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Research article

Effects of an online yoga program on anthropometric parameters among overweight female students during the COVID-19 pandemic

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ABSTRACT

The coronavirus disease 2019 (COVID-19) outbreak is a public health concern. However, stay-at-home regulations to prevent disease spread increased sedentary behavior with unintended adverse outcomes. Overweight is a major global health issue, and standard treatments have a poor track record of long-term effectiveness. The purpose of this study was to evaluate how online yoga affected participants who were overweight in terms of anthropometric measurements. The study, which was designed as a experimental study, enrolled sixty overweight adolescents. The participants were divided into two groups: a control group (n = 30) and an intervention group (n = 30) who performed an online yoga home exercise program comprising basic yoga practice with 15 poses and minimal rest periods on Monday Wednesday and Friday, from 5.00 to 5.45 pm for 12 weeks. The intensity of the exercise was 65–75 percent of maximum heart rate (MHR). Anthropometric parameters, including body weight (BW), body mass index (BMI), body circumference measurements (BCM), and resting heart rate (RHR) were assessed. All parameters were measured at weeks 0, 8, and 12. Within group and between group comparisons were performed. The results revealed improved BW, BMI, BCM, and RHR in the intervention group; the median BW and BMI of the intervention group was significantly decreased at week 12, and the BCM of the intervention group showed a significant decrease in the chest, waist, hip, and thigh. This declining trend started from week 8. This 12-week online yoga program decreased BW, BMI, BCM, and RHR, which indicates that practicing yoga at home is effective on anthropometric parameters and may be an alternative therapy for health promotion and controlling body weight during the COVID-19 pandemic. However, an appropriate and continuous exercise program must be followed.

1. Introduction

Coronavirus disease 2019 (COVID-19) is an infectious disease of pandemic proportions, approximately 278,000 deaths and more than 4,000,000 cases have been reported globally as of May 12, 2020 [1]. The COVID-19 pandemic makes it challenging to maintain required physical activity (PA). COVID-19 transmits through people who are in close proximity. Therefore, preventive strategies include avoiding public gatherings and maintaining a social distance of at least six feet from each other. This makes exercising in public gyms difficult and maintaining an appropriate social distance impossible as many people frequently use the same space every day [2, 3]. Diminished PA due to home isolation may worsen a variety health conditions, including chronic diseases such as cardiac diseases, metabolic diseases, obesity, and infectious diseases, due to negative immune modulation [4].

Obesity and being overweight are global health concerns. Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health and present a health risk. The number of overweight and obese individuals is rising worldwide. Between 1975 and 2016, there was a more than fourfold increase (from 4% to 18%) in the prevalence of overweight or obesity among children and adolescents worldwide, ages 5 to 19; this increase in adults was >1.9 billion for overweight and >650

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million for obesity [5]. In adolescents, overweight and obesity are rising worldwide, especially in developing and newly industrialized countries [6], and have been linked to more deaths than underweight and normal weight. Overweight or obesity is a major cause of morbidity and mortality among the global population [5]. The prevalence of obesity among people aged 15 years in Thailand was reported to be 37.5% in 2014 by the Thai National Health Examination Surveys V (NHES V), with averages of 32.9% and 41.8% for men and women, respectively [7].

Risks associated with obesity include chronic non-communicable diseases (NCDs) [8], especially cardiovascular disease, type 2 diabetes mellitus, and numerous acute and chronic diseases [9, 10]. A previous study has shown a low correlation with myocardial infarction, a moderate association with stroke, and a high association with high blood pressure [11]. Apparently, the hypothalamus pituitary adrenal (HPA) axis is overstimulated in obesity [12] due to chronic stress [13]. Disorganization of the endocrine system and abdominal obesity with metabolic abnormalities are highly correlated with poor HPA axis control and perceived stress-dependent cortisol levels [14].

The COVID-19 lockdown showed a negative effect of COVID-19 home confinement on PA levels, leading to a significant decrease of PA that might lead to health-related problems such as obesity [15]. Therefore, therapeutic interventions for obesity are necessary. Several studies have shown that two powerful strategies are monitoring food intake and increasing PA. Yoga is a PA that hugely impacts weight control and improves body composition in healthy middle-aged men and women [16]. Yoga is a traditional Indian way of living that incorporates the use of specialized methods including breathing exercises (pranayamas), meditation, and yoga asanas (postures) in order to reach the greatest state of awareness [17]. Regular yoga practice not only gives the body the necessary amount of exercise, but also, through discipline, promotes stability, balance, and normalcy. Because yoga provides mild and subtle psychological management strategies, it is effective for moderate, sustained weight loss. It also lessens the perception of stress, worry, and depression, which are significant contributors to overeating [18]. Yoga can increase strength and flexibility as well as help regulate physiological factors like blood pressure, lipids [19], respiration, heart rate, and metabolism to increase total exercise capacity [20]. Adolescent obesity may be avoided by yoga. Therefore, it is essential to research yoga as a suitable and advantageous kind of exercise for a healthy body weight (BW). In this study, we investigated the effects of a continuous yoga practice on anthropometric measurements and weight loss [21]. Although surveys and clinical research have shown preliminary evidence for the usefulness of yoga in weight loss and improved body composition, the benefits of online yoga on anthropometric measurements such as body circumference have yet to be examined.

