RESEARCH ARTICLE

Analysis on Influencing Factors of Adolescents' Physical Activity from the Perspective of Social Cognitive Theory

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Abstract: Objective: To make a systematic review and meta-analysis of the literature on the influencing factors of adolescent physical activity from the perspective of social cognitive theory (SCT) model. **Methods:** The databases at home and abroad were searched, and 18 literatures meeting the requirements were included. The effect quantities were combined by Stata 15.0 software and analyzed by subgroup. **Results:** (1) SCT model could predict physical activity in a moderate degree (R^2 = 17%, $P < 0.01$, $z = 7.59$). (2) Meta-analysis of the literature including self-efficacy, barrier self-efficacy, social support and social status showed that these factors were significantly correlated with physical activity ($N \geq 75\%$). (3) Influenced by different regions, gender and statistical methods, there are heterogeneity among the research results. **Conclusion:** SCT model can predict adolescent physical activity to a moderate extent; self-efficacy, barriers self-efficacy, social support and social status are the key indicators to predict physical activity; affected by different regions, gender and cultural environment, the prediction results of SCT model on adolescent physical activity are different.

***Keywords*:** Social cognitive theory; Physical activity; Teenagers; Influencing factors; Systematic overview; Meta-analysis

1. Introduction

The Regular physical activity is crucial to the healthy development of adolescents. It is an effective means to reduce the risk of chronic diseases, reduce the incidence of cancer and obesity, and prevent mental health problems[1,2]. Although more and more evidence show that there are many benefits of participating in physical activity, the proportion of adolescents who can meet the international physical activity recommendation is not high in both developed and developing countries[3-5], and the problem of insufficient physical activity of adolescents worldwide is still serious[6,7]. Some studies[6,8] pointed out that the exercise habits formed in childhood and adolescence are likely to exist to adulthood. Therefore, developing the habit of participating in

doi: 10.18063/esp.v5i1.1394

Received: Feb 16, 2020; Accepted: Apr 10, 2020; Published online: Apr 16, 2020.

physical activity in adolescence is particularly important in the individual life cycle.

Many scholars[9-12] have studied the influencing factors of teenagers' physical activity from different angles to explore the psychological, behavioral, environmental and social factors that affect individuals' participation in physical activity. Dai *et al.*[9] explored the influencing factors of physical activity behavior of Chinese teenagers outside school from the perspective of social ecology, and found that peer support and family support at the interpersonal level, self-efficacy and activity barriers at the individual level have a direct impact on physical activity behavior, and the community environment at the community level has an indirect impact on physical activity behavior through variables such as self-efficacy, activity barriers and peer support. Han *et al.*[13] reviewed the research on physical activity of adolescents in Western countries from the perspective of social ecology, and clarified the relationship of individual, interpersonal, institutional, community and policy factors with physical activity. Wang *et al.*[14] found that due to the differences of age, exercise ability and family economic background, the influence mechanism of peer support behavior on teenagers' physical activity is different. From an international perspective, more scholars[15-17] analyze the factors affecting teenagers' physical activity behavior from the perspective of theoretical models, such as social ecological model (SEM), theory of planned behavior (TPB) and social cognitive theory (SCT), and formulate measures and methods to encourage teenagers to participate in more physical activity. It has been confirmed by studies[18] that intervention based on theoretical model is more effective than non-theoretical method.

Generally speaking, the existing research is less based on the theoretical model of health behavior promotion, and comprehensively analyzes the influencing factors of physical activity of Chinese teenagers from the perspectives of psychology, behavior and environment. Although the prediction models of influencing factors of physical activity are extensive and diverse, scholars pay more attention to social cognitive variables, because these variables are considered to be most related to behavior and easier to change than social and demographic factors. Therefore, from the perspective of SCT model, the author reviews its origin, development and application in the research of physical activity behavior, and uses the systematic review method to sort out the methodological characteristics of relevant research, then synthesizes the previous research results with meta-analysis method, so as to evaluate whether SCT model is effective for the healthy behavior of physical activity of young people, and explore the key influencing factors. In this way, we provide reference for domestic scholars in discussing the influencing factors of physical activity of Chinese teenagers and formulating effective intervention programs.

2. Overview of Social Cognitive Theory

SCT was first put forward by Stanford psychologist Bandura[19]. The theory analyzes the social basis of thought and action in detail, and holds that in addition to personal factors, environmental and social factors also promote the change of behavior[20]. The three constitute a dynamic relationship that is interactively decisive, in which the changes are caused by the differences of behavior, individual and environment. After that, Bandura[20] further expanded the SCT model from the promotion of healthy behavior (including physical activity, healthy diet, etc.). He established a multi-dimensional causal structure model, and proposed that individuals regulate their motivation and behavior through self-efficacy, outcome expectation and perceived environment promotion and hindrance (**Figure 1**). He divided the social psychological factors that affect health behavior into four categories[21,22]: (1) self-efficacy reflects the individual's judgment on whether he or she can complete a specific health behavior; (2) result expectation refers to the individual's perception of the possible results of successfully completing a certain health behavior; (3) self adjusting behaviors (goals and plans) are used for controlling and adjusting healthy behaviors; (4) perceived obstacles refer to the obstacles that individuals perceive to complete a

specific health behavior. In this causal structure model, the individual's belief in self-efficacy directly affects health behavior, and it indirectly affects health behavior through goals, outcome expectations and perceived promotion and hindrance factors[22]. Individual self-efficacy as the core factor directly or indirectly affects behavior, which is the common path of social psychological factors affecting health behavior. With the proposal and development of SCT, the theory has received extensive attention and has been effectively applied to many health behavior interventions, such as physical activity promotion, dietary habit adjustment and risk-taking behavior change of cancer patients[23-25].

