ISSN 2618-1584 Vol. 5, Issue 7: 14-22, DOI: 10.25236/FMSR.2023.050703

A Meta-Analysis of the Effects of Otago Exercise in Patients after Hip and Knee Replacement

Jiayang Zhang[1,a], Yin Yang[2,b,*], Xinyu Zhang[1,c], Xinjian Ai[1,d]

[1]School of Nursing, Shaanxi University of Chinese Medicine, Xianyang, Shaanxi, China
[2]Second Department of Orthopedics, Xi'an Central Hospital, Xi'an, Shaanxi, China
[a]3162523134@qq.com, [b]yydoctor@126.com, [c]2237692850@qq.com, [d]2665787576@qq.com
[*]Corresponding author

Abstract: *Hip and knee osteoarthritis is common in the elderly, and its prevalence is increasing, which is one of the important causes of physical disability. At present, hip and knee replacement is one of the important means of treatment, and it is of great significance to promote the recovery of limb function as soon as possible. In order to evaluate the effect of Otago exercise on hip and knee replacement after hip and knee replacement, this study conducted a meta-analysis of relevant clinical studies to provide a theoretical basis for clinical care. Meta results showed that Otago exercise had a good effect after hip/knee replacement, which could reduce the level of phobia, improve fall efficiency and balance ability, promote the recovery of hip/knee function, reduce joint swelling, and further improve patients' daily living ability.*

Keywords: *Hip arthroplasty; Knee arthroplasty; Otago exercise program; Meta-analysis*

1. Introduction

Osteoarthritis of the hip and knee is common in middle-aged and elderly people and is an important cause of physical disability, with clinical manifestations of joint pain, limitation of movement, and reduced quality of life [1,2]. The prevalence of osteoarthritis of the hip and knee has gradually increased with the global increase in life expectancy and obesity levels, and the number of patients in China has grown to 61.2 million [1,3]. Hip/knee arthroplasty is currently one of the most important means of treating hip and knee osteoarthritis, with the primary aim of relieving pain and improving joint function to a lesser extent [4]. Hip/knee replacement is a major orthopedic surgery [5], and it is important to promote the early removal of patients from bed and rehabilitation exercises after surgery. The Otago Exercise Program (OEP) originated in New Zealand and was created by Campbell et al [6] in association with the Otago School of Medicine as an exercise rehabilitation program consisting of two components, one of which is a five-warm-up activity also containing twelve muscle exercises and twelve balance exercises, and the other is a walking exercise, mainly for the prevention of falls in the elderly. In recent years, the application of Otago exercises after hip/knee arthroplasty has gradually increased. To clarify the role of Otago exercises in the rehabilitation after hip/knee arthroplasty, this paper, from the perspective of evidence-based medicine, comprehensively retrieved relevant randomized controlled trials on the application value of Otago exercises after hip/knee arthroplasty and conducted Meta-analysis to increase the sample size and provide some reference for clinical care.

2. Data and methods

2.1. Literature Inclusion and exclusion criteria

2.1.1. Inclusion criteria

(1) study subjects were those who underwent hip arthroplasty or knee arthroplasty and were ≥18 years old; (2) study type: randomized controlled trial (RCT); (3) interventions: the control group used conventional nursing therapy, and the experimental group applied Otago on top of the control group (4) Outcome indicators: ①Thymophobia score (TSK), ②Berg Balance Scale score (BBS), ③Barthel index, ④New York Hospital for Special Surgery knee score (HSS), ⑤Falls Effectiveness Scale score (MFES), ⑥Joint swelling, ⑦Harris Hip Function Score (HHS)

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2.1.2. Exclusion criteria

Literature with incorrect data or unavailable data for comparison; non-English and Chinese literature; conference papers, duplicate publications, and unavailable full-text literature.

