HEART RATE RESPONSE DURING A VINYASA YOGA SESSION

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Original article

Abstract

The practice of Yoga seems to have beneficial effects on holistic health and wellness. The purpose of this study was to evaluate the exercise intensity of a Vinyasa yoga session. Heart rate (HR) response of 24 moderately trained adults (12 male, 12 female; mean age ± sd; 39±7.33 years) was recorded during two Vinyasa yoga sessions consisted of four phases (warm up, surya namaskar, 45-minute remaining exercise and cool down). HRmax had been estimated seven days earlier after a maximal effort treadmill test. Data analysis included the mean of HR (b.p.m) and %HRmax in each phase of the two sessions and an ANOVA with repeated measures (gender X Vinyasa phases) was applied. The results revealed that there was no significant interaction between the two factors or significant main effect of gender either in HR or %HRmax. Significant, though, differences ($p<0.01$) were found between the four phases of Vinyasa session, with surya namaskar presenting the highest mean values. Vinyasa yoga participants in the present study used 68.8%-71.7% of their %HRmax for at least 60 minutes. The above exercise intensity and duration are within the widely accepted guidelines for improving cardiorespiratory endurance parameters in moderately trained people. It seems that systematic participation in Vinyasa yoga may effectively improve aerobic fitness and promote health.

Keywords: *exercise intensity, endurance, energy expenditure, aerobic capacity.*

INTRODUCTION

Yoga is one of the six fundamental, traditional Hindu philosophical systems and a form of asceticism (Iyengar, 2005; Ninan, 2003; Filinis, 2009).It includes body postures (asanas), breathing control techniques (pranayama), deep relaxation (nidra yoga) and meditation (chanda) which aim at connecting the "outer" human (physical existence) with the "inner" human being (soul-spirit) (Margioris, 1983; Varenne, 1978).Although yoga is clearly a Hindu traditional philosophical system, it is considered in the western world as one of the most popular alternative forms of exercise. There are many different types of yoga emphasising different parameters and aspects, such as breathing techniques, relaxation techniques, flexibility, alignment,

muscle strength and endurance orflow of motion in combination with breathing (Berger & Owen, 1992; Groessl, Weingart, Aschbacher, Pada, &Baxi, 2008; Roland, Jakobi, & Jones, 2011). The term "vinyasa" is a general term for every type of yoga in which practitioners follow a sequence of asanas linked to each other by flow and proper breathing (Fraser, 2005). This sequence of Vinyasa yoga postures usually includes a wide range of motions performed at a fast pace with frequent changes of levels in space, which increases the heart rate of practitioners and potentially benefits the cardiorespiratory and metabolic system(Caroll, Blansit, Otto, &Wygand, 2003; Mody, 2011).

The practice of Yoga seems to have beneficial effects on holistic health and well-being (Iyengar, 2005; Mehta, 2002) including the improvement of physical fitness parameters (Cowen & Adams, 2004; Gruber, 2008; Oken et al., 2006; Tran, Holly, Lashbrook, &Amsterdam, 2001); the cardiovascular and respiratory system (e.g. Abel, 2011; Cowen & Adams, 2004;Shinde, Shinde, Khatri, & Hande, 2013; Tran et al., 2001); weight reduction (Benavides & Caballero, 2009; Bernstein, Bar, Ehrman, Golubic, & Roizen, 2013; Gokal, Shillito, & Maharaj, 2007; Seo et al, 2012) and decrease in anxiety, stress and depression in healthy individuals and patients with mild symptoms (Gruber, 2008; Oken et al., 2004; Silva et al., 2009).

