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Comparative study between effect of Retrowalking and self-selected pace forward walking on improving pain and function in people with osteoarthritis knee

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Abstract
Background: Osteoarthritis is a common cause of knee pain and lower limb disability. Previous studies reported the beneficial effects of walking in individual with mild to moderate knee osteoarthritis (OA). The current study aimed to compare the effect of retrowalking and self-selected pace forward walking along with conventional treatment on improving pain and function in people with OA knee.
Objective: To compare the effect of retro-walking along with conventional exercise and self-selected pace forward walking along with conventional exercise on improving pain and function in people with OA knee.
Method: 30 subjects with OA knee fulfilled the inclusion criteria were randomly assigned into 2 groups, group A and group B[15 in each group].Group A received retro-walking along with conventional treatment and group B received self-selected pace forward walking along with conventional treatment. The treatment duration will be 45 min in each session for a regular period of 6 days in a week. Pre-test values were taken on the first day and post-test values was taken on the third week of treatment. Outcome measures used were WOMAC, VAS and Isometric H and Held Dynamometer.
Result and Discussion: Statistical analysis of inter group significance by Independent sample t-test for WOMAC [t=2.36>table value, t=2.05], VAS [3.09>table value, t=2.05], and Isometric knee extension strength [t=4.83>table value, t=2.05] reveals that group B (retrowalking) shows significant difference between pre-test and post-test values of WOMAC, VAS and Isometric knee extension strength than in group A (self-selected pace forward walking).
Conclusion: Both group shows significant difference in their pre and post-test values of WOMAC, VAS and Isometric knee extension strength. But group B who received retrowalking along with conventional treatment shows greater improvement on pain and physical function in people with OA knee than in group A who received self-selected pace forward walking along with conventional treatment.

Keywords: Retro-walking, self-selected pace forward 7 walking, osteoarthritis of knee (OA)

Introduction
Osteoarthritis is a degenerative joint disease, occurring primarily in older person, characterized by erosion of the articular cartilage, hypertrophy of bone at the margins that is osteophytes, subchondral sclerosis, and a range of biochemical and morphological alteration of the synovial membrane and joint capsule [1].
The prevalence of osteoarthritis (OA) is gradually increasing in both low- and highincome countries [2]. The Global Burden of Disease studies recently indicated that knee OA is the fastest increasing major health disorder and the second global cause of disability [3]. Men are effected than women before 50 years of age whereas after 50 years of age the prevalence in women is 2-3 times greater than men [4].
The common clinical manifestations of knee OA include pain, stiffness, joint enlargement, crepitus, muscle weakness, deformity, impaired proprioception, reduced joint motion, and disability [5].
Walking can reduce the pain and improves the function in patients with OA Knee by rebuilding the Joints, strengthens the legs, and reduces body weight [6].
Retro-walking is walking backwards [7]. Since there is propulsion in backward direction and reversal of leg movement in Retro-walking, different muscle activation patterns from those in forward walking are required [8].

Backward walking increases stride rate decreases stride length and increases support time. Muscular structure supporting ankle and knee reversed their role during retro-walking. [In retro-walking knee provides the primary power producer and ankle plantar flexors shock absorber]. Direction of knee joint shear force directed forward initially during backward walking where as backward in forward walking. According Flynn *et al*. [1995] backward walking produces significantly lower patellar compressive force than forward walking and helps to reduce maximal vertical force and impulsive force on knee in comparison to forward walking because of toe heel contact pattern. Retro-walking is associated with increased cadence, decreased stride length and different joint kinematics as compared to forward walking and hence may offer some benefits over forward walking alone [9-10].

Outcome measures used in this study are Western Ontario and McMaster Universities Arthritis Index (WOMAC), Visual Analogue Scale and Baseline push-pull Hand Held Isometric dynamometer. WOMAC is used to assess pain, stiffness, and physical function levels in the subjects. It measures five items for pain, two for stiffness, and for functional limitation. Physical functioning questions cover activities of daily living [12]. Pain can be assessed with Visual Analogue Scale with terminal descriptors of "no pain" and "worst pain" possible [13]. A Baseline Push-Pull Hand Held Isometric dynamometer is used to measure the isometric strength of quadriceps muscle [14].

According to studies, both retro-walking and forward walking along with conventional exercise can improve the pain and function in people with osteoarthritis knee. In this study ,aims to compare the effectiveness of retro-walking and self-selected pace forward walking on improving pain and function in people with osteoarthritis knee.