2.2. Literature search strategy

A computer search of China Knowledge Network, Wanfang Medical Network, Weipu database, PubMed, Cochrane Library, Embase, Scopus, and Web of Science databases was conducted from the establishment of the database until March 2023. The Chinese search terms were ("Otago exercise" or "Otago exercise" or "Otago exercise" or "Otago exercise program ") AND ("hip replacement" or "knee replacement" or "hip and knee replacement"); English search terms(“Otago” or“OEP” or “Otago exercise program”)AND (“replacement, hip”or“hip replacement, total”or“Knee arthroplasty” or “arthroplasties, replacement, replacement, knee” or “knee arthroplasty, total”or“total hip and knee arthroplasty” or “arthro-plasty,total knee”). The search used a combination of subject words and free words.

2.3. Literature screening and data extraction

A literature search was conducted by two researchers according to the literature inclusion and exclusion criteria, after which the retrieved literature was imported into NoteExpress software for initial de-weighting, read the titles and abstracts of the literature for initial screening, read the full text for re-screening, and finally built an Excel sheet for literature data extraction. The data extraction included first author, year of publication, country, sample size, interventions, and outcome indicators. Two investigators independently performed the literature screening and data extraction and cross-checked. They were resolved through discussion and consultation with a third investigator when disagreements arose.

2.4. Literature quality evaluation

The included literature was evaluated by two investigators using the Cochrane Evaluation Manual [7] RCT trial evaluation criteria, which included: ① random sequence generation method; ② allocation concealment; ③ blinding of subjects and staff; ④ blinding of outcome assessment; ⑤ completeness of outcome data; ⑥ selective reporting of study results; and ⑦ other biases. If the included literature meets all the indicators, it is rated A; Meet some indicators and is rated B; If the indicators are not met at all, it will be rated C. When disagreements arise, they are resolved in consultation with a third investigator, resulting in a final literature quality assessment.

2.5 Statistical methods

The RevMan 5.4 software was used for meta-analysis of the included data, using weighted mean difference (WMD) to describe continuous variables using the same measurement tool, and if using different measurement tools, standardized mean difference (SMD) was selected as the effect indicator, and 95% confidence intervals (95% CI) were calculated. The I^2 test and P value were used to determine whether there was heterogeneity among the literature and the magnitude of heterogeneity. If $P \geq 0.1$, $I^2 \leq 50\%$ indicated that the heterogeneity was small and the fixed-effect model was used for analysis; if $P < 0.1$, $I^2 > 50\%$ indicated that the heterogeneity was significant and the random-effect model was used for Meta-analysis.

3. Results

3.1 Literature search results

A total of 252 literature were searched, 196 were initially de-weighted remaining, 177 literature unrelated to the content of this study were excluded after reading the title abstract, and 14 literature were finally included after reading the full-text re-screening [8,9,10,11,12,13,14,15,16,17,18,19,20,21], see Figure 1.

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Figure 1: Flowchart of literature screening

3.2 Basic characteristics and qualitative evaluation of the included literature

Table 1: Basic features of the included literature

Included studies	Year	Country	Intervention/control group (example)	Interventions	Comparitive measures	Outcome measures
Sumaiyah et al[8]	2018	Malaysia	17/17	Otago Sports + Regular Training	Regular training	⑤
Yu Qing[9]	2022	China	60/60	Otago Sports + Regular Training	Regular training	②④⑥
Liu Heng et al[10]	2019	China	33/32	Otago Sports + Regular Training	Regular training	②⑤
Zhou Cen[11]	2022	China	60/59	Otago Sports + Regular Training	Regular training	①②
Zong Shujun et al[12]	2018	China	30/31	Otago Sports + Regular Training	Regular training	④⑤
Zhang Qingyu[13]	2022	China	63/63	Otago Sports + Regular Training	Regular training	②⑤
Li Haiyun et al[14]	2020	China	48/47	Otago Sports + Regular Training	Regular training	①②④
Yang Hong et al[15]	2016	China	40/39	Otago Sports + Regular Training	Regular training	③⑤
Niu Min et al[16]	2022	China	73/73	5E rehabilitation concept of Otago sports + regular training	Regular training	③⑦
Wang Qian et al[17]	2018	China	30/31	Otago Sports + Regular Training	Regular training	③④⑤
Xiao Meihui et al[18]	2022	China	34/34	Otago Sports + Regular Training	Regular training	③⑦
Fan Linlin et al[19]	2022	China	35/35	Otago exercise + compression cold therapy + regular training	Regular training + compression cold therapy	②④⑥
Jia Xiaodong et al[20]	2018	China	41/41	Otago Sports + Regular Training	Regular training	⑤
Chen Fuqin[21]	2020	China	38/38	Otago exercise + compression cold therapy + regular training	Regular training	②⑥

