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# Application of the teaching games for understanding model to improve decision-making in sport learning: a systematic review and meta-analysis

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## Abstract

**Background** Issues related to sport teaching at different educational stages is a subject of wide interest. Teaching Games for Understanding has been established as the most effective way to teach students the elements related to the field of sport. The objectives of this study were (a) to examine the impact of the Teaching Games for Understanding model on decision-making in sports education and (b) to compare the effect of the interventions analysed according to educational stage.

**Method** A systematic review and meta-analysis of studies published before August 2024 was conducted. A total of 4937 scientific studies were obtained. The quantitative synthesis consisted of 25 scientific articles ($n = 1692$). The studies were analyzed using three-level random effects models with variance estimation. Results were calculated as raw mean differences and Hedges' g effect sizes.

**Results** This model is suitable for decision-making in sports education ($g = 0.82$; *CI 95%* = [0.55; 1.09]). This pedagogical model was also found to be effective for working on decision-making in primary education ($g = 0.6108$; *CI 95%* = [0.3587; 0.8628]), secondary education ($g = 0.7523$; *CI 95%* = [0.2348; 1.2706]) and higher education ($g = 0.8803$ [*CI 95%* = 0.2851 to 1.4855]).

**Conclusions** Teaching games for understanding effectively addresses decision-making during sports learning. In addition, this pedagogical model is effective for facilitating decision-making according to the role and the moment of the game. The use of this model enables effective technical-tactical learning to solve various problematic actions in real game situations.

**Keywords** Teaching games for understanding, Decision making, Systematic review, Meta-analysis, Educational stages

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## Introduction

The teaching of sport is highly relevant in the physical education curriculum [1]. Traditionally, the teaching of sport has been carried out through games that simulate different technical-tactical situations specific to each sport [2]. Sport teaching through games offers different profiles because its purpose is to work on different technical-tactical elements through the modification of rules [3].

The teaching of sport is traditionally performed through technical methods [4]. In this method, the teacher is the most relevant, as it is who proposes activities that simulate different sporting situations [4]. Likewise, the predominant teaching style in the technical model of sport teaching is direct instruction [5]. Each task proposed has a specific objective linked to the development of a technical-tactical skill specific to each sport [4]. Despite being one of the most widely used sport teaching models, it has received several criticisms [6]. The first is related to the level of application, as it has been observed that it cannot cater for the characteristics of all students [7]. Through the technical teaching model, only the most effective learners benefit [7]. In addition, there is a high dependence on the teacher's instructions, which limits the learner's autonomy of choice in decision-making [7].

Recent sport teaching techniques have offered more benefits for students' learning [8]. The traditional model of classical sports teaching isolates the learning of skills and then transfers them to the real game [8]. This can create an obstacle for students in engaging in physical-sport tasks [6]. Teaching strategies have been recognized as the main constraint to support adequate development in psychomotor, affective and cognitive areas [9].

Teaching Games for Understanding was proposed as an alternative to teaching sport [10]. The appearance of a sport represents an important evolution in sports work [11]. Understanding sports activities is placed at the core of learning [12]. Its development and application focus on the integration of technical-tactical skills in simulated or real game contexts [12]. The aim of this pedagogical model is to improve decision-making and problem-solving skills [5].Its application seeks to get students to consider the "why" of doing something during the game, rather than the "how" [5]. Through this learning philosophy, one can develop thinking related to collective work and context [5].

This pedagogical model is based on four pedagogical principles [6, 13]. The first approach seeks transfer through global games [6, 13]. Through these games, the tactical aspects common to different sports are developed [6, 13]. The second principle is modification-representation [6, 13]. It involves adapting games to the level of the pupils while maintaining the tactical structure [6, 13]. The third principle is modification-exaggeration [6, 13]. Through this, rules are modified or included to acquire technical-tactical knowledge [6, 13]. The last principle focuses on tactical complexity [6, 13]. The task set is intended to have a progression in complexity [6, 13]. Through the principle of tactical complexity, the student works the cognitive section to find the most effective solution to the given problem [6, 13].

Review studies have identified several concepts related to play-based approaches to teaching [14]. This emphasizes the need for a deeper analysis of tactical methods in educational environments, improved evaluation of tactical awareness development, and the application of long-term research designs [14]. It has also been found that the role of the teacher with the educational stage are variables to be considered when applying this model [6, 14, 15].

The traditional model of sport education has been found to increase perceived competence in subjects with previous experience [6]. This has led many inexperienced students showing a lower degree of perceived competence [6, 15]. Students with no previous experience in sport showed statistically significant differences in decision-making [5]. In contrast, students with previous experience did not demonstrate significant improvements in decision-making [5]. To avoid this, it is necessary to conduct a study on the initial level of students [8]. Based on the results, tasks should be designed according to the level of the young people [9].

This study is based on the hypothesis that the application of the Teaching Games for Understanding model promotes decision-making during sport practice. Based on this initial research hypothesis, the following objectives are proposed:

- O.1. To analyze the effect of the Teaching Games for Understanding approach on decision-making in sports education.
- O.2. To compare the effect of interventions according to educational stage.

## Method

### Design

Due to the characteristics of this type of research, the criteria set out in the latest PRISMA statement [16] were followed. In addition, the research was registered in the Prospective International Register of Systematic Reviews (PROSPERO). The registration code was CRD42024579474.

### Search strategy

A comprehensive search was conducted between May and November 2024 using PubMed, Scopus, Web of Science, Cochrane Library, ERIC, and PsycINFO databases.

The search for research was carried out through the following combination: *"Teaching Games for Understanding"* OR *"TGFU"* OR *"Tactical Games Model"* OR *"Game-Centered Learning"* OR *"Game Sense Approach"* AND *"Decision-Making"* AND *"Physical Education*"* AND *"Intervention".* The Web of Science search was conducted within the fields of *"Sport Sciences"*, *"Psychology Applied"*, *"Psychology Educational"* and *"Education and Educational Research".* Scopus was examined in the fields of *"Social Sciences"* and *"Psychology"*. The search time range was defined as 2000 to 2024. References from systematic review studies and meta-analyses were also consulted for related research. The PICOT model [17] was used to establish the inclusion criteria. The inclusion criteria are presented in Table 1.

#### Research selection strategies

In Web of Science, once the search terms were entered, an initial sample of 304 research papers was obtained. This was then refined according to the type of document. Only research articles were selected, reducing the sample to 214 scientific studies. The sample was then refined according to the following areas: *"Sport Sciences"*, *"Applied Psychology"*, *"Educational Psychology"* and *"Education and Educational Research"*. After applying these criteria, the number of scientific articles was reduced to 162. In ERIC, the initial search yielded 5084. After the descriptors *"Decision Making"* and *"Teaching Methods"* were flagged, the sample was reduced to 1089 research papers. It was then refined according to the document type. Only scientific articles were selected. This reduced the sample to 927 scientific articles.

A total of 2622 scientific research papers were retrieved from PsycINFO. It was then refined according to the document type. Only research articles were selected. This reduced the sample to 1341 research articles. Next, the descriptors selected were *"Physical Education"* and *"Teaching Methods"*. This reduced the number of scientific articles to 233 studies. The initial search in SCOPUS revealed 13 research studies. After filtering by document type, the sample was reduced to 10 scientific articles. We then proceeded to refine this according to the following areas: *"Social Sciences"* and *"Psychology"*. After applying this criterion, the sample was reduced to 6 scientific articles. In the Cochrane Library, the introduction of the search terms revealed 6 scientific articles.