From the perspective of SCT model, the author uses systematic review and meta-analysis methods to sort out, evaluate and analyze the relevant research on the influencing factors of adolescent physical activity, so as to explore the following three issues: (a) what is the overall explanatory and predictive ability of SCT model to adolescent physical activity behavior? (b) What are the key factors and variables affecting adolescents' physical activity behavior? (c) Is the effectiveness of SCT model affected by different factors?

3. Research Methods and Design

3.1. Research methods

Literature retrieval and reporting methods follow the requirements of systematic review and meta-analysis report[26].

3.1.1. Inclusion and exclusion criteria of literature

Literature inclusion criteria: (1) the measured variables include SCT model related factors and physical activity behavior. (2) The explanatory degree R^2 of the model or variable or regression coefficient β value is provided in the results. (3) The respondents were adolescents (the average age was 11-18 years old). (4) The literature is from peer-reviewed journals. (5) The language is English or Chinese. Literature exclusion criteria: (1) review articles. (2) Monographs or conference papers. (3) Two or more theoretical models were included, and the relationship between SCT and adolescent physical activity behavior was not analyzed separately. (4) Intervention study on physical activity promotion with SCT.

3.1.2. Literature retrieval strategy

Foreign literature was retrieved through the Web of Science, Scopus, PubMed, Academic Search Complete database and Google Scholar on April 30, 2019. The retrieval method is that the main search words (subject words) are connected through the logical words "AND" and "OR". The search term of "shehui renzhi lilun" are "social cognitive theory" and "SCT". The search terms of "tili huodong" are "exercise" "physical activity" "physical activities" "physical exercises" "acute exercise" "aerial exercises" "exercise training" "exercise training" "acute exercises" "leisure-time activity" "leisure-time activities". The search terms of "ertong qingshaonian" are "child" or "children" or "childhood" or "juvenile" or "pubescent" or "pubertal" or "puberty" or "adolescent" or "adolescents" or "adolescence" or "youth" or "teen" or "teens" or "teenage" or "teen-age" or "teenaged" or "teen-aged" or "teenager" or "teen-agers" or "youngster" or "youngsters" or "minor" or "minors" or "student" or "students". Due to the lack of Chinese literature, the research object is not limited. Advanced retrieval methods are adopted on CNKI and Wanfang Data knowledge service platform. The search terms are "shehui renzhi lilun" or "SCT" or "shehui renzhi" and "shenti huodong" or "duanlian" or "tili huodong" or "yundong". One researcher will independently screen the titles and abstracts according to the inclusion and exclusion criteria of the literature, and then another researcher will carry out the same operation and check all

the literature. In case of inconsistency, the two researchers will discuss and make the decision with the third researcher.

3.2. Data extraction

Standardized data extraction tables were used to collect sample characteristics, research methods and main research results from each selected study: (1) sample characteristics and test variables included in the research literature, including country, sample size, gender, age, research design, physical activity measurement methods and main test variables. (2) Statistical methods and main results.

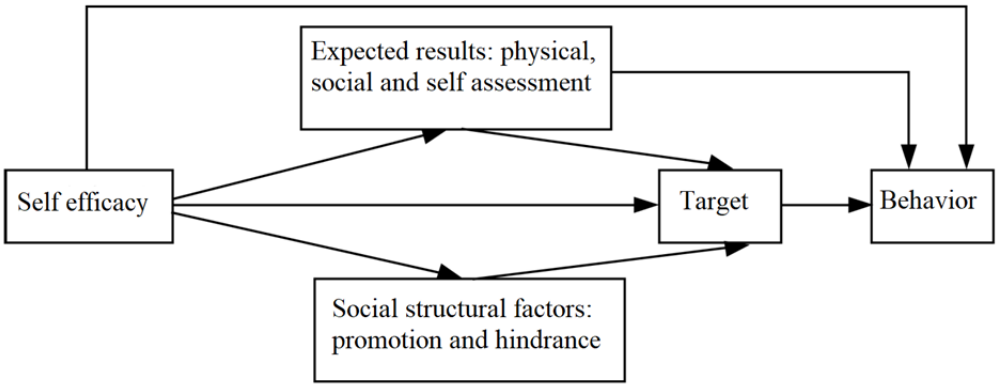

Figure 1. Structure of SCT that promotes healthy behavior.

3.3. Meta-analysis

Stata 15.0 SE (StataCorp, College Station, TX) software was used to test the effect quantity of the predicted value of SCT model. Calculate the effect amount according to the method of Field *et al.*[27]: calculate the effect quantity r value with the square root of each R^2 value, and then convert the r value into Fisher transform coefficient. The random-effects model of Hedges *et al.*[28] is used to test and combine statistics. The Fisher conversion coefficient is meta-analyzed and then transformed into the R^2 value of correlation coefficient to evaluate the prediction ability, so as to compare with the R^2 value of other studies and theories. Based on the heterogeneity analysis of research based on Q statistics, Begg-Egger test, loss of safety factor method and funnel chart[29,30] are used to detect publication bias.

