Predictors of and barriers to adherence in a 16-week randomised controlled trial of Bikram yoga in stressed and sedentary adults

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ABSTRACT

Background: Bikram yoga may enhance health outcomes in healthy adults and those at risk for chronic disease, however, challenges remain in achieving optimal adherence to this practice. This study investigated factors influencing adherence to a 16-week Bikram yoga intervention in stressed and sedentary adults.
Methods: Experimental group participants (n = 29) were instructed to attend 3–5 Bikram yoga classes weekly for 16 weeks. Baseline demographics, behaviours and health measures were investigated as predictors of adherence. Barriers were assessed via documentation of adverse events, and exit survey responses.
Results: Participants (38.2 ± 10.1 years) were predominantly overweight-obese (83%), female (79%), and attended 27 ± 18 classes. Higher adherence was associated with older age ($p = 0.094$), less pain ($p = 0.011$), fewer physical limitations ($p = 0.011$), poorer blood lipid profile, and higher heart rate variability (HRV; total power, ($p = 0.097$)). In multi-variable analysis, three variables: age ($\beta = 0.492$, $p = 0.006$), HRV ($\beta = 0.413$, $p = 0.021$) and pain ($\beta = 0.329$, $p = 0.048$) remained predictors of adherence. Difficulty committing to the trial, lack of enjoyment and adverse events were barriers to adherence.
Conclusions: These findings should be considered in the development of future Bikram yoga trials to facilitate higher levels of adherence, which may enhance health outcomes and inform community practice. Future trials should investigate and address additional barriers and facilitators of Bikram yoga practice.

1. Introduction

Bikram yoga is a standardised style of *hatha* (physical) yoga characterised by an unchanging sequence of *asanas* (postures), heated environment and instructional dialogue.[1] Studies have demonstrated that eight weeks of Bikram yoga practice can enhance health outcomes in apparently healthy adults and those at risk for chronic disease.[2–4] Bikram yoga consists of beginner-level *asanas,* making it suitable for virtually all fitness levels. However, despite its applicability and potential benefits, challenges remain in successfully applying this intervention in adults who are sedentary.

Conventional forms of exercise exert a dose-response effect such

that more frequent and/or vigorous exercise contributes to higher levels of health status.[5,6] Dose-response effects have been noted in studies of Bikram yoga. A recent 16-week randomised controlled trial (RCT) reported that higher adherence to Bikram yoga intervention in a cohort of stressed and sedentary adults was associated with significant reductions in body fat percentage ($p = 0.001$), fat mass ($p = 0.003$), diastolic blood pressure ($p = 0.039$), and body mass index (BMI) ($p = 0.05$).[7] Higher adherence in this trial was also associated with favourable psychological adaptations, including improvements in exercise self-efficacy ($p = 0.002$), perceived stress ($p = 0.03$), and several domains of health-related quality of life (HRQoL) ($p \leq 0.022$).[8] Notably, class attendance averaged 54% of the minimum prescribed classes and only

four participants (14%) met or exceeded the minimum requirement of 48 classes over 16 weeks. Other studies of Bikram yoga (eight weeks) have either not reported on adherence,[2,9–11] or have reported that attendance varies, ranging from 60%[3,4] to 94%.[12,13] However, none of these studies provided an *a priori* definition of how attendance was computed indicating a lack of consistency in reporting attendance across trials.[2–4]

To our knowledge, only one study has reported on factors influencing adherence to Bikram yoga.[14] A study of women with elevated self-reports of dietary restraint, emotional eating and perceived stress revealed a three-way interaction of distress tolerance, BMI and body image on adherence. In women with 'few body image concerns', higher distress tolerance was associated with higher Bikram yoga attendance regardless of BMI ($p = 0.009$), while in women with 'poor body image', higher distress tolerance was associated with higher adherence in overweight women ($p < 0.001$) but lower adherence in obese women ($p = 0.007$).[14] Characteristics that have been reported as barriers to conventional exercise including low self-efficacy, high levels of psychological stress, time constraints, and lack of readiness to change behaviour[15] may also affect participation in *hatha* yoga,[16,17] For example, 'family commitments and occupational commitments', have acted as significant barriers to yoga practice in yoga instructor graduates.[17] 'Health problems', 'pain' and 'being too busy' have also been noted as barriers to *hatha* yoga in a study of older women with osteoarthritis.[16]

Bikram yoga can induce positive health-related adaptations,[2,4] however, there has been limited investigation of factors that contribute to adherence to a Bikram yoga intervention. Such investigation is required to enhance the uptake of Bikram yoga in those who could benefit significantly from it. Therefore, the purpose of the present study was to investigate factors that predicted and acted as perceived barriers to adherence to a 16-week Bikram yoga intervention in a cohort of stressed and sedentary adults.

