

Low Glycemic Load or Index Diet in Association with Acne Vulgaris: A Systematic Review and Meta-analysis

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ABSTRACT

Background: Social life can be affected by skin condition. Acne Vulgaris (AV) is a multi-factorial skin disorder that affects many people. Several dietary factors are associated with AV.


Objectives: Different findings on glycemic indices led us to investigate the effect of the dietary glycemic index (GI) and glycemic load (GL) on AV by a systematic review and meta-analysis.

Methods: Observational studies and clinical trials were extracted from PubMed, EMBASE, Scopus, and Google Scholar. The mean \pm Standard deviation (SD) for acne grading in clinical trials and the mean \pm SD GI or GL of the diet for observational studies were used for meta-analysis.

Results: We found that nine out of 15 studies were eligible for systematic review clinical trials (N = 3) and observational studies (N = 6) designs. The meta-analysis of three studies clinically assessed the effect of GI/GL on acne and showed that a diet with lower GI/GL reduced the acne severity (Hedges'g = -0.91, 95% CI: -1.57, -0.25, P = 0.007). The analysis of six observational studies showed that dietary habit with higher GI might not affect the acne severity in patients with AV (Hedges'g = 0.07, 95%CI: -0.23, 0.38, P = 0.636), but individuals with higher acne severity had a diet with higher GL (Hedges'g = 0.64, 95%CI: 0.01, 1.26, P = 0.045).

Conclusions: Diet, as a part of life style, is associated with AV. Adherence to lower GL diet may reduce the severity of AV. Further well-designed clinical trials are required to confirm these results.

Key words: Acne Vulgaris; Glycemic Index; Glycemic Load; Diet

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Introduction

Acne vulgaris (AV) is known as a chronic skin abnormality [1, 2], which might affect everyone at the age of 15 to 17 years [3-5]. It was estimated that about 40 to 50 million Americans were suffering from acne [6]. It is proposed that AV affects mental health [7], as patient with AV are more depressed [7] and show higher behavioral and emotional symptoms [8]. Thus, treatment or prevention measures are needed to reduce effect of AV.

Acne is considered as a multifactorial disorder associated with several genetic factors [9], hormonal change [10], as well as lifestyle determinants like stress



[11] and diet [12]. It is not fully understood how diet might affect the risk of AV [13]. Various aspects of diet including the amount and the type of dietary oils [14, 15] as well as the intake of fruits and vegetables [14, 16], fish [16], dairy products [17], meat, chocolate [18], and fast food [19] were investigated in relation with acne. In addition to all these factors, association of the glycemic index (GI) and glycemic load (GL) were investigated in association with the development of AV and its aggravation [20-28]. The concept of GI represents the relative ability of existing carbohydrates in foods that induce responses to increased blood glucose [29, 30]. Since GI can be used in the case that the amounts of carbohydrates in foods are equal, another concept was introduced: GL considers not only the types, but also the amount of carbohydrates in diet. Therefore, it can be used for the individuals' whole diet or meal [31]. It is proposed that high GI diet might increase the risk of AV through some hormonal effects of consumed carbohydrates. Increase in IGF-1 and reduction of IGF-BP-3 are the consequences of hyperinsulinemia followed by carbohydrates consumption. These changes led to sebum production and keratinization of the epithelial cells [16] and development AV.

Several studies have tried to assess the association of dietary GI and/or GL with AV. The researches over the effect of low GI and/or GL diets on the disease status have led to inconsistent results. For instance, some available observational studies indicated that participants with AV had a diet with significantly higher GI and/or GL [23-25], while the others could not support this finding [27, 28]. Furthermore, some clinical trials revealed that adherence to low GI or low GL diets by patients with AV might improve the disease [20, 22], while the others could not replicate the same results [21].

To the best of our knowledge, no systematic review and meta-analysis is published regarding the association of dietary GI and GL with AV. Therefore, we aimed to find the studies that examined the association of dietary

GI or GL with AV and to conduct meta-analyses in order to derive the overall estimates and to explore any heterogeneity between the study results and the possible resources.

Materials and Methods

The present study was reported based on the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines [32]. Authors registered this study in the international prospective register of systematic reviews (PROSPERO) under registration code of: CRD42016039182.

Search strategy

We searched for publications indexed in PubMed, Scopus, and Google Scholar up to September 2018. The following sets of MeSH and non-MeSH Keywords and their combinations were used to find the related papers: 1) "glycemic", "glycemic load", "GL", "glycemic index", "GI", "glycemic diet", "GL diet", "GI diet", "glyceamic", and 2) "acne", and "acne vulgaris". In order to maximize the related articles, no limitation was applied for date and language. Moreover, reference lists of related publications were checked to ensure that no article has been neglected unintentionally.

Eligibility criteria

We aimed to include the original clinical trials or observational studies, which investigated the association of dietary GI or GL with acne vulgaris. The clinical trials were included if: 1) they were conducted on human participants, 2) were randomized clinical trial (RCT), 3) included mild to severe acne patients, and 4) used low GI or GL diet for the intervention.

On the other hand, observational the studies were eligible if 1) compared GI or GL of diet for acne patients with healthy control group and 2) compared the chance of developing acne between participants with highest dietary GI or GL to those with the lowest dietary GI or GL. The retrieved studies were assessed for their eligibility by one of the authors (RS), the included articles were double checked by the second

author (MAM), and any differences were resolved by group discussion.

Data extraction

The general characteristics of the studies and participants were extracted: the first author's last name, publication year, location, sample size, participants' gender, age range, recruitment procedure, acne grading system, variables adjusted in the statistical analysis and the dietary assessment method. For the RCTs, we obtained the mean \pm SD for acne severity before and after the intervention or its change for both the intervention and control groups. For the observational studies, mean \pm SD for dietary GI and/or GL reported by the AV cases and the healthy controls were extracted.