After applying the first exclusion criteria, 401 scientific articles were reviewed by title, abstract, and keywords. A total of 287 research papers were discarded. Specifically, 6 were eliminated because they were not written in either English or Spanish. In addition, 281 were eliminated because they were not in open access. This approach reduced the sample to 114 full-text articles to assess their eligibility for the study. Subsequently, the documents were refined based on the study design. Only studies with trial control or randomized controlled trials were selected. Eighty-eight scientific articles were eliminated. After applying this criterion, 26 articles were selected for inclusion in the qualitative synthesis. Five studies were excluded because they did not present any of these statistical indices: number of participants in the control or experimental group, mean values or standard deviation. The number of studies included in this method were 21.

A top-down search was conducted by examining the bibliographic references of the included articles. A total of 31 scientific articles were identified, however 8 research papers could not be retrieved. 23 studies were analyzed for eligibility. Due to inadequate design and insufficient statistical data, 19 data were discarded. 4 new research articles were added. The final quantitative synthesis of this study consisted of 25 research. Figure 1

**Table 1** Inclusion and exclusion criteria

| | Inclusion criteria | Exclusion criteria |
|---|---|---|
| Population | Primary, secondary, and higher education students | |
| Intervention | Applying the TGFU pedagogical model to decision-making | Working on decision-making with any other pedagogical model |
| Comparison | Implementation of trial control and randomized controlled trial design<br>Compilation of pre-test and post-test results for both groups. | Not presenting a trial control design or randomized controlled trial |
| Results | Evaluation of decision making after applying the TGFU pedagogical model | Failure to apply a previously validated and adapted instrument |
| Time range | Research published between 1990 and 2024 | Studies published between 1990 and 2024 |
| Context | Studies conducted in schools or sports schools | Studies not conducted in schools or sports schools |
| Language | Writing in Spanish and English | Studies not written in English or Spanish |
| Research characteristics | Use of validated instruments and effective data collection techniques | Using validated instruments or effective techniques for data collection |
| | Provision of the following statistical data: mean values, standard deviations, and number of participants. | Do not provide any of the following data: Mean value, standard deviation, or number of participants in the control and experimental groups. |
| | Open access research | Not open-access research |

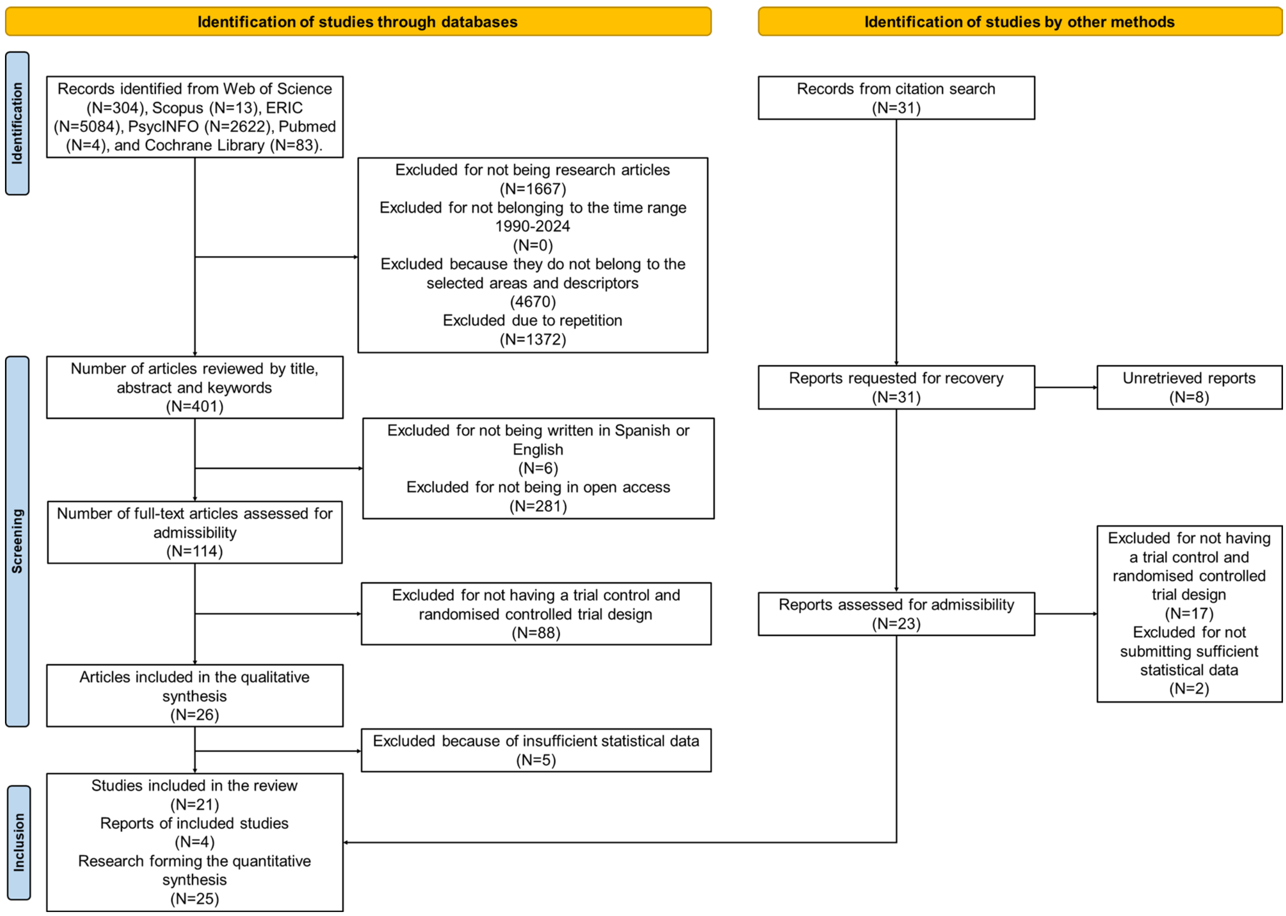


**Fig. 1** Research flowchart

illustrates the process of selection and exclusion of the research.

## Bias study of quantitative synthesis

The Cochrane risk-of-bias tool [18] was used. Three researchers conducted this study according to the criteria set out in the Cochrane handbook [18]. This tool was used with the 25 items that make up the meta-analysis to determine whether there are any risks that influence the effect of the intervention. Three researchers assessed the risk of bias using the following categories: (1) Generation of random consequences; (2) Allocation concealment; (3) Blindness of participants and staff; (4) Incomplete outcome data; (5) Selective information; (6) Other sources of risk [18].

## Effect size of research

Effect size was measured using the Hedge's *g*-statistic [19], which was calculated based on the mean values, participant numbers, and standard deviations [19]. All data were obtained from the original research. The calculation is based on the difference of the standardized mean values, adjusted for sample size [20]. Two types of analysis were carried out. The first focuses on the total effect size of all research. The second analysis was carried out using the moderating variable educational stage.

## Coding of research on quantitative synthesis

Each investigation was coded by each researcher. This was done to extract the data and calculate effect sizes in a concise way. The degree of agreement among the researchers was 86.8%. The effect size was calculated by three researchers.

The Fleiss Kappa index ($K_F$) was used for the methodological evaluation of the study [21]. A value of $K_F = 0.792$ was obtained. Cohen's Kappa ($K_C$) [22] was used to assess the coding level. A value of $K_C = 0.852$ was obtained. Data extraction was performed using the following criteria: (1) Author; (2) Design; (3) Country; (4) Sample; (5) Educational Level; (6) Learning Context; (7) Intervention Sessions; (8) Intervention Weeks; (8) Variable; (9) Instruments; (10) Effect Size [95% CI] (Table 2).