Note: ①Kinetophobia score; ②Berg Balance Scale score; ③Barthel index; ④Knee score at the Hospital for Special Surgery, New York; ⑤Full Effect Energy Meter score; ⑥Swelling of the joints; ⑦Harris hip function score。

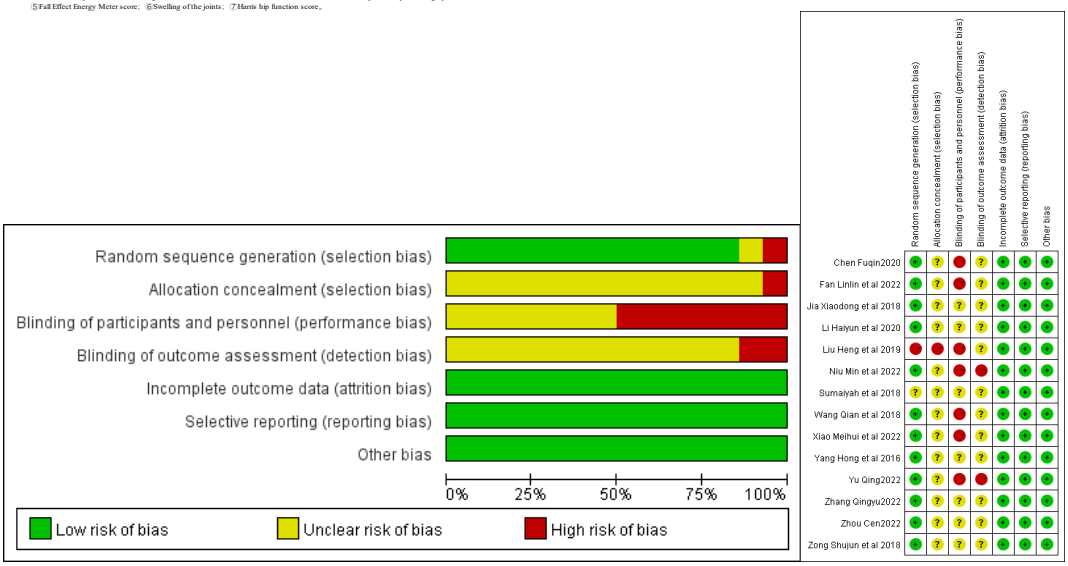

Figure 2: Risk of bias in the included literature

A total of 14 studies [8,9,10,11,12,13,14,15,16,17,18,19,20,21] were included in this paper, from China and Malaysia; the published literature was from 2016-2022, of which 6 papers were included in the 2022 literature, which is relatively new. 1202 cases were included in the 14 papers, of which 602 cases were in the intervention group and 600 cases were in the control group. All 14 pieces of literature described the intervention method specifically and had clear outcome indicators, see Table 1, and the proportion of the risk of bias in the included literature, see Figure 2. The risk of bias was assessed for the 14 studies, all of which were graded B.

3.3. Meta-analysis results

3.3.1. Kinetophobia levels

The results of 2 studies [11,14] showing the effect of OEP on the level of agoraphobia in hip/knee

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arthroplasty patients included a total of 214 cases. Since all used the TSK scale to evaluate the level of agoraphobia, the WMD was chosen for the synthesis of effect sizes, and the heterogeneity of the findings was small (P=0.29, I²=9%). A fixed-effects model was selected for Meta-analysis, and the results showed that OEP reduced the level of agoraphobia in hip/knee arthroplasty patients, and the combined effect was statistically significant [WMD=-4.45,95% CI (-5.71,-3.19),P<0.00001], and the forest plot is shown in Figure 3.