Despite indications that yoga practice can improve cardiorespiratory endurance in healthy practitioners, few studies have measured heart rate (HR) response duringspecific types of yoga practice (Blank, Raman, Chock, & Krieger, 2001; Caroll et al., 2003; Mody, 2011). Carroll et al. (2003) evaluated the HR and volume of oxygen uptake (VO_2) during a 15-minute videotaped session of 6 Astanga vinyasa yoga asanas repeated through verbal guidance. The authors concluded that this type of yoga can be used as a moderate training stimulus (143±14bpm HR, 77%HRmax) contributing to the improvement of the cardiorespiratory system through its aerobic and anaerobic energy requirements. Blank, Raman, Chock and Krieger (2001) also studied HR response and energy requirements during a sixty-minute power yoga session (a type of vinyasa yoga that emphasises muscle strength and flexibility) and found that the mean percentage of the maximum heart rate (%HRmax) during the entire session was about 60-70%.Anders (2005) comparedthe exercise intensity and energy expenditure of two fifty-minute videotaped Hatha and Power Yoga sessions respectively, and concluded that the mean %HRmax was 48±3.4% during Hatha yoga and 62±5.4% during Power yoga. Using a thirty-minute videotaped Hatha yoga session Clay, Lloyd, Walker, Sharp and Pankey (2005), measured the average HR response at 105.29bpm and the corresponding mean %HRmax at 56.89%, concluding that the intensity of this session was too low to be a training stimulus capable of improving the parameters of cardiorespiratory endurance.They did, however, highlight the importance of practising Surya Namaskar, which is a specific series of 12 vinyasa yoga postures, to increase the intensity of exercise during a yoga session. The potential effects of Surya Namaskar on the cardiorespiratory and metabolic system were recently studied by Mody (2011) who observed that practitioners exercised Surya Namaskar for 12minutes and with intensity corresponding to 80% of age-predicted HRmax;a percentage able to elicit a cardiorespiratorytraining effect in healthy adults (Haskell et al., 2007; Thomson, Gordon, & Pescatello, 2010).The findings of Cowen and Adams (2007) relative to the heart response of sixteen adults practitioners in three different types of yoga, i.e. Astanga, Hatha and Gentle, corresponded to low-intensity aerobic physical activity, as the %HRmax of the participants was estimated at 54%, 45% and 42% respectively for each session. Ward, McCluney and Bosch (2013) also reached similar conclusions when studying the HR response in a fifty-minute Vinyasa yoga session. During the session, the mean ± sd HR of the participants was

calculated at 107±23 bpm while the corresponding% HRmax reached 58% (±12). This percentage corresponds to low-intensity aerobic activity which can improve the cardiorespiratory system of individuals with a low baseline fitness level (30-40 $ml.kg.^{-1}.min.^{-1}\dot{V}O_2max$) or those with sedentary lives (Hagins, Moore, & Rundle, 2007; Haskell et al., 2007; Thomson et al., 2010).Finally, Ward et al. (2013) suggest further researchinto the individual HR response during this type of exercise.

Although these results indicate that some types of yoga can be used as an aerobic form of physical activity capable of improving cardiorespiratory endurance in healthy practitioners, the findings are conflicting and it remains unclear which ones meet the American College of Sport Medicine (ACSM; Thomson et al., 2010) and the American Heart Association's (AHA) physical activity guidelines (Haskell et al., 2007). In order to improve the cardiorespiratory system, these guidelines recommend moderate intensity (64-76% HRmax) aerobic activity of at least 30 minutes for five days a week, or higher intensity activity (77-93% HRmax) of at least 20 minutes for three days a week. The purpose of this study was to investigate the intensity of exercise through the HR response to a 90-minute Vinyasa yoga session held under a real classroom environment with the supervision and guidance of an experienced yoga teacher in order to establish the contribution of this kind of exercise to maintaining and improving the parameters of cardiorespiratory endurancein untrained or moderately trained adult practitioners.

METHODS

Twenty-four adults (12 males and 12 females) aged 30-50 years (mean ± sd, 39 ± 7.33) volunteered to take part in this study. All participants were healthy individuals, with no medical history. Furthermore, they had experience in performing various forms of physical activity for more than four hours a weekand had practiced yoga for at least one year, with an exercise frequency of 2-4 times a week. The specific sample selection criteria ensured the safety of the participants and the certainty that the measurements would not be affected by their lack of experience. The participants were members of gyms and yoga practice centres belonging to 5 municipalities of Attica, Greece (Heraklion, Nea Ionia, Kifissia, Athens & Glyfada).

During the sample collection process all practitioners were briefed on the content of the study. Following the briefing, practitioners who volunteered for the study completed a short questionnaire with their personal data**.** The study participants were randomly selected from the volunteersand were the first 12 females and 12 males who fulfilled the participation criteria. All participants, having been informed of the procedures, the difficulties and risks of the study, and having understood and agreed upon the conditions of their participation, signed a written informed consent.

