Does Taekwondo Poomsae Training Impact on Body Composition, Physical Fitness, and Blood Composition in Children and Adolescents? A Systematic Review

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INTRODUCTION

The American College of Sports Medicine (ACSM) advocated that children and adolescent should participate in regular exercise of moderate intensity or above including aerobic exercise and strength training every day [1,2]. In recent years, however, with the improvement of economic level and the change of lifestyle, the physical activity in children and adolescents are obviously insufficient [3]. Insufficient physical activity results in decreased physical fitness, metabolic dysfunction, and body imbalance [4], which are directly related to overweight or obesity, and metabolic syndrome and other primary symptoms. These, easily seen in the adult group are becoming more and more common in children and adolescents [5-7]. In addition, obesity can also induce hypertension, arteriosclerosis, chronic inflammation, sleep apnea syndrome, asthma, etc. [8] and also lead to abnormal levels of Total cholesterol (TC), Triglyceride (TG), insulin and blood pressure [9]. Based on these evidences, preventing and improving the health problems in adolescents and children has gradually become the focus of attention.

Numerous studies have shown that long-term appropriate physical activity can effectively enhance physical fitness and improve health problems such as obesity or metabolic syndrome [6,10-13]. Among numerous physical activities, Especially, Taekwondo is very effective sports or phys-
metrical activity that is targeting children and adolescents in Korea [14,15]. Taekwondo can be largely divided into Kyorugi, Poomsae, and Breaking, etc. Among them, Taekwondo Poomsae is a technical system based on the basic movements of attack and defense technology which assuming the situation of fighting and can be practiced alone [16-18]. At the same time, as a martial arts sport in which martial arts and sports spirit were determined together, it not only Meaning of the practice of Tao and courtesy [19], but also emphasized spiritual cultivation.

Generally, Taekwondo Poomsae refers to Official Poomsae, and recently, in order to induce the diversity and interest of Taekwondo training programs, Music Taekwondo or Taekwon Gymnastics, Rhythm Taekwondo and Taekwondance, which are based on the basic movements of Taekwondo and recreated with music, are diversified and activated [20].

From the perspective of the previous research related to the practice effect of Taekwondo training, studies on primary school students [3,21-26], middle school students [13,27-33], college students [34,35], adults [36] and the elderly [37] are diverse and comprehensive. Also, Taekwondo training is effective in improving physical fitness, promoting exercise performance, resolving body imbalance, improving balance, improving body composition and blood composition, promoting physical development, and improving health status, etc.

Interestingly, in most of these studies, the intervention means are Kyorugi rather than Poomsae. This may be because Kyorugi is an official Olympic event, which is widely spread all over the world, with a high penetration rate and more practitioners. Despite this, we still found some research on the effects of Poomsae training. Seo & Park (2017) found that after 12 weeks of quality intervention, not only the physical condition of primary school students was improved, but also the dynamic and static balance was improved, and it was considered that the quality of Taekwondo was an effective sport [38]. The study by Park & Seo (2017) showed that 12-week Taekwondo can improve the posture stability and sports performance of primary school students, and it is also very effective in reducing the physical imbalance and improving the physical function of the growing children [26]. And the study by Jo (2006) & Lee (2010) said that after implementing a 12-week Poomsae training program, participants’ blood TC, TG, LDL-C decreased, and HDL-C increased [34,36].

In addition, some researchers have Poomsae intervention studies on overweight [39] or obese people [7,13,15,21,29,35,40] and people with metabolic syndrome [6,13] and the results of these studies showed that after 12 weeks of Poomsae intervention, participants’ weight, BMI, body fat rate decreased, and risk factors for obesity and metabolic syndrome such as waist circumference, blood glucose, triglycerides in blood, and Cystatin C, etc. were significantly improved.

Based on this evidence, we have reason to believe that Taekwondo Poomsae is not only a very effective exercise method to help healthy or obese children improve their physique [16], but also a very effective exercise method for early prevention of lifestyle diseases and metabolic syndrome caused by obesity [8,18-20].

However, some research reported that after Taekwondo Poomsae training, the improvement of body composition and physical fitness did not show statistical significance [33,41], or the improvement effect is not ideal.

In this way, researchers made various attempts to verify the physical effects of the Poomsae training, but the results of the previous studies were diverse, and the effects were insignificant or statistically insignificant. Therefore, there is a limit to conclusively presenting appropriate information on improving body composition, blood components and physical fitness. To provide more accurate information for on-site instructors and readers, it is necessary to Systematic Review of the effect in Poomsae training.

Therefore, the purpose of this study is to review the evidence from the previous studies and to determine whether Taekwondo Poomsae is effective physical activity on body composition, physical fitness, and blood components in children and adolescents, thereby determine the applicability of Taekwondo Poomsae training as a training method and kinesiology.

**METHODS**

1. **Search Method**

All relevant studies were searched via Korea’s Research Information Sharing Service (RISS), Korean studies Information Service System (KISS), and Data Base Periodical Information Academic (DBPIA). The search was limited to human subjects and journals published in Korean language from March 1 to 3 in 2021 using the search key words Taekwondo, Poomsae, music Poomsae, Taekwondo Gymnastics, body composition, physical fitness, blood composition. All retrieved studies were cross-referenced at the end of selection, in order to identify other potential studies.
2. Inclusion and Exclusion Criteria

A rigorous review process was carried out for all retrieved studies. Each study was identified and selected according to the inclusion and exclusion criteria. The concrete inclusion and exclusion criteria are as follows.

