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Effect of Fruits Consumption on Malondialdehyde (MDA) Reduction Among Athletes: A Systematic Review and Meta-Analysis

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ABSTRACT
One of the most prominent health problems for athletes is excellent fitness; thus, to meet such condition, training is carried out with the High Intensity Interval Training (HIIT). However, if it is done excessively, negative effects such as oxidative stress may result. External antioxidant (exogen), such as fruits, is therefore needed to reduce oxidative stress. This study further aims to pore over the effects of fruit consumption on the decrease of the malondialdehyde (MDA) level of athletes' during the HIIT with systematic review and meta-analysis as the research designs. The data is obtained through literary study via online platforms, namely PubMed, Semantic Scholar, Google Scholar, Elsevier, BMC, and PMC-NCBI. Furthermore, seven articles are reviewed by utilizing the PICOS and PRISMA principles. The data are further processed by using the RevMan 5.4 software. The summary effect results in CI 95% = -2.19 [-3.09, -1.29], which implies that there is a significant effect of fruit consumption on the athletes' MDA level.

Keywords: Fruit consumption, High Intensity Interval Training (HIIT), malondialdehyde (MDA)

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BACKGROUND

To maintain a healthy body, people tend to consume fruits, which can be consumed directly or processed as juice or extracts. Fruits are also likely to enhance physical performance and recover after exercise. In 2018, the International Olympic Committee (IOC) affirmed that fruit-based dietary supplements are effective for athletes to increase the mitochondrial biogenesis and body endurance (Ammar, 2017).

One of health problems for athletes is the decrease of body endurance that can result in decreased fitness. Excellent fitness for athletes can be achieved through regular physical exercises. Although physical exercises bring tremendous advantages, negative impacts for the body can still be met, for instance, the increase in free radicals that results in muscle injuries and oxidative stress (Ammar, 2017). Physical exercises can also cause the imbalance between free radical production and body antioxidant system (Appolo, 2019).

During physical exercises, the oxygen consumption will increase to 10-20 times higher than at rest (Berawi, K. N. and Agverianti,2017). The increase in the oxygen consumption can be caused by the contracted muscles that trigger the emission of electron in the mitochondria and the formation of the reactive oxygen species (ROS), such as superoxide, hydrogen peroxide, and other radical hydrogen compounds (Budiwanto, S. 2012).

Oxidative stress within the body has its personal damage targets, namely protein, DNA, and lipid. Oxidative stress particularly occurs due to the High Intensity Interval Training (hereafter, HIIT), will form Malondialdehyde (hereafter, MDA) (Copetti, C. L. K. *et al.* 2020). Oxidative stress, however, can be prevented with both endogen and exogen antioxidant activities. Numerous types of exogen antioxidant contained in fruits work by blocking cellular oxidation caused by the ROS (De Sousa Assunção Carvalho, L. C. *et al.* 2018). The most antioxidant compounds are flavonoid, phenolic, vitamin C, vitamin E, vitamin A, betalain, and anthocyanin (Zahir, S., Suleiman, M. and Rahim, K. 2010). A high level of anthocyanin, furthermore, influences antioxidant activities. Fruits, especially berries, contain lots of anthocyanin. Unfortunately, berries are hardly found in Indonesia and, if any, they can be costly so that most Indonesians rarely consume them (Sumarlan, S. H., Susilo, B. and Mustofa, A. 2018).

Another fruit containing a high amount of antioxidant is pomegranate (Di, K. *et al.* 2016). In a comparative spectrophotometric test, pomegranate is proven to be most effective in reducing the oxidation of low-density lipoprotein and hindering the cellular oxidative stress in the macrophage compared to green tea, red grape, and orange, blueberry, or blueberry juices (Febrianti, N. and Sari, F. J. 2016). Moreover, there are other fruits with a high antioxidant level that thrive in Indonesia, such as apple and Java plum.

This study is a part of a review series studying the effects of fruit consumption on the MDA level. This study further systematically considers the published literature and extracts it by following the PICOS principles. Hence, this study aims to identify the effects of fruit consumption on the athletes' MDA level when carrying out the HIIT.

METHODS

This study implemented the systematic review method under the PICOS principles, in which 'P' stands for the athletes, 'I' stands for the fruit consumption, 'C' stands for the HIIT or maximum physical exercises, 'O' stands for decreased MDA, and 'S' stands for study/research design (Table 1). During the article selection process, the current research team consisting of three members selected the articles that meet with the PICOS before being sorted by utilizing Mendeley software. Then, the three members, (K), (M), and (D) voted

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and discussed to determine the eligible articles. After that, the leader, (M), further extracted the articles to be reviewed before merging it with RevMan 5.4 software.

