



Systematic Review

Effects of Taekwondo Training on Body Composition: A Systematic Review and Meta-Analysis

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Abstract: Background: The purpose of this study is to investigate the effect of Taekwondo training on body composition and to evaluate the magnitude of the effect. Methods: Databases were used to select studies related to the effectiveness of Taekwondo training, and the inclusion criteria were as follows. Results: Thirty-seven studies were selected. We found statistically significant differences from the control group in weight, body mass index (BMI), waist circumference (WC), waist-hip ratio (WHR), body fat mass, body fat percentage, lean mass, and muscle mass. Also, the age group was statistically significant in control variables on weight, BMI, and body fat percentage. Conclusions: Taekwondo training had a positive effect on body composition, and these results suggest that Taekwondo training is an effective exercise method to lower obesity.

Keywords: Taekwondo; meta-analysis; body composition; obesity



Citation: Baek, S.; Park, J.-B.; Choi, S.-H.; Lee, J.-D.; Nam, S.-S. Effects of Taekwondo Training on Body Composition: A Systematic Review and Meta-Analysis. *Int. J. Environ. Res. Public Health* **2021**, *18*, 11550. <https://doi.org/10.3390/ijerph182111550>

Academic Editors: Omorogieva Ojo and Paul B. Tchounwou

Received: 31 August 2021
Accepted: 30 October 2021
Published: 3 November 2021

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1. Introduction

Insufficient physical activity was reported as the fourth most important risk factor among the causes of death worldwide [1]. For this reason, Korea has set physical activity goals for all age groups through the 3rd National Health Promotion Plan (HP2020) and is creating various policies and environments to promote physical activity [2]. According to the Korea Centers for Disease Control and Prevention report in 2019, the rate of aerobic exercise among adolescents increased by 3.0% *p* from 10.9% in 2009 to 13.9% in 2018. On the other hand, the rate of aerobic exercise among adults over the age of 19 and older decreased by 9.8% from 58.3% in 2014 to 48.5% in 2017, and the rate of walking among adults over the age of 19 and older decreased by 6.7% *p* from 45.7% in 2007 to 39.0% in 2017 [3]. However, according to the study of Guthold et al. [4], a 2016 survey of 298 schools in 146 countries found that 81.0% of 11–17 year olds were not getting enough physical activity. On the other hand, in the case of Korea, 94.2% of adolescents showed insufficient amount of physical activity, which made Korea recognized as the country with the most insufficient amount of physical activity for adolescents in the world. Since such a decrease in physical activity can cause a decrease in physical strength and muscle mass [5] and an increase in body fat mass, thereby causing metabolic diseases [6], efforts to increase physical activity are required.

Taekwondo is a traditional martial art from Korea and is recognized as a global martial arts and sport with more than 100 million practitioners in 210 countries worldwide [1]. Taekwondo as an exercise has positive effects on the psychological and physiological areas for the growth and development of children and adolescents. In addition, Taekwondo training prevents or positively improves obesity, dyslipidemia, diabetes, hypertension, cerebrovascular, and cardiovascular diseases in adults and the elderly [7–10]. In addition, it is expected to improve various physical strengths, including aerobic capacity, muscle strength, muscular endurance, flexibility, speed, and agility through the physiological effects of Taekwondo practice [11–14]. For this reason, Taekwondo is considered suitable

as an essential exercise for improving the physical activity of Koreans and preventing and improving various diseases. However, although multiple studies have been conducted to verify the effectiveness of Taekwondo training, the results are not consistent, and depend on the study subject, method and duration of interventions, making it difficult to generalize the results. Therefore, it is necessary to present the best evidence to prove the effect of physical activity through Taekwondo among Koreans [15]. Thus, this study shows the effects of Taekwondo training on changes in body composition comprehensively and quantitatively to serve as evidence for the development of Taekwondo training as a way to improve obesity caused by lack of exercise in modern people including not only Koreans but people worldwide.

2. Materials and Methods

This study was conducted with reference to the Preferred Reporting for Systematic Reviews and Meta-Analysis (PRISMA) guidelines [16].

2.1. Search Strategy

In this study, we searched the literature in electronic databases, including the Cochrane Library, EMBASE, and PubMed, and used RISS (Research Information Sharing Service), NDSL (National Science and Technology Information Center) in Korea. The keyword used in the literature search was “Taekwondo”. In addition, we included gray literature such as dissertations to reduce publication bias. The language of the papers was limited to Korean and English. The publication year was not limited to the default setting. The reason we used only ‘taekwondo’ as a keyword is to prevent the omission of literature related to this topic as much as possible.

2.2. Selection of Studies

We selected literature according to the following PICO (participants, interventions, comparisons, outcomes) criteria. We included studies where the study subjects were the general public and excluded studies where the study subjects were not the general public (athletes, disabled people, hypertensive patients, diabetic patients, etc.). In addition, we selected studies where the intervention method was Taekwondo training and excluded studies that added interventions other than Taekwondo. Also, we included only studies with a control group who did not practice Taekwondo. We selected studies that presented actual measurements of body composition and studies with an RCT (randomized controlled trial) study design.

2.3. Moderator

The effects of Taekwondo intervention were analyzed by looking at how the results were influenced by the differences in the moderators, including gender, age, training period, research method, types of literature, and quality evaluation. Age was divided into three groups: students who attend elementary, middle, and high school, adults, and the elderly. The training periods were divided into 12 weeks or less and more than 12 weeks. Publication types were identified by dividing them into degree thesis and journal publications.

2.4. Quality Assessment

For the qualitative evaluation of the selected literature, the Cochrane Collaboration’s RoB (Risk of Bias) tool [16] was used. The evaluation consists of 7 items, including: (1) generating order of random assignment; (2) hiding assignment order; (3) blinding study participants and researchers; (4) blinding outcome evaluation; (5) insufficient result data; (6) selective reporting; and (7) other biases. The evaluation was rated as low risk, high risk, and uncertain.

2.5. Statistical Analysis

The effect size of the Taekwondo intervention and the heterogeneity were analyzed using the R program (version 3.6.2, R Foundation for Statistical Computing, Vienna, Austria) [17]. The outcome variables were all continuous variables and included Height, weight, BMI, WC, WHR, fat mass, lean mass, body fat percentage, and muscle mass. The overall effect size was analyzed when there were three or more outcome variables. The measurement unit was the same, expressed as mean difference (MD) and 95% confidence intervals (CIs). The random effects model was used under the assumption that the outcome variables of each study were heterogeneous [18]. Meta-ANOVA and meta-regression were performed for the moderating variables, and both continuous variables (sample sizes) and categorical variables (gender, age, study period, publication type) were estimated using the Restricted Maximum Likelihood (REML) method [19].

2.6. Assessment of Heterogeneity

Heterogeneity was assessed using the Cochran Q test and Higgins' I^2 statistics. When the p -value of the Cochran Q test was 0.1 or less or the Higgins' I^2 was 50% or more, it was considered that there was statistically significant heterogeneity.

2.7. Publication Bias

For the publication bias analysis, we applied a funnel plot using standard error and MD, additionally applied Egger's test and Begg's test [20].

3. Result

3.1. Inclusion of Studies

Of the 803 studies, we selected 171 studies, excluding duplicate studies (280) and those unrelated to this study (352). Then, as a result of full-text screening according to the PICO criteria, 131 studies without a control group and three studies that did not explain the Taekwondo training program were excluded. Therefore, we finally selected 37 studies for meta-analysis. All 37 papers were satisfied for both qualitative and quantitative analysis. The detailed process is shown in Figure 1.

