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| REVIEW  The effectiveness of intervention with board games: a systematic review | | Open Access |
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Abstract

To examine the effectiveness of board games and programs that use board games, the present study conducted a systematic review using the PsycINFO and PubMed databases with the keywords “board game” AND “trial;” in total, 71 studies were identified. Of these 71 studies, 27 satisfied the inclusion criteria in terms of program content, intervention style, and pre–post comparisons and were subsequently reviewed. These 27 studies were divided into the following three categories regarding the effects of board games and programs that use board games: educational knowledge (11 articles), cognitive functions (11 articles), and other conditions (five articles). The effect sizes between pre- and post-tests or pre-tests and follow-up tests were 0.12–1.81 for educational knowledge, 0.04–2.60 and − 1.14 – − 0.02 for cognitive functions, 0.06–0.65 for physical activity, and − 0.87 – − 0.61 for symptoms of attention-deficit hyperactivity disorder (ADHD). The present findings showed that, as a tool, board games can be expected to improve the understanding of knowledge, enhance interpersonal interactions among participants, and increase the motivation of participants. However, because the number of published studies in this area remains limited, the possibility of using board games as treatment for clinical symptoms requires further discussion.

Keywords: Board game, Systematic review, Education, Cognitive function

Background colors, and stone and wood materials) combined with

A board game is a generic term for a game played by placing, moving or removing pieces on a board and that utilizes a game format in which pieces are moved in particular ways on a board marked with a pattern. Ex-amples of board games include chess, Go, and Shogi. Re-search involving chess, which is played by two players on a board with 64 black and white squares and 16 pieces for each player [1], has contributed to the theoret-ical development of cognitive psychology [2]. For ex-ample, Burgoyne et al. [3] conducted a meta-analysis and demonstrated that chess skills are significantly and positively correlated with four broad cognitive abilities: fluid reasoning, comprehension-knowledge, short-term

simple rules that generate subtleties that have enthralled players for millennia [5]. Go is a famous board game in Asian countries and has been used as a tool for increas-ing or maintaining brain activity for more than 5000 years [6]. It is currently gaining popularity in the United States and Europe [6], and Kim et al. [7] has suggested that playing Go might be effective for children with attention-deficit hyperactivity disorder (ADHD) due to its activation of hypo-aroused prefrontal cortical func-tion and the enhancement of executive function. Lin et al. [8] conducted an intervention study using GO in patients with Alzheimer’s disease and showed that play-ing Go can also improve the clinical symptoms associ-

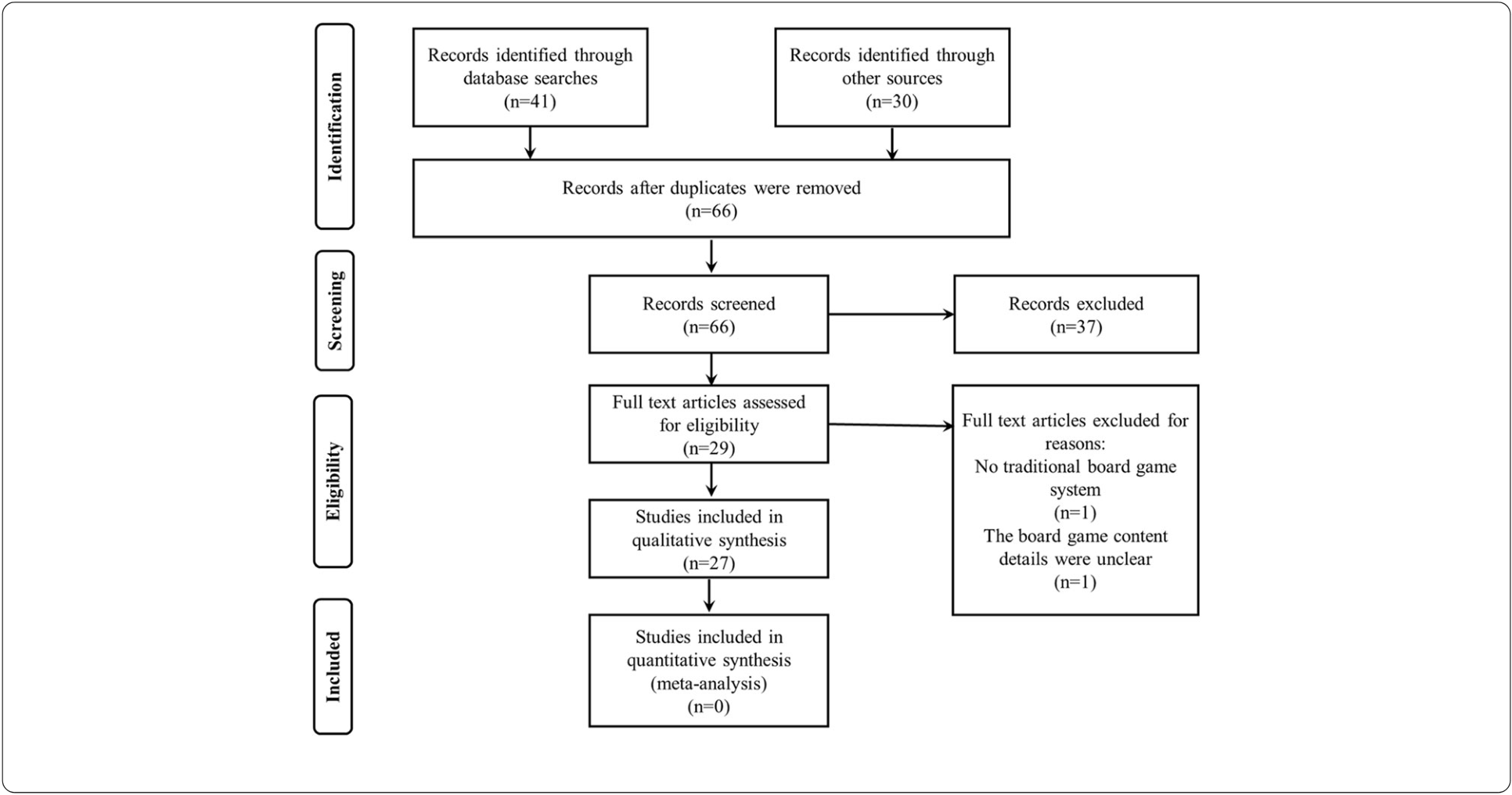
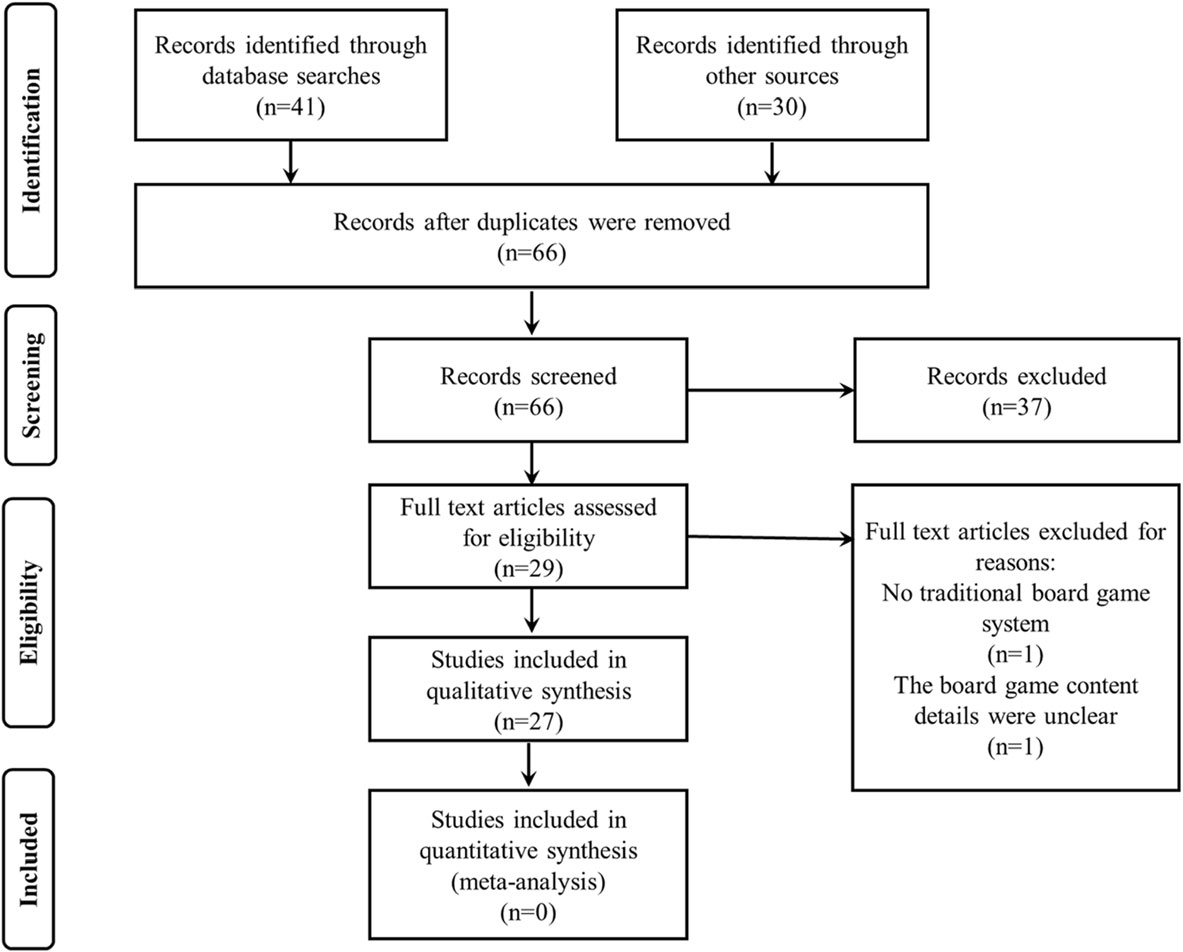
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| memory, | and | processing | speed. | Similarly, | a | meta- | ated with depression, anxiety, and Alzheimer’s Disease. |