Methodology

Outcome measures

- WOMAC [Western Ontario and McMaster universities osteoarthritis index]: is used to assess pain, stiffness and physical function levels in the subjects. It measures five items for pain, two for stiffness, and functional limitation. Physical functioning questions cover activities of daily living.
- Visual Analogue Scale (VAS)
- Isometric baseline push pull Hand Held Dynamometer

Variables

Dependent Variables

- Pain
- Function

Independent variables

- Retro-walking
- Self selected pace forward walking

Selection criteria

Inclusion Criteria

- Patients with clinical diagnosis of OA knee
- (Tibiofemoral) confirmed by x-rays
- Symptoms more than 3 months
- Age: 55-60 years both genders
- Unilateral involvement
- Sub-acute OA [Kellengran and Lawrence scale 2-3]

Exclusion Criteria

- Previous history of any lower limb surgery
- Systemic inflammatory disease Osteoporosis
- Patients with balance problems
- Patient who had undergone physiotherapy treatment for the same condition before 3 months
- Patients with poor eye sight
- Non cooperative patients

Study Procedure

All the participants with pain in the joint and who are clinically diagnosed as osteoarthritis of knee will be screened and included in this study based on selection criteria and an informed consent will be taken. The study population will include 30 patients with unilateral OA knee fulfilling both inclusion and exclusion criteria.

They are divided into 2 groups, Group A and Group B.A brief description about the procedure will given to the subjects before commencing the study. A total of 30 subject should be divided equally into two groups by random sampling methods Group A [n=15] and Group B [n=15].

Group A

Group A received conventional treatment and 30 minutes of self selected pace forward walking conducted in clinic‟s corridor where patients walked on a tiled floor surface that was hard and smooth.

Fig 1: Self-selected forward walking

Group B

Group B received a combination of conventional treatment and retro-walking in treadmill (two sessions per day (10 min per session)).

The total treatment duration was 45 min in each session for a regular period of 6 days in a week. Both group received hot pack for 10 min prior to exercise in order to warm up the muscle.

Pre-test values were taken on the first day and the post-test values were taken after the total study duration of 3 weeks.

Fig 2: Retro-walking

Conventional treatment

- The patient is positioned in supine lying for application of hot pack over knee for 10 min.
- Stretching exercises of the posterior, anterior, medial and lateral muscles of the lower limb
- Concentric and eccentric isotonic progressive resistance exercises of the lower limb muscles.
- Cooling off exercises, with breathing exercises.

All exercises were given in sets of 10 repetitions.1 set of all exercise for 1st week and progressed to 2 sets in 2nd week and 3 sets in 3rd week.

Fig 3: Stretching Exercises

Fig 4: Strengthening Exercise

Isometric Knee Strength Measurement Method

Isometric Base line Push/Pull Hand Held Dynamometer with 50lb/20 Kg capacity, which can measure muscle strength in kilograms (kg) or in pounds (lb).Maximal isometric strength of knee extensors was measured. Knee extensors with the participant seated, hip and knees flexed at 90o. Dynamometer placed on the anterior aspect of the shank, proximal to the ankle joint. Maximum isometric contraction is measured.

Fig 5: Strength Measurement by using Isometric Base line Push/Pull Hand Held Dynamometer

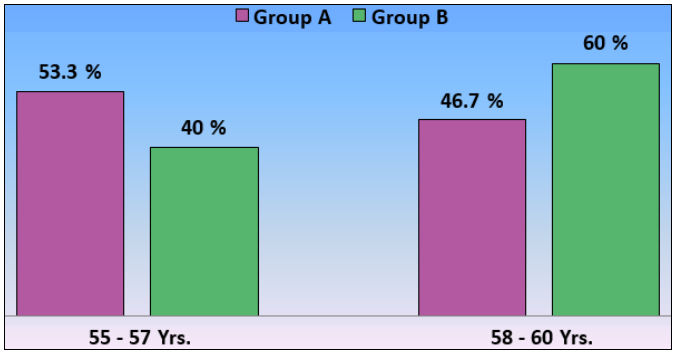
Result

Table 1: Demographic profile of the people with OA knee

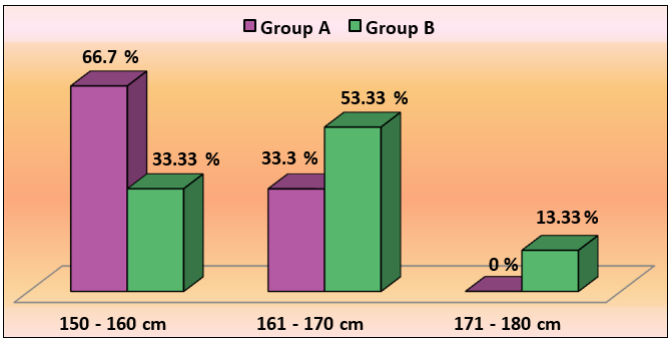
Group	Mean	SD	Minimum	Maximum
Group A	57.6	1.84	55	60
Group B	57.9	2.03	55	60

