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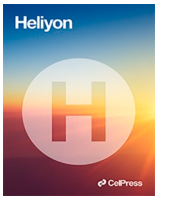

Research article

Factors affecting outdoor physical activity (OPA) in children and adolescents: A systematic review and meta-analysis

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ABSTRACT

Aim: The outdoor physical activity (OPA) of children and adolescents in the "Z" era decreased sharply compared with the previous generation, and the purpose of this study is to explore the factors that influence children and adolescents' participation in OPA.
Method: For this systematic review and meta-analysis, we searched Eric, PsycArtical, PsycINFO, Pubmed, Pubmed, Medline, SCOPUS, Web of Science Core Collection, CNKI, and the search ending date was March 20, 2024.The quality of the evidence was assessed with the crosssectional study tool (Appraisal tool for Cro-SS-Sectional Studies, AXIS).Employing meta-analysis to evaluate the strength of evidence for the influencing factors.
Results: Results show that, in the dimension of basic demographic characteristics, parents' educational level and family income are significant factors affecting children and adolescents' participation in OPA. In the dimension of family characteristics, parents' attitudes towards their children and adolescents' participation in OPA, as well as their encouragement and support, are significant factors influencing participation, but the factor of parents' attitudes is unstable. In the dimension of perceived social environment, perceived community cohesion, community safety, and peer support are significant factors affecting children and adolescents' participation in OPA, but the factors of community safety and peer support are unstable. In the dimension of the physical environment, access to activity facilities is the only significant influencing factor.
Suggestion: The factors affecting the participation of children and adolescents in OPA are relatively complex. It is suggested to consider building child-friendly communities from many aspects to increase OPA for children and adolescents to enhance their physical health and mental health.

1. Introduction

The World Health Organization (WHO) recommends that children and adolescents participate in at least 1 h of moderate-intensity physical activity (MVPA) per day to maintain and promote healthy physical development [1]. However, due to the change in parents' parenting concept and the increase of electronic devices, sedentary behavior and physical activity have increased since the "Z" era, seriously affecting their physical and mental health. Outdoor physical activity (OPA), especially outdoor free play, as a popular physical activity among children and adolescents, has been proven by many studies as a convenient, readily available, and effective

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means to promote the participation of children and adolescents in MVPA [2]. OPA refers to children and adolescent's active or passive physical activities in outdoor environments (community, courtyard, park, playground etc.) in their spare time, including free play, adventure games, and independent action. These outdoor physical activities are essential in children's and adolescents' physical and mental development. Studies have shown that children and adolescents who regularly participate in OPA perform better in physical performance, such as muscle strength, bone development, motor development, physical coordination and agility [3,4]At the same time, they can also develop social skills, cognitive ability, navigation ability, and self-protection ability in outdoor physical activities [5]。

However, because OPA for children and adolescents is conducted in an open environment and has limited parental supervision, parents usually play a role of "gatekeepers". Although parents know their children can benefit from OPA participation, they will also limit their OPA for safety reasons. Based on Sails's [6]Social and ecological theory, behavioral development in children and adolescents is influenced by multiple factors centered on parental perceived safety.Both the distal social environment (such as community economic status, social security, community cohesion, social contact satisfaction, etc.) and the proximal social environment (such as parents' views on outdoor games, the number of siblings, etc.) also include the distal physical environment (urban center, urban green space, pool, etc.) and the proximal physical environment (type of residence, home gardens, electronic equipment, pet excreta, etc.)

Socioecological theory suggests that the factors affecting OPA in children and adolescents are multi-dimensional. First, many studies have shown that the parent-perceived physical and social environment of the neighborhood have an essential impact on OPA, such that children with poorer parental-perceived neighborhood walking facilities have less chance to perform OPA in the neighborhood [7]; Children and adolescents whose parents perceived greater community cohesion had more opportunities to perform an OPA in the community [8]. Secondly, parents' own factors also influence OPA in children and adolescents [9]. Parents with higher education and better economic status are more reluctant to allow their children to participate in OPA than those with lower education and poor economic status. Of course, the characteristics of children and adolescents also influence their participation in OPA. Older children, boys, and children in better physical health had more opportunities to participate in OPA than younger children, girls, and poor subject health [10]。

Despite the abundance of research results on the factors of OPA in children and adolescents, many studies's result that focus on a specific factor are inconsistent, such as Aggio [10]'s study noted that boys had more opportunities to participate in OPA than girls, while in Lingyi Qiu's study [11],there is no difference in gender among children and adolescent participation in OPA was found.In addition, the results were inconsistent due to differences in study types (included cross-sectional, longitudinal and cohort studies), study sample and regional cultures. Although Karolina B [12] has conducted a systematic review about factors concerning parental child and adolescent involvement in outdoor play, evidence of findings is limited given the absence of literature from Europe and Asia region and using only a systematic review approach. To date, there is a lack of literature that employs a meta-analytic approach to investigate the factors influencing children and adolescents' participation in OPA. Consequently, this study employs a combination of semi-quantitative and meta-analysis methodologies to comprehensively evaluate the determinants of children and adolescents' engagement in OPA. The objectives of the study are as follows: 1) To build upon the findings of previous research by incorporating the most recent literature, including studies focused on the Asian region, to conduct a comprehensive systematic review of the factors affecting children and adolescents' participation in OPA; 2) More significantly, to utilize an evidence-based approach by conducting a meta-analysis of studies that employ the same outcome measures, thereby deriving evidence-based conclusions that are more persuasive than a systematic review alone. The significance of this research lies in: 1) Identifying which variables within the social-ecological framework are directly associated with children and adolescents' participation in OPA; 2) More importantly, it aims to provide evidence for the development of effective interventions and policies at the national, community, and familial levels.

