

# Is *Nigella sativa* an Effective Bodyweight Lowering Agent and a Mitigator of Obesity Risk? A Literature Review

Lubna Al Asoom 

Physiology Department, College of Medicine, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia

Correspondence: Lubna Al Asoom, Physiology Department, College of Medicine, Imam Abdulrahman Bin Faisal University, P.O. 2114, Dammam, 31541, Saudi Arabia, Tel +966 133335131, Email lasoom@iau.edu.sa

**Abstract:** Obesity is one of the major health-threatening conditions nowadays. *Nigella sativa* (NS) is a medicinal plant that demonstrates multiple therapeutic effects. In the current review, we aim to evaluate the weight lowering effect of NS in both clinical trials and experimental studies and to explore the possible reported mechanisms of this effect. We searched PubMed and Web of science and retrieved 14 clinical trials and 5 experimental studies that justify our inclusion criteria. After the analysis of these articles, we can conclude that long-term administration of NS for 6–12 weeks can significantly lower bodyweight and other anthropometric indices. NS-oil is more potent than NS-powder in lowering bodyweight probably due to the higher concentration of fatty acids and thymoquinone. The weight lowering effect of NS is not a toxic effect, it conversely and preferably lowers the elevated liver enzymes in condition of fatty liver. It is also frequently accompanied by positive metabolic modifications, such as enhancement of lipid profile, lowering blood glucose and improving insulin resistance. Possible mechanisms for NS-bodyweight lowering effect might include an appetite-suppression effect, lowering caloric-intake and inhibition of intestinal glucose absorption. However, further experimental evidence is required to support these mechanisms or unveil new ones.

**Keywords:** *Nigella sativa*, obesity, bodyweight, BMI, waist-circumference

## Introduction

Obesity is a major health-threatening condition. It affects about 1.9 billion people in the year 2016 worldwide, and its incidence continues to increase exponentially. The prevalence of overweight and obesity has increased by four folds from the year 1975 to the year 2016 in both adults and children, according to the World Health Organization report.<sup>1</sup> The main concern about the increasing prevalence of obesity is that obesity is a risk factor for all-cause mortality and a predisposing factor for diabetes mellitus, hypertension, ischemic heart disease, stroke, and cancer.<sup>2</sup> One of the proposed theories for the explanation of the high incidence of obesity is the contemporary modifications of the modern lifestyle; people tend to rely in their nourishment on the highly processed food, which is rich in sugar and fat, and ignore the healthy ingredients of nature, which provide fibers, vitamins, and antioxidants.<sup>3</sup> Many natural products, which were frequently consumed by human in old ages, are found to be rich in antioxidants and provide numerous protective effects against multiple diseases, among which are the black seeds.<sup>4</sup> The black seed is a medicinal plant known generically as *Nigella sativa* Linn and it belongs to the family of Ranunculaceae. It is composed of fixed oil, proteins, alkaloids, saponin and essential oil. The main constituents of the essential oil are thymoquinone in addition to other fatty acids, such as palmitoleic acid, palmitic acid, arachic acid, and linoleic acid.<sup>5</sup> It is commonly used as a food herb and flavoring in the countries of the Middle East, India, and Iran. Furthermore, it is considered a natural remedy for multiple purposes, such as cough, asthma, stomach ache, vomiting, allergy, and eczema.<sup>6</sup> Currently, the therapeutic effects of *Nigella sativa* (NS) are supported by accumulating evidence in the literature from extensive research work.<sup>7</sup> Both experimental and clinical studies showed reproducible preferable effects of long-term supplementation of NS such as antioxidation and anti-inflammation.<sup>8</sup> Not only this but also