2. Methods

2.1. Study design

The data presented in this study were collected during a 16-week RCT. The study methodology adhered to CONSORT guidelines[18] and is detailed elsewhere.[7] Briefly, eligible participants were randomised to a Bikram yoga experimental group or no-treatment control group. Outcomes were assessed at baseline, eight weeks post-randomisation (questionnaires only), and at completion of the trial. Two trained researchers collected all outcome measures, except for haematological measures, which were collected and analysed by an independent blood collection centre (blinded). The Western Sydney University (H10549) and University of Canberra Human Research Ethics Committees (H10549-14/009174) approved all procedures, and written informed consent was obtained from all participants.

2.2. Participants and recruitment

Eligibility criteria: (1) Adult (> 18 years); (2) sedentary (i.e. $<$ 150 min of moderate-intensity exercise per week[19] for six months or more); (3) a score > 14 on the stress component of the Depression, Anxiety and Stress Scale (DASS-21)[20] indicating at least mild stress; (4) no diagnosed chronic diseases; 5) no acute or chronic medical condition that would make Bikram yoga potentially hazardous (e.g. pregnancy) or outcomes difficult to assess; (6) able to attend three to five Bikram yoga classes per week for 16 weeks; (7) cognition and English language sufficient to understand research procedures and provide informed consent; (8) no participation in Bikram yoga in the past 6 months. Original inclusion criteria included waist circumference ≥ 94 cm for men and ≥ 80 cm for women but was removed due to low rate of recruitment. Participants were recruited between August 2014 and September 2015 in the Australian Capital Territory (ACT). Data collection

was completed by January 2016.

2.3. Intervention

Participants in the experimental group engaged in 16-weeks of Bikram yoga classes free of charge at either of two affiliated Bikram yoga studios in Canberra, ACT. Participants were instructed to attend three to five regularly scheduled classes per week. Certified Bikram yoga teachers taught all classes using the standard (scripted) instructions. Classes were 90 min in duration and held in a temperature-controlled room (40.6 °C, 40% humidity). Details of the 90-minute Bikram yoga practice are described elsewhere.[1,2] Participants were treated as normal beginner students by the instructors.

2.4. Data collection

2.4.1. Adherence

Adherence was recorded as the total number of classes attended and was recorded electronically upon arrival at each respective studio via an online booking system controlled by reception staff.

2.4.2. Predictors of adherence

All data, including demographics, behaviours and health status, were collected during the screening process and baseline data collection sessions.[7] Demographic variables included age and sex. Behavioural variables included smoking status, previous yoga experience and previous Bikram yoga experience. Participant choice of studio location was also determined. Depression, anxiety and stress levels were collected via the DASS-21.[20] Perceived stress was measured by the 10-item Perceived Stress Scale (PSS).[21] The 10-item General Self-Efficacy (GSE) scale was used to assess general self-efficacy[22] and a 5-item questionnaire was used to assess exercise self-efficacy.[23] HRQoL was assessed by the *RAND 36-Item Health Survey 1.0* (SF36).[24] The SF-36 is comprised of eight separate HRQoL domains: physical functioning, social functioning, emotional well-being, energy/fatigue, pain, physical role limitations, emotional role limitations and general health. Heart rate variability (HRV) variables and augmentation index (AIx) were assessed via the SphygmoCor system and HRV software (SphygmoCor, AtCor Medical Pty, Sydney, Australia) using standard procedures.[25] HRV variables included the absolute high frequency (HF) power component of HRV, absolute low frequency (LF) power component of HRV, LF/HF ratio, total power, percentage of absolute differences between successive normal r-wave to r-wave intervals that exceed 50 ms (pNN50), standard deviation of the normal-normal interval (SDNN), root-mean-square of the successive normal sinus RR interval difference (RMSSD) and triangular index. Body composition (body fat percentage, lean body mass, fat mass, fat free mass) was assessed using a Lunar Prodigy Pro™ Dual-energy X-ray Absorptiometry (DXA) scan analysed with manufacturer software (enCORE™ v 14.1 software, GE Healthcare, Sydney, Australia) and anthropometric outcomes including body weight, BMI and waist circumference, were assessed using standardised procedures.[6] Resting heart rate and resting brachial systolic and diastolic blood pressures were assessed using an automatic monitor (M10-IT, Omron Inc., Japan) using standard procedures.[6] Haematological measures, assessed via standard blood collection procedures and assays (coefficients of variation: 2.0%–4.2%), included total cholesterol, high density lipoprotein (HDL), total cholesterol to HDL ratio, low density lipoprotein (LDL), triglycerides, fasting blood glucose and high-sensitivity c-reactive protein (hsCRP).