2. Materials and methods

2.1. Study design

By retrieving literature on factors affecting children and adolescents' participation in OPA, we systematically evaluated these influencing factors using a semi-quantitative approach, and further provided evidence through meta-analysis. The systematic review and meta-analysis strictly adhered to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) principles.

2.2. Literature search strategy

According to the study topic, Eric, PsycArtical, PsycINFO, Pubmed, Pubmed, Medline, SCOPUS, Web of Science Core Collection, CNKI (China National Knowledge Infrastructure), and the search ending date was March 20, 2024. The literature in each database spans from the inception of the database to the end date of the search.Search restrictions included peer review, English or Chinese, and academic journal articles. The Chinese keywords were "儿童" "青少年" "父母" "户外活动" "户外身体活动" "户外玩耍" "自由玩耍" "冒险游戏" "独立行动".The corresponding English keyword is "children," "adolescence," "parent/parents/maternal/paternal/," "outdoor activity," "outdoor physical activity," "outdoor play," "free play," "risk play," "independent mobility," The Boolean logical retrieval link is used between the keywords. All the retrieved documents were imported into the literature management software EndnoteX9 for screening.

2.3. Literature inclusion and exclusion criteria

The literature included in the systematic review and Meta-analysis must meet the following criteria according to the principles of PICOS: 1) the study subjects is healthy children and adolescents with a maximum age of 17 years; 2) the dependent variables must be factors affecting the participation of children and adolescents in OPA, such as parental perceived neighborhood physical environment or social environment; 3) the independent variables must report the results of the time, frequency or accelerometer measurement of OPA participation of children and adolescents; 4) the quantitative research methods such as crosssectional or longitudinal studies; 5) English or Chinese. Exclusion criteria include 1) meetings, books, and dissertations; 2) qualitative research; and 3) non-English or Chinese literature.4)To conduct a meta-analysis, the literature included in the systematic review was further filtered. The exclusion criteria comprised studies that did not provide data suitable for meta-analysis, such as those unable to supply odds ratios (OR) and 95 % confidence intervals. Additionally, studies reporting an outcome measure that could not be combined with other literature due to being the sole report of that particular outcome were also excluded.

2.4. Selection of the literature

The study selection process was done in three steps by two independent researchers: (1) title

screening, (2) abstract screening, and (3) full-text screening. The studies were screened by considering the eligibility criteria. If all mentioned criteria have been met, the article was included in the systematic review. Any disagreement was solved by discussion of both reviewers and if necessary by also discussing with a third reviewer. If there were slightest ambiguity regarding exclusion the study was taken over in the next step. Every step was documented in EndNote (X9).

2.5. The extraction of the data

Collect relevant data from the included study literature, including document name (year), country, sample size, gender, age, measures of dependent variables (method of measuring OPA), and study results. In addition, EXCEL is used to record and evaluate the quality of the literature.

2.6. Quality evaluation of the included literature

Two independent researchers evaluated the methodological quality of the included literature. Since most of the included literature were cross-sectional study designs, the literature quality was evaluated using a modified version of the cross-sectional study tool (Appraisal tool for Cro-SS-Sectional Studies, AXIS) [13]. The AXIS scoring tool provides a multi-dimensional evaluation for the introduction, methods, results, and literature discussion. For the content of this study, the Karolina B was used [12]. The modified version of et al. has 18 entries, including criteria for sample size, target population, selection process, statistical method, or data description. The specific scoring rules are as follows: if the criteria of an entry are fully met, the entry will get 1 point; if the part is satisfied, it will get 0.5 points; and if the criteria are not transparent or not applicable, the score will be 0. Finally, the composite score was calculated as the percentage of those meeting the quality criteria. Studies with scores of 66.7 % were classified as 'high quality', between 50 % and 66.6 %, and below 50 % were classified as 'low quality' [14,15]. In order to ensure the researchers' correct understanding of the evaluation items, two English teachers from the School of Foreign Languages were invited to translate according to the Chinese context and semantics.

2.7. Results analysis and integration of the included literature

First, a systematic review of the included literature was performed by semi-quantitative methods. As follows: If 60–100 % of the samples included in the analysis provide significant associations in the same direction, a positive (+), negative (−), or no relationship is assumed. If 60–100 % of the included studies are all high-quality, the results will be seen as solid evidence. If only 34–59 % of the analyzed samples reported significant associations, the results were assessed as inconsistent with the expected direction. It was classified as unrelated if 0–33 % of the sample showed a significant association between parental correlation and outdoor play. Moreover, in agreement with previous studies, the evidence was rated as very limited if less than three samples were available to describe the association [16]。

Second, extracting available data according to the different dimensions of factors that affect children and adolescents' OPA.,and a meta-analysis was performed. Effect sizes in the Meta-analysis included the OR value in the Logistic regression and its 95%CI, the Pearson correlation coefficient in the correlation analysis, and its sample size. If the heterogeneity test results are $p < 0.05$, a random effect model was used for analysis; otherwise, a fixed effect model, when $p > 0.05$.The combined significance was judged by $p < 0.05$. For results with significant differences after combination, further analysis will be conducted:1)For combined results with high heterogeneity, we will conduct sensitivity analyses to explore them.2)We use Egger's test to examine publication bias. If publication bias is present, we discuss it using the trim-and-fill method.3)When random effect model was used,and its heterogeneity was high,we also used prediction intervals (PI) in our meta-analysis, aiming to compare the differences between prediction intervals and confidence intervals, and to discuss the extent to which the effect sizes of future new studies fall within the prediction intervals, thereby providing evidence for the development of future intervention measures.