the intake of *NS* culminates in specific and favorable modulations of cardiac structure and function,<sup>9,10</sup> vascular growth and regeneration,<sup>11,12</sup> and immunoregulatory effects.<sup>13</sup> *NS* in multiple studies demonstrated favorable modifications of the glucose and lipid metabolism in diabetic patients.<sup>14</sup> However, less attention was given to the direct effect of *NS* on bodyweight and BMI. Few systematic reviews and meta-analyses are available in the literature, which discussed the effect of *NS* as an anti-obesity agent in human clinical trials. However, these systematic reviews included either numerous metabolic parameters in the discussion, missed some negative studies, excluded animal studies, or included multiple herbs besides *NS*.<sup>15–17</sup> On the other hand, these reviews did not discuss the mechanisms of the anti-obesity effect of *NS*, particularly in regard to the bodyweight lowering effect. Therefore, in the present review, we aim to analyse and evaluate the effect of *NS* supplementation on the bodyweight and anthropometric values in both human and animal studies. Moreover, we aim to explore the reported mechanisms of *NS* weight-lowering effect if present.

## Methods

We searched the following databases: PubMed and Web of Science using the following terms: *Nigella sativa* or black seed and bodyweight, or anthropometric measures, waist-circumference, or appetite with no time restriction. PubMed search first yielded 170 articles and Web of Science yielded 281 articles. We excluded reviews and included only research articles, clinical trials, systematic reviews and meta-analyses. After meticulous review, we included studies that used *NS* supplementation as a crude substance, either powdered, oil or extract. Studies that used thymoquinone only – which is the active ingredient of *NS* – were excluded. We also excluded the studies that used *NS* in combination with other drugs or other natural products and did not show the sole effect of *NS* in any of the tested groups. The selected clinical trials and experimental studies were then evaluated using CONSORT checklist for herbal medicine and ARRIVE 2, respectively. The final number of included studies was 14 clinical trials, and 5 animal experimental studies (Figure 1).