## Characteristics and statistical analysis of meta-analysis

A random-effect meta-analysis was performed. This meta-analysis allowed the effect sizes of each study to be

**Table 2** Information from research forming the quantitative synthesis

| Author | Design | Country | Sample | Educational Level | Learning Context | Intervention sessions | Intervention weeks | Variable | Instruments | Effect Size [CI 95%] |
|---|---|---|---|---|---|---|---|---|---|---|
| French et al. [23] | RCT | United States of America | 90 students | Secondary Education | Badminton | 30 | 6 | Contact Decision | Systematic observation of decision-making and execution in real game situations | 0.03 [−0.39; 0.44] |
| | | | | | | | | Serve Decision | | 1.41 [0.94; 1.87] |
| | | | | | | | | Decision Making (general | | 1.27 [0.82; 1.73] |
| Chatzopoulos et al. [24] | CT | Greece | 72 girls | Elementary Education | Soccer | 15 | 5 | Decision Making (general) | Game Performance Assessment Instrument | 0.53 [0.06; 1.00] |
| Chatzopoulos et al. [25] | CT | Greece | 101 boys | Elementary Education | Soccer | 15 | 5 | Decision Making (general) | Decision Made Index | 0.61 [0.21; 1.01] |
| Harvey et al. [26] | RCT | United Kingdom | 34 students | Secondary Education | Soccer | 8 | 8 | Decision Making (general) | Game Performance Assessment Instrument | 0.13 [−0.54; 0.80] |
| Gray and Sproule [27] | CT | United Kingdom | 52 students (41 boys and 36 girls) | Secondary Education | Basketball | 10 | 5 | Decision-making with the ball | Decision Made Index | 0.83 [0.23; 1.43] |
| | | | | | | | | Decision-making (general) | | 0.54 [−0.04; 1.13] |
| | | | | | | | | Decision-making without the ball | | 2.38 [1.62; 3.14] |
| Psotta and Martin [28] | CT | Czech Republic | 24 girls | Higher Education | Soccer | 17 | 5 | Dribbling Decision | Soccer Performance Observation System | 0.88 [0.04; 1.73] |
| | | | | | | | | Passing Decisions | | 0.37 [−0.44; 1.18] |
| | | | | | | | | Decision-making (general) | | 0.81 [−0.02; 1.65] |
| Nathan [29] | RCT | Malaysia | 30 students | Secondary Education | Hockey | 15 | 5 | Decision making (general) | Game Play Observation Instrument | 0.21 [−0.51; 0.93] |
| Miller et al. [30] | RCT | Australia | 168 students (72 boys and 96 girls) | Elementary Education | Teaching Invasion Games | 6 | 7 | Throw Decision Making | Decision Made Index | 0.11 [−0.19; 0.42] |
| | | | | | | | | Catch Decision Making | | 0.35 [0.04; 0.66] |
| | | | | | | | | Kick Decision Making | | 0.24 [−0.07; 0.55] |
| | | | | | | | | Decision-making (general) | | 0.30 [−0.01; 0.61] |
| Miller et al. [31] | RCT | Australia | 107 students (59 boys and 48 girls) | Elementary Education | Teaching Invasion Games | 6 | 7 | Decision-making (general) | Game play decision making | 0.18 [−0.20; 0.56] |
| Miller et al. [32] | RCT | Australia | 90 girls | Elementary Education | Netball | 9 | 9 | Decision-making (general) | Decision Made Index | 0.14 [−0.28; 0.55] |
| López-Lemus et al. [33] | CT | Spain | 46 students (22 boys and 24 girls) | Secondary Education | Basketball | 9 | 5 | Shooting Decision | Systematic observation of decision-making and execution in real game situations | 0.27 [−0.31; 0.85] |
| | | | | | | | | Passing Decision | | 0.41 [−0.17; 1.00] |
| | | | | | | | | Decision-making (general) | | 0.12 [−0.46; 0.70] |

**Table 2** (continued)

| Author | Design | Country | Sample | Educational Level | Learning Context | Intervention sessions | Intervention weeks | Variable | Instruments | Effect Size [CI 95%] |
|---|---|---|---|---|---|---|---|---|---|---|
| Nathan [34] | RCT | Malaysia | 32 students (16 boys and 16 girls) | Secondary Education | Badminton | 12 | 5 | Decision-making (general) | Decision Made Index | 0.80 [0.08; 1.52] |
| Práxedes et al. [35] | CT | Spain | 18 boys | Elementary Education | Soccer | 21 | 18 | Dribbling Decision | Systematic observation of decision-making and execution in real game situations | 0.87 [−0.11; 1.85] |
| | | | | | | | | Passing Decision | | 0.66 [−0.30; 1.61] |
| | | | | | | | | Decision-making (general) | | 1.05 [0.06; 2.04] |
| Morales-Belando and Arias-Estero [36] | RCT | Spain | 67 students (45 boys and 22 girls) | Elementary Education | Sailing | 11 | 2 | Decision-making (general) | Game Performance Assessment Instrument | 1.07 [0.56; 1.58] |
| Ashraf [37] | RCT | Egypt | 45 students | Higher Education | Soccer | (-) | 8 | Striker's decision with the ball | Game Performance Evaluation Tool | 1.03 [0.40; 1.65] |
| | | | | | | | | Striker's decision without the ball | | 1.04 [0.42; 1.67] |
| | | | | | | | | Defender's decision with the ball | | 1.24 [0.60; 1.89] |
| | | | | | | | | Defender's decision without the ball | | 1.16 [0.52; 1.80] |
| | | | | | | | | Decision-making (general) | | 1.38 [0.73; 2.03] |
| Dorak et al. [38] | RCT | Turkey | 43 students | Higher Education | Handball | (-) | 12 | Decision-making (general) | Game Performance Assessment Instrument | 0.08 [−0.52; 0.69] |
| Guijarro-Romero et al. [39] | RCT | Spain | 67 students | Elementary Education | Soccer | 16 | 16 | Decision-making (general) | Game Performance Assesment Instrument | 0.53 [0.02; 1.03] |
| Morales-Belando et al. [40] | CT | Spain | 41 students (23 boys and 18 girls) | Elementary Education | Floorball | 8 | 9 | Decision-making (general) | Game Performance Assessment Instrument | 1.49 [1.00; 1.98] |
| Calabria-Lopes et al. [41] | CT | Brazil | 20 students | Elementary Education | Basketball | 9 | (-) | Shooting Decision | Declarative Knowledge Questionnaire | 1.77 [1.03; 2.52] |
| | | | | | | | | Passing Decisions | | 1.36 [0.66; 2.05] |
| | | | | | | | | Decision-making (general) | | 0.80 [0.15; 1.44] |
| Gouveia et al. [42] | CT | Portugal | 62 students | Secondary Education | Teaching Invasion Games | 12 | 8 | Decision-making (general) | Game Performance Assessment Instrument | 0.83 [0.28; 1.38] |
| Dania and Harvey [43] | CT | Greece | 35 boys | Elementary Education | Basketball | 16 | 8 | Decision-making (general) | Game Performance Assessment Instrument | 0.53 [−0.16; 1.22] |

**Table 2** (continued)

| Author | Design | Country | Sample | Educational Level | Learning Context | Intervention sessions | Intervention weeks | Variable | Instruments | Effect Size [CI 95%] |
|---|---|---|---|---|---|---|---|---|---|---|
| Hastie et al. [44] | RCT | United States of America | 72 students (54 boys and 18 girls) | Higher Education | Badminton | 24 | 16 | Decision-making (general) | Game Performance Assessment Instrument | 1.23 [0.72; 1.73] |
| Sgró et al. [45] | RCT | Italy | 81 students | Secondary Education | Volleyball | 18 | 11 | Decision-making (general) | Game Performance Assessment Instrument | 0.47 [0.02; 0.91] |
| Pan et al. [46] | CT | Taiwan | 90 students (47 boys and 43 girls) | Secondary Education | Basketball | 20 | 10 | Decision-making (general) | Game Performance Assessment Instrument | 0.43 [0.01; 0.85] |
| Devrilmez et al. [47] | RCT | Turkey | 158 students (89 boys and 67 girls) | Secondary Education | Badminton | 10 | 5 | Serve decision<br>Game decision<br>Contact decision<br>Decision-making (general) | Tactical and skill behaviors during gameplay | 3.10 [2.64; 3.57]<br>7.36 [6.48; 8.24]<br>2.60 [2.17; 3.02]<br>2.53 [2.11; 2.95] |

combined. The total effect of interventions applying the Teaching Games for Understanding pedagogical model on decision-making was calculated. The educational stage was established as a moderating variable. This variable was categorized into primary education, secondary education, and higher education.

