**Abstract**

*Background:* Hatha yoga has become a popular form of exercise that has demonstrated to elicit marked increases in muscular strength and muscular flexibility. However, minimal inquiry towards its influence on cardiovascular health and performance is available. *Methods:* Published investigations including and preceding December 2016 were systematically reviewed and appraised. The terms, “Yoga”, “Yoga AND Exercise”, “Yoga AND Exercise Test” identified 337 articles, 6 of these articles were relevant and utilized in this review. *Results:* The cardiovascular demands on a Bikram yoga class appear to be light in nature while further demonstrating individual variation in metabolic cost and heart rate. The variations observed may have been a result of a diverse sample size with age, sex and fitness. Short term (ie. 8 wks) adaptions failed to demonstrate a significant difference in resting cardiovascular measurements with minimal support for enhancing aerobic power. Long term (ie. 1yr) Bikram yoga practice may elicit position adaptions in resting heart rate, systolic and diastolic blood pressure in obese individuals. There remained a lack of significant difference when examining cardiovascular performance measures between long term and novice Bikram yoga practitioners. *Conclusions:* Bikram yoga continues to increase in popularity as an alternative exercise option; however minimal evidence exists demonstrating its positive impact on cardiovascular health and performance. It appears this form of light exercise may be an effective and exciting means of activity for individuals looking to start an exercise program. Individuals wishing to pursue this form of exercise are encouraged to acquire approval and consent from a medical doctor and a certified exercise professional prior to starting. **Health & Fitness Journal of Canada 2016;8(3):3-13 [Vol(issue):Pages].**

*Keywords:* [Cardiovascular, Heat Stress, Exercise, Yoga, Thermoregulation]

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**Introduction**

 Hatha yoga is a popular branch of yoga that includes physical postures held for periods of time that flow into proceeding postures. Each pose challenges participants to maintain correct posture and form throughout each transition and the entire session. Hatha yoga is commonly practiced and is widely accepted for its health benefits in the Middle East especially in India (Bhavanani, 2003; Corliss, 2001; Dash & Telles, 2001; Ray, Sinha, Tomer, & Pathak, 2001; Telles, Praghuraj, Ghosh, & Nagendra, 2006). Recently due to its popularity in North America it has become more accepted in the fitness industry as an alternative means of exercise and health (Corliss, 2001; Garfinkel & Schumacher, 2000). Longitudinal research has demonstrated regular participation in Hatha yoga is correlated with improved muscular strength, flexibility (Bhavanani, 2003; Dash & Telles, 1999; Tran, Holly, Lashbrook, & Amsterdam, 2001; US RAY et al., 2001) and improved exercise tolerance and aerobic capacity (US RAY et al., 2001). Additionally, enhanced pulmonary function has also been demonstrated with regular Hatha yoga participation (Bhavanani, 2003; Harinath et al., 2004; Joshi & Gokhale, 1992; Makwana, Khirwadkar, & Gupta, 1988; Telles, Nagarathna, Nagendra, & Desiraju, 1993; Yadav & Das, 2001). When examining cardiovascular adaptations to Hatha yoga and its ability to positively influence parameters such as aerobic power (VO2max), resting heart rate (RHR) and resting blood pressure (BP) current literature reveals diverse results (Bowman et al., 1997; Harinath et al., 2004; Murugesan, Govindarajulu, & Bera, 2000; Raju et al., 1994; Raju, Prasad, Venkata, Murthy, & Reddy, 1997; Telles et al., 1993; Tran et al., 2001). The slow paced, separated nature of this style of yoga involving durations of static stretching are thought to be too light of a stimulus to positively enhance aerobic performance (Clay, Lloyd, Walker, Sharp, & Pankey, 2005; Prasad, Ramana, Raju, Reddy, & Murthy, 2001). However, the observed diversity of results may be in part to the wide range in participant age, health status, physical activity habits, experience practicing yoga and the variation in the style and intensity each Hatha yoga class provides.