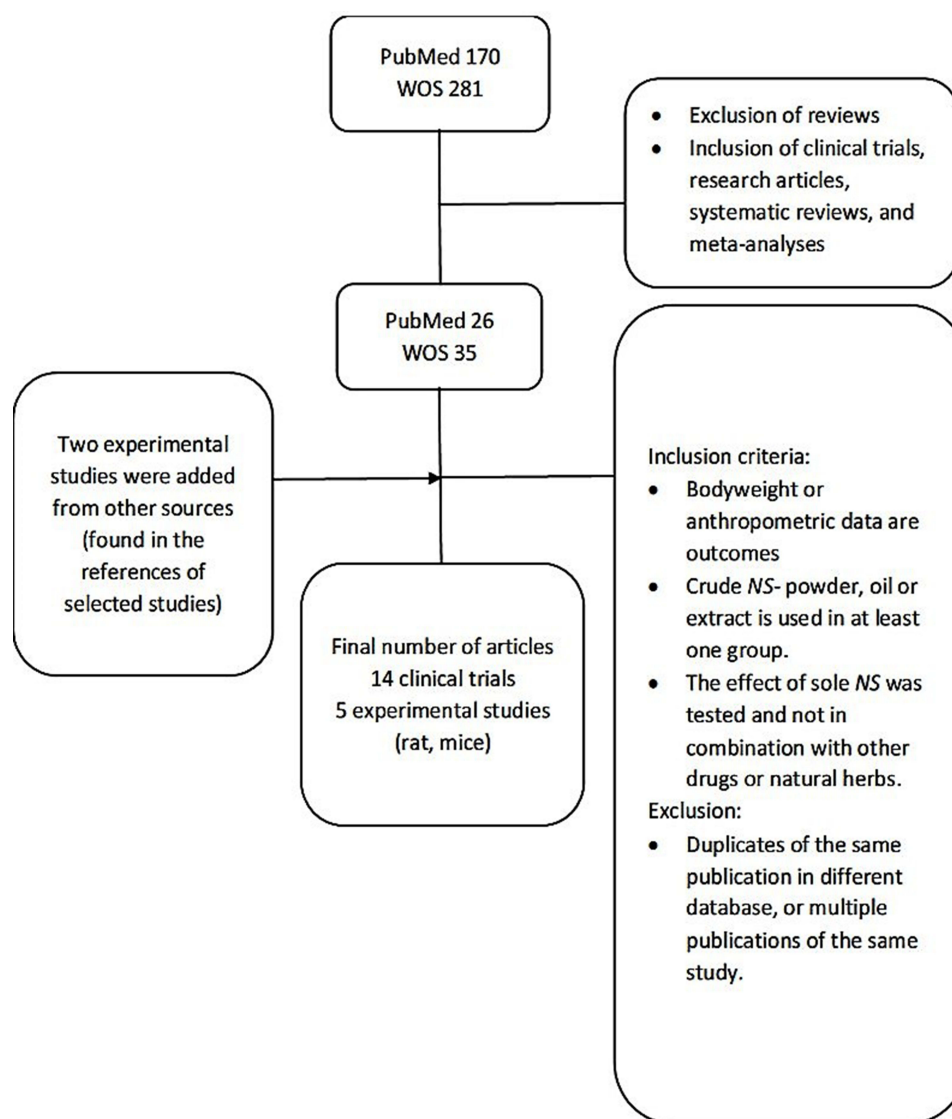
## Results

We have reviewed 14 clinical trials and 5 animal studies for understanding and evaluating the effect of long-term administration of *NS* on bodyweight. Most of the clinical studies include both male and female participants (8 studies), while 5 includes women only and one study includes men only. The targeted populations were diverse but all shared metabolic derangements such as diabetic patients, prediabetics, patients with autoimmune hypothyroidism, patients with non-alcoholic fatty liver or obese and overweight individuals. All the included studies employed an oral administration of *NS* capsules that either contain *NS*-powder or oil. Ten out of the 14 clinical studies revealed significant effect of *NS* on bodyweight, BMI, and waist circumference, and the effect was more consistent with the use of *NS*-oil (Table 1). The experimental studies were mostly on rats (4 studies) and one on mice. Two of the animal studies were on male rats, one used both male and female rats, one used ovariectomised female rats, and one used female mice. The preparations of *NS* used in the experimental studies were either *NS*-oil, petroleum ether extract, or aqueous extract of *NS*-powder. The duration of *NS* feeding ranges from 6 to 12 weeks. Four out of 5 animal studies showed a significant effect of *NS* intake on the weight gain of the growing animals (Table 2).

The mechanisms of the weight reduction effect of *NS* were investigated by some authors, and the proposed mechanisms include induction of anorexia, reduction of intestinal glucose absorption, reduction of insulin secretion and increase in adiponectin level (Table 3).

## Discussion

In this review, we aimed to evaluate the bodyweight reduction effect of *NS* and explore the possible underlying mechanisms of this effect. Most of the analysed studies, whether clinical trials or experimental studies, revealed that *NS* administration in the form of *NS*-oil or powdered capsules for 6–12 weeks can culminate in bodyweight reduction as well as enhancement of BMI, waist, and hip circumference. We observed that studies that utilized *NS*-oil in doses of 1–3g/day for 6–12 weeks showed more pronounced effect on the bodyweight and the other anthropometric parameters than those which employed *NS*-powder of equivalent doses. This might be related to the difference in the composition of these two preparations for *NS*. *NS*-oil has higher concentrations of fatty acids, such as linoleic acid, linolenic acid, and palmitic acid in addition to a higher concentration of thymoquinone.<sup>38,39</sup> Dalle et al demonstrated different composition and



**Figure 1** Flow diagram for the process of article selection.

**Abbreviations:** NS, *Nigella sativa*; WoS, Web of science.

concentration of multiple specific active compounds, such as thymoquinone, multiple fatty acids, catechin, rutin and gallic acid when they used different methods and solvents for the extraction of NS.<sup>5</sup> Therefore, higher NS-powder or extract doses might be needed to induce the bodyweight-lowering effect of NS, and this can explain why Al Asoom<sup>33</sup> who utilized 800 mg/Kg dose of powdered NS failed to demonstrate weight lowering effect in rats, while Meddah et al<sup>35</sup> who adopted 2g/Kg for rats showed a significant reduction of rat weight gain. In addition, the responsiveness of the targeted subjects in each of the included clinical trials might also be different, because those subjects suffer from different aspects of metabolic derangements; Some are healthy obese and overweight, but others are diabetics or patients with fatty liver or Hashimoto's hypothyroidism.