3.4. Literature quality evaluation

The methodological quality was evaluated according to the contents of object selection, research design and measurement in the literature. According to the requirements of *CONSORT Statement* and the *Statement on Strengthening the Quality of Observational Research Report in Epidemiology (STROBE)*: *Specification for Observational Research Report*, the evaluation is made about the quality of the report. There are 11 items in total, which are divided into three cases: compliance (1 point), non-compliance (0 point) and not mentioned (0 point). The evaluation is carried out at the level of two points. The quality of the literature was evaluated by two researchers respectively, and each item was scored independently. If there were disparities about the score, the evaluation was determined through consultation with the third researcher.

4. Results

4.1. Literature screening results

By searching Academic Search Complete, PubMed, Scopus and Web of Science databases, 219, 245, 1,910 and 376 literatures were obtained respectively. The above 2,750 literature titles were imported into Endnote document management software to remove 569 repetitive documents. 2,137 documents were preliminarily screened out by reading the title and abstract. The remaining documents were evaluated after downloading the full text, and 15 documents meeting the requirements were determined. In addition, through the manual search of Google Scholar and the forward & backward reference search of 15 references and citations included in the literature, 3 documents meeting the requirements were obtained. Finally, a total of 18 literatures (all in English) were included, of which 17 were included in meta-analysis, and there were no Chinese literatures that meet the requirements. The literature screening process is shown in **Figure 2**.

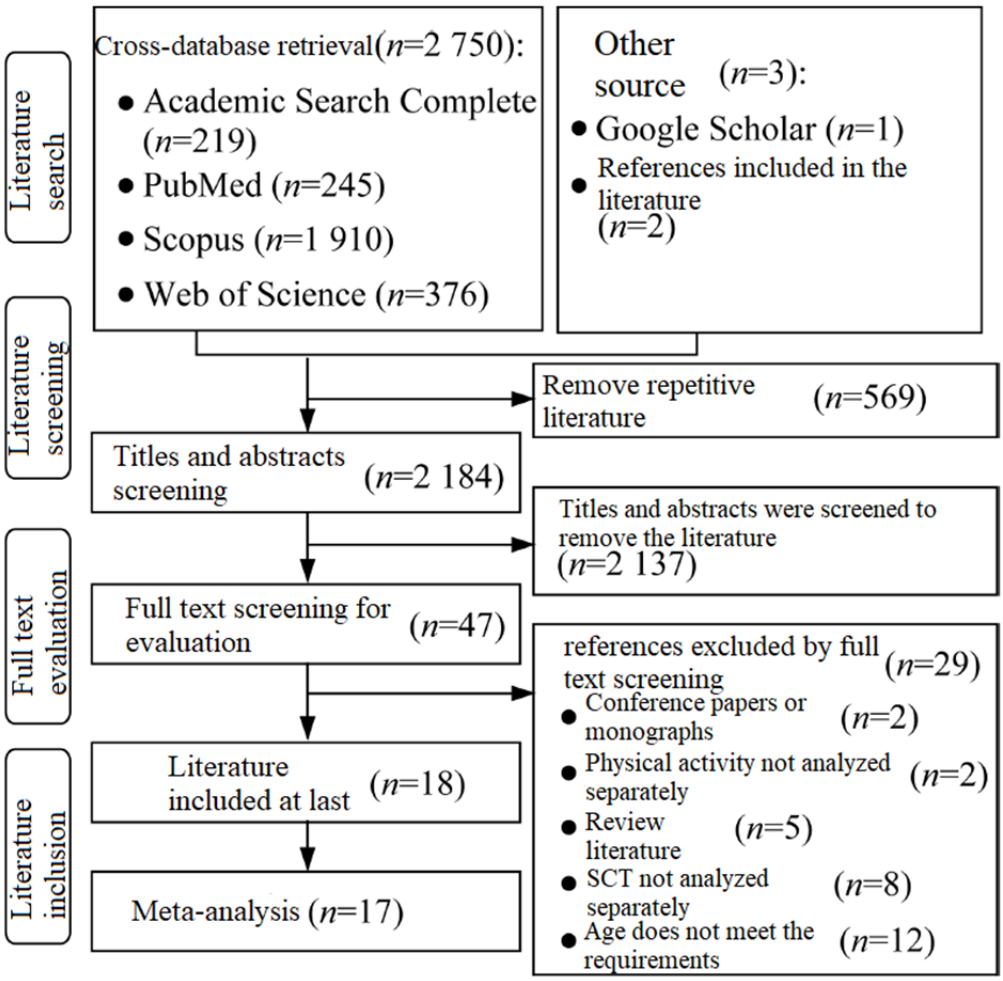

Figure 2. Study selection flowchart.

4.2. Basic characteristics of included literature

The basic features of the included literature are extracted and summarized. The results are shown in **Table 1**. Based on the classified statistics of the basic characteristics of 18 literature samples, it is found that only 3 (16.7%) studies have a sample size <100, 7 (38.9%) studies have a sample size of 100-300, and 4 (22.1%) studies have a sample size of 301-500 or >500. With regard to the gender of the respondents, 10 (55.5%) studies included boys and girls (including 8 combined studies and 2 separate studies), 5 (27.8%) studies included only girls, and 3 (16.7%) studies did not indicate gender. In terms of the region of the respondents, most (66.6%) are from North America (all from the United States), and the others are from Asia and Oceania (both accounting for

16.7%).