Bikram yoga has recently developed into a popular alternative in North America to the traditional style of Hatha yoga (Orsini-Meinhard, 2005). Bikram yoga was developed and brought to the public by Bikram Choudhury in the early 1970’s. Commonly referred to as hot yoga this unique and standardized practice sets itself apart from other forms of hot yoga. Bikram yoga involves 26 Hatha style postures that are standardized and led by certified Bikram yoga instructors who have completed a 9 week intensive training course through Bikram’s Yoga College of India (Tracy & Hart, 2013). This style of yoga is performed in a specialized studio that controls its ambient temperature to the exact specifications required for all Bikram yoga classes. An ambient temperature between 35-40oC with a relative humidity level between 40-60% must be held for the entirety of each Bikram yoga class offered. This style of yoga is believed to be more intense than the traditional option and involves rapid transitions between each of the 26 postures providing a considerable cardiovascular response and development of muscle fatigue (Tracy & Hart, 2013). With its recent gain in popularity there remains limited inquiry into the cardiovascular demands required. Therefore, the purpose of this systematic review was to examine the cardiovascular demands of a single hot yoga class and to examine the long term cardiovascular adaptations observed when practicing hot yoga.

**Methods**

A systematic review on Bikram Yoga was conducted and several electronic databases were investigated (MEDLINE, Embase, SPORTDiscus). 806 articles were identified which involved yoga and its relation to cardiovascular demands and adaptations, physical fitness or physical fitness testing. Six articles were included in the review: (n=4) examined an 8 week Bikram Yoga intervention and its ability to positively influence cardiovascular parameters; (n=1) examining a single Bikram yoga session and its cardiovascular demands; and (n=1) examining the long term cardiovascular benefits in experienced Bikram yoga practitioners.

A thorough process was completed to ensure all relevant articles were included (Figure 1). This review was able to identify six articles (Table 2) that examined hot yoga and its influence on the cardiovascular system. Bikram yoga is the only style of hot yoga researched to date when examining its temporary or long term effect on the cardiovascular system. Each Bikram yoga class lasts 90 minutes in duration and encompasses 60 minutes of standing and balance postures and 30 minutes including seated postures which finish with two breathing exercises (Abel, Lloyd, Williams, & Miller, 2012; Pate & Buono, 2014). Each posture is repeated twice, held for a period of time that requires strong muscular contractions and calls upon each joint to be used in its full range of motion. This exclusive standardized style of hot yoga makes it unique and more suited for research purposes; potentially explaining why each of the 6 articles found in this review involved this licensed form of hot yoga (Tracy & Hart, 2013).

 A modified Downs and Black scoring system (Downs and Black, 1998) was utilized to assess the quality of the included articles. The questions from the original Downs and Black scoring system that were applicable to the topic of this systematic review were included. The question number from the original scoring system was maintained to provide clarity to the reader. The included questions were selected by the reviewers prior to any scoring of the articles. The results of the modified Downs and Black scoring system are provided (Table 3).

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|  |  |  |  |  |  |
|  | **Citations examined from electronic database search:** |
|  | MEDLINE |  |  |  | 436 |
|  | EMBASE |  |  |  | 576 |
|  | SportDiscus |   |   |   | 332 |
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|  | **Total with duplicates excluded (n = 806)** |  |
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|  | **Citations excluded after scanning titles (n = 615)** |
|  |  |  |  |  |  |
|  | **Total abstracts assessed for eligibility after scanning titles** **(n = 193)** |
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|  | **Citations excluded after assessing Abstracts (n = 187)** |
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|  | **Total full articles assessed for eligibility after**  |
|  | **assessing Abstracts (n = 6)** |  |  |
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|  | **Articles excluded after full review (n = 0)** |  |
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|  |  |  |  |  |
|  |  | **Total** | **Total n = 6** |   |
|  |  |  |  |  |  |
| **Figure 1** Citations examined for systematic review. |  |

