Effect of School-Based Interventions on Body Mass Index Among Adolescents: A Systematic Review and Meta-Analysis

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ABSTRACT

Background: High body mass index is a common well-known issue among adolescents, its related morbidity track to adulthood life and decrease life expectancy. The review aims to derive a consensus on school-based intervention on body mass index. Objective: This review evaluates the effect of school-based interventions in reducing or preventing high body mass index for adolescents.

Method: A literature search was performed in six electronic databases: Pubmed, Science Direct index, Sci-Hub, HINARI, and Google Scholar to identify published studies between January 2010 and December 2020. Only randomized controlled studies evaluated the effect of physical activity and/or physical education and nutritional education and/or dietary behavior, sedentary behavior outcome reporting on body mass index among adolescents were included. The Standard Cochrane tool was used to assess the risk of bias for individual studies. An evaluation of the effects of included interventions on body mass index was done using a random effects model.

Results: There were 6 trials included. 2503 adolescent partakers met the inclusion criteria. Meta-analysis showed there is a significant difference between length of intervention between 3 to 12 months were MD -0.44 kg [95% CI: 1.06, 0.18], p-value = 0.04, with evidence of substantial study between heterogeneity (I^2 = 61%).

Discussion: Intervention less than three to twelve months more effective with multiple school-based interventions among adolescents. Numerous studies are needed for evaluation to determine long-term intervention effectiveness targeted on adolescents.

Keywords: adolescent, body mass index, diet, physical activity, schools, sedentary behavior

INTRODUCTION

High body mass index (BMI) is a major known health issue, dramatically rising in all countries, both rural and urban settings among adolescent[1]. Body mass index is coupled with a myriad of lifestyle risk factors, including insufficient physical activity[2], being sedentary[3], unhealthy food habits[4], blood pressure[5], socioeconomic background[6], and non-modifiable characteristics including age, gender, and family history[2]. Such elements are putting adolescents at serious risk for serious problems later in life. There is a lot of info demonstrating the tremendous advantages of living an active lifestyle. Adolescents who lead healthy lifestyles have a lower risk of developing physical and mental health issues like obesity, cardiovascular disease, diabetes, depression, furthermore morbidity[7].

According to a global assessment, physical inactivity is one of the fourth top risk factors for mortality and is linked to 3.2 million deaths annually. In India, adolescents aged 11 to 17 had an insufficient physical activity prevalence of 71.6% for girls and 69.6% for boys[8]. Adolescents should perform at least 60 minutes of moderate to vigorous-intensity physical

exercise every day, but 81% of those between the ages of 11 and 17 do not reach these recommendations, according to the World Health Organization[9]. As per the Global Burden of Disease Study, physical inactivity and dietary risk factors were responsible for a 23.7% and 20.7% increase from 2010 to 2017 as estimated[10].

Teenagers should limit their sedentary activity (SA) by reducing screen-based activities and by active commuting. Evidence shows that increased SA is associated with abnormal adiposity changes, poor cardio-metabolic fitness, behavioral problems, eating disorders, and decreased sleep duration[11]. Since the impacts on mortality and morbidity in adults have already been shown, if limiting sedentary lifestyle habits, improving PA and a healthy diet can be developed in adolescence, this may have advantageous preventive value[12,13]. Teenagers need interventions to boost PA, reduce SB, and encourage good eating behaviors because PA even lowers, they spend a lot of time sedentary[14], and they have unhealthy eating habits[4,15] during adolescence.

Schools are the ideal setting to start early prevention-related activities to promote the health of adolescents and future adults. Previous research has shown that numerous school-based interventions have a considerable impact on BMI. However, the effects were minor, transient, and most varied among interventions. Furthermore, effects of PA, SA, and diet together are not often observed[16,17]. To our knowledge, no contemporary review has focussed exclusively on PA, SA, and nutrition intervention and follow-up at two levels 3 months to 1 year and 12 months to 24 months effect on BMI. Making evidence-based decisions throughout the development of an intervention would be made possible by having a better knowledge of whether the qualities stated above are related to the success of the intervention. To provide a current systematic analysis of the effectiveness of school-based multiple interventions addressing PA, diet, and SB among 11-18-year-old adolescents, this study uses an investigative review with an analysis of intervention components purely based on BMI.