Table 1. Basic characteristics of included articles

Serial No.	Author	Year	Country	Total sample size (male)	Age	Research design	Physical activity (PA) measurement tool	Test variables
1	Trost, *et al.*[46]	1997	U.S.A	202 (92)	N/A	Longitudinal study	PDPAR	Seeking support, barriers self-efficacy, competitive activities, outcome expectations, social impact, home equipment, school sports, community sports, community organizations, TV/video games, parents' activities, friends' activities, fond of physical education
2	Strauss, *et al.*[41]	2001	U.S.A	92 (44)	N/A	Cross-sectional study	Accelerometer	Self-efficacy, social impact, health beliefs, self-esteem and anxiety
3	Winters, *et al.*[47]	2003	U.S.A	248 (98)	N/A	Cross-sectional study	GLTEQ	Social status, self-efficacy, outcome expectation, self-regulation
4	Motl, *et al.*[33]	2005	U.S.A	1 038 (0)	13.6 ± 0.6	Longitudinal study	3DPAR	Equipment availability, barriers self-efficacy, neighborhood safety
5	Sharma, *et al.*[31]	2005	U.S.A	159 (62)	N/A	Cross-sectional study	PDPAR	Physical education time and self-efficacy
6	Petosa, *et al.*[32]	2005	U.S.A	256 (130)	N/A	Cross-sectional study	PDPAR	Self regulation, social status, social outcome expectation, appearance outcome expectation, overall health outcome expectation, negative outcome expectation, ability self-efficacy, barriers self-efficacy
7	Martin, *et al.*[37]	2008	U.S.A	348 (171)	12.2 ± 0.9	Cross-sectional study	GLTEQ	Barriers self-efficacy, parental support, behavioral intention
8	Martin, et al.[38]	2008	U.S.A	331 (150)	12.1 ± 1.0	Cross-sectional study	GLTEQ	Barriers self-efficacy, social support, enjoying PA fun, outdoor time, nearby environment support and obstacles
9	Martin, *et al.*[39]	2008	U.S.A	99 (54)	11.9 ± 1.0	Cross-sectional study	GLTEQ	Barriers to self-efficacy, social support, enjoying PA fun, outdoor time, support from nearby environment
10	Taymoori, *et al.*[35]	2008	Iran	558 (0)	14.4 ± 1.6	Cross-sectional study	CAAL	Social support (father, mother, siblings and friends), outcome expectation, self-efficacy
11	Roberts, *et al.*[34]	2010	New Zealand	72 (35)	16.9 ± 0.1	Cross-sectional study	4DPAR	Goal intention, task effectiveness, obstacle effectiveness and realistic intention
12	Martin, *et al.*[40]	2011	U.S.A	506 (250)	12.0 ± 0.9	Cross-sectional study	Accelerometer	Self-efficacy, peer social support, school sports environment
13	Ramirez, *et al.*[42]	2012	U.S.A	479 (250)	9.8	Cross-sectional study	GLTEQ	Self-efficacy, outcome expectations, barriers and social support
14	Lubans, *et al.*[43]	2012	Australia	1,035 (0)	13.6 ± 0.02	Cross-sectional study	Pedometer	Self-efficacy, self-worth, enjoying PA, behavior strategy, environment and social support
15	Gao[44]	2012	U.S.A	155 (66)	10.8	Cross-sectional study	Accelerometer	Self-efficacy, outcome expectation, social support, physical and environmental factors
16	Dewar, *et al.*[45]	2013	Australia	235 (0)	13.2 ± 0.4	Longitudinal study	Accelerometer	Self-efficacy, intention, parental support, outcome expectation
17	Bagherniya, *et al.*[36]	2015	Iran	172 (0)	N/A	Cross-sectional study	Accelerometer	Self-efficacy, social support, outcome expectation
18	Hong, *et al.*[48]	2017	Thailand	609 (280)	N/A	Cross-sectional study	CAAL	Self-efficacy, parental monitoring, discipline and reinforcement

Note: N/A means the original text is not marked.

In terms of measurement methods that can directly affect the validity of measurement, 12 (66.7%) studies obtained the data of physical activity though subjective self-report (assessment), such as previous day physical activity recall (PDPAR)[31,32], 3-day physical activity review (3DPAR)[33], 4-day physical activity review (4DPAR)[34], child/adolescent activity log (CAAL)[35,36], Godin Leisure-Time Exercise Questionnaire (GLTEQ)[37-40], physical activity questionnaire (PAQ), etc. Only 6 items (33.3%) obtained physical activity data by objective measurement methods, such as pedometer and accelerometer[34,41-45]. It is worth mentioning that in

recent years, some cross-sectional studies with large sample size tend to adopt objective measurement methods, which is particularly crucial to improve the validity of the study. In addition, most (83.3%) studies were cross-sectional and a few (16.7%) studies were longitudinal.

4.3. Main research results

The main research results included in the literature are extracted and summarized. The results are shown in **Table 2**.