2.8. Sub-group analysis

In the Meta-analysis, sub-group analyses will be conducted on the following influencing factors: gender(boy VS girl),parents educational level(medium level VS other),family income(low income VS high income),parent attitude towards to OPA of children and adolescent(positive VS negative),parent's encourage and support(agency report VS self-report. This factor is classified as a perceived factor, and specifically, there may be significant differences between the degree of encouragement and support parents provide to children and the degree children perceive.),peer support, parental encouragement and support), peer support(weekends VS weekdays, children and adolescents often participate in OPA with their peers on weekends or after school, therefore, there may be some differences in the reports of whether the subjects engaged in OPA on weekends versus non-weekends.

Different types of effect sizes are required for the Meta-analysis so that the analysis will be performed in the CMA (Comprehensive Meta-analysis) software.

Finally, the systematic review evaluation and meta-analysis results were integrated to explore the factors affecting OPA in children and adolescents comprehensively.

3. Results

3.1. Literature search results

Using keywords in eight electronic databases, a total of 3661 literature, eliminate duplicate literature remaining 2401 by reading the title, abstract, and full-text review; the last has 41 qualified literature. After the manual search, the associated literature supplement 4 study, finally included 45 articles, and among that can be used for Meta-analysis of literature are 20, as shown in Fig. 1.

3.2. Basic characteristics of the included studies

A total of 31 articles were published in the last 10 years, Accounting for 68.9 %, Mainly in the United States, Canada, and Australia, And were mostly crosssectional studies (88.9 %); of 21 articles with a sample size of more than 1000 people, For 46.7 %, Large age span of the subjects (2–17 years), 26 articles of boys greater than 50 %, OPA was mainly in the form of duration (46.7 %), OPA was mostly reported by parental proxy (71.1 %), 35.6 % of the literature reported OPA for children and adolescents on weekdays and weekends,

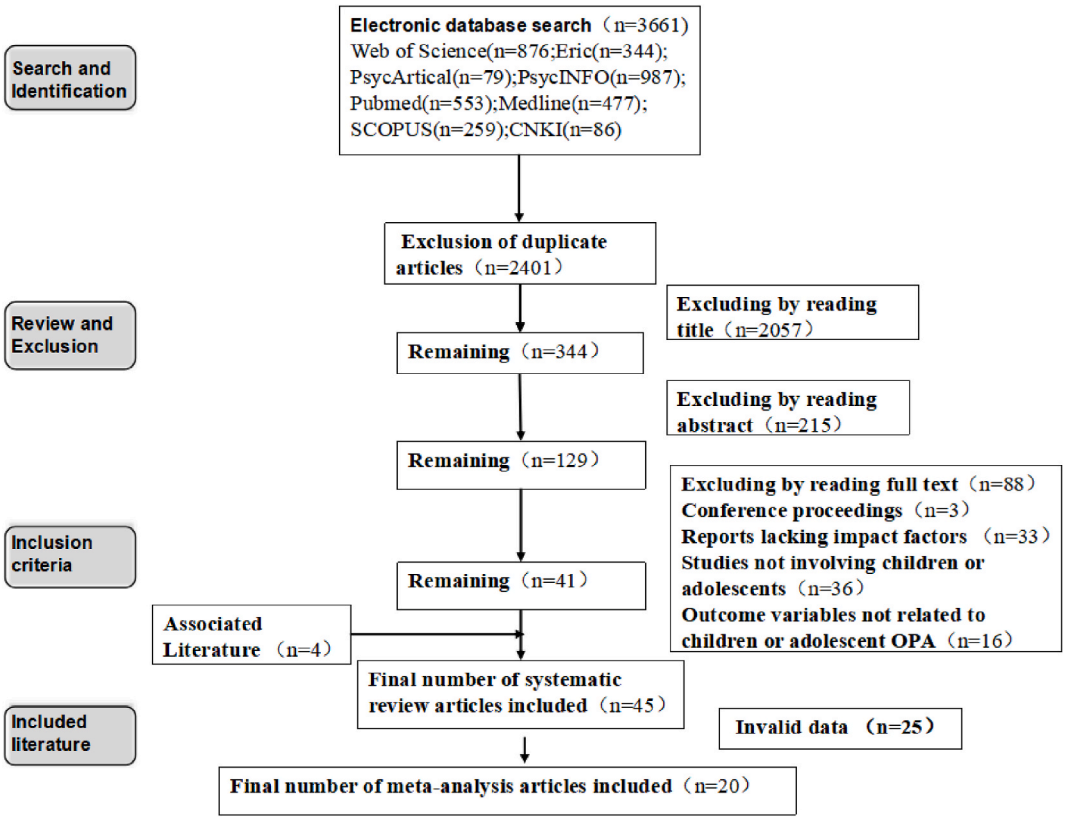

Fig. 1. Flow chart of the included literature search.

respectively, Other basic characteristics of the included literature are shown in Table 1.

3.3. Methodological quality evaluation of the included literature

The quality of the included documents was "medium" or "high". Specifically, 16 documents were rated as medium quality, accounting for 35.6 %, and 30 were rated as high quality, accounting for 66.7 %. The consistency of the two literature quality reviewers was 91 %, see Table 2. Most of the literature is fully consistent with entries clearly describing the study purpose, the clear definition of the target population, the appropriateness of selecting relevant variables and outcome variables, the description of the study findings, and the discussion of study limitations. Since some of the literature is studied using panel data, there is a lack of response rate to the questionnaire and treatment measures for non-responders. In addition, only a small amount of literature reports the reliability of instruments measuring OPA factors and OPA outcome variables (e. g. ICC and Cronbach's α coefficient)

Table 1
Characteristics of included studies.