Table 2: Age distribution of people with OA knee

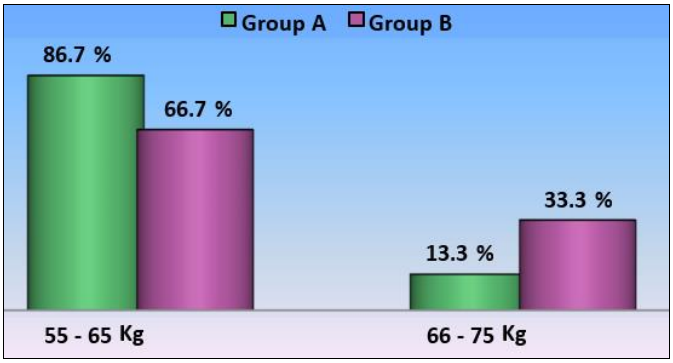
Age	Group A Frequency	Percentage	Group B Frequency	Percentage
55 - 57 yrs	8	53.3%	6	40.0%
58 - 60 yrs	7	46.7%	9	60.0%
Total	15	100.0%	15	100.0%



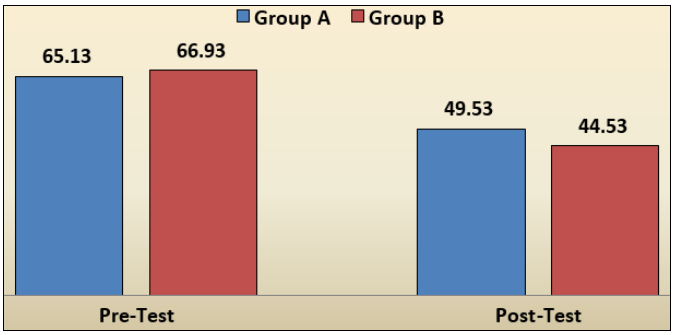
Graph 1: Age distribution of people with OA knee



Graph 2: Height distribution of people with OA knee



Graph 3: Weight distribution of people with OA Knee



Graph 4: Statistical analysis of WOMAC using t-tests Comparison of Pre-test Post-test WOMAC In Group A and Group B

Table 3: Mean S.D. and t-value to compare Pre-test Post-test WOMAC in Group A

Test	Mean	SD	Mean change	n	*t*	df	table value	p-value
Pre-test	65.13	6.32						
			15.6	15	8.91	14	2.15	*p < 0.05*
Post-test	49.53	5.65						

Table 4: Mean S.D. and t-value to compare Pre-test Post-test WOMAC in Group B

Test	Mean	SD	Mean change	n	*t*	*df*	*table value*	*p-value*
Pre-test	66.93	5.55						
			22.4	15	14.13	14	2.15	*p < 0.05*
Post-test	44.53	5.96						

Table 5: Mean S.D. and t-value to compare the pre-test WOMAC between Group A and Group B using t-test

Group	Pre-test Mean	S.D.	Difference in mean	*n*	*t*	*df*	*table value*	*p-value*
Group A	65.13	6.32						
			1.8	30	0.829	28	2.05	*p = 0.414*
Group B	66.93	5.55						

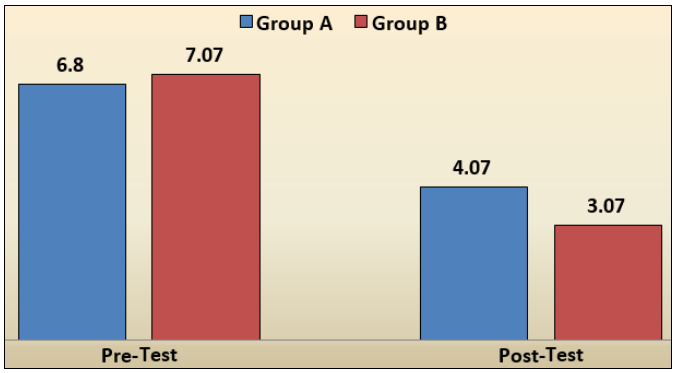
Table 6: Mean S.D. and t-value to compare the post-test WOMAC between Group A and Group B using t-test

Group	Pre-test Mean	S.D.	Difference in mean	n	t	df	table value	p-value
Group A	65.13	6.32						
			1.8	30	0.829	28	2.05	*p = 0.414*
Group B	66.93	5.55						