**Cardiovascular Demands of a Single Bikram Yoga Session**

The physical postures required to perform a Bikram yoga class are advertised as both mentally and physically challenging. Each posture demands participants to have full control over each body movement while forcefully contracting their muscles for a lengthy period of time, all the while coping with the environmental heat stress (Abel et al., 2012). The physical demands of a Bikram Yoga class are thought to be in contrast to the more common and less standardized form of Hatha yoga. Previous literature has demonstrated Hatha yoga to elicit low to moderate metabolic and cardiovascular demands which further depend on the teaching variability of the yoga instructor (Harinath et al., 2004; US RAY et al., 2001). Only a single article was identified that directly measured the metabolic demands of an entire Bikram yoga class. Pate and Buono (2014) recruited both novice and experienced Bikram yoga practitioners to perform a full 90 minute Bikram yoga session in an environmental chamber that matched the requirements for a standardized Bikram yoga class. Each participant was outfitted with a one way Hans Rudulph non-rebreathing valve that was attached to a True One Parvomedics metabolic cart in an effort to examine the oxygen demands for each of the 26 postures. On average the metabolic demand for all 26 postures during the 90 minute session was 9.56 mL•kg-1•min-1, an average metabolic equivalent (MET) score of 2.73 mL-1•kg-1•min-1 (Table 1) (Pate & Buono, 2014). According to the American College of Sports Medicine a MET that is <3, 3-6 and >6 is considered light, moderate and vigorous activity (Medicine, 2013). Although the range in both the MET and metabolic demands was greatly dependent on the posture, the average session provided little demand on the cardiovascular system. However, when examining a single participants response a peak VO2 reaching as high as 35mL•kg-1•min-1 during a standing pose was observed (Table 1). With a sample mean age of 32.7, comprised of both sexes, this highlighted individual response not only sheds light on the diverse fitness levels involved in the study but may suggest how a standardized Bikram session can elicit varied cardiovascular responses that may be dependent on fitness and sex. This transient VO2 value achieved in a random participant may indicate a potentially large but yet short term stress than can be placed on the cardiovascular system during periods of Bikram yoga. According to the American College of Sports Medicine guidelines this transient VO2 value occurring in a sample with a mean age of 32.7 would be considered a VO2max score for most women and a slightly below average value for most men (Medicine, 2013). Furthermore this observation exhibits the variation within each participant’s cardiovascular response and fitness levels, a potential constraint for ascertaining the metabolic demands of 90 minute Bikram yoga class. Further investigation is warranted to identify the metabolic demands between fit and unfit individuals and between age and sex differences.

**Cardiovascular Adaptations to Short and Long Term Bikram Yoga Practice**

**Short Term 8 Week Intervention**

The implementation and practice of yoga into society’s exercise regime has been reinforced by its multi approach to improving health and overall wellbeing. Yoga’s ability to enhance one’s feeling of wellbeing, improve psychological functioning along with mitigating overall perceived levels of stress have been well documented (Carmody & Baer, 2008; Carmody, Baer, LB Lykins, & Olendzki, 2009). Finding an alternative option to participate in an exercise program that not only improves the physiological but also the psychological wellbeing is an attractive option for beginners who are looking to become more physically active and improve their health.

Three, eight week Bikram yoga interventions examining its ability to positively influence cardiovascular functioning were identified for this review as seen in Table 2. Only a single investigation recruited participants who were already somewhat active and continued their regular training during the hot yoga intervention**.** Each remaining investigation involved a sedentary population with an extensive range in age.

An eight week intervention was utilized in each study based on preliminary research on Bikram yoga’s ability to positively influencing balance, muscular strength and steadiness in young adults (Hart & Tracy, 2008). The single randomized control study in this review found no change in VO2max, RHR and resting systolic blood pressure in both the control and intervention groups after an eight week intervention (Tracy & Hart, 2013). Although the participants were young adults who had little to no experience with yoga and were considered sedentary; the implementation of 24 Bikram yoga sessions failed to elicit any positive cardiovascular adaptations after eight weeks as seen in Table 4. (Tracy & Hart, 2013)When examining the resting systolic and diastolic blood pressure response after eight weeks Hunter et al., demonstrated no significant change between pre and post values in both young and old participants (Hunter et al., 2013).

However, the main objective of their investigation focused on arterial stiffness and its response to an 8 week Bikram yoga intervention. Their results demonstrated a significant reduction in arterial stiffness only in younger participants (Hunter et al., 2013). They hypothesized that these results may have been from the following adaptations. First, the stretching involved in yoga could have induced a traction stimulus to the arteries where the smooth muscle and cell matrix adaptations may have positively affected the cross sectional arterial compliance (Hunter et al., 2013). Previous literature from the same investigators supports this hypothesis (Abel et al., 2012). A second possible explanation in the reduced stiffness may have been initiated from reductions in sympathetic vasoconstrictor tone on the arterial walls from enhanced relaxation and meditation experienced during each yoga session (Hunter et al., 2013).