Basic characteristics of literature	Literature code	Quantity and proportion
The year of publication		
In 2019–2023	[4,7–9,11,11,15,17,18,18,19,19,20,20,21,21–25,27,28,30,32]	12(26.7 %)
In 2014–2018	[3,6,7,10,12–14,23–27,27–29,29–31,31–33,33–35,35–37,37–40,40–42, 42–45]	19(42.2 %)
Before the year of 2013	[1,2,5,8,10,16,17,22,26,34,36,38,39,41,43–56]	14(31.1 %)
Regional and National		
The American region	US [5,10,12,14,16,18,23,28,34,38,41,43] Canadian [7,8,11,13,15,20,37,42,45]	21(46.7 %)
European region	UK [3,39,40] Netherlands [1,2,25,44] Danish [4] German [19,32] Cyprus [35] Switzerland [36]	12(26.6 %)
Asia	China [21,30] Japan [27]	3(6.7 %)
Oceania area	Australian [6,9,17,22,24,26,29,31,33]	9(20 %)
Type of study design		
crosssectional study	[1–21,23,26–32,34–44] [45]	40(88.9 %)
longitudinal research	[22,24,25,33]	5(11.1 %)
Sample size		
>1000	[1–4,8–10,15,17,25,28,30–32,34,36,38,41,44,45]	21(46.7 %)
<1000	[5–7] [11–14,16,18–24,26,27,29,33,35,37,39,40,42,43]	24(53.3 %)
age		
Infants (0–6 years old)	[1,2,8–10,12,15,16,18,19,21,22,25,27,29,30,32] [33] [34,36,38,41,44,45]	25(55.6 %)
Children (aged 7–12 years)	[1–9,11,13,14,17,18,20,21,23,25–28,31,32,35–37,39,40,42,43]	30(66.7 %)
Youth (aged 13–18 years)	[4,6–9,11,13,18,20,23,32,36]	12(26.7 %)
sex		
Boys> 50 %	[1–4,8,11–13,15,16,19,23–26,28–31,33,34,38,39,41,42,44]	26(57.8 %)
Boys <50 %	[5–7,9,14,17,18,20,22,27,32,35–37,40,43,45]	17(37.8 %)
not described	[10,21]	2(4.4 %)
Measuring the form of the OPA		
frequency	[4,6–8,15,18,23,32,38,42,43]	11(24.4 %)
duration	[1,2,9–12,14,16,17,22,24,29,30,33,34,36,37,40,41,45]	21(46.7 %)
Frequency and duration	[19,25,26,35,44]	5(11.1 %)
Objective measurement (accelerometer, GPS)	[5,13,20,23,26,35,37]	7(15.6 %)
Allowed or not allowed	[3,21,27,28,31,39]	6(13.3 %)
The time period for which the OPA was measured		
day	[10,34,45]	3(6.6 %)
Weekdays and weekends were measured separately.	[1,5,9,16,21,22,24–26,29,33,36,37,40,41,44]	16(35.6 %)
No matter of weekdays or weekends	[2–4,6–8,11–15,17–20,23,27,28,30–32,35,38,42,43]	25(55.6 %)
not described	[39]	1(2.2 %)
OPA		
Self-report of children	[5,11,13,15,17,19,32,35,39,40,43]	11(24.4 %)
Parents report	[1–4,6,7,9,10,12,16,18,20–31,33,34,36–38,41,42,44,45]	32(71.1 %)
Children and the parents were reported simultaneously	[8,14]	2(4.5 %)

Note: (1) Age: Due to the large age span of the research subjects in some literature, such literature will appear in different age characteristics at the same time, so the sum of the proportion is not equal to 100; (2) OPA measurement form: some literature use different measurement forms, so the sum of the proportion is not equal to 100. The sum of the remaining features is 100.

Table 2
Results of methodological quality Assessment for included studies.

Document serial number	score	Score ratio	ranking	Document serial number	score	Score ratio	ranking
1	13	0.722	High	24	11.25	0.625	Medium
2	13	0.722	High	25	12.75	0.708	High
3	13	0.722	High	26	13	0.722	High
4	14.5	0.806	High	27	15.5	0.861	High
5	12.75	0.708	High	28	14	0.778	High
6	11.75	0.653	Medium	29	13.75	0.764	High
7	11	0.611	Medium	30	13	0.722	High
8	13.5	0.750	High	31	13.5	0.750	High
9	12.75	0.708	High	32	14	0.778	High
10	11.75	0.653	Medium	33	11.75	0.653	Medium
11	13.5	0.750	High	34	13.75	0.764	High
12	12.25	0.681	High	35	12.75	0.708	High
13	14.75	0.819	High	36	11	0.611	Medium
14	13.25	0.736	High	37	12	0.667	Medium
15	14	0.778	High	38	12	0.667	Medium
16	9.75	0.542	Medium	39	11.25	0.625	Medium
17	14.25	0.792	High	40	12.25	0.681	High
18	11.5	0.639	Medium	41	11.25	0.625	Medium
19	13.75	0.764	High	42	13.5	0.750	High
20	12.75	0.708	High	43	12.5	0.694	High
21	10.5	0.583	Medium	44	14.25	0.792	High
22	11.25	0.625	Medium	45	12	0.667	Medium
23	10.5	0.583	Medium				

Note: "score" is the sum of scores for each item; "score ratio" is the ratio between the total score and full score; "rating" is assessed according to the score ratio in three grades:> 66.7 % (high-quality study), 50–66.6 % (medium quality study) and <50 % (low-quality study).

3.4. Systematic review results

Based on socioecological theory and a review of the included literature, four dimensions were identified as influencing factors affecting children and adolescents, including basic demographic characteristics, family characteristics, perceived social environment, and physical environment. Different factors under the four dimensions were systematically analyzed by a semi-quantitative systematic review method, and the analysis results are shown in Table 3.