Statistical Analysis of VAS (Pain) Using t-tests

Table 7: Comparison of Pre-test Post-test VAS in Group A and Group B

Group	Pre-test mean	SD	Post-test mean	SD
Group A	6.8	1.08	4.07	0.88
Group B	7.07	0.79	3.07	0.88



Graph 5: Comparison of Pre & Post VAS in Group A and Group B

Table 8: Mean S.D. and t value to compare Pre-test Post-test VAS in Group A

Test	Mean	SD	Mean change	n	*t*	df	table value	p-value
Pre-test	6.8	1.08						
			2.73	15	11.97	14	2.15	*p < 0.05*
Post-test	4.07	0.88						

Table 9: Mean S.D. and t value to compare Pre-test Post-test VAS in Group B

Test	Mean	SD	Mean change	n	*t*	*df*	*table value*	*p-value*
Pre-test	7.07	0.79						
			4.0	15	23.66	14	2.15	*p < 0.05*
Post-test	3.07	0.88						

Table 10: Mean, S.D. and t value to compare the pre-test VAS between Group A and Group B using t-test

Group	Pre-test Mean	S.D.	Difference in mean	*n*	*t*	*df*	*table value*	*p-value*
Group A	6.8	1.08						
			0.27	30	0.768	28	2.05	*p = 0.45*
Group B	7.07	0.79						

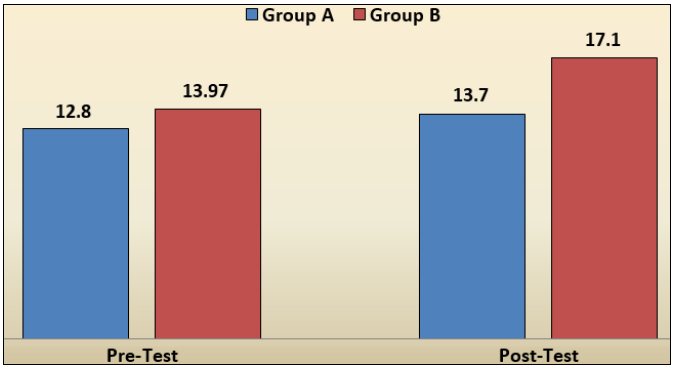
Table 11: Mean S.D. and t value to compare the post-test VAS between Group A and Group B using t-test

Group	Pre-test Mean	S.D.	Difference in mean	n	t	df	table value	p-value
Group A	65.13	6.32						
			1.8	30	0.829	28	2.05	*p = 0.414*
Group B	66.93	5.55						

Statistical analysis of Knee extension strength using t-tests

Table 12: Comparison of Pre-test Post-test knee extension strength in Group A and Group B

Group	Pre-test mean	SD	Post-test mean	SD
Group A	12.8	1.83	13.7	1.89
Group B	13.97	1.5	17.1	1.96



Graph 6: Comparison of Pre & Post Knee extension strength in Group A and Group B

Table 13: Mean S.D. and t-value to compare Pre-test Post-test knee extension strength in Group A

Test	Mean	SD	Mean change	n	*t*	*df*	*table value*	*p-value*
Pre-test	12.8	1.83						
			0.9	15	6.44	14	2.15	*p < 0.05*
Post-test	13.7	1.89						

Table 14: Mean S.D. and t-value to compare Pre-test Post-test Knee extension strength in Group B

Test	Mean	SD	Mean change	n	*t*	*df*	*table value*	*p-value*
Pre-test	13.97	1.5						
			3.13	15	9.32	14	2.15	*p < 0.05*
Post-test	17.1	1.96						

Table 15: Mean S.D. and t-value to compare the pre-test Knee extension strength between Group A and Group B using t-test

Group	Pre-test Mean	S.D.	Difference in mean	n	t	df	table value	p-value
Group A	12.8	1.83						
			1.17	30	1.91	28	2.05	*p = 0.067*
Group B	13.97	1.5						

Table 16: Mean S.D. and t-value to compare the post-test Knee extension strength between Group A and Group B using t-test

Group	Difference			*table*			
	Mean	S.D.	n	*t*	df	p-value	In mean value
Group A	13.7	1.89	3.4	*304.83*	28	2.05 *p < 0.05*	Group B 17.1 1.96

Result

When comparing the post-test values of WOMAC, vas and Isometric knee extension of both Group A and Group B through statistical analysis of inter group significance by Independent sample t-test, WOMAC [t=2.36>table value, t=2.05], VAS [3.09>table value, t=2.05], and Isometric knee extension strength [t=4.83>table value, t=2.05] reveals that group B (retrowalking) shows significant difference between pre-test and post-test values of WOMAC,VAS and Isometric knee extension strength than in group A (Self-selected pace forward walking).