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| **Table 1. Metabolic demands of a 90 minute Bikram Yoga class**

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| --- | --- | --- | --- |
| Study | VO2 (mL•kg-1•min-1) | METS | Mean Intensity |
| Mean*(26 poses)* | Range  *(26 Poses)* | Range  *(Individual Participant)* | Mean | Range |
| Pate J,L. & Buono, M,J. (2014) | 9.56 | 5.71;13.93 | 2.5;35 | 2.73 | 1.63;3.98 | Light |

**Table 2. Investigations Included in the Cardiovascular Adaptations and Responses to Hot Yoga Review** |
| Publication | Study Design | Purpose | Population | Sample Size | Age |
|
| (mean ± SD[range]) |
| **1 Year Study**  |
| Guo et al., (2014) | Prospective Cohort | Examine the change in physical and mental wellbeing in middle aged and young overweight women | Active overweight female yoga club members | 36.8 | 36.8 [18-48] |
| **8 Week Study** |
| Hunter et al., (2013) | Prospective Cohort | Examine the change in arterial stiffness between young and old populations after 8 weeks of Bikram Yoga involving 90 minutes sessions 3 times per week. | Sedentary males and females for ≥6 months leading into experiment | Young - 24 Old - 18 | Young - 30 ± 1 Old - 53± 2 |
| Hewett et al., (2011) | Prospective Cohort | Examine the change in mindfulness, physical fitness and perceived stress after 8 weeks of Bikram Yoga involving 90 minutes sessions 3 times per week. | Males and females with no previous experience with Bikram Yoga for two years before intervention. 20% were already engaged in physical activity leading into the study and continued throughout. | 80 | 31.57 ± 9.29 |
|  |  |  |  |  |  |
| Tracy,B,L. & Hart,C,E.F., (2013) | Randomized Controlled | Examine the change in physical fitness in healthy young adults after 8 weeks of Bikram Yoga involving 90 minutes sessions 3 times per week. | Males and females who participated in ≤2hrs of purposeful activity per week with no experience practicing yoga for 4 months leading into the intervention. | Yoga - 21 Control - 11 | Yoga – 29.0±6.1[21-39] Control - 25.1±5.0 [21-39] |
| **Single Session Study** |
| Pate J,L. & Buono, M,J. (2014) | Cross Sectional | Examine the physiological response of a single Bikram Yoga session in novice and experienced Bikram Yoga practitioners. | Male and female Bikram Yoga practitioners were considered novice if their total session completed were <20 or considered experienced if they complete ≥20 sessions | 24 | 32.7 ± 13.3 [18-57] |
|  |  |  |  |  |  |
| Abel et al., (2012) | Cross Sectional | Examine the differences in physiological characteristics between long and short termed Bikram Yoga practitioners | Male and female Bikram Yoga practitioners where considered short term experienced if practicing for < 3months or long term experienced if practicing for ≥ 1 year  | Short Term - 17 Long Term - 14 | Short Term - 43.88 ± 11.54 Long Term - 38.39±9.31 |