analysis by Sala and Gobet [4] found that chess instruc-tion moderately improves the cognitive skills of children. In contrast, Go is ancient board game that consists of simple elements (a line and circle, black and white

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Similar to chess and Go, Shogi is a board game for two players that is also referred to as Japanese chess. Wan et al. [9] conducted an experiment with undergraduate students and found that Shogi training is related to acti-vation in the head of the caudate nucleus. Taken to-gether, the abovementioned findings suggest that chess, Go, and Shogi are effective ways to achieve various outcomes.

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There are many board games other than chess, Go, and Shogi. For example, educational board games, such as Kalèdo, have been used to improve nutrition know-ledge and promote a healthy lifestyle for children [10]. Zeedyk et al. [11] investigated the effectiveness of a board game for increasing knowledge about road safety and danger and found that the interventions were sig-nificantly effective in increasing children’s knowledge. Although the impacts of various board games have been previously examined, their effects have yet to be compre-hensively reviewed. As a result, the functions and effects of board games as a whole remain unclear. Thus, the present review systematically examined the effectiveness of board games and programs that use board games.

The inclusion criteria for the present study were as follows: (a) studied the effects of board games and pro-grams using board games on psychological and educa-tional outcomes, (b) included pre–post comparative tests, (c) used an interventional or experimental rather than a review approach, (d) had full text availability, (e) was written in English, and (f) was peer reviewed. A screening to remove articles that were judged not to sat-isfy any of the criteria from (a) to (f) was conducted, and 29 articles were extracted. Additionally, one study was excluded because it did not use a traditional board game (it used a Wii Fit balance board), and one study was ex-cluded because the content details of the board game were unclear. Ultimately, 27 articles were selected for the present study; the literature search process is pre-

Methods sented in Fig. 1.

For the present review, a literature search based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses [12] using the PsycINFO and PubMed databases was conducted to collect findings on the ef-fectiveness of board games and programs using board

Furthermore, in the studies where the means and standard deviations of the intervention group are de-scribed, Cohen’s d was calculated to assess effect sizes between pre- and post-tests or between pre-tests and follow-up tests with the following formula based on

games. The keywords for the literature search were Cohen [13].

“board game” AND “trial,” and the date selected was September 13th, 2018. The search identified nine studies from PsycINFO and 32 studies from PubMed. The first author of this review performed a manual search that identified six additional studies, and 24 additional stud-ies were extracted from Sala & Gobet [4], which con-ducted a meta-analysis about the benefits of chess. Duplicate studies were deleted and, ultimately, a list of references consisting of 66 articles was prepared.

Fig. 1 PRISMA flow chart of the study selection process

d ¼M2‐M1

SDpooled ¼ v u u t ffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffi�n2 þ n1‐2 !

Note: M1 and M2 are the mean of the intervention

group at the pre-test session and the post-test session or

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follow-up test session, respectively. SDpooled is the pooled standard deviation (SD1 is the standard deviation of the intervention group at the pre-test session and SD2 is the standard deviation at the post-test session or follow-up test session). n1 is the number of samples at the pre-test session. n2 is the number of samples at the post-test session or follow-up test session.

In the studies where the means and standard devia-tions are described in the intervention group and the other groups, Cohen’s d was also calculated to assess ef-fect sizes compared to the other groups (control groups) with the following formula based on Sala et al. [14].

|  |  |  |
| --- | --- | --- |
| d ¼Mgi‐Mgc SDpooled‐pre | | |
| SDpooled‐pre ¼ | v u u t | ffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffiffi 2�ni þ nc‐2 ! |

Note: Mgi and Mgc are the mean gain of the interven-tion group and the control group (other group) at the post-test session or at the follow-up test session, respect-ively, and SDpooled-pre is the pooled standard deviation of the two pre-test standard deviations. SDpre.i is the standard deviation of the intervention group at the pre-test session, and SDpre.c is the standard deviation of the

An overview of the findings about the effects of board games and programs that use board games on cognitive functions is shown in Table 2 [6, 24–33]. This category included board games such as Go, Ska, and chess, and the effect sizes (Cohen’s d) between pre- and post-tests of cognitive function ranged from 0.04 to 2.60 and − 1.14 to − 0.02. The effect size of the exacerbation was calcu-lated in only the chess group of Sala et al. [27]. The ef-fect sizes (Cohen’s d) between the mean gain of the main intervention group and the other groups ranged from 0.06 to 2.36 and − 1.38 to − 0.22.

An overview of the findings about the effects of board games and programs that use board games on other conditions is shown in Table 3 [7, 8, 34–36]. This cat-egory addressed the impacts of board games on physical activity, anxiety, ADHD symptoms, and the severity of Alzheimer’s Disease. The effect sizes (Cohen’s d) be-tween pre- and post-tests or between pre-tests and follow-up tests ranged from 0.06 to 0.65 for physical ac-tivity and from − 0.87 to − 0.61 for ADHD symptoms.

Board games and educational knowledge   
Eleven studies that used board games to increase educa-tional knowledge were selected for this review. The present findings showed that board games influence educational knowledge and concomitant outcomes, with the effect sizes for educational knowledge ranging from

control group at the pre-test session. ni is the number of very small to large.

samples in the intervention group who received the pre-test session and post-test session or the pre-test session and follow-up test session. nc is the number of samples in the control group who received the pre-test session and post-test session or the pre- test session and follow-

Board games can be used as a tool to encourage learn-ing. In previous studies, specialized board games aimed at improving knowledge in the field of education were targeted and subsequently developed and investigated. For example, Wanyama et al. [16] conducted a study of

up test session. the Make a Positive Start Today game, which is a board

According to Cohen [13], Cohen’s d of approximately 0.20 is small, 0.50 medium, and 0.80 large.

Results and discussion   
The effect of interventions with board games   
In the present review, the selected studies were divided into the following three categories regarding the effects of board games and programs that use board games: educational knowledge (11 articles), cognitive functions (11 articles), and other conditions (five articles).