Furthermore, we believe that the weight-lowering effect of NS is a positive therapeutic effect and not a sign of toxicity based on the findings of multiple studies that showed an improvement of liver enzymes when diabetic patients or patients of fatty liver were treated by NS.<sup>23,24</sup> In addition, Le et al compared the acute effect of NS to Dimethyl sulfoxide (DMSO) on isolated hepatocytes and found no toxic effect of NS.<sup>36</sup> Furthermore, the acute administration of high doses of NS-oil whether orally or intraperitoneally up to 28.8 mL/kg of bodyweight showed no signs of toxicity. Similarly, the oral administration of 6g/kg methanol extract of NS for 14 days showed no change in the activity of hepatic enzymes in

**Table 1** Clinical Trials That Tested the Effect of *Nigella sativa* (NS) on the Anthropometric Data. The Studies are Presented in a Descending Chronological Order

#	Authors	Type of Study	Country of the Study	Population and Groups	Dose and Duration	Anthropometric Effects	Other Metabolic Effects
1	Safi et al 2021. <sup>18</sup>	Crossover, double-blinded, randomized controlled, clinical trial	Iran	39 women aged 25–55 years with BMI 27–35 kg/m <sup>2</sup> divided into two groups: Group 1: NS Group 2: Placebo	2 NS capsules/day (each capsule contains 1000 mg of NS-oil) or placebo (capsules filled with paraffin oil-produced by Barij Essence Pharmaceutical Co.) for 8 weeks then 4 weeks washout then cross over for 8 weeks.	Significant reduction of BW, WC, body fat mass, body fat percent, fat-free mass, and visceral fat area	Sensation of appetite decreased significantly as assessed by a visual scale and no difference in dietary intake
2	Mostafa et al 2021. <sup>19</sup>	Open label, randomized, study, no negative control	Egypt	117 obese prediabetic individuals age (18–65 years), participants with BMI ≥ 30 kg/m <sup>2</sup> and subjects randomly allocated into three groups: Group 1: LM lifestyle (diet and exercise) Group 2: Metformin Group 3: NS	-NS soft gelatin capsules containing 450 mg NS-oil twice daily (Total 900mg/day- Baraka®450; Pharco Pharmaceutical Company) -Metformin 1000 mg/day. for six months	NS-group showed significant reduction of BW and BMI	Significant reduction in TC, triglyceride, LDL, FBG, HOMA-insulin resistance, fasting insulin serum and TNF-α level,
3	Hadi et al 2021. <sup>20</sup>	Double blinded controlled clinical trial	Iran	43 patients with type 2 diabetes (23 women and 20 men; aged 53.5 ± 7.4 years) Group 1: Treatment n=23. Group 2: control n=20	Two 500-mg per day soft gel capsules containing NS-oil extract (Total 1000mg/day) Placebo: two 500-mg per day soft gel capsules containing sunflower oil (Total 1000mg /day) for 8 weeks	Significant reduction of BMI and WC.	Significant reduction of HbA <sub>1c</sub> , TC, triglyceride, LDL, SBP, and DBP
4	Tavakoli-Rouzbehani et al 2021. <sup>21</sup>	Double-blinded, randomized, controlled clinical trial	Iran	60 patients with coronary artery disease divided into two groups: Group 1: NS Group 2: placebo	2 g of NS-oil or sunflower oil as a placebo both in the form of soft gel capsules for 8 weeks	Significant reduction of BW, BMI, WC, HC W/P ratio	Significant reduction of SBP, DBP, and FBG
5	Shirazi et al 2020. <sup>22</sup>	Double-blinded randomized, controlled trial	Iran	140 menopausal women within the age of 45–60 years old, who were suffering from metabolic syndrome divided into two equal groups: Group 1: NS n=70 Group 2: Control n=7	500 mg NS-vinegar extract daily or placebo (starch) for 8 weeks	No significant difference in BW, and WC	Significant difference in LDL, triglyceride, TC, and FBG

(Continued)

Table 1 (Continued).