Quality assessment

The quality of RCTs was checked by Cochrane collaboration's tool [33]. For every single study, randomization allocation of participants and its concealment, incomplete outcome data, and selective reporting were assessed. Considering that the intervention in these studies focused on the change in the diet, blinding for participants and investigators was impossible. Therefore it was not considered as a key domain in the quality assessment. In this method, each domain was categorized as: 1) low risk of bias, 2) high risk of bias, and 3) unclear. If any of the studies achieved low grade in two domains, it was considered as high quality. The studies that were low risk for only two fields or lower, were regarded as middle and low quality, respectively.

The Newcastle-Ottawa scale (NOS) [34] was used in order to evaluate the quality of observational studies. This scale was designed to assess the case-control studies in three major domains: 1) selection (population representativeness): each study can earn maximum 4 stars, 2) comparability of cases and control groups based on the design or analysis: maximum 2 stars can be allocated in this domain, and 3) ascertainment of the outcome with maximum 3 stars. The studies were categorized as low, moderate, and

high quality if they received 0-3, 3-6, and 7-9 points, respectively.

Statistical analysis

The pre and post intervention mean \pm standard deviation (SD) values for acne severity were used to calculate the mean changes from the baseline and their corresponding SDs were calculated for the intervention and the control groups in RCTs. The difference in mean changes [\pm standard error (SE)] between the intervention and the control groups were calculated and converted to Hedges' g and its corresponding standard error to be used as effect size for the meta-analysis. For observational studies, mean \pm SD of the dietary GI/GL score were extracted for patients with AV and healthy participants. These values were used to calculate the mean difference and its corresponding SE. Later, the mean differences \pm SEs were converted to Hedges' g and its corresponding SE to be used for meta-analysis of the observational studies. DerSimonian and Liard's random effects model was applied to conduct the meta-analysis [35] because this all meta-analyses hypothesis considers the between-study variability. The heterogeneity was checked using Cochran's Q test and I-squared (I^2) [35]. The possible sources of heterogeneity were explored using subgroup analysis. Sensitivity analysis was done by sequentially excluding each study from the overall meta-analysis. Publication bias was also assessed by visual inspection of funnel plots, Egger's regression, and Begg's adjusted rank correlation tests [36]. All analyses were conducted using STATA software, version 11.2 (Stata Corp, College Station, TX). $P \leq 0.05$ was considered as statistically significant.

Results

Database search resulted in 226 articles. After omitting the duplicate findings, 169 papers were remained. By reading the titles and abstracts, 154 articles were excluded and 15 clinical and observational studies were remained [20-28, 37-42]. The remaining articles were checked manually and 5 other related papers were

added to the initial search [43-47]. After reading the articles' full-text, one article was removed, since its participants used medications along their diet [39], another research was omitted because it was duplicate [42], and three publications were excluded since they were based on the same research [40-42]. Thus, we selected the publications with higher number of the participants and omitted a pilot study [40], a research conducted on specific outcome with less participants

[41], and one review study [45]. Furthermore, a study [47], found in manual search was also omitted since it did not use randomized controlled clinical trial design. Overall, 14 articles were included in our systematic review [20-28, 37, 38, 43, 44, 46]. [Figure 1](#) depict the study selection process. [Table 1](#) summarizes the studies with clinical trials design and [Table 2](#) provides data on observational studies.

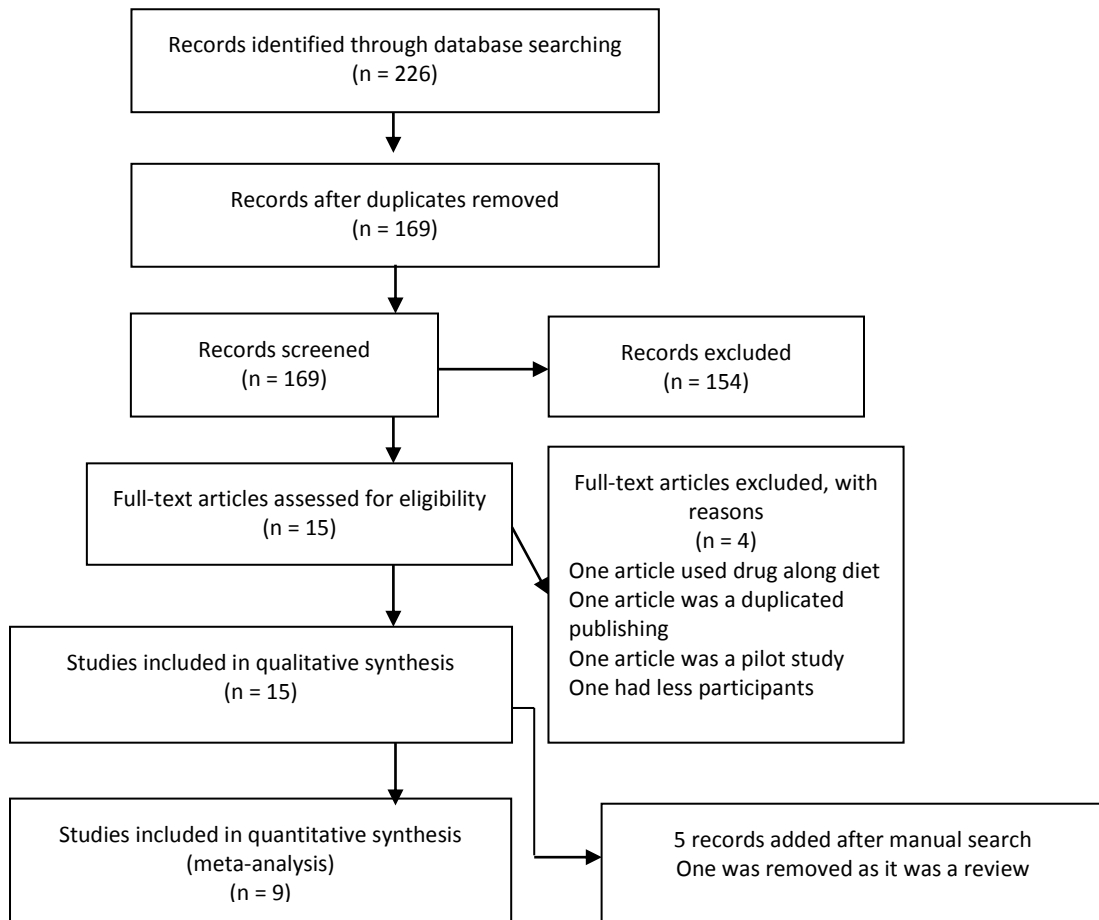


Figure 1. PRISMA flow diagram of included studies

Table 1. Characteristic of randomized controlled trials that evaluated the effect of the low GI/GL diet on acne severity and were eligible to be included in systematic review.