Review questions

(1) How effective are physical activity (PA), diet, and sedentary behavior interventions in reducing or preventing high BMI of adolescents aged 11 to 18 years?

(2) Does the effectiveness of the interventions differ depending on whether they last three months to a year or one year to two years?

MATERIAL AND METHODS

The systematic review was performed as per Preferred Reporting Items for Systematic review and Meta-Analysis (PRISMA) guideline[18].

Systematic Search: This systematic search was car-ried out on online data records of Pubmed, MEDLINE, Science Direct index, Sci-Hub, HINARI, and Google Scholar to identify studies published in English language, open access journals from January 2010 and December 2020 by using the search term "adolescent OR teenage OR teen", "PA OR exercise AND physical education", "nutrition OR diet", "BMI OR body mass index", "intervention/prevention", "schools OR school-based" and "randomized controlled trial OR RCT".

Eligibility criteria

Participants: Adolescents aged 11 to 18 years healthy, BMI <85th percentiles, BMI ≥85th percentiles, studies conducted on boys or girls or both genders included. Studies excluded adolescents with medical conditions such as diabetes, dyslipidemia, eating disorders, cognitive measurement, and physical or mentally challenged.

Interventions: The studies reported on physical activity (PA) measured by subjective or objective assessment (e.g., accelerometer) or physical education and nutritional education and diet and sedentary behavior or screen time represented with three interventions at baseline and a post-intervention measurement on BMI. The duration of interventions should be not less than 3 months and not more than 24 months. Studies excluded purely electronic-based interventions such as mobile, internet, computers, tablets, and telehealth except for text messages.

Comparators: The control group with no intervention or education as usual or any other intervention.

Outcome measures: The study reported on BMI as a primary or secondary or as another outcome.

Study design: Randomized controlled trials (randomization at the school grade or class or partakers level) were considered for inclusion. Observational and non-randomized controlled trials, non-controlled trials, case reports, case series, opinion papers, letters to the editor, commentary, conference abstracts, reviews and meta-analysis, and study protocols.

Timeframe and setting: There intervention and follow-up lengths are not more than 24 months. Intervention is primarily based on the school setting.

Language: Studies in English and available full-text open access are considered for inclusion.

Study selection: After evaluation of titles and brief scanning of abstracts 2052 studies were found out of context. Hence 60 abstracts remained for subsequent scanning. Among these abstracts, 17 were found duplicated, and hence, they were also excluded based on eligibility criteria. The 43 relevant full-text articles were screened, and 37 were eliminated by the authors based on inclusion criteria. Finally, 6 articles were left that were reviewed by two independent authors for extraction of data.

Data extraction: Data extraction was performed by

two independent authors by using a well-developed form prepared by investigators. All articles identified in this review were investigated for applicability, inter-rater reliability (78%), reviewed abstracts, and re-examined for inclusion criteria. The authors were resolved in consonance through discussion and concurrence was met related to eligibility for the study.

Data Synthesis: The outcomes of included studies were summarized in tables by mentioning the outcomes in terms of study populations, study design, participants' age, study period, intervention duration, sample size, follow-up, intervention characteristics, outcome measures, and major findings on BMI.

Risk of bias assessment: Two independent authors evaluated the risk of bias in included studies by using criteria outlined by the International Cochrane Collaboration[19] appropriate for quantitative RCTs. The following areas were taken into account: sequence generation, allocation concealment, blinding of study personnel and participants, incomplete outcome data, selective outcome reporting, and other possible sources of bias. Each article had a thorough evalua-

tion for each topic, and assessments of potential bias were made in one of three categories: low risk, high risk, or uncertain risk.