The Egger regression test was used to study the level of research [48]. Although Begg's test is widely used to detect asymmetries, Egger's regression test is more effective [48]. This test demonstrated a higher degree of specificity [49, 50]. The effect is significant if $Z \geq 1.96$ or $Z \leq -1.96$ [50].

The heterogeneity of the meta-analysis has been studied through the $I^2$ statistic. The value of this index, the total variability of the meta-analysis can be calculated [50]. The value of this index ranges from 0 to 100 [51]. Heterogeneity is classified based on thresholds of 25%, 50%, and 75%, corresponding to low, moderate, and high levels, respectively [51]. To measure the level of heterogeneity, Q statistic is another useful index [20]. Some researchers have claimed that the *Q* index is conservative, does not facilitate group diversity and becomes less accurate when little research is available [20, 50]. For this reason, the significance level has been set at $p < 0.1$ [51].

Student residuals and Cook's distances were employed to identify whether studies are influential or outliers. Studies with a Cook's distance exceeding the median plus six times the interquartile range are classified as influential [52]. The rank correlation and regression tests were used to evaluate skewness in the funnel plot [52]. The standard error of the observed results was used as a predictor variable.

## Results

### Characteristics of quantitative synthesis

The quantitative synthesis comprises 25 investigations. The sample of participants in this study is 1645 students. Regarding the distribution of the sample according to educational stage, 786 belonged to primary education (47.78%), 675 to secondary education (41.03%) and 184 to higher education (11.19%). %). In terms of design, 14 studies show a randomized controlled trial design (56.0%) and 11 studies show a controlled trial design (44.0%). Turning to the learning domain, 84% of the studies analysed focus on the following learning areas: soccer ($N=8$; 32.0%), basketball ($N=5$; 20.0%), badminton ($N=4$; 16.0%), invasion games ($N=3$; 12.0%) and volleyball ($N=1$; 4.0%).

### Analysis of research bias

Figure 2 presents the bias distribution according to seven categories. There is research with a high level of bias in the following areas: random sequence generation ($N=1$; 4.00%), allocation concealment ($N=1$; 4.00%), blinding of outcome assessment ($N=1$; 4.00%), blinding of participants and staff ($N=1$; 4.00%), selective reporting ($N=2$; 8.00%), and other biases ($N=2$; 8.00%). There are also studies with a low level of bias: random sequence generation ($N=19$; 76.00%), allocation concealment ($N=17$; 68.00%), blinding of outcome assessment ($N=18$; 72.00%), blinding of participants and staff ($N=14$;

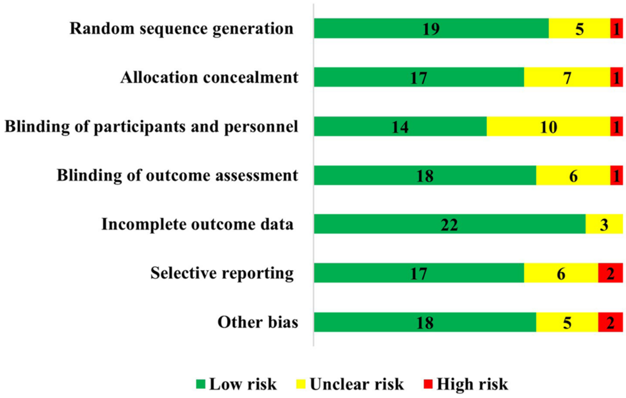


**Fig. 2** Distribution of bias according to study areas

56.00%), incomplete outcome data (*N*=22; 88.0%), selective reporting (*N*=17; 68.0%), and other biases (*N*=18; 72.00%).

### Effect of proposals based on the application of teaching games for understanding on decision-making

Figure 3 presents the effects of the different studies on decision-making. A total of 25 studies were included in this analysis. The observed standardized mean differences ranged from 0.0821 to 2.5320, with most estimates being positive. The estimated average standardized mean differences based on the random-effects model was $g=0.7183$; *95% CI* = [0.4866; 0.9500]). Therefore, the average outcome differed significantly from zero ($Z=6.0768$; $p<0.0001$). According to the Q-test, the true outcomes appear to be heterogeneous ($Q$ (24) = 137.7177, $p<0.0001$, $Tau^2=0.2694$, $I^2=80.4423\%$). The 95% prediction interval for the true outcomes is given by −0.3250 to 1.7616. Hence, although the average outcome is estimated to be positive, the true outcome may in fact be negative. An examination of the studentized residuals revealed that one study (Devrilmez et al. [46]) had a value larger than ±3.0902 and may be a potential outlier in the context of this model. According to the Cook's distances, one study (Devrilmez et al. [46]) could be overly influential. Neither the rank correlation nor the regression test indicated any funnel plot asymmetry ($p=0.3419$ and $p=0.9458$, respectively).

### Analysis of interventions according to education stage

The distribution according to educational stage was as follows: primary education ($k=11$), secondary education ($k=10$) and higher education ($k=4$).

According to the $Q$-test, the results were heterogeneous for primary education studies ($Q(10)=29.0817$; $p=0.0012$; $Tau^2=0.1140$; $I^2=66.5636\%$). The 95% prediction interval was 0.0975–1.3190. The average result is expected to be positive. The test of studentized residuals and the Cook's distance test found that Morales-Belando et al. [40] is overly influential and could be an outlier. Neither the rank correlation nor the regression test indicated any funnel plot asymmetry ($p=0.1210$ and $p=0.1163$ respectively). Figure 4 illustrates the effects of the different investigations on decision-making in primary school. The application of this pedagogical model had a positive