An overview of the findings about the effects of board games and programs that use board games related to educational knowledge is shown in Table 1 [10, 11, 15–23]. Board games in this category were used for the purpose of improving educational knowledge, and the effect sizes (Cohen’s d) between pre- and post-tests or between pre-tests and follow-up tests ranged from 0.12 to 1.81 and between the mean gain of the main intervention group and the other groups ranged from 0.81 to 0.93 and − 1.84 to − 1.65.

game aimed at improving knowledge about human im-munodeficiency virus (HIV) and sexually transmitted in-fections (STIs). Similarly, Kalèdo is an educational board game used to increase nutrition knowledge [10, 19, 21]. It has been shown that these board games contribute to increasing knowledge related to each particular field. Board games are also efficacious for goals other than increasing knowledge. According to Charlier and De Fraine [22], board games can be an enjoyable and motiv-ational method for learning content and enhancing group interactions, competition, and fun. Martins et al. [18] reported that board games teach educational con-tent in a playful and enjoyable way and involve interac-tions with family and friends; thus, they favor knowledge acquisition by enabling exchanges of experiences and learning. Furthermore, Wanyama et al. [16] showed that, as a method of health education, board games increase the acquisition of knowledge as well as result in more positive experiences than do health talks among both participants and facilitators. Amaro et al. [10] found that

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| Effect size of board | game between the | mean gain of the | main experimental  group and the other | groups (Cohen’s d) | Unable to calculate |

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| Table 1 Overview of the studies reporting the effectiveness of board games in educational knowledge | Effect size of board game | between pre test and post | test or follow-up test | (Cohen’s d) | d = 0.71 (between pre and | post test) on Attitudes | Towards Nicotine | Replacement Therapy Scale | (ANRT)-Perceived Advantage. | d = 0.59 (between pre and | follow-up) on ANRT- | Perceived Advantage. | d = 0.14 (between pre and | post test) on ANRT-Drawback. | d = 0.23 (between pre and | follow-up) on ANRT- | Drawback. | d = − 0.46 (between pre and | post test) on ANRT-"Don’t | know” Answers. | d = − 0.60 (between pre and | follow-up) on ANRT-"Don’t | know” Answers. | d = 0.21 (between pre and | post test) on Attitudes | Towards Smoking Scale | (ATS)- Adverse Effects of | Smoking. | d = 0.12 (between pre and | follow-up) on ATS - Adverse | Effects of Smoking. | d = − 0.27 (between pre and | post test) on ATS- | Psychoactive Benefits of | Smoking. | d = − 0.26 (between pre and | follow-up) on ATS- | Psychoactive Benefits of | Smoking. | d = − 0.30 (between pre and | post test) on ATS-Pleasure of | Smoking. | d = − 0.44 (between pre and | follow-up) on ATS-Pleasure of | Smoking. | d = 0.15 (between pre and | post test) on Smoking Self- | Efficacy Questionnaire. | d = 0.51 (between pre and |
| Impact | Scores on attitudes | towards nicotine | replacement | therapy, attitudes | towards smoking, | and smoking self- | efficacy improved | for participants allo | cated to the Pick- | Klop group and the | psychoeducation | group with respect | to the waiting list. | age: 30.0 ± 10.0), 2 weeks: | completers n = 47, 3 months: | completers n = 41. | benefits of quitting smoking, | (7) stages of change, (8) cog | nitive and behavioral mecha | nisms involved in behavioral | change, and (9) medications | and treatments that help dur | ing smoking cessation. | Players draw a card in one of | the following categories: | question, surprise, or tempta | tion. If they answer the ques | tion cards correctly, players | may gain points. Surprise | cards add amusement, allow | ing players to obtain a gift or | secret cards that allow them | to help or block another | player during play at the mo | ment of their choice. The | number of temptation cards | which illustrate lapse and re | lapse processes, as well as re | lapse prevention strategies, | increases at the end of the | game board. |
| The Pick-Klop group: two ses | sions (1.5 h each) of the Pick- | The psychoeducation group: |
| two sessions (1.5 h each) of |
| psychoeducation about |
| smoking and smoking |
| Intervention | Klop game. |
| cessation. |
| n = 43, 3 months: completers | The waiting list: n = 60 (mean , |
| n = 60 (mean age: 28.7 ± | 10.8), 2 weeks: completers |
| n = 38. |
| The Pick-Klop group: n = 120 | weeks: completers n = 97, 3 | The psychoeducation group: |
| Participants were current | daily smokers who were | adults (18–65 years old). | (mean age: 33.7 ± 13.4), 2 k | month: completers n = 94. |
| Participants |
| The Pick-Klop game: it in | cludes more than 300 cards | with questions, each with | three response options. The | questions are about (1) smok | ing and tobacco history, (2) | tobacco components and | their biological effects, (3) | reinforcement mechanisms | involved in smoking addic | tion, (4) cognitive and behav | ioral mechanisms involved in | the maintenance of smoking, | (5) smoking cigarettes as a | coping strategy, (6) costs of | tobacco addiction and the |
| Content of board game |
| Design | RCT | et al. | (2013) [15] |
| Authors | Khazaal |

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| Noda et al. BioPsychoSocial Medicine (2019) 13:22 | | | | | Unable to calculate | Page 5 of 21 |
| Effect size of board  game between the | mean gain of the | main experimental | group and the other  groups (Cohen’s d) | Unable to calculate |

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| Table 1 Overview of the studies reporting the effectiveness of board games in educational knowledge (Continued) | Effect size of board game  between pre test and post | test or follow-up test | (Cohen’s d) | follow-up) on Smoking Self- | Efficacy Questionnaire. | d = − 0.09 (between pre and | post test) on Cigarettes | Smoked Per Day. | d = − 0.67 (between pre and | follow-up) on Cigarettes | Smoked Per Day. | Unable to calculate | group which played | the “make a positive | start today!” board | game has higher | uptake of | knowledge of HIV | and sexually | transmitted | infections than the | standard of care | group. | to enhance prevention | behavior. | Unable to calculate | game significantly | increased players’ | knowledge about | bullying. | The game-with- | debriefing group | showed a larger in | crease in bullying | knowledge than the | game-only group. | The game-with- | debriefing group | also showed a | change in bullying | attitude and | empathy. | third stage is a collaborative | game in which the players | need to work together to | accomplish their training | tasks. |
| Impact | The intervention | The Galaxy Rescuers |
| Intervention | The intervention group | played the “make a positive | start today!” board game. | The standard of care group | participated a standardized | health talk. | intended to increase people | living with HIV’s participation | and attention, to generate | knowledge on HIV, sexually | transmitted infections and | antiretroviral treatment, and | The game-only group played | the Galaxy Rescuers game. | The game-with-debriefing | group played the Galaxy Res | cuers game and conducted | reflection and discussion. | The control group conducted | regular bulling curriculum | using conventional teaching | methods, such as antibullying | videos and worksheet | assignments. | and match game by | matching characters, such as | a bully, a victim, a reinforcer, | or a defender and their roles | in a bullying incident. The |
| The intervention group: n = | The standard of care group: |
| students (11–12 years old). | The game-only group: n = | The game-with-debriefing | The control group: n = 87. |
| Participants were 180 | n = 90 (mean age: 55). | Participants were 328 |
| 90 (mean age: 60). |
| group: n = 125. |
| Participants |
| patients. |
| 116. |
| bullying. At the second stage, |
| stages. At the first stage, the | answering questions about | the players complete a mix |
| players earn points by |
| today!” board game: it is an | educational board game on | The Galaxy Rescuers game: it | is designed for 2 to 6 players. | The storyline of the game is | about 6 characters attending | become the rescuers of the | Galaxy. The game includes 3 |
| The “make a positive start | the uptake of knowledge | transmitted infections. It is |
| Content of board game | about HIV and sexually |
| the training school to |
| Design | RCT | et al. | (2012) [16] | cRCT | (2018) [17] |
| Wanyama | Nieh & Wu |
| Authors |

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| Noda et al. BioPsychoSocial Medicine (2019) 13:22 | | | | | | | | | | | | | | | | | | Knowledge. | knowledge on | breastfeeding in the | posttest for the | 30th day. | Unable to calculate | significantly | increased the | consumption of | healthy food, and | decreased junk food | consumption | compared to the | control group. | The treated group | significantly | increased in | frequency and | duration of physical | activity compared | to the control | group. | The BMI z-score in | the treated group | significantly de | creased compared | to that in the con | Page 6 of 21 | | | |
| Unable to calculate | | | |
| Effect size of board  game between the | | mean gain of the | main experimental | group and the other  groups (Cohen’s d) | d = 0.81 (between the | mean gain of the | intervention group | and the control group | at the 7th day) on | Breastfeeding | Knowledge. | d = 0.93 (between the | mean gain of the | intervention group | and the control group | at the 30th day) on | Breastfeeding |
| Effect size of board game  between pre test and post | | test or follow-up test | (Cohen’s d) | | d = 1.50 (between pre and | post test at the 7th day) on | Breastfeeding Knowledge. | d = 1.81 (between pre and | post test at the 30th day) on | Breastfeeding Knowledge. | | | | | | | | scores for | Unable to calculate | Unable to calculate | | | |
| Table 1 Overview of the studies reporting the effectiveness of board games in educational knowledge (Continued) | Impact | | | | Scores for | knowledge on | breastfeeding were | higher in the | intervention group, | on the 7th and | 30th, than the | control group. | Within the | intervention group, | there was a | significant increase | of the means of | The treated group | trol group. | The board game | group significantly | increases |
| Intervention | | | | The intervention group: | children participated in the | educational intervention with | the board game. | The control group: children | did not participate in the | educational intervention with | the board game. | post-assessment after 30th: | n = 51. | The treatment group: the | children participated in one | session (15–30 min) with the | board game Kaledo, every | week for 20 weeks. | The control group: the | children did not play with | Kaledo. | the first post-assessment at 8 | months: n = 356, the second | post-assessment at 18 | months: n = 202. | The board game group: | | participants played board | game “AntimicroGAME”. |
| children in the third grade of | elementary school. Analyzed | The intervention group: n = | The treatment group: n = 837, | the first post-assessment at 8 | months: n = 651, the second | The control group: n = 476, | Participants were 124 | | students. | The board game group: n = |
| 51, post-assessment after | The control group: n = 56, |
| Participants were 171 | participants were 99. | Participants were 1313 | post-assessment at 18 |
| months: n = 254. |
| Participants | | | | 30th: n = 48. |
| children. |
| Content of board game | | | | The board game educational | intervention “Trilha Família | Amamenta” (Breastfeeding | Family’s Trail). | The board game “Kaledo”: it | is a new educational board | game to improve nutrition | knowledge and to promote a | healthy lifestyle. The game is | designed to be attractive for | people of every age from | kids to adults. A typical game | session requires two to four | players and lasts about 15– | 30 min. | The board game | | “AntimicroGAME” was | designed to integrate |
| Design | | | | cRCT | et al. | (2018) [18] | cRCT | et al. | (2018) [19] | RCT | | | |
| Karbownik | | et al. | (2016) [20] |
| Authors | | | | Martins | Viggiano |