2.4.3. Barriers to adherence

Adverse events were documented throughout the trial via weekly status checks. At the completion of all data collection, all participants were asked to complete an exit survey to gather participant feedback about the trial and intervention (Table 1). The survey was delivered via email, and participants had the option of returning it via email or post.

Table 1
Exit survey questions.

1.	How did you find out about the trial? (e.g. Facebook post, flyer at local shops, friend)
2.	Do you feel the written information and discussions with the principal researcher adequately explained what your involvement in the trial would be like?
3.	What was the best part of your involvement in the trial? *This question is about the trial itself rather than the yoga classes, if you attended them.*
4.	What was the most difficult part of your involvement in the trial? *This question is about the trial itself rather than the yoga classes, if you attended them.*
5.	If you were assigned to the yoga group, could you please describe your overall experience of receiving the intervention?
6.	What were the main benefits you got from your participation in the trial? *If there was nothing, please write that.*
7.	Would you recommend this trial or a similar trial in the future to friends, family, colleagues etc.?
8.	Do you have any additional comments you'd like to make that have not been addressed by the above questions?

Exit survey responses were kept anonymous to the researcher during analysis.

2.5. Statistical analyses

The characteristics of the sample were summarised using counts and percentages for categorical variables, and means and standard deviations for numeric variables. Natural logarithm (Ln) transformations were applied to continuous variables showing positive skew, and accepted where normality was improved. Prior to analysis of predictors, outlier attendance scores for participants who attended > 48 classes ($n = 3$) were reassigned a maximum score of 48 (minimum classes required) in a process akin to Winsorizing. These adjustments were made to decrease the effect of influential observations on the analyses. Univariate linear regression models were applied to investigate each continuous and categorical variable as a potential predictor of class adherence. Variables were also checked for excessive correlation between predictors but none were found. A *p*-value < 0.05 was considered indicative of statistical significance with *p*-values < 0.10 providing weaker evidence of association. Variables were then selected for inclusion in a multiple regression analysis based on clinical plausibility and with consideration for not overfitting the model. Fitted regression models are presented using *p*-values, R-squared values and regression coefficients. All quantitative analyses were carried out using SPSS (IBM©, Version 23). Adverse events and exit surveys were analysed qualitatively. Responses were collated for each exit survey question and common responses were identified and illustrated with participant quotes. For example, responses stating that improvements to physical health were the best part of the trial were grouped together, as were responses stating that mental health benefits were the best part of the trial.

3. Results

Baseline characteristics for experimental group participants ($n = 29$) are presented in Table 2. The cohort was predominantly female (79%), aged 23–64 years, and primarily Bikram-yoga naïve (86%). More than a third of the group met the clinical criteria for obesity (BMI $> 30 \, \mathrm{kg/m^2}$), while 45% were in the overweight category (i.e. BMI 25–29.9 kg/m²). The DASS-21 stress score indicated a moderate level of stress. Participants attended 27 ± 18 classes (range: 4–79) over the 16-week trial period. After adjusting for outliers, participants attended 54% (26 ± 15, range: 4–48) of the minimum 48 prescribed classes.

3.1. Predictors of adherence

A total of 45 variables were individually investigated for possible association with adherence (Table 3). Seven of these showed at least some evidence of association ($p < 0.10$). Higher adherence to the Bikram yoga intervention was associated with: (1) older age, (2) less pain, (3) fewer physical limitations, (4) poorer blood lipid profile (i.e. higher total cholesterol to HDL ratios, (5) higher fasting blood glucose, (6) lower HDL) and (7) higher HRV (Ln total power).

HRQoL measures associated with higher attendance, including

Table 2
Baseline characteristics.