Statistical analysis: The Cochrane Review Manager (RevMan 5.3) program was used to conduct the meta-analysis. The results of each follow-up evaluation are provided individually. We entered means and standard deviations for each outcome variable as they were all continuous data. The results of each follow-up evaluation are provided individually. The mean difference (MD) with a 95% confidence interval (CI) was used to compare treatment and control group results. A p-value of 0.05 was deemed statistically significant for this review. The I^2 statistic was used to estimate trial heterogeneity (I^2). In this study, I^2 was rated as low for 25%, moderate for 50%, and high for 75 %. A random effect model[20] was used for percentages of $I^2 > 50\%$. Using Egger's regression test to analyze the funnel plots for all comparisons, the potential for publication bias was visually investigated. There is no solid evidence of publishing bias, and our assessment did not point to any systemic heterogeneity.
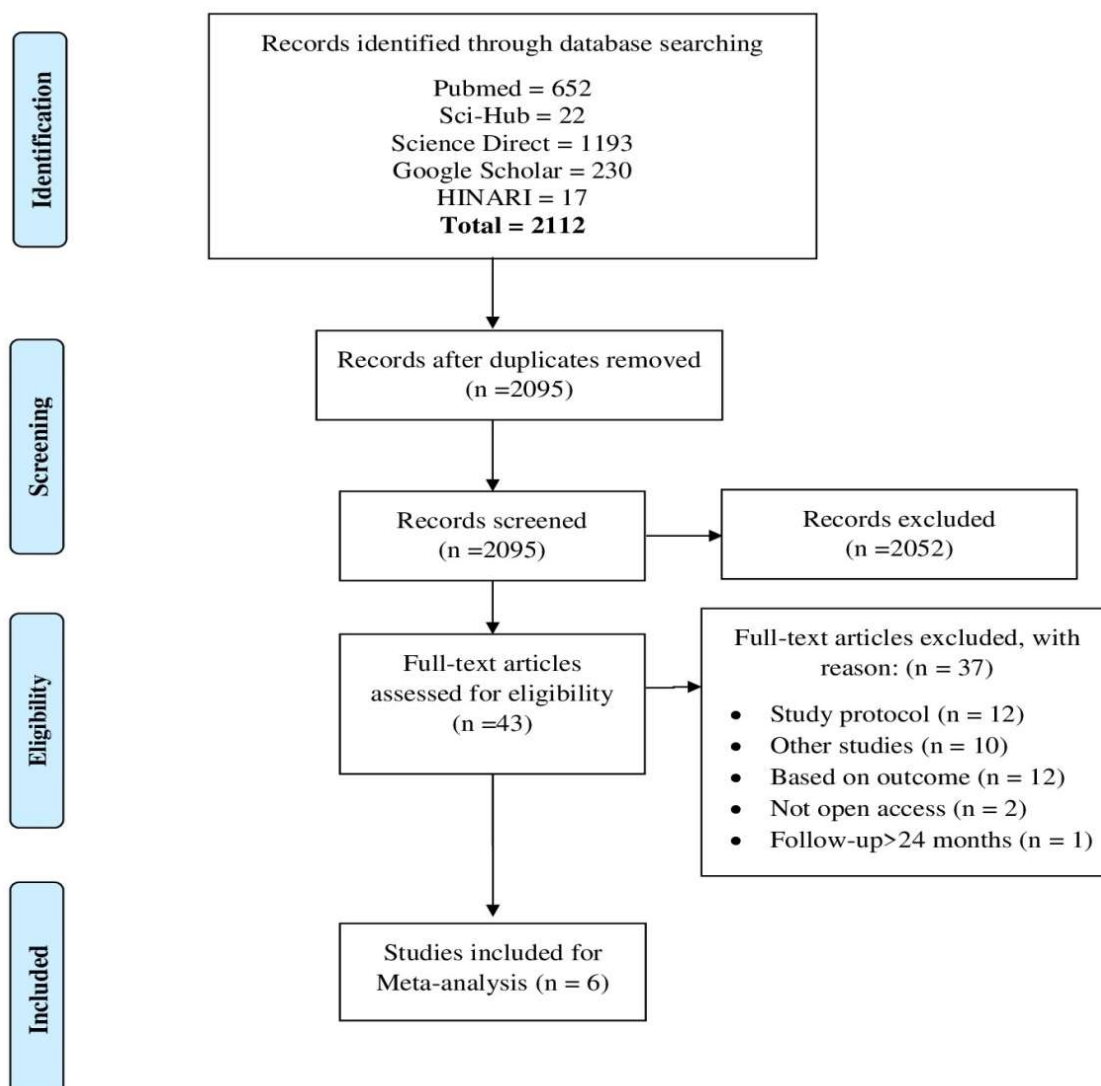