First author	Publication year	No of participants	Gender	Design	Study duration (week)	Subjects characteristic	Intervention diet	control diet	Outcome measured
Smith [22]	2007	43	M	Parallel	12	Mild to moderate facial acne	LGL diet CHO: 45% Fat: 30% Pro: 25% CHOs used, was low glycemic	CHO dense diet	Total lesion count
Reynolds [21]	2010	43	M	Parallel	8	Healthy adolescents with acne	Low GI diet	High GI diet	Facial acne score
Kwon [20]	2012	32	M/F	Parallel	10	Mild to moderate acne	LGL diet CHO: 45% Fat: 30% Pro: 25% CHOs used, was low glycemic	Regular diet CHO-rich foods daily	Inflammatory and non-inflammatory acne

M: male; F: female; LGL: Low Glycemic Load; CHO: Carbohydrate; Pro: Protein; GI: Glycemic Index

Low glycemic load/index diet and acne vulgaris

Three studies with (randomized clinical trial design) investigated the effect of low glycemic load/index diet on acne [20-22]. Kwon et al. [20] and Smith et al. [22] used glycemic load and Reynolds et al. [21] applied the glycemic factors to plan diet for their interventions. Kwon et al. [20] and Smith et al. [22] used lesion count but Reynolds et al. [21] used acne scoring to show the changes in acne severity. In contrast, Reynolds et al.

[21] did not see any improvement after consuming low glycemic diet. The quality assessment showed that all included studies were low risk in 3 or more domains out of seven. Therefore, all publications included in the meta-analysis of clinical trials were of high quality regarding the Cochrane collaboration's tool. [Table 3](#) shows the quality assessment results for the studies with clinical trial design.

Table 2. Characteristics of the observational studies over the effect of low GI/GL diet on acne severity included in the systematic review

First author	Publication year	No. of participants	Gender	Design	Country	Outcome measured	Questionnaire	Study quality
Adebamowo [43]	2005	47355	F	Nested case-control	US	GL	FFQ	7
Kaymak [27]	2007	91	M/F	Case - control	Turkey	GI/GL	FFQ	7
Jung [26]	2010	1285	M/F	Case - control	Korea	GI/GL	Food record	7
Ismail [25]	2012	88	M/F	Case - control	Malaysia	GL	Food record	7
Salomone [38]	2012	80	M/F	Analytic study	India	GI	-----	-----
Aghasi [44]	2013	140	F	Case - control	Iran	GI	FFQ	6
Burris [23]	2014	248	M/F	Case - control	US	GI	FFQ	8
Okoro [46]	2016	464	M/F	Case - control	Nigeria	GI	FFQ	7
Cerman [24]	2016	86	M/F	Case - control	Turkey	GI/GL	Food recall	7
LaRosa [28]	2016	225	M/F	Case - control	US	GI/GL	Food recall	8
Burris [37]	2017	64	M/F	Case - control	US	GI/GL	Food record	8

F: female, M: male, GL: Glycemic Load; GI: Glycemic Index; FFQ: Food frequency questionnaire

Table 3. Study quality and risk of bias assessment for RCT using Cochrane collaboration tool

First author (year)	Random Sequence generation	Allocation concealment	Blinding	blinding of outcome assessment	Incomplete outcome data	Selective reporting	Score	Overall quality
Smith (2007)							5	Good
Reynolds (2010)							3	Good
Kwon (2012)							4	Good

Eleven observational studies were found, which were case-control in design [23-28, 37, 38, 43, 44, 46]; eight studies were found in database search [23-28, 37, 38], and 3 were found during the manual search [43, 44, 46]. Among these studies, four [23, 38, 44, 46] used GI to assess the diet, 2 applied GL [25, 43], while 5 studies

[24, 26-28, 37] assessed both GI and GL. Almost all included publications had high quality (Table 2 shows the quality scoring). Of all these 11 studies, 5 were not included in the meta-analysis; they were included in the systematic review, because their data were not appropriate to be used in the meta-analysis.

