body composition but rather because of discrepancies in the participant's ability to perform the postures. BMI data can be found in Table 2. However, the literature has demonstrated the inability of BMI to accurately predict body composition in highly trained individuals.<sup>28</sup> Therefore, future research should measure body composition via a method with higher validity, such as skin folds or hydrostatic weighing, to provide greater insight on the possible effect of body composition on energy expenditure in Bikram yoga.

Heart rate was variable across postures and individuals; however, for many participants, observed heart rates were higher than expected when compared with the corresponding  $\text{VO}_2$  values.<sup>29</sup> This finding is consistent with previous findings that have demonstrated the relationship between an increased heart rate and elevated body temperature.<sup>30</sup> Elevated heart rates in environments with high ambient temperatures have been explained as a reactionary mechanism to the shift in blood flow toward the cutaneous vessels, which occurs to maintain thermal homeostasis.<sup>31</sup> This shift in blood flow results in reduced stroke volume and, therefore, an increased heart rate to maintain cardiac output during exercise.

Therefore, both heart rate and the %PMHR that was reached are poor indicators of exercise intensity in Bikram yoga. This conclusion is also consistent with studies investigating other forms of yoga that are not practiced in the heat.<sup>32</sup> This disparity suggests that additional factors may be

**Table 2.** Physiological Responses in Novice and Experienced Practitioners

Response	Novice Mean (SD)	Experienced Mean (SD)
Relative energy expenditure (kcal/kg)	3.7 ± 0.5	4.7 ± 0.8 <sup>a</sup>
%PMHR (%)	72.3 ± 10.6	86.4 ± 5.2 <sup>a</sup>
Sweat rate (kg/h)	0.6 ± 0.2	1.1 ± 0.5 <sup>a</sup>
Oral temperature increase (°F)	1.0 ± 1.2	1.8 ± 1.4 <sup>a</sup>
BMI (kg/m <sup>2</sup> )	25.4 ± 4.1	23.1 ± 3.9

Abbreviations: PMHR = percentage of predicted maximum heart rate.

<sup>a</sup>Indicates a significant difference between groups.

involved in heart rate control during yoga. One possible explanation demonstrated in the literature is the elevated heart-rate responses associated with isometric contraction.<sup>33</sup> This finding would also explain the significantly higher heart rates found in experienced practitioners because they were likely contracting more musculature than novice practitioners. Future research should investigate additional mechanisms that might be involved in chronotropic responses (ie, those that change the heart rate because of yoga).

The major limitation of the current study is that it only measured the energy expenditure of a single Bikram yoga class. Other potential health benefits of regular participation in Bikram yoga should be investigated by future research.

## CONCLUSION

In comparison with other exercise modalities, the metabolic cost and intensity level of Bikram yoga is relatively low and appears to be related to the practitioner's experience level, because increased experience elicits higher energy expenditure and physiological responses. Furthermore, the low effect and intensity associated with Bikram postures makes Bikram a potential alternative for individuals with joint problems who cannot engage in many traditional forms of exercise or individuals who prefer light over moderate- or vigorous-intensity exercise. Clearly further studies that examine the health benefits of yoga and involve larger populations for longer periods of time are warranted.

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