**Inclusion Criteria**

1) The studies which intervention methods are Taekwondo Poomsae, Music Poomsae or basic movement of Poomsae and Taekwon Gymnastics.

   - **Taekwondo Poomsae**: It refers to an official Poomsae and includes a total of 17 items, including the Taegeuk 1-8 jang, and Koryo, Keumgang, Taebaek, Pyongwon Poomsae, etc.
   - **Basic movement of Poomsae**: It is the minimum unit of technology created by Poomsae, including the Seogi, Makgi, Jireugi, Jjireugi, Chigi, Chagi, etc.
   - **Music Poomsae**: It is a method of performing poomsae in accordance with the rhythm of the background music when performing the certified Poomsae of Taekwondo.
   - **Taekwon Gymnastics**: It is an interesting performance form that uses music based on basic movements of Poomsae to create new creations according to movements, music or rhythm.
   2) The participants of studies who were children and adolescents.
   3) The type of study was randomized controlled trial (RTC).
   4) The studies that must have a detailed training program.

**Exclusion Criteria**

1) If there were inappropriate interventions in the included studies (the training program included both character/music character/Tae kwondo Gymnastics and Kyorugi), they were excluded.
2) If the participants included in the study were not only children and adolescents, but also participants of other age groups, they were excluded.
3) If the results of the included RTC studies were not comprehensive, they were excluded.
4) If the included studies did not provide a detailed training program, they were excluded.

**Data Extraction and Quality Assessment**

The two authors independently extracted data and quality assessment of the included studies according to the Cochrane Handbook. The low, high, or unclear risk of bias in all studies were evaluated by considering the following 7 factors: 1) Random sequence generation, 2) Allocation concealment, 3) Blinding of participants and personnel, 4) Blinding of outcome assessment, 5) Incomplete outcome data, 6) Selective reporting, 7) Other.

When there is any uncertainty or disagreement in data extraction and quality assessment, a third person will make the decision.

**RESULTS**

1. Study characteristics

The entire process of the literature search is shown in Fig. 1. A total of 202 results were retrieved at the initial step, of which 92 studies from RISS, 43 studies from KISS, and 67 studies from DBPIA. After EndNote X9 and manual deletion of duplicates, there are 115 documents associated with the topic. Then, after excluding unqualified articles based on title and abstract and studies type, 69 studies may be eligible. Through the review of the full text of the remaining literatures, it was concluded that 22 studies met the inclusion and exclusion criteria of this review. The basic characteristics of the included studies are shown in Table 1.

A total of 765 subjects participated in the 22 studies. The sample size

![Fig. 1. Flowchart illustrating the different steps of the study selection.](https://www.ksep-es.org)
of each study ranged from 9 to 145, and the age of participants was mainly between 7 and 19 years old. The main participants included elementary school students (14 studies), middle school students (4 studies) and high school students (4 studies). In addition, 2 studies focused on female students, 7 studies were related to overweight or obesity and metabolic syndrome, and there were 1 study related to children with Intellectual Disability.

2. Effects of Taekwondo Poomsae Training on Outcome Indicators

In the 22 included studies, the effects of Taekwondo Poomsae training on outcome indicators of children and adolescents were described. These outcome indicators were mainly divided into three categories: body composition, physical fitness and blood composition. The detailed information is included in Tables 2-4.

1) Body Composition

Of the 22 studies, 11 studies reported the effect of Taekwondo Poomsae Training on body composition (Table 2). Except for one study which showed that there was no significant change in body composition after 12 weeks of Taekwondo Poomsae intervention, all the other studies demonstrated significant changes in varying degrees [33].

Regarding the study of changes in body weight, the 4 studies declare that the body weight had a significant change after the Taekwondo Poomsae intervention [23,39,44,45]. And 4 Studies emphasized significant differences in body weight before and after training, respectively \( p < .05 \) [13,14,29] and \( p < .001 \) [21]. However, in the studies of Jang (2013), Jeong (2014), Kim & Kwon (2009) and Park (2009) although the body weight was decreased, it was not statistically significant [6,13,29,43].

In the case of the body fat, the study of Cho & Jeoung (2013) stated that the body fat rate had a significant change after the intervention of Taekwondo Poomsae [21]. The similar results were found in 5 studies, and the significance was \( p < .01 \) [6,14,43-45]. And in the study result of Kim & Kwon (2009), the significance was \( p < .05 \) [29]. However, the other studies showed that the body fat rate had no significant difference, but it changed in different degrees compared with that before training [13,33,39].

For the BMI, the study on Cho & Jeoung (2013) reported that there was a significant difference in BMI before and after training [21]. In addition, the studies also declared significant differences in BMI, which respectively were \( p < .01 \) [44,45] and \( p < .05 \) [29,43]. However, other studies have indicated that although BMI was changed, it did not show no statistical significance [6,13,14,23,29].

