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Original research

Effect of adding retro-walking or whole-body vibration in the routine physiotherapy program on knee functional disability in patients with chronic knee osteoarthritis: A randomized controlled study.

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Abstract

Background: Knee osteoarthritis (OA) is a highly prevalent degenerative joint disease with a significant global healthcare burden. Over 70% of the population experiences symptomatic knee OA. Purpose: This study compared the efficacy of adding retro-walking (RW) or whole-body vibration (WBV) on knee functional disability in individuals with chronic grade III knee OA. Methods: A randomized controlled trial enrolled 45 participants diagnosed with chronic grade III knee OA, aged 40-55 years. Participants were randomly assigned into three groups (n=15/group): Group A: Routine physiotherapy program (straight leg raise, isometric quadriceps, isometric hip adduction, terminal knee extension, semi-squat, and leg press). Group B: Routine physiotherapy program, in addition to the RW program. Group C: Routine physiotherapy program and WBV training. Knee functional disability was assessed using the Arabic version of the Western Ontario and McMaster Universities Osteoarthritis Index (ArWOMAC) at baseline and after six weeks. **Results:** All groups showed significant improvements in knee function (pain, stiffness, physical function) (p < 0.05) after six weeks compared to baseline. However, no statistically significant differences (p > 0.05) were noticed between the groups in any subscales or the total ArWOMAC scores posttreatment. **Conclusion:** Adding RW or WBV to the routine physiotherapy program produces a similar improvement in knee function as the routine physiotherapy program. So, when routine physiotherapy is used, either adding RW or WBV will not produce better results for improving knee function in individuals with chronic grade III knee OA.

Keywords: Osteoarthritic knee, Backward-walking, Del vibration, Knee self-reported function, WOMAC scale.

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Introduction

Knee osteoarthritis (OA) is a growing concern based on its increasing prevalence in the aging population¹. Characterized by persistent discomfort and joint dysfunction, OA affects various structures within the knee, including the meniscus, bone, and ligaments². By 2020, the worldwide prevalence of knee OA reached 16% in people over fifteen years old and a staggering 22.9% in those over forty, with a higher prevalence observed in females³.

The degree of OA is often classified utilising the Kellgren-Lawrence (KL) system. Grade III OA, considered moderate, is characterized by moderate osteophyte formation, noticeable joint space narrowing, and potential bone deformity^{4,5}. Pain associated with knee OA is frequently linked to bone marrow lesions and synovial inflammation⁶.

Several risk factors participate to knee pain onset, including weight increase, previous joint injuries, age, and female sex⁷. Notably, pain and physical limitations tend to worsen with increasing KL grade. While subchondral sclerosis and joint space narrowing are linked to pain intensity, functional disability shows a stronger correlation with medial joint space narrowing and overall joint alignment⁸. Articular incongruity further exacerbates both pain and stiffness⁸.

Although radiographic evidence of OA significantly increases the risk of functional limitations (as evidenced by a 1.9-fold increase in the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score and a 1.8-fold increase in walking speed reduction) compared to those without radiographic OA, other factors beyond joint damage play a crucial role⁹. Studies investigating women with knee OA have revealed that pain intensity, body mass index, stress levels, and weak knee muscles collectively explain sixty percent of variation in physical function scores $(WOMAC)^{10}$. Interestingly, factors such as radiological severity, depression, presence of comorbidities, and disease duration did not display significant associations with functional limitations¹⁰.

It has been claimed that exercise therapy may benefit knee OA management, extending far beyond mere symptom relief. Well-designed exercise programs demonstrably improve pain, stiffness, and overall joint dysfunction¹¹.

The other way of improving knee function is retro-walking (RW). Studies have shown that beginning with 30 minutes of RW combined with traditional therapy can effectively lessen discomfort and enhance function in those with OA of the knee, However the majority of the sample (80%) in this study was females so the results may be gender-biased¹².

RW exhibits a distinct muscle pattern associated with activation less velocity, smaller stride length, and greater cadence compared to forward walking. Despite these differences, RW elicits a greater metabolic cost and evokes a stronger cardiorespiratory response at similar speeds, leading to positive outcomes in pain management, disability reduction, and improved balance among individuals with OA of the knee 13 .

In people with chronic knee OA, a significant increase in function was previously shown following RW protocol (30 minutes daily of only 3 weeks) in addition to routine physiotherapy¹⁴. unfortunately, following a twelve-week walking program of seventy minutes every week, those with severe knee OA experienced better cardiovascular health with no change in knee pain, according to a phase II randomized controlled trial¹⁵.