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| Noda et al. BioPsychoSocial Medicine (2019) 13:22 | | | | | | | | | | | | | | | | | | Unable to calculate | assessment after 6 | months, the treat | ment group ob | tained significantly | higher scores than | the control group | on the adolescent | food habits checklist | (the examination of | healthy eating be | haviors in adoles | cents), nutrition | knowledge, healthy | and unhealthy diet | and food, physical | activity and lifestyle, | food habits. | The treated group | had significantly | lower BMI z-score | with respect to the | controls at the first | post-assessment | after 6 months, and | second post- | assessment after 18 | Page 7 of 21 | | | |
| Effect size of board  game between the | | mean gain of the | main experimental | group and the other  groups (Cohen’s d) | | | | | | | | | | | | | | d = − 1.84 (between | | the mean gain of the | intervention group |
| Effect size of board game  between pre test and post | | test or follow-up test | (Cohen’s d) | | | | | | | | | | | | | | | Unable to calculate | d = 1.40 (between pre and | | post test) on Knowledge of | First Aid. |
| Table 1 Overview of the studies reporting the effectiveness of board games in educational knowledge (Continued) | Impact | | | | knowledge | retention at post- | test in final | examination. | Knowledge | retention of board | game group was | higher than lecture- | based seminar | group. | by an independent senior | specialist in medical | pharmacology. | At the first post- | months. | The board game | group and the | lecture group |
| Intervention | | | | The control group: | participants received lecture- | based seminar. | age: 23.6 ± 1.7). | “AntimicroGAME” was based | around the existing basic | medical pharmacology | syllabus for the | undergraduate course in | medicine and further revised | The treatment group: the | treatment group received | Kaledo each week over 20 | consecutive weeks. | The control group: the | control group did not receive | any intervention. | The control group: n = 1447 | (mean age: 13.0), the follow- | up after 6 months: n = 1080, | the follow-up after 18 | months: n = 421. | The board game group: | | participants played the board | game. |
| based seminar): n = 61 (mean | Participants were 3110 (9–19 | follow-up after 6 months: n = |
| The control group (lecture- | 1663 (mean age: 13.3), the | 1076, the follow-up after 18 |
| 63 (mean age: 23.2 ± 1.1). | The treatment group: n = |
| Participants were 120 | | children in general | secondary. |
| months: n = 624. |
| Participants | | | |
| years old). |
| The educational board game | | in first aid: the game board is | a landscape of a developing |
| Content of board game | | | | mechanisms of action of | antimicrobial drugs. The | The board game “Kaledo” |
| factual content of the |
| bacteriology and |
| Design | | | | cRCT | et al. | (2015) [21] | cRCT | | | |
| Charlier & | | Fraine | (2013) [22] |
| Authors | | | | Viggiano |

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| Noda et al. BioPsychoSocial Medicine (2019) 13:22 | | | | | | | | | | | | | | | | | | group showed a | significant increase | in nutrition | knowledge and in | weekly vegetable | intake with respect | to the control | group. | age: 12.5 ± 0.7). | Unable to calculate | were signieficantly | effctive in increasing | children’s | knowledge about | safe and dangerous | locations at which | to cross the street, | and that the | knowledge was | retained for a | period of 6 months. | At post-test, score | of the knowledge | for the control | group was siginifi | cantly lower than | scores for the inter | Page 8 of 21 | | | | |
| Unable to calculate | | | | |
| Effect size of board  game between the | | mean gain of the | main experimental | group and the other  groups (Cohen’s d) | and the lecture | group) on Knowledge | of First Aid. | d = − 1.65 (between | the mean gain of the | intervention group | and the lecture | group) on Knowledge | of First Aid. | | | Unable to calculate | |
| Effect size of board game  between pre test and post | | test or follow-up test | (Cohen’s d) | | d = 0.78 (between pre and | retention test) on Knowledge | of First Aid. | Unable to calculate | | | | | | | | | | Unable to calculate | Unable to calculate | | | | |
| Table 1 Overview of the studies reporting the effectiveness of board games in educational knowledge (Continued) | Impact | | | | showed significantly | increase in first aid | knowledge. | The lecture group | was significantly | more effective in | increasing | knowledge for first | aid, as compared to | the board game | group. | | The treatment | Each interventions | vention groups. | The board game | | | group significantly |
| Intervention | | | | The lecture group: | participants received a | lecture about first aid with | video, pictures, and | demonstrations. | question cards (representing | building material). | Treatment group: the | treatment group participated | Kalèdo every week in one | play session (15–30 min), | during 24 weeks. | Control group: control group | did not receive any | intervention. | assessment: n = 88 (mean | The playmat model group, | the board game group, and | the talk using illustrated | posters and flip-chart mate | rials group: each intervention | was administered for only a | single session, lasting ap | proximately 20 min. | The control group: control | group did not receive any | intervention. | office, returning a book to | the library), each of which | involves crossing the road. | The players must decide the | safest way of accomplishing | the road crossing. The first | player to get their playing | The board game group: the | | | | board game group |
| The treatment group: n = 188, | Participants were 23 students. | | | | The board game group: n = |
| The board game group: n = | The lecture group: n = 58. | Participants were 291(11–14 | assessment: n = 153 (mean | The control group: n = 103, | Participants were 120 (4–5 | The playmat model group: | posters and flip-chart mate | The control group: n = 35. |
| The board game group: | The talk using illustrated |
| the complete post | the complete post | rials group: n = 29. |
| age: 12.3 ± 0.8). |
| Participants | | | |
| years old). | years old). |
| n = 27. | n = 29. |
| 62. |
| the most first aid posts and | posting a letter at the post |
| hospitals by collecting |
| country built by the players | goal of the game is to build | The road safety board game: | characters who have to get | home from school safely, by | rolling dice and moving the | getting home, characters are | piece ‘home’, having | completed all the tasks safely, | is declared the winner. | The lifestyles board game: it | is a board game (50 by 60 |
| as the game progress. The | The board game “Kaledo” | playing piece around the |
| Content of board game | | | | players take the part of | board. In the process of | required to carry out a | number of errands (e.g., |
| Design | | | | cRCT | et al. | (2006) [10] | RCT (the | control | group only is | convenience | sampling) | A quasi- | | | | randomized |
| (2001) [11] |
| Authors | | | | Amaro | Zeedyk | Bartfay & | | | | Bartfay |
| et al. |

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| Noda et al. BioPsychoSocial Medicine (2019) 13:22 | | | | Page 9 of 21 |
| Effect size of board  game between the | mean gain of the | main experimental | group and the other  groups (Cohen’s d) |

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| Table 1 Overview of the studies reporting the effectiveness of board games in educational knowledge (Continued) | Effect size of board game  between pre test and post | test or follow-up test | (Cohen’s d) | increased | knowledge of | anatomy and | physiology, diet and | nutrition, and | lifestyle risk factors. | The gain knowledge | on post-test were | found to be signifi | cant between the | board game group | and the control | group. | questions on the 40 game | cards. |
| Impact |
| Intervention | participated twice, 2 weeks | apart, for a period of 60 min. | The control group: the | control group carried on with | their regularly scheduled | classroom activities. | approximately 60 min to | complete. Players attempt to | collect tokens awarded by | the nurse to cancel the 10 | lifestyle risk factors depicted | on their score cards, by | providing correct answers to |
| The control group: n = 11. |
| Participants |
| 12. |
| games can be played by two | to six individuals and requires |
| factor score cards, and 40 | game question cards. The |
| plastic tokens, six lifestyle risk |
| Content of board game | cm) that consists of dice, |
| Design | experimental | study |
| Authors | (1994) [23] |

