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SYSTEMATIC REVIEW

Cardiovascular Demands and Adaptations from Hot Yoga

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Abstract

Background: Hatha yoga has become a popular form of exercise for improving musculoskeletal fitness. However, little is known about its influence on cardiovascular health and performance. *Methods:* We conducted a systematic review of the literature (up to December 2016) identifying 337 articles; six 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 with individual variation in metabolic cost and heart rate. The variations observed were the result of small sample sizes, and differences in participant age, sex, and fitness levels. Short-term (i.e., 8 week) adaptions failed to demonstrate a significant difference in resting cardiovascular function or maximal aerobic power. Long-term (i.e., 1 yr) Bikram yoga practice was associated with some positive adaptions in resting heart rate, and systolic and diastolic blood pressure in obese individuals. There was no significant difference in cardiovascular function/performance between long-term and novice Bikram yoga practitioners. *Conclusions:* Bikram yoga continues to increase in popularity as an alternative exercise option. This form of exercise appears to be light in nature and enjoyable for participants. However, minimal evidence exists demonstrating its positive impact on cardiovascular health and performance. Further evidence is warranted to elucidate more clearly the potential cardiovascular benefits of this form of exercise. .**Health & Fitness Journal of Canada 2016;9(3):3-13.**

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 and Telles, 2001; Ray et al., 2001b; Telles et al., 2006). Recently, due to its popularity in North America it has become more accepted in the fitness industry as an alternative means of exercise (Corliss, 2001; Garfinkel and Schumacher, 2000). Longitudinal research has demonstrated regular participation in Hatha yoga is correlated with improved musculoskeletal fitness (e.g., muscular strength and flexibility) (Bhavanani, 2003; Dash and Telles, 1999; Ray et al., 2001a; Ray et al., 2001b; Tran et al., 2001) and improved exercise tolerance and aerobic capacity (Ray et al., 2001a). Additionally, enhanced pulmonary function has also been demonstrated with regular Hatha yoga participation (Bhavanani, 2003; Harinath et al., 2004; Joshi and Gokhale, 1992; Makwana et al., 1988; Telles et al., 1993; Yadav and Das, 2001). When examining cardiovascular adaptations to Hatha yoga and its ability to positively influence parameters such as

maximal aerobic power (VO2max), resting heart rate (HR), and resting blood pressure (BP) current literature reveals diverse results (Bowman et al., 1997; Harinath et al., 2004; Murugesan et al., 2000; Raju et al., 1994; Raju et al., 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 et al., 2005; Prasad et al., 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 and 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 35-40^{o}C 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 and 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.

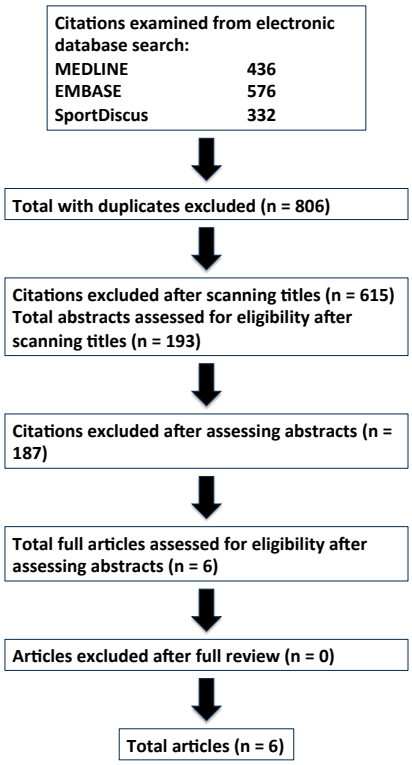
Methods

A systematic review on Bikram Yoga was conducted and several electronic databases were investigated (MEDLINE, Embase, SPORTDiscus). A total of 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 1) 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 min in duration and encompasses 60 min of standing and balance postures and 30 min including seated postures which finish with two breathing exercises (Abel

et al., 2012; Pate and 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 six articles found in this review involved this licensed form of hot yoga (Tracy and Hart, 2013).

Figure 1: Systematic review search.



A modified Downs and Black scoring system (Downs and Black, 1998) (Table 2) 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 reviewers selected the included questions prior to any scoring of the articles. The results of the modified Downs and Black scoring system are provided (Table 2).

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; Ray et al., 2001a). 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. On average the metabolic demand for all 26 postures during the 90 min session was 9.56 $mL \cdot kg^{-1} \cdot min^{-1}$, an average metabolic equivalent (MET) score of 2.73 $mL \cdot kg^{-1} \cdot min^{-1}$(Pate and 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, respectively (Pescatello et al., 2014). Although the range in both the MET and metabolic demands was greatly dependent on the posture, the

Table 1: Investigations examined the cardiovascular adaptations and responses to Hot Yoga.

