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Original Article

Improving exercise capacity and reducing the risk of falls in osteoarthritis patients: the role of perturbation and functional training

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Abstract
Research objectives included assessing the effects of Perturbation and Functional Task Training on cardiovascular endurance, strength, balance and risk of falls, ability to perform daily activities and basic functional mobility, gait speed and the ability to go out in elderly osteoarthritis patients.
Both Experimental groups: Perturbation Training (PT), n=15; Functional Task Training (FT), n=15 demonstrated significant improvements in cardiovascular endurance (6 min walk distance) as compared to Control group (CG), n=15, with however no group/time interactions discovered.
In strength related variables, experimental groups demonstrated specific responses in terms of time and in terms of group. In the ability to perform daily activities and basic functional mobility at the post test, FT group was significantly advantageous in scores. In stiffness scores at mid tests, PT group was significantly better than in other groups. At the post test, subjects of both intervention groups have shown significantly better scores ($p< .05$) than the subjects from control group. In physical function scores however no group/time interactions were discovered. In gait speed and the ability to go out at the post test, subjects of both intervention groups have shown significantly better timings ($p< .05$) than the subjects from CG with no significant differences between experimental groups at the post-test.
In balance and risk of falls at mid tests, the scores shown by the subjects of PT group were significantly better than in FT group. At the post test, subjects of both intervention groups have shown significantly better scores ($p< .05$) than the subjects from the CG. There were, however no significant differences between experimental groups at the post-test.
Key Words: perturbation training; functional training; osteoarthritis.

Introduction

Osteoarthritis (OA) is an increasingly common musculoskeletal disorder with lack of effective prevention, and its prevalence increases with age. OA causes pain and impairment in body functions such as muscle strength, range of joint motion, and joint stability. Furthermore, OA has a major impact on physical functioning in daily life and frequently leads to moderate to severe limitations in participation and a decreased quality of life (Le et al., 2012).

The frequency and chronicity of OA makes this disease a substantial economic burden for patients, health care systems and fitness in all nations (DiBonaventura et al., 2012; Uher and Liba, 2017a).

The physical disability arising from knee OA prevents the performance of daily life activities such as walking, squatting and climbing stairs, thus negatively affecting patients' wellbeing (Diracoglu, Baskent and Celik, 2005; Sisto and Malanga, 2006). Several factors cause the occurrence of physical disability including pain, limitation of joint movement, coordination impairment and muscle weakness (Uher and Liba, 2017b). Current goals of OA management are pain control, prevention of joint damage, maximizing function and quality of life, and minimizing therapeutic toxicity (Pelletier, Pelletier, and Raynauld, 2006). At this moment, the management of OA includes a combination of pharmacological and non-pharmacological treatments.

Non-pharmacologic treatments of OA include education programmes, changes of life style, physical therapy and exercises programmes (Sisto and Malanga, 2006; Ilinka et al., 2013). Based on several previous studies, physical activities including exercises have been identified as the most effective non-pharmacological treatments in OA (Sharma, 2002; Krasilshchikov et al., 2012) and a crucial component of primary, secondary and tertiary prevention of OA. Exercises were proved to be safe and well tolerated by osteoarthritic patients (Bischoff and Roos, 2003).

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Despite the well-known fact that exercises are the effective treatment in OA, exact amount and types of exercise that would be beneficial and not destructive to the affected joint are unknown and most effective types and combinations of exercise as well as the amount are still unclear (Deyle et al., 2005).

One of the trends in rehabilitation exercise for OA is to emphasize functional types of exercises that include weight-bearing activity. The term 'functional' relates to those activities that most closely resemble day-to-day activities, such as rising to stand, ascending and descending stairs, stepping, walking, squatting and lunging. Functional exercises have been shown to have many benefits over open chain exercises.

Another popular trend emerged from the fact that a significant proportion of people with knee OA have complaints of knee instability. Fitzgerald et al., (2002) introduced balance-perturbation approach to benefit patients with knee OA. Agility and perturbation training techniques provide exposure to various challenges of motor function (e.g. quick stops, turns, and changes in direction; challenges to balance; negotiating obstacles) that may be encountered during daily functional activities.

The agility exercises focused on exposing the individual to quick stops and starts, quick turns and changes in direction, and negotiating obstacles encountered in the environment. The perturbation training involved the use of rollerboards and tiltboards to expose the individual to challenges in balance (Fitzgerald et al., 2011). Surprisingly, the above developed approaches and exercise programmes were very rarely compared and tested in the domain of the risk of falls.