Figure 1: PRISMA flow diagram

RESULTS

Literature search

In total, 2112 records were identified. The search turned up 2112 records, and 6 papers reporting 3 distinct intervention studies were chosen after screening and eligibility assessments (Figure 1).

Study characteristics

Study characteristics and participant

Table 1 presents the general study and participant characteristics. Three studies were cluster RCTs[21–23], one group RCTs[24], and two were matched-pair cluster RCTs[25,26]. Overall study participants were aged 11-18 years, in that, studies girls only: aged 12-18 years, boys only: aged 12-14years. Five studies showed participant numbers <500, with the minimal sample size being 82[25], one study contained n=1324 adolescents, with the highest sample size[23]. Four studies aimed at only girls[21,24–26], one study only on boys[22], and one study aimed at both gender[23]. Five

studies were follow-up assessments between 6 to 12 months[21,22,24–26] and three studies were follow-ups at 12 to 24 months[22–24]. Two studies were 2 to < 3 years of duration[23–25], two studies were < 1-year duration[21,26], and one study was not reported study duration[22].

Intervention characteristics

Table 2 shows the attributes of the PA, DB, and SB interventions as well as their impacts on BMI. Duration of intervention was > one year in one study[23] and in five studies intervention duration was less than one year[21,22,24–26]. Three studies demonstrated PA through physical education class[21–23], one study aimed at an interactive educational seminar on PA[24], and two interacted with PA via counselling session[25,26]. DB intervention pointed to limiting SSB and increasing fruits and vegetable intake in four studies[22,23,25,26], two were aimed at energy estimation[21,24], and one was lined up with nutrition education[24]. All six studies were focused on reduction in SB among partakers[21–26].
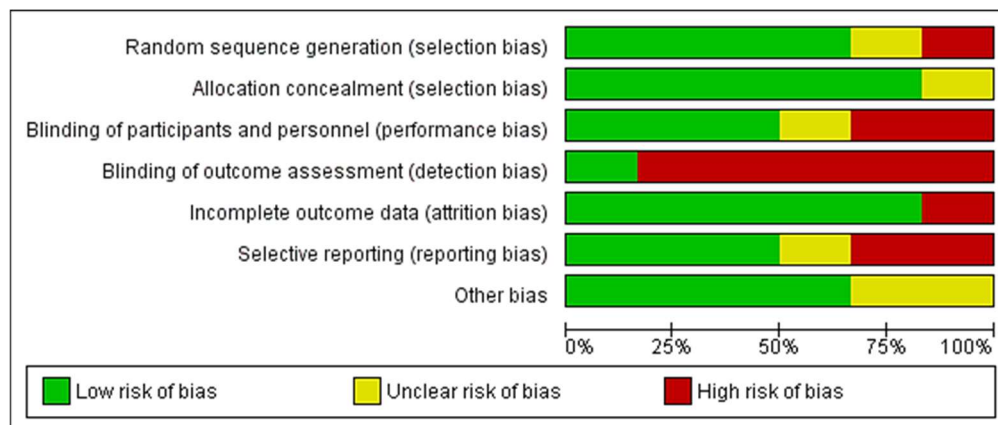