Table 2. Main findings and statistical methods of included articles

Document serial No.	Variables and their regression coefficients	Predicted value R^2	Statistical method
1	Girls: community sports* (β = 0.11, R^2 = 0.079); barriers self-efficacy* (β = 0.07, R^2 = 0.077); fond of physical education* (β = 0.23, R^2 = 0.036); race* (β = 0.23, R^2 = 0.036); mother PA* (β = 0.19, R^2 = 0.036) Boys: barriers self-efficacy* (β = 0.10, R^2 = 0.053)	High intensity: 26% (girls); 5% (boys) Medium intensity: 17% (girls); 17% (boys)	Stepwise regression model
2	Medium intensity: age* (R^2 = 0.15); sedentary time* (R^2 = 0.25) High intensity: self-efficacy* (R^2 = 0.10); age and sex* (R^2 = 0.19)	High strength: 29% Medium strength: 35%	Multiple regression analysis
3	Moderate intensity: self-efficacy* (R^2 = 0.02); social status (R^2=0.01); self regulation* (R^2 = 0.06); expected results* (R^2 = 0.04) High intensity: gender* (R^2 = 0.06); social status* (R^2 = 0.06); self efficacy* (R^2 = 0.08); self regulation* (R^2 = 0.08); expected results* (R^2 = 0.10)	High strength: 35% Medium strength: 12%	Hierarchical regression analysis
4	Baseline data: self-efficacy* (β = 0.35); equipment available (β = 0.13); neighborhood security (β = 0.01) Follow up data: self-efficacy* (β = 0.11); equipment availability (β = -0.01); neighborhood security (β = -0.04)	—	Structural equation model
5	Physical education time* (β = 0.21) Self-efficacy* (β = 0.21)	7.2%	Multiple regression model
6	Self regulation* (β=0.36, R^2=0.26) self-efficacy* (β=0.17, R^2=0.02) Social outcome expectation* (β=-0.12, R^2 = 0.02) barriers self-efficacy* (β = 0.15, R^2 = 0.01)	31%	Multiple regression model
7	Barriers self efficacy* (β = 0.22, R^2 = 0.09)	9%	Multiple regression analysis
8	Outdoor time*/social support of friends* (β value not listed)	19%	Multiple regression analysis
9	Enjoy physical activity* (β = 0.21)	14%	Multiple regression analysis
10	Expected results* (β = 0.17) Self-efficacy* (β = 0.61)	52%	Linear regression analysis
11	Subjective PA measurement: executive intention* (β = 0.60, R^2 = 0.35); goal intention* (β = 0.23, R^2 = 0.05); perceived behavior control (β = -0.04); barriers self efficacy (β = 0.08); task effectiveness (β = 0.01) Objective PA measurement: executive intention* (β = 0.24, R^2 = 0.06); goal intention (β = 0.23); perceived behavior control (β = -0.04); barriers self efficacy (β = 0.08); task effectiveness* (β = 0.01, R^2 = 0.12)	Subjective: 1% Objective: 8%	Multiple regression analysis
12	Barriers self-efficacy* (β = 0.167) Peer social support* (β = 0.134) Gender* (β = -0.93) Physical activity environment* (β = -0.091)	12%	Multiple regression analysis
13	Outcome expectation*/self-efficacy*/goal*/social support* (β value not listed)	2%	Structural equation model
14	Self-efficacy* (β = 0.09) Self-worth* (β = 0.07)	5%	Structural equation model
15	Self-efficacy* (β = 0.27, R^2 = 0.07) Social support* (β = 0.19, R^2 = 0.03)	11%	Multiple regression analysis
16	Self-efficacy* (β = 0.26) expected results* (β = 0.06) Intention* (β = -0.18)	28%	Path analysis
17	Self-efficacy (β = 0.09) Social support (β = -0.10) Expected results (β = 0.03)	There was no significant difference	Linear regression analysis

Table 2. (Continued.)

18	Girls: social support self-efficacy* (β = 0.236); parental restrictions* (β = -0.214); parental monitoring* (β = 0.16); discipline* (β = 0.221) Boys: social support self-efficacy* (β = 0.341); discipline* (β = -0.147); strengthen* (β = 0.192)	13% (girls) 16% (boys)	Multiple regression analysis

Note: PA refers to physical activity; "—" indicates the overall R^2 unreported; * indicates that the difference is statistically significant ($P < 0.05$).

Using the systematic analysis method, the characteristics, measurement variables and results of 18 included literatures were extracted. According to the relationship between social cognitive variables and physical activity in the literature, the variables in the literature were coded and analyzed in **Table 2**. The main research results and statistical methods included in the literature. The coding principle refers to the method of Teixeira *et al.*[49]: ++ indicates that the literature results with significant correlation in the report are ≥75%, + indicates that the literature results with significant correlation in the report account for 50%-75% (excluding 75%); 0/+ indicates that the literature results reported as significantly related are <50%, and the other part is not related. It can be seen from **Table 3** that factors such as self-efficacy, barriers self-efficacy, social support, social status, physical appearance outcome expectation, overall health outcome expectation and neighborhood safety are significantly correlated (++), but the last three factors are only included in one literature for measurement, and the evidence is insufficient, so they are excluded. The results of systematic analysis finally show that self-efficacy, barriers self-efficacy, social support and social status are the key indicators to predict physical activity. The results answer the question (b) of this paper.

Table 3. The relationship between predictive variables of SCT and adolescents' physical activity (PA)

Predictive variable	Literature quantity	Sample size①	Proportion of research results/%			Coding
			+	-	0	
Self-efficacy						
Self-efficacy	9	11	81.8	0	18.2	++
Support seek self-efficacy	2	6	33.3	0	66.7	0/+
Proxy self-efficacy	1	6	33.3	0	66.7	0/+
Barriers self-efficacy	7	11	100.0	0	0	++
Competing activities self-efficacy	2	5	20.0	0	80.0	0/+
Outcome expectation						
Outcome exp.	6	7	42.9	14.3	42.9	0/+
Physical appearance outcome exp.	1	1	100.0	0	0	++
General health outcome exp.	1	1	100.0	0	0	++
Social support						
Social support	4	8	75.0	0	25.0	++
Parental support	2	2	50.0	0	50.0	+
Mother PA	2	5	40.0	0	60.0	0/+
Father PA	2	5	20.0	0	80.0	0/+
Sibling PA	1	1	0	0	100.0	0/+
Friends PA	3	6	16.7	0	83.3	0/+
Social situation	2	3	100.0	0	0	++
Neighborhood safety	1	2	100.0	0	0	++
School support	3	6	33.3	0	66.7	0/+
Other						
Like school PE	1	4	50.0	0	50.0	+

Note: ① part of the literature studies boys and girls, medium and high intensity respectively, so the literature contains more than one sample result.