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	50	37 [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.	Inactive 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	32 ± 9
Tracy and Hart (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 ± 6 [21-39] - Control – 25 ± 5 [21-39]
Single Session Study					
Pate and Buono (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	33 ± 13 [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 < 3 months or long term experienced if practicing for ≥ 1 year	Short Term - 17 Long Term - 14	Short Term - 44 ± 12 Long Term – 38 ± 9

average session provided little demand on the cardiovascular system. However, when examining a single participant's response a VO_2peak reaching as high as 35 $mL \cdot kg^{-1} \cdot min^{-1}$ during a standing pose was observed. 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 VO_2 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. 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 min Bikram yoga class. Further investigation is warranted to identify the metabolic demands between fit and unfit individuals and between age and sex differences.

Table 2. Modified Downs and Black Scoring System

No.	Article	Q1 (/1)	Q2 (/1)	Q3 (/1)	Q4 (/1)	Q5 (/2)	Q6 (/1)	Q7 (/1)	Q8 (/1)	Q9 (/1)	Q10 (/1)	Q13 (/1)
1	Tracy and 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 and 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 (/1)	Q17 (/1)	Q18 (/1)	Q19 (/1)	Q20 (/1)	Q21 (/1)	Q22 (/1)	Q23 (/1)	Q26 (/1)	Q27 (/5)	Total (/26)
1	Tracy and 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 and 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

Table 3: Cardiovascular adaptations to Bikram Yoga.

Study (Year)	Duration (Sessions)	Training Status	Resting Heart Rate (bpm)		Resting Blood Pressure (mmHg)		Maximal Aerobic Power (mL·kg^{-1}·min^{-1})			
			Pre	Post	Pre	Post	Pre	Post	Pre	Post
Guo et al., (2014)	1 Year / 4x week (208)	Active	78 ± 5	*74 ± 5 *p<0.05*	124 ±11 / 78 ± 8	*120 ± 10/ *75 ± 8 *p<0.05*				
Hunter et al., (2013)	8 weeks / 3x week (24)	Inactive			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)		64 ± 10	63 ± 9					38 ± 7	40 ± 7 *p<0.01*
Tracy and Hart (2013)	8 weeks / 3x week (23 ± 2)	Inactive			Yoga & Control – 120 ± 7 *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*		

Table 4: Cardiovascular differences at rest and peak exercise between Novice and Experienced Bikram Yoga practitioners. Findings from Abel et al. (2012).

	Novice	Experienced
Rest		
Heart Rate (bpm)	67 ± 5	68 ± 8
Blood Pressure (mmHg)	123 ± 11 / 81 ± 7	120 ± 10/ 76 ± 10
Peak Exercise		
Heart Rate (bpm)	*133 ± 45	175 ±13
Maximal Aerobic Power (mL·kg^{-1}·min^{-1})	35 ± 10	35 ± 8

*, significant difference between Novice and Experienced ($p < 0.05$).

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 and Baer, 2008; Carmody et al., 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, 8 week Bikram yoga interventions examining its ability to positively influence cardiovascular functioning were identified for this review as seen in Table 1. 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 an inactive population with an extensive range in age.

An 8 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 and Tracy, 2008). The single randomized controlled study in this review found no change in VO_2max, resting heart rate, and resting systolic blood pressure in both the control and intervention groups after an eight week intervention (Tracy and Hart, 2013). Although the participants were young adults who had little to no experience with yoga and were considered inactive; the implementation of 24 Bikram yoga sessions failed to elicit any positive cardiovascular adaptations after eight weeks as seen in Table 3 (Tracy and Hart, 2013). When examining the resting systolic and diastolic blood pressure response after 8 weeks Hunter et al., (2013) demonstrated no significant change between pre and post values in both young and old participants. 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).inally, 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 predicted VO2max was demonstrated using the Rockport 1 Mile Walk Test (Hewett et al., 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 et al., 1994) which may limit the accuracy and generalizability of the findings.

Longer Term Bikram Yoga Practice

When examining the longer 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 et al., 2014). Significant changes in resting heart rate, systolic blood pressure, 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 skewed by the participants' level of fitness. When comparing novice to long term Bikram practitioners Abel et al. (2012) further demonstrated no significant difference in VO2max, resting heart rate, resting systolic and diastolic blood pressure, peak min 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 finding.

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 VO2max and its ability to affect resting haemodynamic parameters were identified for this review. Current literature has yet to examine alterations in blood volume when practicing this form of yoga.

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 30^{o}C ranging between 20-50% relative humidity (Buchheit et al., 2011; Castle et al., 2011; Fujii et al., 2012; Garrett et al., 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 and Buono, 2014; Quandt et al., 2015). Further inquiry towards alterations in plasma volume after experiencing repeated hot yoga sessions are warranted to identify hemodynamic regulations.

Conclusion

This systematic 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 inactive 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 and Tracy, 2008; Hewett et al., 2011).

As with any form of exercise, participants should complete pre-participation screening (e.g., the PAR-Q+) (Warburton et al., 2014). Those over the age of 45 yr that are not accustomed to regular vigorous to maximal effort exercise should consult a qualified exercise professional or a physician before engaging in this form of exercise.

Authors' Qualifications

The authors' qualifications are as follows: Andrew S. Perrotta PhD (C), MKin, BSc (HON), CEP, CSCS, USSF "C"; Nicholas J. Held MHK, BSc (HON), CEP, CSCS; Anne M Lasinsky PhD (C), MSc, BSc, Darren E.R. Warburton PhD, MSc.

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