Regarding the LBM, only Jang (2013) and Jo & Ann (2010) two studies demonstrated significant differences. The other studies, although more or less the trend of increase or decrease or unchanged can be seen, but there was no statistical significance [13,14,29,33,43,45].

2) Physical Fitness

Of the 22 studies, 16 studies reported the effect of Taekwondo Poomsae training on physical fitness [3,6,7,14,15,22-24,26,28,30,33,42,43,45] (Table 3). Only one study of Song (2003) said 12 weeks of Taekwondo Poomsae intervention did not have a positive effect on physical fitness factors. This is because static strength (3.6%), abdominal muscle endurance (2.6%), endurance (37.2%), and full-body endurance (10.4%) of the physical fitness factors have improved slightly after the intervention of Taekwondo Poomsae training, but they have not reached the statistically significant level [33]. In addition to this, other studies have declared significant changes to varying degrees.

Among these 17 studies, 5 studies are about cardiopulmonary endurance, and all 5 studies revealed that the cardiopulmonary endurance was significant improvement in varying degree after 12 weeks of Taekwondo Poomsae intervention compared with before the experiment [14,22,23,26,30]. There are 16 studies involving both muscle strength and flexibility, among which 10 studies showed different degrees of significance in the case of muscle strength [3,7,15,24,26,27,29,30,43,45], and 6 studies were improved compared to before the Taekwondo Poomsae intervention, but did not show significance [6,14,23,28,33,42]. In the case of flexibility, 12 studies were significantly improved after the intervention of Taekwondo Poomsae [3,6,7,14,24,26,28-30,42,43,45], while 4 studies were improved compared with those before the Taekwondo Poomsae intervention, but had no statistical significance [15,22,23,33]. In the case of explosive power, except for 3 studies of 12 related studies, which said that the explosive power was improved after intervention but had no statistical significance [7,42,43]. The other 9 studies all reported that the explosive power was obviously improved after Taekwondo Poomsae intervention, and it had statistical significance [3,6,14,15,23,24,26,30,45].

In addition, 11 studies related to agility, 10 studies alleged significant changes in agility [3,7,15,24,26,29,30,42,43,45], and only one study said no significant changes, but there was a trend of improvement [28]. Among the 11 studies involving muscle endurance, 8 studies declared that the muscle endurance level was significant improved [3,7,23,26,28-
| Author/ Year | Participants N (EG, CG) | Age | Intervention | Outcome |
|-------------|-------------------------|-----|--------------|---------|
| An HS (2017) [42] | 40 (20, 20) | 11.10 ± 0.91 EG, 11.55 ± 1.10 CG | 12 3 60 | Taekwondo Reverse Poomsae Training | RPE: 7-9 | Basic Physical Fitness |
| Cho WJ (2013) [21] | 24 (12, 12) | 11.17 ± 0.72 EG, 11.33 ± 0.65 CG | 12 3 60 | Normal physical activity | Taekwondo Poomsae Training | VO_{2max}: 50-60% | Body Composition Blood Lipid (TC, TG, HDL-C), Adiponectin |
| Choi JI (2009) [22] | 145 (80, 45) | 10-12 | 12 5 60 | No training | Basic movements of Poomsae, Taekwondo gymnastic, Taekwondo Poomsae |
| Ham KW (2020) [23] | 19 (10, 9) | 11.10 ± 1.37 EG, 10.67 ± 1.66 CG | 12 4 55 | Taekwondo Poomsae | Auditory and Visual stimulation Taekwondo Poomsae Training | RPE: 8-15 | Body Composition Physical Fitness |
| Jang CH (2013) [6] | 16 (8, 8) | 11.38 ± 1.85 EG, 10.63 ± 1.51 CG | 12 5 60 | No training | Basic movements of Poomsae, Taekwondo gymnastic, Taekwondo Poomsae (Taeguk 1-4 Jang) | HR_{max}: 50-70% | Body Composition Physical Fitness, Cystatin C |
| Jeong MK (2014) [43] | 16 (8, 8) | 7-8 | 12 3 60 | No training | Basic movements of Poomsae, Taekwondo gymnastic, Taekwondo Poomsae (Taeguk 1-3 Jang) | HR_{max}: 55-70% | Body Composition Physical Fitness, Precocious Puberty Risk Factors |
| Jo KY (2010) [39] | 20 (10, 10) | 11.60 ± 1.07 EG, 11.90 ± 1.19 CG | 12 4 60 | Taekwondo poomsae | Rhythmic Taekwondo poomsae training | HR_{max}: 50-70% | Body Composition Blood Lipid (TC, TG, HDL-C, LDL-C) |
| Kim WK (2009) [29] | 20 (10, 10) | 14.70 ± 1.25 EG, 15.10 ± 0.88 CG | 12 5 50 | No training | Basic movements of Poomsae, Taekwondo gymnastic, Taekwondo Poomsae | | Body Composition Physical Fitness, Growth Hormone, IGF-1 or DHEAs Concentration |
| Kim HD (2008) [44] | 24 (12, 12) | 13.35 ± 0.48 EG, 12.42 ± 0.50 CG | 12 2 70 | No training | Basic movements of Poomsae, Taekwondo gymnastic, Taekwondo Poomsae | HR_{max}: 50-80% | Body Composition Growth hormone, IGF-I, IGFBP-III |
| Kim JT (2009) [28] | 41 (14, 13, 14) | 16.21 ± 1.12 EG1, 15.94 ± 1.83 EG2, 15.74 ± 2.13 CG | 14 2-4 35-70 | No training | Basic movements of Poomsae, Taekwondo Poomsae | | Physical Fitness |
| Kim KJ (2001) [24] | 96 (32, 32, 32) | 10.98 11.30 11.21 | 8 - 85 | Basic movements of Poomsae, Taeguk Poomsae | Basic movements of Poomsae, Koryo Poomsae, Kumgang Poomsae | | Physical Fitness |