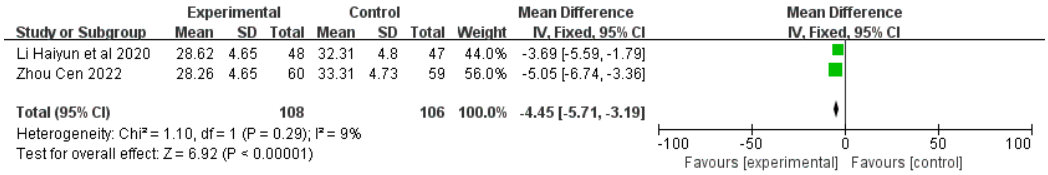

Figure 3: Effect of OEP on the level of dyskinesia in hip/knee replacement patients

3.3.2. Balance function

The results of seven studies [9,10,11,13,14,19,21] showed the effect of OEP on balance function in hip/knee arthroplasty patients, with a total of 671 cases included. Since the equilibrium function was evaluated by the Berg scale, WMD was selected for the synthesis of effect size, the results were heterogeneous, (P<0.00001, I²=97%), and the random-effects model was selected for meta-analysis, and the pooled effect was statistically significant [WMD=6.2, 95%CI (2.97, 9.43), P=0.0002], and the forest plot was shown in Figure 4. After sensitivity analysis, the heterogeneity test was (P<0.00001, I²=90%) by excluding the study by Yu Qing [9]; (P<0.00001, I²=97%) by excluding the study by Fan Linlin et al [19]; and (P<0.00001, I²=97%) by excluding 2 studies at the same time. P=0.53, I²=0%), with less heterogeneity, and a fixed-effects model was selected for Meta-analysis, which showed that OEP improved the combined effect of balance in hip/knee arthroplasty patients with statistical significance [WMD=4.05, 95% CI (3.38,4.73), P<0.00001], and the forest plot is shown in Figure 5.

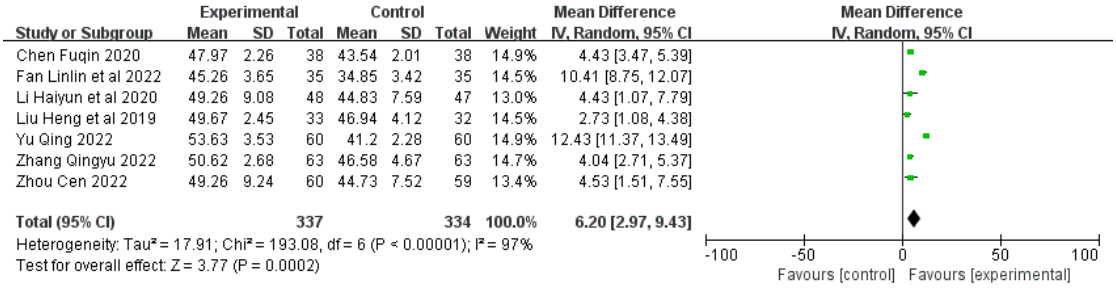

Figure 4: Effect of OEP on balance function in hip/knee replacement patients

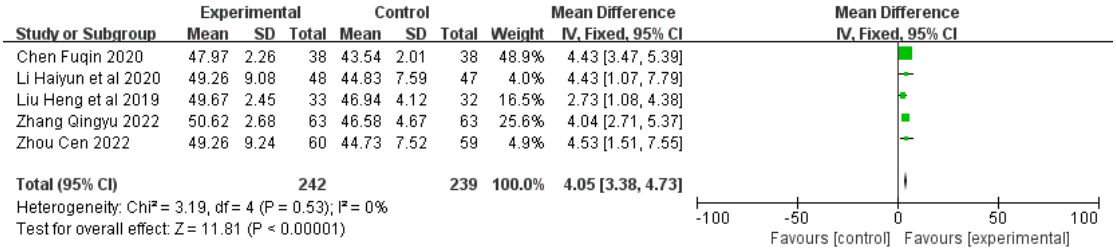

Figure 5: Forest plot of sensitivity analysis of the effect of OEP on balance function in hip/knee replacement patients

3.3.3. Abilities of daily living

4 studies [15,16,17,18] with results showing the effect of OEP on the level of ability to perform daily living in hip/knee arthroplasty patients were included in a total of 354 cases. The WMD was chosen for the synthesis of effect sizes because all Barthel Index scores were used, and the study results were less heterogeneous (P=0.22, I²=33%). A fixed-effects model was selected for Meta-analysis, and the results showed that OEP improved the level of daily living ability in hip/knee arthroplasty patients with a statistically significant combined effect [WMD=7.08, 95% CI (6.00,8.16), P<0.00001], and the forest plot is shown in Figure 6.