The results showed that in the fundamental population characteristics dimension, no factors related to OPA in children and adolescents, gender, parental education level, and family economic income had an uncertain positive relationship with OPA, and it cannot be determined whether parental work status was associated with OPA.

In the family trait dimension, parents' positive attitudes towards childhood and adolescent OPA were positively associated with OPA. Second, parental encouragement and support were positively associated with child and adolescent OPA; child screen time and the number of electronic devices in the home and vehicle situation in the family were not associated with OPA.

In the perceived social environment dimension, community cohesion and collective efficacy, perceived community safety, and peer support had positive associations with childhood and adolescent OPA. In the physical environment dimension, the trail facilities in the neighborhood were positively associated with child and adolescent OPA, uncertain whether traffic conditions were positively associated with OPA and whether the activity facilities were not associated with OPA. Identified that the built environment has a positive relationship with the OPA.

3.5. Meta-analysis

3.5.1. Basic meta-analysis and subgroup analysis

To enhance the strength of evidence for the results of the semi-quantitative systematic review, the pooled analysis of the literature that could extract the data available for Meta-analysis was performed, and the results are shown in Table 4.

(1) Dimension of basic characteristics of population

In the dimension of basic population characteristics, there was still no relationship between child gender and parental working status and OPA, and there is no significant relationship between parents' educational level and children and adolescents' OPA. However, when the educational level is divided into those with a secondary education and other educational levels for sub-group analysis, it is found that parents with a secondary education significantly reduce their children and adolescents' OPA,OR = 0.85 (95%CI:0.72–0.99), whereas no significant relationship is observed for parents with other educational levels,OR = 1.12(95% CI:0.68–1.83),overall PI is 0.42–1.80,Egger's test show that there is no publication bias(Table 5).Family income significantly predicts children and adolescents' OPA,OR = 1.43((95%CI:1.32–1.55). When it is divided into low-income and high-income families for sub-group analysis, the results show that both high-income(OR = 1.52,95%CI:1.20–1.93) and low-income families(OR = 1.42,95% CI:1.31–1.54) can significantly predict children and adolescents' OPA.However, the prediction interval being 0 suggests that the

Table 3
Systematic review of the factors influencing children and adolescents participating in OPA.

Factor	Relationship with child and adolescent participation in the OPA			The strength of the evidence	
	positive correlation (+)	Irrelevant (0)	negative correlation (−)	n/N(%)	relativity
Basic characteristics of a population					
Gender					
boy	[3,22,29,30,37,39,40]		[45]	7/14(50)	+?
girl			[31,36,38]		
no relationship		[15,17,28]			
Parents with secondary education	[8,14,27,45]	[26,30,30,31]	[2,36,38,44,44]	5/13(38)	- ?
low-income family	[3,15,40,44]	[8,37,45]	[39]	4/8(50)	+?
parents working status	[17,37]	[26,28,44]	[10,38,46]	3/7(43)	?
Family characteristics					
Health status of children		[3]	[10,28]	2/3	N/A
Attitude of parents (positive)	[2,11,12,25,29]			5/5(100)	++
Attitude of parents (negative)			[28]	1/1	N/A
Parents' encouragement and support	[5,7,14,16,19,22,30,32,34,35,38,43]	[26,29]		12/14 (86)	++
Screen time and electronic devices	[2,40]	[3,29,30,38,41]	[25]	5/8(63)	0
Family vehicles		[28,36,37]	[24]	3/4(75)	0
There are pets at home	[2]	[28]		1/2(50)	N/A
Perceive the social environment					
Strict education	[42]		[6]	1/2(100)	N/A
social communication	[9,22,25]			3/3(100)	N/A
Community cohesion and collective efficacy	[2,9–11,23,31]	[6,28]		6/8(75)	++
Community security	[2,6,14,17,24,26,28,37]			8/8(100)	++
Social crime		[26,28]		2/2(100)	N/A
Neighborhood trust	[15,20]			2/2(100)	N/A
Companion support	[19,26,28,28,32,32,35,38]	[3]		8/9	++
stranger			[28,37]	2/2(100)	N/A
physical environment					
Trail facilities	[1,9,20,37]	[28]	[13]	4/6(67)	++
traffic condition	[1,4,13,25,36]	[24,28,40]	[37]	5/9(56)	+?
Green vegetation	[2,6,21]			3/3(100)	N/A
architectural environment	[2,18,21,36]			4/4(100)	+
Activity facilities	[2,24,25,29,30]	[1,28,28,28,33,37]		6/11(55)	0?

Note: n/N (%) represents the proportion of the literature with relevant results (positive, negative, or irrelevant) in the literature studying this influencing factor. If the proportion is 60 %–100 %, the influencing factor is considered to be positively, negatively, or not related to OPA, expressed by +, -, and 0, respectively; if the proportion is 34 %–59 %, it is not confident whether the influencing factor has a positive, negative or unrelated relationship with OPA, using +, respectively?、-?And 0? Representation: If the proportion is 0 %–33 %, the influencing factor is unrelated to child and adolescent OPA. N/A indicates that less than 3 articles are studying this influencing factor, and the relevant conclusions cannot be drawn.+ + indicates that this influencing factor has a positive correlation with children's participation in OPA and that the high-quality literature accounts for 60 %–100 %.? The number of positive, negative, or irrelevant documents in the literature representing this influencing factor is the same in both directions.

results may have some deviation. Moreover, the Egger's test indicates the possibility of publication bias. Using the trim-and-fill method, it is predicted that at least 3 more relevant studies are needed to provide solid evidence for this(Table 5).