The COVID-19 pandemic has been a barrier to what was previously considered normal daily living. Home-based exercise programs have been postulated as a potential tool for maintaining health status during the pandemic [22]. Semi-supervised home-based exercise is a safe, inexpensive, and easy-to-implement therapeutic resource. Hence, a form of online exercise was devised to promote and maintain the health of adolescents. This study aimed to investigate the effect of online yoga on anthropometric parameters in overweight female students. This study concentrated on the creation of online yoga programs. As yoga is a simple, safe exercise that does not have high equipment requirements, it can be performed at home. Additionally, if performed consistently, it may aid in the improvement of health and weight loss. Determining the benefits of an online yoga program may be used by health professionals to develop exercise guidelines.

2. Materials and methods

2.1. Study design and participants

This prospective study was conducted between January and December 2021, and involved pre-mid-post test of an online yoga intervention group and a control group. The total duration was 12 weeks. The design was an experimental study using an online platform. This study was approved by the Walailak University Ethics Committee on Human Research (WU EC) at Walailak University, Nakhon Si Thammarat, Thailand (approval no. WUCE-21-076-01).

The sample size was determined as a randomized controlled experiment with a continuous outcome using the n4Studies tool [23]. This was calculated using the data from a previous study; the difference of body mass in the treatment group was 3.30 ± 4.40 (mean ± standard deviation), and the difference of body mass in the control group was 0.70 ± 0.10, with a precision of 0.05, confidence level of 95%, and power (with β% of type II error) of 80% [24]. Therefore, 23 people per group were the minimal sample size for each group needed to detect the difference between the two means. With a 30% dropout rate in mind, the study needed 30 volunteers for each treatment group (online yoga intervention and control groups).

Through purposive sampling, we used simple random sampling to divide 60 selected and invited participants into two groups (online yoga intervention and control groups). Female Walailak University students who were 1) between the ages of 18 and 22 years old, 2) with a BMI of 23–26 kg/m^2, as determined by World Health Organization (WHO) Western Pacific Region (WPRO) guidelines [5], and 3) physically capable of exercising met the inclusion criteria. Participants who had musculoskeletal injuries, congenital diseases with contraindications for exercise, history of being a university athlete or a vigorous exerciser, had ever participated in a physical fitness enhancement or weight loss program, or participated in more than three research projects were excluded. All subjects were given written informed permission before being enrolled in the study.

2.2. Online yoga intervention

The online yoga intervention included the basic asanas followed in a previously published study [21]. It was modified to administer online and was validated by five yoga experts; it was preliminarily tried out among 25 female students. Stretching techniques and sun salutations were incorporated in the curriculum. The intervention was performed three times a week on Mondays, Wednesdays, and Fridays, from 5:00 to 5:45 pm for a total of 12 weeks, with each session lasting 45 min. This program was created to emphasize the physicality of yoga exercises. The program comprised basic yoga practice with 15 consecutive poses and minimal rest periods. Individuals in the control group did not participate in any exercise training program and were evaluated only before (baseline), week 8, and week 12.

The goal of this study was to modify the fundamental yoga pose in order to provide an aerobic workout and speed up the energy metabolism process [21]. In the present study, all participants trained at home while every training session was controlled by one of the researchers. The exercise sessions were divided into three phases and lasted a total of 45 min: 10 min were spent warming up and stretching in standing and sitting poses, and the remaining 25 min were spent performing 15 yoga poses. With only brief breaks, all poses were executed, and then the sitting and death poses were held for 10 min for cool down (Table 1). The target heart rate (THR) for intensity of exercise was between 65 and 75 percent of the maximum heart rate (MHR) and was used to design the intensity of the exercise program. The MHR was estimated from the formula MHR = 220 − age. The MHR was also used for calculating the THR from the following formula: THR = MHR × exercise intensity percentage.

2.3. Assessments of anthropometric parameters and target heart rate

The participants were trained by researchers before they measured their own anthropometric parameters. The anthropometric parameters, including BW, BMI, body circumference measurments (BCM) of the chest, waist, hip, and thigh, resting heart rate (RHR), and target heart rate (THR) were assessed three times prior to the intervention (baseline), as well as at weeks 8 and 12 of the intervention. The RHR and THR were measured by checking the pulse at the wrist: placing two fingers between the bone and the tendon over the radial artery located on the thumb side of the wrist, and counting the number of beats in 1 min. RHR was measured 1 min after waking up in the morning. THR at 65–75 percent of MHR was measured 1 min after 25 min yoga practice, before the cool-down session. All the participants in both groups evaluated themselves, supervised by a researcher.

Height was recorded in centimeters (cm) without socks and shoes to the nearest 0.1 cm. A digital electronic weighing scale was used to determine the weight in kilograms (kg), which was recorded to the closest 0.1 kg. BMI was calculated as weight in kg divided by the square of height in m. Body circumferences were measured in centimeters (cm) using a non-elastic measuring tape to the nearest 0.1 cm. The circumference of the chest was measured at the level of the nipple, and the waist was measured midway between the lowest rib margin and iliac crest. Hip circumference was measured at the level of the anterior superior iliac spine and at the broadest circumference below the waist. Thigh circumference was measured using a standardized position (standing with most of the weight on the left leg with the right leg forward, knee slightly flexed, and soles of both feet flat on the floor), on the right side of the mid-thigh.