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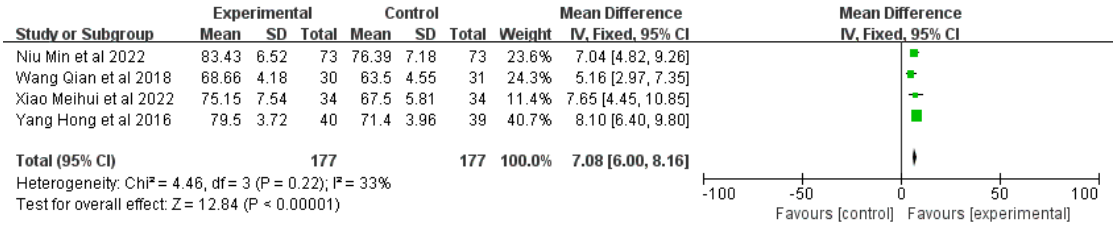

Figure 6: Effect of OEP on the level of daily living ability in hip/knee replacement patients

3.3.4. Knee function

Five studies of knee function [9,12,14,17,19] showed the effect of OEP on knee function scores in patients undergoing hip/knee replacement. Since HSS was used to evaluate knee function, WMD was selected for the synthesis of effect size, and the results were heterogeneous, (P<0.00001, I^2=86%), and the random-effects model was selected for meta-analysis, and the pooled effect was statistically significant [WMD=10.21, 95% CI (7.21, 13.22), P<0.0001], forest plot shown in Figure 7. After sensitivity analysis, the heterogeneity test was (P=0.92, I^2=0%) with less heterogeneity by excluding the studies of Yu Qing [9] and Fan Linlin et al [19], and the fixed-effect model was selected for Meta-analysis, which showed that OEP could promote hip/knee function recovery in patients with hip/knee replacement with a statistically significant combined effect [WMD=6.87,95% CI (4.52,9.23),P<0.00001], and the forest plot is shown in Figure 8.

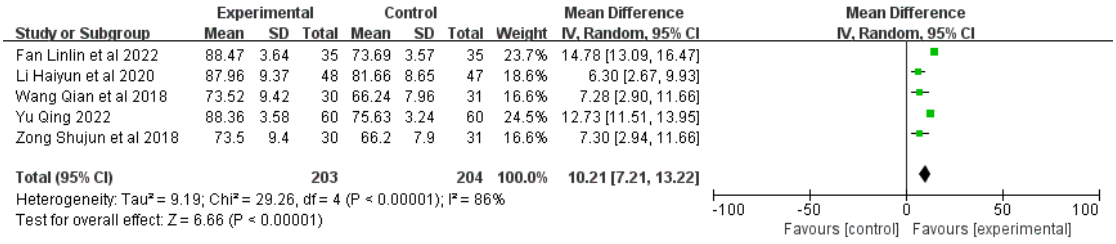

Figure 7: Effect of OEP on knee function score in hip/knee replacement patients

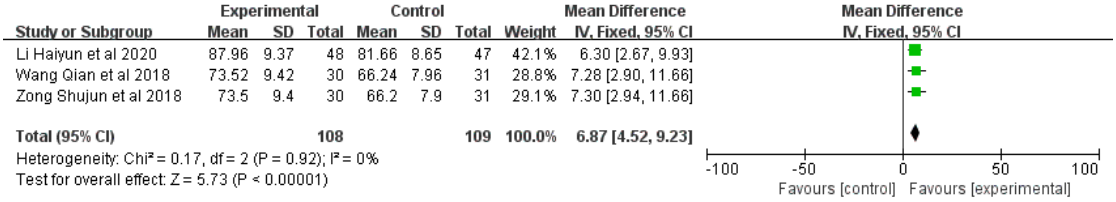

Figure 8: Forest plot of sensitivity analysis of OEP on the influence of knee function score in hip/knee arthroplasty patients