Discussion

Osteoarthritis (OA) of the knee is the most common type of arthritis and the major cause of musculoskeletal pain and mobility disability in the elderly, and there for represents a significant burden on healthcare provision. This study was a comparative study conducted to assess the effectiveness of retro-walking and self selected pace forward walking along with the conventional exercise for reducing pain and improving physical function in people with OA knee.

In this study subject with sub acute OA (Kellengran and Lawrence scale 2-3) were taken into consideration. The subjects were selected by proper screening and fulfilling the inclusion and exclusion criteria. 30 patients were diagnosed with sub acute OA were divided into two groups Group A and Group B (15 patients ion each group). Group A received conventional exercise along with self selected pace forward walking and Group B received conventional exercise along with retro-walking. Each group received treatment for a total period of six week, 45 minutes in each session for a regular period of six days in a week.

The present randomized controlled trial aimed to compare the effects of retro or self selected pace forward walking programs on improving pain and function in people with OA knee. Statistical analysis revealed that conventional exercise along with retro-walking shows significant effect over conventional exercise along with self selected pace forward walking in reducing pain and improving strength and physical function.

Walking is a closed kinetic chain exercise program which allows initiation of weight bearing and early mobilization in knee rehabilitation. Regular walking exercises are beneficial, and it is recommended to reduce pain and disability in people with OA knee [41-43]. Kovar *et al*. reported improved function and no worsening of OA related symptoms after supervised fitness walking program compared to patient education program [44].

Biomechanically muscles around ankle and knee reverse their action during retro-walking. In retro-walking knee gives the primary power producer with co54 -contraction of quadriceps and hamstring and ankle plantar flexors works as shock absorber [45]. Direction of knee joint shear force directed forward initially during retro-walking where as backward in forward walking [46]. Retro-walking produce significantly lower patellar compressive force than forward walking [47]. Retro-walking helps to reduce maximal vertical force and impulsive force on knee compare to forward walking because of toe-heel contact pattern. It is well known that physical exercise in the form of walking is cost-effective, accessible, and effective in reducing cardiovascular disease [48], obesity [49-50], and symptoms of depression [51-52]. Additionally, walking is the most common form of physical activity in the United Kingdom and the United States [53-54]. Another study indicated that the retro-walking reduces eccentric activity of the quadriceps, while isometric and concentric quadriceps activity was maintained [55]. This is one of the advantages of retro walking over forward walking. Reduced eccentric activity of quadriceps will results decrease compressive force at knee joint, therefore, pain intensity at the knee will be reduced. The results of current study indicate a large significant effect of retro walking compared to self-selected pace forward walking.

In addition to walking program, conventional exercise including stretching and strengthening are also used in this study for better outcome. Strengthening of lower limb muscles surrounding knee joint give additional protection from shock and stress. Stretching exercises will restore or increase the extensibility of the muscle-tendon unit and,

therefore, regain or achieve the flexibility and ROM required for necessary or desired functional activities. In addition to improving flexibility and ROM, stretching exercises used for warm-up prior to or Cool-down following walking program [56].

The outcome measures used in this study are WOMAC, VAS, and isometric hand held dynamometer.

On statistical analysis, the mean pre-treatment WOMAC of Group A and Group B is 65.13 and 66.93 and mean post treatment WOMAC is 49.53 and 44.53 respectively. This result shows that there is a decrease of 15.6% in group A and22.4% in group B. Group B shows significant less WOMAC as compared to Group A.

The mean of pre-treatment VAS of group A and group B is 6.8% and 7.07% and mean of post treatment VAS is 4.07% and 3.07% respectively. This result shows that there is decrease of 2.73% in group A and 4% in group B. This shows that there is a considerable decrease of pain in group B.

The mean pre-treatment knee extension strength of group A and group B is 12.8% and 13.97% and mean post treatment knee extension strength is 13.7% and 17.1% respectively.

This result shows there is an increase of 0.9% in group A and 3.13% in group B.Which shows that there is a considerable increase in knee extension strength in group B. Statistically both groups show significant improvement in pain function and strength. Findings shows that, the improvement in group B is greater than that of group A.

The present study had some potential limitations. A long-term follow-up was not included in the present study due to a poor history of patient follow-up in the current hospital setting. Long term trial might bring greater changes in the outcomes and therefore, we could see significant difference between retro- and self-selected pace forward-walking programs. In addition, only subjects aged 50–60 years participated. Impaired cognitive function and severe pain were reported in patient's ≥70 years with knee OA. Furthermore, another study reported a relationship between poor physical function and worse cognitive function in elderly individuals with knee OA.[57] Moreover, a risk of falls was increased in elderly individuals with knee OA as reported previously In the future, we should include both younger and older patients to see a comprehensive clinical picture of these exercise program.