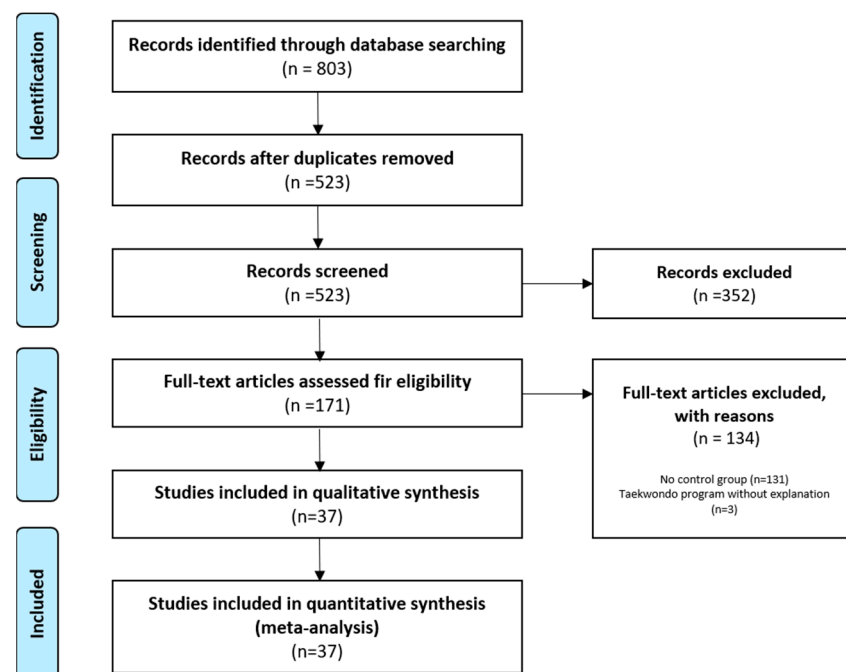


Figure 1. PRISMA flow diagram.

3.2. Characteristics of the Included Studies

The total sample size was 801. The average age of the participants was 32.19 years old, ranging from 7.46 to 75.07, and 54.2% of the participants were male. 18 studies [21–37] were for students, 12 studies [38–49] were for adults, and 7 studies were for seniors [50–56], and the training period was 8–24 months. According to the publication type, 15 were for dissertations studies, and 22 studies were for journal publication. The characteristics of the included studies are summarized in Table 1.

3.3. Quality Assessment

Two independent researchers (S.B., S.N.) performed quality assessment as shown in Figure 2, based on the criteria of the Cochrane Collaboration. All 37 studies were randomized control studies, and all studies analyzed the results, excluding participants who dropped out during the intervention.

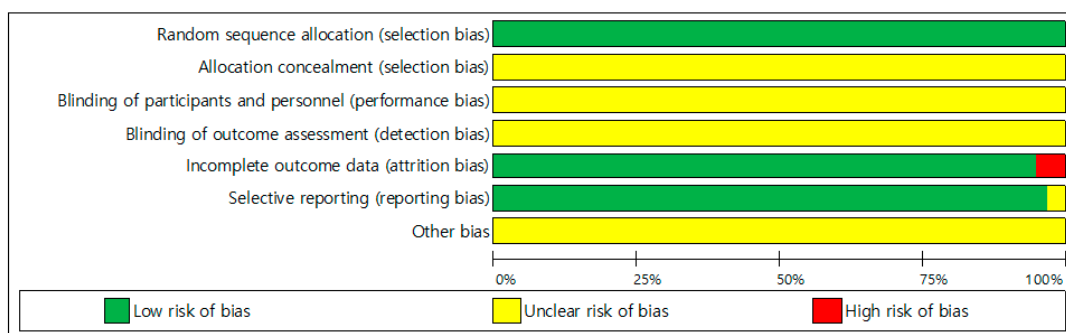
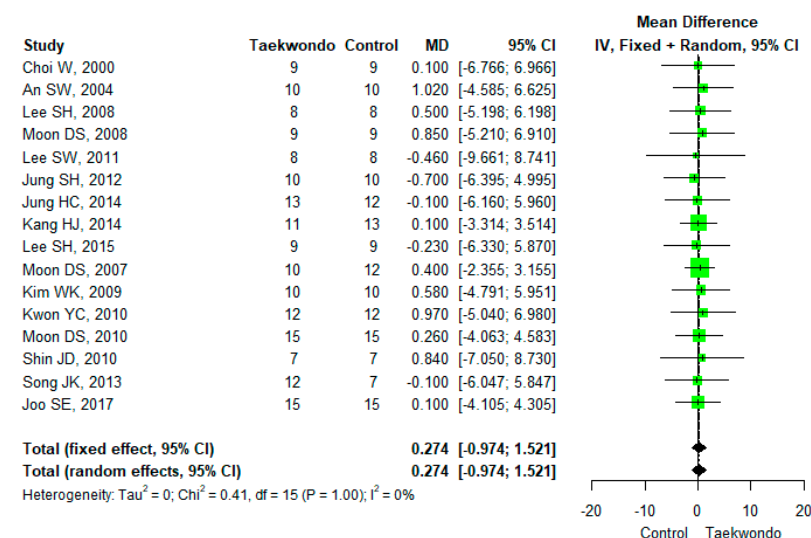


Figure 2. Assessment of risk of bias in included studies.

3.4. Outcome Findings

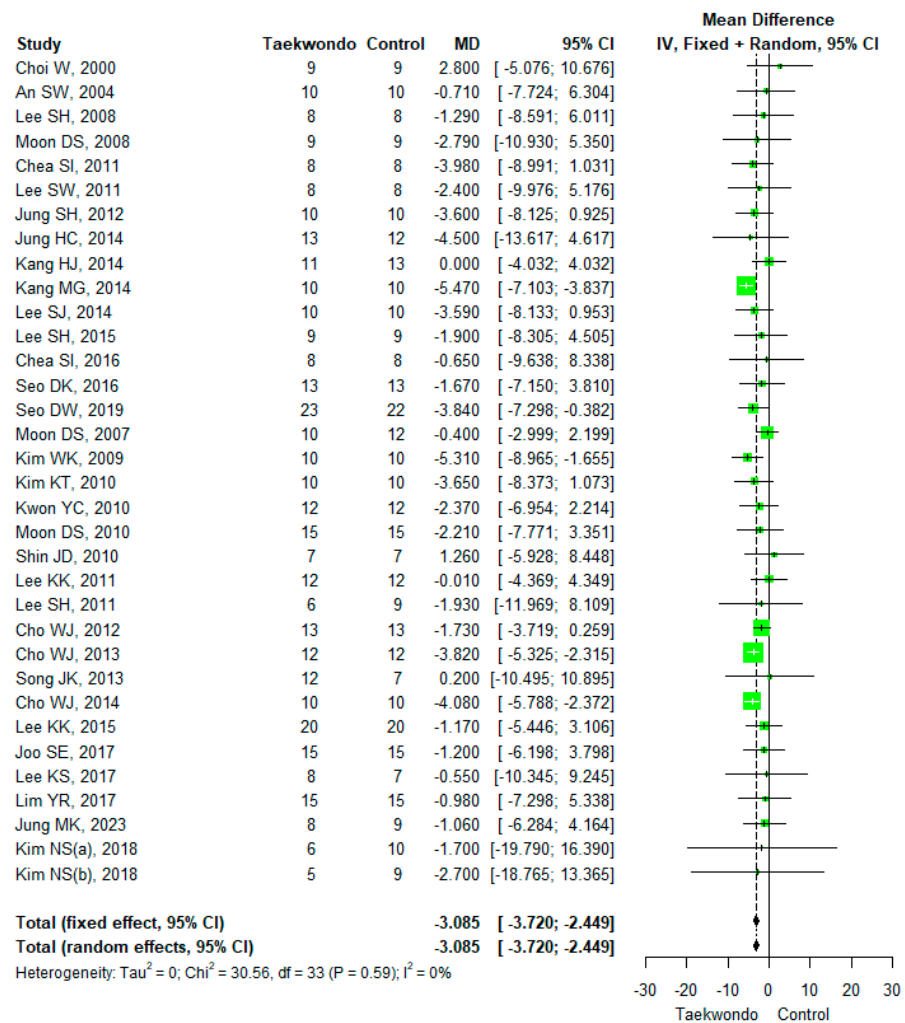
3.4.1. Height

Sixteen studies reported height (total $n = 184$; taekwondo training group $n = 168$, control group $n = 166$). The mean difference (MD) in heights between the Taekwondo training and the control group was 0.274 (95% CI; $-0.974, 1.521$), and no statistically significant difference was found. For the heterogeneity test, the results of Cochrane Q were $p = 1.00$, and Higgins' I^2 was 0% (Figure 3a).