#	Authors	Type of Study	Country of the Study	Population and Groups	Dose and Duration	Anthropometric Effects	Other Metabolic Effects
6	Moustafa et al 2019 <sup>23</sup>	Open label randomized clinical trial	Egypt	21 Newly diagnosed diabetic patients with age range 18–60 years and not on antidiabetic medications. Group 1: NS Group 2: Metformin	NS-oil capsules (Baraka) 450 mgs three times daily (Total 1350mg/day-supplied by Pharco Pharmaceuticals, Egypt). Metformin: 2000 mg/day for three months.	Significant reduction of BVW, WC, BMI comparable to the effect of metformin	Significant reduction of FBG, fasting insulin, insulin resistance, liver enzyme: ALT, TC, LDL, HDL, triglycerides, and total antioxidant capacity but not HbA1c, and B cell secretory function, comparable to the effect of metformin
7	Hussain et al 2017 <sup>24</sup>	Randomized Controlled clinical trial	UAE & Pakistan	70 non-alcoholic fatty liver patients, male 66–60% aged 20–45 years, BMI $\geq 25$ kg/m <sup>2</sup> , presence of fatty liver grading 0–3 on abdominal ultrasound, divided into Group 1: Treatment. Group 2: Control.	2 capsules each contains 1 g of freshly grinded NS from local market /day (Total 2g/day) Placebo: 2 capsules each contains 1 g of microcrystalline cellulose for 3 months	Significant reduction of BVW, and BMI.	Significant reduction of liver enzymes: ALT and AST.
8	Farhangi et al 2016 <sup>25</sup>	Randomized controlled study	Iran	40 patients of Hashimoto's thyroiditis aged 22–50 years, 85% females, divided randomly into two groups: Group 1: Treatment Group 2: Control	2 capsules of 1 g powdered NS/day. (Total 2g/day-obtained from local market in Iran, and prepared in capsules by Goldaroo pharmaceutical company. Isfahan, Iran) Placebo: 2 capsules each contains 1 g of starch/day for 8 weeks	Significant reduction of BVW, BMI, WC, and HC.	Significant increase in T3, and T4, and significant reduction of TSH. VEGF, nesfatin-I
9	Mahdavi et al 2015 <sup>26</sup>	Double-blinded, randomized controlled clinical trial	Iran	84 obese women aged 25–50 years old with BMI= 30–35 kg/m <sup>2</sup> Group 1: intervention n=43 Group 2: placebo n=41	Intervention: low-calorie diet with 3 g NS-oil or placebo sunflower oil divided into three doses/day for 8 weeks. The fatty acids and thymoquinone content was analysed. NS-oil contain 12.5% thymoquinone.	Significant reduction in BW and WC in the NS-group	Significant decline in triglyceride and VLDL levels in the NS-group
10	Namazi et al 2015. <sup>27</sup>	Double-blinded, controlled randomized clinical trial	Iran	49 volunteer obese women, BMI = 30–35 kg/m <sup>2</sup> , aged 25–50 years. Participants were randomly divided into Group 1: Intervention n= 25 Group 2: Placebo n=24	Intervention group: low-calorie diet with 3 g/day NS-oil (NS-oil was obtained by cold press procedure and prepared in soft gel capsules of 1 g by Dana Company, (Tabriz-Iran) Placebo group: low-calorie diet with 3 g/day sunflower capsules for 8 weeks	BW is reduced in both groups but more in the NS-group BMI change significantly in NS-group vs control	Significant increase in superoxide dismutase (SOD) in NS-group

(Continued)

Table 1 (Continued).