Conclusion

The study was to compare the effect of retro-walking and self-selected pace forward walking along with conventional treatment on people with OA knee. Both regimen shows improvement in pain and function in OA knee patients. However, according to statistically observed result, the effect of retro-walking along with conventional treatment is greater than that of self-selected pace forward walking. Hence retro-walking adjunct to conventional treatment is a better regimen for OA knee patients.

References

1. Srinivas Mondan, Srikanth Babu: A comparative study of proprioceptive exercise versus conventional training program on osteoarthritis of knee Research journal of recent scientist. 2012 December, 12.
2. Cross M, Smith E, Hoy D, Nolte S, Ackerman I, Fransen M, *et al*. The global burden of hip and knee osteoarthritis: estimates from the global burden of disease 2010 study. Ann Rheum Dis. 2014;73:1323-30.
3. GBD 2016 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990–2016: A systematic analysis for the Global Burden of Disease Study 2016. Lancet. 2017;390(10100):1211–59
4. Robin Mcckenzie, Stephen May. The human extremities; mechanical diagnosis and therapy. Spinal publication New Zeeland limited 1st edition: 2007, 255-260.
5. Van der Esch M, Knoop J, van der Leeden M, Roorda LD, Lems WF, Knol DL, *et al*. Clinical phenotypes in patients with knee osteoarthritis: A study in the Amsterdam osteoarthritis cohort. Osteoarthr Cartil. 2015;23(4):544–9.
6. Web Md. Osteoarthritis Feature Stories: Walking to ease knee pain by Mary Jo Dilonardo
7. Nor AM, Lyn KS, Effects of passive joint mobilization on patients with knee osteoarthritis. Sains Malays. 2011;40:1461-5.
8. Kumar TR, Ashraf M. The effect of backward walking treadmill training on kinematics of the trunk and lower limbs. Serb J Sports Sci. 2009;3:121-7.
9. Jönsson T, Ekvall Hansson E, Thorstensson CA, Eek F, Bergman P, Dahlberg LE. The effect of education and supervised exercise on physical activity, pain, quality of life and self-efficacy - an intervention study with a reference [60] group. BMC Musculoskelet Disord. 2018;19(1):198.
10. Hurley M, Dickson K, Hallett R, Grant R, Hauari H, Walsh N, *et al*. Exercise interventions and patient beliefs for people with hip, knee or hip and knee osteoarthritis: a mixed method review. Cochrane Database Syst Rev. 2018, 4.
11. Chen LY, Su FC, Chiang PY. Kinematic and EMG analysis of backward walking on treadmill. Conf Proc IEEE Eng Med Biol Soc. 2000;2:825–7.
12. Cipriani DJ, Armstrong CW, Gaul S. Backward walking at three levels of treadmill inclination: an electromyographic and kinematic analysis. J Orthop Sports Phys Ther. 1995;22:95–102.
13. Jan MH, Tang PF, Lin JJ, Tseng SC, Lin YF, Lin DH. Efficacy of a targetmatching foot-stepping exercise on proprioception and function in patients with knee osteoarthritis. J Orthop Sports Phys Ther. 2008;38(1):19–25.
14. Ojoawo AO, Olaogun MO, Hassan MA. Comparative effects of proprioceptive and isometric exercises on pain intensity and difficulty in patients with knee osteoarthritis: A randomized control study. Technol Health Care. 2016;24(6):853–63.
15. Takacs J, Krowchuk NM, Garland SJ, Carpenter MG, Hunt MA. Dynamic balance training improves physical function in individuals with knee osteoarthritis: A pilot randomized controlled trial. Arch Phys Med Rehabil. 2017;98(8):1586–93.
16. McAlindon TE, Bannuru RR, Sullivan MC, Arden NK, Berenbaum F, Bierma- Zeinstra SM, *et al*. OARSI guidelines for the non-surgical management of knee osteoarthritis. Osteoarthr Cartil. 2014;22(3):363-88.
17. Egan BA, Mentes JC. Benefits of physical activity for knee osteoarthritis: a brief review. J Gerontol Nurs. 2010;36(9):9–14.
18. Hochberg MC, Altman RD, April KT, Benkhalti M, Guyatt G, McGowan J, *et al*. American College of Rheumatology 2012 recommendations for the use of non-pharmacologic and pharmacologic therapies in osteoarthritis of the hand, hip, and knee. Arthritis Care