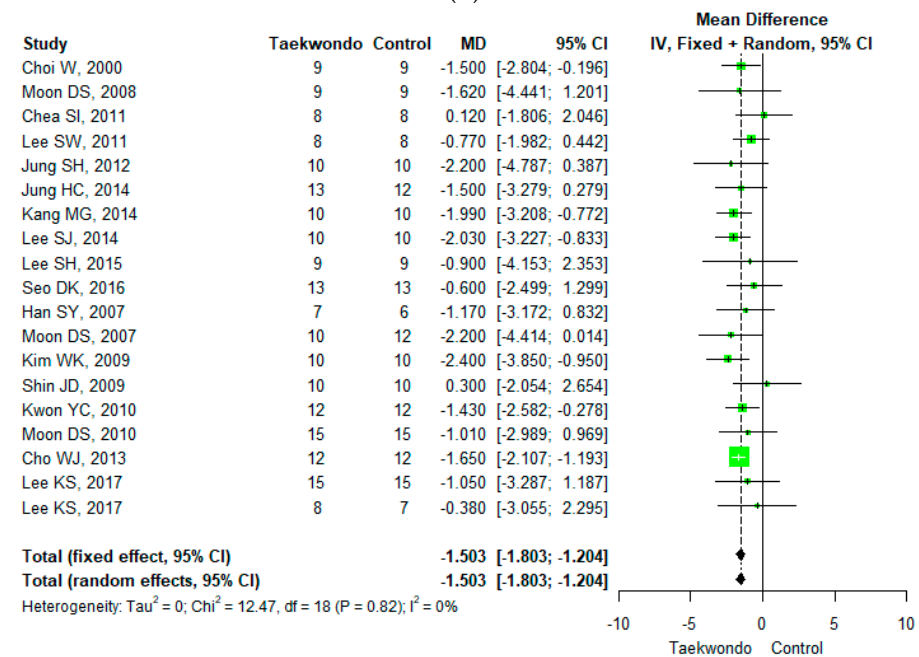


(a)

Figure 3. Cont.

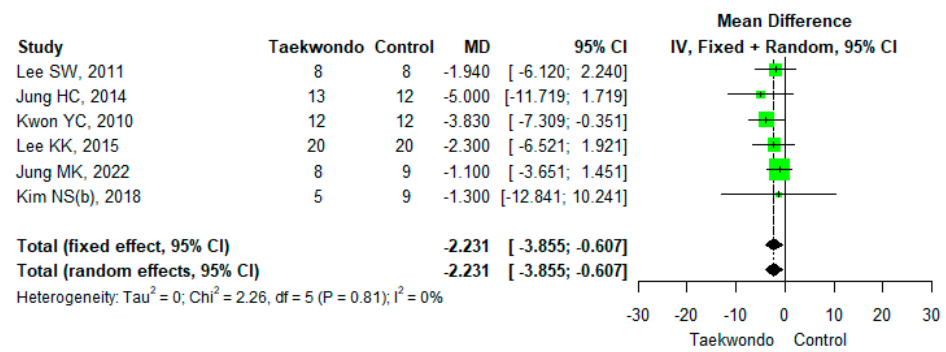


(b)

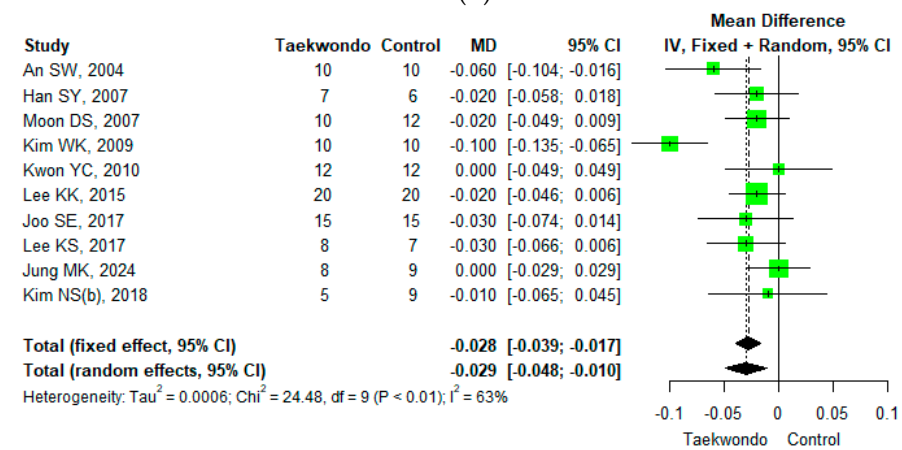


(c)

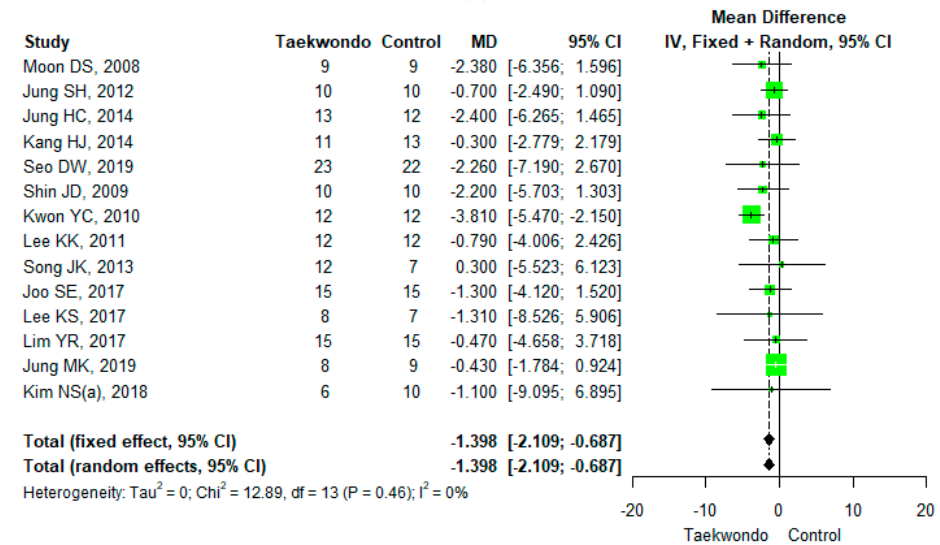
Figure 3. Cont.