| | Experimental | | | Control | | | | Std. Mean Difference |
|---|---|---|---|---|---|---|---|---|
| Study or Subgroup | Mean | SD | Total | Mean | SD | Total | Weight | IV, Random, 95% CI |
| Dorak et al. [38] | 38.32 | 7.2 | 25 | 37.67 | 8.52 | 18 | 3.9% | 0.08 [-0.52, 0.69] |
| López-Lemus et al. [33] | 0.629 | 0.384 | 22 | 0.586 | 0.34 | 24 | 3.9% | 0.12 [-0.46, 0.70] |
| Harvey et al. [26] | 2.5 | 1.5 | 18 | 2.3 | 1.49 | 16 | 3.7% | 0.13 [-0.54, 0.80] |
| Miller et al. [32] | 65.94 | 19.33 | 49 | 63.17 | 20.94 | 41 | 4.4% | 0.14 [-0.28, 0.55] |
| Miller et al. [31] | 72.14 | 13.41 | 52 | 69.52 | 15.14 | 55 | 4.5% | 0.18 [-0.20, 0.56] |
| Nathan [29] | 6.93 | 6.58 | 15 | 5.53 | 6.23 | 15 | 3.5% | 0.21 [-0.51, 0.93] |
| Miller et al. [30] | 11.54 | 3.39 | 97 | 10.57 | 2.94 | 71 | 4.7% | 0.30 [-0.01, 0.61] |
| Pan et al. [46] | 58.5 | 15.56 | 46 | 50.78 | 19.83 | 44 | 4.4% | 0.43 [0.01, 0.85] |
| Sgró et al. [45] | 0.82 | 0.21 | 45 | 0.7 | 0.3 | 36 | 4.3% | 0.47 [0.02, 0.91] |
| Guijarro-Romero et al. [39] | 0.73 | 0.15 | 25 | 0.59 | 0.31 | 42 | 4.2% | 0.53 [0.02, 1.03] |
| Chatzopoulos et al. [24] | 1.63 | 1.23 | 37 | 1.05 | 0.91 | 35 | 4.3% | 0.53 [0.06, 1.00] |
| Dania and Harvey [43] | 3.43 | 2.01 | 14 | 2.32 | 2.07 | 21 | 3.6% | 0.53 [-0.16, 1.22] |
| Gray and Sproule [27] | 19 | 10.68 | 25 | 13.75 | 7.92 | 27 | 4.0% | 0.55 [-0.00, 1.11] |
| Chatzopoulos et al. [25] | 2.37 | 1.81 | 52 | 1.46 | 0.99 | 49 | 4.5% | 0.61 [0.21, 1.01] |
| Nathan [34] | 12.75 | 4.52 | 16 | 9.25 | 4.02 | 16 | 3.5% | 0.80 [0.07, 1.52] |
| Calabria-Lopes et al. [41] | 1.16 | 0.26 | 20 | 0.96 | 0.23 | 20 | 3.7% | 0.80 [0.15, 1.45] |
| Psotta and Martin [28] | 0.81 | 0.12 | 12 | 0.7 | 0.14 | 12 | 3.2% | 0.81 [-0.02, 1.65] |
| Gouveia et al. [42] | 0.85 | 0.16 | 41 | 0.73 | 0.1 | 21 | 4.0% | 0.83 [0.28, 1.38] |
| Morales-Belando and Arias-Estero [36] | 3.3 | 0.3 | 40 | 1 | 3.47 | 27 | 4.1% | 1.03 [0.51, 1.55] |
| Práxedes et al. [35] | 0.85 | 0.14 | 9 | 0.64 | 0.23 | 9 | 2.8% | 1.05 [0.05, 2.05] |
| Hastie et al. [44] | 6.08 | 1.99 | 36 | 4.08 | 1.12 | 36 | 4.2% | 1.23 [0.72, 1.73] |
| French et al. [23] | 59.9 | 16.4 | 45 | 39.4 | 15.5 | 45 | 4.3% | 1.27 [0.82, 1.73] |
| Ashraf [37] | 45.86 | 14.56 | 24 | 23.58 | 17.32 | 21 | 3.7% | 1.38 [0.72, 2.03] |
| Morales-Belando et al. [40] | 7.9 | 5.81 | 41 | 1.54 | 1.4 | 41 | 4.2% | 1.49 [1.00, 1.98] |
| Devrilmez et al. [47] | 0.47 | 0.23 | 79 | 0.05 | 0.04 | 79 | 4.4% | 2.53 [2.11, 2.95] |
| **Total (95% CI)** | | | **885** | | | **821** | **100.0%** | **0.72 [0.47, 0.97]** |

Heterogeneity: Tau² = 0.31; Chi² = 136.83, df = 24 (P < 0.00001); I² = 82%
Test for overall effect: Z = 5.73 (P < 0.00001)

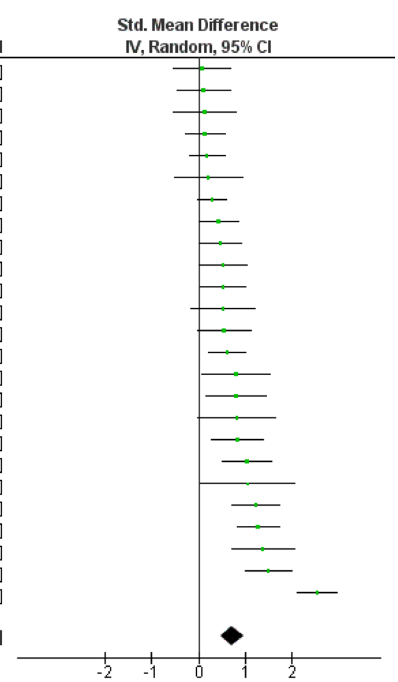


**Fig. 3** Forest plot of the quantitative synthesis

| Study or Subgroup | Experimental Mean | Experimental SD | Experimental Total | Control Mean | Control SD | Control Total | Weight | Std. Mean Difference IV, Random, 95% CI |
|---|---|---|---|---|---|---|---|---|
| **2.1.1 Elementary Education** | | | | | | | | |
| Miller et al. [32] | 65.94 | 19.33 | 49 | 63.17 | 20.94 | 41 | 4.4% | 0.14 [-0.28, 0.55] |
| Miller et al. [31] | 72.14 | 13.41 | 52 | 69.52 | 15.14 | 55 | 4.5% | 0.18 [-0.20, 0.56] |
| Miller et al. [30] | 11.54 | 3.39 | 97 | 10.57 | 2.94 | 71 | 4.7% | 0.30 [-0.01, 0.61] |
| Guijarro-Romero et al. [39] | 0.73 | 0.15 | 25 | 0.59 | 0.31 | 42 | 4.2% | 0.53 [0.02, 1.03] |
| Chatzopoulos et al. [24] | 1.63 | 1.23 | 37 | 1.05 | 0.91 | 35 | 4.3% | 0.53 [0.06, 1.00] |
| Dania and Harvey [43] | 3.43 | 2.01 | 14 | 2.32 | 2.07 | 21 | 3.6% | 0.53 [-0.16, 1.22] |
| Chatzopoulos et al. [25] | 2.37 | 1.81 | 52 | 1.46 | 0.99 | 49 | 4.5% | 0.61 [0.21, 1.01] |
| Calabria-Lopes et al. [41] | 1.16 | 0.26 | 20 | 0.96 | 0.23 | 20 | 3.7% | 0.80 [0.15, 1.45] |
| Morales-Belando and Arias-Estero [36] | 3.3 | 0.3 | 40 | 1 | 3.47 | 27 | 4.1% | 1.03 [0.51, 1.55] |
| Práxedes et al. [35] | 0.85 | 0.14 | 9 | 0.64 | 0.23 | 9 | 2.8% | 1.05 [0.05, 2.05] |
| Morales-Belando et al. [40] | 7.9 | 5.81 | 41 | 1.54 | 1.4 | 41 | 4.2% | 1.49 [1.00, 1.98] |
| **Subtotal (95% CI)** | | | **436** | | | **411** | **44.9%** | **0.61 [0.36, 0.86]** |
| Heterogeneity: Tau² = 0.11; Chi² = 28.86, df = 10 (P = 0.001); I² = 65% | | | | | | | | |
| Test for overall effect: Z = 4.81 (P < 0.00001) | | | | | | | | |
| **2.1.2 Secondary Education** | | | | | | | | |
| López-Lemus et al. [33] | 0.629 | 0.384 | 22 | 0.586 | 0.34 | 24 | 3.9% | 0.12 [-0.46, 0.70] |
| Harvey et al. [26] | 2.5 | 1.5 | 18 | 2.3 | 1.49 | 16 | 3.7% | 0.13 [-0.54, 0.80] |
| Nathan [29] | 6.93 | 6.58 | 15 | 5.53 | 6.23 | 15 | 3.5% | 0.21 [-0.51, 0.93] |
| Pan et al. [46] | 58.5 | 15.56 | 46 | 50.78 | 19.83 | 44 | 4.4% | 0.43 [0.01, 0.85] |
| Sgró et al. [45] | 0.82 | 0.21 | 45 | 0.7 | 0.3 | 36 | 4.3% | 0.47 [0.02, 0.91] |
| Gray and Sproule [27] | 19 | 10.68 | 25 | 13.75 | 7.92 | 27 | 4.0% | 0.55 [-0.00, 1.11] |
| Nathan [34] | 12.75 | 4.52 | 16 | 9.25 | 4.02 | 16 | 3.5% | 0.80 [0.07, 1.52] |
| Gouveia et al. [42] | 0.85 | 0.16 | 41 | 0.73 | 0.1 | 21 | 4.0% | 0.83 [0.28, 1.38] |
| French et al. [23] | 59.9 | 16.4 | 45 | 39.4 | 15.5 | 45 | 4.3% | 1.27 [0.82, 1.73] |
| Devrilmez et al. [47] | 0.47 | 0.23 | 79 | 0.05 | 0.04 | 79 | 4.4% | 2.53 [2.11, 2.95] |
| **Subtotal (95% CI)** | | | **352** | | | **323** | **40.2%** | **0.75 [0.23, 1.27]** |
| Heterogeneity: Tau² = 0.61; Chi² = 85.93, df = 9 (P < 0.00001); I² = 90% | | | | | | | | |
| Test for overall effect: Z = 2.85 (P = 0.004) | | | | | | | | |
| **2.1.3 University Education** | | | | | | | | |
| Dorak et al. [38] | 38.32 | 7.2 | 25 | 37.67 | 8.52 | 18 | 3.9% | 0.08 [-0.52, 0.69] |
| Psotta and Martin [28] | 0.81 | 0.12 | 12 | 0.7 | 0.14 | 12 | 3.2% | 0.81 [-0.02, 1.65] |
| Hastie et al. [44] | 6.08 | 1.99 | 36 | 4.08 | 1.12 | 36 | 4.2% | 1.23 [0.72, 1.73] |
| Ashraf [37] | 45.86 | 14.56 | 24 | 23.58 | 17.32 | 21 | 3.7% | 1.38 [0.72, 2.03] |
| **Subtotal (95% CI)** | | | **97** | | | **87** | **14.9%** | **0.88 [0.28, 1.48]** |
| Heterogeneity: Tau² = 0.27; Chi² = 10.64, df = 3 (P = 0.01); I² = 72% | | | | | | | | |
| Test for overall effect: Z = 2.87 (P = 0.004) | | | | | | | | |
| **Total (95% CI)** | | | **885** | | | **821** | **100.0%** | **0.72 [0.47, 0.97]** |
| Heterogeneity: Tau² = 0.31; Chi² = 136.83, df = 24 (P < 0.00001); I² = 82% | | | | | | | | |
| Test for overall effect: Z = 5.73 (P < 0.00001) | | | | | | | | |
| Test for subgroup differences: Chi² = 0.79, df = 2 (P = 0.67), I² = 0% | | | | | | | | |