The experimental design consisted of four distinctphases with seven days between eachphase: (a) the familiarisation with the measuring instruments phase; (b) the laboratory measurement phase; c) the 1stand 2ndVinyasa yoga session with seven days apart. (Figure 1)

All laboratory measurements were performed in the presence of a physician and an experienced Exercise Physiologist, while the Vinyasa yoga sessions were held in a specially designed room in to SPESS (School of Physical Education and Sport Science) under the supervision of an internationally recognised yoga teacher (Yoga Alliance). The environmental conditionswere kept constant using a central air-conditioning system with the temperature set at 20±1° C and the relativehumidity at 60%±2.

Prior to the start of the laboratory measurements, the participants were provided with nutritional and physical activity guidelines for the day preceding the test and during the test day. In particular, carbohydrate-rich meals and abundance of

fluids were recommended prior to the tests while they were also advised to avoid caffeine and alcohol containing beverages and cigarette smoking on the test day. The participants were requested to have their last meal at least 5 hours prior to the start of the measurements while the consumption of liquids was allowed ad libitum until the start of the tests, to avoid dehydration. Additionally, it was recommended that the participants abstain from intense physical activity at least 24 hours prior to the test (Williams & Wilkins, 2000).

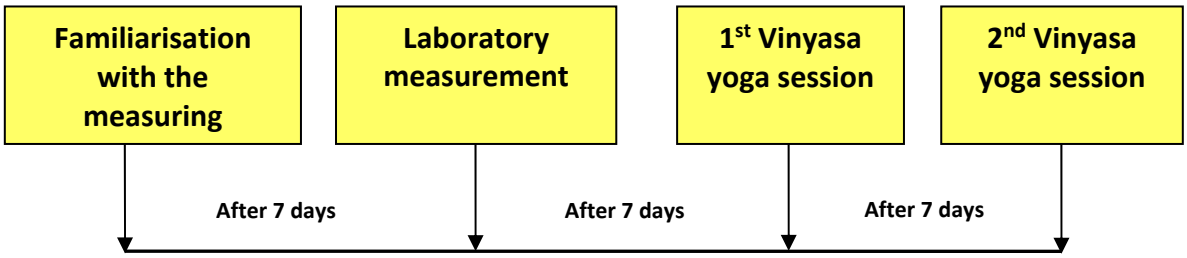

Figure 1. Experimental Design Phases.

The participants' somatometric characteristics (height, body mass, %body fat) and basic parameters of cardiorespiratory endurance (HRmax, VO_2peak) were measured in the laboratory. Height was measured barefoot, after full inhalation, to the nearest millimetre with a height measure (Seca Leicester, U.K).The body mass measurement was done using a mechanical column scale (Seca 710, U.K.) and the participants wore only shorts and a t-shirt. A skinfold caliper (Harpenden, U.K.) was used to measure the percentage of body fat. Four skinfolds (biceps, triceps, subscapular, suprailiac) on the right side of the body were measured. The calculation of the percentage of body fat was made according to the equations of Durnin and Womersley (1974). In order to find HRmax and VO_2peak, the participants performed a maximal effort test on a treadmill (Technogym runrace 1200, Italy), starting at a speed corresponding to about 30% of HRmax and with progressively increasing intensity. The treadmill's incline was maintained at 0% throughout the test and the speed increased 1km.h^{-1} every 2 minutes to the point where the participant was unable to follow the pace of the treadmill (Scott & Houmard, 1994). During the test, the participants were breathing through a face mask (full face Hans Rudolph, U.S.). The volume of exhaled air and the determination of VO_2 and VCO_2 was made by an online metabolic cart (Quark CPET, Cosmed, Italy). VO_2peak was calculated from the mean of the two highest values per 30 seconds of the parameter. The HR measurement was performed throughout VO_2peak test. The participants wore a belt around their chest (Polar, Finland) which had built-in electrodes to detect the electrical charge of each cardiac contraction and a transmitter to send the corresponding signal to a receiver that was connected to the program of the spirometer. Thus, along with other values, HR was also stored for later analysis. The HRmax value for each participant was determined during the last ten seconds of the VO_2peak test.