On the other hand, deterioration of OArelated symptoms was also noted in obese women with knee OA following a 30-minute daily walking program for 8 weeks¹⁶. Therefore, we concluded that a less rigorous walking program like the RW program (10minutes and progressed to 30 minutes over six weeks and only 3 times per week)¹⁷ of both

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gender and lower weight participants might offer an extra advantage in the previous studies.

More recently, Loew et al.,(2017)¹⁸ saw increased levels of cardiovascular fitness and pain alleviation without exacerbating symptoms in knee OA patients following a nine-month walking regimen. However, Loew et al.(2017)¹⁸ did not have a control group in their study to compare the effects on pain and degree of aerobic fitness.

Most previous studies suggest the program that is running backward might offer more advantages to healthy adults^{19,20}. However, limited evidence supports the use of RW in chronic knee OA patients, despite its demonstrated capacity to reduce pain and disability. Therefore, more research was required to fully explore the advantages of RW in the rehabilitation of severely crippling musculoskeletal conditions¹³.

Another potentially effective technique for enhancing function in a variety of populations, including the elderly and those with knee OA, is whole-body vibration $(WBV)^{21}$. Which is demonstrated for lessening patients' discomfort when they have ongoing knee OA²¹.

WBV exercise exhibits a warm-up effect and improves muscle power and balance in elderly individuals²², and even displayed the potential to modulate T-cell-mediated immunity, suggesting a possible role in slowing OA progression²³.

Little studies have concentrated on WBV's impact on knee OA's discomfort and functional abilities. Furthermore, The evidence supporting WBV training's advantage over other types of exercise is not entirely convincing^{24,25}. Wang et al.,(2015)²⁶ observed better functional performance with WBV training but neither pain relief nor stiffness improvements. Several studies found no significant improvement in functional performance or pain intensity. This suggests that the amount of training with 12-14 Hz of WBV might not have been adequate to change the physiological processes influencing how patients perceived the condition of their illness²⁷ or the small population size²⁸.

Positive outcomes on function and pain alleviation had also been documented using the Japanese Knee Osteoarthritis Measure (JKOM), mainly with grade I-II OA²⁴, and with 12-week WBV²⁹. The validity of the WBV training's advantages for improving knee OA patients' pain and physical function is hampered by the contradictory findings of earlier studies.

Therefore, this study intends to evaluate the efficacy of adding RW or WBV in the routine physiotherapy program on knee functional disability in patients with chronic knee osteoarthritis.

There is no study to investigate if adding RW or WBV to routine physiotherapy has better benefits than a routine physiotherapy program alone for treating chronic knee OA. This could potentially save time and effort while providing an effective option for alleviating symptoms.

Methods

Study design:

This study depended on a randomized controlled design and was conducted within the outpatient physical therapy departments of Sadr El Maamora Hospital, House of Grace Hospital, and the Integrated Pain Management clinics (March 2023 - October 2023). The Cairo University Department of Physiotherapy's Ethics Committee approved study 11/12/2022 the on (No: P.T.REC/012/004280). The research was recorded on clinicaltrials.gov (PRS), (Unique NCT06110104). Protocol ID: Before participation, all subjects were informed regarding the publication of collected data and granted informed consent in writing.

Sample size:

According to a pilot study, the sample size was calculated. Using G*Power software (version 3.0.10), a minimum sample size of

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41 subjects was determined, assuming 80% power, a significance level of alpha = 0.05, two repeated measures, three groups being compared, and a medium effect size of 0.25 (F-test MANOVA within-between interaction). To account for potential participant dropout, a 10% buffer was added, resulting in a final sample size of 45 subjects (15 per group), figure (1).

Subjects Enrollment:

This study recruited forty-five participants diagnosed with chronic knee

osteoarthritis (OA) grade III based on the Kellgren and Lawrence classification scale⁴. All diagnoses were confirmed by a specialized orthopedic surgeon to ensure accuracy and consistency. To ensure group equivalence, patients were randomly allocated (n = 15/group) to three groups (A, B, and C) using a concealed allocation Allocation concealment was method. rigorously maintained by using sealed, opaque envelopes.





Inclusion criteria:

ensure a well-defined То study population, participants met strict inclusion criteria based on the American College of Rheumatology's clinical and radiological diagnostic guidelines ³⁰. All were aged 40-55 encompassing genders³¹. years, both Radiographic confirmation of grade III chronic knee was mandatory⁴. Additionally, participants scored within a range of 52.22 ± 10.15 on the ArWOMAC scale³², indicating moderate to severe pain. These criteria ensure a homogeneous sample with consistent knee OA and pain severity.