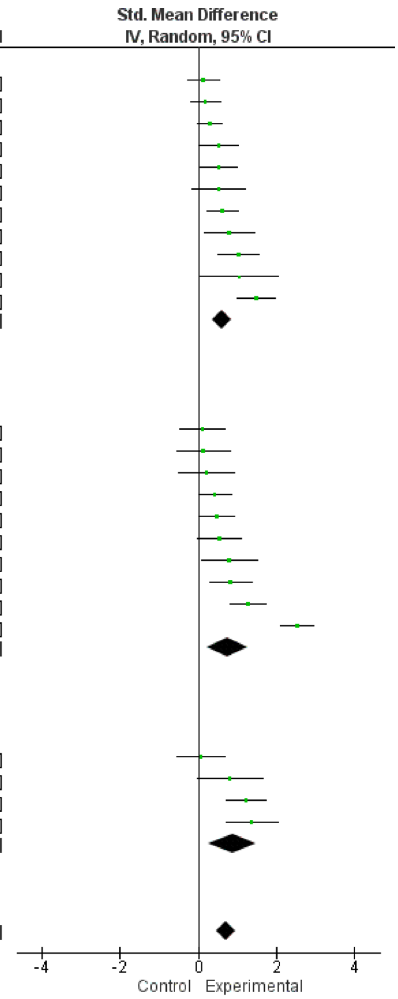


**Fig. 4** Forest plot according to educational stage

effect on decision-making is observed ($g$=0.6108; *CI 95%* = [0.3587; 0.8628]).

A total of 10 investigations were included in the analysis of secondary education studies. The observed standardized mean differences ranged from 0.1169 to 2.5320. Most of the estimates were positive. The average result was significantly different from zero ($Z$=2.8712, $p$=0.0016). The results were heterogeneous ($Q(9)$=86.6461; $p<0.0001$; $Tau^2$=0.4896; $I^2$=87.25). The 95% prediction interval lies between 0.1169 and 2.5320. The average result is expected to be positive. The test of Cook's distances together with the test of studentized residuals showed that Devrilmez et al. [46] can be considered too influential and atypical. Neither the rank correlation ($p$=0.7275) nor the regression test ($p$=0.1126) indicated asymmetry. Figure 4 presents the effects of different studies on decision-making in secondary education. The application of this pedagogical model had a positive effect on decision-making can be observed ($g$=0.7523; *CI 95%* = [0.2348; 1.2706]). This effect is greater than that observed for primary education ($g$=0.6108; *CI 95%* = [0.3587; 0.8628]).

A total of 4 higher education studies were included. The observed standardized mean differences varied between 0.0821 and 1.3764, with all estimates being positive. These estimates are positive. The estimated average standardized mean difference was $g$=0.8803 [*CI 95%* = 0.2851 to 1.4855]. The average result was significantly different from zero ($Z$=2.8735, $p$=0.0028). The results were heterogeneous ($Q(3)$=10.2414; $p$=0.0166; $Tau^2$=0.2306; $I^2$=70.8764%). The 95% prediction interval was between −0.2375 and 1.9582. With these data, the average result was positive. The test of Cook's distances with the test of studentized residuals showed the study of Dorak et al. [38] as too influential and outlier. Neither the rank correlation ($p$=0.9458) nor the regression test ($p$=0.8351) indicated possible skewness. Figure 4 presents the effects of the Teaching Games for Understanding model on decision-making at the university level. A positive effect is denoted ($g$=0.8803 [*CI 95%* = 0.2851 to

1.4855]). This effect is larger than that for primary education ($g$=0.6108; *CI 95%* = [0.3587; 0.8628]) and secondary education ($g$=0.7523; *CI 95%* = [0.2348; 1.2706]).

## Discussion

The data from this research demonstrate that the Teaching Games for Understanding model is useful for the work on decision-making in sports education. In addition, the multi-group analysis reflects the existence of differences in the effect of decision-making according to educational stage. The results of this research are in line with those found by several studies [37, 42, 43].

Most studies on primary education have focused on students aged eleven and twelve, while secondary education studies involve participants no older than sixteen. Interventions in primary education tend to have a lower impact compared to those in secondary education. Implementing Teaching Games for Understanding in primary education can be particularly effective for fostering positive experiences [23, 26, 33, 36]. These factors can thus reduce the dropout of physical activity that occurs upon reaching the secondary education stage [6, 15]. Play is an essential element of physical education [5, 36]. The primary benefit of the proposed model lies in learning through error [5]. For all these reasons, it is important to increase the number of studies that implement this model from the early educational stages [5, 6, 15].

It is observed that the greatest effect of decision-making occurs during the university stage. Abad-Robles et al. [5] found that significant improvements in decision-making from tactical models are not related to educational level. Improvements in decision-making were found to be mainly due to improved technical-tactical knowledge of the sport [5]. Given these results the development of technical-tactical approaches is related to the context in which they are applied [5, 36]. The differences between educational stages may be because physical education teachers have different pedagogical characteristics [5, 36]. These differences relate to the teaching style, the role of the students, and the role of the teacher in the physical education class [5, 36].