(Continued to the next page)
| Author/Year | Participants N (EG, CG) | Age | Intervention | Outcome |
|------------|-------------------------|-----|--------------|---------|
| Lee SJ (2009) [30] | 78 (39, 39) | 15-16 | 12 | 5 | 50 | No training | Basic movements of Poomsae, Taekwondo Poomsae (Taeguk 1-6 Jang) | Physical Fitness |
| Nam SN (2008) [31] | 16 (8, 8) | 17.75 ± 1.50 | 12 | 5 | 60 | No training | Basic movements of Poomsae, Taekwondo Poomsae (Taeguk 1-3 Jang) | Stress Hormones (epinephrine, norepinephrine, cortisol) |
| Moon DS (2009) [45] | 18 (9, 9) | EG: 12.18 ± 2.12 | 12 | 5 | 60 | No training | Basic movements of Poomsae, Taekwondo Poomsae (Taeguk 1-3 Jang) | HRmax: 60-70% | Body Composition, Physical Fitness, Growth Factors, Women's Hormones |
| Nam SN (2011) [7] | 20 (10, 10) | EG: 11.60 ± 1.07 | 12 | 4 | 60 | General Poomsae training | Music Poomsae training | HRmax: 60-70% | Leptin, Physical Fitness |
| Park JM (2017) [26] | 40 (20, 20) | EG: 11.84 ± 1.64 | 12 | 5 | 60 | Basic movements of Poomsae, Taekwondo Kyoyugi | Basic movements of Poomsae, Taekwondo Poomsae, Music Poomsae training | RPE: 11-13 | Physical Fitness, Balance Capability |
| Park SK (2009) [13] | 30 (15, 15) | EG: 14.67 ± 1.40 | 12 | 5 | 60 | No training | Basic movements of Poomsae, Taekwondo Poomsae, Music Poomsae training | HRmax: 60-70% | Body Composition, Metabolic Syndrome Risk Factors |
| Park SK (2010) [14] | 24 (12, 12) | EG: 11.92 ± 0.90 | 12 | 3 | 60 | No training | Basic movements of Poomsae, Taekwondo Poomsae, Music Poomsae training | HRmax: 55-70% | Body Composition, Physical Fitness, Serum Adiponectin |
| Park TH (2009) [15] | 20 (10, 10) | EG: 9.10 ± 0.90 | 12 | 5 | 50 | No training | Basic movements of Poomsae, Taekwondo Poomsae, Music Poomsae training | HRmax: 65.7-67.7% | Body Composition, Health-related Physical Fitness, Blood Lipid |
| Shin GS (2006) [3] | 20 | 8.75 ± 0.75 | 12 | 5 | 60 | No training | Basic movements of Poomsae, Taekwondo Poomsae, Music Poomsae training | - | Physical Fitness |
| Son YN (2019) [32] | 10 | 17.0 ± 0.67 | 60 | Taekwondo Poomsae training without kinesio taping | Taekwondo Poomsae training with kinesio taping | - | Blood Lipid Concentration |
| Song JK (2013) [33] | 19 (12, 7) | EG: 14.0 ± 0.64 | 12 | 3 | 50 | No training | Basic movements of Poomsae, Taekwondo Poomsae, Music Poomsae training | HRmax: 60-70% | Body composition, Health-related fitness |
Table 2. Effect of Taekwondo Poomsae Training on Body Composition

| Author/Year | Outcome measurement | Results |
|-------------|---------------------|---------|
| Cho WJ (2013) [21] | Weight, Fat%, BMI | Weight ↓ & Fat% ↓ & BMI ↓ (p<.001) |
| Ham KW (2020) [23] | Weight, BMI | Weight ↑ (p<.01), BMI ↓ (p<.001) |
| Jang CH (2013) [6] | Weight, Fat%, BMI, LBM | Weight ↓ & BMI ↓ & Fat% ↓ (p<.01), LBM ↑ (p<.001) |
| Jeong MK (2014) [43] | Weight, Fat%, BMI, LBM | Weight & Fat% ↓ (p<.01), BMI ↓ (p<.05), LBM ↑ |
| Jo KY (2010) [39] | Weight, Fat%, BMI | Weight ↑ (p<.01), Fat% ↓ & BMI ↓ (p<.001) |
| Kim WK (2009) [29] | Weight, Fat%, BMI, LBM | Weight ↓, Fat% ↓, BMI ↓, LBM ↑ |
| Kim HD (2008) [44] | Weight, BMI | Weight ↓, & Fat% ↓ & BMI ↓ (p<.01) |
| Moon DS (2009) [45] | Weight, Fat%, BMI, LBM | Weight ↓ & Fat% ↓ & BMI ↓ (p<.01), LBM ↓ |
| Park SK (2009) [13] | Weight, Fat%, BMI, LBM | Weight ↓, Fat% ↓, BMI ↑, LBM ↓ |
| Park SK (2010) [14] | Weight, Fat%, BMI, LBM | Weight (p<.05), Fat% ↓ (p<.001), BMI ↓, LBM ↑ |
| Song JK (2013) [33] | Fat%, LBM | Fat% ↑, LBM ↑ |

BMI, body mass index; LBM, lean body mass.
↓: decrease; ↑: increase; &: and.