#	Authors	Type of Study	Country of the Study	Population and Groups	Dose and Duration	Anthropometric Effects	Other Metabolic Effects
11	Abdul Latiff et al 2014. <sup>28</sup>	Open label crossover study	Malaysia	69 perimenopausal women aged 45–65 years divided randomly into two groups: Treatment group: NS then placebo Control group: placebo then NS	Treatment group: 1600mg/day of encapsulated pure powdered NS for 12 weeks (local GMP compliant pharmaceutical company SabitBananiSdnBhd, Malaysia), then 2 weeks wash out, then another 12 weeks with placebo. Control group: vice versa	No significant change in body weight, waist circumference, BMI, W/H ratio.	Significant decrease in LDL only.
12	Bamosa et al 2010. <sup>29</sup>	Randomized clinical trial	Saudi Arabia.	94 uncontrolled diabetic patients (43 males and 51 females) divided into 3 groups.	1,2 or 3 g of grinded NS in capsules ((Bioextract (Pvt) Ltd, Sri Lanka) for 3 months adjuvant to antihyperglycemic agents	No significant change in BW	A dose of 2 gm/day caused significant reductions in FBG, 2-hours postprandial glucose, insulin resistance, and HbA <sub>1c</sub>
13	Datau et al 2010. <sup>30</sup>	Double-blind randomized Controlled clinical trial	Indonesia	39 Central obese men aged 30–45 years divided randomly into two groups Group 1: Treatment Group 2: Control	Treatment: two capsules of 750 mg of grinded NS twice daily (Total 3 g NS/day) Placebo: two capsules of 750 mg of flour twice daily which is equal to 3 g flour / day for three month	Significant reduction of BW and WC in the treatment group in comparison to pre-treatment and to the control group.	
14	Qidwai et al 2009. <sup>31</sup>	Randomized, double-blinded, controlled trial	Pakistan	73 individuals aged ≥18 years, with serum total cholesterol level between >180 to <250 mg/dl or >250 mg/dl on statins for a minimum of one month divided into two groups: Group 1: NS n=39 Group 2: Control n=34	2 capsules of 500 mg crushed powdered NS (Total 2 gm/day) Control: Placebo. Both groups recommended dietary changes and lifestyle changes: dietary advice from dietician and brisk 30- minute walk for 5 days in a week, for six weeks	No significant change was found in BMI, WC, and HC.	No significant change was found in TC, LDL, HDL, triglyceride between NS and control.

**Abbreviations:** ALT, alanine transaminase (Liver enzyme); AST, aspartate aminotransferase (liver enzyme); BMI, body mass index; BW, body weight; DBP, diastolic blood pressure; FBG, fasting blood glucose; HbA<sub>1c</sub>, glycated hemoglobin; HC, hip circumference; HDL, high density lipoprotein; HOMA-insulin resistance, Homeostatic Model Assessment for Insulin Resistance; LDL, low density lipoprotein; NS, *Nigella sativa*; SBP, systolic blood pressure; TC, total cholesterol; TNF- $\alpha$ , tumor necrosis factor alpha; T3, tri-iodothyronine (thyroid hormone); T4, thyroxine (thyroid hormone); TSH, thyroid stimulating hormone; VEGF, vascular endothelial growth factor; VLDL, very low density lipoprotein; WC, waist circumference; W/H, waist/Hip ratio.

histological preparation. *NS-oil* or thymoquinone exerted protective effect against the toxicity induced by cyclophosphamide.<sup>40</sup> Thymoquinone also demonstrated in multiple studies a protective effect against the toxicity of chemotherapy in multiple types of cancer.<sup>41</sup>