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| Noda et al. BioPsychoSocial Medicine (2019) 13:22 | | | | | | | | | | | | | | | | | Digit Span Forward Task. | d = 0.57 (between the | mean gain of the  intervention group and | the control group) on | Digit Span Backward Task. | d = 2.36 (between the  mean gain of the | intervention group and | the control group) on | Verbal Pair Association I.  d = 2.32 (between the | mean gain of the | intervention group and | the control group) on  Verbal Pair Association II. | d = 2.24 (between the | mean gain of the | intervention group and  the control group) on | Visual Reproduction I. | d = 2.00 (between the | mean gain of the  intervention group and | the control group) on | Page 10 of 21 | | | | |
| Visual Reproduction II. | d = − 1.20 (between the  mean gain of the | intervention group and | the control group) on | Trail Making Test part A. |
| Effect size of board game | | between the mean gain | of the main experimental | group and the other | groups (Cohen’s d) | d = 0.41 (between the | mean gain of the  intervention group and | the control group) on | Montreal Cognitive | Assessment.  d = 0.85 (between the | mean gain of the | intervention group and | the control group) on  total of Digit Span Test. | d = 0.55 (between the | mean gain of the | intervention group and  the control group) on |
| Effect size of board game | | between pre test and | post test or follow-up test | (Cohen’s d) | | d = 0.13 (between pre | and post test) on  Montreal Cognitive | Assessment. | d = 0.46 (between pre | and post test) on total of  Digit Span Test. | d = 0.49 (between pre | and post test) on Digit | Span Forward Task.  d = 0.16 (between pre | and post test) on Digit | Span Backward Task. | | d = 2.07 (between pre  and post test) on Verbal | Pair Association I. | d = 2.60 (between pre | and post test) on Verbal  Pair Association II. | d = 1.54 (between pre | and post test) on Visual | Reproduction I.  d = 1.82 (between pre | and post test) on Visual | Reproduction II. | d = − 1.02 (between pre  and post test) on Trail | Making Test part A. | d = − 1.14 (between pre | and post test) on  Wisconsin Card Sorting | Test. | d = 0.09 (between pre | and post test) on  Acetylcholinesterase | Activity. | | |
| Impact | | | | | | The intervention group | showed improved  attention and working | memory scores, while the | control group showed | declines in these scores. | | | | | | | The Ska group showed  significant better scores | of cognitive functions in | memory, attention, | executive function  compared to the control | group. | The Ska group: the | participants received Ska  program. | The control group: the | activities of the control | group included 1) Self- introduction, 2) Back | ground telling, 3) | Changes in older age, 4) | Our body, 5) Food pyra  mid, 6) Watching televi | sion, 7) Listening to the | radio, 8) Watering trees, | 9) Parties, 10) Cleaning,  11) Listening to dhamma | talks, 12) Diseases in the | elderly, and 13) Your own | health. |
| Table 2 Overview of the studies reporting the effectiveness of board games in cognitive functions | Intervention | game | | | | The intervention group: | participants received the  intevention program | once a week for 1 h, for a | total of 15 classes. Each 1- | h session consisted of a  lecture on the basic rules | and techniques of the | game GO (15 min), solv | ing GO game exercises  (15 min), and playing | games (30 min). | The control group: | participants received the  usual care. | In the Ska group and the  control group, the | was 50 min per day, three | sessions per week for the  continuous duration of |
| duration of the practice |
| 16 weeks. |
| Participants | There are 33 | participants at  randomization. | Analyzed | participants were | 17.  The intervention | group: n = 9 (mean | age: 89.1 ± 4.1). | The control group:  n = 8 (mean age: | 89.1 ± 6.6). | Participants were 40.  The Ska group: n = 20 | (mean age: 64.20 ± | 3.22). | The control group:  n = 20 (mean age: | 65.15 ± 3.19). | holes are called | ‘Jooms’. Each side of  the board contains 1 | to 12 Jooms. |
| The board game “Go”: | it is a famous board  game in Asian | countries, particularly | Korea, and it is  gaining popularity in | the United States and | The board game “Ska”: it is a traditional | Thailand. The players | move the pieces in  the holes provided on |
| Content of board | Japan, China, and | the board. These |
| board game in |
| Europe. |
| Design | RCT | (2018) [6] | RCT | [24] |
| Panphunpho  et al. (2013) |
| Iizuka et al. |
| Authors |

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| Noda et al. BioPsychoSocial Medicine (2019) 13:22 | | | | | | | | | | | | | | | | | | significantly made more | perseverative errors on | Wisconsin Sorting Card | Test than the treatment | as usual group in the pre- | test assessment. | But, this difference was | no longer present in the | second assessment. | On the Stroop Test, the | number of read items of | chess group was | significantly increased in | the second assessment | for the Stroop A (Colour) | and C (Interference). | d = 0.33 (between the | mean gain of the | intervention group and | the control group) on | mathematical problem- | solving scores. | courses lasted between | 10 and 15 h (1 or 2 h per | week). | The control group: the | control group performed | Page 11 of 21 | | | | |
| Experiment 1 | | | | d = −0.23 (between the |
| Effect size of board game  between the mean gain | | of the main experimental | group and the other | groups (Cohen’s d) | d = − 1.38 (between the | mean gain of the | intervention group and | the control group) on | Wisconsin Card Sorting | Test. | d = 0.06 (between the | mean gain of the | intervention group and | the control group) on | Acetylcholinesterase | Activity. | Unable to calculate |
| Effect size of board game  between pre test and | | post test or follow-up test | (Cohen’s d) | | Unable to calculate | | | | | | | | | | | | | d = 0.34 (between pre | and post test) on | mathematical problem- | solving scores. | with the control group. | training). The chess | Experiment 1 | | | | d = 0.04 (between pre |
| solving scores compared |
| The intervention group | significantly improved | mathematical problem- | Experiment 1 | | | | The results showed no |
| Table 2 Overview of the studies reporting the effectiveness of board games in cognitive functions (Continued) | Impact | | | | The chess group | | | | | | | | | | | | |
| chess 10 times (twice per | week; 60 min per session). |
| The chess group: the | | | | | | | | | | | | | chess group practiced | The intervention group: | the intervention group | received a mandatory | only the normal school | activities without any | chess-related activity. | Experiment 1 | The chess group: the |
| chess course (chess |
| course and online |
| Intervention | | | |
| Participants | | | | Participants were 26 | | | | | | | | | | | | | with schizophrenia. | The chess group: n = | 13 (mean age: 34.7 | years old). | The treatment as | usual group: n = 13 | (mean age: 38.9 years | old). | Participants were 560 | students in the third, | fourth, and fifth | grades. | The intervention | group: n = 309 (169 | males and 140 | females). | The control group: | n = 251 (116 males | and 135 females). | Experiment 1 | | | | Participants were 233 |
| Content of board  game | | | | The chess game | | | | | | | | | | | | | (2009) [25] | The chess game | experimental | longitudinal | study: two | group pre-post | comparative | test | The chess game, the | | | | checkers game and |
| A quasi- | | | | experimental |
| Design | | | | A quasi- |
| RCT | | | | | | | | | | | | |
| Demily et al. | | | | | | | | | | | | | Sala & Gobet. | | | | (2017) [27] |
| (2015) [26] |
| Authors | | | | Sala et al. |