The application of intervention programs has demonstrated numerous benefits in decision-making and tactical knowledge of sport [39, 43, 46]. A didactic approach oriented toward knowing the reason for playing contributes to the technical-tactical development of the game [35, 37, 38, 46]. Interventions show that in the control group there was no significant improvement in decision-making [39, 45]. A notable and significant improvement was observed in studies that applied situations in a real-game context [6]. These results demonstrate that the application of the Teaching Games for Understanding model is suitable for optimizing decision-making along with the technical skills of sport [3, 11, 28].

Gray and Sproule [27] presented the aim of improving tactical understanding along with tactical problem-solving decision-making within a game-practice-game format. The research results revealed effective results in motor problem solving through the application of the Teaching Games for Understanding model [27]. It has been claimed that the improvement in decision-making occurs because students in different situations understand why they should act in a particular way [27]. In addition, through this teaching model students understand their role in the game dynamics [26]. This helps students acquire a higher level of autonomy and competence [38]. Although Teaching Games for Understanding presents a stage where isolated technical skills are practised, this is done within a game context [14]. This requires learners to develop problem-solving skills and understand the purpose of practicing a technical skill [14]. Meta-analyzed studies point to improvements in decision-making related to different technical gestures [23, 33, 37, 47] as well as decision-making for different game moments [27].

Improved decision-making was one of the main reasons for the emergence of this pedagogical model [5, 28, 35, 37]. Students are at the center of learning and, consequently, their involvement increases, regardless of their level of performance in the game [38]. It is also important to teach students that decision-making is important in attacking and defending situations [27]. The effectiveness of a player without a ball has an impact on team performance and involvement [27]. This has implications not only for improvement but also for the perception of competence [27]. Gray and Sproule [27] and Dania and Harvey [42] found that students in the game-based group improved in their decision-making performance and showed a greater perception of their decision-making.

### Limitations and applicability of the research

The limitations of this research are outlined below. This study focused on research conducted over a specific time range. In addition, the studies were extracted from specific knowledge areas of the databases. This may have excluded similar research. Despite a meta-analysis of all studies, a high level of heterogeneity was observed in the different multi-group analyses performed. This was based on the low presence of research for each subgroup analysed.

The applicability of this research focuses on the application of a specific pedagogical model. It is emphasized that it provides different benefits in the physical education area and in increasing students' competence. Based on the results obtained, it would be convenient to perform future research focused on the application of pedagogical models on the technical-tactical knowledge of students.

## Conclusions

This research shows how the application of the pedagogical model of Teaching Games for Understanding is effective to work on decision making in the sports teaching process. In addition, it has been observed that the effect of this pedagogical model depending on the educational stage. A greater effect is noted for students at the university level. The educational stage at which less effect has been denoted has been in secondary education.

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**Author contributions**
EMI and GGV conceived the study. RFG and JLUJ collected the data. EMI and JLUJ analyzed and interpreted the data. GGV and RFG wrote the drafts of the manuscript. All authors read and approved the final version of the manuscript.

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**Data availability**
No datasets were generated or analysed during the current study.

## Declarations

**Consent for publication**
Not applicable.

**Competing interests**
The authors declare no competing interests.

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**References**
1. Alfrey L, O'Connor J. Transforming physical education: an analysis of context and resources that support curriculum transformation and enactment. Phys Educ Sport Pedagogy. 2024;29(1):1–17. https://doi.org/10.1080/17408989.2022.2028759.
2. Gutiérrez D, García López LM, Segovia Y, Fernández-Bustos JG, González-Martí I. Developing social and school facilitators for a positive school transition through a Sport Education and Service-Learning programme. Phys Educ Sport Pedagogy. 2024;1–16. https://doi.org/10.1080/17408989.2024.2319078.
3. Guijarro E, Evangelio C, González-Víllora S, Arias-Palencia NM. Hybridizing Teaching games for understanding and Cooperative Learning: an educational innovation. ESHPA- Educ Sport Health Phys Act. 2020;4(1):49–62.
4. Kagan S, Kagan M. Cooperative Learning. Kagan Publishing; 2009.
5. Abad Robles MT, Collado-Mateo D, Fernández-Espínola C, Castillo Viera E, Giménez Fuentes-Guerra FJ. Effects of Teaching games on decision making and skill execution: a systematic review and meta-analysis. Int J Environ Res Public Health. 2020;17(2):505. https://doi.org/10.3390/ijerph17020505.
6. Barba-Martín RA, Bores-García D, Hortigüela-Alcalá D, González-Calvo G. The application of the Teaching games for understanding in Physical Education. Systematic review of the last six years. Int J Environ Res Public Health. 2020;17(9):3330. https://doi.org/10.3390/ijerph17093330.
7. Quennerstedt M. Physical education and the art of teaching: transformative learning and teaching in physical education and sports pedagogy. Sport Educ Soc. 2019;24(6):611–23. https://doi.org/10.1080/13573322.2019.1574731.
8. Fernandez-Rio J, Iglesias D. What do we know about pedagogical models in physical education so far? An umbrella review. Phys Educ Sport Pedagogy. 2022;1–16. https://doi.org/10.1080/17408989.2022.2039615.
9. Arufe-Giráldez V, Sanmiguel-Rodríguez A, Ramos-Álvarez O, Navarro-Patón R. News of the pedagogical models in Physical Education—A quick review. Int J Environ Res Public Health. 2023;20(3):2586. https://doi.org/10.3390/ijerph20032586.
10. Parkes C, Hemphill MA. Hardcore coaching and hardcore fitness-oriented preservice teachers delivery of teaching games for understanding. Phys Educ Sport Pedagogy. 2023;1–15. https://doi.org/10.1080/17408989.2023.2194908.
11. Gil-Arias A, Harvey S, García-Herreros F, González-Víllora S, Práxedes A, Moreno A. Effect of a hybrid teaching games for understanding/sport education unit on elementary students' self-determined motivation in physical education. Eur Phy Educ Rev. 2021;27(2):366–83. https://doi.org/10.1177/1356336x20950174.
12. Gil-Arias A, Diloy-Peña S, Sevil-Serrano J, García-González L, Abós Á. A hybrid TGfU/SE Volleyball teaching unit for enhancing motivation in physical education: a mixed-method approach. Int J Environ Res Public Health. 2020;18(1):110. https://doi.org/10.3390/ijerph18010110.
13. Thorpe R, Bunker D, Almond L. Rethinking games teaching. Loughborough; 1986.
14. Morales-Belando MT, Kirk D, Arias-Estero JL. A systematic review of teaching games for understanding intervention studies from a practice-referenced perspective. Res Q Exerc Sport. 2022;93(4):670–81. https://doi.org/10.1080/02701367.2021.1897066.
15. Ortiz-Gómez OR, Nuñez-Enriquez O, Candía-Luján R, Nájera-Longoria RJ, Valenzuela-Jurado F, Santos-Sambrano G. Teaching games for understanding (TGfU) as comprehensive teaching method in physical education: systematic review of the last 5 years). Retos. 2023;48:374–9. https://doi.org/10.47197/retos.v48.97137.
16. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;71. https://doi.org/10.1136/bmj.n71
17. Riva JJ, Malik KMP, Burnie SJ, Endicott AR, Busse JW. What is your research question? An introduction to the PICOT format for clinicians. J Can Chiropr Assoc. 2012;56(3):167–71.
18. Higgins JPT, Altman DG, Gotzsche PC, Juni P, Moher D, Oxman AD, et al. The Cochrane collaboration's tool for assessing risk of bias in randomised trials. BMJ. 2011;343(2):5928–5928. https://doi.org/10.1136/bmj.d5928.
19. Hedges LV, Olking I. Statistical methods for Meta-Analysis. Academic; 2012.
20. Sánchez-Meca J, Botella-Ausina J. Meta-análisis en ciencias sociales y de la salud. Dykinson; 2015.
21. Fleiss JL. Statistical methods for rates and proportions. Wiley; 1981.
22. Cohen J. A coefficient of agreement for nominal scales. Educ Psychol Meas. 1960;20(1):37–46. https://doi.org/10.1177/001316446002000104.
23. French KE, Werner PH, Taylor K, Hussey K, Jones J. The effects of a 6-week unit of tactical, skill, or combined tactical and skill instruction on badminton performance of ninth-grade students. J Teach Phys Educ. 1996;15(4):439–63. https://doi.org/10.1123/jtpe.15.4.439.
24. Chatzopoulos D, Drakou A, Kotzamanidou M, Tsorbatzoudis H. Girls' soccer performance and motivation: games vs technique approach. Percept Mot Skills. 2006;103(2):463–70. https://doi.org/10.2466/pms.103.2.463-470.
25. Chatzopoulos D, Tsorbatzoudis H, Drakou A. Combination of technique and games approaches: effects on game performance and motivation. J Hum Mov Stud. 2006;50:157–70.
26. Harvey S, Cushion CJ, Wegis HM, Massa-Gonzalez AN. Teaching games for understanding in American high-school soccer: a quantitative data analysis using the game performance assessment instrument. Phys Educ Sport Pedagogy. 2010;15(1):29–54. https://doi.org/10.1080/17408980902729354.
27. Gray S, Sproule J. Developing pupils' performance in team invasion games. Phys Educ Sport Pedagogy. 2011;16(1):15–32. https://doi.org/10.1080/17408980903535792.
28. Psotta R, Martin A. Changes in decision-making skill and skill execution in soccer performance: the intervention study. Acta Gymnica. 2011;41(2):7–15. https://doi.org/10.5507/ag.2011.008.
29. Nathan S. Effect of pedagogical model on Indian and Malaysian junior hockey players' decision making and skill execution. Int J Kinesiol Sports Sci. 2015;3(3):43–53. https://doi.org/10.7575/aiac.ijkss.v.3n.3p.43.
30. Miller A, Christensen EM, Eather N, Sproule J, Annis-Brown L, Lubans DR. The PLUNGE randomized controlled trial: evaluation of a games-based physical activity professional learning program in primary school physical education. Prev Med. 2015;74:1–8. https://doi.org/10.1016/j.ypmed.2015.02.002.
31. Miller A, Christensen E, Eather N, Gray S, Sproule J, Keay J, et al. Can physical education and physical activity outcomes be developed simultaneously using a game-centered approach? Eur Phy Educ Rev. 2016;22(1):113–33. https://doi.org/10.1177/1356336x15594548.