Table 1. Criteria Selection based on PICOS

Criteria	Inclusion	Exclusion
Population	Athletes or non-athletes (students) aged under 30 years old	Experimental animals, general public
Intervention	Administration of fruits in form of juices or extracts	Administration of antioxidant supplement or intervention without fruits
Outcome	MDA level	VO2max level
Comparison	Placebo, mineral water	Carbonated drinks
Outcome	MDA level	VO2max level, muscular damage
Research design	Randomized controlled trial	Cross-section, case control, crossover, cohort

The search resulted in 233 research that are potentially relevant in the electronic database searches (Figure 1).

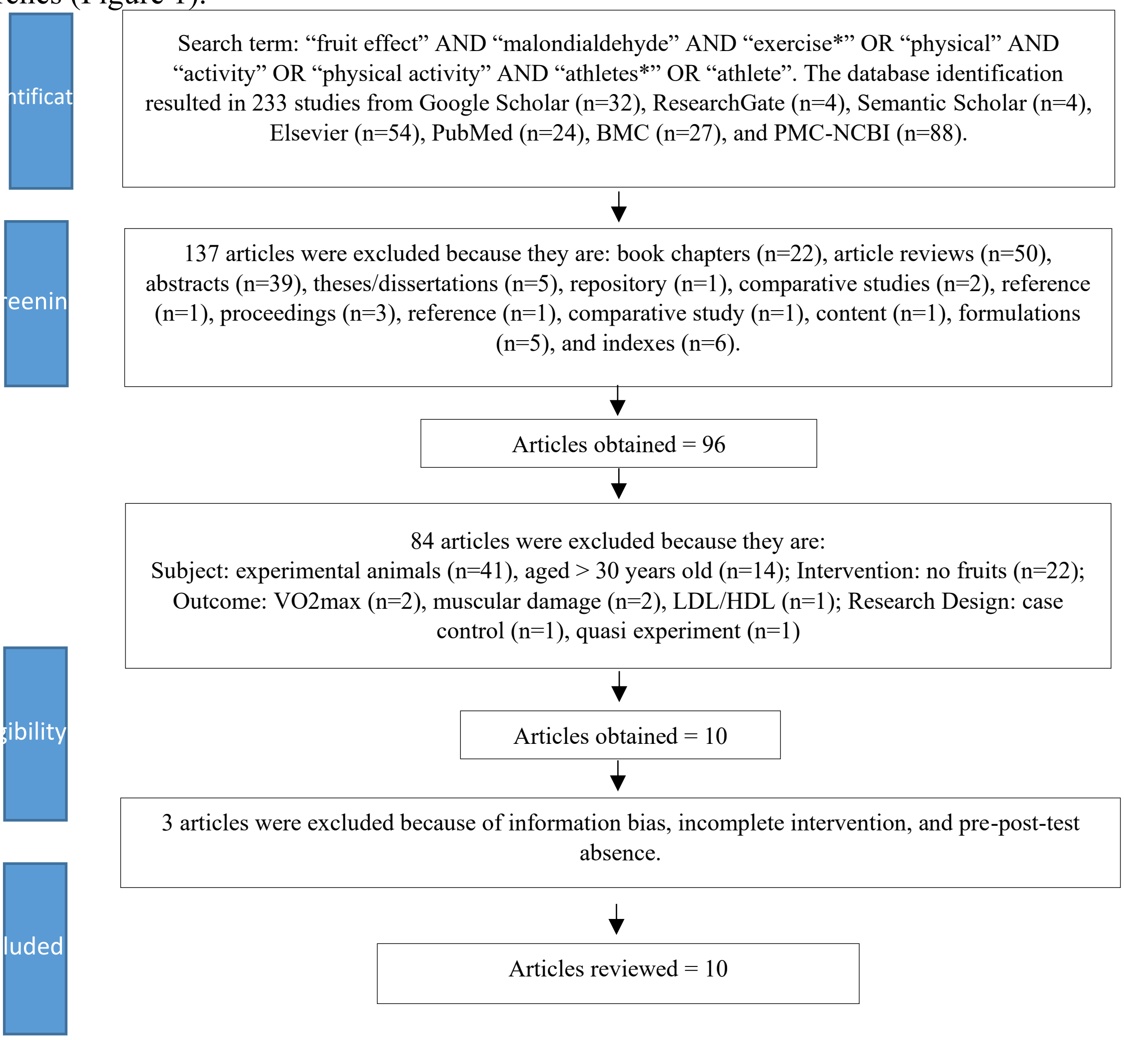

Figure 1. The Flow Diagram of the Search Result and Research Selection

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Research Question
Is there any effect of fruit consumption on reducing the malondialdehyde (MDA) level in athletes carrying out the High Intensity Interval Training (HIIT)?
Statistical Analysis
The statistical analysis was completed by utilizing the RevMan 5.4 software

RESULTS

According to the search results by using the keywords, 233 studies were obtained. Then, the articles were screened following the PICOS principles, which resulted in ten eligible articles (Table 2). However, three out of ten articles had rather flawed quality; thus, the final seven were reviewed. Articles 2, 3, and 6, furthermore, were consider flawed since the number of control and experiment samples during the intervention in the papers was not explained; the dosage administration, intervention duration, and blood sampling were performed once and more than twice. Given the intervention was not similar to the other articles, thus, the three articles were excluded.

The participants of this study came from various sports, namely weightlifting, athletics, running, Muay Thai, and martial arts. The physical exercises intervention occurred between 1-6 weeks with the frequency of 5-6 times per week for 30-60 minutes and a 15-20-minute break. While at rest, the experiment group was given fruits, juices, or extracts 1 x 1/day. On the other hand, the control group was given placebo. After that, blood sampling was completed both shortly before intervention or physical exercises and three minutes after the break as well as 48 hours after intervention.

Effects of fruits on the MDA level

Figure 1 showed that the I-square (I2) was 99%, implying high heterogeneity that assumed if the level of the intervention effect between the experiment and control groups varied. Therefore, the suitable statistical analysis to be implemented was the random effects model with 95% CI, which further results can be found in each study (green box). The study carried out by Ammar, A. et al. (2017), for example, concluded that there is an effect of pomegranate juice on reducing MDA levels (MD = -0.50 [-0.80 to -0.20]. In the study conducted by Apollo, F. et al. (2019) the result was MD = -12.35 [-13.16 to -11.54], which indicated that the