Table 3. Effect of Taekwondo Poomsae Training on Physical Fitness

| Author/Year | Outcome measurement | Results |
|-------------|---------------------|---------|
| An HS (2017) [42] | Muscular strength, Muscle endurance, Agility, Flexibility, Explosive power | Agility ↑ (p<.001), Flexibility ↑ (p<.05), Muscular strength ↑, Muscle endurance ↑, Explosive power ↑ |
| Choi JI (2009) [22] | Muscular strength, Muscle endurance, Flexibility, Cardiopulmonary endurance | Muscular strength ↑ (p<.001), Muscle endurance ↑ (p<.001), Flexibility ↑, Cardiopulmonary endurance ↑ |
| Ham KW (2020) [23] | Muscular strength, Muscle endurance, Explosive power, Flexibility, Cardiopulmonary endurance | Muscle endurance ↑ & Explosive power ↑ (p<.05), Cardiopulmonary endurance ↑ (p<.01), Muscular strength ↑, Flexibility ↑ |
| Jang CH (2013) [6] | Muscular strength, Muscle endurance, Explosive power, Flexibility, Equilibrium | Explosive power ↑ (p<.01), Flexibility ↑ (p<.05), Muscular strength ↑, Muscle endurance ↑, Equilibrium ↑ |
| Jeong MK (2014) [43] | Muscular strength, Abdominal strength, Agility, Flexibility, Explosive power, Equilibrium | Muscular strength & Flexibility & Equilibrium ↑ (p<.05), Abdominal strength, Agility ↑ (p<.001), Explosive power ↑ |
| Kim WK (2009) [29] | Muscular strength, Abdominal strength, Agility, Flexibility, Equilibrium | Agility & Flexibility ↑ (p<.01), Muscular strength ↑ (p<.05), Equilibrium |
| Kim JT (2009) [28] | Muscular strength, Muscle endurance, Agility, Flexibility, Equilibrium | Muscle endurance, Flexibility ↑ (p<.01), Muscular strength & Agility & Equilibrium ↑, Taegeuk Poomsae: Abdominal strength & Agility & Explosive power & Flexibility ↑ (p<.01) |
| Kim KJ (2001) [24] | Abdominal strength, Explosive power, Agility, Flexibility, Equilibrium | Kyryo Poomsae: Agility ↑ (p<.01), Equilibrium ↑ (p<.05), Keumgang Poomsae: Agility ↑ (p<.01) |
| Lee SJ (2009) [30] | Muscular strength, Muscle endurance, Explosive power, Flexibility, Agility, Cardiopulmonary endurance | Muscular strength & Muscle endurance & Agility & Explosive power, & Flexibility & Cardiopulmonary endurance ↑ |
| Moon DS (2009) [45] | Back strength, Muscle endurance, Explosive power, Flexibility, Agility, Equilibrium | Back strength & Muscle endurance & Flexibility & Agility & Explosive power & Equilibrium ↑ (p<.001), Muscular strength ↑ (p<.01), Muscle endurance ↑ (p<.05), |
| Nam SN (2011) [7] | Muscular strength, Muscle endurance, Explosive power, Flexibility, Agility, Equilibrium | Agility & Flexibility ↑ (p<.001), Explosive power & Equilibrium ↑ |
| Park JM (2017) [26] | Muscular strength, Muscle endurance, Explosive power, Flexibility, Agility, Cardiopulmonary endurance | Muscle endurance & Explosive power & Agility & Cardiopulmonary endurance ↑ (p<.001), Muscular strength & Flexibility ↑ (p<.01) |
| Park SK (2010) [14] | Muscular strength, Flexibility, Back strength, Agility, Equilibrium, Explosive power, Cardiopulmonary endurance (Maximum oxygen uptake & Maximum oxygen uptake per maximum) | Flexibility & Equilibrium & Explosive power ↑ (p<.05), Agility, Maximum oxygen uptake ↑ (p<.01), Maximum oxygen uptake per maximum ↑ (p<.001), Muscular strength & Back strength ↑ |
| Park TH (2009) [15] | Muscular strength, Muscle endurance, Agility, Flexibility, Explosive power, Equilibrium | Muscular strength & Muscle endurance & Explosive power & Agility ↑ (p<.01), Flexibility & Equilibrium ↑ |
| Shin GS (2006) [3] | Muscular strength, Muscle endurance, Explosive power, Flexibility, Agility, Equilibrium | Muscular strength & Explosive power & Flexibility & Equilibrium ↑ (p<.01), Muscle endurance ↑ (p<.05), Agility ↑ (p<.001) |
| Song JK (2013) [33] | Static strength, Muscle endurance, Abdominal endurance, Flexibility, Whole body endurance | Static strength & Muscle endurance & Abdominal endurance & Whole-body endurance & Flexibility ↑ |