2.4. Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics, version 26 (Armonk, NY: IBM Corp). The survey data were analyzed using descriptive and inferential statistics. Continuous variables were described using the median and interquartile range (quartile 1, quartile 3). The Shapiro–Wilk test was used to check the normality of the data, and Levene's test was used to check for homogeneity of variance between treatments. Two-way repeated-measures analysis of variance (ANOVA) was used to evaluate the main effects (group, time), interaction effects (group × time), and the effect size between group and time. The median was compared between groups using the Mann-Whitney U test. Each group's median change from baseline to 8th and 12th weeks was examined using the Friedman test. Furthermore, the Wilcoxon test was applied for pairwise comparisons with significant differences from baseline to the 8th and 12th weeks, and the 8th week to the 12th week within group. Statistical significance was set at $p < 0.05$.

Table 1. Components of the online yoga intervention (three times/week for 12 weeks).

Components	Duration
Step 1: Warm up	10 min
Step 2: Yoga, 15 poses	25 min
1. Pranamasana (Prayer pose)	
2. Hastauttanasana (Raised hands pose)	
3. Hasta Padasana (Standing forward bend)	
4. Ashwa Sanchalanasana (Equestrian pose)	
5. Dandasana (Staff pose)	
6. Bhujangasana (Cobra pose)	
7. Adho mukha svanasana (Downward Dog Pose)	
8. Virabhadrasana (Warrior pose)	
9. Vrikshasana (Tree pose)	
10. Trikonasana (Triangle pose)	
11. Natarajasana (Lord of the dance)	
12. Malasana (Yogi squat)	
13. Padmasana (Lotus pose)	
14. Supta Matsyendrasana (Spinal twist pose)	
15. Balasana (Child pose)	
Step 3: Cool down period	10 min

3. Results

3.1. Demographic characteristics of the participants

Sixty participants, screened between August and October 2021, were randomized into two groups (n = 30 each). Online yoga intervention group was the first group, while control group was the second. The baseline data showed no statistically significant differences between the control and yoga groups for median BW (kg), height (cm), BMI (kg/m^2), RHR (bpm), chest circumference (cm), waist circumference (cm), and thigh circumference (cm). In comparison to the control group, the yoga group's median hip circumference (cm) was significantly higher ($p = 0.003$) (Table 2).

3.2. Body weight

There was no significant difference in BW between the groups (F = 0.18, $p = 0.05$, effect size (η_p^2) = 0.006); however, there were significant differences with time (F = 32.91, $p < 0.001$, $\eta_p^2 = 0.53$) and interaction (group × time) effects (F = 81.31, $p < 0.001$, $\eta_p^2 = 0.73$) (Figure 1). In the yoga group, BW significantly decreased at week 8 (p < 0.001) and week 12 (p < 0.001) compared with baseline; further, there was a statistically significant decrease at week 12 (p ≤ 0.001) compared with week 8. Contrarily, BW in the control group showed a significant increase at week 8 (p = 0.02) and week 12 (p = 0.002) compared with baseline and at week 12 (p = 0.019) compared with week 8. At baseline, the median BW of the yoga group was greater than that of the control group, while the median BW of the yoga group at week 12 was significantly lower than that of the control group (p < 0.019) (Table 3).

3.3. Effects on BMI

There was no significant difference in BMI between the groups (F = 3.44, $p = 0.07$, $\eta_p^2 = 0.10$), but there was a difference in time effects (F = 33.27, $p < 0.001$, $\eta_p^2 = 0.53$) and interaction (group × time) effects (F = 83.66, $p < 0.001$, $\eta_p^2 = 0.74$) (Figure 2). BMI significantly decreased at weeks 8 and 12 compared with baseline values in the yoga group and increased at week 12 compared with baseline values in the control group. In the yoga group, BMI showed a significant decrease at week 8 ($p < 0.001$) and week 12 ($p < 0.001$) compared with baseline and at week 12 ($p \leq 0.001$) compared with week 8. However, BMI in the control group showed a significant increase at week 12 (p = 0.004) compared with baseline and at week 12 (p = 0.011) compared with week 8. Intergroup comparisons revealed significant decreases in the median BMI of the yoga group compared with the control group consistently at week 8 (p = 0.006) and week 12 (p ≤ 0.001) (Table 4).

3.4. Effects on chest circumference

Chest circumference showed no significant differences between the groups (F = 0.55, $p = 0.46$, $\eta_p^2 = 0.01$). Chest circumference showed significant differences with time (F = 8.65, $p = 0.003$, $\eta_p^2 = 0.23$) and interaction (group × time) effects (F = 8.65, $p = 0.003$, $\eta_p^2 = 0.23$) (Figure 3). Chest circumference in the yoga group showed a significant decrease at week 8 ($p = 0.011$) and week 12 ($p = 0.001$) compared with baseline, and at week 12 ($p = 0.008$) compared with week 8; the chest circumference of the control group did not change from baseline (Table 5).

3.5. Effects on waist circumference

Waist circumference showed a statistically significant difference between the groups (F = 13.63, $p = 0.001$, $\eta_p^2 = 0.32$), and with time (F = 42.67, $p \leq 0.001$, $\eta_p^2 = 0.59$) and interaction (group × time) effects (F = 118.12, $p < 0.001$, $\eta_p^2 = 0.80$) (Figure 4). It demonstrated significantly changes from baseline values at weeks 8 and 12 in both groups. In the yoga group, the waist circumference showed a significant decrease at

Table 2. Demographic characteristics of the participants at baseline.