4.4. Document quality evaluation results

According to the internationally recognized *CONSORT Statement*, the higher the score, the better the document quality. The results show that the evaluation results of 11 items are 2-11 points, including 9 articles with 2-5 points, 8 articles with 6-8 points and 1 article with 9-11 points.

4.5. Meta-analysis results

4.5.1. Consolidated statistics

In order to explore the explanatory degree of SCT model for adolescents' physical activity behavior (question (a) of this paper), the effect quantities of 17 literatures that reported R^2 value in the included literature were combined. The fixed effect model is used for analysis, which shows that there is obvious heterogeneity in the included literature, so the random-effect model[28] is used for effect quantity consolidation. The results (**Table 4**) show: R^2 = 0.17, P < 0.001, Z = 7.59, indicating that the overall interpretability of the theoretical model is 17%. According to the R^2 value evaluation standard proposed by Cohen[50], 0.13 < R^2 < 0.26 is the moderate effect quantity, which can be considered that SCT model can predict adolescent physical activity to a medium extent.

Table 4. Meta-analysis result of SCT predict physical activity

Literature	Total sample	I^2	R^2	Heterogeneity	Q test	95% CI		17	6 094
						Lower	Upper		
93.5%	0.17	219.9	P < 0.05	0.11	0.28	Z	7.59	P	<0.001

4.5.2. Heterogeneity analysis and subgroup analysis

Heterogeneity test was conducted on the included literature, and the results are shown in **Table 4**. Q test showed P < 0.05, indicating heterogeneity. After the effect amount was combined by random-effect model, I^2 was 93.5% (>75%), indicating considerable heterogeneity. Therefore, meta regression and subgroup analysis are needed to explore the source of heterogeneity. Five factors including obesity, location, gender, statistical methods and research design were included in the model to analyze their impact on heterogeneity. Overall model results: F (5, 11) = 5.73, P < 0.01, R^2 = 66.13%, indicating that the model composed of these variables can explain 66.13% of the sources of heterogeneity. The specific results are shown in **Table 5**.

Table 5. Meta regression analysis of the effect of factors on the study heterogeneity

Factor	Coefficient	Standard error	t	P	95% CI
Obesity	-0.80	0.18	-4.37	0.001	[-1.21, -0.40]
Gender	-0.15	0.05	-3.11	0.010	[-0.25, -0.04]
Region	-0.10	0.04	-2.1	0.089	[-0.23, 0.02]
Statistical method	-0.38	0.12	-3.26	0.008	[-0.64, -0.12]
Research design	-0.06	0.12	-0.5	0.625	[-0.33, 0.21]

After the source of heterogeneity was observed by meta regression analysis, the literature was further analyzed by subgroup, and the results are shown in **Table 6**. Only one study of obese children showed that SCT could not predict physical activity in obese children. Two studies used structural equation model, while others used regression analysis (such as stepwise regression, hierarchical regression, multiple regression, etc.). Subgroup analysis of statistical methods showed that the results of structural equation model showed no heterogeneity (I^2 = 50.0%, $Q_{[P]}$ > 0.05); there was significant heterogeneity in the results of the study using regression analysis (I^2 = 92.6%, $Q_{[P]}$ < 0.05). The results of meta regression analysis showed that the regional factors were marginal significant. Due to the small amount of research literature in countries other than the United States, they were divided into North America (the United States), Asia (South Korea, Thailand and Iran) and Oceania (New Zealand and Australia) according to different regions. Subgroup analysis was carried out after excluding the interference of obesity and statistical methods.

The results show that: (1) SCT is the most effective predictor of physical activity in Asian adolescents, but the heterogeneity is also the largest (R^2 = 42.77%, I^2 = 98.7%), which may be due to the lack of literature in Asia; (2) SCT model can predict 34.92% physical activity of adolescents in Oceania without heterogeneity (I^2 =

0, $Q_{[P]} > 0.05$); (3) SCT can predict physical activity of 18.58% of adolescents in North America, with great heterogeneity (I^2 = 70.9%, $Q_{[P]} < 0.05$). Excluding the factors of obesity and different statistical methods, subgroup analysis was conducted on gender. It was found that the respondents of the two studies were girls. The combined results showed that SCT could predict 56.7% of girls' physical activity, but there was great heterogeneity (I^2 = 66.3%, $Q_{[P]} < 0.05$). The results show that SCT model can predict physical activity to a medium extent, and its predictive value is 18.75%, with a large degree of heterogeneity (I^2 = 66.3%, $Q_{[P]} < 0.05$).

