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Yoga in women with abdominal obesity – Do lifestyle factors mediate the effect? Secondary analysis of a RCT

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ABSTRACT

Introduction: The reduction of obesity is an important challenge for health policy. Although dietary interventions are widely available, patient adherence is usually low. A promising alternative is yoga. We hypothesized that weight reduction through yoga is mediated by aspects related to eating habits as well as physical aspects.
Methods: This is an exploratory secondary analysis of a randomized controlled trial comparing the effects of yoga to waiting list in women with abdominal obesity. *Body mass index* (BMI) and *waist circumference* were assessed as outcomes; *physical exercise habits*, *physical activity habits at leisure time, physical activity habits at work time, daily fruit and vegetable intake, nutrition self-efficacy*, and *physical self-efficacy* were captured as mediators. Measures were assessed at weeks 0 and 12. The original trial was conducted between April and August 2015. The secondary analysis was performed December 2019.
Results: Forty patients were randomized to the 12 weekly yoga sessions (48.5 ± 7.9 years) and 20 patients to the waitlist group (46.4 ± 8.9 years). Physical exercise habits fully mediated the effect of yoga on BMI (B=−0.26;CI [−.56;−.07]). Daily fruit and vegetable intake partially mediated the effect of yoga on BMI (B=−0.13;CI [−.38;−.01]). No further mediation effects were found.
Conclusions: Yoga supports people with overweight in eating healthier and increasing their physical activity which in turn leads to a reduced BMI. Yoga's effects on waist circumference seem to be due to other mechanisms.

1. Introduction

Obesity is a health problem that occurs primarily in the industrialized world. In recent decades, the number of overweight people in these countries has continued to rise. For the coming years, the World Health Organization and the Organization for Economic Co-operation and Development predict a further increase in industrialized countries, but also in emerging and developing countries.[1,2] Obesity is associated with coronary heart disease, cerebrovascular disease, and leads to an increase in the risk of all-cause mortality.[3] Particularly in the abdominal region, obesity is dangerous as these visceral fat cells produce hormones that may affect one's health. The reduction of obesity is therefore one of the most important challenges health policy will be facing in the coming years.

Although dietary interventions are widely available, patient adherence is usually very low.[4] Alternative strategies that promise better patient adherence are needed. A promising alternative is yoga. Although yoga is mainly associated with body postures, breathing exercises and meditation in North America and Europe, it traditionally also encompasses advice for a healthy and ethical lifestyle, moral imperatives (e.g. non-violence) and habits (e.g. self-discipline or asceticism).[5] This is reflected in a generally healthier lifestyle of yoga users: compared to the general population, yoga users more often are physically active, follow a vegetarian or vegan diet and do not smoke.[6–8] Yoga users regularly studying the philosophical foundations of yoga are more likely to follow a plant-based diet.[9]

In a randomized trial, 60 patients with abdominal obesity practiced 90 min of yoga twice a week for 12 weeks. Compared to the wait-list control group, the patients in the yoga group showed a significant reduction in their abdominal circumference, more favorable waist / hip ratio, reduced body weight, BMI and body fat percentage as well as an increase in the body muscle mass percentage. On the psychosocial level, too, positive changes took place: mental and physical well-being, body awareness, trust in bodily sensations and self-esteem increased,