**Table 3. Modified Downs and Black Scoring System**

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|   |   |   |   |   |   |   |   |   |   |   |   |   |
| **No.** | **Article** | **Q1** | **Q2** | **Q3** | **Q4** | **Q5** | **Q6** | **Q7** | **Q8** | **Q9** | **Q10** | **Q13** |
| **(/1)** | **(/1)** | **(/1)** | **(/1)** | **(/2)** | **(/1)** | **(/1)** | **(/1)** | **(/1)** | **(/1)** | **(/1)** |
| **1** | **Tracy & Hart, 2013** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** |
| **2** | **Hunter el al., 2013** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **0** | **1** |
| **3** | **Guo et al., 2014** | **0** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **0** | **1** |
| **4** | **Hewett et al., 2011** | **0** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **0** | **1** |
| **5** | **Pate & Buono, 2014** | **1** | **1** | **1** | **1** | **0** | **1** | **1** | **1** | **1** | **0** | **1** |
| **6** | **Abel et al., 2012** | **0** | **1** | **1** | **1** | **2** | **1** | **1** | **0** | **1** | **0** | **0** |
| **No.** | **Article** | **Q16** | **Q17** | **Q18** | **Q19** | **Q20** | **Q21** | **Q22** | **Q23** | **Q26** | **Q27** | **Total** |
| **(/1)** | **(/1)** | **(/1)** | **(/1)** | **(/1)** | **(/1)** | **(/1)** | **(/1)** | **(/1)** | **(/5)** | **(/26)** |
| **1** | **Tracy & Hart, 2013** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **5** | **11** |
| **2** | **Hunter el al., 2013** | **1** | **1** | **1** | **1** | **1** | **1** | **0** | **1** | **1** | **5** | **10** |
| **3** | **Guo et al., 2014** | **1** | **1** | **1** | **1** | **1** | **1** | **0** | **1** | **1** | **5** | **9** |
| **4** | **Hewett et al., 2011** | **1** | **1** | **1** | **1** | **1** | **1** | **0** | **1** | **1** | **5** | **9** |
| **5** | **Pate & Buono, 2014** | **1** | **1** | **1** | **1** | **1** | **1** | **0** | **1** | **1** | **5** | **9** |
| **6** | **Abel et al., 2012** | **1** | **1** | **1** | **1** | **1** | **1** | **0** | **1** | **1** | **5** | **8** |
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Finally a third hypothesis was based on the heat itself. Although the mechanism by which thermal therapy affects arterial stiffness is unknown, it is postulated that the enhanced expression of endothelial nitric oxide synthase-3 messenger RNA may be responsible for such adaptations (Ikeda et al., 2001).

The results observed in this investigation were unique as only the younger participants who were thought to have the least amount of potential for change demonstrated the greatest decrease in arterial stiffness (Abel et al., 2012). This phenomenon was thought to be the result of an increased plasticity to change in the arteries of the younger participants compared to the older participants (Hunter et al., 2013). The only study to demonstrate a positive adaptation in VO2max was demonstrated using the Rockport 1 Mile Walk Test, an indirect method for assessing aerobic power (Hewett, Ransdell, Gao, Petlichkoff, & Lucas, 2011).

Although this result is encouraging for promoting Bikram yoga and its use for improving aerobic performance, consideration for the method of assessment should be taken. The Rockport 1 Mile indirect aerobic power test has demonstrated a large technical error of measurement ranging from 18% in males to 23% in females (Dolgener, Hensley, Marsh, & Fjelstul, 1994). A typical error of this nature may prevent any confidence when comparing pre and post test results.

**Long Term Bikram Yoga Practice**

When examining the long term cardiovascular adaptations from practicing Bikram yoga, Guo et al. were able to demonstrate positive adaptations in young and older overweight and obese women (Guo, Wang, Hu, Wang, & Zhang, 2014). Significant changes in RHR, resting systolic and diastolic blood pressure were observed after completing 208 sessions at a rate of four sessions per week (Guo et al., 2014). It should be recognized that these participants were already engaged and accustomed to Bikram yoga along with potentially having extra motivation to become healthier due to weight management.

The potential for cardiovascular improvement in these participants may have been positively skewed due to their level of fitness. When comparing novice to long term Bikram practitioners Abel et al. further demonstrated no significant difference in VO2max, RHR, resting systolic and diastolic blood pressure, peak minute ventilation and peak respiratory exchange ratio (Abel et al., 2012). The only significant difference observed was a higher maximum heart rate in the experienced practitioners as seen in Table 4. No explanation from the authors was provided for this phenomenon.

**Future Direction**

Current literature examining Bikram yoga and its impact on cardiovascular performance is still in its infancy. Only a single study examining the metabolic demands of a complete Bikram yoga session and four articles examining its long term impact on VO2maxand its ability to affect resting hemodynamic parameters were identified for this review. Current literature has yet to examine alterations in blood volume when practicing this form of yoga.