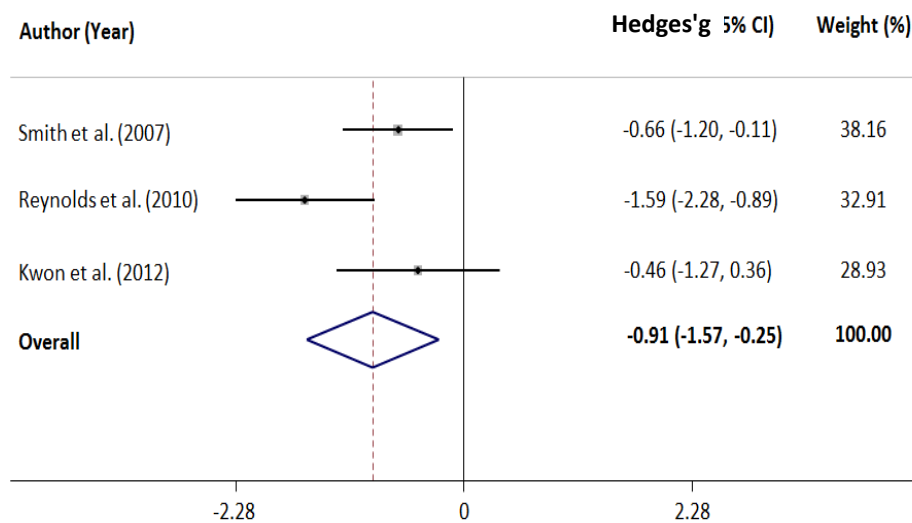


Figure 2: Forest plot for the effect of low glycemic diet on the acne severity

Meta-analysis

Randomized controlled clinical trials

Three studies with 118 participants were included in the meta-analysis. Results indicated that adherence to diet with lower GI/GL decreased the acne severity compared to the control diet (Hedges'g = -0.91, 95%CI:-1.57,-0.25, P = 0.007). The heterogeneity among included studies was moderate (Q statistic = 5.65 Cochrane Q test, P = 0.059, I² = 64.6%). [Figure 2](#) shows the meta-analysis of controlled clinical trials.

Observational studies

Among 11 eligible studies, 6 studies were included in the meta-analysis. Data for the 5 remaining studies were not available [26, 38, 43, 44, 46]. In our meta-analysis, we assessed the observational studies in 2 groups based on the index used to assess the diet (GI or GL).

GI and Acne

The meta-analysis of 5 studies [23, 24, 27, 28, 37] with 714 participants showed that diet's GI might not be significantly different between participants with acne vulgaris and healthy controls (Hedges'g = 0.07, 95%CI:

-0.23, 0.38, P = 0.636). A high heterogeneity was observed between the included studies (Q statistic = 14.61 Cochrane Q test, P = 0.006, I² = 72.6%). A subgroup analysis based on the diet evaluation method investigated the possible sources of heterogeneity. As a result, we found that three studies [23, 27, 28] with 564 individuals used retrospective questionnaires (24 hr. recall, and food frequency questionnaire Hedges'g = 0.01, 95%CI: -0.41, 0.44, P = 0.951). The heterogeneity found among studies was very high (Q statistic = 11.57 Cochrane Q test, P = 0.003, I² = 82.7%). The meta-analysis of studies that used questionnaires and were not based on the participants' memory (food records) [24, 37] (150 participants) led to the same finding (Hedges'g = 0.18, 95%CI: -0.36, 0.71, P = 0.519). The heterogeneity between studies was not significant (Q statistic = 2.67 Cochrane Q test, P = 0.102, I² = 62.5%). Moreover, no significant difference was observed between subgroup analysis results (P value = 0.539). [Figure 3](#) indicates the meta-analysis results for the association between GI and acne severity in observational design.

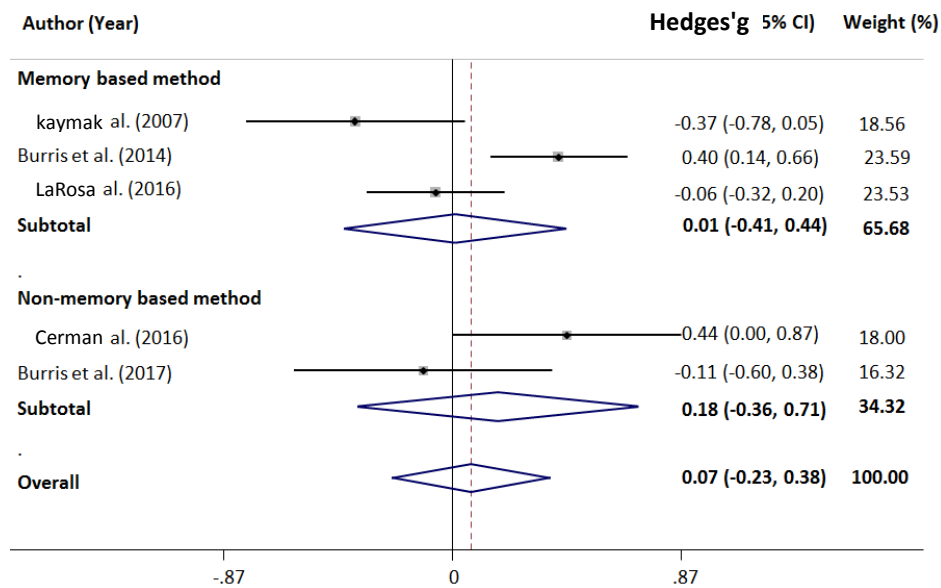


Figure 3: Forest plot for the effect of GI on the acne severity

GL and Acne

In order to find the relationship between GL and AV, 5 studies [24, 25, 27, 28, 37] with 554 participants were entered in our meta-analysis. The overall analysis showed that individuals with higher acne severity had higher GL diets (Hedges'g = 0.64, 95%CI: 0.01, 1.26, P = 0.045). The heterogeneity was high in the included studies (Q statistic = 46.50 Cochrane Q test, P < 0.001, I² = 91.4%). the subgroup analysis showed that GL was not significantly different between those with AV and healthy participants in studies which used retrospective methods to assess diet [27, 28] (316 participants) (Hedges'g = -0.03, 95%CI: -0.37,

0.32, P = 0.878). The heterogeneity between studies was not significant (Q statistic = 2.09 Cochrane Q test, P = 0.148, I² = 52.2%). In contrast, analysis of studies that used food records [24, 25, 37] (238 participants) showed that participants with higher acne severity had a higher GL diet compared to the healthy controls (Hedges'g = 1.13, 95%CI: 0.57, 1.68, P < 0.001); however, a high heterogeneity was observed between studies (Q statistic = 7.91 Cochrane Q test, P=0.019, I² = 74.7%). The between-groups heterogeneity was significant (P value < 0.001). [Figure 4](#) illustrates the meta-analysis results for the association between GL and acne severity in observational studies.