(2) Dimension of family characteristics

There is no relationship between screen time and electric devices and OPA. And although there is no significant relationship between parents' attitudes towards children and adolescents' participation in OPA and their actual participation, when attitudes are divided into positive and negative, it is found that positive attitudes significantly increase children and adolescents' OPA,OR = 2.68 (95%CI: 1.46–4.93), and negative attitudes decrease their participation,OR = 0.48 (95%CI: 0.40–0.58),it's overall PI is 0.04–11.21. However, the results of the Egger test suggest the possibility of publication bias. After using the trim-and-fill method, when at least 2 more studies are provided for supporting the evidence(Table 5),it still exist publication bias.In addition, parental encouragement and support was also an important factor to predict OPA positively, OR = 1.61 (95%CI: 1.34–1.94). After subgroup analysis, the main cause of heterogeneity was the way of reporting OPA in children and adolescents. The results of the Egger test suggest the possibility of publication bias. When using the trim-and-fill method, the findings indicate that supplementing 2 more studies can lead to more authentic evidence(Table 5).Household vehicles had a significant negative relationship with OPA, with OR = 0.69 (95%CI: 0.51–0.94), but only 2 articles exist,so the PI is 0,the strength of the evidence is insufficient.

Table 4
Meta-analysis results of factors influencing children and adolescents' OPA.

Factors	Numbers (Piece)	Age range (years-old)	Sample size	Heterogeneity	Effect model		Results of the meta-analysis		PI
				I^2(%)	p	Random/ Fixed	OR(95%CI)	p	
Basic characteristics of population									
Gender	9	2–15	28038	82.44	0.00	random	1.05 (0.87–1.25)	0.61	1.05 (0.60–1.83)
Subgroup analysis of gender									
boy	3	3–11	14989	79.73	0.01	random	1.55 (0.94–2.55)	0.09	1.55 (0.01–519.4)
girl	2	2–15	10243	84.19	0.01	random	0.73 (0.53–1.01)	0.06	0
no relation	4	2–12	2804	20.12	0.29	fixed	1.04 (0.90–1.20)	0.62	1.05 (0.64–1.74)
Education Level	8	3–12	11797	74.10	0.00	random	1.00 (0.78–1.29)	0.95	1.00 (0.46–2.17)
Subgroup analysis of education level									
Medium level	5	3–12	11797	0.00	0.73	fixed	0.85 (0.72–0.99)	0.04[a]	0.87 (0.42–1.80)[c]
Other	3	4–17	13704	87.90	0.00	random	1.12 (0.68–1.83)	0.64	
Family income	5	3–17	29606	0.00	0.75	fixed	1.43 (1.32–1.55)	0.00[b]	0
Subgroup analysis of family income									
low income	3	3–11	27326	0.00	0.43	fixed	1.42 (1.31–1.54)	0.00[b]	
high income	2	4–17	11258	0.00	0.91	fixed	1.52 (1.20–1.93)	0.00[b]	0
Parent job	5	4–12	15750	79.64	0.00	random	0.98 (0.74–1.30)	0.90	0.98 (0.41–2.37)
Family characteristics									
Parent's attitude	5	2–11	1758	95.51	0.00	random	1.33 (0.59–2.99)	0.49	1.33 (0.06–29.81)
Subgroup analysis of parent's attitude									
Negative	2	8–11	525	56.63	0.13		0.48 (0.40–0.58)	0.00[b]	0.65 (0.04–11.21)[c]
Positive	3	2–7	1233	71.73	0.03		2.32 (1.73–3.11)	0.00[b]	
Parent's encourage and support	9	2–12	17554	52.65	0.03	random	1.61 (1.34–1.94)	0.00[b]	1.61 (0.98–2.64)
Subgroup analysis of parental encouragement support									
Agency report	6	2–9	13895	66.61	0.01	/	1.53 (1.37–1.72)	0.00[b]	1.67 (1.02–2.73)[#]
self-report	3	3–12	4178	0.00	0.86	/	1.81 (1.48–2.22)	0.00[b]	
Screen time and electronic devices	5	2–11	24436	58.66	0.05	random	0.93 (0.81–1.07)	0.33	0.93 (0.61–1.42)
Family vehicles	2	2–11	1434	50.44	0.16	fixed	0.69 (0.51–0.94)	0.02[a]	0
Perceived social environment									
Community cohesion	3	8–15	1996	32.29	0.23	fixed	1.05 (1.02–1.08)	0.00[b]	1.05 (0.19–5.63)
Community security	5	2–12	3731	87.23	0.00	random	2.26 (1.29–3.94)	0.00[b]	2.26 (0.29–17.42)
Peer support	9	3–12	26478	88.84	0.00	random	2.34 (1.75–3.13)	0.00[b]	2.34 (0.87–6.29)
Subgroup analysis of peer support									
report on weekdays and weekends	3	3–12	712	0.00	0.76	/	2.39 (1.80–3.17)	0.00[b]	2.36 (0.90–6.10)[#]
no distinction	6	3–9	26288	91.22	0.00	/	2.32 (1.60–3.36)	0.00[b]	
Physical environment									
traffic condition	4	2–11	2083	74.89	0.01	random	0.92 (0.50–1.69)	0.80	0.07–11.96
Activity facilities	7	2–5	5830	33.85	0.17	fixed	1.37 (1.12–1.67)	0.00[b]	1.37 (0.85–2.20)

Note.
[a] presented $p < 0.01$,and indicates a significant difference.
[b] presented $p < 0.001$,and indicates a very significant difference.

[c] presented overall prediction interval.