(d)

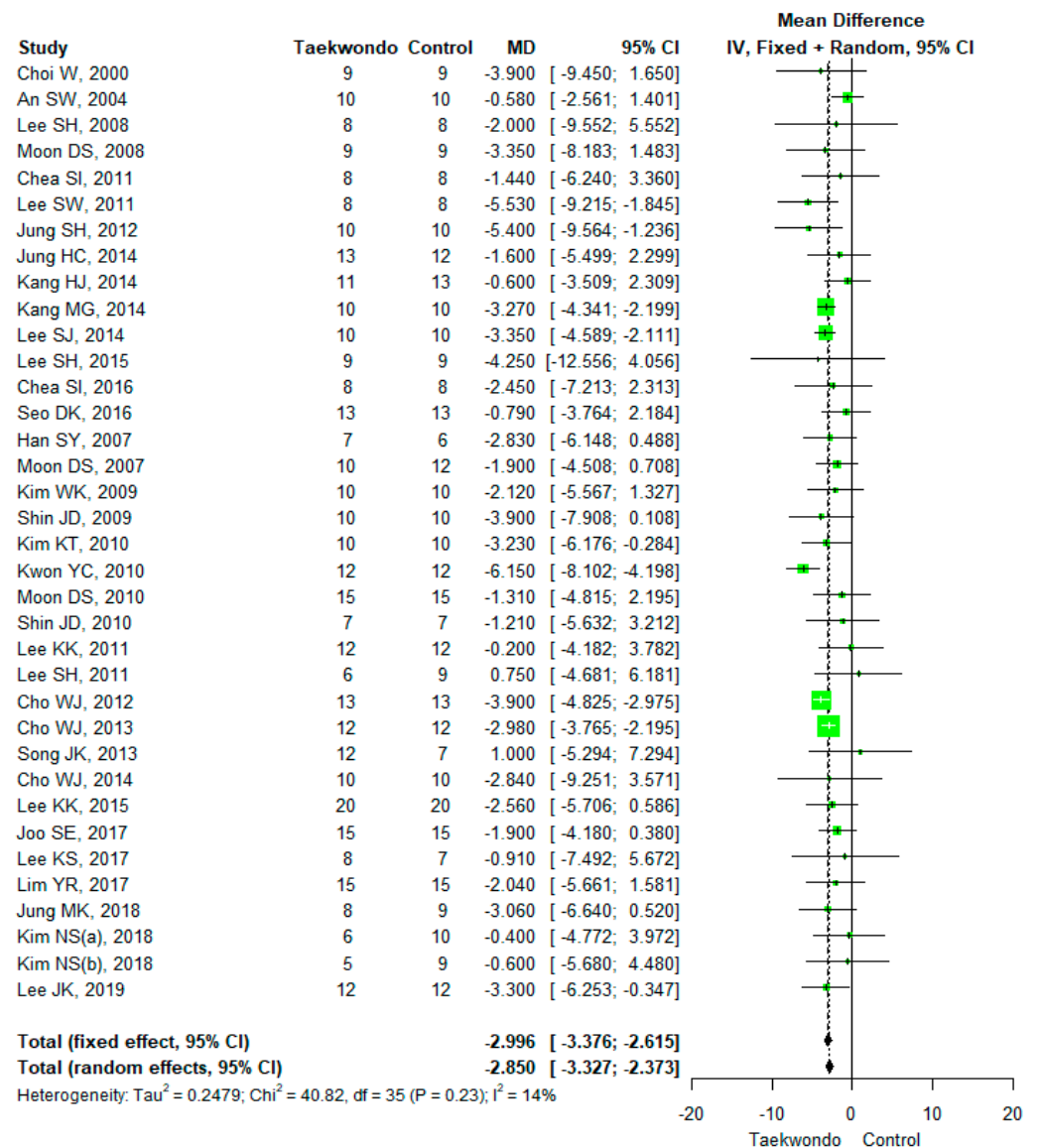


(e)



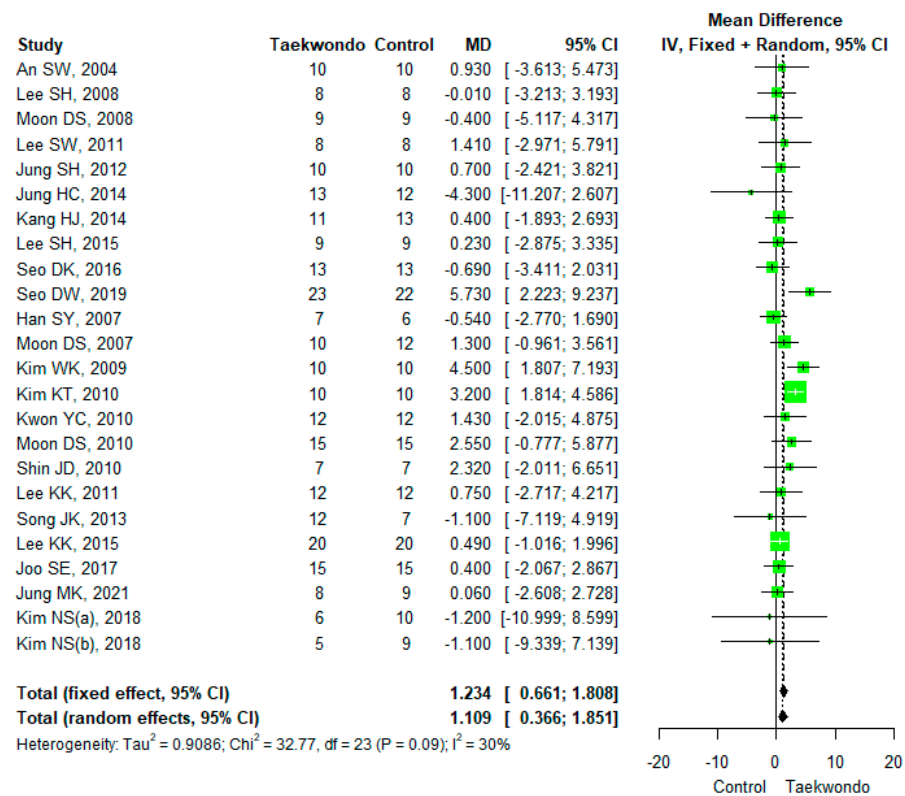
(f)

Figure 3. Cont.

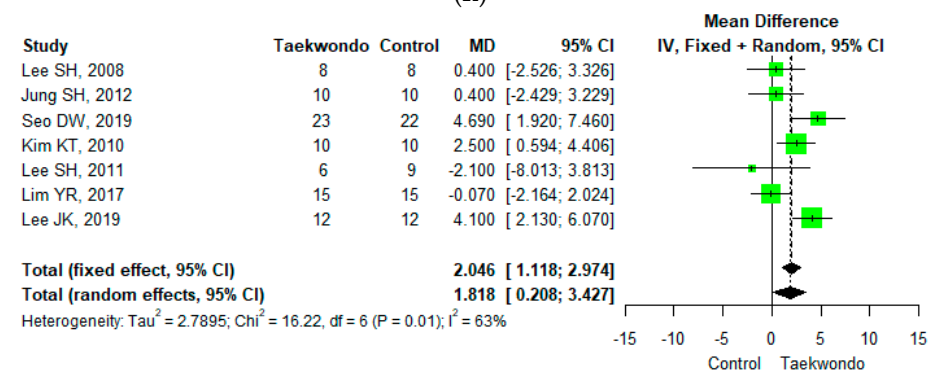


(g)

Figure 3. Cont.



(h)



(i)

Figure 3. Forest plot of the mean difference in physique and body composition. (a) Height; (b) weight; (c) body mass index; (d) waist circumference; (e) waist-hip ratio; (f) body fat mass; (g) body fat percentage; (h) lean mass; (i) muscle mass.

Table 1. Characteristics of included studies.