Res. 2012;64(4):465–74.
19. Roddy E, Zhang W, Doherty M. Aerobic walking or strengthening exercise for osteoarthritis of the knee? A systematic review. Ann Rheum Dis. 2005;64:544–8.
20. Kovar PA, Allegrante JP, MacKenzie CR, Peterson MG, Gutin B, Charlson ME. Supervised fitness walking in patients with osteoarthritis of the knee. A randomized, controlled trial. Ann Intern Med. 1992;116(7):529–34.
21. Uthoff A, Oliver J, Cronin J, Harrison C, Winwood P. A new direction to athletic performance: understanding the acute and longitudinal responses to backward running. Sports Med. 2018;48(5):1083–96.
22. Threkeld AJ, Horn TS, Wojtowicz GM, Rooney JG, Shapiro R. Kinematics, ground reaction force, and muscle balance produced by backward running. J Orthop Sports Phys Ther. 1989;11:56–63.
23. Zhang M, Liu A, Jiang L, Pang J, Guo H, Chen B. The biomechanical effects of backward walking on the knee: a new method for releasing the joint loading. Osteoarthr Cartil. 2015;23:A121–2.
24. Masumoto K, Soucy MT, Bailey JP, Mercer JA. Muscle activity during backward and forward running with body weight support. Hum Mov Sci. 2017;55:276–86.
25. Loew L, Brosseau L, Kenny GP, Durand-Bush N, Poitras S, De Angelis G, *et al*. An evidence-based walking program among older people with knee osteoarthritis: the PEP (participant exercise preference) pilot randomized controlled trial. Clin Rheumatol. 2017;36(7):1607-16.
26. Gondhalekar GA, Deo MV. Retro walking as an adjunct to conventional treatment versus conventional treatment alone on pain and disability in patients with acute exacerbation of chronic knee osteoarthritis: a randomized clinical trial. N Am J Med Sci. 2013;5:108–12.
27. Wallis JA, Webster KE, Levinger P, Singh PJ, Fong C, Taylor NF. The maximum tolerated dose of walking for people with severe osteoarthritis of the knee: a phase I trial. Osteoarthr Cartil. 2015;23:1285–93.
28. Wallis JA, Webster KE, Levinger P, Singh PJ, Fong C, Taylor NF. A walking program for people with severe knee osteoarthritis did not reduce pain but may have benefits for cardiovascular health: a phase II randomised controlled trial. Osteoarthr Cartil. 2017;25(12):1969–79.
29. Toda Y. The effect of energy restriction, walking and exercise on lower extremity lean body mass in obese women with osteoarthritis of the knee. J Orthop Sci. 2001;6:148–54.
30. Boutron I, Altman DG, Moher D, Schulz KF. Ravaud P; CONSORT NPT Group. CONSORT statement for randomized trials of non-pharmacologic treatments: A 2017 update and a CONSORT extension for nonpharmacologic trial abstracts. Ann Intern Med. 2017;167(1):40–7.
31. Damen J, van Rijn RM, Emans PJ, Hilberdink WKHA, Wesseling J, Oei EHG, *et al*. Prevalence and development of hip and knee osteoarthritis according to American College of Rheumatology criteria in the CHECK cohort. Arthritis Res Ther. 2019;21(1):4.
32. Kellgren JH, Lawrence JS. Radiologic assessment of osteoarthritis. Ann Rheum Dis. 1987;16:494–501.
33. Anwer S, Alghadir A. Effect of isometric quadriceps exercise on muscle strength, pain, and function in patients with knee osteoarthritis: a[63] randomized controlled study. J Phys Ther Sci. 2014;26:745–8.
34. Anwer S, Alghadir A, Brismée JM. Effect of home exercise program in patients with knee osteoarthritis: A systematic review and meta-analysis. J Geriatr Phys Ther. 2016;39:38–48.
35. Yeğin T, Altan L, Kasapoğlu AM. The effect of therapeutic ultrasound on pain and physical function in patients with knee osteoarthritis. Ultrasound Med Biol. 2017;43:187–94.
36. Zhang C, Xie Y, Luo X, Ji Q, Lu C, He C, *et al*. Effects of therapeutic ultrasound on pain, physical functions and safety outcomes in patients with knee osteoarthritis: A systematic review and meta-analysis. Clin Rehabil. 2016;30(10):960–71.
37. Bruce-Brand RA, Walls RJ, Ong JC, Emerson BS, O'Byrne JM, Moyna NM. Effects of home-based resistance training and neuromuscular electrical stimulation in knee osteoarthritis: A randomized controlled trial. BMC Musculoskelet Disord. 2012;13:118.
38. Alghadir AH, Anwer S, Iqbal A, Iqbal ZA. Test-retest reliability, validity, and minimum detectable change of visual analog, numerical rating, and verbal rating scales for measurement of osteoarthritic knee pain. J Pain Res. 2018;11:851–6.
39. Ayala A, Bilbao A, Garcia-Perez S, Escobar A, Forjaz MJ. Scale invariance and longitudinal stability of the physical functioning Western Ontario and MacMaster universities osteoarthritis index using the Rasch model. Rheumatol Int. 2018;38(3):473–9.
40. Matsuse H, Hashida R, Takano Y, Omoto M, Nago T, Bekki M, *et al*. Walking exercise simultaneously combined with neuromuscular electrical stimulation of antagonist‟s resistance improved muscle strength, physical function, and knee pain in symptomatic knee osteoarthritis: A single-arm study. J Strength Cond Res. 2017;31(1):171–80.
41. Talbot LA, Gaines JM, Huynh TN, Metter EJ. A home-based pedometerdriven walking program to increase physical activity in older adults with osteoarthritis of the knee: a preliminary study. J Am Geriatr Soc. 2003;51(3): 387–92.
42. Podsiadlo D, Richardson S. The timed “up & go”: a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc. 1991;39:142–8.
43. Alghadir A, Anwer S. Effect of retro and forward walking on quadriceps muscle strength, pain, function, and mobility in patients with knee osteoarthritis: A protocol for a randomized controlled trial. BMC Musculoskelet Disord. 2016;17:161.
44. Rathi M, Palekar T, Varghese A. Efficacy of backward walking on patients with osteoarthritis of knee on quadriceps strength, pain, and physical functions. Indian J Physiother Occup Ther. 2014;8(4):192–6.
45. Dossing A, Tarp S, Furst DE, Gluud C, Wells GA, Beyene J, *et al*. Modified intention-to-treat analysis did not bias trial results. J Clin Epidemiol. 2016;72: 66–74.
46. Joseph R, Sim J, Ogollah R, Lewis M. A systematic review finds variable use of the intention-to-treat principle in musculoskeletal randomized controlled trials with missing data. J Clin Epidemiol. 2015;68(1):15–24.
47. Kumar TR, Ashraf M. The effect of backward walking treadmill training on kinematics of the trunk and lower limbs. Serb J Sports Sci. 2009;3:121–7.
48. Van der Esch M, Holla JF, van der Leeden M, Knol DL, Lems WF, Roorda LD, *et al*. Decrease of muscle strength is associated with increase of activity limitations in early knee osteoarthritis: 3-year results from the cohort hip and