(3) Dimension of perceived social environment

In the perceived social environment dimension, community cohesion (OR = 1.05,95%CI: 1.02–1.08,with PI = 0.19–5.63)is associated with children OPA, but the results of the Egger test suggest the possibility of publication bias, after using the trim-and-fill method, when at least 1 more studies are provided for supporting the evidence(Table 5).Community safety (OR = 2.2,95%CI: 61.29–3.94) had significant positive associations with OPA,with PI = 0.29–17.42.Sensitivity analysis indicates that the heterogeneity stems from Jenny Veitch's research. After its exclusion, the heterogeneity among the studies is reduced to 17.86. The reason lies in their method of measuring children and adolescents' OPA, which involved using accelerometers combined with questionnaires, and the data only included the time period from Monday to Friday. Peer support had significant positive associations with OPA (OR = 2.3,95%CI: 1.75–3.13),with PI 0.87–6.29,but the results of the Egger test suggest the possibility of publication bias, after using the trim-and-fill method, when at least 4 more studies are provided for supporting the evidence,it still exist publication bias (Table 5). Subgroup analysis was conducted by dividing the reporting methods of children and adolescents' OPA into those that do not distinguish between weekdays and weekends and those that report weekdays and weekends separately.

(4) Dimension of physical environment

In this dimension,the activity facility was an important factor in positively predicting OPA in children and adolescents, OR = 1.37 (95%CI: 1.12–1.67),with PI 0.85–2.20,I^2 = 33.85,and Egger's test show that there is no publication bias(Table 5).

4. Discussion

Through a systematic review and meta-analysis of 45 articles on the factors affecting OPA in children and adolescents, the factors strongly predictive of OPA were initially identified in four dimensions. However, further analysis and discussion were still combined with the systematic review and meta-analysis results.

4.1. Factors influencing OPA in the dimension of basic population characteristic

Previous studies have suggested that boys have more opportunities for OPA than girls. however, some other studies have point out that child gender is unrelated to OPA, as supported by this systematic review and Meta-analysis (p = 0.06). On the one hand, it may be that due to the increase in academic burden in modern education, the OPA of both boys and girls is affected on weekdays, thus affecting the overall OPA [57]. On the other hand, the past traditional belief that boys should participate in more OPA than girls has begun to change with gender-specific increasing rates of myopia and sedentary behavior, and parents have begun to encourage girls to participate in more OPA [58]. Studies also showed that parents with secondary education were less willing to engage their children in OPA than those without, which was similar to past studies [54]. In general, the more educated the parents, the higher the family income, and they are more willing to let their children exercise in professional institute (such as schools and clubs). Conversely, families with relatively low economic income are more willing to let their children outdoors without guardianship despite perceived community safety and high community cohesion despite child safety concerns, which is also consistent with the results of this study.

Therefore, when encouraging children and adolescents to participate in OPA through intervention practices in the future, it is crucial to pay special attention to families with a secondary education level and those with a household income that is moderately high. The focus should be on publicizing the benefits that children and adolescents can gain from participating in OPA. By doing so, it can change these families' attitudes towards their children and adolescents' involvement in OPA.

4.2. Factors that influence OPA in the dimensions of basic family characteristics

Under this dimension, parental attitudes towards children and adolescents' participation in OPA and parental encouragement and support for child and adolescent OPA were significant positive predictors, broadly consistent with previous studies [48]. In terms of parents' attitudes, parents as "gatekeepers" guardianship of children's OPA, give them the participation in outdoor physical activity "license." Therefore, how parents view OPA is a critical determinant, and how parents treat children and adolescents' OPA factor is complex and is worth more in-depth study. Regarding parental encouragement and support, parental verbal encouragement, behavioral support (joint participation with children), and parental sports role models may all have a strong positive relationship with children and adolescents participating in more OPA. Unlike previous studies, no relationship was found between screen time and electronic devices and OPA in children and adolescents. The reasons may be the generally younger age of the children investigated, less exposure to electronic devices, and parents 'recognition that frequent use of electronic media can adversely affect the child's health, proactively limiting their screen time and exposure to electronic devices.

4.3. Factors that influence OPA in the perceived social environment dimension

Perceived community cohesion, perceived community safety, and peer support in children and adolescents were all influencing

Table 5
Results of publication bias test and trim &fill.

	No.	Egger's regression test						Publication bias	Trim&Fill				
Basic characteristics of population		Intercept	S.E	95%CI	t	df	p	Yes or No	Studies trimmed	OV and AV	Fixed effect	Random effect	The effect of after trim and fill
Education level	8	0.06	1.67	−4.04~4.15	0.03	6	0.97	No	/	/	/	/	/
Family income	5	0.93	0.28	0.02–1.83	3.26	3	0.04	Yes	3	OV	1.43	/	Good
										AV	1.39	/	
Family characteristics													
Parent attitude	5	8.64	3.70	−3.13~20.41	2.34	3		Yes	2	OV	/	1.33	Poor
										AV	/	0.63	
Parent encourage and support	9	0.55	1.03	−1.89~2.99	0.53	7	0.61	Yes	2	OV	/	1.61	Good
										AV	/	1.52	
Perceived social environment													
Perceived cohesion	3	0.12	1.32	−16.63–16.88	0.09	1	0.94	Yes	1	OV	1.05	/	Good
										AV	1.05	/	
Community security	5	4.80	2.04	−1.69~11.29	2.35	3	0.10	Yes	2	OV	/	2.25	Poor
										AV	/	1.42	
Peer support	9	3.46	1.68	−0.51~7.42	2.06	7	0.08	Yes	4	OV	/	2.34	Poor
										AV	/	1.72	
Physical environment													
Activity facility	7	−0.41	1.28	−3.70~2.87	0.32	5	0.76	No	/	/	/	/	/

Note:OV:Observed value; AV:Adjusted value; After using the trim-and-fill method, if the difference between the AV value and the OV value is small, it is rated as good. If the difference between the AV value and the OV value is large, it is rated as poor.

factors that positively predict OPA, consistent with previous studies [35]. This positively reflects the atmosphere of harmonious coexistence and high security in the community so that parents or guardians can give children and adolescents more "licenses" to participate in OPA, reducing parents' concerns about neighborhood crime, neighborhood trust, social interaction, and contact with strangers. In addition, having classmates or friends living nearby will also significantly increase the OPA in children and adolescents.