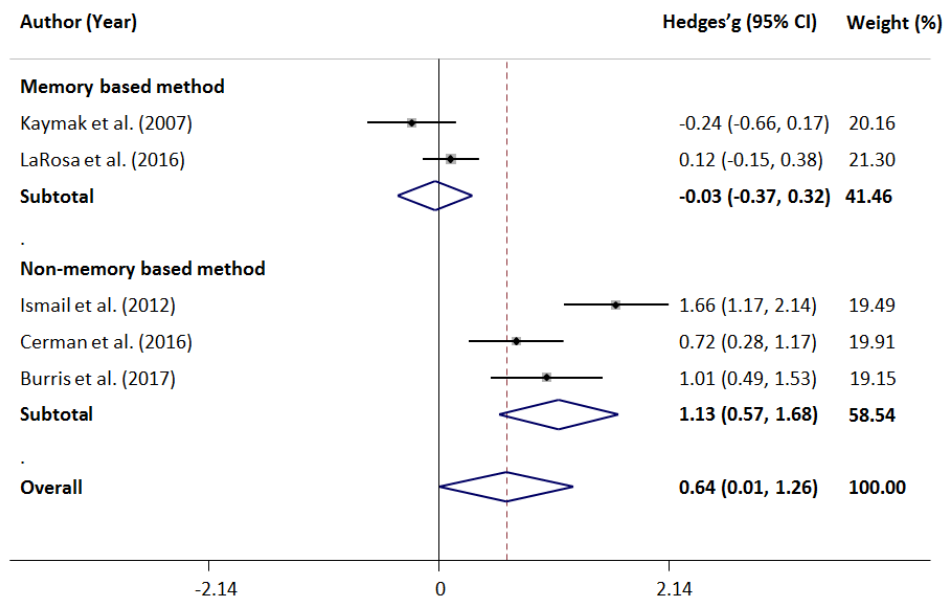


Figure 4: Forest plot for the effect of GL on the acne severity

Publication bias and sensitivity analysis

The Begg's funnel plot was almost symmetric for the trial studies [Figure 5A](#). On the other hand, a slight asymmetry was seen in Begg's funnel plot for studies that investigated the difference in GI [Figure 5B](#) and GL [Figure 5C](#) between participants with acne vulgaris and healthy participants, but the results of the asymmetry tests did not show any evidence of publication bias for the meta-analysis

regarding the association of GI (Begg's test, $P = 0.806$, Egger's test, $P = 0.630$) and GL (Begg's test, $P = 0.221$, Egger's test, $P = 0.226$) with acne vulgaris.

Sensitivity analysis showed that omission of the studies from the analysis with regard to the effect of diet's GI or GL on AV severity did not apparently alter the summary effects.

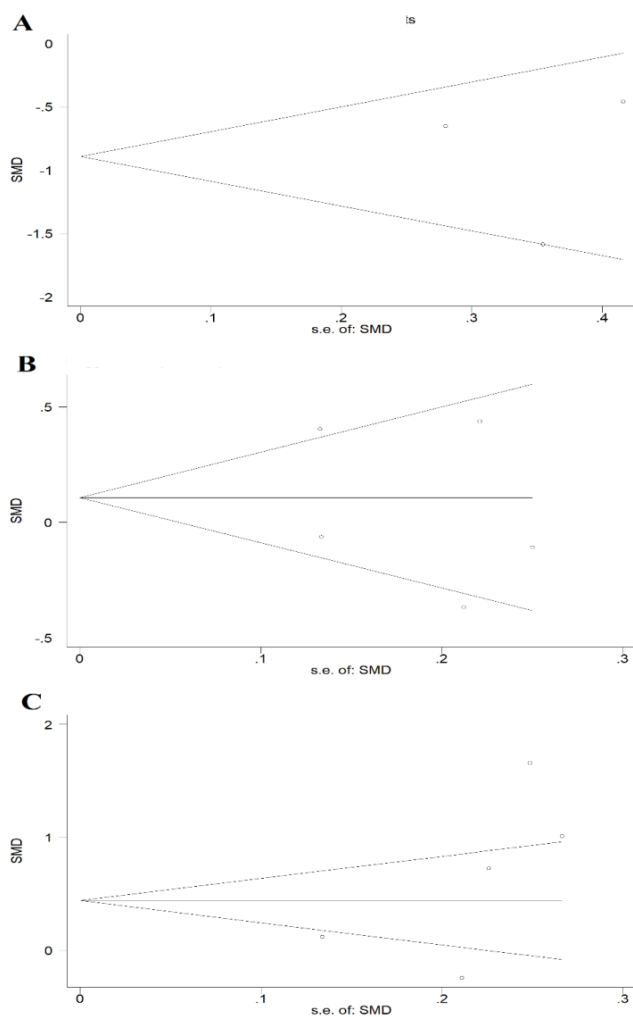


Figure 5: Begg's funnel plot for the publication bias, A: Trial studies, B: Studies investigated the GI, and C: studies investigated the GL

Discussion

The Current systematic review and meta-analysis indicated that consuming a low glycemic diet might decrease the severity of AV. However, the meta-analysis of observational studies suggested that diet's GL could establish a better relationship than GI. In the other words, results showed that healthy participants followed a diet with lower GL compared to the patients suffering from AV.

The trials included in the meta-analysis [20-22] also confirmed our findings. Moreover, the same result was seen in a study by Tayel et al. [47]. As this study did

not use randomization and was a before–after study, we did not include this study in our systematic review and meta-analysis. Tayel et al. reported that concordance with a low GL diet for 12 weeks might alleviate the acne in comparison with the baseline.

Analyses of the observational studies showed a high heterogeneity between studies; therefore, we separated the publications based on the factor used to assess the dietary carbohydrate (GI or GL). The subgroup analysis based on the dietary assessment method (memory based and non-memory based methods) could partly explain the heterogeneity; the meta-analysis showed that a higher GL diet was associated with AV. However, we could not see the same association for GI. The GI assesses the types and quality of food carbohydrates using the presence of fiber, fat protein, or other factors such as food processing method, but GL considers the amount of carbohydrate in diet. Therefore, GL is more useful to assess the effect of food on postprandial glycaemia and insulin demands and level [48, 49]. A lower GL diet has a lower amount of glucose, which can decrease subcutaneous glands glycogen concentration; thus, decreases the lipogenesis in these glands [41]. According to the results, we can hypothesize that the amount of carbohydrate in the diet may affect severity of AV more than the types of the carbohydrates.