Objectives of the study

Study objectives included assessing the effects of Balance Perturbation Training (PT) and Functional Task Training (FT) on cardiovascular endurance, ability to perform daily activities and basic functional mobility, gait speed and the ability to go out and balance and risk of falls in osteoarthritis patients**.**

Materials and Methods

Subjects

The sample size was calculated using G Power software with the power of the study was set at 80% with 95% confident interval and effect size f' was set at 0.25. The sample size was calculated as 45 subjects with each group containing 15 subjects.

Eligible 48 patients (considering possible dropouts) who fulfilled the criteria were selected at Orthopedic clinic Hospital Universiti Sains Malaysia, Master Skill College Kota Bharu Physiotherapy Department, and MAHSA University Kuala Lumpur Physiotherapy Department. Subjects were randomly assigned into three groups (one control and two experimental groups) with 15 patients per group.

Inclusion criteria

- In the range of 40-65 years old
- Having a bilateral knee OA with grade one and two
- Have no contraindication from a personal physician for participation in resistance and functional exercises
- Both genders
- A history of knee pain for longer than 6 months (chronic knee osteoarthritis).

Exclusion criteria included:

- Knee surgery or intra-articular corticosteroid injection within past six months;
- Systemic arthritic conditions;
- History of hip or knee joint replacement or tibial osteotomy;
- Any other condition affecting lower limb function;
- A Vestibular disorder,
- Patients will be excluded if they had received physical therapy, acupuncture or massage therapy treatment for their knee during the preceding 3 months.
- Musculoskeletal conditions involving the knee joint (e.g., tendon/ligament tears),
- Severe uncontrolled hypertension (>160/100 mm/hg).
- Cardiorespiratory disease (ischemia, arrhythmia, chest pain, or exercise-induced bronchospasm), liver abnormalities;

Experimental variables and assessment protocol

The parameters measured in the study helped assessing patients' ability to perform daily activities, daily life activities efficiency and the risk of falls. Two intervention groups and control group performed pre-experimental test evaluation before beginning the exercise programme, mid-experimental test after six weeks of intervention and post-experimental test after twelve weeks of the study.

The test conducted included:

1. WOMAC physical function questionnaire to assess patient's ability to perform daily activities. It consists of 25 questions corresponding to a Likert scale that was designed to measure patient's perceptions of pain (5 questions), stiffness (3 questions) and physical function (17 questions) during the last week. High scores show self-perfection (greater severity) (Davies, Watson and Bellamy, 1999).

2. Timed "Up and Go" (TUG) test protocol to assess subjects' basic functional mobility. The TUG test is a simple test used to assess a person's mobility and requires both static and dynamic balance (Podsiadlo and Richardson, 1991; Shumway-Cook, Brauser and Woollacott, 2000).
3. The Berg Balance Scale (BBS) test, which is a 14-item scale designed to measure balance of the older adult in a clinical setting (Berg, Wood-Dauphinee and Williams, 1995; Jung et al., 2006).
4. Six minutes walking distance test (Evcik and Sonel, 2002).

Intervention Protocols

Agility and Perturbation Training (PT)

Agility and Perturbation Training (PT) group protocol was based on the ACSM prescription recommendations, whereby manipulated load and recovery variables included:

Duration of the session	-40-50 min
Weekly frequency	-3 days / week
Initial volume (Sets and repetitions)	-1 set, 12-15 repetitions
Progression:	-adding 1 set every 4 weeks
Initial intensity of exercises	-light to moderate (67-65% of 1 RM)
Progression:	-when 15 reps get too easy to perform
Rest Intervals	-1 min between sets, 3 min between exercises
Rhythm of execution	-Medium to slow (except isokinetic training)

Exercises included walking in different directions (including change in the direction), Stair walking Shuttle walking, Braiding Activities, Front and Back Crossover Steps during Forward Ambulation, Multiple changes in direction while walking, Standing Star Exercise and Double Leg Foam Balance Activity.

Functional Task Training (FT)

Experimental group 3 received Functional Task Training thrice a week, 45 to 50 min each session for 12 weeks. Each exercise was either timed or expressed in number of repetitions. Intervention protocol in this group is divided in three phases.

Practice phase (2 weeks). Exercises in this phase consist of short, simple tasks Weight transported and repetitions were noted.

Activities to be performed in practice phase (2 Weeks)

Step forward onto a raised (20cm) platform, or a step.	Lift a weighted box (from knee high).
Step sideways onto a step.	Lift a weighted box (from the floor).
Step on and off a step. Repeat for 1 minute	Lift (from the floor) and carry a weighted box.
Step forward sideward over the step. Repeat for one min.	Get up out of a chair and carry a small object.
Walk for 2 minutes.	Get out of bed and carry a small object.
Walk through an obstacle course.	Putting on socks, taking of socks

Variation phase (weeks 3 to 6) –Participants apply basic tasks to various training conditions, such as environment, attributes, and interaction.