| Study | Study Type | Frequency (Day/Week) | Participants | Sex | Taekwondo (<i>n</i> , Age) | | Control (<i>n</i> , Age) | | Body Composition Method | Outcome Variable |
|--------------------|-----------------|----------------------|--|-------|-----------------------------|-------|---------------------------|-------|-------------------------|---|
| Choi W, 2000 [21] | Thesis | 3/24 | Elementary student, 40% body fat ↑ | M | 9 | 11.78 | 9 | 11.89 | Skinfold | % Body fat, BMI, Height, Weight |
| Lee SH, 2008 [22] | Thesis | 5/12 | Elementary student | M | 8 | 11.1 | 8 | 11.1 | BIA | % Body fat, Height, Lean mass, Muscle mass, Weight |
| Lee SW, 2011 [23] | Thesis | 5/12 | Elementary student | Mixed | 8 | 11.13 | 8 | 10.88 | BIA | % Body fat, BMI, Height, Lean mass, WC, Weight |
| Jung SH, 2012 [24] | Thesis | 5/12 | Elementary student | M | 10 | 10.2 | 10 | 10.3 | BIA | % Body fat, BMI, Fat mass, Height, Lean mass, Muscle mass, Weight |
| Lee SJ, 2014 [25] | Thesis | 3/16 | Elementary student, 25% body fat ↑ | M | 10 | 12.6 | 10 | 12.7 | BIA | % Body fat, BMI, Weight |
| Lee SH, 2015 [26] | Thesis | 5/12 | Elementary student | M | 9 | 7.46 | 9 | 7.74 | BIA | % Body fat, BMI, Height, Lean mass, Weight |
| Seo DW, 2019 [27] | Thesis | 5/12 | Elementary student | M | 23 | 10 | 22 | 9.67 | BIA | Fat mass, Lean mass, Muscle mass, Weight |
| An SW, 2004 [28] | Thesis | 5/12 | Adolescent, 30% body fat ↑ | M | 10 | ND | 10 | ND | BIA | % Body fat, Height, Lean mass, Weight, WHR |
| Shu DK, 2008 [29] | Thesis | 5/12 | Adolescent. first menstruation | M | 9 | 12.18 | 9 | 12.73 | BIA | % Body fat, BMI, Fat mass, Height, Lean mass, Weight |
| Jung HC, 2014 [30] | Thesis | 3/16 | Adolescent | M | 15 | 13.9 | 15 | 13.9 | DXA | % Body fat, BMI, Fat mass, Height, Lean mass, WC, Weight |
| Kang MG, 2014 [31] | Thesis | 3/12 | Adolescent, 30% body fat ↑ | F | 10 | ND | 10 | ND | BIA | % Body fat, BMI, Weight |
| Moon DS, 2007 [32] | Journal article | 5/12 | Elementary student | M | 12 | 12.35 | 12 | 12.42 | BIA | % Body fat, BMI, Height, Lean mass, Weight, WHR |
| Kim WK, 2009 [33] | Journal article | 5/12 | Adolescent men, 20% body fat ↑ | M | 10 | 14.7 | 10 | 15.1 | BIA | % Body fat, BMI, Height, Lean mass, Weight, WHR |
| Kwon YC, 2010 [34] | Journal article | 3/12 | Elementary student, 25% body fat ↑ | Mixed | 12 | 11.92 | 12 | 12.5 | BIA | % Body fat, BMI, Fat mass, Height, Lean mass, WC, Weight, WHR |
| Lee SH, 2011 [35] | Journal article | 4/10 | Adolescent | M | 6 | 16.8 | 9 | 16.4 | BIA | % Body fat, Muscle mass, Weight |
| Cho WJ, 2013 [36] | Journal article | 3/12 | Elementary student, BMI 25 kg/m ² ↑ | M | 12 | 11.17 | 12 | 11.33 | BIA | % Body fat, BMI, Weight |

Table 1. Cont.

| Study | Study Type | Frequency (Day/Week) | Participants | Sex | Taekwondo (n, Age) | | Control (n, Age) | | Body Composition Method | Outcome Variable |
|--------------------|-----------------|----------------------|--|-----|--------------------|-------|------------------|-------|-------------------------|--|
| Song JK, 2013 [37] | Journal article | 3/12 | Adolescent | M | 12 | 14 | 7 | 13.9 | DXA | % Body fat, Fat mass, Height, Lean mass, Weight |
| Cho WJ, 2014 [38] | Journal article | 3/12 | Elementary student, BMI 25 kg/m ² ↑ | M | 10 | 11.77 | 10 | 11.51 | BIA | % Body fat, Weight |
| Chea SI, 2016 [39] | Thesis | 3/12 | Middle-aged women, obesity | F | 8 | 39.25 | 8 | 39.7 | BIA | % Body fat, Weight |
| Seo DK, 2016 [40] | Thesis | 5/12 | Middle-aged women | F | 13 | 42.77 | 13 | 42.54 | BIA | % Body fat, BMI, Lean mass, Weight |
| Han SY, 2007 [41] | Journal article | 5/14 | Middle-aged women, no menopause | F | 7 | 41 | 6 | 38 | BIA | % Body fat, BMI, Lean mass, WHR |
| Kim KT, 2010 [42] | Journal article | 3/12 | Adult | M | 10 | 27.3 | 10 | 27.4 | BIA | % Body fat, Lean mass, Muscle mass, Weight |
| Lee KK, 2011 [43] | Journal article | 3/12 | Middle-aged | F | 12 | 41.44 | 12 | 42.16 | DXA | % Body fat, Fat mass, Lean mass, Weight |
| Lee KK, 2015 [44] | Journal article | 3/12 | Middle-aged women, menopause | F | 20 | 54.3 | 20 | 53.1 | DXA | % Body fat, Lean mass, WC, Weight, WHR |
| Joo SE, 2017 [45] | Journal article | 3/12 | Middle-aged women, 30% body fat ↑ | F | 15 | 40.1 | 15 | 40.2 | BIA | % Body fat, Fat mass, Height, Lean mass, Weight, WHR |
| Lee KS, 2017 [46] | Journal article | 3/8 | Middle-aged | M | 7 | 40.85 | 7 | 40.71 | BIA | % Body fat, BMI, BMI, Fat mass, Weight, WHR |
| Jung MK, 2018 [47] | Journal article | 3/24 | Middle-aged women, menopause & obese | F | 8 | 61.05 | 9 | 59.89 | BIA | % Body fat, Fat mass, Lean mass, WC, Weight, WHR |
| Lee JK, 2019 [48] | Journal article | 3/12 | Middle-aged women, 30% body fat ↑ | F | 12 | 50.9 | 12 | 50.3 | BIA | % Body fat, Muscle mass |
| Kim NS, 2018 [49] | Journal article | 13/2 | University student | M | 6 | 21.3 | 10 | 22.1 | BIA | % Body fat, Fat mass, Lean mass, Weight |
| Kim NS, 2018 [50] | Journal article | 3/12 | University student | M | 5 | 21 | 9 | 22 | BIA | % Body fat, Lean mass, WC, Weight, WHR |
| Chea SI, 2011 [51] | Thesis | 3/12 | Elderly women | F | 8 | 69.53 | 8 | 70 | BIA | % Body fat, BMI, Weight |
| Kang HJ, 2014 [52] | Thesis | 3/12 | Elderly women | F | 11 | 69.4 | 13 | 70.4 | DXA | % Body fat, Fat mass, Height, Lean mass, Weight |
| Shin JD, 2009 [53] | Journal article | 3/12 | Elderly women | F | 10 | 69.7 | 10 | 71.7 | BIA | % Body fat, BMI, Fat mass, |

Table 1. Cont.

| Study | Study Type | Frequency (Day/Week) | Participants | Sex | Taekwondo (n, Age) | | Control (n, Age) | | Body Composition Method | Outcome Variable |
|--------------------|-----------------|----------------------|-------------------------------|-----|--------------------|-------|------------------|-------|-------------------------|--|
| Moon DS, 2010 [54] | Journal article | 3/12 | Elderly women | F | 15 | 72.13 | 15 | 75.07 | BIA | % Body fat, BMI, Height, Lean mass, Weight |
| Shin JD, 2010 [55] | Journal article | 3/12 | Elderly women, 30% body fat ↑ | F | 7 | 70.86 | 7 | 71.68 | BIA | % Body fat, Height, Lean mass, Weight |
| Cho WJ, 2012 [56] | Journal article | 3/12 | Elderly women, 30% body fat ↑ | F | 13 | 69 | 13 | 68.62 | BIA | % Body fat, Weight |
| Lim YR, 2017 [57] | Journal article | 4/12 | Elderly women, over Weight | F | 15 | ND | 15 | ND | BIA | % Body fat, Fat mass, Muscle mass, Weight |

3.4.2. Weight

A total of 34 studies reported body weight (total $n = 738$; taekwondo training group $n = 365$, control group $n = 373$). The mean difference (MD) in body weight between the Taekwondo training and the control group was -3.085 (95% CI; $-3.720, -2.449$). That is, the weight of the Taekwondo training group decreased by 3.1 kg compared to the control group, which was statistically significant ($p < 0.001$). For the heterogeneity test, the results of Cochrane Q were $p = 0.59$, and Higgins' I^2 was 0% (Figure 3b).