Exclusion criteria:

The study participants were not allowed to continue if they had a BMI \ge 30 Kg/m² As the walking program had worse knee OA symptoms in obese women participants¹⁶. Additionally, participants with a history of three-month knee surgery were recent excluded to avoid potential confounding effects from recent surgical procedures that could impact knee pain and function. Furthermore, any underlying neurological, joint, or muscle disorder that affects lower limb function isolates the effect of knee OA pathology in the study population. Finally, participants who had undergone intra-articular knee injections or physical therapy in the previous three months were excluded to control for potential confounding effects from these recent interventions³¹.

Assessment procedure:

All participants underwent a comprehensive evaluation and recording of all relevant parameters at the study beginning (baseline) and again at the study end (six weeks).

Assessment of knee functional disability:

The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) was selected as the main finding measure due to its well-established psychometric properties and its capacity to evaluate functional impairment in the knee OA population comprehensively³³. The WOMAC demonstrates good internal consistency (α =0.70 to 0.93) and good reliability, with intraclass correlations of 0.83 to 0.90, making it a valid and reliable tool for assessing function in knee OA ones³⁴. The Arabic version of WOMAC (ArWOMAC) was utilised in this study to ensure cultural appropriateness and accurate assessment of functional limitations in the target population³⁵.

The WOMAC is a 24-item self-reported questionnaire segmented into three subscales: pain (5 items), stiffness (2 items), and physical function (17 items). Each item is evaluated on a 5-point Likert scale varying from 0 (none) to 4 (extreme). Subscale scores are established with adding the item scores within each subscale (pain: 0-20, stiffness: 0-8, physical function: 0-68. The total WOMAC score is obtained by adding the scores of all three subscales and ranges from 0 to 96, with higher indicating scores greater functional disability³⁶.

Treatment procedure:

Participants in group (A) (Control Group): received a routine physiotherapy program alone, as published previously³⁷. It consisted of isometric quadriceps exercise, straight leg raising exercise, isometric hip adduction exercise, terminal knee extension exercise (**Figure 2**), semi-squat exercise, and leg press exercise.



Figure (2): Terminal knee extension exercise.

Participants in group (B): received the same routine physiotherapy program in addition to the RW program. Every session is made up of a 5-minute warm-up and a 5-

minute cool-down. They finished supervised RW training sessions for 10 minutes, three days per week for six weeks at their comfortable walking speed. The participants were informed to raise their walking time progressively towards 30 minutes through the six weeks³¹, if they consistently experienced less pain every 2 weeks (e.g. score of pain < 3 on the numerical rating scale)³⁸.

Participants in group (C): received the routine physiotherapy program along with WBV training. Every session made up of a 5minute warm-up and a 5-minute cool-down. The WBV training was carried out using a apparatus crazy massage fit (model CFM001C1, made in China) three days per week for six weeks³⁹. The frequency was set at 20 Hz. Participants on the platform applied static squats with 30° and 60° of knee flexion. The participant began with 30 seconds of vibration sets with 30 seconds of rest in between, completing 6 sets of 30° knee flexion and 6 sets of 60° knee flexion, resulting in a total training time of 12 minutes. Over the 6week intervention, this progressed to 50 seconds of each vibration set with 50 seconds rest in between, totaling 8 sets of 30° knee flexion and 8 sets of 60° knee flexion with a total training time of 29 minutes (Figure 3). The spacing between the feet and the shoulders was the same, and the duration time, sets, and total time raised gradually through the 6-week training period based on a previous study 40 .



Figure (3): Whole-body vibration training.

Statistical analysis

Data were displayed as percentages (%) or mean \pm standard deviations. Baseline characteristics were compared across groups utilising one-way analysis of variance (MANOVA) for continuous variables after confirming normality with the Kolmogorov-Smirnov test. The chi-square test was applied to evaluate sex distribution. A significant level of alpha (α) = 0.05 was put for all statistical tests. Data analysis was performed using the statistical package for the social sciences (SPSS) software (version 20; IBM Corp., Armonk, NY, USA). P less than or equal to 0.05 was considered significant.