Daily tasks phase (weeks 7 to 12) - The aim of this phase is to train situations that closely match the participants' daily activities.

Medications

Medications among the subjects in the control group and intervention groups were standardized to T. Glucosamine Sulphate of 500 mg three times a day.

Ethical clearance

Research protocol was approved by the USM Human Research Ethics Committee (JEPEM USM) on 19th May 2014, protocol USM/JEPeM/280.3.(5).

Statistical Analysis

The data was analysed using the Statistical Package for Social Science (SPSS) version 22.0 software. Normality of data was determined through histogram where the normality curve was used as an indication whether the data was normally distributed or not. Two-way repeated measured ANOVA was used to analyse interaction between groups in all parameters and across the experimental time.

A simple effect or post-hoc test was used to locate the differences when the two-way repeated measured ANOVA revealed a significant interaction between groups or across the experimental time. Difference were considered significant at $p<0.05$.

Results

Statistical analysis of the data from 45 patients (age 51.6±6.32 and weight 69.74±12.05) who successfully concluded the intervention revealed some statistically significant effects of various types of training in terms of time (from pre- to mid- to post) and in terms of group/time (various training groups differences at pre- at mid- and at posttest).

Cardiovascular Endurance

Both experimental groups have demonstrated steady and significant improvements from the pre- to mid- mid- to posttests and pre- to posttests in six minutes' walk distance (all at $p<0.05$). There were no group/time interactions discovered (Tab 1).

Table 1. Six minutes' walk distance (m) of the subjects of all study groups at various testing sessions

Time	Pre-test		Mid-test		Post-test	
Group	MEAN	SD	MEAN	SD	MEAN	SD
Perturbation	404.67	101.74	466.47*	106.23	487.73**,***	106.49
Functional	405.47	64.26	431.40*	72.13	477.47**,***	78
Control	443.8	94.76	444.13	87.44	457.87	91.8

*Significant: at p<.05 *from pre- to mid- ; **from pre- to posttest; ***from mid- to posttest*

Ability to perform daily activities and basic functional mobility

In WOMAC questionnaire pain scores both experimental groups have demonstrated steady and significant improvements (Tab 2). Perturbation and functional training group improved from the pre- to mid- and further to posttests, as well as from pre- to posttests (all at $p<0.05$).

Besides, group/time interactions were discovered as well. At the post test, bot Perturbation and Functional training groups were significantly different in scores than Control group ($p< .05$). There was however no significant difference between experimental groups at posttest.

Table 2. WOMAC scores of the subjects of all study groups at various testing sessions

			Pain Scores			
Time	Pre-test		Mid-test		Post-test	
Group	MEAN	SD	MEAN	SD	MEAN	SD
Perturbation	8.13	0.99	6.13*	0.64	5.00**,***	0.76
Functional	7.87	1.3	6.6*	0.99	4.53**,***	0.91
Control	8.2	2.21	7.27	1.62	7.13	1.41
			Stiffness scores			
Perturbation	4.53	0.91	2.47*	1.25	1.87**,***	0.64
Functional	4.73	0.88	4.07*	0.704	1.73**,***	0.88
Control	4.47	1.36	4.2	1.15	3.87	1.36
			Physical function scores			
Perturbation	26.73	6.73	23.73*	5.86	21.07**,***	6.48
Functional	27.07	7.36	24.73*	5.69	19.6**,***	4.19
Control	24.67	8.78	22.6	7.3	21.87	7.19

*Significant: at p<.05 *from pre- to mid- ; **from pre- to posttest; ***from mid- to posttest*

In WOMAC questionnaire stiffness scores both experimental groups have demonstrated steady and significant improvements from the pre- to mid- and further to posttests and also from pre- to posttest (all at $p<0.05$). Besides, group/time interactions were discovered as well. At mid tests, the scores shown by the subjects of Perturbation training groups were significantly better than in two other groups. At the post test, subjects of both intervention groups have shown significantly better scores ($p< .05$) than the subjects from control group. There were, however no significant differences between experimental groups at the posttest (Tab 2).

In WOMAC questionnaire physical function both experimental groups have demonstrated steady and significant improvements (Tab 2). Perturbation and Functional training group improved from the pre- to mid- and further to posttests as well as from pre- to the posttest (all at $p<0.05$). There were no group/time interactions discovered whatsoever.

Gait speed and the ability to go out

All three experimental groups have demonstrated steady and significant improvements from the pre- to mid- and further to posttests as well as from pre- to posttests in Timed Up and Go (TUG) test (all at p<0.05).