↓: Decrease; ↑: Increase; &: and.
Table 4. Effect of Taekwondo Poomsae Training on Blood Composition

| Author/Year | Characteristics of participants | Outcome measures | Results |
|-------------|---------------------------------|-----------------|---------|
| Cho WJ (2013) [21] | Obese children | TC, TG, HDL-C, Adiponectin | TC ↓ (p < .05), HDL-C ↑ (p < .01), TG ↓ & Adiponectin ↑ (p < .001) |
| Jang CH (2013) [6] | Metabolic syndrome | TG, HDL-C, Glucose, Cystatin C | TG ↓ (p < .01), Glucose ↓ & Cystatin C ↓ (p < .001), HDL-C ↑ |
| Jeong MK (2014) [43] | Obese girls | TC, TG, HDL-C, LDL-C, Leptin, LH, FSH, Estradiol | Leptin ↓, TC ↓, TG ↓, HDL-C ↓, LDL-C ↓, Estradiol ↓, LH ↓, FSH ↑ |
| Jo KY (2010) [39] | Overweight students | TC, TG, HDL-C, LDL-C | TC ↓ (p < .01), TG ↓ & LDL-C ↓ & HDL-C ↑ (p < .05) |
| Kim WK (2009) [29] | Obese adolescent | TC, TG, HDL-C, LDL-C, CIGF-1, DHEAs, Insulin, HOMA-IR | Growth hormone ↑ & IGF-1 ↑ & IGFBP-III ↑ (p < .05) |
| Kim HD (2008) [44] | Children | Growth hormone, IGF-1, IGFBP-III | Growth hormone ↑ & IGF-1 ↑ & IGFBP-III ↑ (p < .05) |
| Nam SN (2008) [31] | High school student | Epinephrine, Cortisol, Norepinephrine | Epinephrine ↓ (p < .01), Cortisol ↓ & Norepinephrine ↓ (p < .001) |
| Moon DS (2009) [45] | Female students | IGF-1, Progesterone, Estradiol, Estrogen | IGF-1 ↑ (p < .05), Estradiol ↓, Estrogen ↓, Progesterone ↑ |
| Nam SN (2011) [7] | Obese children | Leptin | Leptin ↓ (p < .05) |
| Park SK (2009) [13] | Metabolic syndrome | TG, HDL-C, Glucose | TG ↓ & HDL-C ↑ (p < .05), Glucose ↓ |
| Park SK (2010) [14] | Obese children | TC, TG, HDL-C, Glucose, Adiponectin, HOMA-IR, Insulin | TC ↓ & Glucose ↓ & Adiponectin ↓ & Insulin ↓, HOMA-IR ↓ (p < .05), HDL-C ↑ (p < .01), TG ↓ |
| Park TH (2009) [15] | Obese children | TC, HDL-C, LDL-C, Glucose, IGF-1, Growth hormone, Insulin, HOMA-IR | TC ↓, HDL-C ↑, LDL-C ↓, Glucose ↑, IGF-1 ↑ (p < .01), Growth hormone ↑ & Insulin ↑ & HOMA-IR ↑ (p < .05) |
| Son YN (2019) [32] | High school student | Glucose, TG | Glucose ↓ & TG ↓ (p < .05) |

TC, Total cholesterol; TG, Triglyceride; HDL-C, High density lipoprotein cholesterol; LDL-C, Low density lipoprotein cholesterol; LH, Luteinizing hormone; FSH, Follicle stimulating hormone; GH, Growth hormone; IGF-1, Insulin growth factor 1; IGFBP-III, Insulin like growth factor binding protein-III; DHEAs, Dehydroepiandrosterone sulfate; HOMA-IR, Homeostasis model of insulin resistance.

↓: Decrease; ↑: Increase; &: and.

30,45], while the remaining 3 studies reported seeing changes after the intervention of Taekwondo Poomsae training, but it was not statistically significant [6,33,42]. And the case of equilibrium, 10 studies are related to it, of which 5 studies showed significant changes after the Taekwondo Poomsae intervention[3,14,24,43,45]. However, there are also 5 studies revealed no significant changes after the Taekwondo Poomsae intervention, but the trend of improvement could be seen [6,7,15,28,29].

3) Blood Composition

Of the 22 studies, 13 studies declared the effects of Taekwondo Poomsae training on blood components [6,7,13-15,21,29,31,32,39,43-45]. 9 studies involved blood lipid factors such as TC, TG, HDL-C, LDL-C, etc. After 12 weeks of different times of the Taekwondo Poomsae intervention, the concentration of TC, TG, LDL-C in blood of the participants decreased significantly, while the concentration of HDL-C increased significantly [6,13-15,21,29,32,39,43].

There are 7 studies related to overweight or obese children, among which 6 studies showed the effect of Taekwondo Poomsae training on neutral lipid variability (TC, TG, HDL-C,LDL-C) [14,15,21,29,39,43], and 2 studies reported that adiponectin of obese children increased significantly after 12 weeks Taekwondo Poomsae potentials intervention [14, 21].