Characteristic	Yoga group n = 29
Age (years)	38.2 ± 10.1
Women (n; %)	23; 79%
Body weight (kg)	86.4 ± 21.2
Body mass index (BMI) (kg/m²)	29.9 ± 6.2
Obese (BMI 30 +) (n; %)	11; 38%
Waist circumference (cm)	93.9 ± 14.5
Depression score (DASS-21)	15.2 ± 10.7
Anxiety score (DASS-21)	9.2 ± 6.6
Stress score (DASS-21)	23.3 ± 6.0
Current smoker or quit in last 6 months (n; %)	1; 3%
< 5 previous Bikram yoga classes	25; 86%

Continuous data presented as mean ± standard deviation.
Abbreviations: DASS-21 = 21-item Depression-Anxiety-Stress-ScaleDepression categories: 0–9 = normal, 10–13 = mild, 14–20 = moderate, 21–27 = severe, 28 + = extremely severeAnxiety categories: 0–7 = normal, 8–9 = mild, 10–14 = moderate, 15–19 = severe, 20 + = extremely severeStress categories: 15–18 = mild, 19–25 = moderate, 26–33 = severe, 34 + = extremely severe.

lower pain score ($p = 0.048$) and physical role limitations score ($p = 0.011$) were statistically significant predictors of adherence, and according to their R^2 statistics explained up to 21.6% and 13.7% of the variance in adherence, respectively. Haematological outcomes, including higher fasting blood glucose ($p = 0.011$), higher total cholesterol to HDL ratio ($p = 0.037$), and lower HDL ($p = 0.049$) were associated with higher attendance and explained up to 21.6%, 15.1%, and 13.6% of the variance in adherence, respectively. Variables which displayed only a weak evidence of association ($p < 0.1$), including age ($p = 0.094$) and HRV (total power; $p = 0.097$), explained 10.1% and 9.9% of the variance in adherence, respectively. As few participants were male, few were smokers and few had previous experience with Bikram yoga, we were unable to examine these variables' associations with adherence. Predictors were entered into a multi-variable regression analysis one by one. Three variables: age ($\beta = 0.492$, $p = 0.006$), HRV (total power) ($\beta = 0.413$, $p = 0.021$) and pain ($\beta = 0.329$, $p = 0.048$) remained significant predictors of adherence and collectively explained 41% of the variance in adherence in the model.

3.2. Barriers to adherence

3.2.1. Exit surveys & adverse events

Twelve (41%) exit surveys were returned from the experimental group. When asked what the best part of the trial was, the responses from 50% of the experimental group participants were related to learning about and improving themselves. Three participants (25%) reported that the best part was assessing their health through the data collection testing sessions. The remaining 25% of answers did not form a cohesive category. When asked what the main benefits of participation in the trial were, five (42%) of the experimental group participants gave responses that described improvements in both physical and mental well-being. Two of the 12 participants (17%) who reported a lack of enjoyment of the intervention, also reported that the main

Table 3
Predictors of adherence (n = 29).

Variable	Significance (p-value)	r-value	Regression coefficient
Categorical variables			
Male (compared to female)	0.682	–	+2.91
Smoker (compared to non)	0.497	–	−10.70
Previous yoga experience			
Bikram < 5 classes (compared to > 5)	0.525	–	−5.29
Non-Bikram < 5 classes (compared to > 5)	0.308	–	−6.12
South studio (compared to north)	0.143	–	+8.56
Continuous variables			
Age	0.094*	0.317	+0.47
Depression (DASS-21)	0.467	−0.141	−0.20
Anxiety (DASS-21)	0.157	−0.270	−0.62
Stress (DASS-21)	0.764	−0.058	−0.15
Perceived stress scale	0.428	−0.153	−0.49
General self-efficacy	0.154	0.272	+0.93
Exercise self-efficacy	0.829	0.042	+0.16
SF-36			
Physical functioning	0.491	0.133	+0.10
Social functioning	0.179	0.257	+0.15
Emotional well-being	0.540	0.119	+0.11
Energy/fatigue	0.418	0.156	+0.15
Pain	0.048*	0.371	+0.32
Role limiting – physical	0.011*	0.465	+0.23
Role limiting – emotional	0.198	0.246	+0.11
General health	0.189	0.251	+0.20
Heart Rate Variability			
Ln HF power (absolute)	0.548	0.116	+1.36
Ln LF power (absolute)	0.197	0.247	+3.19
LN LF/HF ratio	0.454	0.145	+2.31
Ln total power	0.097*	0.314	+4.69
pNN50	0.980	0.000	0.00
Ln SDNN	0.221	0.234	+7.69
Ln RMSSD	0.314	0.194	+4.53
Ln triangular index	0.483	0.136	+4.53
Body composition			
Body weight	0.631	−0.093	−0.07
Body mass index	0.674	−0.082	−0.20
Waist circumference	0.799	0.050	+0.05
Body fat %	0.580	−0.109	−0.17
Fat mass	0.662	−0.086	−0.09
Lean mass	0.774	0.057	+0.08
Fat-free mass	0.716	0.072	+0.10
Haemodynamic measures			
Resting heart rate	0.292	−0.203	−0.38
Systolic blood pressure	0.205	0.242	+0.33
Diastolic blood pressure	0.237	0.227	+0.44
Augmentation index	0.626	0.110	+0.18
Haemotological measures			
Total cholesterol	0.662	0.085	+1.52
LDL	0.334	0.190	+3.83
HDL	0.049*	−0.368	−10.6
TC:HDL	0.037*	0.389	+4.75
Triglycerides	0.259	0.217	+3.50
Fasting blood glucose	0.011*	0.465	+12.13
Ln hsCRP	0.179	−0.257	−2.87