Characteristics	Groups		p value
	Yoga (n = 30)	Control (n = 30)	
Weight (kg)	59.5 (55, 63)	56 (54,60)	0.084
Height (cm)	157 (155, 161)	156 (153, 161)	0.329
BMI (kg/m^2)	23.14 (22.6, 24.22)	22.88 (22.6, 23.15)	0.254
RHR (bpm)	78.5 (75, 83)	77.5 (74, 82)	0.458
Chest circumference (cm)	34 (33,36)	34 (34,36)	0.933
Waist circumference (cm)	28.25 (27,31)	30 (28,32)	0.160
Hip circumference (cm)	38 (36,40)	36 (34,38)	0.003*
Thigh circumference (cm)	20.5 (19,22)	21 (19.5, 22)	0.526

Data are presented as the median (quartile 1, quartile 3).
* $p < 0.05$, significant difference between the groups.

week 8 ($p < 0.001$) and week 12 ($p < 0.001$) compared with baseline and at week 12 ($p \leq 0.001$) compared with week 8. Contrarily, waist circumference in the control group showed a significant increase at week 8 (p = 0.013) and week 12 (p = 0.001) compared with baseline and at week 12 (p = 0.022) compared with week 8. Intergroup analysis showed a significant and consistent decrease in the yoga group at week 8 (p = 0.001) and week 12 (p ≤ 0.001) compared with the control group (Table 6).

3.6. Effects on hip circumference

Hip circumference showed no significant differences between the groups (F = 1.18, $p = 0.28$, $\eta_p^2 = 0.03$). Hip circumference showed a significant difference with time (F = 36.45, $p < 0.001$, $\eta_p^2 = 0.55$) and interaction (group × time) effects (F = 37.58, $p < 0.001$, $\eta_p^2 = 0.56$) (Figure 5). In the yoga group, the hip circumference significantly decreased at week 8 ($p < 0.001$) and week 12 ($p < 0.001$) compared with baseline and at week 12 ($p < 0.001$) compared with week 8, whereas the hip circumference of the control group did not change from baseline. At baseline, the median hip circumference in the yoga group was significantly greater than that in the control group (Table 7). In addition, there was no significant difference between the groups ($p = 0.28$) (Figure 5).

3.7. Effects on thigh circumference

There was a significant difference between the groups (F = 14.77, p = 0.001, $\eta_p^2 = 0.33$) and time (F = 33.80, $p < 0.001$, $\eta_p^2 = 0.53$) and interaction (group × time) effects (F = 50.32, $p < 0.001$, $\eta_p^2 = 0.63$) in thigh

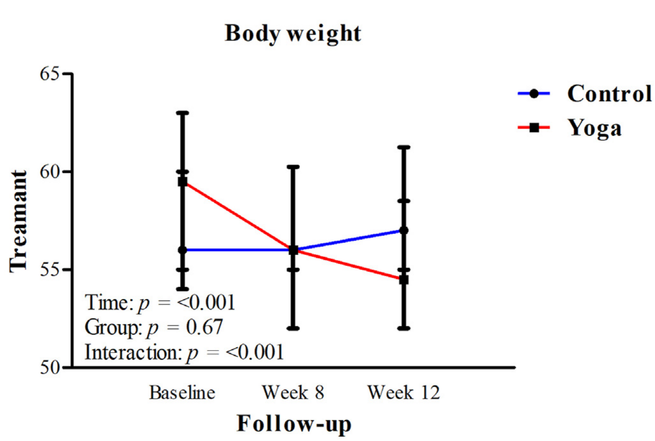

Figure 1. Body weight patterns in the yoga and control groups at baseline, week 8, and week 12. The median and interquartile range are used to display the data. A two-way repeated-measures analysis of variance was used to analyze the data.

Table 3. Body weight of the participants.

Time point	Groups		p value*
	Yoga (n = 30)	Control (n = 30)	
Baseline	59.5 (55, 63)	56 (54,60)	0.084
Week 8	56 (52,60)†	56 (55,60)†	0.301
Week 12	54.5 (52,58)††,†††	57 (55, 61)††,†††	0.019
p value**	<0.001	0.002	

Data are represented as median (quartile 1, quartile 3).
Statistical analysis: * Mann-Whitney U, ** Friedman's test, † Significant difference between baseline and week 8 within groups ($p \leq 0.05$), †† Significant difference between baseline and week 12 within groups ($p \leq 0.05$), ††† Significant difference between week 8 and week 12 within groups ($p \leq 0.05$).

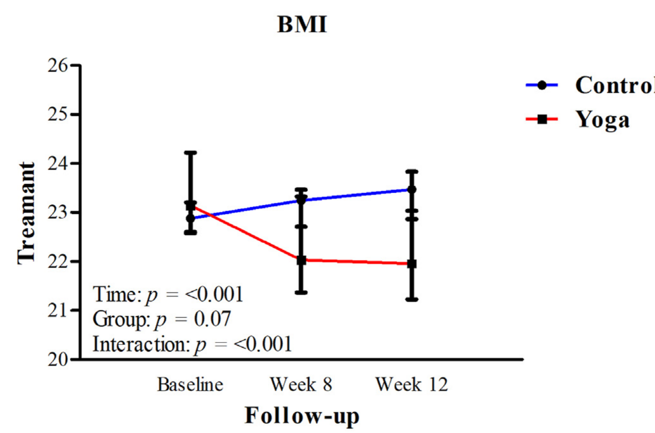

Figure 2. Body mass index (BMI) patterns in the yoga and control groups at baseline, week 8, and week 12. The median and interquartile range are used to display the data. A two-way repeated-measures analysis of variance was used to analyze the data.

circumference (Figure 6). The thigh circumference in the yoga group showed a significant decrease at week 8 (p < 0.001) and week 12 (p < 0.001) compared with baseline and at week 12 (p < 0.001) compared with week 8. Contrarily, the thigh circumference in the control group showed a significant decrease at week 12 (p = 0.026) compared with baseline. Intergroup comparisons showed that the median thigh circumference of the yoga group significantly decreased consistently by week 8 (p = 0.001) and week 12 (p ≤ 0.001) compared with the control group (Table 8).