Table 6. Subgroup analysis of different factors

Factor	Category	Literature quantity	Model	*Z*	R^2	95% CI	I^2	P (heterogeneity)	Q inspection
Region	North America	10	Random-effect	10.48***	18.58%	[12.25, 26.01]	70.9%	$P < 0.05$	30.92
	Asia	2	Random-effect	2.56**	42.77%	[2.25, 79.21]	98.7%	$P < 0.05$	76.16
	Oceania	2	Random-effect	9.78***	34.92%	[22.09, 50.41]	0	$P > 0.05$	0.01
Gender	Girls	2	Random-effect	4.69***	56.70%	[19.36, 75.69]	93.6%	$P < 0.05$	15.73
	Boys and girls	12	Random-effect	12.83***	18.75%	[13.69, 25.00]	66.3%	$P < 0.05$	32.68
Statistical method	Structural equation model	2	Random-effect	4.56***	3.69%	[9.61, 28.09]	50.0%	$P > 0.05$	2.00
	Regression analysis	15	Random-effect	9.07***	23.04%	[14.44, 24.81]	89.9%	$P < 0.05$	138.61

Note: *** indicates that the effect amount is significant at the level of $P < 0.001$; ** indicates that the effect amount is significant at the level of $P < 0.01$.

4.5.3. Publication bias analysis

The publication bias was analyzed by Begg-Egger test, loss of safety factor method and funnel chart. The funnel diagram is shown in **Figure 3**. It can be seen that the effect amount of all studies is distributed around the average effect amount, and the left and right distribution is basically symmetrical. The results of Begg test (Z = 0.57, P = 0.60) and Egger test (Coefficent = 1.79, P = 0.54) were not significant, indicating no bias. The greater the loss of safety factor, the more unpublished studies are needed to reverse the meta-analysis results, indicating that the smaller the publication bias is, the more stable the meta-analysis results are. In this paper, the loss of safety factor N = 5 305, indicating that the study is unbiased.

5. Discussion

Falk *et al.*[51] believed that the theoretical model $R^2 > 10\%$, indicating that the structural variables of the model are sufficient to explain a specific result. The meta-analysis results show that the R^2 of SCT model for the prediction of physical activity behavior is 17%, indicating that SCT can predict adolescents' physical activity behavior to a medium extent. Martin *et al.*[37] pointed out that SCT model has a higher degree of explanation for physical activity than planned behavior theory (TPB). Their two tests of the same sample of Arab American adolescents found that SCT accounted for 9% of physical activity, while TPB accounted for 7%. Ramirez *et al.*[42] believe that in addition to self-efficacy (β = 0.33), social support (including multi-dimensional perspectives such as parents, sisters and friends) is a major factor in predicting physical activity, and peer support is more effective than older people (parents, etc.). Through a systematic review, this paper finds that self-efficacy, barriers self-efficacy and social support are the key factors affecting physical activity. This result is similar to the study of Hamilton *et al.*[52], who found that self-efficacy, social support and the interaction between them have a significant impact on adolescents' willingness to participate in high-intensity physical

activity (VPA). Its interaction effect is as follows: Adolescents with high self-efficacy are not affected by the support of friends and have a higher willingness to participate in physical activities; adolescents with low self-efficacy have low willingness to participate in physical activities if they have low support from friends. If the case is the opposite, they are more willing to participate in physical activities. Petosa *et al.*[32,53] found that SCT can predict 31% of physical activity by comprehensively measuring multiple variables of SCT model. In the adjusted model, self-regulation, ability self-efficacy, obstacle self-efficacy and social outcome expectation were related to physical activity, while other variables were not related to physical activity. These studies have certain reference significance for formulating effective intervention strategies for adolescent physical activity.

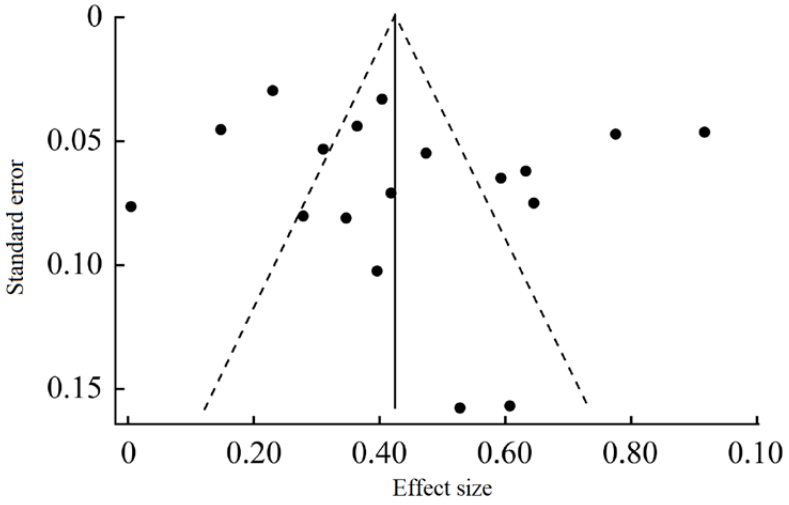

Figure 3. Funnel plot of effect size and standard error (random-effect model).

The results show that SCT model can predict adolescent physical activity behavior, but its prediction ability is affected by many factors. Among them, different regions result in different prediction ability. For example, the prediction ability of SCT on physical activity of adolescents in North America, Oceania and Asia is 18.58%, 34.92% and 42.77% respectively, but it shows great heterogeneity in the research of North America and Asia. In Asian countries, Taymoori *et al.*[35] studied 559 Iranian teenagers and found that the SCT model has 52% explanation for physical activity behavior, indicating that the SCT model has the greatest prediction for physical activity and self-efficacy of ordinary Iranian teenagers (β = 0.61) and expected results (β = 0.17) directly and significantly affect physical activity. However, Bagherniya *et al.*[36] found that SCT model could not predict physical activity of obese adolescents in Iran. Hong *et al.*[48] also found that the prediction of physical activity of primary and secondary school students in Thailand by SCT model is only 16%. On the whole, there are few prediction studies of SCT in Asian countries, and the heterogeneity is large. Subgroup analysis also showed that SCT could moderately predict physical activity of adolescents in North America (R^2 = 24.01%), but the study has great heterogeneity.