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| Noda et al. BioPsychoSocial Medicine (2019) 13:22 | | | | | | | | | | | | | | | | | | | ability scores. | d = − 0.22 (between the | mean gain of the chess | group and the regular | school activities group) | on matacognitive ability | scores. | Experiment 2 | Unable to calculate | d = 0.09 (between pre | and post test) on | matacognitive ability | scores in the regular | school activites. | Experiment 2 | Unable to calculate | d = 0.26 (between the | mean gain of the | extracurricular activity of | chess group and the | extracurricular activities of | soccer or basketball | group) on similarities in | Wechsler Intelligence | Scale for children (WISC- | R). | Page 12 of 21 | | | | | |
| d = 0.43 (between the | mean gain of the | extracurricular activity of | chess group and the | extracurricular activities of | soccer or basketball |
| Effect size of board game  between the mean gain | | of the main experimental | group and the other | groups (Cohen’s d) | mean gain of the chess | group and the checkers | group) on mathematical | problem-solving scores. | d = − 0.32 (between the | mean gain of the chess | group and the regular | school activities group) | on mathematical | problem-solving scores. | d = − 0.22 (between the | mean gain of the chess | group and the checkers | group) on matacognitive |
| Effect size of board game  between pre test and | | post test or follow-up test | (Cohen’s d) | | and post test) on | mathematical problem- | solving scores in the | chess group. | d = 0.30 (between pre | and post test) on | mathematical problem- | solving scores in the | checker group. | d = 0.36 (between pre | and post test) on | mathematical problem- | solving scores in the | regular school activites. | d = − 0.14 (between pre | and post test) on | matacognitive ability | scores in the chess group. | d = 0.07 (between pre | and post test) on | matacognitive ability | scores in the checker | group. | d = 0.38 (between pre | and post test) on | similarities in Wechsler | Intelligence Scale for | children (WISC-R). | d = 0.55 (between pre | and post test) on digit | span in WISC-R. | d = 0.41 (between pre | and post test) on object | assembly in WISC-R. | d = 0.38 (between pre | and post test) on mazes | in WISC-R. | d = 0.82 (between pre | and post test) on |
| Table 2 Overview of the studies reporting the effectiveness of board games in cognitive functions (Continued) | Impact | | | | siginificant differences | between the three | groups in mathmatical | ability or metacognitive | ability. | Experiment 2 | The chess group | marginally outperformed | the Go group in | mathematical ability. | No significant difference | was found between the | control and the chess | group in mathematical | No significant differences | were found between the | three groups with regard | The extracurricular activity | object assembly mazes) | and coping (identifies the | alternatives, assesses the | performance) compared | to the extracurricular | activities of soccer or | basketball group. | | |
| significantly improved | (similarities, digit span | alternatives, confident |
| to metacognition. | cognitive abilities | problem, thinks of |
| of chess group |
| ability. |
| Intervention | | | | participants attended 25 | h of chess lessons. | The checkers group: the | participants attended 25 | h of checkers lessons. | The regular school | activities group: the | participants attended | regular school activities | only. | Experiment 2 | The chess group: the | participants attended 15 | h of chess lessons during | school hours, along with | regular school activities. | The Go group: the | participants attended 15 | h of Go lessons during | school hours, along with | regular school activities. | The regular school | activities group: the | participants attended | regular school activities | only. | The extracurricular activity | of chess group: the | participants were | conducted chess as | extracurricular. | The extracurricular | activities of soccer or | basketball group: the | participants were | conducted soccer or | basketball as | extracurricular. | | | | |
| Participants | | | | students in three | classes of third and | fourth grades from | eight Italian schools | (mean age 8.50: ± | 0.67 years). | The chess group: n = | 53 | The checker group: | n = 82 | The regular school | activites group: n = 98 | Experiment 2 | Participants were 52 | students in three | classes of fourth | grades primary school | (mean age: 9.32 ± | 0.32 years). | The three classes | were randomly | assigned to three | groups (a chess | group, a Go group, a | control group). | Participants were 230 | students. | The extracurricular | activity of chess | group: n = 170 | The extracurricular | activities of soccer or | basketball group: n = | 60 |
| Content of board  game | | | | the Go game | three group pre-post | comparative test | The chess game | longitudinal study: | two group pre-post | comparative test |
| A quasi-experimental |
| longitudinal study: |
| Design | | | |
| Authors | | | | Aciego et al. | (2012) [28] |

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| Noda et al. BioPsychoSocial Medicine (2019) 13:22 | | | | | | | | | | | | | | | | | | | extracurricular activities of | soccer or basketball | group) on mazes in WISC- | R. | d = 0.52 (between the | mean gain of the | extracurricular activity of | chess group and the | extracurricular activities of | soccer or basketball | group) on identifies the | problem in coping. | d = 0.48 (between the | mean gain of the | extracurricular activity of | chess group and the | extracurricular activities of | soccer or basketball | group) on thinks of | alternatives in coping. | d = 0.60 (between the | mean gain of the | extracurricular activity of | chess group and the | extracurricular activities of | soccer or basketball | group) on assesses the | Page 13 of 21 | | | | |
| alternatives in coping. | d = 0.33 (between the | mean gain of the | extracurricular activity of | chess group and the |
| Effect size of board game  between the mean gain | | of the main experimental | group and the other | groups (Cohen’s d) | group) on digit span in | WISC-R. | d = 0.30 (between the | mean gain of the | extracurricular activity of | chess group and the | extracurricular activities of | soccer or basketball | group) on object | assembly in WISC-R. | d = 0.25 (between the | mean gain of the | extracurricular activity of | chess group and the |
| Effect size of board game  between pre test and | | post test or follow-up test | (Cohen’s d) | | identifies the problem in | coping. | d = 0.71 (between pre | and post test) on thinks | of alternatives in coping. | d = 0.77 (between pre | and post test) on assesses | the alternatives in coping. | d = 0.65 (between pre | and post test) on | confident performance in | coping. | | |
| Table 2 Overview of the studies reporting the effectiveness of board games in cognitive functions (Continued) | Impact Intervention Participants Content of board Design Authors  game | | | | | | | | | | | | | | | | | |

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| Noda et al. BioPsychoSocial Medicine (2019) 13:22 | | | | | | | | | | | | | | | | | | | mean gain of the chess | group and the | compairson group) on | end of year course | grades. | d = 0.76 (between the | mean gain of the chess | group and the | compairson group) on | number, operations and | quantitative reasoning. | d = 0.48 (between the | mean gain of the chess | group and the | compairson group) on | probability and statistics. | Unable to calculate | significantly increased | school performance with | respect to the control | group. | participants received in a | fun math program. | n = 18 (mean age: | 9.71 ± 0.77, 10 males | and 8 females) | Page 14 of 21 | | | | |
| d = − 0.39 (between the | mean gain of the chess | group and the control | group) on Test of | Nonverbal Intelligence- |
| Effect size of board game  between the mean gain | | of the main experimental | group and the other | groups (Cohen’s d) | extracurricular activities of | soccer or basketball | group) on confident | performance in coping. | d = 1.73 (between the | mean gain of the chess | group and the control | group) on math scores. | | | | d = 0.84 (between the | | |
| Effect size of board game  between pre test and | | post test or follow-up test | (Cohen’s d) | | d = 1.72 (between pre | | | | | and post test) on math | scores. | d = 0.21 (between pre | | | | | | |
| and post test) on end of | d = − 0.02 (between pre | number, operations and | probability and statistics. | d = 0.29 (between pre | and post test) on Test of | Nonverbal Intelligence- | Third Edition. | |
| quantitative reasoning. | d = 0.13 (between pre |
| year course grades. | Unable to calculate |
| and post test) on | and post test) on |
| statistics” compared with |
| Table 2 Overview of the studies reporting the effectiveness of board games in cognitive functions (Continued) | Impact | | | | The chess group | | | | | significantly improved | math scores. | period (1 day a week, 4 h) | The control group: the | participants were not | trained for chess. | | females) | The chess group | significantly improved | quantitative reasoning” | the comparison group. | The chess group | performance on the | nonverbal abilities was | not different from the | control group |
| “end of year course | and “probability and |
| grades”, “number, | The chess group |
| operations and |
| Intervention | | | | The chess group: the | | | | | participants were trained | for chess over a 12 week- | The chess group: the | students received chess | instruction (1 day a week | for 30 weeks) instead of | the standard math | curriculum. | The comparison group: | the students received | instruction in the | standard math curriculum | that was individualized to | meet the goals and | objectives of each | student’s individualized | education program. | The chess group: the | participants received one | training session of chess | per week for 10 weeks. | The control group: the | The chess group: the | participants received a 90 | minute chess lesson once | per week over a three- | month period. |
| Participants | | | | Participants were 26 | | | | | students. | The chess group: n = | 14 (9 males and 5 | females) | The control group: | n = 12 (8 males and 4 | | Participants were 31 | students. | The treatment group: | n = 15 (5 males and | 10 females) | The comparison | group: n = 16 (6 males | and 10 females) | Participants were 38 | students. | The chess group: n = | 20 (mean age: 9.85 ± | 0.67, 10 males and 10 | females) | The control group: | Participants were 38 | students. | The chess group: n = | 18 (mean age: 9.71, | 12 males and 6 |
| Content of board  game | | | | The chess game | | | | | longitudinal study: | two group pre-post | comparative test | The chess game | longitudinal study: | two group pre-post | comparative test | The chess game | (2014) [31] | The chess game | | | | |
| A quasi-experimental | | | | | A quasi-experimental |
| Design | | | |
| RCT | RCT | | | | |
| Gliga & Flesner |
| Aydin (2015) | | | | | Barrett & Fish | Hong & Bart | (2007) [32] | | | |
| (2011) [30] |
| Authors | | | | [29] |