Results

Demographic and Baseline data:

A total of 45 participants were randomized into three groups (A, B, and C), with 15 participants in each group. There were no statistically significant differences between the groups in terms of age, weight, height, BMI, and sex distribution ($\chi^2 = 0.178$, p > 0.05). (**Table 1**)

Subject characteristic	Group A	Group B	Group C	f	р
Age (years)	48 ± 6	46.1 ± 5.7	46.3 ± 6.2	0.460	0.635
Weight (kg)	75 ± 8	75.1 ± 12.9	75.8 ± 6	0.031	0.970
Height (cm)	166.3 ± 6.6	169.4 ± 12	167.6 ± 9.2	0.403	0.671
BMI (kg/m ²)	27.1 ± 2.2	26 ± 1.7	27 ± 1.9	1.62	0.208
Complain	$2.7\pm~0.7$	1.7 ± 0.4	2.2 ± 0.6	2.92	0.065
Sex N (%) Male Females	7 (46.7%) 8 (53.3%)	8 (53.3%) 7 (46.7%)	7 (46.7%) 8 (53.3%)	χ ²	0.915

1	•		
Table 1. General	characteristics	of subjects of	of three groups:

Data were expressed as mean \pm standard deviation, N (%): number (percentage), χ 2: chi-square, p-value: Significance.

Within-Group Differences after 6 Weeks Intervention:

The group (A, B, and C) demonstrated significant improvements in knee functional disability as measured by pain, stiffness, physical function, and total ArWOMAC scale after 6 weeks (P<0.05) (**Table 2**).

Between-Group Differences after 6 Weeks Intervention:

There were no significant differences between the groups in terms of knee functional disability, as measured by pain, stiffness, physical function, and total ArWOMAC scale after 6 weeks (P>0.05) (**Table 2, Figure 4,5,6,7**).

Table (2): Comparison between pre- and post-study	mean values of WOMAC between and
within groups	

WOMAC	Group A	Group B	Group C	f-value	P-value ²	η2
Pain						
Pre-study	11.6 ± 1.9	11.9 ± 2.1	10.6 ± 2	1.66	0.202	0.072
Post-study	6.9 ± 1.9	5.7 ± 1.8	5.4 ± 2.3	2.2	0.119	0.096
% of change	40.5%	52%	49%			
P-value ¹	0.001*	0.001*	0.001*			
Stiffness score						
Pre-study	4.4 ± 1.3	4± 1	4.5 ± 1.2	0.818	0.448	0.037
Post-study	2.7 ± 1	2.1 ± 0.8	2.9 ± 1.4	1.9	0.161	0.083
% of change	39%	47.5%	36%			
P-value ¹	0.001*	0.001*	0.001*			
Physical function						
Pre-study	41.2 ± 7	41.8 ± 4.3	37.2 ±	2.89	0.066	0.121
Post-study	23.5 ± 6	20.9 ± 4.4	21.1 ±	0.96	0.390	0.044
% of change	43%	50%	43%			
P-value ¹	0.001*	0.001*	0.001*			
Total						
Pre-study	57.3 ± 9.3	57.7 ± 6.5	51.4 ±	3	0.061	0.125
Post-study	34.8 ± 6	29.6 ± 7.4	29.7 ±	2.58	0.088	0.109
% of change	39%	49%	42%			
P-value ¹	0.001*	0.001*	0.001*			

Data is represented as mean \pm SD, *: significant, η 2: partial eta square, p-value¹: within group significance, p-value²: between group significance.





Figure (5): Mean values of the total score of WOMAC pre- and post-study between groups



Figure (6): Mean values of stiffness score pre- and post-study between groups.



Discussion:

This randomized clinical trial investigated the efficacy of adding RW or WBV in the routine physiotherapy program for improving knee functional disability in patients with chronic grade III knee OA.

The results showed that the knee functional disability improved significantly (P<0.05) in all three groups following six weeks of intervention. However, there was no significant difference in pain, stiffness, physical function, or total ArWOMAC scores between the groups.

This aligns with prior studies (e.g., Rathi et al., 2014; Rangey et al., 2016)^{41,42} that found similar results in pain, functional disability, and total WOMAC score after adding the RW program to conventional physical therapy in knee OA participants. However, they focused on grade I-III knee OA rather than our severe grade III OA individuals, the small sample size (20-30 participants) or short duration (2 weeks) may be the main cause of their negative results.

Also, some research suggested the potential benefits on WOMAC score following RW combined with other modalities like ultrasound with RW (30 minutes, 5 days per week for 3 weeks) was more effective than RW with TENS in chronic knee OA⁴³. Also, using Novel Herbal Iontophoretic Gel with RW (10-15 minutes, 4 times per week for 4 weeks) in a 50-years osteoarthritic tailor⁴⁴

Our study also aligns with some authors (e.g., Li et al., 2015; Tossige-Gomes et al., 2011)^{28,45} discovered no significant differences in WOMAC pain, stiffness, and function between WBV and home-based exercise or squat training alone in knee OA patients.