* Included in analysis. Abbreviations – DASS-21: 21-item Depression-Anxiety-Stress Scale; SF-36: RAND 36-Item Health Survey 1.0; HF: high frequency; LF: low frequency; pNN50: percentage of absolute differences between successive normal RR intervals that exceed 50 ms; SDNN: standard deviation of the normal-normal interval; RMSSD: root-mean-square of the successive normal sinus RR interval difference; HDL: high-density lipoprotein; TC:HDL: ratio of total cholesterol to HDL; LDL: low-density lipoprotein; hsCRP: high sensitivity c-reactive protein.

benefit of participating in the trial was a "*Pride in this stint of self-care… motivation to keep engaging in self-care activities*" and "*it motivated me to seek out exercise options that were better suited to me*".

When asked about the most difficult aspect of the trial, seven responses (58%) related to the obligations and commitment of attending weekly classes. Explanations for commitment difficulties included arranging with partner to watch the children during class time, choosing between attending class and spending time with one's children, and juggling other commitments to prioritise class attendance. Anecdotally, one participant reflected that with her job demands and young family, prioritising the time required by the trial, regardless of intervention, would have been difficult. Overall experiences across the experimental group of the Bikram yoga itself were reported as positive by six (50%) participants. For example: "*I could manage stress more easily and noticed increased confidence*", "*a challenge but also an opportunity to experience my body doing postures I'd not thought I could do at this time in my life*", and "*amazing. So difficult! But an incredible achievement!*". Two responses (17%) were negative, for example: "*I didn't like going to classes at all. Bikram yoga is not right for me*" and "*I think that I entered the trial at the wrong point in my life….I also found that the time each class took out of my day was an added source of stress and I often felt guilty for being unable to attend the requested amount of classes*". Four participants (33%) had mixed feelings about the trial. For example, three participants (25%) stated that they enjoyed classes initially and could make time to attend but over the course of the trial this became more difficult or the enjoyment decreased. All participants in the experimental group except for one ("*too much of a commitment*") reported that they would recommend this trial or a similar trial to others in the future. One participant stated that the data collection location was inconvenient.

Six participants attributed exacerbation of a pre-existing condition to the intervention (i.e. back pain, foot pain, knee pain, calf pain, psychological discomfort). One additional participant experienced a non-intervention related event (sprained ankle). Before or during week eight, four of these seven participants discontinued the intervention completely (8 ± 4 classes attended). The other three continued (28 ± 11 classes attended). Adverse events that lead to discontinuation of the intervention reduced the average adherence from 60% to 54%.

4. Discussion

This study investigated predictors of and barriers to Bikram yoga participation in a cohort of stressed and sedentary adults. Higher adherence to the intervention was predicted independently by less pain, fewer physical limitations, poorer blood lipid profile (i.e. higher total cholesterol to HDL ratios, higher fasting blood glucose, lower HDL), older age, and higher HRV (Ln total power). In multi-variable analysis, age, HRV (total power) and pain remained significant predictors of adherence and collectively explained 41% of the variance in adherence.