administration of beets can reduce MDA levels. Carvalho-Peixoto, J. et al. (2015) also revealed that there is a difference between the intervention group being administered apple juice supplementation and the control group being given placebo (MD = -2.33 [-4.01, -0.65]. On the contrary, the research carried out by Khouloud, A. et al. (2018) (MD = 0.55 [-0.19, 1.29]), Hurst, R. D. et al. (2020) (MD = 0.04 [-0.07, 0.15]), and De Sousa Assunção Carvalho, L. C. et al. (2018) (MD = -0.08 [-0.09, -0.07]) concluded that there is a significance. Prasertsri, P. et al. (2019) further resulted in the significance with 95% CI (MD = -0.09 [-3.76, 3.58]). Additionally, if the final result is on the right of the horizontal line, it suggests that there is no significant relationship between the administration of fruits and the reduction of MDA levels.

Overall, the results of those studies are presented in diamond shape with a total score of 2.19 [95% confidence interval, between -3.09 and -1.29] and a p-value of ($p < 0.00$). These results denoted that there is a significant effect of fruit consumption on MDA levels when practicing the HIIT.

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Based on Figure 2 below, it can be perceived that there is one dot inside the triangle and six dots outside the triangle. This spread further indicates that the spread of the size effect is rather abnormal and there is a possibility of publication biases.

DISCUSSION

The analysis of this current study revealed that the intervention of fruits on athletes can reduce MDA levels. MDA, furthermore, can increase due to the low level of vitamin C and the high level of free radical production as a result of HIITs, namely high impact aerobics, running, swimming, and other exercises that result in the imbalance between free radicals and antioxidant defenses. Vitamin C serves as antioxidant whose task is to break the lipophilic radical chain and can react with the lipid peroxide radicals that will prevent the oxidation of unsaturated fat acids, especially arachidonic acid. Vitamin C can be further found in beets; thus, the administration of beet juice can lower the MDA level after practicing HIIT (Driss, T. and Yaich, S. (2020). Besides vitamin C, beets also contain betalain that can protect the cellular component from oxidative injuries to inhibit lipid peroxidation. The betalain in beets mostly weighs 300-600 mg/kg; hence, betalain can increase the total antioxidant capacity (TAC), for instance superoxide dismutase, glutathione peroxidase, and catalase. NO3 (nitrate) can also be found in beets, which is proven to suppress the free radical formation, such as superoxide and hydrogen peroxide (Mcleay, Y. et al. 2012). Next, vitamin C can also be discovered in acai berries. The fruit is familiar in South America, especially in Brazil (NaghizadehBaghi, A. et al. 2015). Prickly pears (Opuntia ficus-indica) also contain vitamin C (Khouloud, A. et al. 2018), which in Indonesia can be met in forms of supplements rather than fresh fruits.

