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# CHIEF EDITOR'S MESSAGE

## Message from Chief Editor:
## Assoc. Prof. Dr. Nor Azlin Mohd Nordin

Dear readers of Malaysian Physiotherapy Journal (MPJ),

On behalf of the editorial team, I am pleased to welcome you to the second volume of MPJ. In this issue, we are proud to present to our readers five new original research, one systematic review, one case study, a commentary and two special issue articles from our international and national contributors who have generously shared their research or review findings on various aspects of physiotherapy-related interventions. Being an important field in the health care and rehabilitation, physiotherapy practice must be informed by scientific, evidence-based decisions pertaining to tools, techniques, and methods. We believe that MPJ, to a certain extent, contributes to fill the gaps in the existing physiotherapy and rehabilitation-related literature.

We take this opportunity to thank our innovative and talented authors for being a part of this journal and made the production of this second volume of MPJ possible. We are pleased to inform everyone that in spite of the MPJ being still at its infancy, the journal received a substantial number of articles to be considered for publication in this second volume of MPJ. However, despite our best efforts, some of the papers could not be included in the present issue due to the decision of the reviewers and editorial board. We hope this will not deter any of the authors from sending their scholarly works for publication in MPJ in the future.

We extend our gratitude to our expert reviewers and distinguished editors for their unlimited support, timely reviewing of the manuscripts and for guiding the journal to greater heights. Undoubtedly, the future success of MPJ is attributed to their commitment, alongside the contributions of our talented authors, and not forgetting our Editorial Assistant for her effort in ensuring the smooth processing of all submitted articles.

We hope everyone, from readers to authors to reviewers and editors, will continue to give their strong support to this journal. Together, let's make MPJ our journal of choice.

Best regards,

*Nor Azlin Mohd Nordin*

## ORIGINAL ARTICLE

# Moderate Intensity Physical Exercise Effectiveness on Stress and Happiness Level Among Parents of Physically Disabled Children

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## ABSTRACT

The upbringing of a physically disabled child involves huge monetary funds and constant attention from the parent. It leads to minimal sociability and personal attention for the parents, which contributes to high stress and low happiness in the long run. Hence, this experimental study was conducted to measure the effect of moderate physical exercise on stress and happiness among parents of physically disabled children using the Perceived Stress Scale and Subjective Happiness Scale. The study goals were to evaluate the potential sociodemographic variables and the benefits of moderate-intensity exercise in stress and happiness management. Participants were allocated into either an exercise group or a control group; parents in the exercise group were given clear-cut instructions on moderate-intensity exercises to complete in 6 weeks. The data were analysed using Chi-square, Pearson correlation, and ANOVA from SPSS software. The findings showed sociodemographic variables and physical activity level have no significant relationship ($p$>0.05) on stress and happiness level among parents of physically disabled children except for employment status ($p$<0.05). The moderate intensity exercise has a significant effect on stress levels ($p$<0.05) but no significant effect on happiness levels ($p$>0.05) among parents of physically disabled children. Altogether, the findings from this study proclaimed that moderate-intensity exercise affects stress but not the happiness level of parents of physically disabled children. With that, a potential intervention tool through exercise adoption can be utilized as a medium to manage stress in parents of physically disabled children. On that account, elucidation on physical exercise towards stress levels in parents of physically disabled children can be achieved and explained in an informative manner. Further studies are warranted to confirm this study findings.

**Keywords:** Parents; Physically disabled children; Stress; Happiness; Exercise

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## INTRODUCTION

The presence of disabled children in one's family has irreversible consequences for the family's mental health. Most physically disabled children have difficulty conducting their daily activities independently and need help from family members, especially parents. Having physically disabled children have changed parents' lives, and a huge burden falls on them as the primary caregiver (Lebni et al. 2020). The parents are affected by the emotional, physical, and psychosocial aspects (Qian et al. 2015). Most of the parents felt having physically disabled children have changed their life because they need to cope with the needs of their children (Wang et al. 2007). A higher level of emotional burnout was seen among parents with disabled children, especially mothers, compared to parents of children without disabilities (Kurtoğlu & Özçirpici 2019).

The emotional and physical burden of caring for disabled children can overwhelm the parent. The continuous effort in day-to-day activities related to the children, such as transferring, dressing, and so on, typically makes the parents fatigue and unintentionally affects their behaviour changes where they tend to isolate themselves from other peers (Vassilis 2017). Apart from that, time taken in managing the physically disabled children led to compromising the parent's usual activities, where they have less time for themself and socialize with their partners. This time-constraint situation psychologically affects the parents and their social and marital relations, and they are socially isolated (Laskar et al. 2010).

Outdoor social lifestyles such as exercising and physical activities reduce stress and increase both parents' and children's happiness. However, in families with physically disabled children, parents and children cannot socialize or engage in outside physical activity for various reasons. Lack of sufficient local leisure facilities and accessible transportation for wheelchair users, such as the door or slope being too narrow, is one reason they feel disappointed in participating in outdoor social activities (Rimmer et al. 2017). The need to protect children from respiratory infections is also why parents limit outdoor programs, especially exercising, contact sports, or physical activities (Qian et al. 2015). In addition, the need for specialized equipment for these children to assist with their breathing or movement, causing preparing for out-of-the-house activities, time-consuming and overwhelming, resulting in the parents not interested in outdoor physical activities and socializing with others (Qian et al. 2015).