For the measurement of the HR during the two Vinyasa yoga sessions a HR telemetry device (HOSAND TM 200, Italy) was used to send, every four seconds, the HR values to a PC, where they were stored for future analysis.

Vinyasa yoga session protocol

Initially, participants were informed of nutrition and physical activity recommendations for the day prior and the day of the sessions which were similar to those given prior to the laboratory measurements. Vinyasa yoga sessions and

laboratory measurements were conducted on the same time of day.

The 90 minutes duration Vinyasa yoga sessions (this is the usual duration of a traditional yoga session) during phase 3 and 4 of the experimental design, were held on the same day of the week at the same time, with seven days apart (Figure 1) and consisted of four phases:1) Warm up**:** for fifteen minutes with a three-minute practice of ujjayi pranayama (breathing control technique) in supine position, as well as specific yoga postures and basic exercises from a stand position that activated all body muscle groups and joints; 2) Main part: for sixty minutes which included a) practice in Surya namaskar for fifteen minutes b) the remaining of the exercise of the main part for forty-five minutes, including standing asanas, supports, balances, positions in prone and supine, inverse and sitting asanas, practicing ujjayi pranayama; 3) Cool down: for 15-minutes including asanas in supine and sitting positions, breathing control techniques (nadisodhana pranayama) and relaxation techniques (nidra yoga) in supine position (savasana).

Statistical analysis was performed with Microsoft Office Excel 2003 and the SPSS 21 statistical software. Initially the descriptive statistics of the variables (mean±sd) were calculated. Data analysis included the mean of HR (b.p.m) and %HRmax in each phase of each session, as well as the mean values between the two sessions. A2 (Gender) x 4 (Vinyasa phases) analysis of variance (ANOVA), with repeated measures on the second factor was calculated. Post hoc analyses were also conducted with the use of the Bonferroni test, with alpha set at $p \leq 0.05$ (Keppel, 1991).

RESULTS

The participants somatometric characteristics are presented in Table 1. The basic parameters of the participants cardiorespiratory response are presented in Table 2.

Table 1
Somatometric characteristics of females (n_1=12), males (n_2=12) and all participants (n=24): Mean values (± sd) and range of values (minimum- maximum) of age, body mass, height and percentage of body fat.

Variable	FEMALES (n_1=12)	MALES (n_2=12)	ALL PARTICIPANTS (n=24)
Age (years)	39.2 ± 7.6 (30- 50)	38.17 ± 7.31 (31- 50)	39±7.33 (30- 50)
Body mass (kg)	56.6 ± 10.73 (38.40- 83.0)	76.63 ± 8,90 (61.10- 85.00)	66.60±14.07 (38.40-85.00)
Height (cm)	160 ± 5.48 (146 -167)	174.42 ± 5.85 (161- 181)	167.38±9.32 (146 -181)
% Body fat	26.7 ± 5.3 (18.73- 37.18)	19.9 ± 4.27 (13.21- 26.86)	23.30±5.86 (13.21-37.18)

Table 2
Cardiorespiratory response parameters for females (n_1=12), males (n_2=12) and all participants (n=24): Mean values (± sd) and range of values (minimum-maximum) of HRmax and VO_2peak.

Variable	FEMALES	MALES	ALL PARTICIPANTS
	(n_1=12)	(n_2=12)	(n=24)
HRmax (bpm)	182.58 ± 11.1	184.50 ± 9.51	183.54±10.13
	(165 -199)	(164 - 197)	(164 - 199)
VO_2peak (ml.kg^{-1}.min^{-1}) (peak oxygen uptake)	41.3 ± 4.9	49.7 ± 6.63	45.48±7.12
	(32.52 – 49.32)	(39.50 – 59.84)	(32.52 – 59.84)

Table 3
Mean values (± sd) and statistically significant differences in HR (bpm), relative to the four phases, among males, females and all participants.

	Vinyasa session phases				
		Main Part			
SEX	Warm up	Surya Namaskar	45΄ Remaining exercise	Cool down	Whole session
Females (n_1=12)	109.02±6.65	135.77±9.58	129.09±7.57	101.55±7.62	118.86±5.93
Males (n_2=12)	105.15±8.38	127.41±12.02	123.06±11.96	99.32±9.22	113.87±8.62
All participants (n=24)	107.08±7.66^{1,2}	131.59±11.45^{1,3}	126.35±10.18^{1,3,4}	100.43±8.35^{2,3,4}	116.36±7.67

Table 4
Mean values (±sd) and statistically significant differences in the %HRmax of males, females and all participants, in the four phases.