Figure: 2 Risk of bias summary

Table 1: General study characteristics

First author (yr), country	Design, study name	Theory basis	Participants, age in years/mean age (SD) years grade	Study period, intervention duration	Sample size (n) BA = I:C	Follow up months I:C 3 to 12	12 to 24
Dewar (2013), Australia[24]	Group RCT, NEAT girls	Bandura's SCT	Girls, 13.2 (± 0.5)	2010 - 2012, 12 months	n = 357 BA -178:179	12th 141:153	24th 113:121
Pbert (2013), USA[25]	Pair-matched cluster RCT, Lookin' Good Feelin' Good	SCT	Girls, 15.8 (1.02)	2008 - 2009 16 wks	n = 82 BA - 42:40	6th month 42:40	Nil
Grydeland (2014), Norway[23]	Cluster RCT, HEIA	Nil	Boys & girls, 11 – 12 / 11.2 (0.3)	2007 - 2009, 20 months	n = 1,324 BA -465:859	Nil	20th 465:859
Pbert (2016), USA[26]	Pair-matched cluster RCT, Lookin' Good Feelin' Good	Bandura's SCT	Girls, 16.4 (1.21)	Sep 2012 – Jun 2013, 6 months	n = 126 BA - 58:68	8th 54:57	Nil
Lubans(2016), Australia[22]	Cluster RCT, ATLAS	SDT and SCT	Boys, 12 - 14 / 12.7 (± 0.5)	NR, 20 wks	n = 361 BA -181:180	8th 139:154	18th 121:143
Leme (2018), Brazil[21]	Cluster RCT, H3G-Brazil	Bandura's SCT	Girls, 14 - 18 / 15.6 (0.87)	Feb to Aug 2014, 6 months	n = 253 BA-142:111	6th 89:55	Nil

Note. ATLAS = Active Teen Leaders Avoiding Screen-time, BA = baseline assessment, C=control group, HEIA = HEalth In Adolescents, H3G = Healthy Habits, Healthy Girls, I = intervention group, NR = not reported, NEAT = Nutrition and Enjoyable Activity for Teen, PALs = Physical Activity Leader's, RCT = randomized controlled trial, SDT = self-determination theory, SCT = social cognitive theory.

Table 2: Intervention Characteristics and Effects of Physical Activity, Dietary, Sedentary Behaviour findings on BMI

Study	PA session/ Physical education session	DB content/ education session	SB or Screen time	Outcome measures	Findings
Dewar[24]	School sport sessions, steps count ≥600 min/day for 3 days, LTPA min/day/ Interactive seminar	Energy intake kcal per day/nutrition workshops, handbook, interactive seminar	Screen time min/day	Primary outcome: BMI Secondary outcome: accelerometer, ACAES food frequency questionnaire, ASAQ	No significant intervention effects on BMI (p = 0.353).
Pbert[25]	1 hour or more PA a day / 6 x 1 to 1 counseling session x 18 to 29 minutes x 2 months	3 structured meals a day, including breakfast, 5 or more servings of fruits and vegetables a day, zero limits of soda and SSB	2 hours or less viewing of TV, computer, and video games a day	BMI accelerometer, 24-hour dietary recall, youth risk behavior survey	No significant differences in BMI (p > 0.68)
Grydeland[23]	PA break in regular classes 10 min of PA/wk, awareness on leisure time activity, step counts/day, sports recess activities / PE class	Fruit and vegetable intake, limit SSB, lesson with booklet and posters	Active community campaigns 5 x 3 weeks, hours of screen time use advice	Primary outcome: BMI pedometer, self-reported screen time	Significant effect on BMI (p =0 .02).
Pbert[26]	After-school exercise program includes games, walking, and dance 3 sessions/week, step counts/day 1 hour for the last 7-day period, 6 x 1 to 1 counselling session x 18 to 29 minutes x 2 months	Counselling on nutrition 30 min × 6 wks, booklet, food and tracking log (Increase fruit and vegetable, limit consumption of soda, SSB, fast food, and unhealthy snacks)	TV/computer/game use for the average school day in the past 7 days	Primary outcome: BMI Secondary outcome: accelerometer, 24-hour dietary recall, youth risk behavior survey	Not found improvement on BMI (p = 0.731)
Lubans[22]	Sport session includes aerobic exercises and resistance training 6 × 20 min, sport recess 1 pack/school, LTPA, step counts ≥ 480 min/day for at least 3 days × 17 weeks / PE class/20 × ~90 min, researcher-led seminars (3 × 20 min)	SSB consumption	Recreational screen time min/day	Primary outcome: BMI Secondary outcome: muscular fitness, pedometer, resistance training skills battery, ASAQ, NSW schools PA, and nutrition survey	No significant changes in BMI (P = 0.656)
Leme[21]	Lifetime PA ≤ 30 min/week to ≥90 min/week /PE lesson	Healthy food choices, dietary intake, estimate energy intake	TV / computer use, SB for weekdays, weekends (hours/day)	Primary outcome: BMI Secondary outcome: Godin - Shephard Leisure Time PA Questionnaire, BFFQ, self-report for SB	No significant effect on BMI (p = 0.426).