Our cohort ranged in age from 23 to 64 years, and older age explained 10% of the variance in adherence ($p = 0.094$). Physical activity typically declines with age.[26] However, studies in metabolically diseased and overweight-obese populations have reported that age is positively associated with adherence to exercise and lifestyle intervention.[27–30] Similar findings exist in the yoga literature. For example, adults engaged in yoga, including those who participated in yoga to help with a primary medical complaint[31] are more likely be middle-aged than younger.[32,33] By contrast, Baird et al. found a negative correlation (not significant when accounting for other variables correlated with age) between age and Bikram yoga attendance in an RCT of stressed females with disordered eating aged 25–45 years.[14] Contrasting findings may be due to the different participant profiles between studies. Factors that may contribute to greater Bikram yoga uptake by our older participants in the current study may have included fewer work and family obligations, greater awareness of ageing and age-related susceptibility to morbidity, greater perceived health benefit

of the practice, greater desire to participate in supervised exercise, and higher self-efficacy.[34] Self-efficacy was found to be positively correlated with age in the present cohort.[8] Age-related increase in altruism, including respect for the research process, may have also influenced adherence. Further research is warranted to further explain age as a predictor of adherence to Bikram yoga, and to determine factors that may enhance adherence in younger adults who are stressed and sedentary.

Higher HRV (total power), a reflection of increased parasympathetic and reduced sympathetic activity,[25] explained 9.9% of variance in adherence ($p = 0.097$), suggesting that participants with lower physiological stress levels at baseline were more likely to adhere to the intervention. Higher HRV is associated with lower perceived (psychological) stress,[35] and perceived stress is a barrier to engagement in exercise.[15,36] Habitual exercisers report that during times of higher stress, enjoyment and satisfaction of exercise decreases ($p < 0.05$), and self-efficacy ($p < 0.01$) for meeting exercise goals decreases.[36] Further investigation is required to determine how physiological (i.e. lower HRV) and psychological stress interrelate and impact upon coping skills and adherence to Bikram yoga intervention.

Participants with less pain ($p = 0.048$) and fewer physical limitations ($p = 0.011$) at baseline may have been better able to cope with the demands of the Bikram yoga intervention. Similarly, Cadmus-Bertram et al (2014) reported that lower levels of pain predicted higher adherence to a 12-month exercise program in a cohort of sedentary, overweight (BMI 25–29.9 kg/m^2) adults. Evidence suggests that *hatha* yoga can reduce pain compared to no-treatment.[37] Bikram yoga has been shown to improve strength, flexibility and balance,[2] and these effects may possibly be associated with a reduction in physical limitations and pain. A recent review suggests that adherence to therapeutic exercise in populations with pain and physical limitations (i.e. osteoarthritis, low back pain) could be enhanced by a more graded approach to increasing exercise dosage.[38] Perhaps a graded approach to Bikram yoga intervention in participants with pre-existing pain or physical limitations may improve adherence. Further research is warranted.

Higher total cholesterol to HDL ratio, higher fasting blood glucose, and lower HDL at baseline predicted adherence to the intervention. These results are congruent with our findings for age in that aging is associated with a progressive decline in metabolic health.[5] The same reasons for age-related adherence may indirectly explain these results. A previous study reported that a sub-group of participants with metabolic conditions (i.e. diabetes, hyperlipidaemia) were more likely to adhere to exercise compared to sub-groups of participants with cardiovascular or orthopaedic conditions.[27] It is important to note, however, that the cohort in the present study had metabolic disease risk factors only (i.e. sedentary, stressed), therefore comparisons with cohorts with confirmed metabolic disease must be made with caution.

Variables associated with enhanced adherence to non-Bikram yoga interventions, including higher self-efficacy, lower fatigue, reduced anxiety, lower waist circumference, and lower BMI[39–41] did not predict adherence in the present study. A potential explanation for these incongruent findings requires further exploration using larger sample sizes than present (n = 29).