32. Miller A, Harvey S, Morley D, Nemes R, Janes M, Eather N. Exposing athletes to playing form activity: outcomes of a randomised control trial among community netball teams using a game-centred approach. J Sports Sci. 2017;35(18):1846–57. https://doi.org/10.1080/02640414.2016.1240371.
33. López-Lemus I, Práxedes A, del Villar F. Effect of an Intervention Teaching Program, based of TGFU Model, on the cognitive and execution variables in the Physical Education Context. Eur J Hum Mov. 2016;37:88–108.
34. Nathan S. Badminton instructional in Malaysian schools: a comparative analysis of TGfU and SDT pedagogical models. Springerplus. 2016;5(1). https://doi.org/10.1186/s40064-016-2872-3.
35. Práxedes A, Moreno A, Sevil J, García-González L, Del Villar F. A preliminary study of the effects of a comprehensive teaching program, based on questioning, to improve tactical actions in young footballers. Percept Mot Skills. 2016;122(3):742–56. https://doi.org/10.1177/0031512516649716.
36. Morales-Belando MT, Arias-Estero JL. Effect of teaching races for understanding in youth sailing on performance, knowledge, and adherence. Res Q Exerc Sport. 2017;88(4):513–23. https://doi.org/10.1080/02701367.2017.1376032.
37. Ashraf O. Effects of Teaching games for understanding on tactical awareness and decision making in soccer for college students. Sci Mov Health. 2017;17(2):170–6.
38. Dorak F, Yildiz L, Canpolat AM, Yüzbaşıoğlu Y, Vurgun N. A comparison of the Tactical Game Approach and the direct teaching models in the teaching of Handball: cognitive – psychomotor field and game performance. World J Educ. 2018;8(3):76. https://doi.org/10.5430/wje.v8n3p76.
39. Guijarro-Romero S, Mayorga-Vega D, Viciana J. Tactical learning in invasion sports in physical education: influence of students' baseline. Mov. 2018;24(3):889. https://doi.org/10.22456/1982-8918.79839.
40. Morales-Belando MT, Calderón A, Arias-Estero JL. Improvement in game performance and adherence after an aligned TGfU floorball unit in physical education. Phys Educ Sport Pedagogy. 2018;23(6):657–71. https://doi.org/10.1080/17408989.2018.1530747.
41. Calábria-Lopes M, Greco PJ, Pérez-Morales JC. Teaching games for understanding in basketball camp: the impact on process and product performance. [Teaching games for understanding en un campamento de baloncesto: impacto en El rendimiento del proceso y del producto]. Rev Int Cienc Deporte. 2019;15(56):209–24. https://doi.org/10.5232/ricyde2019.05606.
42. Gouveia ER, Gouveia BR, Marques A, Kliegel M, Rodrigues AJ, Prudente J, Lopes H, Ihle A. The effectiveness of a tactic games approach in the teaching of invasion games. J Phys Educ Sport. 2019;19(3):962–70. https://doi.org/10.7752/jpes.2019.s3139.
43. Dania SH, Harvey S. Teaching basketball to sampling-year athletes: a game-centered and situated learning perspective. J Phys Educ Sport. 2020;20(2):529–38. https://doi.org/10.7752/jpes.2020.02079.
44. Hastie PA, Wang W, Liu H, He Y. The effects of play practice instruction on the badminton content knowledge of a cohort of Chinese physical education majors. J Teach Phys Educ. 2022;41(3):347–55. https://doi.org/10.1123/jtpe.2021-0075.
45. Sgrò F, Barca M, Schembri R, Coppola R, Lipoma M. Effects of different teaching strategies on students' psychomotor learning outcomes during volleyball lessons. Sport Sci Health. 2022;18(2):579–87. https://doi.org/10.1007/s11332-021-00850-8.
46. Pan Y-H, Huang C-H, Hsu W-T. A comparison of the learning effects between TGfU-SE and TGfU on learning motivation, sport enjoyment, responsibility, and game performance in physical education. Front Psychol. 2023;14:1165064. https://doi.org/10.3389/fpsyg.2023.1165064.
47. Devrilmez E, Li W, Dervent F, Çabıtçı M, Chen S. Effects of situated game teaching through set Plays on badminton tactical knowledge, technical ability, and game performance among Turkish secondary school students. J Teach Phys Educ. 2024;1–11. https://doi.org/10.1123/jtpe.2023-0279.
48. Egger M, Smith GD, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. BMJ. 1997;315(7109):629–34. https://doi.org/10.1136/bmj.315.7109.629.
49. Fernández-Castilla B, Declercq L, Jamshidi L, Beretvas SN, Onghena P, Van den Noortgate W. Detecting selection bias in meta-analyses with multiple outcomes: a simulation study. J Expe Educ 2021 89(1), 125–44. https://doi.org/10.1080/002209732019.1582470
50. Molina-Arias M. Aspectos metodológicos Del metaanálisis. Rev Pedi Aten Pri. 2018;20:297–302.
51. Borenstein M, Hedges LV, Higgins JPT, Rothstein H. Introduction to Meta-Analysis. Wiley; 2021.
52. McDonald B. (2002). A Teching Note on Cook's Distance- A Guideline. Res. Letters Inform Mathe Sci, 2002; 3: 122–128.

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