Furthermore, another study conducted 12 weeks of Music Poomsae intervention on obese children, and the results demonstrated that the leptin content in blood of the participants decreased from 12.62 ± 4.72 ng/mL before training to 11.60 ± 4.67 ng/mL after training, with a significant difference [7].

Two studies were related to metabolic syndrome, and the results asserted that the concentration of risk factors of metabolic syndrome (Waist circumference, Glucose, SBP, DBP, TC) decreased significantly and HDL-C increased after 12 weeks of Taekwondo Poomsae intervention [6,13]. And Jang (2013) also reported the changes in the concentration of Cystatin C was significantly decreased before and after Taekwondo Poomsae intervention.

And beyond that there are 2 studies on female children. The study of Jeong (2014) was the risk factors of precocious puberty of obese girls aged 7-8 through 12 weeks Taekwondo Poomsae training. The results found that estradiol, LH decreased and FSH increased after 12 weeks, but did not show statistical significance [43]. And the study of Moon (2009) conducted a 12-weeks Taekwondo Poomsae intervention on girls aged 11-13 who had undergone menstruation. The results discovered that Estradiol and Estrogen were significantly reduced, and the content of Progesterone increased, although there was no significant difference, the growth hormone and IGF-1 increased significantly [45].
3. Intervention time and intensity

From these 22 studies of Taekwondo Poomsae intervention on children and adolescents, it was found that the intervention period is between 8 and 20 weeks. 86.96% (20 of 23 studies) lasted for 12 weeks, and the frequency of intervention varied from 2-5 times a week, and the duration of each time is 35-85 minutes.

In addition, 14 studies showed training intensity, and most of them were set between medium and medium-high intensity (Table 1). Four studies used HRRmax to express exercise intensity, including one study HRRmax: 50-80% [44], one study HRRmax: 65.7-67.7% [15], and other two studies HRRmax: 60-70% [13,33]. Six studies used HRmax to express exercise intensity, specifically HRmax: 50-70% [6,39], HRmax: 55-70% [14,43] and HRmax: 60-70% [7,45]. In the other four studies, RPE [23,26,42] and VO2max [21] were used to represent exercise intensity.

From the setting of exercise intensity, these intensities are consistent (similar) to those emphasized by the American College of Sports Medicine, that is, in order to maintain and improve the body composition, the 40-70% VO2max exercise intensity is needed [46], and in order to promote the physical enhancement of children and adolescents, the daily exercise intensity is above medium and medium-high [1,2].

4. Quality assessment

The risk of bias in the included studies was overall low (Figs. 2, 3). 14 studies [6,7,13,14,21-23,26,28,29,32,33,44,45] described the allocation concealment, and the other 8 studies [3,15,24,30,31,39,42,43] did not mention the allocation concealment. All studies did not mention whether the participants and personnel were blinded, which is related to the nature of the intervention, and it is not easy to be blind to the participants and personnel. In addition, most of the included studies showed that the total sample size was low. Except that the total sample size of the three studies were 145 [22], 96 [24], 78 [30] respectively, the total sample size of the other studies did not exceed 42.

DISCUSSION

This review is the first systematic review of Taekwondo Poomsae intervention in children and adolescents. The purpose is to explore whether Taekwondo Poomsae training can improve the body composition, physical fitness and blood composition of children and adolescents. Although there was a similar systematic review and meta-analysis before, the intervention mode was not the Taekwondo Poomsae or the study participant was the elderly rather than children and adolescents.

1. Body Composition

Among the many elements of body composition, the proportion of Fat%, BMI, LBM etc. are the standard to judge the balance of body composition and the most basic condition to maintain health, which has an important impact on obesity, health, and sports performance.

Taekwondo training significantly reduce the weight, fat% and BMI of healthy and overweight or obese adolescents and children (10 reports in 11 studies), which seems to indicate that it is effective in improving body composition. According to results, Taekwondo is considered to be a very suitable aerobic exercise for teenagers and children [47]. Although previous studies have different opinions on the impact of exercise training intensity on body composition, aerobic exercise is considered to be the most appropriate activity to reduce the percentage of body fat and in-

![Fig. 2. Risk of bias graph.](https://www.ksep-es.org)
crease the level of aerobic exercise (such as peak oxygen uptake) [48]. Especially compared with low-intensity exercise, high-intensity training is more effective in reducing BF% [49,50], which is due to higher energy consumption during exercise lead to more body fat loss, thus reducing body weight and body fat [40,50,51]. This is also the reason why the body composition of the subjects changed after the Taekwondo Poomsae intervention.

2. Physical Fitness

Physical fitness is the basic guarantee to maintain daily work and leisure activities and to deal with emergencies, and it’s also the basis to promote health and improve sports performance. ACSM advocates more than 30 minutes of continuous moderate intensity aerobic exercise and strength training every day to promote the improvement of adolescents’ physical fitness [2].

In this review, agility [3,7,14,15,24,26,28-30,42,43,45], cardiopulmonary endurance [14,22,23,26,30], explosive power [2,3,6,7,14,15,23,24,26,30,42,43,45], flexibility [3,6,7,14,15,22-24,26,28-30,33,42,43,45] muscle endurance [3,6,7,15,22-23,26,28,30,33,42,43,45] muscle strength [3,6,7,14,15,22-24,26,28-30,33,42,43,45] and equilibrium [3,6,7,14,15,24,28,29,43,45] of the 16 literatures related to physical fitness were presented significantly improved in different degrees, which shows that Taekwondo Poomsae training is effective in promoting the physical fitness of children and adolescents.