Our qualitative investigation suggests that the main barriers to adherence related to the required commitment to the trial and lack of enjoyment of the intervention. Similarly, previous Bikram yoga trials mentioned briefly that experimental group dropouts were attributed to either scheduling conflicts or lack of enjoyment of the intervention.[9,10,12,42] Modern life, for example work and family commitments, has been identified as a major barrier ongoing yoga practice.[17] As one participant reflected, commitment to any intervention for the time required by the current trial would have been difficult with her work and family commitments. The two participants who disliked Bikram yoga both reported that involvement in the trial motivated them to seek self-care activities that suited them better. Supporting this finding, previous

studies suggests that *hatha* yoga intervention increases non-yoga physical activity in previously inactive adults.[43,44] Three participants reported that enjoyment waned over the course of the trial. A cross-sectional report has shown that yoga practice is often initiated for exercise and stress-relief; however, 'spirituality' was the top reason for ongoing participation.[45] Enhancing the understanding of how *hatha* yoga can fit into a healthy lifestyle may help to overcome perceived barriers to yoga adherence. Adverse events due to pre-existing conditions were also barriers to adherence in the current trial and contributed to complete discontinuation of the intervention in four participants. *Hatha* yoga tradition and modern research suggest that certain imbalances in either body or mind may be alleviated by continued Bikram yoga practice.[3,8] Additional research is required to determine why some health issues may be exacerbated by participation in Bikram yoga. Methodology, for example, the use of public classes and varying teachers instead of private classes conducted specifically for participants, might also influence the management of pre-existing conditions.

This is the first study to examine factors predicting adherence to Bikram yoga that also includes a qualitative examination of perceived barriers to attendance. Secondly, the intervention took place in established Bikram yoga studios and participants attended classes with regular students of varying experience levels. Although this introduces more uncontrolled factors into the treatment experience it mimics the real-life experience of joining Bikram yoga as a beginner. Limitations of the trial include the modest sample size, which limits the power of our statistical analyses by possible over-fitting of the multi-variable model. Alternative statistical approaches including latent class analysis and multi-level modelling were considered, however, based on sample size and the number of possible predictors for attendance the multi-variable regression model was deemed most appropriate. The low return rate of the exit surveys (12/29, 41%) was also a limitation. Participants with strong opinions either way may be most likely to return the surveys, which may bias qualitative feedback. Further, limited demographic data was collected, reducing the ability to explore a range of other possible predictors of adherence, including income, occupation, level of education, and geographic location (i.e. access to the studio).

Future research should prioritise investigation into the minimum dose of Bikram yoga required for adaptation of various health outcomes. Future research should also consider ways, for example, through pre-intervention planning sessions, to effectively identify and reduce individual perceived barriers to Bikram yoga adherence not explored in this study. Further, the relationship between gender differences and adherence is worth exploring, considering that a major barrier to adherence in the current study was juggling parental responsibilities. Lastly, yoga research is generally limited by the heterogeneity of both interventions themselves and reporting of data.[46–48] Future research should consider common guidelines for conducting yoga trials.[46,49]

5. Conclusion

In summary, our findings show that higher adherence to a 16-week Bikram yoga intervention was independently predicted by older age, less pain, fewer physical limitations, poorer blood lipid profile (i.e. higher total cholesterol to HDL ratios, higher fasting blood glucose, lower HDL) and higher HRV (Ln total power). Barriers to the intervention included lack of enjoyment of the intervention, time commitment to participate in the trial, and adverse events. These findings should be considered in the development of future trials of Bikram yoga in similar cohorts, to facilitate higher levels of adherence, which may better inform community practice. Future trials should also continue to investigate and address additional barriers and facilitators of Bikram yoga practice.

Ethics approval and consent to participate

The Western Sydney University (H10549) and University of

Canberra Human Research Ethics Committees (H10549-14/009174) approved all procedures and written informed consent was obtained from all participants.

Consent for publication

Not applicable.

Availability of data and material

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Competing interests

ZLH declares that she became a co-owner of Bikram Yoga Kingston in July 2014, after the conception and design of the study. Caroline A Smith declares that as a medical research institute, the National Institute of Complementary Medicine receives research grants and donations from foundations, universities, government agencies and industry. Sponsors and donors provide untied funding for work to advance the vision and mission of the Institute. In general, NICM respects confidentiality in these arrangements, so as to avoid any likelihood of generating unwelcome further solicitations to the donor or sponsor from outside parties. The project that is the subject of this article was not undertaken as part of a contractual relationship with any organisation. All other authors declare they have no competing interests.

Authors contributions

Conceived study: ZLH. Designed the study: ZLH, BSC, KLP, CAS. Acquisition of data: ZLH, KLP. Delivered intervention: ZLH (and primarily other instructors at Bikram Yoga Canberra and Bikram Yoga Kingston). Prepared manuscript: ZLH, BSC, KLP, PPF, CAS. Statistical analysis guidance: PPF. All authors have read and approved the final manuscript.

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