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subjective stress decreased.[10] A meta-analysis also found effects of yoga on body mass index in overweight or obese individuals.[11] However, it is not yet clear by which mechanisms of action the positive effects of yoga are mediated. Identifying mediators can help determine the critical intervention components. Since yoga for beginners is usually not very strenuous physically, it cannot be the physical activity alone. Ross et al. identified five topics that people with overweight and people with normal weight attributed to weight loss through yoga: a *shift towards healthy eating* (patients changed their eating preferences, ate more mindful, and practiced less stress-related eating), *impact of yoga community* (support of yoga teachers and experienced yoga users as well as general support of the yoga community; participants positively highlighted that yoga was not practiced in the typical sports environment, characterized by athletic people), *physical changes* (e.g. increased muscle tone and changes in metabolism), *psychological changes* (such as changing the focus on losing weight to a focus on health and spirituality, improved mood and emotional stability, reduced stress and increased self-esteem and self-acceptance as well as increased awareness and concentration), and *a different weight loss experience* (losing weight was often unintended and not difficult).[12] A second study comes to similar findings. Here, 20 diaries of 25 women with obesity who participated in a 12-week yoga class with the primary goal of controlling their binge eating were analyzed. The yoga program resulted in a *healthy reconnection to food* and a *development of physical self-empowerment.*[13] Thus, there seems to be an effect of yoga on various processes related to weight loss: On the one hand, people with overweight are learning new ways of eating or developing a new relationship with food, on the other hand, people experience changes on the physical level as well. Hence, we hypothesized that the beneficial effects of yoga on abdominal circumference and BMI are mediated by different aspects related to eating habits and physical aspects (Fig. 1). To test this assumption, we performed mediation analysis of a secondary analysis of a randomized controlled trial comparing the effects of yoga to waitlist in patients with abdominal obesity.[10]

2. Methods

2.1. Design

The original study was a single-blind randomized controlled clinical trial conducted at a single center. The study had been approved by the ethics committee of the University of Duisburg-Essen (approval number: 15-6194-BO) and registered at ClinicalTrials.gov (registration number: NCT02420145) prior to patient recruitment. The study was conducted and reported in accordance with the CONSORT 2010 guideline[14] and performed in accordance with the Declaration of Helsinki. It was conducted at the Clinics Essen-Mitte, Germany, between April and August 2015. The secondary analysis was performed December 2019.

2.2. Participants

Women were recruited through local newspaper announcement and through mailing lists of local companies. Inclusion criteria included age 18–64 years, a waist circumference $\geq$ 88 cm, and a BMI $\geq$ 25 (for full eligibility criteria see Cramer, Thoms[5]). Women calling in were screened by a research assistant and if apparently eligible, participants were assessed by a study physician. Assessment included physical examination, and assessment of medical history and medication usage. Eligible participants received detailed written information describing the study, and written informed consent was obtained.

2.3. Randomization

Participants were randomly allocated to yoga or no treatment by block-randomization with randomly varying block lengths using a 2:1 allocation ratio. The randomization list was created by the biometrician not involved in patient recruitment or assessment using the Random Allocation Software.[15] The list was password-secured and no other person than the biometrician was able to assess it. After obtaining