Besides, group/time interactions were discovered as well. At the post test, subjects of both intervention groups have shown significantly better timings (p< .05) than the subjects from Control group. There were, however no significant differences between experimental groups at the post-test (Tab 3).

Table 3. Timed Up and Go time (s) of the subjects of all study groups at various testing sessions

Time	Pre-test		Mid-test		Post-test	
Group	MEAN	SD	MEAN	SD	MEAN	SD
Perturbation	14.69	1.105	13.89*	0.95	11.69**,***	0.89
Functional	14.77	1.16	13.46*	1.15	12.14**,***	1.38
Control	14.77	1.76	14.17	1.69	14.11	1.53

*Significant: at p<.05 *from pre- to mid- ; **from pre- to posttest; ***from mid- to posttest*

Balance and risk of falls

All three experimental groups have demonstrated steady and significant improvements from the pre- to mid- and further to posttests as well as from pre- to posttest in Borg's Balance Scale test (all at p<0.05).
Besides, group/time interactions were discovered as well. At mid tests, the scores shown by the subjects of PT groups were significantly better than in FT group (p=.046). At the post test, subjects of both intervention groups have shown significantly better scores (p< .05) than the subjects from control group.
There were, however no significant differences between experimental groups at the posttest (Tab 4).

Table 4. Borg's Balance Scale scores of the subjects of all study groups at various testing sessions

Time	Pre-test		Mid-test		Post-test	
Group	MEAN	SD	MEAN	SD	MEAN	SD
Perturbation	23.8	2.98	31.73*	3.03	35.87**,***	3.6
Functional	23.00	2.83	28.00*	4.03	37.00**,***	4.64
Control	24.8	4.33	25.4	4.85	25.93	4.27

*Significant: at p<.05 *from pre- to mid- ; **from pre- to posttest; ***from mid- to posttest*

Discussion

It has been reported that focusing on open chain exercises compromises the specificity and selectivity principles of training, which state that optimal gains in a motor activity are made when the exercise most closely resembles the activity (Durward, Bear and Rowe, 1999). Improvements in daily function would be best served by exercise resembling the daily activity. In previous research authors developed a supplemental approach to exercise therapy that included the use of agility and perturbation techniques in conjunction with a standard impairment based exercise therapy program for people with knee OA (Fitzgerald et al., 2002). The program developed for our research consisted of some of the traditional activities, however with modifications which included performing agility techniques using stepping-based rather than walking-based activities and combining double-limb support with than single-limb support for the perturbation techniques.

In the ability to perform daily activities and basic functional mobility both PT and FT group improved from the pre- to mid- and further to post-tests (all at p<0.05) with obvious advantage of FT group. In the ability to perform daily activities; basic functional mobility; and in gait speed and the ability to go out both groups improved but with no significant differences between them at any point of testing.

In balance and risk of falls, both experimental groups have demonstrated steady and significant improvements from the pre- to mid- and further to post-tests (all at p<0.05). At mid tests, the scores shown by the subjects of PT group were significantly better than in FT group. There were, however no significant differences between experimental groups at the post-test.

Previous studies reported FT improving all measures of pain, balance and functional outcomes. However FT group benefited by significant relief in pain achieved good balance & functional mobility than traditional exercise group. FT is confirmed as an effective rehabilitation program for improving functional mobility and decreasing pain in knee OA (Stutz-Doyle, 2011).

Singh and Tiwari (2016) reported that FT training on regular basis is an effective rehabilitation program for improving functional mobility, balance and decreasing pain and stiffness in knee OA. McGibbons, Krebs and Moxley (2003) found that faster rise times noted for the FT group may indicate improvements in postural stability (balance) required to accommodate to larger changes in the centre of gravity associated with this activity. Our findings support the possibility of task-specific training in transfer to task performance. Whitehurst et al. (2005) found similar results in their 12-week study of functional task exercises with elderly population. The exercises included wall squats, single leg balance, star exercise, modified push-ups and walking over obstacles while carrying bags. The environment was varied by obstacle height, changing directions and walking backward.

Outcome measures were significant for the get up and go test (TUG), standing reach, sit and reach and self-report of physical function.

Conclusions

Both experimental groups demonstrated steady and significant improvements in cardiovascular endurance from the pre- to mid- and further to posttests (all at $p<0.05$) with no obvious advantage of any of the programs. In some instances FT was more reliable and impactful through involving more positive changes in higher number of variables.

It was difficult however to mark the superior training programme. At mid tests, the scores in balance and risk of falls by PT group were significantly better than in FT group. At the post test, subjects of all three intervention groups have shown significantly better scores ($p< .05$) than the subjects from control group.
There were significant differences between PT and FT groups at the post-test in functional capacity and balancing domains.

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