3.3.5. Fall efficacy

The results of seven studies [8,10,12,13,15,17,20] showing the effect of OEP on fall efficacy in hip/knee arthroplasty patients included a total of 508 cases. Since the MFES scale was used to evaluate the fall efficacy, WMD was selected for the synthesis of the effect amount. The results of the study were heterogeneous, (P=0.0008, I^2=74%), the random-effects model was selected for meta-analysis, and the pooled effect was statistically significant [WMD=1.48, 95% CI(0.56, 2.41), P=0.002], and the forest plot is shown in Figure 9. by sensitivity analysis. excluding the studies of Liu Heng [10], Zhang Qingyu [13], and Jia Xiaodong [20], the heterogeneity test was (P=0.27, I^2=24%), which was less heterogeneous, and a fixed-effect model was selected for Meta-analysis, which showed that OEP improved fall efficacy in hip/knee arthroplasty patients, and the combined effect was statistically significant [WMD=3.40,95% CI(1.26,5.54), P=0.002], and the forest plot is shown in Figure 10.

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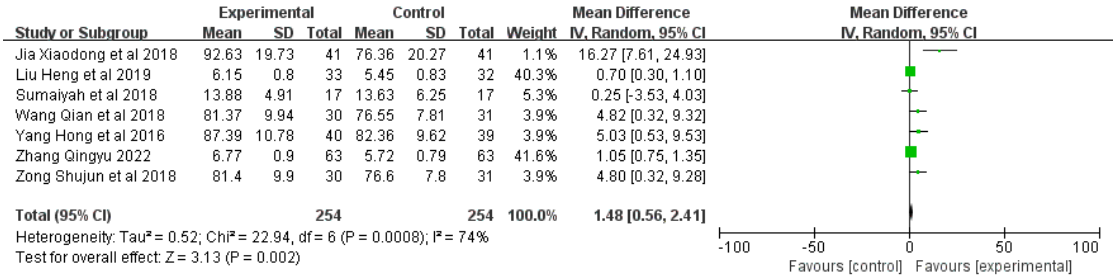

Figure 9: Effect of OEP on fall efficacy in hip/knee replacement patients

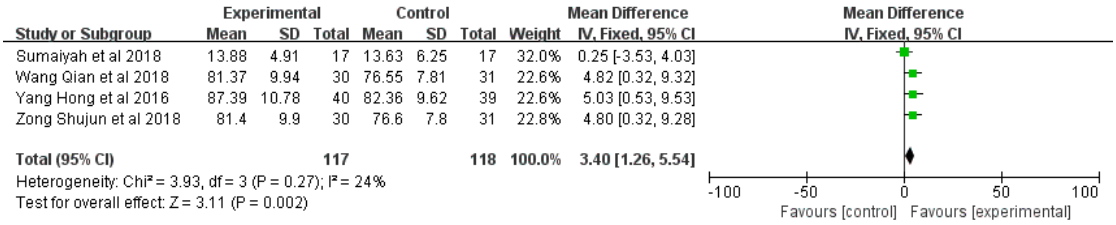

Figure 10: Sensitivity analysis forest plot of the effect of OEP on fall efficacy

3.3.6. Articular swelling

3.3.6.1. Patellar circumference

Three studies [9,19,21] with results showing the effect of OEP on the patellar circumference in patients undergoing hip/knee arthroplasty were included in 266 cases. The heterogeneity of the study results was small (P=0.21, I^2=37%). A fixed-effects model was selected for Meta-analysis, and the results showed that OEP reduced the patellar circumference and joint swelling in hip/knee arthroplasty patients. The combined effect was statistically significant [WMD=-4.79, 95% CI (-5.18,-4.40), P<0.00001], and the forest plot is shown in Figure 11.