Other than vitamin C, lycopene is also a useful antioxidant as a precursor to vitamin A and beta-carotene, which are hydrophobic and easy to dissolve fat. Lycopene further acts as a strong inhibitor towards lipid peroxide on liposome membrane which inhibits MDA accumulation. Lycopene is mostly contained in tomato fruits, a fruit that also contains carotenoid: a substance that can reduce muscular damages due to HIITs by reducing oxidative stress in muscular tissues. Other than that, people also generally tend to choose guava since it can be easily brought from the market. Some fruits that can grow well in Indonesia are pomegranates, apples, and Java plums. Along with vitamin C, those fruits also contain polyphenol, α tocopherol, and other active substances such as flavonoid, gallic acid, ellagic acid, quercetin, ellagitannins, and nitrate. Pomegranates, moreover, increase antioxidant up to +130% and decrease oxidative stress markers, namely lipid peroxidation (-65%) (Febrianti, N. and Sari, F. J. 2016). The antioxidant power contained in pomegranates is stronger than in other fruits, given pomegranates still have benefits until up to three weeks after consumption [17]. Consuming pomegranate juice for 15 days, furthermore, can reduce MDA levels in addition to carbonyl and matrix metalloproteinase 2 and 9, as well as boost the erythrocyte glutathione, superoxide dismutase, and glutathione peroxidase levels (Parwata, M. O. A. 2015).

Flavonoids (0.61 ± 0.00 mg/L) in forms of catechin (0.53 ± 0.00), epicatechin (1.39 ± 0.07), epigallocatechin gallate (0.74 ± 0.00), and epicatechin gallate (2.12 ± 0.05) are also noticed in Java plums [28, 29]. In the study conducted by Layana Cibelle (2018), it was revealed that galactic acid, epicatechin, and epigallocatechin gallate can activate the core factor in the denomination of transcription factor 2 associated with erythroid 2 (Nfr2), and then transported to nucleus cells to synthesize the antioxidant enzymes (Larsen, F. J. et al. 2011).

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Most Indonesians like to consume apples since it can easily be found in the market. Apple juice contains vitamin C as much as 3.36 mb/100 g and helps the immune system during HIITs (Safyudin, S. and Subandrate, S. 2016). Another antioxidant, anacardic acid, is also found in apples, which role is to prevent the superoxide radical generation by inhibiting xanthine oxidase through increasing the heme oxygenase-1, an antioxidant enzyme in the immune system (Maughan RJ, Burke LM, Dvorak J, et al. IOC 2018). In other words, apple consumption can enhance the body immune function that can decrease the oxidative stress risks after doing HIITs.

From several studies that have been analyzed, it can be inferred that every fruit is beneficial for health although not all fruit is rich of antioxidant. For that reason, the results of this study are expected to be an additional reference for fruit consumption besides supplement consumption, so that athletes, in particular, can be fit and have increased performance.

CONCLUSION

From the systematic review and meta-analysis, seven relevant studies are obtained by implementing the randomized control trial design. The summary effect analysis further concludes that there is a significant effect of fruit consumption on MDA levels due to HIITs.

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Table 2. The Results of the Eligible Articles