To promote children and adolescents' participation in OPA within the community, communities should focus on ensuring safety within the area, promoting the importance of building harmonious communities, and providing a foundation for stronger cohesion among residents. Additionally, regularly organizing community events can also enhance the sense of unity among residents.

4.4. Factors that influence the OPA in the physical environment dimension

The results of the systematic review showed that community trail facilities and built environment were positively associated with OPA, whether traffic was positively associated with OPA and OPA, and whether activity facilities and OPA were not related, but the results of the Meta-analysis identified no relationship with OPA, while activity facilities and OPA were positively related, and the inter-study heterogeneity was small. Combined with the actual situation, the OPA of children and adolescents may not be much related to whether activity facilities are nearby and the number of facilities. The reason is that the activity facilities near most homes are old and limited, so parents reduce the chances of their children's OPA because of safety concerns. On the other hand, although parents give their children the opportunity to OPA, these facilities can only meet the play needs of some children and adolescents in the neighborhood [59]. Similarly, playgrounds or schools near homes may mostly be closed to the public, suggesting that nearby activity facilities are unrelated to the OPA.

Relevant government departments should prioritize the construction, maintenance, and updating of sports and fitness facilities within the region. The accessibility of these facilities greatly influences children and adolescents' participation in OPA. If there are more activity facilities nearby, children and adolescents will have more opportunities to exercise with their peers.

4.5. Analysis of study method heterogeneity

The heterogeneity of the two study methods was found by subgroup analysis. The first is the finding that reporting childhood and adolescent OPA in parental encouragement support is the main reason for heterogeneity across the literature. Although some literature has been related to the results of self-reported and parent-proxy reported by children, it is believed that the two have some relation. However, for parental proxy reports, the father's results may differ from the mother's because, in most cultural backgrounds, fathers are less aware of the child's recent OPA than the mother. In addition, when the child can self-report, the parent will report it [51]. It is also the cause of the heterogeneity. This suggests the need to select reporting methods in future studies carefully. The second is the finding that the period of reporting OPA in peer support is the main reason for the heterogeneity. In addition to sharing OPA with their parents, children, and adolescents spend more time with their peers. During working days, parents work, and children have homework burdens, so they spend less time participating in OPA if most work with their peers near their homes. Therefore, OPA time on weekdays and weekends should be recorded separately in similar future studies to reduce bias in study findings.

4.6. Weakness of the study

According to the theory of social ecology, this paper makes a semi-quantitative systematic review and quantitative meta-analysis of the influencing factors of children and adolescents, determines the predictors of OPA of children and adolescents, provides a theoretical reference for the development of an intervention for children and adolescents to participate in more OPA policy, and found the heterogeneity of three research methods through subgroup analysis, and provides methodological suggestions for future studies to explore similar problems. However, the research still needs some improvement. First, since the studied literature is primarily observational studies, it cannot provide a conclusion about causality, which only indicates a positive or negative correlation between various factors and OPA. Secondly, only the English and Chinese literature were included, and there may be an incomplete search. Thirdly, although the meta-analysis identified factors affecting children and adolescents' participation in OPA across different dimensions, some studies' Egger test results suggest the possibility of publication bias, with a lack of studies with small sample sizes and negative results. Even after using the trim-and-fill method, there is still bias present. These dimensions should be further investigated in future research.

5. Conclusion

A total of 45 observational research articles of moderate and high quality were included in this study, and relevant predictors affecting OPA participation of children and adolescents were identified in four dimensions through a semi-quantitative systematic review and Meta-analysis methods. Regarding basic demographic characteristics, parents receiving secondary education are negatively associated with childhood and adolescent OPA, and low-income families are positively associated with childhood and adolescent OPA. In the family characteristics dimension, parental attitude towards childhood and adolescent OPA and support and encouragement were positively associated with OPA, whether households had vehicles and their number may be negatively associated with OPA, and screen time and electronic devices had no relationship with OPA. In the perceived social environment dimension, community cohesion, community safety, and peer support are positively associated with OPA, and trail facilities are positively associated with OPA in the physical environment dimension. In addition, three factors related to the study's methodological heterogeneity were also

identified: the manner of reporting OPA, the time period of reporting OPA, and the age of children and adolescents.

Based on the results of this study, policymakers aiming to promote the physical health of children and adolescents should recognize that the factors influencing their participation in OPA are multidimensional. It is important to consider not only the physical environment but also the social environment. While providing as much convenience as possible for children and adolescents to engage in fitness activities, attention should also be paid to creating a harmonious atmosphere. As for parents, they may benefit even more from this study. Parents should understand the importance of OPA for the physical health of children and adolescents and, ensuring safety, should support them in participating in various types of OPA as much as possible. To some extent, they can even encourage them to engage in adventurous games and play. Overall, parents play a significant role in the process of children and adolescents participating in OPA. They should not only act as "Gatekeepers" in this process but, more importantly, as "Wise Gatekeepers".

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Declaration of availability of data

The data that support the findings of this study are available from the corresponding author upon reasonable request.

CRediT authorship contribution statement

Jinghui Deng: Writing – original draft, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Tong Liu:** Writing – review & editing, Visualization, Supervision, Project administration, Conceptualization. **Zhengyin Long:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:Deng jinghui reports financial support was provided by National Center for Early Childhood Physical Education Development Research at Chengdu University. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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