Moreover, Simão et al. $(2012)^{29}$ described that no effects on self-reported pain WOMAC score between WBV with squat and squat training alone, while a significant decrease was in pain with both interventions than the control group who didn't receive any training in elderly patients with knee OA.

Furthermore, previous researches^{40,46} found no improvement on the WOMAC scale in WBV training over conventional treatment in milder degrees knee OA. It might be due to a small sample, short treatment duration (8 weeks), or the lack of standardized protocols across studies, which makes it challenging to draw definitive conclusions.

certain research Conversely, findings indicated favourable impacts on WOMAC scores RW programs in durations (3-4 weeks program)^{14,32,47} over conventional physical therapy alone. However, the short duration RW session (only 10 minutes) may be more effective in severe OA participants than our progressed duration sessions (10-30 minutes) protocol¹⁴. Also, RW and closed kinematic chain exercises only seemed to work together to help reduce discomfort and symptoms in individuals with chronic knee osteoarthritis than our combination of open and kinematic chain exercises routine closed physiotherapy that was chosen on the basis of evidence⁴⁸ may cause shear forces³². The difference in low-intensity RW technique manner (10 minutes on treadmill) may add more benefit and support for severe knee OA ones⁴⁷.

Moreover, some authors showed significant improvement in pain and function disability scales with the RW program compared to conventional physical therapy alone. That may be due to milder OA participants (grade I-III)^{12,17}, or higherfrequency RW program (6 days a week on treadmill) than our moderate RW regimen (10-30 minutes RW, 3 times per week)⁴⁹.

Wadhwa & Hande (2023)⁵⁰ highlight the unique kinematics of RW, suggesting it may reduce knee pain by limiting knee flexion during the swing phase, reducing knee ROM and compressive forces.

However, our findings contradict Wallis et al., $(2017)^{15}$ who observed increased stiffness scores in patients with severe OA following a walking program (70-minutes per week for 12 weeks) while our results showed that progressed RW program type can decrease stiffness so may be protective than usual walking but not differ than routine physiotherapy alone. Similarly, Dewanti & $(2022)^{51}$ Rahmawati reported a potential association between increased WOMAC risk of knee OA complications after a 4-week RW program in a specific population (tea pickers), negative results of this study may be because the picking tea job requires a lot of standing, which strains the knees harder when the subject has regular RW program. While our participants had moderate daily duties.

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Another study by Wang et al. (2016)⁵² indicates potential advantages for knee OA function and pain in WBV training after 6 months of WBV intervention (30 min per day, 5 days per week for 6 months). The positive results of this study suggested that a 24-week long-term impact WBV intervention is required to activate the motor unit and enhance performance than our 6 weeks 0f training (3 days per week). More research will be helpful to ensure that WBV training follows the ideal protocol.

Limitations:

Our study has some limitations that warrant consideration. Firstly, the standard RW technique for treating knee OA is hampered by the inconclusive evidence currently available on RW⁵⁴. Secondly, there is a lack of standardized guidelines for ideal WBV training schedules for OA of the knee. Prior research included a variety of elements, like platform, vibration device, posture during WBV training, frequency, amplitude, and duration, making comparisons difficult. Thirdly, it's possible that the administered exercise dose (20Hz) was too low to produce WBV-exercise's therapeutic effects⁴⁰. Finally, the study design failed to assess the interventions' long-term impacts.

Future Research Directions:

Future research directions could address these limitations and explore ways to optimize these interventions.

- Implementing longer intervention durations (e.g., 12 weeks) for RW programs.
- Increasing the sample size for potentially better generalizability of results.
- Investigating the effects of different WBV parameters (frequency, amplitude, and platform) or combining WBV with other modalities like strength training.
- Including more different knee function measurement tools like the Knee Injury and Osteoarthritis Outcome Score (KOOS) and the Lysholm Knee Score.

Conclusion:

This study demonstrated that neither adding RW nor WBV training to the routine physiotherapy program provided a better statistically significant advantage over the routine physiotherapy program alone in improving knee functional disability in individuals with chronic grade III knee OA. Future research should focus on optimizing intervention protocols and exploring the effectiveness of these approaches, particularly for managing severe knee OA symptoms.

Scientific Responsibility Statement:

The authors confirm that they contributed to this study by collecting, analyzing, and interpreting data, as well as writing, preparing, and approving the final article draft.

Human rights statement:

Every procedure used in this study complied with the Helsinki Declaration (1964) and its subsequent modifications, as well as similar ethical norms, and the guidelines of the organizational and/or national research committee.

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Conflict of interest:

The authors declare no conflicts of interest.

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