3.8. Effects on RHR

There was no significant difference in RHR between groups (F = 2.94, p = 0.09, $\eta_p^2 = 0.09$); there were significant differences with time (F = 18.43, $p < 0.001$, $\eta_p^2 = 0.38$) and interaction (group × time) effects

Table 4. Body mass index of the participants.

Time point	Groups		p value*
	Yoga (n = 30)	Control (n = 30)	
Baseline	23.14 (22.6, 24.22)	22.88 (22.6,23.15)	0.254
Week 8	22.03 (21.37, 23.31)†	23.24 (22.72,23.44)	0.006
Week 12	21.96 (21.23, 22.94)††,†††	23.47 (22.89,23.81)††,†††	<0.001
p value**	<0.001	0.002	

Data are represented as the median (quartile 1, quartile 3).
Statistical analysis: * Mann-Whitney U, ** Friedman's test, † Significant difference between baseline and week 8 within groups ($p \leq 0.05$), †† Significant difference between baseline and week 12 within groups ($p \leq 0.05$), ††† Significant difference between week 8 and week 12 within groups ($p \leq 0.05$).

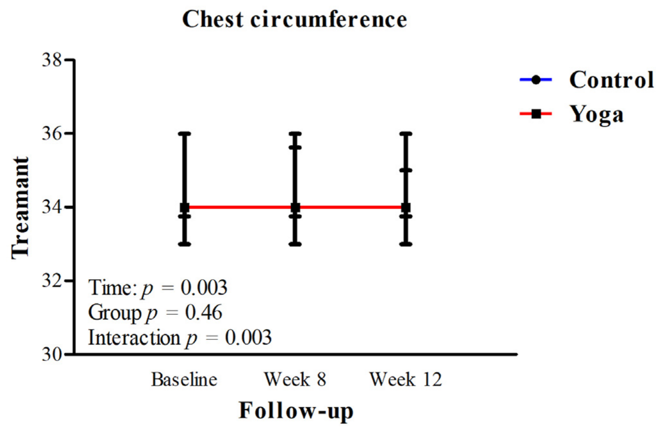

Figure 3. Chest circumference patterns in the yoga and control groups at baseline, week 8, and week 12. The median and interquartile range are used to display the data. A two-way repeated-measures analysis of variance was used to analyze the data.

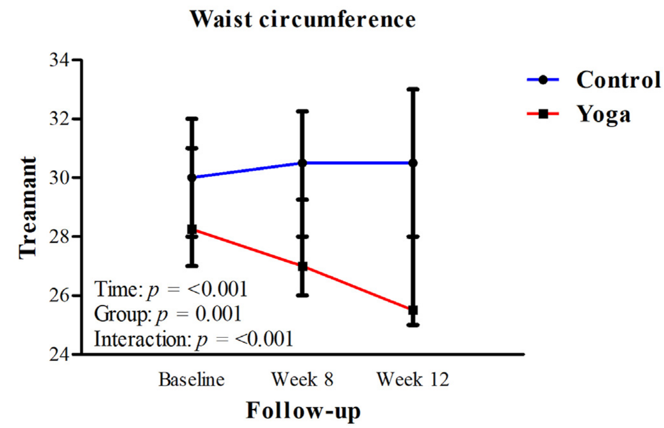

Figure 4. Waist circumference patterns in the yoga and control groups at baseline, week 8, and week 12. The median and interquartile range are used to display the data. A two-way repeated-measures analysis of variance was used to analyze the data.

($F = 41.86, p < 0.001, \eta_p^2 = 0.59$) (Figure 7). Moreover, the RHR showed a significant decrease at week 12 ($p \leq 0.001$) compared with baseline and at week 12 ($p \leq 0.001$) compared with week 8 in the yoga group, while the RHR of the control group remained constant from the starting point. When compared to the control group at week 12, the median RHR in the yoga group consistently decreased (Table 9).

4. Discussion

PA in the Thai population was negatively impacted by the COVID-19 pandemic. When the government implemented strong efforts to contain the virus by limiting people's movement in society at large, PA started to decline after peaking in the early stages of the pandemic. From March 28 to May 2, 2020, public offices, schools, and other places of business were closed to urge people to stay at home; through July 1, 2020, some travel was permitted with restrictions. Individuals' concern of contracting an infection also drove them to separate themselves by working from home and substituting teleconferencing and online socializing for in-person encounters. As a result of the majority of office work being done at home, the cumulative minimum PA for work-related and transit purposes decreased. The opportunity for Thai people to regularly engage in recreational PA outside of their homes was further diminished by the closure of public parks, gyms, and other sports facilities [25]. Consequently, many organizations began exploring options to promote health. Maintenance of health may prevent infection. Hence, the Thai Health Promotion Foundation issued a series of guidelines (i.e. Fit from Home (FFH)) on how to stay fit during the pandemic to help Thai people maintain/regain good health [25]. Home workouts remain the only possibility to stay active during the COVID-19 pandemic [26]; therefore, online exercises are of interest as they increase PA. The WHO recommends practicing at least 150 min per week of moderate-to-vigorous intensity PA, 75 min per week of high intensity PA, or a combination of both [27, 28]. This study, which involved an online platform, aimed to create an online yoga exercise program that could be performed at home and had an influence on regulating anthropometric parameters. The difference between this study and past research is that it was a home-based online yoga practice, which focused on controlling the

Table 5. Chest circumference of the participants.