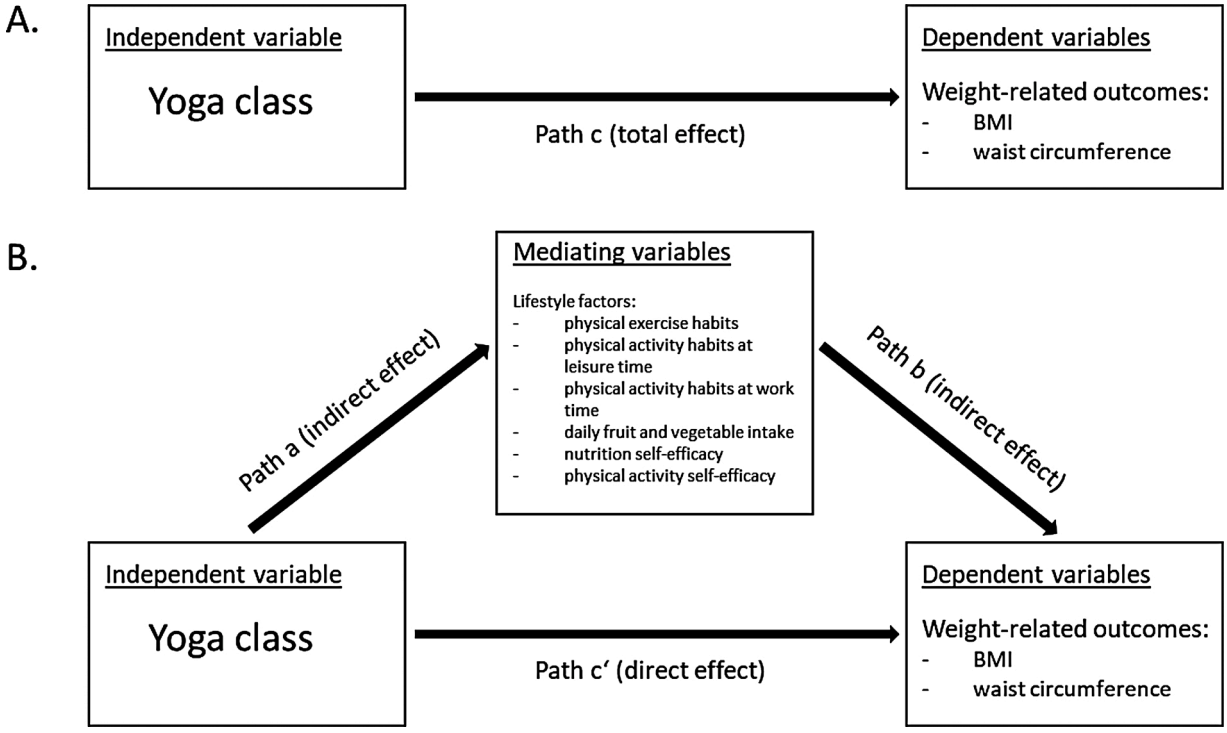

Fig. 1. Mediator Modell.
A. Direct association of the attendance to a yoga class on the change in BMI and waist circumferences.
B. Association of the attendance to a yoga class on the change in BMI and waist circumferences mediated by lifestyle factors.
Abbreviation: BMI – body-mass index.

written informed consent and baseline assessment, the included woman was centrally allocated by the biometrician.

2.4. Interventions

2.4.1. Yoga

The yoga intervention included an initial whole-day workshop followed by two weekly traditional hatha yoga sessions of 90 min each, based on the integral yoga of Swami Sivānanda and an adaption of the Yoga Vidya basic yoga-program, over a period of 12 weeks.[16] The yoga intervention was specially conceived for this study by a certified teacher of hatha yoga with longstanding experience, in cooperation with a large national professional association of yoga teachers (BYV). The intervention was specifically adapted to the needs, capabilities, and limitations of women with abdominal obesity, with a particular focus on a reduction in waist circumference. Difficulty of the physical components progressively increased over the course of the intervention. The yoga sessions were delivered by a certified teacher of hatha yoga.

The initial workshop and each yoga session included yoga postures, breathing exercises, deep relaxation/meditation, and dietary recommendations based on traditional yoga teachings, as well as instructions and practical exercises from the areas of meditation, positive thinking, and relaxation. The aim of the dietary recommendations was to achieve a change in the composition of the diet (e.g. a mostly plant based diet, more fresh and fewer industrially processed foods) and a more conscious approach to eating (e.g. mindful eating), not primarily a reduction in calories. Participants were asked not to start a calorie-restricted diet during the study period.

For more details on the yoga program see the original paper.[10]

2.4.2. Control

Women in the control group were wait-listed and did not participate in any study intervention for the first 12 weeks of the trial. They were asked not to initiate a yoga practice or other exercise regimen during this period. At week 12, they were offered the same yoga classes as the yoga group.