**Table 2** Experimental Studies That Tested the Effect of *Nigella sativa* (NS) on Bodyweight

		Animal	Groups and Treatment	Anthropometric Findings	Other Metabolic Findings
1	Anwar et al 2021. <sup>32</sup>	40 female BALB/c mice	4 equal groups: Group 1: Control Group 2: Letrozole 1mg/kg once daily for 8 weeks Group 3: Letrozole +NS-powder 10g/kg commences at day 22 till the end of the experiment Group 4: Letrozole + NS-oil 4mL/Kg commences at day 22 till the end of the experiment	Group 2: increase BW significantly compared to the other groups. Group 3 and 4 maintain a comparable BW to the control group and mainly group 3.	
2	Al Asoom 2017. <sup>33</sup>	40 male albino Wistar rats	3 equal groups: The control group: equivalent volume of distilled water. The NS-treated group: 800 mg/Kg powdered NS in water solution daily. The exercise-trained group: training on a treadmill. The experiment continued for 8 weeks.	No difference in final BW or BWG among all the groups	
3	Parhizkar et al 2011. <sup>34</sup>	40 ovariectomized female Sprague Dawley rats, weighting 250–350 g	5 equal groups: Control: distilled water. Negative control: distilled water and conjugated equine estrogen (CEE) (200 µg/kg/day) NS-group (three groups): 300, 600, 1200 mg/kg/day For 21 days	The NS-treated groups showed significant less BWG.	Significant less LDL, HDL, and BG in NS- groups.
4	Meddah et al 2009. <sup>35</sup>	30 male and female (50:50) Sprague Dawley weighing 220–260 g	3 equal groups: Control: no treatment NS-group: aqueous extract of crude powdered NS 2g/Kg/day Metformin group: metformin 300mg/Kg/day for 6 weeks OGTT was performed before and after the NS, and metformin treatment (0, 6 weeks)	BW was significantly lower in NS and Metformin groups compared to controls	In vivo glucose tolerance test: chronic feeding of NS significantly reduced peak glucose level and area under the curve of OGTT. Metformin acutely and chronically lower peak glucose and AUC.
5	Mai Le et al 2004. <sup>36</sup>	14 Male Sprague–Dawley rats, aged 7 weeks and weighing approximately 250 g	2 equal groups: NS-group: petroleum ether extract equivalent to 2 g/kg/day of NS-powder. Control: equivalent volume of tap water by intragastric gavage. For 4 weeks	Final body weight and weight gain was significantly less in NS compared to controls	Significant reduction of insulin, and triglyceride and significant increase of HDL.

**Abbreviations:** AUC, area under the curve; BG, blood glucose; BW, body weight; BWG, body weight gain; HDL, high density lipoprotein; LDL, low density lipoprotein; NS, *Nigella sativa*; OGTT, oral glucose tolerance test.



**Table 3** Clinical Trials and Experimental Studies That Explore the Mechanisms of *Nigella sativa* (NS) Effect on Bodyweight and Anthropometric Data

#	Study	Proposed and Tested Mechanism	Result
1	Mahdavi et al <sup>26</sup> 2015* <sup>¥</sup>	Anorexic or reduce food intake	Dietary intake was changed in both groups compared to the baseline, but the difference was not significant between the two groups.
2	Farhangi et al <sup>25</sup> 2016*.	Anorexic or reduce food intake	No significant difference in total dietary intake for 3 days
3	Safi et al <sup>18</sup> 2021*	Anorexic or reduce food intake	Sensation of appetite decreased significantly as assessed by a visual scale and no difference in dietary intake after NS-treatment
4	Mai Le et al <sup>36</sup> 2004**	Anorexic or reduce food intake	Food intake was significantly less in NS (20 ± 3 g/day) versus control (27 ± 2 g/day).
5	Meddah et al <sup>35</sup> 2009**	Inhibition of intestinal glucose absorption	In vitro examination showed NS dose-dependent inhibition of intestinal glucose transport
6	Moustafa et al <sup>23</sup> 2019*	Decrease insulin secretion	NS decreased fasting insulin secretion and enhanced insulin resistance
7	Mai Le et al <sup>36</sup> 2004	Decrease insulin secretion	NS decreased fasting insulin secretion
8	Mahdavi et al <sup>37</sup> 2016 <sup>¥</sup>	Increased adiponectin levels	NS-oil increased adiponectin in obese ladies after 8 weeks of treatment.

**Notes:** \*The same study mentioned in Table 1. \*\*The same study mentioned in Table 2. <sup>¥</sup>Both articles belong to the same study.