Note. ACAES = Australian Child and Adolescent Eating Survey, ASAQ = adolescent sedentary activity questionnaire, BMI = body mass index, BFFQ = Brazilian food frequency questionnaire, DB = dietary behavior, min = minutes, NSW = New South Wales, SB = sedentary behaviour, SCB = sugar containing beverages, SSB = sugar sweetened beverages

Behaviour changes theories

The theoretical framework used to develop their intervention: four studies stated that they used a Social Cognitive Theory (SCT)[21,24–26], one was integrated with SCT and Self Determination Theory (SDT)[22], and one study did not state any theoretical framework[23].

Risk of Bias

When necessary, disagreements were rectified through discussion. The risk of bias summary is presented in **Figure 2**. Among included studies, three studies were assessed as being at low-risk bias[21-23] and two were at high-risk bias[25,26] across all quality criteria.
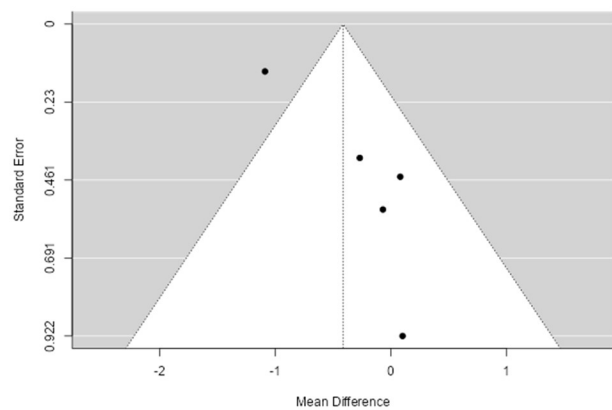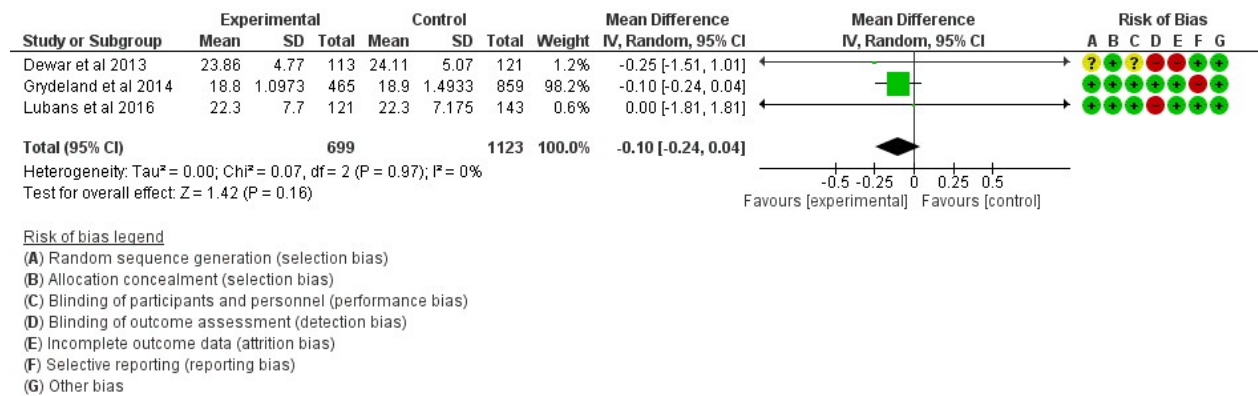
Effects on BMI