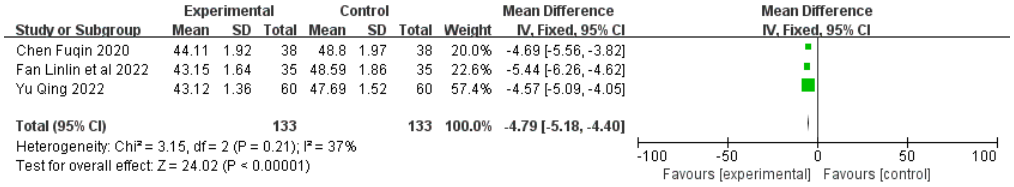

Figure 11: Effect of OEP on peripatellar diameter in hip/knee replacement patients

3.3.6.2. Gastrocnemius circumference

Three studies [9,19,21] with results showing the effect of OEP on gastrocnemius circumference in hip/knee arthroplasty patients were included in 266 cases. The results were heterogeneous (P=0.001, I^2=86%). A random-effects model was selected for meta-analysis and pooled effects were statistically significant [WMD = -5.77, 95% CI (-6.77 to -4.78), P<0.00001], forest plot shown in Figure 12. After sensitivity analysis, the heterogeneity test was (P=0.842, I^2=0%) after excluding the study by Chen Fulin [21], which was less heterogeneous, and the fixed-effect model was selected for Meta-analysis, which showed that OEP reduced gastrocnemius circumference and joint swelling in hip/knee arthroplasty patients, and the combined effect was statistically significant [WMD=-6.30, 95% CI (-6.72,-5.88), P<0.00001], and the forest plot is shown in Figure 13.

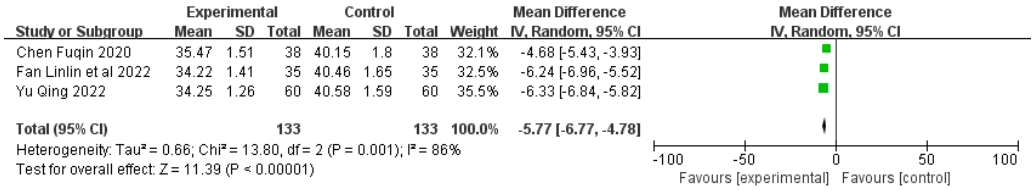

Figure 12: Effect of OEP on gastrocnemius circumferential diameter in hip/knee arthroplasty patients

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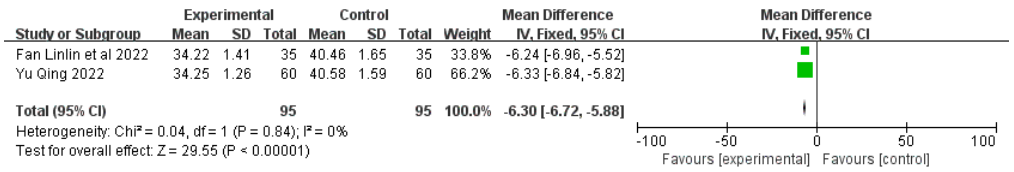

Figure 13: Forest plot of sensitivity analysis of the effect of OEP on the circumferential diameter of the gastrocnemius muscle in hip/knee arthroplasty patients

3.3.7. Hip function scores

Two studies [16,18] with results showing the effect of Otago exercise on hip function in hip/knee arthroplasty patients were included in 214 cases. The heterogeneity of the study results was small (P=0.98, I^2=0%). A fixed-effects model was selected for Meta-analysis, and the results showed that OEP promoted the recovery of hip function in hip/knee arthroplasty patients. The combined effect was statistically significant [WMD=8.60, 95% CI (7.40, 9.80), P<0.00001], and the forest plot is shown in Figure 14.