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| **Table 3 Cardiovascular Adaptations from Practicing Bikram Yoga** |
| Study | Length  | Yoga Sessions Completed | Training Status | Resting Heart Rate (beats•min-1) | Resting Blood Pressure (mmHg) | VO2max mL•kg-1•min-1 |
| Direct Examination | Indirect Examination  |
| Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| Guo et al., (2014) | 1 Year / *4x week* | 208 | Active | 78±5.15 | \*74.41±4.88 *p<0.05* | 124.01±10.57 / 78.35±8.26 | \*120.38±9.62/ \*75.46±8.49  *p<0.05* |  |  |  |  |
| Hunter et al., (2013) | 8 weeks / *3x week* | 24 | Sedentary |  |  | Young - 113±2/66±2 Old - 120±6/70±3 | Young - 112±2/65±2 Old - 116±4/68±3 |  |  |  |  |
| Hewett et al., (2011) | 8 weeks /  *3x week* | [20-24] Minimum 80% Completion |  | 64.04±9.95 | 63.22±8.70 |  |  |  |  | 38.44±7.07 | Ŧ40.12±7.15  *p<0.01* |
| Tracy,B,L. & Hart,C,E.F., (2013 | 8 weeks / *3x week* | 22.5±2.3 | Relatively Sedentary |   |   | Yoga & Control - 120±7.8  *p=0.60* | No Change between Yoga & Control  *p=0.33* | Yoga & Control - 37.9±7.9  *p=0.60* | No Change between Yoga & Control  *p=0.27* |   |   |

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| **Table 4. Cardiovascular Differences at Rest and Maximum Exercise between Novice and Experienced Bikram Yoga Practitioners** |
|   | Resting | Peak |
|  | Yoga Experience | Yoga Experience |
|   | Low (*<3 Months*) | High (*≥ 1 Year*) | Low (*<3 Months*) | High (*≥ 1 Year*) |
| Study  | Blood pressure (mmHg) | Heart Rate (beats•min-1) | Blood pressure (mmHg) | Heart Rate (beats•min-1) | Heart Rate (beats•min-1) | VO2 mL•kg-1•min-1 | Heart Rate (beats•min-1) | VO2mL•kg-1•min-1 |
| Abel et al., (2012) | 123.41±10.72 / 80.71±7.38 | 67.35±5.14 | 119.93±9.975 / 75.71±9.86 | 67.8.23±8.23 | \*132.69±45.21 *p<0.05* | 34.76±10.48 | 174.54±13.15 | 35.45±7.64 |

Previous investigations examining heat acclimation have demonstrated low intensity exercise (50% VO2max)to be an effective means for enhancing cardiovascular and aerobic performance when exercising in temperatures at or above 30oC ranging between 20-50% relative humidity (Buchheit, Voss, Nybo, Mohr, & Racinais, 2011; Castle, Mackenzie, Maxwell, Webborn, & Watt, 2011; Fujii et al., 2012; Garrett, Creasy, Rehrer, Patterson, & Cotter, 2012; Racinais et al., 2012).

The ambient conditions of most heat acclimation studies are very similar to what Bikram yoga studios offer its practitioners; as such this environment may support a hypothesis for using Bikram yoga as a means for heat acclimation in a sporting population. To our knowledge only two investigations have examined alterations in core temperature during Bikram yoga; whereby demonstrating marked increases (Pate & Buono, 2014; Porcari & Steffen, 2015). Further inquiry towards alterations in plasma volume after experiencing repeated hot yoga sessions are warranted to identify hemodynamic regulations.

**Conclusion**

This review identified that practicing Bikram yoga may elicit diverse results in resting cardiovascular parameters and performance values, results that may have be due to sample size, fitness, and participant age. Current literature has demonstrated minimal support for hot yoga as a means for improving resting and peak cardiovascular measures; however its current popularity may tentatively overshadow this lack of evidence. The very fact that its attendance and availability continues to increase throughout local neighbourhoods may support the notion that sedentary individuals have found a form of enjoyable exercise. Although this review focused solely on the cardiovascular impact from hot yoga, there is limited research demonstrating healthy adaptations to practicing this form of yoga such as weight management, improvement in balance and enhanced mindfulness that should not be overlooked (Hart & Tracy, 2008; Hewett et al., 2011).

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**Authors’ Qualifications**

The author’s qualifications are as follows: Andrew S. Perrotta PhD (ABD), MKin, BSc (HON), CEP, CSCS, USSF “C”; Nicholas J. Held MHK, BSc (HON), CEP, CSCS; Anne M Lasinsky PhD (ABD), MSc, BSc, Darren E.R. Warburton PhD, MSc, CEP.

**References**

Abel, A. N., Lloyd, L. K., Williams, J. S., & Miller, B. K. (2012). Physiological characteristics of long-term Bikram Yoga practitioners. *Journal of Exercise Physiology online, 15*(5), 32-39.