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| Noda et al. BioPsychoSocial Medicine (2019) 13:22 | | | | | | | | | | | | | | | | | | The control group: the | participants received the | planned five regular | lessons of mathematics | per week. | Page 15 of 21 |
| Effect size of board game  between the mean gain | | of the main experimental | group and the other | groups (Cohen’s d) | Third Edition. | Unable to calculate | | | | | | | | | | | |
| Effect size of board game  between pre test and | | post test or follow-up test | (Cohen’s d) | | Unable to calculate | | | | | | | | | | | | |
| Table 2 Overview of the studies reporting the effectiveness of board games in cognitive functions (Continued) | Impact | | | | performance. | participants regularly | attended school activities | after class. | females) | Calculation abilities for | simple addition tasks and | counting improved | significantly more in the | chess group than in the | control group. | duration of one school- | year. |
| Intervention | | | | The control group: the | The chess group: the | participants received 1 | hour of chess lesson | instead of 1 hour of | regular mathmatics | lessons per week for the |
| Participants | | | | females) | The control group: | n = 20 (mean age: | 9.74, 15 males and 5 | Participants were 53 | students. | The chess group: n = | 31 | The control group: | n = 22 |
| Content of board  game | | | | The chess game | longitudinal study: | two group pre-post | comparative test |
| A quasi-experimental |
| Design | | | |
| Authors | | | | Scholz et al., | (2008) [33] |

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| Noda et al. BioPsychoSocial Medicine (2019) 13:22 | | | | | | | | | | | | | | | | | nor to get involved in | any new type of physical  activity. | endurance. The rules | were simple and made | available to the  participants in a folder | adjacent to the mat. | Taking turns, participants | turned the wheel and  had reach the next | square with the color | targeted by the arrow. | After completing the  requested exercises, | participants were | expected to do | systematically two laps  on the walking lane. | Participants made their | way through the squares | until the finish line after  the 24th square. The | playing time of a session | ranged between 30 and | 60 min and the game  requires a minimum of 2 | Page 16 of 21 | | | |
| Unable to calculate | | | |
| Effect size of board game | | between the mean gain | of the main experimental | group and the other | groups (Cohen’s d) | Unable to calculate | | | | | | | | | | |
| Effect size of board game | | between pre test and | post test or follow-up test | (Cohen’s d) | | d = 0.06 (between pre | and post test) on Steps | Per Day (number). | d = 0.50 (between pre  and follow-up) on Steps | Per Day (number). | d = 0.36 (between pre | and post test) on Tinetti  Test. | d = 0.65 (between pre | and follow-up) on Tinetti | Test. | | Unable to calculate | | | |
| Impact | | | | | | The intervention group | significantly increases | steps per day (number), | energy expenditure per  day and quality of life | and improves body | balance and gait | abnormalities, the  strength of ankle | extensors and flexors. | | | | Children in the | | experimental group  showed significant lower | preoperative worries than |
| Table 3 Overview of the studies reporting the effectiveness of board games in the other conditions | Intervention | | | | | The intervention group: 4 | supervised exercising | sessions were planned on | the board game during  the first week and then 3, | 2, and 1 sessions were | planned during the | second, third, and fourth  week of the intervention. | The control group: | participants in the control | group were requested  neither to change their | lifestyle during the study | The experimental group: | | participants received  educational materials | about surgery and |
| Participants | | | | | Participants were 21. | board game: it required | The intervention group: | n = 10 (mean age: 82.5 ± 6.3), the post-intervention: | n = 9, the follow-up after | 3 months: n = 8. | The control group: n = 11  (mean age: 89.9 ± 3.1), the | post-intervention: n = 10, | the follow-up after 3 | months: n = 9. | fitness that was to be | performed (ie, 6 squares/ | component): strength,  flexibility, balance, and | Participants were 125 | | children (mean age:  10.09 ± 1.43). | The experimental group: , |
| Content of board game | | | | | participants to perform | strength, flexibility,  balance and endurance | activities. The tarpaulin | surface was printed with | 24 numbered squares of  50 × 50 cm and | surrounded by a walking | lane. Each square was | colored according to the  component of physical | participants. | The educational board- | game: in this study, the  educational materials are | composed of seven parts, |
| The giant exercising |
| Design | | | | | A quasi- | experimental lon | gitudinal study: | two group pre- post comparative | test | RCT | | | |
| Authors | | | | | Mouton | et al. | (2017) [34] | Fernandes | | et al.  (2014) [35] | |

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| Noda et al. BioPsychoSocial Medicine (2019) 13:22 | | | | | | | | | | | | | | | | | | | (mean age: 10.14 ± 1.57). | professionals, medical in | struments, clinical proce | dures and induction of | anesthesia), as well as ex | planations of specific hos | pital and medical rules | (e.g. reasons why they | should not eat or drink | before surgery, the chan | ging of clothes and par | ental separation during | surgery). These educa | tional information was | provided though a board | game. | Unable to calculate | and post test) on | Swanson, Nolan and | Pelham Scale for parents | (SNAP-IV)-total. | d = − 0.87 (between pre | and post test) on SNAP- | IV-Inattention. | d = − 0.61 (between pre | and post test) on SNAP- | Page 17 of 21 | | | | | |
| Effect size of board game  between the mean gain | | of the main experimental | group and the other | groups (Cohen’s d) | | | | | | | | | | | | | | |
| Effect size of board game  between pre test and | | post test or follow-up test | (Cohen’s d) | | | | | | | | | | | | | | | | d = − 0.85 (between pre | IV-Hyperactivity- | Impulsivity. | d = − 0.86 (between pre | and post test) on | Abbreviated Conner’s | Rating Scales for parents. |
| Table 3 Overview of the studies reporting the effectiveness of board games in the other conditions (Continued) | Impact | | | | children in both the | comparison group and | the control group. | Children received the | educational board-game | showed lower preopera | tive worries than children | received the entertain | ment booklet, video, or | board-game group. | or hospitalization. | The control group did | not receive any material. | The control group: n = 35 | significantly decreased in | hyperactivity-impulsivity). |
| Children with ADHD | the severity of ADHD | (both inattention and |
| Intervention | | | | hospitalization in the | format of a board game, | a video or a booklet. | The comparison group: | participants received | materials in the format of | a board game, a video or | a booklet but the | materials contained no | information about surgery | All children had weekly 1 | h sessions over a period | of 11 consecutive weeks | taught by a chess expert. | Participants took chess | training lessons in groups | of up to 10 individuals. |
| Participants | | | | n = 45 (mean age: | 10.29 ± 1.25), the | educational booklet (n = | 15), the educational video | (n = 15), the educational | board-game (n = 15). | The comparison group: | n = 45 (mean age: 9.84 ± | 1.48), the entertainment | booklet (n = 15), the | entertainment video (n = | 15), the entertainment | board-game (n = 15). | Participants were 44 | children with Attention | deficit hyperactivity | disorder (ADHD) (6–17 | years old). |
| Content of board game | | | | illustrating the hospital | stages: (i) Hospital admis | sion; (ii) Healthcare pro | fessionals and hospital | rules; (iii) Medical instru | ments; (iv) Medical proce | dures; (v) Anesthesia and | Surgery room; (vi) Recov | ery room; and (vii) After | care and Going home. | Each part is composed of | clear explanations about | specific topics and inter | vention stages (e.g. infor | mation about healthcare | The chess game | experimental lon | gitudinal study: | one pre-post | comparative test |
| Design | | | | A quasi- |
| Authors | | | | Blasco- | Fontecilla | et al. | (2016) [36] |