Time point	Groups		*p* value*
	Yoga (n = 30)	Control (n = 30)	
Baseline	34 (33, 36)	34 (34, 36)	0.933
Week 8	34 (33, 35.5)†	34 (34, 36)	0.458
Week 12	34 (33, 35)††,†††	34 (34, 36)	0.213
p* value*	<0.001	-	

Data are represented as the median (quartile 1, quartile 3).
Statistical analysis: * Mann-Whitney U, ** Friedman's test, † Significant difference between baseline and week 8 within groups ($p \leq 0.05$), †† Significant difference between baseline and week 12 within groups ($p \leq 0.05$), ††† Significant difference between week 8 and week 12 within groups ($p \leq 0.05$).

Table 6. Waist circumference of the participants.

Time point	Groups		*p* value*
	Yoga (n = 30)	Control (n = 30)	
Baseline	28.25 (27, 31)	30 (28, 32)	0.160
Week 8	27 (26, 29)†	30.5 (28, 32)†	<0.001
Week 12	25.5 (25, 28)††,†††	30.5 (28, 33)††,†††	<0.001
p* value*	<0.001	<0.001	

Data are represented as the median (quartile 1, quartile 3).
Statistical analysis: * Mann-Whitney U, ** Friedman's test, † Significant difference between baseline and week 8 within groups ($p \leq 0.05$), †† Significant difference between baseline and week 12 within groups ($p \leq 0.05$), ††† Significant difference between week 8 and week 12 within groups ($p \leq 0.05$).

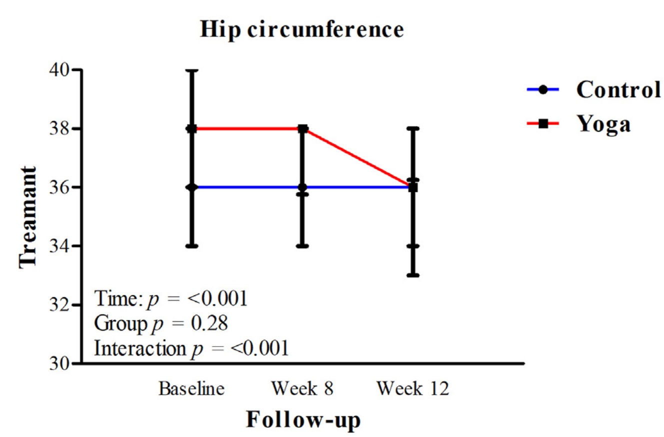

Figure 5. Hip circumference in the yoga and control groups at baseline, week 8, and week 12. The median and interquartile range are used to display the data. A two-way repeated-measures analysis of variance was used to analyze the data.

Table 7. Hip circumference in the participants.

Time point	Groups		p value*
	Yoga (n = 30)	Control (n = 30)	
Baseline	38 (36, 40)	36 (34, 38)	0.03
Week 8	38 (36, 38)†	36 (34, 38)	0.187
Week 12	36 (33, 36)††,†††	36 (34, 38)	0.204
p* value*	<0.001	0.368	

Data are represented as the median (quartile 1, quartile 3).
Statistical analysis: * Mann-Whitney U, ** Friedman's test, † Significant difference between baseline and week 8 within groups ($p \leq 0.05$), †† Significant difference between baseline and week 12 within groups ($p \leq 0.05$), ††† Significant difference between week 8 and week 12 within groups ($p \leq 0.05$).

intensity of exercise and individually measuring parameters throughout the duration of the research project. This study investigated the effects of the online yoga program on anthropometric parameters and RHR in overweight female students.

The present study found a 12-week online yoga practice with THR controlled during exercise, performed three times per week, resulted in positive changes in all variables, including significant reductions in BW, BMI, BCM, and RHR in overweight female students in the intervention group compared to controls. This is consistent with the results of previous studies that showed low-intensity exercises to be the most beneficial for health. Yoga classes are easily accessible and often offered by fitness clubs, providing a universal availability [29]. A recent systematic review reported that yoga can be considered a safe and effective intervention for weight reduction [30]. Yoga practice for 10 days was shown to be effective for fat mass reduction in both overweight and obese individuals. We speculated that yoga for a longer duration would be beneficial for further reduction of fat mass. Yoga practice for two or more months has shown statistically significant reductions in the percentage of body fat in obese individuals [31, 32].