3.4.3. Body Mass Index

Eighteen studies reported body mass index (total $n = 395$; 198 Taekwondo training group, 197 control group). The mean difference (MD) of body mass index between the Taekwondo training and the control group was -1.503 (95% CI; $-1.803, -1.204$). The Body mass index of the Taekwondo training group decreased by 1.5 compared to the control group, and there was a statistically significant difference ($p < 0.001$). For the heterogeneity test, the results of Cochrane Q were $p = 0.82$, and Higgins' I^2 was 0% (Figure 3c).

3.4.4. Waist Circumference

Six studies reported waist circumference (total $n = 136$; taekwondo training group $n = 66$, control group $n = 70$). The mean difference (MD) in waist circumference between the Taekwondo training and the control group was -2.231 (95% CI; $-3.855, -0.607$). The waist circumference of the Taekwondo training group decreased by 2.2 cm compared to the control group, and there was a statistically significant difference ($p < 0.05$). For the heterogeneity test, the results of Cochrane Q were $p = 0.81$, and Higgins' I^2 was 0% (Figure 3d).

3.4.5. Waist–Hip Ratio

Ten studies reported the waist–hip ratio (total $n = 215$; Taekwondo training group $n = 105$, control group $n = 110$). The mean difference (MD) in the waist–hip ratio between the Taekwondo training and the control groups was -0.029 (95% CI; $-0.015, -0.010$). The waist–hip ratio of the Taekwondo training group decreased by 0.03 compared to the control group, and there was a statistically significant difference ($p < 0.05$). For the heterogeneity test, the results of Cochrane Q were $p < 0.01$, and Higgins' I^2 was 0% (Figure 3e).

3.4.6. Body Fat Mass

Fourteen studies reported body fat mass (total $n = 327$; Taekwondo training group $n = 164$, the control group $n = 163$). The average difference (MD) in body fat mass between the Taekwondo training and the control group was -1.398 (95% CI; $-2.109, -0.687$). The body fat mass of the Taekwondo training group decreased by 1.40 kg compared to the control group, and there was a statistically significant difference ($p < 0.01$). For the heterogeneity test, the results of Cochrane Q were $p = 0.46$, and Higgins' I^2 was 0% (Figure 3f).

3.4.7. Body Fat Percentage

Thirty-six studies reported body fat percentage (total $n = 750$; taekwondo training group $n = 371$, control group $n = 379$). The mean difference (MD) in body fat percentage between the Taekwondo training and the control group was -2.850 (95% CI; $-3.327, -2.373$). The body fat percentage of the Taekwondo training group decreased by -2.90% compared to the control group, and there was a statistically significant difference ($p < 0.001$). For the heterogeneity test, the results of Cochrane Q were $p = 0.23$, and Higgins' I^2 was 14% (Figure 3g).

3.4.8. Lean Mass

Twenty-four studies reported lean mass (total $n = 531$; taekwondo training group $n = 263$, control group $n = 268$). The average difference (MD) in lean mass between the

Taekwondo training and the control groups was 1.109 (95 % CI; 0.366, 1.851). The lean mass of the Taekwondo training group increased by 1.11 kg compared to the control group, and there was a statistically significant difference ($p < 0.05$). For the heterogeneity test, the results of Cochran Q were $p = 0.09$, and Higgins' I^2 was 30% (Figure 3h).

3.4.9. Muscle Mass

Seven studies reported muscle mass (total $n = 170$; Taekwondo training group $n = 84$, control group $n = 86$). The mean difference (MD) in muscle mass between the Taekwondo training and the control group was 1.818 (95% CI; 0.208, 3.427). The muscle mass of the Taekwondo training group increased by 1.82 kg compared to the control group, and there was a statistically significant difference ($p < 0.05$). For the heterogeneity test, the results of Cochran Q were $p = 0.01$, and Higgins' I^2 was 63% (Figure 3i).

3.5. Moderator Analyses

The results of meta-ANOVA with categorical variables (gender, age, study period, publication type) are shown in Tables 2 and 3. No statistical significance was reported on moderating variables of height, WC, WHR, body fat mass, lean mass, and muscle mass. Meanwhile, in the case of body weight ($p = 0.044$), BMI ($p = 0.036$), and body fat percentage ($p = 0.026$), the age group was confirmed as a statistically significant moderating variable. It was confirmed that the decrease rate of weight and BMI was the highest among the student group, and the decrease rate of body fat percentage was highest among the elderly group.

3.6. Publication Bias

Funnel plots were used to analyze publication bias or effects of small-sized research, as shown in Figure 4. No publication bias was found from Egger's linear regression test among all variables except weight and body fat percentage, excluding small-sized studies (WC, muscle mass). Also, as a result of Begg's test using a rank correlation test, no factor showed a significant difference, so the publication bias of the literature used in this study could not be confirmed.

Table 2. Effects of moderators on height, weight, BMI, WC, WHR.

| Variables | Height | | | | Weight | | | | BMI | | | | Waist Circumference | | | | WHR | | | | | | | | |
|------------------|--------|--------|--------|-------|----------------|----|--------|--------|--------|----------------|----|--------|---------------------|--------|----------------|---|--------|---------|--------|----------------|----|--------|--------|--------|--|
| | k | MD | 95% CI | | p [†] | k | MD | 95% CI | | p [†] | k | MD | 95% CI | | p [†] | k | MD | 95% CI | | p [†] | | | | | |
| Sex | | | | | 0.985 | | | | | 0.154 | | | | | 0.100 | | | | | 0.404 | | | | 0.111 | |
| Male | 9 | 0.246 | -1.412 | 1.905 | | 18 | -3.314 | -4.171 | -2.455 | | 9 | -1.708 | -2.074 | -1.342 | | 2 | -4.063 | -9.870 | 1.743 | | 5 | -0.045 | -0.078 | -0.012 | |
| Female | 5 | 0.271 | -1.774 | 2.136 | | 14 | -2.147 | -3.505 | -0.790 | | 8 | -1.068 | -1.738 | -0.399 | | 2 | -1.421 | -3.605 | 0.762 | | 4 | -0.015 | -0.031 | -0.001 | |
| Age | | | | | 0.988 | | | | | 0.044 | | | | | 0.036 | | | | | 0.473 | | | | 0.192 | |
| Student | 12 | 0.312 | -1.213 | 1.836 | | 18 | -3.748 | -4.503 | -2.992 | | 12 | -1.657 | -1.981 | -1.334 | | 3 | -3.322 | -5.807 | -0.838 | | 4 | -0.046 | -0.090 | -0.002 | |
| Adult | 2 | 0.1 | -2.55 | 2.75 | | 11 | -1.129 | -2.839 | 0.582 | | 3 | -0.243 | -1.434 | 0.948 | | 2 | -2.182 | -6.147 | 1.783 | | 5 | -0.023 | -0.039 | -0.006 | |
| Elderly | 2 | 0.394 | -3.397 | 4.185 | | 6 | -1.775 | -3.333 | -0.217 | | 4 | -0.832 | -1.907 | 0.242 | | 1 | -1.100 | -3.651 | 1.451 | | 1 | -0.000 | -0.029 | 0.029 | |
| Study duration | | | | | 0.898 | | | | | 0.689 | | | | | 0.542 | | | | | 0.405 | | | | - | |
| ≤12 weeks | 14 | 0.297 | -1.001 | 1.595 | | 31 | -3.107 | -3.753 | -2.462 | | 16 | -1.465 | -1.789 | -1.141 | | 5 | -2.059 | -3.732 | -0.386 | | 10 | -0.029 | -0.048 | -0.010 | |
| >12 weeks | 2 | -0.012 | -4.556 | 4.531 | | 3 | -2.315 | -6.143 | 1.513 | | 3 | -1.731 | -2.521 | -0.941 | | 1 | -5.000 | -11.719 | 1.719 | | - | - | - | - | |
| Publication type | | | | | 0.865 | | | | | 0.132 | | | | | 0.593 | | | | | 0.726 | | | | 0.169 | |
| Thesis | 9 | 0.156 | -1.689 | 2.001 | | 15 | -3.775 | -4.874 | -2.675 | | 10 | -1.392 | -1.9 | -0.884 | | 2 | -2.794 | -6.343 | 0.756 | | 1 | -0.060 | -0.104 | -0.016 | |
| Journal | 7 | 0.373 | -0.321 | 2.067 | | 19 | -2.739 | -3.518 | -1.960 | | 9 | -1.563 | -1.935 | -1.192 | | 4 | -2.082 | -3.908 | -0.256 | | 9 | -0.026 | -0.046 | -0.006 | |

MD—Mean difference by the Hedges. *k*—number of observations. [†] *p*-value of meta-ANOVA for categorical moderators.