Bhavanani, A. B. (2003). Effect of yoga training on handgrip, respiratory pressures and pulmonary function. *Indian J Physiol Pharmacol, 47*(4), 387-392.

Bowman, A., Clayton, R., Murray, A., Reed, J., Subhan, M., & Ford, G. (1997). Effects of aerobic exercise training and yoga on the baroreflex in healthy elderly persons. *European journal of clinical investigation, 27*(5), 443-449.

Buchheit, M., Voss, S. C., Nybo, L., Mohr, M., & Racinais, S. (2011). Physiological and performance adaptations to an in-season soccer camp in the heat: associations with heart rate and heart rate variability. *Scand J Med Sci Sports, 21*(6), e477-485.

Carmody, J., & Baer, R. A. (2008). Relationships between mindfulness practice and levels of mindfulness, medical and psychological symptoms and well-being in a mindfulness-based stress reduction program. *Journal of behavioral medicine, 31*(1), 23-33.

Carmody, J., Baer, R. A., LB Lykins, E., & Olendzki, N. (2009). An empirical study of the mechanisms of mindfulness in a mindfulness‐based stress reduction program. *Journal of clinical psychology, 65*(6), 613-626.

Castle, P., Mackenzie, R. W., Maxwell, N., Webborn, A. D., & Watt, P. W. (2011). Heat acclimation improves intermittent sprinting in the heat but additional pre-cooling offers no further ergogenic effect. *Journal of sports sciences, 29*(11), 1125-1134.

Clay, C. C., Lloyd, L. K., Walker, J. L., Sharp, K. R., & Pankey, R. B. (2005). The metabolic cost of hatha yoga. *The Journal of Strength & Conditioning Research, 19*(3), 604-610.

Corliss, R. (2001). The power of yoga. *Time, 157*(16), 44-53.

Dash, M., & Telles, S. (1999). Yoga training and motor speed based on a finger tapping task.

Dash, M., & Telles, S. (2001). Improvement in hand grip strength in normal volunteers and rheumatoid arthritis patients following yoga training. *Indian journal of physiology and pharmacology, 45*(3), 355-360.

Dolgener, F. A., Hensley, L. D., Marsh, J. J., & Fjelstul, J. K. (1994). Validation of the Rockport Fitness Walking Test in college males and females. *Research quarterly for exercise and sport, 65*(2), 152-158.

Fujii, N., Honda, Y., Ogawa, T., Tsuji, B., Kondo, N., Koga, S., et al. (2012). Short-term exercise-heat acclimation enhances skin vasodilation but not hyperthermic hyperpnea in humans exercising in a hot environment. *European journal of applied physiology, 112*(1), 295-307.

Garfinkel, M., & Schumacher, H. R. (2000). Yoga. *Rheumatic Disease Clinics of North America, 26*(1), 125-132.

Garrett, A. T., Creasy, R., Rehrer, N. J., Patterson, M. J., & Cotter, J. D. (2012). Effectiveness of short-term heat acclimation for highly trained athletes. *European journal of applied physiology, 112*(5), 1827-1837.

Guo, Y.-H., Wang, F., Hu, J.-P., Wang, Y., & Zhang, L.-Y. (2014). Effect of high temperature yoga exercise on improving physical and mental well-being of overweight middle-aged and young women. *International journal of clinical and experimental medicine, 7*(12), 5842.

Harinath, K., Malhotra, A. S., Pal, K., Prasad, R., Kumar, R., Kain, T. C., et al. (2004). Effects of Hatha yoga and Omkar meditation on cardiorespiratory performance, psychologic profile, and melatonin secretion. *The Journal of Alternative & Complementary Medicine, 10*(2), 261-268.

Hart, C. E., & Tracy, B. L. (2008). Yoga as steadiness training: effects on motor variability in young adults. *The Journal of Strength & Conditioning Research, 22*(5), 1659-1669.

Hewett, Z. L., Ransdell, L. B., Gao, Y., Petlichkoff, L. M., & Lucas, S. (2011). An examination of the effectiveness of an 8-week bikram yoga program on mindfulness, perceived stress, and physical fitness. *Journal of Exercise Science & Fitness, 9*(2), 87-92.