	Vinyasa session Phases				
		Main Part			
Sex	Warm up	Surya Namaskar	45΄ Remaining exercise	Cool down	Whole session
Females (n_1=12)	59.55±5.69	74.12±8.87	70.39±4.70	55.47±5.37	64.88±4.95
Males (n_2=12)	56.98±3.93	69.23±7.46	67.17±7.45	54.09±6.85	61.87±5.69
All participants (n=24)	58.27±4.96^{1,2}	71.68±7.45^{1,3}	68.78±6.31^{1,3,4}	54.78±6.06^{2,3,4}	63.38±5.44

Statistically significant difference ^{1,3,4}: p< 0.01
Statistically significant difference ^{2}: p< 0.05

The participants' mean VO_2peak (45.48±7.12 ml.kg^{-1}.min^{-1}) indicates that they initially had a moderate level of aerobic capacity (McArdle, Katch, & Katch, 1986).

According to the results of the ANOVA, there was no significant interaction between the two factors (p=0.419) or significant main effect of gender (p=0.113) in participants' HR. However, significant differences (p<0.01) were found between the four phases of Vinyasa session ($F_{3,66}$=125.86, p<0.01). Specifically, the Bonferroni analysis revealed that in all participants (male and female) (Table 3) (a) warm up had lower values than Surya Namaskar (p <.001) and the 45 min remaining of the main exercise (p <.001) and higher values than cool down (p = .029), (b) Surya Namaskar had higher values than the 45 min remaining exercise (p = .002) and cool down (p <.001) and (c)

the 45 min remaining exercise had higher values than the cool down ($p < .001$).

Regarding the %HRmax, the results revealed that there was no significant interaction between the two factors ($p=0.394$) or significant main effect of gender ($p=0.180$) in %HRmax. However, significant differences were found between the four phases of Vinyasa session ($F_{3,66}=124.16$, $p<0.01$). Specifically, the Bonferroni analysis revealed that in all participants (male and female) (Table 4) (a) warm up had lower values than Surya Namaskar ($p < .001$) and the 45 min remaining exercise of the main part ($p < .001$) and higher values than cool down ($p = .040$), (b) Surya Namaskar had higher values than the 45 min remaining exercise ($p = .002$) and cool down ($p < .001$) and (c) the 45 min remaining exercise had higher values than cool down ($p < .001$).

DISCUSSION

In recent years, in the various sports venues, there has been an increase in popularity of alternative ways of exercising, including the practice of yoga which seems to have beneficial effects on health and well-being (Iyengar, 2005; Mehta, 2002). The purpose of this study was to investigate the intensity of the exercise through the HR response to a 90-minute Vinyasa yoga session under a real classroom environment with the supervision and guidance of an experienced teacher and to study also the use of this type of exercise to maintain and/or improve the parameters of cardiorespiratory endurance of untrained or moderately trained adult practitioners. The results of this study revealed that for at least 60 min (main part) during a Vinyasa yoga session, the participants used 68.8% to 71.7% of their %HRmax, while the mean absolute HR value ranged between 126.35±10.18 and 131.59±11.45 bpm. The intensity and duration of this form of exercise is within the limits proposed by the ACSM and AHA (Haskell et al., 2007; Thomson et al, 2010) for maintaining or improving the parameters of cardiorespiratory endurance in moderately trained subjects. It seems that systematic participation in Vinyasa yoga sessions can help preserve and improve these parameters. Although these results indicate that some types of yoga, such as Vinyasa, can be used as an aerobic form of physical activity capable of improving cardiorespiratory endurance in healthy practitioners, the literature review reveals that the findings are conflicting and it remains unclear which of these values are in line with the guidelines of the ACSM and AHA (Haskell et al., 2007; Thomson et al, 2010). Recently, Ward et al. (2013) studied the HR response of thirty-eight healthy adults (31.4 ± 8.7 years) during a fifty-minute Vinyasa yoga session. The mean HR value was calculated at 107±23 bpm while the corresponding %HRmax reached 58% (±12). This percentage is similar to the values (63.38 ± 5.44%, 116.36 ± 7.67 bpm) of the present study. The slightly larger values of our study may be explained from the duration of the session (90 min vs 50min) and the mean age of the subjects (39.2 ± 7.33vs 31.4 ± 8.7 years). Ward et al. (2013) also noted that further investigation of individual HR during a Vinyasa yoga session was needed due to the diversity found in exercise intensity, from the individual participant values throughout the session, which ranged from 50-93% of HRmax. In the study by Blank et al. (2001) all six participants during a sixty minute Power yoga session had similar rate of intensity (60-70% HRmax) compared with the present study. In agreement with the findings of the present study are the results of Anders' (2005) who compared the exercise intensity and the energy expenditure of two fifty-minute videotaped Hatha and Power Yoga sessions. During the sessions, the fifteen highly experienced yoga practitioners had a mean HR value (bpm) and corresponding %HRmax, 89 ± 5.8 bpm, 48 ± 3.4% and 115 ± 8.0 bpm, 62 ± 5.4% for Hatha and Power yoga respectively. The mean HR (bpm) value and the corresponding %HRmax value of the Power yoga session reported by Anders (2005), are consistent with