Table 3. Effects of moderators on fat mass, % fat, lean mass, muscle mass.

| Variables | Fat Mass | | | | % Body Fat | | | | Lean Mass | | | | Muscle Mass | | | | | | | | | | |
|------------------|----------|--------|--------|--------|----------------|----|--------|--------|-----------|----------------|----|--------|-------------|--------|----------------|---|-------|--------|-------|----------------|--|--|-------|
| | k | MD | 95% CI | | p [†] | k | MD | 95% CI | | p [†] | k | MD | 95% CI | | p [†] | k | MD | 95% CI | | p [†] | | | |
| Sex | | | | | 0.761 | | | | | 0.404 | | | | | 0.088 | | | | | | | | 0.896 |
| Male | 6 | -1.043 | -2.480 | 0.393 | | 17 | -2.641 | -3.228 | -2.121 | | 12 | 1.718 | 0.388 | 3.048 | | 5 | 1.733 | -0.125 | 3.59 | | | | |
| Female | 7 | -0.777 | -1.717 | 0.163 | | 17 | -3.006 | -3.556 | -2.457 | | 10 | 0.364 | -0.440 | 1.169 | | 2 | 2.031 | -2.056 | 6.117 | | | | |
| Age | | | | | 0.240 | | | | | 0.026 | | | | | 0.700 | | | | | | | | 0.621 |
| Student | 6 | -2.180 | -3.614 | -0.745 | | 17 | -3.047 | -3.842 | -2.304 | | 12 | 1.419 | 0.152 | 2.686 | | 4 | 1.313 | -1.336 | 3.962 | | | | |
| Adult | 6 | -0.750 | -2.198 | 0.698 | | 13 | -1.867 | -2.802 | -0.931 | | 9 | 0.715 | -0.420 | 1.850 | | 3 | 2.201 | -0.12 | 4.522 | | | | |
| Elderly | 2 | -0.660 | -1.923 | 0.603 | | 6 | -3.549 | -4.370 | -2.728 | | 3 | 1.276 | -0.600 | 3.151 | | - | - | - | - | | | | |
| Study duration | | | | | 0.610 | | | | | 0.475 | | | | | 0.122 | | | | | | | | |
| ≤12 weeks | 13 | -1.370 | -2.134 | -0.606 | | 33 | -2.756 | -3.298 | -2.213 | | 23 | 1.173 | 0.447 | 1.900 | | 7 | 1.818 | 0.208 | 3.427 | | | | |
| >12 weeks | 1 | -2.400 | -6.265 | 1.465 | | 3 | -3.220 | -4.375 | -2.065 | | 1 | -4.300 | -11.207 | 2.607 | | - | - | - | - | | | | |
| Publication type | | | | | 0.544 | | | | | 0.627 | | | | | 0.132 | | | | | | | | 0.952 |
| Thesis | 5 | -1.039 | -2.283 | 0.205 | | 14 | -2.673 | -3.457 | -1.889 | | 15 | -3.775 | -4.874 | -2.675 | | 3 | 1.854 | -0.984 | 4.692 | | | | |
| Journal | 9 | -1.572 | -2.438 | -0.706 | | 22 | -2.923 | -3.551 | -2.295 | | 19 | -2.739 | -3.518 | -1.960 | | 4 | 1.742 | -0.522 | 4.007 | | | | |

MD—Mean difference by the Hedges. *k*—number of observations. [†] *p*-value of meta-ANOVA for categorical moderators.

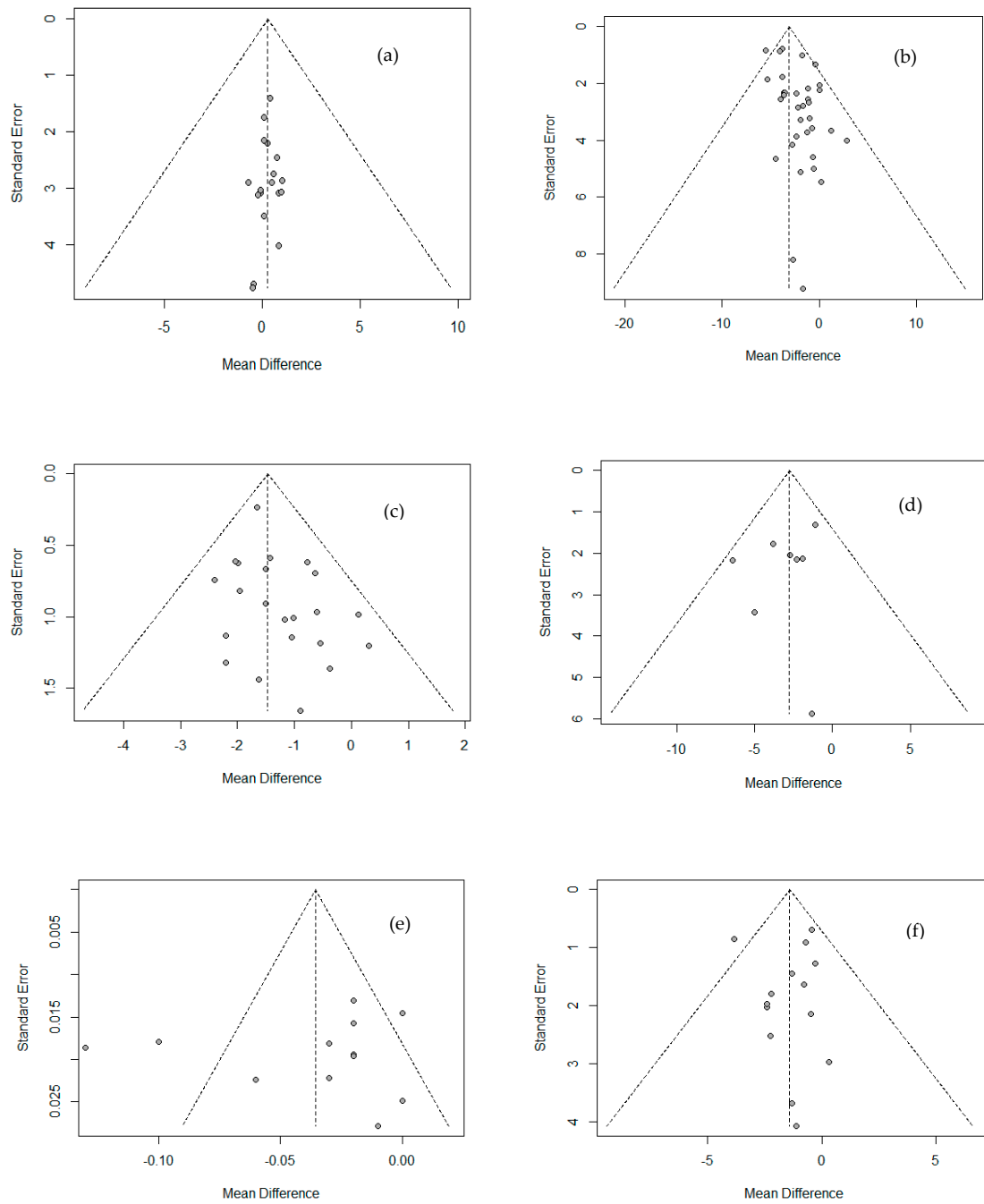


Figure 4. Cont.