2.5. Outcome measures

The outcome assessor was blinded to patients' allocation throughout the study period and was not involved in patient recruitment, allocation, or treatment. Waist circumference and body mass index (BMI) at week 12 were included as outcomes within the present analysis. BMI was calculated as body weight in kg divided by body height's square in meters. For safety results (i.e. frequency of adverse events and serious adverse events) see previous publication.[5]

2.6. Mediators

Habitual physical activity was measured using the short questionnaire by Baecke, Burema[17] which contains three subscales: *physical activity at work, sport during leisure time,* and *physical activity during leisure time excluding sport.* Daily fruit and vegetable intake was assessed with the *Five A Day Food Frequency Questionnaire* (FADFFQ) which consists of seven items measuring fruit and vegetable consumption.[18] *Nutrition and physical self-efficacy* was assessed using the health-specific self-efficacy scales by Schwarzer.[19]

2.7. Sample size calculation

The required sample size was calculated a priori within the main study based on a study that compared yoga to no intervention in South Korean postmenopausal women with obesity.[20] Based on this study, a post-intervention group difference in waist circumference of d = 1.02 was expected. In this case a two-sided level 5% *t*-test needs a total of 48 participants to detect this group difference with a statistical power of 90 % if a 2:1 allocation ratio is used. Accounting for a potential loss of power due to a maximum of 20 % dropouts, it was planned to include 60 participants in this trial, with 40 being randomized to the yoga group and 20 being randomized to the control group. Those recruitment plans were not specifically designed for the mediation analysis. Recruitment was terminated after the announced 60 patients were recruited.

All analyses were based on an intention-to-treat basis, including all participants being randomized, regardless of whether or not they gave a full set of data or adhered to the study protocol. Missing data were multiply imputed by Markov chain Monte Carlo methods[21,22]; yielding a total of 50 complete data sets.

2.8. Statistical analysis

Baseline group differences in sociodemographic and weight-related outcomes were analyzed using Student t-tests for continuous data and chi-square tests for categorical data. To analyze the mediating effects of lifestyle variables on changes in BMI and waist circumferences the procedure recommended by Hayes (2009) was followed.[23] The total (*c* path), direct (*c*′ path) and indirect effects (*a* & *b* paths) of the attendance to a yoga class on the change in BMI and waist circumferences were estimated using a bootstrap sampling procedure with 10.000 resamples using z-standardized change scores. Separate analyses were undertaken for each independent variable. The total effect represents the association of the attendance to a yoga class with the change in BMI and waist circumferences without adjusting for the mediating variable. The direct effect represents the effect of the attendance to a yoga class on changes in BMI and waist circumferences after adjusting for the mediating variable. While the indirect effect represents the effect of the attendance to a yoga class on changes in BMI and waist circumferences that occurs through the mediator. For this procedure point estimates and 95 % bias-corrected confidence intervals (CI) were calculated. Where 0 falls outside the 95 % confidence intervals, an indirect effect is evident.[23] Mediation analyses were performed by using the "Process" macro (Version 3.00) for the Statistical Package for Social Sciences software (IBM SPSS Statistics for Windows, release 22.0; IBM Corporation, Armonk, NY).

3. Results

3.1. Descriptive statistics

Sixty women were enrolled after giving informed consent (Supplemental Fig. S1). Participants' characteristics are given in Supplemental Table S1. The women's mean age was 47.8 ± 8.2 years; most women were married, at least high school graduated, and employed. There were no group differences in sociodemographic characteristics. Participants in the control group had higher BMI compared to the yoga group (Supplemental Table S1).

All women in the yoga group attended the initial whole-day workshop; compliance gradually declined during the study. Overall, women in the yoga group attended a mean of 16.1 ± 6.1 out of 24 yoga classes (67.1 %). This equals an overall mean of 30.2 ± 9.2 out of 42 h of supervised yoga practice including the workshop (71.9 %). The participants also stated that they practiced at home for 38.7 ± 16.1 min per week.

3.2. Mediation effects: BMI

The total effect was significant (Table 1). Indirect effects were found for physical exercise habits and daily fruit and vegetable intake (Table 1). Also, a significant indirect effect was found if both variables were included in a multiple mediator model (Table 3). After adjusting for the mediator, only for the mediating model including daily fruit and vegetable intake a significant direct effect was evident.