Although previous studies have shown that various sports such as soccer [52,53], basketball [54,55], volleyball [56], martial arts [57] and karate [58,59], etc. all contribute to the growth and development of young children and improvement of basic physical fitness. However, it is worth mentioning that, compared with these sports, on the other hand, Taekwondo is not an exercise that uses only the limited parts of the body, but requires various movements, such as Jireugi, Jjireugi, Chagi, Breaking, jumping and rapid body movement etc. therefore, it can experience physical activity throughout the body [28,30]. Especially, Taekwondo has extremely strict requirements for physical elements such as strength, flexibility and balance when it completes various movements in an abnormal posture. Through Taekwondo Poomsae training, it can not only induce physical activities of the whole body and promote the functions of the nervous system and circulatory system [30,60], but also balance train the physical fitness such as muscle strength, muscular endurance, agility, flexibility, explosive power and equilibrium [28,30]. In addition, as a martial arts sport, Taekwondo Poomsae pursues the technical prac-
ticability of physical exercise, and also includes the educational and philosophical factors in oriental thought such as personality cultivation, spiritual exercise and self-discovery [61]. Through Personality education and martial arts education, it is possible to achieve educational effects and values that emphasize character completion or self-education. This is very beneficial for growing children [62].

3. Blood Composition

In this review, we found that Taekwondo Poomsae training caused significant changes in adiponectin [14,21], leptin [7,43], blood composition (TC, TG, HDL-C, etc.) and the risk factors of metabolic syndrome (TG, HDL-C, glucose, Cystatin C, insulin, HOMA-IR, etc.). This indicates that Taekwondo Poomsae training is an effective exercise method to improve obesity and metabolic syndrome [10,63-66].

According to previous studies, exercise can reduce plasma TG concentration, which is mainly caused by TG baseline level rather than energy consumption [67]. In addition, although the mechanism of exercise-induced changes in blood lipids (TC, TG, HDL-C) is not clear, total energy expenditure and exercise intensity are considered as the main factors affecting the changes in blood lipids [68]. On the one hand, exercise itself may increase blood lipid consumption, thus reducing blood lipid level [69]. Also, under the same amount of exercise, the higher the exercise intensity, the more obvious the change of blood lipid [70]. The mechanism of this change may be related to the increased activity of lipoprotein lipase (LPL), which is responsible for the hydrolysis of chyle particles and VLDL TAG in particles [67,71].

Previous studies have shown that increased plasma adiponectin levels are caused by weight loss [72-76], and the decrease of exercise-related leptin may be due to the change of nutrient availability or nutrient flow of adipocytes (the main place of leptin production and secretion) [77,78]. Exercise with high energy consumption has a greater impact on circulating leptin level [77,79]. Many studies have confirmed that the change of HOMA-IR is related to the decrease of fat, and the decrease of total body fat and percentage is the intermediary of the change of HOMA-IR caused by exercise [80-83].

In addition, there were significant changes in growth related factors (growth hormone, IGF-1, IGFBP-Ⅲ) caused by Taekwondo Poomsae training. This is because an increase in the concentration of lactic acid produced during exercise, or more accurately, an increase in the concentration of hydrogen ions, regulates the release of growth hormone (GH) [84-86]. The mechanism of the decrease of IGF-1 and IGFBP-Ⅲ in pre-adolescent and early adolescent boys is explained as may be partly related to the increase of the basic level of some pro-inflammatory cytokines related to training [87].

4. Limitations

Although this systematic review shed light on many benefits, it still has some limitations. For example, when searching for studies, only the published studies in Korean are searched, which may be a limitation. Therefore, other databases and languages can be considered for further research. In addition, it should be emphasized that the number of included studies is small, and most studies have few participants, which may lead to inconsistent results. And in terms of allocation concealment and blind method of participants and personnel, it is usually poorly reported, which will be solved in the future research on Taekwondo Poomsae training for children and adolescents, so as to improve the quality of current research in this field.

CONCLUSIONS

In conclusion, we firmly believe that Taekwondo Poomsae is an effective sport to improve the physical condition of children and adolescents. It is even worth recommending to more people, such as the middle-aged and the elderly. However, only from the 7 literatures included, we cannot assert that taekwondo Poomsae is also an effective exercise therapy for special groups such as overweight, obesity or metabolic syndrome in growth and development. Although some reports say it is, more evidence is needed to verify it. Therefore, we suggested that sports formulators, Taekwondo Poomsae experts, coaches and other professionals provide more Taekwondo Poomsae training programs suitable for physical exercise and exercise kinesitherapy for different ages and groups (healthy and non-healthy or ordinary and special groups).

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this paper.

AUTHOR CONTRIBUTIONS

Conceptualization: I. Ye, H Jun; Data curation: I. Ye; Formal analysis: I. Ye, H Jun; Funding acquisition: N/A; Methodology: I. Ye, H Jun; Proj-
Yi Lei, et al. Poomsae Training in Children and Adolescents

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