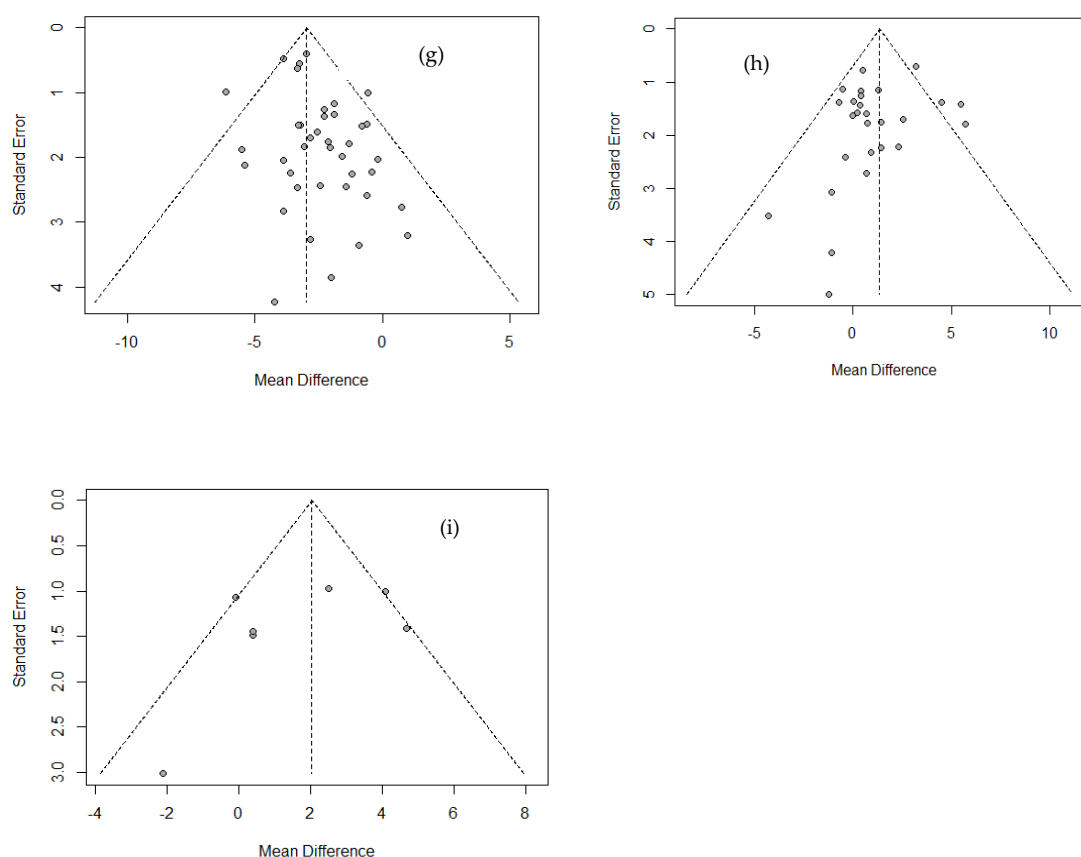


Figure 4. Funnel plot showing the publication bias of Physique and body composition. (a) Height; (b) weight; (c) BMI; (d) WC; (e) WHR; (f) fat mass.; (g) % body fat; (h) lean mass; (i) muscle mass.

4. Discussion

Since changes in body composition occur throughout the lifespan due to growth, maturation and aging, as well as factors such as diseases and behaviors, it is a representative indicator for determining the level of body development [58]. Observing changes in body composition is an important factor in determining health, disease, exercise, and nutrition. It is also a very important factor in physique and athletic performance [59].

In general, Taekwondo training in Korea consists of 5 sessions per week, 1 h per session [60]. The training period is about 12 weeks, which we present in Table 1. Taekwondo exercise consists of 5 min each of warm-up and cool-down routines, followed by 50 min of exercise including basic Taekwondo movements, Poomsae, and Gyeorugi (fighting simulation) as the main exercises. Most taekwondo training centers apply a similar method. Therefore, the effect of taekwondo training in this study has very suitable conditions for meta-analysis.

As a result of analyzing the effect of Taekwondo training on changes in body composition, statistically significant differences were found in body weight, BMI, WC, body fat mass, body fat percentage, lean mass, and muscle mass, excluding height. Especially in the case of students, body weight and body fat percentage decreased significantly, and lean mass and muscle mass also tended to increase. In the elderly, a significant decrease in body fat percentage and an increase in muscle mass were found.

According to ACSM guidelines, exercise intensity 40–70% VO_2R (oxygen uptake reserve) is recommended for overweight and obesity management [61]. Taekwondo's basic movements, kicks, and Poomsae movements have an exercise intensity of 84% HR_{max} and 56.8–82.2% VO_2max [62]. Taekwondo competition is a high-intensity exercise with an exercise intensity of 10 METs [63]. As such, Taekwondo exhibits anaerobic exercise patterns

during matches and competitions and aerobic exercise patterns during taekwondo aerobics, Poomsae, sparring steps, basic movements, and moving kicks.

Therefore, the results of this study are clear evidence that the type of exercise and intensity of Taekwondo has positive effects on reducing body weight and body fat and increasing lean mass. In addition, there is a disadvantage that long and tedious exercise time is required to obtain meaningful exercise effects with general aerobic exercise such as walking or running [64]. In contrast, Taekwondo is an interval training type that alternates high- and low-intensity exercise repeatedly. In addition, Taekwondo gives interest and has higher exercise effects within the same amount of exercise time than other exercise types such as walking or moderate running [65]. Therefore, the exercise program using Taekwondo will positively improve obesity, the most severe health issue in Korea, and contribute significantly to preventing chronic diseases such as cardiovascular disease.

We found one unfortunate thing while conducting this study. That is, many studies reporting on the effectiveness of Taekwondo training do not apply an RCT design or even have no control group. In fact, there were many documents excluded from the analysis because there was no control group during this study. Therefore, if researchers who want to explain the effects of Taekwondo training in the future follow the RCT design well, follow-up researchers will find clearer results.

5. Conclusions

We found that taekwondo training at a frequency of five times per week for more than 12 weeks positively improved the obesity factor through this study. These findings are clear evidence that Taekwondo training is an effective exercise that can prevent or positively improve obesity. In addition, it shows that Taekwondo has value as a lifestyle sport that can contribute to the promotion of human health, not just bounded in the field of martial arts and sports.

Author Contributions: Conceptualization, S.B. and S.-S.N.; methodology, S.B., J.-D.L. and S.-S.N.; software, S.B.; validation, S.B., J.-B.P. and S.-S.N.; formal analysis, S.B. and S.-S.N.; investigation, S.B., S.-H.C. and J.-B.P.; resources, S.B. and J.-D.L.; data creation, S.B. and J.-D.L.; writing original draft preparation, S.B. and S.-S.N.; writing—review and editing, S.B., J.-D.L. and S.-S.N.; visualization, S.B.; supervision, S.-H.C., J.-B.P. and S.-S.N.; project administration, S.B. and S.-S.N.; funding acquisition, J.-D.L., S.-H.C., J.-B.P. and S.-S.N. All authors have read and agreed to the published version of the manuscript.

Funding: This research was supported by Taekwondo Research Institute of Kukkiwon.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of SungShin Women's University SSWUIRB-2021-030 and 06-12-2021).

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: All authors sincerely thank Kukkiwon President Lee Dongsub for supporting this study.

Conflicts of Interest: The authors declare no conflict of interest.

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