Five studies corroborated intervention delivered between 3 to 12 months as yielded effectiveness (Figure 3) of multiple intervention pooled analysis MD -0.44 kg [95% CI: 1.06, 0.18], p-value = 0.04, with evidence of substantial study between heterogeneity (I^2 = 61%). It shows that there is a significant change in BMI among adolescents with a smaller effect. At an-

other end evaluation of intervention delivered between 12 to 24 months were yielded effectiveness (Figure 4) of collective intervention pooled analysis MD -0.10 kg [95% CI: 0.24, 0.04], p-value = 0.97, with no evidence of between-study heterogeneity (I^2 = 0%). We examined the effectiveness of intervention length between two pooled analyses. It shows that there is a small effect in reduction of BMI < 1-year intervention duration than >1 year.
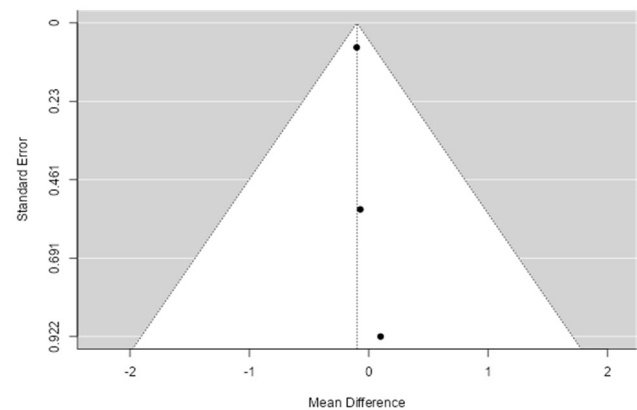
Figure 3: Physical activity, dietary behavior, sedentary behavior intervention (3 to 12 months) effects on BMI
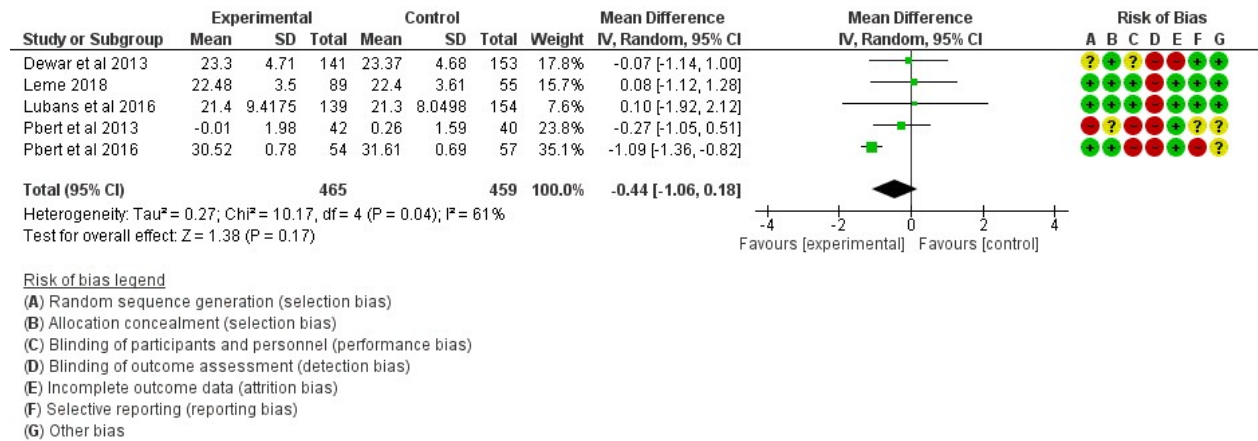
Figure 4: Physical activity, dietary behavior, sedentary behavior intervention (12 to 24 months) effects on BMI