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| Noda et al. BioPsychoSocial Medicine (2019) 13:22 | | | | | | | | | | | | | | | | | | | intervention group and | the control group at the | post test) on Digit Span | Backward Task. | d = 0.32 (between the | mean gain of the | intervention group and | the control group at the | post test) on Children’s | Trails Test (CCTT)-1. | d = − 0.29 (between the | mean gain of the | intervention group and | the control group at the | post test) on CCTT-2. | Unable to calculate about | the severity of ADHD | Unable to calculate | depression and anxiety | and ameliorated | Alzheimer Disease | manifestations by up- | regulating brain derived | neurotrophic factor levels. | control group play | doesn’t play Go. | Page 18 of 21 |
| Effect size of board game  between the mean gain | | of the main experimental | group and the other | groups (Cohen’s d) | d = 1.18 (between the | mean gain of the | intervention group and | the control group at the | post test) on total of Digit | Span Test. | d = 0.88 (between the | mean gain of the | intervention group and | the control group at the | post test) on Digit Span | Forward Task. | d = 1.28 (between the | mean gain of the |
| Effect size of board game  between pre test and | | post test or follow-up test | (Cohen’s d) | | d = 0.57 (between pre | and post test) on total of | Digit Span Test. | d = 0.80 (between pre | and post test) on Digit | Span Forward Task. | d = 1.33 (between pre | and post test) on Digit | Span Backward Task. | d = 1.28 (between pre | and post test) on | Children’s Trails Test | (CCTT)-1. | d = − 0.23 (between pre | and post test) on CCTT-2. | Unable to calculate about | the severity of ADHD | Unable to calculate |
| Table 3 Overview of the studies reporting the effectiveness of board games in the other conditions (Continued) | Impact | | | | There were significant | improvement of severity | of ADHD symptoms in | children with ADHD. | Children with ADHD | ameliorated cognitive | flexibility and cognitive | persistence. | The change of theta/beta | right of prefrontal cortex | during 16 weeks was | greater in children with | ADHD than children of | the control group. |
| Playing Go improved |
| Intervention | | | | During the 16 weeks, | both ADHD children | without medication and | children of control group | were asked to learn and | play Go for 2 hours/day | with an instructor of the | game of Go. Participants | played Go under the | instructor’s education for | 2 h a day during | weekday, Monday to | Friday. Go training with | the same protocol had | been provided. | The short-time group: the | short-time group play Go | 1 h daily for 6 months. | The long-time group: the | long-time group play Go | 2 h daily for 6 months. | The control group: the |
| Participants | | | | Participants were 34 | children. | The ADHD group: 17 | drug-naïve children with | ADHD (mean age: 10.1 ± | 1.5). | The control group: 17 | age- and sex-matched | comparison subjects | with-out ADHD (mean | age: 10.2 ± 1.6). | Participants were 147 | patients. | The short-time group: | n = 49. | The long-time group: n = | 49. | The control group: n = 49. |
| Content of board game | | | | The Go game | experimental lon | gitudinal study: | two group pre- | post comparative | test | The Go game | (2015) [8] |
| Design | | | | A quasi- |
| RCT |
| Kim et al. | (2014) [7] |
| Authors | | | | Lin et al. |

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class teachers noted improvements in student interest and appreciation of the board game. Taken together, these findings suggest that board games may improve the motivation of participants. Furthermore, Karbownik et al. [20] showed that a board game was warmly wel-comed by students; in their opinion, it facilitated clinical thinking and peer communication. Therefore, board games may also have a positive influence on interper-sonal interactions among participants.

Based on the above findings, board games can be used as a tool to encourage learning as well as to enhance motivation and interpersonal interactions. In clinical treatment, it is important to increase motivation because low motivation to cooperate with a particular interven-tion may lead to a patient dropping out of treatment or to interference with the therapeutic effects. Based on the above findings, the use of board games may help in-crease the benefit of treatment for less motivated

Board games and other conditions   
The “other studies” category in the present review included five studies that examined the effects of board games on physical activity, physical and psychological outcomes, ADHD symptoms, and the severity of Alzheimer’s Disease. Mouton et al. [34] showed that a giant board game inter-vention for nursing home residents led to significant in-creases in ambulatory physical activity, daily energy output, quality of life, balance and gait, and ankle strength. The ef-fect sizes in the present review of studies related to physical activity ranged from very small to medium. Fernandes et al. [35] reported that board games used as educational pre-operative materials decreased the preoperative anxiety of children. Additionally, the use of board games contributed to improvements in the ADHD symptoms of children [7, 35]. The effect sizes for ADHD symptoms in the present re-view ranged from medium to large. Lin et al. [8] showed that playing Go improved the symptoms of depression and

patients. anxiety and ameliorated the manifestations of Alzheimer’s

Disease. Although a study by Barzegar and Barzegar [37]

Board games and cognitive functions   
In the present review, 11 of the assessed studies investi-gated the effects of board games and programs that use board games on cognitive functions. These studies used Go, chess, and Ska, which are not educational games but abstract strategy games. Studies investigating the use of Go found that older adults experiencing cognitive de-cline and/or living in nursing homes showed improve-ments in attention and working memory after regularly playing the game [6]. Studies assessing the use of Ska found that the game appeared to enhance the cognitive functioning of older adults in terms of memory, atten-tion, and executive function [24]. Studies evaluating chess showed that training with the game improved the planning ability of patients with schizophrenia and the mathematical ability of children [25, 26]. But, Sala & Gobet [27] indicated that interventions that use chess are not significantly different from interventions that use checkers and regular school activities that address the mathematical and metacognitive ability of children.

The effect sizes for cognitive functions ranged from very small to large, but the effect size of exacerbation on metacognitive ability was shown in the chess training of Sala & Gobet [27]. The number of studies included in this category was relatively limited. Further investiga-tions will be necessary to clarify the more detailed effects of board games on cognitive function. Articles about Shogi were not selected for this category in the present review. Because Shogi was also included with the ab-stract strategy games, this may influence cognitive func-

was not selected for the present review because it was a case report, these authors found that playing chess pre-vented panic attacks and contributed to the amelioration of this condition. Taken together, these findings indicate that board games might be an effective complementary inter-vention for the treatment of the clinical symptoms of ADHD and Alzheimer’s Disease.

In terms of Alzheimer’s disease, board games may also play a role in the prevention of the onset of this disorder. According to an epidemiological survey in Japan [38], the prevalence rates of dementia in 1980, 1990, and 2000 were 4.4, 4.5, and 5.9, respectively, for all types of dementia and 1.9, 2.5, and 3.6, respectively for Alzheimer’s Disease. In Japan, the number of patients with Alzheimer’s disease has increased, and the prevention of this disorder is a problem that must be addressed. Because playing board games ameliorates the manifestations of Alzheimer’s dis-ease [8], these types of games may contribute to the pre-vention of this disorder. However, the number of studies in the present review that investigated the effects of board games on clinical symptoms was quite small, and further research will be required.

Possible clinical applications of board games   
It is also important to note that board games can be played without the use of language. Language-based therapies may not be appropriate for people with under-developed linguistic functions, such as children and pa-tients with speech disorders. However, board games may be a viable treatment option for these populations. In

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| tions. | In | the | future, | it | will | be | necessary | to | use | the present review, the subjects in 18 of the assessed |

intervention studies to examine the effects of additional types of board games, including Shogi, on cognitive

studies included children, which is a group that is still developing linguistic functions and is more likely to have

function. poor knowledge about diseases. The present review also

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revealed that board games and programs that use board promotion models using board games, such as Shogi and other traditional

games are effective for achieving various outcomes for games.

children, including increasing educational knowledge, en-hancing cognitive functions, and decreasing anxiety and the severity of ADHD. Furthermore, board games can be an enjoyable and motivational tool for children [22]. Based on these findings, it is possible that board games can be a useful intervention for children in particular because such games can be expected to result in the maintenance and promotion of health and the prevention of disease.

Limitations and future directions   
Several limitations of the present study must be consid-ered. First, the number of studies assessed in the present review was rather limited. Therefore, further investigations of the effects of board games will be necessary. Second, many of the papers selected for the present review exam-

Research involving animals   
Not applicable.

Note   
This paper was proofread in English by Textcheck (reference number: 19022617).

Authors’ contributions   
SN designed the study and conducted the literature searches. SN wrote the first draft of the manuscript. KS and MN revised the draft of the manuscript. All authors approved the final version of the manuscript.

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Availability of data and materials   
Not applicable.

Ethics approval and consent to participate

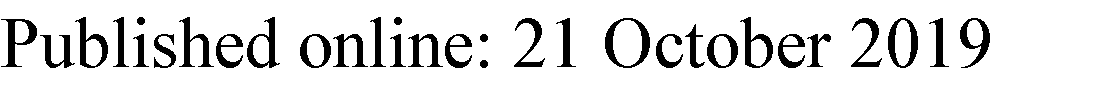
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| ined the effectiveness of board games by comparing pre-post intervention for a single group or by comparing with a control group without intervention. These research de- | Not applicable.  Consent for publication  Not applicable. |

signs do not control for the possibility of placebo effects. Intervention studies must include an active control group to control for possible placebo effects [39], thus it will be necessary to compare the effect of board game groups and active control groups in future research. Third, in the arti-cles selected for the present review, some studies were conducted with relatively small sample sizes. In cases in which the sample size is small, there is the possibility of increased sampling error. In order to reduce sampling error, it is necessary to do a power analysis to set an ap-propriate sample size in intervention studies. In addition, it is desirable that multiple assessment indicators be used to examine the effects of board games in various perspec-tives and to reduce measurement errors.

Competing interests   
The authors declare that they have no competing interests.

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