Our results showed significantly reduced BW in the yoga intervention group, with a statistically significant difference between week 8 and week 12 within groups ($p \leq 0.05$). In general, the reduction of BW will effect BMI and BCM. A previous study showed BW decreased significantly after yoga practice. A controlled trial in India showed that yoga practice contributed to a reduction in excess body fat in school students and obese patients [33]. The BMI in the yoga group showed a significant decrease at week 8 and week 12 compared with baseline and at week 12 compared with week 8. Body circumference also showed significant decreases after intervention, with chest, waist, hip and thigh circumferences in the intervention group showing significant showing decreases at week 8 and week 12 compared with baseline and at week 12 compared with week 8. Exercise in overweight and obese older individuals improves anthropometric measures such as BMI and WC [34]. Specifically examining yoga's effects on anthropometric parameters in overweight or obese adults has only been the subject of a small number of randomized research. Recent meta-analyses based on the limited trials that were available demonstrated that yoga was useful in terms of anthropometric factors in patients with type 2 diabetes or other cardiovascular risk constellations, as well as in overweight or obese individuals [30, 35]. According to the existing literature, the effects of yoga on anthropometric measurements can be enhanced by practicing it more frequently, for a longer period of time, using complex yoga interventions that include multiple components, and combining it with dietary/nutritional advice (particularly a vegetarian diet with or without calorie restriction) and homework [36]. Suchetha et al. demonstrated that a month-long yoga program for people who never previously practiced yoga regulated BMI and reduced the risk of obesity-related complications [37]. Similarly, in the study by Shetty et al., a three–month yoga program among obese individuals decreased anthropometric parameters such as BMI, waist circumference, and hip circumference [38]. Chauhan et al. showed

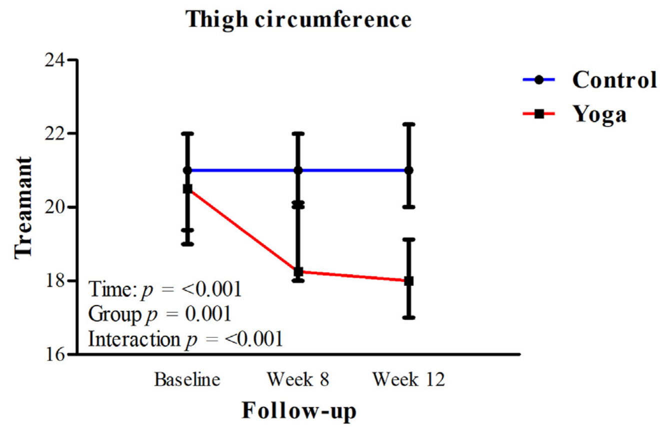

Figure 6. Thigh circumference patterns in the yoga and control groups at baseline, week 8, and week 12. The median and interquartile range are used to display the data. A two-way repeated-measures analysis of variance was used to analyze the data.

Table 8. Thigh circumference of the participants.

Time point	Groups		p value*
	Yoga (n = 30)	Control (n = 30)	
Baseline	20.5 (19, 22)	21 (19.5, 22)	0.526
Week 8	18.25 (18, 20)†	21 (20,22)	0.001
Week 12	18 (17, 19)††,†††	21 (20,22)††	<0.001
p* value*	<0.001	0.013	

Data are represented as the median (Quartile 1, Quartile 3).
Statistical analysis: * Mann-Whitney U, ** Friedman's test, † Significant difference between baseline and week 8 within groups ($p \leq 0.05$), †† Significant difference between baseline and week 12 within groups ($p \leq 0.05$), ††† Significant difference between week 8 and week 12 within groups ($p \leq 0.05$).

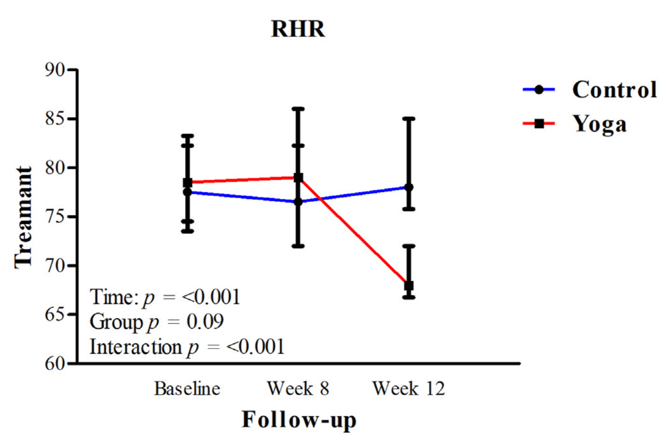

Figure 7. Resting heart rate patterns in the yoga and control groups at baseline, week 8, and week 12. The median and interquartile range are used to display the data. A two-way repeated-measures analysis of variance was used to analyze the data.

similar results: after practicing a yoga program for a month, BMI significantly decreased in the intervention group compared to the control group [39]. The effectiveness of yoga for weight control and improving anthropometric parameters is evident in surveys [16] and clinical studies [30]. Similar conclusions were found by Ariel-Donges et al. and Neumark-Sztainer et al., who claimed that yoga practice, which is widely available, could help people create good relationships with their bodies

Table 9. Resting heart rate of the participants.

Time point	Groups		p value*
	Yoga (n = 30)	Control (n = 30)	
Baseline	78.5 (75, 83)	77.5 (74, 82)	0.458
Week 8	79 (72, 86)	76.5 (72, 82)	0.583
Week 12	68 (67, 72)[††,†††]	78 (76, 85)	<0.001
p value**	<0.001	0.092	

Data are represented as the median (quartile 1, quartile 3).
Statistical analysis: * Mann-Whitney U, ** Friedman's test, † Significant difference between baseline and week 8 within groups ($p \leq 0.05$), †† Significant difference between baseline and week 12 within groups ($p \leq 0.05$), ††† Significant difference between week 8 and week 12 within groups ($p \leq 0.05$).