Table 1
Mediating effect analysis: direct and indirect effects of group on BMI mediated over lifestyle factors.

			bootstrapping confidence interval (BC*)	
	B	*SE B*	lower 2,5 %	upper 2,5 %
Total	−.71	.27	−1.24	−.18
physical exercise habits				
indirect	−.26	.12	−.56	−.07
direct	−.44	.28	−1.00	.11
physical activity habits at leisure time				
indirect	−.17	.14	−.53	.03
direct	−.54	.29	−1.11	.04
physical activity habits at work time				
indirect	.01	.04	−.10	.09
direct	.02	.13	−.24	.27
daily fruit and vegetable intake				
indirect	−.13	.09	−.38	−.01
direct	−.57	.27	−1.11	−.04
nutrition self-efficacy				
indirect	−.04	.05	−.13	.08
direct	−.15	.12	−.40	.09
physical self-efficacy				
indirect	−.01	.04	−.10	.08
direct	.04	.13	−.21	.29

Notes. $N = 60$; if the confidence interval does not include zero, the effect is significant; * BC = bias corrected; B = mean of unstandardized estimators of 20.000 bootstrapping samples; *SD B* = standard deviation of *B;* Yoga was coded as "1" and waitlist as "0"; z-standardized change scores.

3.3. Mediation effects: waist circumference

The total effect was significant (Table 2). No indirect effects were found. Direct effects were evident for physical exercise habits and physical activity habits at leisure time (Table 2).

4. Discussion

Within this secondary analysis of a randomized controlled trial we showed that the positive effect of yoga on BMI is mediated by patients' physical exercise habits and by vegetable and fruit intake. Overweight is one of the big challenges our healthcare systems face. Yoga is a valuable addition to the existing weight loss interventions,[10] which are available but often do not provide the desired effect. The reason for this is especially the low patient adherence: Only a small number sticks to dietary and exercise recommendations to successfully reduce weight.[4] However, the approach of yoga is different. With yoga, a healthier and mindful lifestyle is within the primary focus.[5–9] Weight reduction is thus rather a welcome side effect. Earlier studies described that just this incidental weight loss is perceived by those affected particularly positive: Patients report that the yoga induced a shift toward healthy eating.[12,13] So it was not about counting calories but about eating more attentively and putting more emphasis on healthy food. These results are in line with the findings of the present study: Here yoga led to increased consumption of fruits and vegetables, which in turn positively influenced the BMI. The Hatha Yoga practiced in the study was specifically tailored to the needs of people with overweight: Yoga poses, breathing and relaxation exercises were supplemented by special yogic nutritional advice – but with the explicit request to start no calorie restriction. The content of this nutritional consultation was a change in diet with a focus on fresh, plant based, less industrially processed food and a more mindful approach to eating. Because yoga's focus is not primarily on weight loss, those affected may experience less pressure than ordinary diets. A prior Indian study has shown comparable effects of yoga combined with diet control and nutritional counseling combined with diet control in women with abdominal obesity.[24] Effects of yoga plus diet control in this prior study were larger than in the current one. It might be worthwhile to compare effects of adhering to advice (as in the Indian study) compared to choosing certain diet in addition to yoga (as in the current study) in future research.

Although it was not the primary goal of this yoga class and yoga for beginners is physically less strenuous, the positive effect of yoga on BMI and weight was also mediated by an increase in physical activity in the yoga group. People with overweight report that it is easier for them to be physically active if this does not happen in an environment where they are constantly confronted with athletic and slim people. Interestingly, no significant mediation effects were found for waist circumference. This indicates that yoga reduces BMI and waist circumference through different mechanism, the latter are not currently fully understood. As not every person with obesity has both high BMI and waist circumference a combination of both might be useful.