The relationship between GL and AV was clearer in the publications which used non-memory based dietary assessment method (dietary record). Food records, as a non-memory-based method are a better tool for calculating the GL of a diet compared to food recalls, FFQ, or other memory-based diet assessing tools [50]. It can be said that recording the diet after each meal [51] leads to a better record of the portion size and amount of food, especially when the food is consumed at home and weighted before and after the meal [52]. However, in memory-based tools, such as 24-hour recall [53], the diet is reported after a while; so, the portion size

and the amount of food are likely to be forgotten [54, 55]. It was observed that reporting energy intake using 24-hour recalls was 16% lower than using food records [52]. Thus, non-memory-based tools are better choices to assess GL, which depends on the amount of foods. In a study by Adebamowo et al. [43], results did not show any relationship between higher GL diet and AV severity, but we have to consider that in this study, researchers used FFQ questionnaire, which is a memory based assessing tool. [56].

Previously, some reviews investigated the possible effect of GI/GL on the acne, but they did not systematically review the literature and meta-analysis was not used to achieve a comprehensive conclusion. Berra et al. [57] also suggested that life style factors like diet and GI may influence the AV. Romanska-Gocka et al. [58] stated that the same relationship exists between GL and AV severity.

It is proposed that the elevated serum insulin increases Insulin growth factor-1 (IGF-1) and reduces Insulin Growth Factor Binding Protein-3 (IGFBP-3) when high amounts of carbohydrate is consumed [45]. It is suggested that IGF-1 has a dual role in the pathogenesis of AV: first, it increases the keratinocyte and sebum production; second, it increases blood androgens by inducing the synthesis. The blood androgens also increase sebum production. The proliferation of keratinocytes and the increased sebum production are associated with aggravating AV; moreover, reduced IGFBP-3 leads to higher binding of IGF-1 to receptors; thus, it increases the effects of IGF-1 [26].

Kwon et al. [20] found that consuming low GL diet for 10 weeks, leads to a considerable dwindling in the size of sebaceous glands and reduces the production of SREBP-1 protein, which is the main protein to regulate the synthesis of lipids. Subsequently, the sebum production decreases.

To the best of our knowledge, the present study was the first one which systematically reviewed the existing publications on the relationship between dietary GI/GL and the AV severity. It also used a quantitative method to summarize the effects. A number of limitations exist that should be considered when interpreting our results: the number of existing studies was low and more clinical trials with higher quality are still needed. Furthermore, since life style factors, such as diet are related to acne vulgaris, prospective investigations are highly needed to confirm the association between dietary GI/GL and AV.

Furthermore, the observational studies only provided crude data for comparison of the diet between participants with AV and healthy controls. In conclusion, the present systematic review and meta-analysis suggested that low GI/GL diets might improve AV. Furthermore, it seems that dietary GL might predict AV better than the dietary GI. Future well-designed prospective investigations are still needed to confirm these results.

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Authors' contributions

The authors' cooperation was as follows: MAM and RS developed the study concept and designed the research; electronic searches, study selection, data extraction, data analysis, interpretation of the results, and composition of the first draft of the manuscript were done by both authors. All authors read and approved the final version.

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Conflict of Interest

The authors state that there is no conflict of interests in this study.