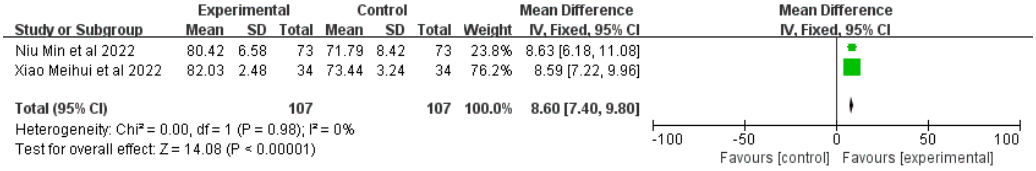

Figure 14: Effect of OEP on hip function in hip/knee replacement patients

4. Discussion

4.1. OEP improves levels of kinetophobia after hip/knee replacement

Kinetophobia refers to a phenomenon in which patients are overly sensitive and fear movement irrationally [22]. Studies have shown [23,24] that after hip/knee replacement, patients have a higher rate of kinesiophobia and even serious complications. Tsonga et al [25] have shown that the main triggers of kinesiophobia include fear of falls and reduced balance. OEP is a set of exercise programs aimed at preventing falls, allowing patients to fully understand the exercise content, strengthen the lower limbs, improve balance and coordination, and further reduce the level of kinesiophobia.

4.2. OEP promotes the recovery of joint function after hip/knee arthroplasty

Meta-analysis showed that OEP improved HSS and HHS scores, reduced joint swelling, and promoted the recovery of hip/knee function. Studies have shown [26] that early postoperative joint exercises are effective in preventing muscle atrophy and joint adhesions, while literature has shown [27] that it takes 2 months or more of exercise duration intervention to achieve improved balance. OEP is a novel intervention method that includes muscle exercises, balance exercises, and walking exercises. Among the muscle exercises specifically include hip strength exercises, knee strength exercises, and ankle strength exercises. The exercise method enhances muscle strength and promotes blood circulation in the lower extremities, while periodic, individualized exercises ensure the effectiveness of the exercise, further reduce joint swelling, and ultimately promote the recovery of hip/knee joint function.

4.3. OEP improves balance function after hip/knee arthroplasty

Meta results showed that OEP improved the Berg score and improved balance function in postoperative patients. The human body requires multiple functions to maintain balance, and patients after hip/knee arthroplasty are prone to poor balance stability and unstable gait. The OEP exercise program includes exercises for balance, such as single-leg standing exercises and backward walking exercises, and all six papers included in this paper have gradually improved balance by exercising for up to 3 months. Son NK et al [28] showed that OEP was more comprehensive than taijiquan in improving balance function.

4.4. OEP improves fall efficacy after hip/knee arthroplasty

Meta-analysis showed that OEP improved postoperative fall efficacy scores and reduced the

ISSN 2618-1584 Vol. 5, Issue 7: 14-22, DOI: 10.25236/FMSR.2023.050703

occurrence of falls. Fall efficacy refers to an individual's self-perception of not falling during daily activities [29] Patients are at high risk for falls after hip/knee arthroplasty due to pain, partial loss of proprioception, and decreased muscle capacity [30]. OEP improves fall efficacy and reduces the occurrence of falls by promoting recovery of joint function, improving balance, and increasing confidence in movement.

4.5 OEP improves the ability of daily living after hip/knee arthroplasty

Meta-analysis showed that OEP improved Barthel index scores, and the difference between the two groups was statistically significant (P<0.00001). Studies have shown [31,32] that there is a correlation between a patient's ability to perform daily living and limb function. Progressive and periodic Otago exercises promoted the recovery of joint function, improved balance, and enhanced the patient's ability to perform daily living activities. Studies have shown that exercise stimulates the production of acetylcholine in the nervous system, producing a calming effect, reducing anxiety, and contributing to physical and mental health [33], improving the patient's ability to perform daily activities and further improving their quality of life.

4.6. Limitations of the study

(1) The included literature in this study may have incomplete search; (2)the quality of the literature is B grade, and there is a certain selection bias in the implementation of both allocation concealment and blinding not described, which may be related to the difficulty of implementing blinding in Otago sports program; (3)the included literature about the time of OEP intervention is different, so some of the outcome indicators are more heterogeneous.

5. Summary

In conclusion, OEP is effective after hip/knee arthroplasty, reducing the level of agoraphobia, increasing fall efficacy and improving balance, promoting functional recovery of the hip/knee joint, reducing joint swelling also further improving the patient's ability to perform daily activities, and can be used as an exercise program for rehabilitation exercises after arthroplasty. This conclusion still needs to be validated in the future by large sample, multicenter, high-quality clinical randomized controlled trials.

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