Figure: 5 Intervention effects on 3 to 12 months (n = 5)

Figure: 6 Intervention effects on 12 to 24 months (n = 3)

Publication bias

The regression test indicated funnel plot asymmetry (p = 0.0201) but not the rank correlation test (p = 1.0000) on intervention between 3 to 12 months duration, implicating no publication bias (Figure 5). Neither the rank correlation nor the regression test indicated any funnel plot asymmetry (p = 0.3333 and p = 0.3255, respectively) for 12 to 24 months intervention duration (Figure 6).

Sensitivity analysis

After removing each study individually, a sensitivity analysis ran, and the pooled estimate was determined for the studies that remain. Sensitivity analysis showed that a little amount of heterogeneity may be accounted for by the standard of the trials and the number of participants[26] who showed a non-significant MD of -0.12 kg (95 % CI: -0.66, 0.41).

DISCUSSION

This existing review analyzed the effect of school-based obesity through multiple interventions solely based on BMI outcomes among adolescents (11-18 years). The past review reported that combined education on PA and nutrition had more positive effects in the reduction of BMI among school-age students than the single component[27]. The results indicate that school-based interventions PA, DB, and SB have only a small effect on reducing BMI and no effect for intervention longer than 12 months.

The overall quality of evidence is very low. Several reviews reported multiple interventions, various study designs, socio-economic backgrounds, and various outcome measures which also showed similar result[28,29]. The effectiveness of school-based PA interventions was, however, shown to be correlated with longer intervention durations in previous reviews[17,30]. The review bias score was found very

strong on the randomization process, negative effects on the absence of allocation of concealment /blinding and low withdrawal and dropout rates, and a moderate effect on intervention integrity. Another study review also observed that fair quality evidence on decreased BMI and moderate-quality evidence on decreased weight, mainly in the intervention group compared with no treatment with multiple interventions. Contradictory results, risk of bias, or uncountable outcome measures used intend that the evidence must be elucidated with caution[31].

Sustained Development Goals (SDG)-3, 2030 agenda "Leaving no one behind" emphasizing to secure, boosting, promote healthy individuals and well-being for all age groups, a 25% curtailment in the risk of early mortality from cardiovascular disease, cancer, diabetes, and 10% limiting the prevalence of insufficient PA[32]. The school setting serves as a foundation for controlling BMI, preventing or reducing overweight/obesity, risk factors, comorbidities, and reducing the rate of early mortality. The use of BMI which provides a measurement for PA, dietary behavior, and sedentary activity that is conventionally known and used in research background, with well consenting reference standards, standard instruments may potentially be reducing participant bias, observer bias, and instrumentation bias.

CONCLUSION

According to the current review, an intervention affects teenagers' BMI. Modifying behavior in adolescents is most important to facilitate a good lifestyle, specifically for selecting healthy food, eating time, increasing physical exercise, and decreasing recreational screen time. However, the current review suggests that delivering multiple interventional strategies consciously should be applied with theory.

What is already known?
Multi-interventional approaches have already been described by several reviews aimed at obesity and overweight.
What does this study add?
This article adds meta-analysis purely on multiple intervention approaches (physical activity, dietary behavior, and sedentary behavior) on BMI among adolescents 11- 18 years.

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