corresponding mean values (116.36±7.67 bpm, 63.38±5.44%) of the Vinyasa yoga session of this study.Conversely, Cowen and Adams (2007), studying the HR response of sixteen male and female adults (31.8±11.96 years) over three eighty-minute Astanga, Hatha and Gentle yoga sessions respectively, found that the mean HR and %HRmax during sessions was 95±12.84 bpm, 80±9.32 bpm and 74±7.41 bpm, and 54±0.09%, 45±0.06% and 42±0.06% respectively. These values do not match the corresponding values (116.36±7.67 bpm, 63.38±5.44%) of this study, as different type of yoga and different asanas were practiced. The study of Cowen and Adams (2007) also recruited small (n=16) sample size and younger (31.8±11.96 years) compared with the participants in this study (n=24; 39±7.33 years respectively). The average HR when recorded and stored every minute during a single session compared to every 4 seconds during the two sessions of this study may be another source of error regarding this value. The conclusion of the study by Carroll et al. (2003) also differed to that of the present study. They evaluated the HR and volume of oxygen uptake (VO_2) of thirteen experienced adult (36.7±6.5 years) practitionerspracticing yoga 3-36 months and concluded that Vinyasa yoga can be a moderate training stimulus (143±14 bpmHR, ~77% HRmax) capable of eliciting an improvement to the cardiorespiratory system. The values of this study (HR, 116.36 ± 7.67 bpm; 63.38 ± 5.44% HRmax) are significantly lower than those of Carroll et al. (2003), even if compared to the sixty-minute practice of the main part of the study during which participants were exercising with higher intensity (68.78±6.31% - 71.68±7.45% HRmax). Such differences are expected, as Carroll et al.'s (2003) routine lasted 15 minutes and included only six asanas and even videotaped guidance, while the routine in this study lasted 90 minutes under the supervision of an experienced teacher and included, among other things, techniques related to the control of breathing and relaxation. During a videotaped 30-minute Hatha Yoga session, Clay et al. (2005) measured 26 adult women (23.39±4.30 years) and reported mean HR response 105.29±14.92bpm and the corresponding mean %HRmax 56.89±8.37%. The corresponding mean values(HR, 116.36 ± 7.67 bpm; 63.38±5.44% HRmax) of this study are in line with the findings of Clay et al. (2005), while the differences can be justified by the type of yoga, the shorter session duration, the videotaped guidance and the female-only participation in the Clay et al. (2005) study.