[40, 41]. It's interesting to note that yoga can enhance positive body image with only a few brief sessions of practice; this is crucial because intervention length affects prospective compliance [42] and is crucial for maximizing psychophysical performance [43, 44].

However, in general, evidence on the effects of regular physical exercise on RHR in various sports and exercises and a comparison of the effects of different exercises and sports is scarce. In this study, the RHR showed a significant decrease at week 12 compared with baseline and at week 12 compared with week 8 in the yoga group, while the RHR of the control group remained constant from the starting point. When compared to the control group at week 12, the mean RHR in the yoga group consistently decreased A six-week yoga and meditation program was used in a study in Connecticut, USA, to monitor brachial artery reactivity; the study's participants also had significant decrease in their blood pressure, heart rate, and body mass index (BMI) [45]. Regular exercise lowers RHR, which has a positive relationship to mortality [46]. The mediating effect of RHR, which can be decreased through regular exercise and/or physical activity, may be a mechanism for increasing life expectancy with exercise and PA [35, 47, 48]. RHR appears to have a negative relationship with life expectancy [49], but a positive relationship with cardiovascular and all-cause mortality [50].

A study that compared a home-based exercise program with group exercise for treating obesity revealed that participants in both categories shown considerable gains in functional capacity, eating habits, and weight loss throughout the first six months of treatment. However, throughout the second six months of training, the home-based program improved the group program in terms of weight loss. Overall, the home-based program showed significant long-term superiority in terms of exercise participation and weight loss [51]. Similarly, other studies also reported that home-based aerobic exercise programs had better long-term exercise participation rates than group-based interventions [52, 53], which could be due to the greater convenience and flexibility of home-based exercise, particularly with ongoing support of healthcare professionals. Consistent with our results, the principles of exercise state that regular and continuous exercise results in reduced BW, BMI, anthropometric parameters, and resting pulse. In this study, the participants were required to exercise three times per week for 12 weeks and maintain their exercise intensity in the range of 65–75% MHR. This demonstrated that home-based yoga exercises can reduce body weight and improve health. This study aimed to develop a simple exercise regimen that could be practiced by individuals at home and allow participants to self-measure and self-assess exercise progress. This was considered a suitable exercise method for teenagers during the COVID-19 pandemic lockdown as most people perform less physical movement and exercise.

Yoga in particular is a widely accepted essential part of health-promoting behavior, which is defined as a broad range of lifestyle factors, such as eating nutrient-dense foods, getting enough sleep, reducing stress, and avoiding unhealthy habits like smoking, which is directly linked to poorer health [54]. The majority of medical professionals agree that exercise lowers the risk of disease, delays mortality, and enhances general quality of life. Exercise is one of the most economical ways to achieve public health objectives from a public health perspective [55]. Exercise is proven to be necessary for a healthy existence, both physically and mentally. Yoga is a popular means of relieving stress and anxiety and improving fitness and health status. Yoga is simple and inexpensive; it can be easily adopted by most individuals without complications [56]. Yoga is also becoming more and more well-liked as a treatment option. Over 16 million Americans (80%) who practice yoga said they started out with the express purpose of enhancing their health [57, 58]. Additionally, one of the main motivations for beginning yoga was the aim to lose weight [59].

The strength of this study is the benefits of online yoga; it is a home exercise that offers more flexibility and can be a more efficient regimen in improving health because it increases PA during the COVID-19 pandemic during which work and studies have been shifted online and at home. The convenience of online yoga delivery was the benefit that was highlighted the most frequently, as it eliminates the need for parking, arranging childcare, and juggling hectic work schedules. The fact that technical features give users more privacy and autonomy is another benefit that is frequently mentioned [60]. However, participants were required to check their THR every time they exercised because the intensity of the exercise was regulated in this study. In addition, the reliability of the results was improved as the variables were compared pre-test, mid-test, and post-test.

This study had some limitations. All participants performed yoga exercises and anthropometric assessments by themselves. In addition, the researchers could not ascertain the use of the same methods for measurements as this was an online study; however, all participants were trained in measurements as part of the introduction to the program. This was a non-face-to-face exercise, nonetheless, the camera was turned on to view and track every training session, supervised by researchers.

5. Conclusions

An online yoga program three times a week for 12 weeks reduced BW and RHR and produces significant improvement in anthropometric measurements such as BW, BMI, and BCM in overweight participants. Moreover, an online yoga exercise program at home is easy, safe, and does not require much equipment; it can enhance physical fitness and quality of life and help in reducing the risk of chronic diseases. The RHR in the online yoga group significantly decreased after week 12, similar to previous studies, indicating that yoga may be used as an alternative therapy for obesity prevention in adolescents. Therefore, yoga is a type of exercise that can be employed at home and workplaces alike and may benefit health in overweight adolescents.

Declarations

Author contribution statement

Marisa Poomiphak Na Nongkhai: Conceived and designed the experiments, Performed the experiments, analyzed and interpreted the data, Wrote the paper.

Udomsak Narkkul: Conceived and designed the experiments, analyzed and interpreted the data, analysis tools or data, Wrote the paper.

Soontaraporn Huntula and Rajesh Kumar: analyzed and interpreted the data, Wrote the paper.

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Data availability statement

Data included in article/supp. material/referenced in article.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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