References

- [1] Thiboutot D, Gollnick H, Bettoli V, Dreno B, Kang S, Leyden JJ, et al. **New insights into the management of acne: an update from the Global Alliance to Improve Outcomes in Acne group.** *Journal of the American Academy of Dermatology.* 2009;60:S1-5010.1016/j.jaad.2009.01.019.
- [2] Gollnick H. **Current concepts of the pathogenesis of acne: implications for drug treatment.** *Drugs.* 2003;63:1579-96
- [3] Law MP, Chuh AA, Lee A, Molinari N. **Acne prevalence and beyond: acne disability and its predictive factors among Chinese late adolescents in Hong Kong.** *Clinical and experimental dermatology.* 2010;35:16-2110.1111/j.1365-2230.2009.03340.x.
- [4] Rademaker M, Garioch JJ, Simpson NB. **Acne in schoolchildren: no longer a concern for dermatologists.** *BMJ (Clinical research ed).* 1989;298:1217-9
- [5] Yahya H. **Acne vulgaris in Nigerian adolescents--prevalence, severity, beliefs, perceptions, and practices.** *International journal of dermatology.* 2009;48:498-50510.1111/j.1365-4632.2009.03922.x.
- [6] White GM. **Recent findings in the epidemiologic evidence, classification, and subtypes of acne vulgaris.** *Journal of the American Academy of Dermatology.* 1998;39:S34-7
- [7] Kubota Y, Shirahige Y, Nakai K, Katsuura J, Morieue T, Yoneda K. **Community-based epidemiological study of psychosocial effects of acne in Japanese adolescents.** *The Journal of dermatology.* 2010;37:617-2210.1111/j.1346-8138.2010.00855.x.
- [8] Smithard A, Glazebrook C, Williams HC. **Acne prevalence, knowledge about acne and psychological morbidity in mid-adolescence: a community-based study.** *The British journal of dermatology.* 2001;145:274-9
- [9] Lichtenberger R, Simpson MA, Smith C, Barker J, Navarini AA. **Genetic architecture of acne vulgaris.** *Journal of the European Academy of Dermatology and Venereology : JEADV.* 201710.1111/jdv.14385.
- [10] Ju Q, Tao T, Hu T, Karadag AS, Al-Khuzaei S, Chen W. **Sex hormones and acne.** *Clinics in dermatology.* 2017;35:130-710.1016/j.clinidermatol.2016.10.004.
- [11] Dreno B, Thiboutot D, Layton AM, Berson D, Perez M, Kang S. **Large-scale international study enhances understanding of an emerging acne population: adult females.** *Journal of the European Academy of Dermatology and Venereology : JEADV.* 2015;29:1096-10610.1111/jdv.12757.
- [12] Kulkarni M, Keny D, Potey AV, Tripathi RK. **A cross-sectional study to assess the incompatible dietary behavior of patients suffering from skin diseases: A pilot study.** *Journal of Ayurveda and integrative medicine.* 2016;7:113-810.1016/j.jaim.2016.06.001.
- [13] Costa A, Lage D, Moises TA. **Acne and diet: truth or myth?** *Anais brasileiros de dermatologia.* 2010;85:346-53
- [14] Burris J, Rietkerk W, Woolf K. **Relationships of self-reported dietary factors and perceived acne severity in a cohort of New York young adults.** *Journal of the Academy of Nutrition and Dietetics.* 2014;114:384-9210.1016/j.jand.2013.11.010.
- [15] Kanlayavattanukul M, Lourith N. **Therapeutic agents and herbs in topical application for acne treatment.** *International journal of cosmetic science.* 2011;33:289-9710.1111/j.1468-2494.2011.00647.x.
- [16] Jung JY, Yoon MY, Min SU, Hong JS, Choi YS, Suh DH. **The influence of dietary patterns on acne vulgaris in Koreans.** *European journal of dermatology : EJD.* 2010;20:768-7210.1684/ejd.2010.1053.
- [17] Adebamowo CA, Spiegelman D, Berkey CS, Danby FW, Rockett HH, Colditz GA, et al. **Milk consumption and acne in teenaged boys.** *Journal of the American Academy of Dermatology.* 2008;58:787-9310.1016/j.jaad.2007.08.049.
- [18] Suh DH, Kim BY, Min SU, Lee DH, Yoon MY, Kim NI, et al. **A multicenter epidemiological study of acne vulgaris in Korea.** *International journal of dermatology.* 2011;50:673-8110.1111/j.1365-4632.2010.04726.x.
- [19] Park SY, Kwon HH, Min S, Yoon JY, Suh DH. **Epidemiology and risk factors of childhood acne in Korea: a cross-sectional community based study.** *Clinical and experimental dermatology.* 2015;40:844-5010.1111/ced.12686.
- [20] Kwon HH, Yoon JY, Hong JS, Jung JY, Park MS, Suh DH. **Clinical and histological effect of a low glycaemic load diet in treatment of acne vulgaris in Korean patients: a randomized, controlled trial.** *Acta dermato-venereologica.* 2012;92:241-610.2340/00015555-1346.
- [21] Reynolds RC, Lee S, Choi JY, Atkinson FS, Stockmann KS, Petocz P, et al. **Effect of the glycemic index of carbohydrates on Acne vulgaris.** *Nutrients.* 2010;2:1060-7210.3390/nu2101060.
- [22] Smith RN, Mann NJ, Braue A, Makelainen H, Varigos GA. **A low-glycemic-load diet improves symptoms in acne vulgaris patients: a randomized**

- controlled trial. *The American journal of clinical nutrition*. 2007;86:107-15
- [23] Burris J, Rietkerk W, Woolf K. **Relationships of self-reported dietary factors and perceived acne severity in a cohort of New York young adults.** *J Acad Nutri Diet*. 2014;114:384-9210.1016/j.jand.2013.11.010.
- [24] Cerman AA, Aktas E, Altunay IK, Arici JE, Tulunay A, Ozturk FY. **Dietary glycemic factors, insulin resistance, and adiponectin levels in acne vulgaris.** *Journal of the American Academy of Dermatology*. 2016;75:155-6210.1016/j.jaad.2016.02.1220.
- [25] Ismail NH, Manaf ZA, Azizan NZ. **High glycemic load diet, milk and ice cream consumption are related to acne vulgaris in Malaysian young adults: a case control study.** *BMC Dermatol*. 2012;1210.1186/1471-5945-12-13.
- [26] Jung JY, Yoon MY, Min SU, Hong JS, Choi YS, Suh DH. **The influence of dietary patterns on acne vulgaris in Koreans.** *Eur J Dermatol*. 2010;20:768-7210.1684/ejd.2010.1053.
- [27] Kaymak Y, Adisen E, Ilter N, Bideci A, Gurler D, Celik B. **Dietary glycemic index and glucose, insulin, insulin-like growth factor-I, insulin-like growth factor binding protein 3, and leptin levels in patients with acne.** *Journal of the American Academy of Dermatology*. 2007;57:819-2310.1016/j.jaad.2007.06.028.
- [28] LaRosa CL, Quach KA, Koons K, Kunselman AR, Zhu J, Thiboutot DM, et al. **Consumption of dairy in teenagers with and without acne.** *Journal of the American Academy of Dermatology*. 2016;75:318-2210.1016/j.jaad.2016.04.030.
- [29] Jenkins DJ, Wolever TM, Taylor RH, Barker H, Fielden H, Baldwin JM, et al. **Glycemic index of foods: a physiological basis for carbohydrate exchange.** *The American journal of clinical nutrition*. 1981;34:362-6
- [30] Wolever TM. **The glycemic index.** *World review of nutrition and dietetics*. 1990;62:120-85
- [31] Salmeron J, Manson JE, Stampfer MJ, Colditz GA, Wing AL, Willett WC. **Dietary fiber, glycemic load, and risk of non-insulin-dependent diabetes mellitus in women.** *Jama*. 1997;277:472-7
- [32] Moher D, Liberati A, Tetzlaff J, Altman DG. **Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement.** *BMJ (Clinical research ed)*. 2009;339:b253510.1136/bmj.b2535.
- [33] Higgins JP, Green S. **Cochrane handbook for systematic reviews of interventions: John Wiley & Sons; 2011**
- [34] Wells G, Shea B, O'Connell D, Peterson J, Welch V, Losos M, et al. **The Newcastle-Ottawa scale (NOS) for assessing the quality of nonrandomized studies in meta-analysis.** **Ottawa, Ontario: The Ottawa Health Research Institute. 2011**
- [35] DerSimonian R, Laird N. **Meta-analysis in clinical trials.** *Controlled clinical trials*. 1986;7:177-88
- [36] Egger M, Smith GD, Altman D. **Systematic reviews in health care: meta-analysis in context: John Wiley & Sons; 2008**
- [37] Burris J, Rietkerk W, Shikany JM, Woolf K. **Differences in Dietary Glycemic Load and Hormones in New York City Adults with No and Moderate/Severe Acne.** *Journal of the Academy of Nutrition and Dietetics*. 201710.1016/j.jand.2017.03.024.
- [38] Salomone C, Nicklas C, Navarrete-Dechent C, Droppelmann K, Pérez-Cotapos M. **Comparative study of dietary habits between acne patients and a healthy cohort.** *Indian J Dermatol Venereol Leprol*. 2012;78:99-10110.4103/0378-6323.90958.
- [39] Fabbrocini G, Izzo R, Faggiano A, Del Prete M, Donnarumma M, Marasca C, et al. **Low glycaemic diet and metformin therapy: a new approach in male subjects with acne resistant to common treatments.** *Clinical and experimental dermatology*. 2016;41:38-4210.1111/ced.12673.
- [40] Smith R, Mann N, Makelainen H, Roper J, Braue A, Varigos G. **A pilot study to determine the short-term effects of a low glycemic load diet on hormonal markers of acne: a nonrandomized, parallel, controlled feeding trial.** *Molecular nutrition & food research*. 2008;52:718-2610.1002/mnfr.200700307.
- [41] Smith RN, Braue A, Varigos GA, Mann NJ. **The effect of a low glycemic load diet on acne vulgaris and the fatty acid composition of skin surface triglycerides.** *J Dermatol Sci*. 2008;50:41-5210.1016/j.jdermsci.2007.11.005.
- [42] Smith RN, Mann NJ, Braue A, Makelainen H, Varigos GA. **The effect of a high-protein, low glycemic-load diet versus a conventional, high glycemic-load diet on biochemical parameters associated with acne vulgaris: a randomized, investigator-masked, controlled trial.** *Journal of the American Academy of Dermatology*. 2007;57:247-5610.1016/j.jaad.2007.01.046.
- [43] Adebamowo CA, Spiegelman D, Danby FW, Frazier AL, Willett WC, Holmes MD. **High school dietary dairy intake and teenage acne.** *Journal of the American Academy of Dermatology*. 2005;52:207-1410.1016/j.jaad.2004.08.007.
- [44] Aghasi M, Motlagh AD, Eshraghian M, Maskooni MD, Mansouri P, Ashouri M. **Association of acne and intake of dairy products and carbohydrates with high glycemic index: a case-control study.** 2013