A number of researchers (Hagins et al, 2007; DiCarlo et al, 1995; Mody, 2011; Walls, 2007) have focused on the importance of Surya Namaskar practice in order to increase the exercise intensity during a yoga session. Clay et al. (2005) found that during the five-minute practice of surya namaskar the highest mean values were observed in both HR (123.85±16.67bpm) and %HRmax (66.99±9.99%). The present study also came to the same conclusion, as the highest mean HR (131.59±11.45bpm) and %HRmax (71.68±7.45%) were observed during surya namaskar's fifteen-minute practice. The potential effects of surya namaskar on the cardiorespiratory and metabolic system were also studied by Mody (2011) who reported that during a 12 minute practice of surya namaskar, the mean HR (bpm) and %HRmax of six adults practitioners (19.8±1.5 years) with surya namaskar practice experience of at least two years, was 156±19 bpm and 80% HRmax. These values are significantly higher than the corresponding mean values (131.59±11.45bpm; 71.68±7.45%) obtained in the present study. This difference is likely to be due to the lower age and the number of participants participating in the Mody (2011) study compared to this study (39±7.77 years; n=24, respectively), the experience in yoga practice (>2 years) of the Mody (2011) study, compared to this study (>1 year), and the fact that the participants in the Mody (2011) study repeated surya namaskar forty-eight times without teacher guidance, while the participants in the

present study repeated surya namaskar twenty-four times under the supervision of an experienced teacher. Significant methodological differences were also observed in the HR recording during the two sessions, as well as in the way the predicted HRmax was determined for each participant. In the present study, the individual HR of each participant was recorded during the two Vinyasa yoga sessions while in the Mody (2011) study it was recorded in only one session. Furthermore, the predicted HRmax for each participant in the Mody (2011) study was determined using the equation: 220-age participant, while in the present study the individual value of HRmax was measured during the VO_2peak test. This most likely affected the accuracy of the mean %HRmax calculation of the participants in the Mody's (2011) study. Both studies though, concluded that the systemic practice of surya namaskar can elicit cardiorespiratory adaptations.

The present study is the first in yoga practice that attempted to investigate the differences in HR response and %HRmax between female and male participants. The relevant findings show that during the Vinyasa yoga sessions, no significant difference was observed either in the mean HR value of female (118.86±5.93) and male (113.87±8.62), or in the corresponding mean %HRmax (64.88±4.94%; 61.87±5.69%) for female and male respectively. Significant differences ($p<0.01$) were only observed for the mean HR value and the corresponding %HRmax when grouping all participants (n=24) between the four phases. Surya namaskar's practice showed the highest mean value in HR and %HRmax, compared to the corresponding mean value of the individual phases (warm up, 45-minute remaining exercise, cool down) of the session for both male andfemale participants and for all participants in the study. It is clear from the findings of this and other studies (Clay et al., 2005; Hagins et al., 2007; Mody, 2011) that surya namaskar practice for more than ten minutes is likely to increase the intensity of exercise and the corresponding energy expenditure during a yoga session, and to improve the cardiorespiratory system parameters of the participants.

Summarising the findings of the present study, it is concluded that Vinyasa yoga is a form of low to moderate intensity exercise which corresponds to 63-72% of HRmax and is suitable to improve the level of cardiorespiratory endurance parameters in people with low to moderate baseline fitness level (30-45 $ml.kg^{-1}.min^{-1}$ $\dot{V}O_2$max; McArdle et al., 1986). Furthermore, systematic participation in Vinyasa yoga sessions may be used as an alternative form of exercise, similar to moderate intensity and continuous aerobic activity, which can contribute to maintaining and/or improving the parameters of the cardiorespiratory system of untrained or moderately trained adult practitioners. The findings of this study could help exercise specialists and yoga professional teachers to better understand the practice of Vinyasa yoga with regard to the physiological requirements and prescription of this type of exercise. Moreover, as yoga practice studiestend to quantify the intensity of exercise during a session, both exercise practitioners and yoga teachers will be able to better define the content of a session based on the individual needs and limitations of each practitioner. Vinyasa yoga is one of the most popular and enjoyable types of yoga for practitioners and since there is an absence of studies relating to its effects on the cardiorespiratory and metabolic system, further research is essential.

Directions for future research

The present study included male and female adults, with a mean age of 39.9±7.33 years and a moderate baseline fitness level (45.48±7.12 $ml.kg^{-1}.min.^{-1}VO_2$peak). Future research could focus on younger or older participants or participants with a higher level of baseline fitness. It would also be interesting to evaluate and compare the HR response of beginners and experienced practitioners in a 90-minute Vinyasa yoga

session. Further research into the practice of Vinyasa yoga, could include a larger number of participants, or more sessions. The findings of the present study were based on participation in two yoga sessions, however the HR response to routine (3-5 sessions/week) vinyasa yoga participation remains unclear.

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