No	Author(s)	Population			Intervention	Comparison	Outcome						
		Subject	Cont	Exp	Dosage; intervention duration; antioxidant; physical activities		Cont	Exp	P	Mean 1	SD 1	Mean 2	SD 2
1	Apollo, F et al, 2019; pre-post	Male; 20-22 years old	15	15	Beetroot juice; 250 mL; 1 x 1/day; 1 month; betaine, vitamin C, carotenoid, phenolic acid; Bleep test	Placebo	Pre; 2.11±0.24 Post: 10.69±0.97	Pre; 1.98±0.37 Post; 5.75±0.51	Pre: P=0.000 Post: P=0.000	4.09	0.61	16.44	1.48
2	Abdul Latif et al, 2018	Muay Thai athletes	10	10	Dragon fruits	Placebo	Pre-post: 0.52 ± 0.654	Pre-post: 0.305 ± 0.380	0.781	-	-	-	-
3	Abbas Naghizadeh et al, 2015	Male	14	14	Pomegranate juice	Placebo	Pre: 0.1950±0.04 II: 0.2029 ± 0.03 Post: 0.3393±0.1	Pre: 0.1993±0.04 II: 0.2029±0.03 Post: 0.2614±0.05	0.78 0.002 0.02	0.24	0.056	0.2212	0.04
4	Carvalho-Peixot. J, et al, 2015; RCT	Runners & sprinters; 26 years old	7	7	Acai (*Euterpe oleracea* Mart); 300 mL, 1 x 1/day; 2 weeks; anthocyanin, phenolic acid; maximum treadmill test	Water	Pre: 3.64 ± 0.72 Post: 3.89 ± 0.73	Pre: 3.26 ± 8.78 Post: 3.20 ± 0.69	Pre: 0.186 Post: 0.048	3.45	4.75	3.54	1.42

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No	Author(s)	Population: Subject	Population: Cont	Population: Exp	Intervention: Dosage; intervention duration; antioxidant; physical activities	Comparison	Outcome: Cont	Outcome: Exp	Outcome: P	Mean 1	SD 1	Mean 2	SD 2
5	Khouloud, A, et al, 2017, RCT	Athletes; 20-21 years old	11	11	Prickly pear (*Opuntia ficus-indica*) juice; 150 mL/day; 1 x 1/day; 2 weeks; phenolic acid, 17.6 g/kg vitamin E, 180 to 300 mg/kg vitamin C; level 1 yo-yo intermittent recovery test	Placebo	Pre: 0.80 ± 0.02 Post: 0.87 ± 0.01	Pre: 0.93 ± 0.02 Post: 1.02 ± 0.02	Eks: p < 0.01 Control > 0.05	0.86	0.02	0.94	0.015
6	Dominic Lomiwes et al, 2019	Athletes	-	-	Blackcurrant juice	Placebo	Pre: 5.4 ± 1.6 Post: 6.6 ± 1.6	Pre: 8.2 ± 2.2 Post: 9.8 ± 2.3	Eks: 0.830 Control: 0.115	6	1.6	9	2.25
7	Hurst, R.D et al, 2020; double blind	Male & female; 25-58 years old	18	18	Blackcurrant extract; 240 mg; 1 x 1/day; 6 weeks; anthocyanin glycosides (90%); delphinidin-3-O-glucoside, delphinidin-3-O-rutinoside, cyanidin-3-O-glucoside, and cyanidin-3-O-rutinoside; paddle test	Air	Pre: 1.38 ± 0.23 Post: 1.48 ± 0.21	Pre: 0.94 ± 0.13 Post: 0.76 ± 0.09	Pre: P < 0.01 Post: P < 0.05	1.16	0.18	1.12	0.15
8	Ammar, A et al, 2017; RCT	Weightlifters; 21 years old	4	5	Pomegranate juice; 500 mL; 1 x 1/day; 1 week; polyphenolic; weightlifting exercises	Placebo	Pre: 1.82 ± 0.22 Post: 2.44 ± 0.18	Pre: 1.76 ±0.24 Post: 2.15 ± 0.26	P < 0.001	1.79	0.23	2.29	0.22
9	De Sousa Assucaou Carvalho, L.C et al, 2018; RCT	Handball athletes; 17-18 years old	13	12	Java plum (*Syzygium cumini*) nectar; 10 mL/kg/day; 28 days; phenolic acid, gallic acid, and flavonoid (catechin, epicatechin, epigallocatechin gallate, and epicatechin gallate); running test, vertical jump, sprint, and anaerobic	Placebo	Pre: 4.0 ±1.0 Post: 4.3 ± 0.7	Pre: 4.6 ± 1.1 Post: 3.2 ±0.9	Pre: 0.048 Post: 0.001	4.3	1.05	3.75	0.8