Most of the analysed studies in this review reported the statistical significance and the safety of the weight-lowering effect of NS. However, one might argue the clinical significance of NS weight-lowering effect, but we can further illustrate that NS-weight lowering effect is also clinically significant based on the relatively large effect size of 0.6 for NS bodyweight-lowering and 0.4 for waist circumference reduction as reported by Safi et al<sup>18</sup> as well as the frequently and repeatedly demonstrated metabolic effect of NS on lowering blood lipids including triglycerides, total cholesterol, LDL, blood glucose and HbA1C and the positive influence on HDL and insulin resistance.<sup>23,29</sup> In the study performed by Mostafa et al,<sup>19</sup> NS administration for 12 weeks was superior to metformin or diet restriction in modifying total cholesterol, LDL, and triglycerides. Moreover, the clinical significance of NS-weight lowering effect can also be augmented by lifestyle modifications such as caloric restriction and exercise training because evidence has been shown that the combined NS administration and lifestyle changes yielded better effect than each of these interventions separately.<sup>27,42</sup>

## Mechanisms of NS-Induced Bodyweight Reduction

Most of the retrieved literature reflecting the weight reduction effect of NS lacks the explanation and the evidence of the exact mechanism of this effect. Some studies proposed an anorexic effect of NS and aimed to estimate the food intake or appetite modifications. Mahdavi et al,<sup>26</sup> Farhangi et al,<sup>25</sup> and Safi et al<sup>18</sup> failed to demonstrate any difference in the total caloric intake of their NS-treated subjects compared to the control group, albeit Safi et al showed a reduction in appetite sensation using a visual scale of appetite before and after meals. On the other hand, Le et al<sup>36</sup> showed a significant reduction in food intake by rats fed with NS compared to control rats. Despite these efforts to estimate the caloric intake or the changes in the appetite, there is a lack of exploration of the appetite regulation pathways and the influence of multiple peptides on the satiety and hunger centers of the hypothalamus.<sup>43</sup> Few studies only, such as Moustafa et al<sup>23</sup> and Le et al,<sup>36</sup> showed a reduction in insulin secretion, and Mahdavi et al<sup>37</sup> demonstrated an increase in adiponectin. However, more mediators and peptides in the pathway of appetite and energy balance need to be explored. Meddah et al<sup>35</sup> showed an in vitro dose-dependent inhibition of intestinal glucose transport by NS. Similarly, Dalli et al,<sup>5</sup> using



different methods for *NS* extraction, also demonstrated an inhibition of intestinal glucose absorption by three different preparations of *NS* with a range of inhibition equals to 24.82–60.12%.

## Limitations

The current review might be limited by the number of databases that were explored for related literature. In addition, the populations studied in the included articles were diverse in multiple metabolic diseases that might skew the interpretation of the effect of *NS* on bodyweight in healthy obese and overweight subjects.

## Conclusion

The current review showed that the administration of about 1–3 g/day of *NS* for 6–12 weeks can culminate in a reduction of the bodyweight and other anthropometric indices. It further showed the advancement in the *NS*-related research particularly in the field of metabolic derangement. About two decades ago, *NS*-reported studies focused mainly on the effect of *NS* on diabetic metabolic profiles such as hyperglycemia, HbA1c and insulin resistance. Later, the studies started to explore the possible prophylactic influence of *NS* through recruiting prediabetic and healthy obese and overweight individuals and reflect explicitly on the direct effect of *NS* on the bodyweight and anthropometric data as primary outcomes.

In this review, we found that *NS*-oil might be superior to other *NS*-preparations in regard to the weight-lowering effect, and the doses used in all the reported clinical and experimental studies are safe and provide positive metabolic modifications that can minimize the hazards of obesity such as lowering the lipid profile and liver enzymes.

Therefore, *NS* can be recommended for bodyweight reduction along with lifestyle modifications in the form of diet restriction and high physical activity. Nevertheless, identification of the best preparation of *NS* for the induction of the weight-lowering effect is needed as well as the identification of the main active ingredients responsible for this effect. Moreover, large prospective clinical trials are also required to explore the efficacy and safety of *NS* on bodyweight in different age groups, such as children and adolescents. Finally, experimental work that focused on unveiling the exact mechanisms of *NS* bodyweight-lowering effect is still needed, which might open new paths for extra-therapeutic applications of *NS*.

## Disclosure

The author reports no conflicts of interest in this work.

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