cohort knee study. Arch Phys Med Rehabil. 2014;95:1962–8.
49. Boone-Heinonen J, Evenson KR, Taber DR, Gordon-Larsen P. Walking for prevention of cardiovascular disease in men and women: a systematic review of observational studies. Obes Rev. 2009;10:204–17.
50. Morabia A, Costanza MC. Does walking 15 minutes a day keep the obesity epidemic away? Simulation of the efficacy of a population wide campaign. Am J Public Health. 2004;94:434–40.
51. Pucher J, Buehler R, Bassett D, Dannenberg A. Walking and cycling to health: a comparative analysis of city, state, and international data. Am J Public Health. 2010;100:1986–92.
52. Robertson R, Robertson A, Jepson R, Maxwell M. Walking for depression or depressive symptoms: a systematic review and meta-analysis. Ment Health Phys Act. 2012;5:66–75.
53. Armstrong K, Edwards H. The effectiveness of a pram-walking exercise programme in reducing depressive symptomatology for postnatal women. Int J Nurs Pract. 2004;10:177–94.
54. Craig R, Mindell J, Hirani V, editors. Health Survey for England 2008: Volume 1 Physical Activity and Fitness. Leeds, UK: NHS Information Centre; 2009.
55. Centers for Disease Control and Prevention. More People Walk to Better Health. [(accessed on 22 January 2019)]
56. Messier SP, Royer TD, Craven TE, O"Toole ML, Burns R, Ettinger WH. Long-term exercise and its effect on balance in older, osteoarthritic adults: results from the fitness, arthritis, and seniors trial (FAST). J Am Geriatr Soc. 2000;48:131–8.
57. Messier SP, Loeser RF, Mitchell MN, Valle G, Morgan TP, Rejeski WJ, *et al*. Exercise and weight loss in obese older adults with knee osteoarthritis: a preliminary study. J Am Geriatr Soc. 2000;48:1062–72.