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No	Author(s)	Population			Intervention	Comparison	Outcome						
		Subject	Cont	Exp	Dosage; intervention duration; antioxidant; physical activities		Cont	Exp	P	Mean 1	SD 1	Mean 2	SD 2
10	Prasertri, P, et al, 2019; RCT	Martial arts athletes and non-athletes; 20-21 years old	10	10	Cashew apple juice supplementation; 3.5 mL/kg/day; 4 weeks; 3.36 mg/100g vitamin C; α tocopherol; high intensity cycling (20 minutes)	Placebo	Pre: 8.83 ± 1.88 Post: 12.28 ± 1.57	Pre: 5.85 ± 1.71 Post: 7.07 ± 2.50	Pre: p < 0.05 Post: p < 0.05	7.34	1.79	9.67	2.03

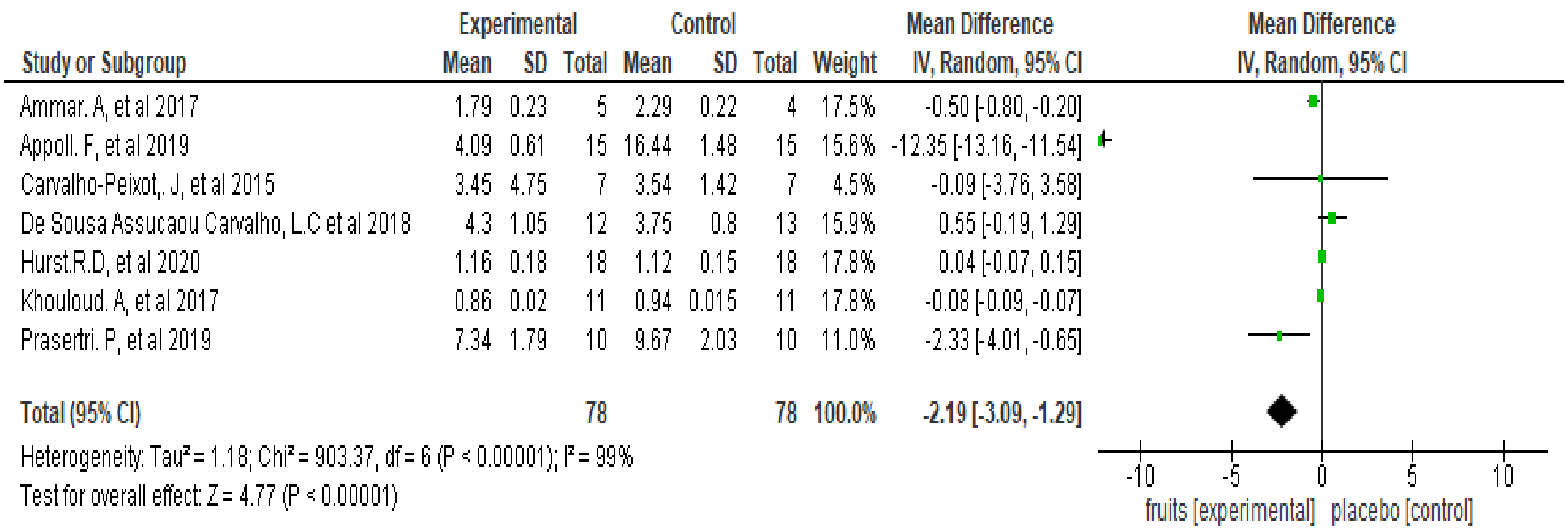

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Table 3. The Effect of Fruits on MDA Level. IV= Inverse Variance; SD = Standard Deviation

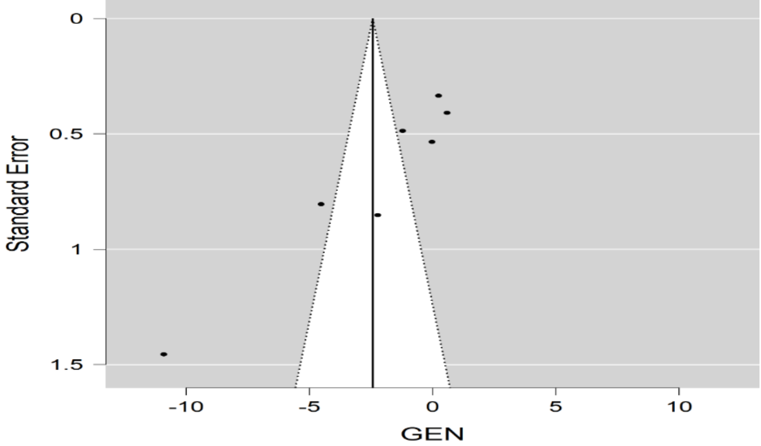

Figure 2. Funnel Plot