Furthermore, in contrast to our expectations, self-efficacy did not mediate the effects of yoga on BMI or waist circumference. It is surprising that self-efficacy has not been shown to be a significant mediator, as previous research has shown that yoga can increase self-efficacy and that self-efficacy has positive effects on reducing obesity. For example, Hewett, Pumpa[25] showed that 16 weeks of Bikram yoga significantly improved general self-efficacy in physically inactive, stressed adults. Chambliss and Murray[26] and Adolfsson, Andersson[27] showed that people who are overweight respond best to behavioral treatment when they

Table 2
Mediating effect analysis: direct and indirect effects of group on waist circumference mediated over lifestyle factors.

			bootstrapping confidence interval (BC*)	
	B	*SE B*	lower 2,5 %	upper 2,5 %
Total	−.87	.25	−1.37	−.38
physical exercise habits				
indirect	−.12	.11	−.39	.06
direct	−.75	.28	−1.30	−.19
physical activity habits at leisure time				
indirect	−.18	.15	−.57	.02
direct	−.69	.28	−1.24	−.14
physical activity habits at work time				
indirect	−.02	.04	−.12	.05
direct	−.05	.12	−.30	.19
daily fruit and vegetable intake				
indirect	−.01	.09	−.30	.07
direct	−.13	.12	−.38	.12
nutrition self-efficacy				
indirect	−.02	.04	−.12	.06
direct	−.08	.12	−.32	.17
physical self-efficacy				
indirect	.02	.05	−.07	.14
direct	−.11	.12	−.35	.13

Notes. $N = 60$; if the confidence interval does not include zero, the effect is significant; * BC = bias corrected; B = mean of unstandardized estimators of 20.000 bootstrapping samples; *SD B* = standard deviation of *B;* Yoga was coded as "1" and waitlist as "0"; z-standardized change scores.

Table 3
Multiple mediator model: direct and indirect effects of group on BMI mediated over physical exercise habits and daily fruit and vegetable intake.

			bootstrapping confidence interval (BC*)	
	B	*SE B*	lower 2,5 %	upper 2,5 %
on BMI				
total	−.70	.26	−1.22	−.18
direct	−.32	.28	−.89	.24
total indirect	−.38	.15	−.74	−.13
physical exercise habits				
indirect	−.26	.12	−.56	−.07
daily fruit and vegetable intake				
indirect	−.12	.09	−.36	−.01

Notes. $N = 60$; if the confidence interval does not include zero, the effect is significant; * BC = bias corrected; B = mean of unstandardized estimators of 20.000 bootstrapping samples; *SD B* = standard deviation of *B;* Yoga was coded as "1" and waitlist as "0"; z-standardized change scores.

have a high sense of self-efficacy.

The strengths and limitations of the study are discussed in detail in the previous publication. In this secondary analysis, some additional methodological limitations must be considered. A methodological difficulty when carrying out mediation analyses often lies in establishing causality or in excluding alternative explanations. Within the present study, only two measurement times were recorded, which is why the question of causality should be critically discussed. However, we are confident that the randomized study design ensures a causal interpretability in the sense of an undistorted parameter estimation of the yoga effects. Energy expenditure nor energy intake were directly assessed so that the analysis had to rely on self-report measures of physical activity and diet.

In conclusion, yoga supports people with overweight in eating healthier and increasing their physical activity which in turn leads to a reduced BMI. Besides being a physical activity in itself, yoga can thus help overweight individuals to adhere to common recommendations for physical activity and healthy nutrition.

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Authors statements

Dennis Anheyer: Conceptualization, Methodology, Formal analysis, Writing - Original Draft, Visualization.

Anna Koch: Methodology, Writing - Original Draft, Visualization, Writing - Review & Editing.

Meral Thoms: Investigation, Writing - Review & Editing.

Gustav Dobos: Writing - Review & Editing, Supervision.

Holger Cramer: Conceptualization, Methodology, Writing - Review & Editing, Project administration.

Declaration of Competing Interest

The authors report no declarations of interest.

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Individual deidentified participant data will not be shared.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ctim.2021.102741.

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