- [45] Cordain L, Lindeberg S, Hurtado M, Hill K, Eaton SB, Brand-Miller J. **Acne vulgaris: a disease of Western civilization.** *Archives of dermatology.* 2002;138:1584-90
- [46] Okoro EO, Ogunbiyi AO, George AO, Subulade MO. **Association of diet with acne vulgaris among adolescents in Ibadan, southwest Nigeria.** *International journal of dermatology.* 2016;55:982-810.1111/ijd.13166.
- [47] Tayel DI, Abdelsalam OM, Elgarem YF, Ali AE. **Dietary Intervention to Alleviate Acne Severity.**
- [48] Bao J, Atkinson F, Petocz P, Willett WC, Brand-Miller JC. **Prediction of postprandial glycemia and insulinemia in lean, young, healthy adults: glycemic load compared with carbohydrate content alone.** *The American journal of clinical nutrition.* 2011;93:984-9610.3945/ajcn.110.005033.
- [49] Roberts CK, Liu S. **Effects of glycemic load on metabolic health and type 2 diabetes mellitus.** *Journal of diabetes science and technology.* 2009;3:697-70410.1177/193229680900300414.
- [50] Barclay AW, Flood VM, Brand-Miller JC, Mitchell P. **Validity of carbohydrate, glycaemic index and glycaemic load data obtained using a semi-quantitative food-frequency questionnaire.** *Public health nutrition.* 2008;11:573-8010.1017/s1368980007001103.
- [51] Thompson FE, Byers T. **Dietary assessment resource manual.** *The Journal of nutrition.* 1994;124:2245s-317s10.1093/jn/124.suppl_11.2245s.
- [52] Willett W. **Nutritional epidemiology:** Oxford University Press; 2012
- [53] Krall EA, Dwyer JT, Coleman KA. **Factors influencing accuracy of dietary recall.** *Nutrition Research.* 1988;8:829-41
- [54] Brown JE, Tharp TM, Dahlberg-Luby EM, Snowdon DA, Ostwald SK, Buzzard IM, et al. **Videotape dietary assessment: validity, reliability, and comparison of results with 24-hour dietary recalls from elderly women in a retirement home.** *Journal of the American Dietetic Association.* 1990;90:1675-9
- [55] Faggiano F, Vineis P, Cravanzola D, Pisani P, Xompero G, Riboli E, et al. **Validation of a method for the estimation of food portion size.** *Epidemiology (Cambridge, Mass).* 1992;3:379-82
- [56] Livingstone MB, Robson PJ. **Measurement of dietary intake in children.** *The Proceedings of the Nutrition Society.* 2000;59:279-93
- [57] Berra B, Rizzo AM. **Glycemic index, glycemic load, wellness and beauty: the state of the art.** *Clinics in dermatology.* 2009;27:230-510.1016/j.clindermatol.2008.04.006.
- [58] Romanska-Gocka K, Wozniak M, Kaczmarek-Skamira E, Zegarska B. **The possible role of diet in the pathogenesis of adult female acne.** *Postepy dermatologii i alergologii.* 2016;33:416-2010.5114/ada.2016.63880.