Hunter, S. D., Dhindsa, M. S., Cunningham, E., Tarumi, T., Alkatan, M., Nualnim, N., et al. (2013). The effect of Bikram yoga on arterial stiffness in young and older adults. *The Journal of Alternative and Complementary Medicine, 19*(12), 930-934.

Ikeda, Y., Biro, S., Kamogawa, Y., Yoshifuku, S., Eto, H., Orihara, K., et al. (2001). Repeated thermal therapy upregulates arterial endothelial nitric oxide synthase expression in Syrian golden hamsters. *Japanese circulation journal, 65*(5), 434-438.

Joshi, L., & Gokhale, L. (1992). Effect of short term pranayam, practice of breathing rate, & ventilatory functions of lung. *Indian J Physiol Phamscol; 1992; 36 (2): 105, 108*.

Makwana, K., Khirwadkar, N., & Gupta, H. (1988). Effect of short term yoga practice on ventilatory function tests. *Indian J Physiol Pharmacol, 32*(3), 202-208.

Medicine, A. C. o. S. (2013). *ACSM's guidelines for exercise testing and prescription*: Lippincott Williams & Wilkins.

Murugesan, R., Govindarajulu, N., & Bera, T. (2000). Effect of selected yogic practices on the management of hypertension. *Indian Journal of Physiology and Pharmacology, 44*(2), 207-210.

Orsini-Meinhard, K. (2005). Yoga industry gains strength. *The Coloradoan. July, 10*.

Pate, J. L., & Buono, M. J. (2014). The physiological responses to Bikram yoga in novice and experienced practitioners. *Altern Ther Health Med, 20*(4), 12-19.

Porcari, J. P., & Steffen, J. (2015). Heart Rate and Core Temperature Responses to Bikram Yoga. *GUNDERSEN, 8*, 3.

Prasad, K., Ramana, Y. V., Raju, P., Reddy, M. V., & Murthy, K. (2001). Energy cost and physiological efficiency in male yoga practitioners. *Energy, 4*(3).

Racinais, S., Mohr, M., Buchheit, M., Voss, S. C., Gaoua, N., Grantham, J., et al. (2012). Individual responses to short-term heat acclimatisation as predictors of football performance in a hot, dry environment. *British journal of sports medicine, 46*(11), 810-815.

Raju, P., Madhavi, S., Prasad, K., Venkata Reddy, M., Eswara Reddy, M., & Sahay, B. (1994). Comparison of effects of yoga & physical exercise in athletes. *Indian Journal of Medical Research, 100*, 81-81.

Raju, P., Prasad, K., Venkata, R. Y., Murthy, K., & Reddy, M. (1997). Influence of intensive yoga training on physiological changes in 6 adult women: A case report. *The Journal of Alternative and Complementary Medicine, 3*(3), 291-295.

Ray, U., Sinha, B., Tomer, O., & Pathak, A. (2001). Aerobic capacity & perceived exertion after practice of Hatha yogic exercises. *Indian Journal of Medical Research, 114*, 215.

Telles, S., Nagarathna, R., Nagendra, H., & Desiraju, T. (1993). Physiological changes in sports teachers following 3 months of training in Yoga.

Telles, S., Praghuraj, P., Ghosh, A., & Nagendra, H. (2006). SHORT COMMUNICATION EFFECT OF A ONE-MONTH YOGA TRAINING PROGRAM ON PERFORMANCE IN A MIRROR-TRACING TASK. *Indian J Physiol Pharmacol, 50*(2), 187-190.

Tracy, B. L., & Hart, C. E. (2013). Bikram yoga training and physical fitness in healthy young adults. *The Journal of Strength & Conditioning Research, 27*(3), 822-830.

Tran, M. D., Holly, R. G., Lashbrook, J., & Amsterdam, E. A. (2001). Effects of Hatha Yoga Practice on the Health‐Related Aspects of Physical Fitness. *Preventive cardiology, 4*(4), 165-170.

US RAY, S. M., PURKAYASTHA, S., ASNANI, V., Tomer, O., PRASHAD, R., THAKUR, L., et al. (2001). Effect of yogic exercises on physical and mental health of young fellowship course trainees. *Indian J Physiol Pharmacol, 45*(1), 37-53.

Yadav, R. K., & Das, S. (2001). Effect of yogic practice on pulmonary functions in young females. *Indian journal of physiology and pharmacology, 45*(4), 493-496.