Martin *et al.* conducted a series of studies on different ethnic groups using SCT model: A study of 348 Arab American adolescents[37] found that barrier self-efficacy was most related to physical activity, and the theory could predict 9% of physical activity as a whole; a study of 331 African American adolescents[38] found that this theory can predict 19% of physical activity; a study of 99 Hispanic American children[39] showed that the overall predictive ability of SCT was 14%, in which parents' social support and enjoyment of physical activity were the most important variables; a study of 506 adolescents from 8 races, including African Americans (60%) and Caucasian whites (12%)[40] showed that the overall prediction of SCT on physical activity was 12%, and barriers self-efficacy and peer social support played an important role in psychological and environmental factors. It can be seen that the prediction degree of SCT for groups with different cultural

backgrounds is different, and the key variables affecting physical activity of different groups are also different. Ramirez *et al.*[42] suggested that in order to enrich the theoretical model and further study the physical activity behavior under different cultural backgrounds, the physical activity behavior of people from different countries and cultural backgrounds should be studied in combination with other ecological factors, such as community, organization and policy factors[30].

In addition, a subgroup analysis of gender found that SCT predicted physical activity in 18.75% of boys and girls. Two studies show that SCT can predict 56.70% of girls' physical activity, but there is great heterogeneity. For the discussion of gender factors, Trost *et al.*[46] found that in the group of girls, race, overcoming obstacles, community sports, physical activity of mothers, like school sports and other factors are significantly related to physical activity; in the boys group, overcoming obstacles, result expectation, social impact, community sports are significantly related to physical activity. The prediction of physical activity intensity for boys is only 5%, but there is no difference in the prediction of physical activity intensity for girls. Hong *et al.*[48] found that SCT model has a slightly higher prediction of physical activity for boys, but there is no significant difference between sexes. There are both similarities and differences between different genders of adolescent students. Different intervention strategies for boys and girls may achieve better results. Therefore, gender issues are also worthy of further research by more scholars. The above series of studies answered the question (c) of this paper, that is, the effectiveness of SCT model is different due to the influence of different regions, gender and other factors.

From the perspective of methodological characteristics, scholars often use regression model or structural equation model to conduct cross-sectional research, establish the path map of SCT variables and physical activity, and verify the overall prediction ability of SCT model on physical activity behavior, so as to reflect the relationship between social cognitive variables and adolescents' physical activity behavior, reveal key impact indicators, and provide basis for formulating physical activity intervention strategies. The results of subgroup analysis in this paper show that the results of structural equation model are not heterogeneous, but the results of different regression methods (hierarchical regression, multiple linear regression, etc.) are heterogeneous. It should be noted that only two of the studies included in meta-analysis were longitudinal designs, and the results of meta-regression analysis showed that the study design factors were not the main source of study heterogeneity.

For the difference between cross-sectional research and longitudinal research, predecessors have made different discussions. In the study of TPB model, McEachan *et al.*[54] found that research design factors significantly adjusted the degree of interpretation of psychosocial variables on behavioral effects, and the research design with shorter time had greater explanatory variance than the model with longer time. In contrast, a test of a two-group design that conducted a cross-sectional and longitudinal study of physical activity in a large sample of adults[55] showed that the variance for different study designs was negligible. Nevertheless, it should be recognized that cross-sectional studies do not include time intervals, which are particularly necessary to reveal causality. Therefore, the author believes that more high-quality longitudinal studies are needed to explore the relationship between social cognitive variables and physical activity behavior. Limitations of this article: although most studies show that SCT can predict adolescent physical activity, due to many interference factors and interaction, there is insufficient literature in some subgroups in subgroup analysis (such as girls, Asian countries, etc.), resulting in large heterogeneity of research results included in the literature. More relevant studies should be included in the future to provide more sufficient evidence.

6. Conclusion

The results show that: (1): the R^2 value of SCT model in predicting physical activity behavior is 17%, suggesting that this model can predict adolescent physical activity to a medium extent; (2) the self-efficacy, barriers self-efficacy, social support, social status and other factors in SCT model are the key indicators to predict physical activity, which can be used as a positive reference for how to better promote and intervene adolescents' physical activity behavior; (3) individual, society and environment interacted with each other. Under the influence of different regions and gender, the factors of SCT model have different effects on teenagers' physical activities. Therefore, in the face of the behavioral characteristics and situation of insufficient physical activity of Chinese teenagers, it is suggested that domestic scholars shall learn from international experience and explore the influencing factors of teenagers' physical activity under the guidance of SCT and other theoretical models, find the key variables and internal mechanisms affecting Chinese teenagers' physical activity behavior, establish the relationship between individuals and external society and environment, and form an interactive mechanism that affects each other and cannot be separated. At the same time, combined with the social and psychological variables in the Western classical theoretical model, according to the personality and common characteristics of Chinese youth groups, social, school and family resources should be employed to formulate effective intervention strategies, which is not only the key to solve the problem of insufficient physical activity of Chinese youth, but also the focus of future research.

Conflict of interest

The authors believe that there is no economic interest or other relationship with individuals and organizations.

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