All this burden and complex situation will affect the parent's level of stress and happiness. The lack of social activity for parents to release all the stress will cause them to be in continued stress state with reduced happiness. Hence, looking into parents' ability to do exercise or physical activity to make them feel happy and less stress is important and should be included in a rehabilitation process to ensure both parents and children with physically disabled have a better health state and quality of life.

## METHODS

### Study design

A single blind randomized controlled trial design experimental study was used to determine the effect of moderate-intensity activity on stress levels and happiness among parents of physically disabled children.

### Participants

The total sample size calculation was based on literature that described the involvement of 30 participants using G-Power version 3.1.9.7 software with a significant level (α) of 5% and the effect size of 0.8; participants became 15 with a 20% attrition rate per group. The inclusion criteria were parents of physically disabled children diagnosed with Spinal Muscular Atrophy Type I, II or III, Cerebral Palsy, Dandy-Walker Syndrome and Tyrosine Hydroxylase Deficiency. In addition, parents diagnosed with a psychiatric or neurological disorder, a history of cardiovascular, respiratory, metabolic, or renal diseases, were pregnant or had any former or current physical impairment unsuitable for moderate-intensity exercise were excluded. Participants' consent was obtained using the informed consent form before answering the selected questionnaires.

### Instrument

The instruments used to measure the desired objectives are the Sociodemographic questionnaire, Perceived Stress Scale, and Subjective Happiness Scale. The two scales were self-administered in nature.

### Procedure

Participants were randomly assigned into two groups: the control and intervention groups. Participants need to answer a sociodemographic survey which includes age, household economic status, employment status, physically disabled children's age, Perceived Stress Scale, and Subjective Happiness Scale using a google form. Participants submitted the questionnaire the week before the program started (T1). Then for six weeks, the control group was not given any intervention except usual education while the intervention group completed the exercises prescribed for six weeks. Finally, after six weeks of study, all participants were asked to answer the questionnaire again (T2).

### Intervention

An indoor moderate-intensity aerobic exercise was prescribed to the intervention group using a live online session via Google Meet and Skype twice weekly for six weeks. The intensity of the exercise was increased every fortnightly. Initially, the exercise intensity started with 6 minutes for week 1 and week 2, and was increased to 12 minutes for week 3 and week 4, and 18 minutes for week 5 and week 6. The exercise was divided into two types, exercise 1 (E1) every Wednesday and exercise 2 (E2) every Saturday (Table 1) and was conducted by an experienced physiotherapist.

### Statistical analysis

All data were analysed using SPSS version 22 (SPSS Inc., Chicago, IL, USA). A two-way repeated measures ANOVA was used to measure the effect of 6 weeks of moderate-intensity exercise on stress and happiness among parents of physically disabled children. Chi-square and Pearson correlation tests were used to measure the relationship between the sociodemographic variables and physical activity level with stress and happiness among parents of physically disabled children. The level of significant differences was set at $p < 0.05$. Data were expressed as mean and standard deviation (M ± SD).

## RESULTS

A total of 26 of 38 parents of physically disabled children successfully completed the study intervention. The parents' mean age was 37.73 ± 7.28 years old (ranged from 28 to 53 years old) and with the children's mean age was 7.28 ± 4.94 years old (range between 1 and 18 years old) (Table 2). The mean pre-test score mean for Perceived Stress Scale and Subjective Happiness Scale for all 26 participants were M=21.11±3.66 and M=4.74 ± 1.03, respectively.

In this study, for the control group, the number of employed and unemployed was 5 (38%) and 8 (62%) people, respectively. The participant according to

**Table 1: E1 and E2 exercise program (Herbert, Meixner, Wiebking, & Gilg, 2020)**

| | E1 (Continuous jog on the spot during the entire exercise) | E2 (Continuous hopping on the spot during the entire exercise) | |
|---|---|---|---|
| Warm-up | Run on the sport | Hop on the sport | 20 sec |
| | Turn In hips while running | Turn In hips while jumping | 15 sec |
| | Butt kick exercise with hands on hip | Butt kick exercise with hands on hip | 15 sec |
| | Windmill arm rotation exercise | Jumping with arms to the front | 20 sec |
| Exercise | • Overhead arm raises<br>• Side air punches<br>• Front air punches<br>• Kicks to the front<br>• High knees forward<br>• Kicks with wrist touch the opposite toe<br>• Overhead arm raises<br>• Side air punches<br>• Front air punches<br>• Kicks to the front<br>• High knees forward<br>• Kicks with wrist touch the opposite toe | • Arm circles<br>• Uppercuts<br>• Punches overhead<br>• Arms crossed and jump side to side<br>• Side taps squat<br>• X - jumps<br>• Arm circles<br>• Uppercuts<br>• Punches overhead<br>• Arms crossed and jump side to side<br>• Side taps squat<br>• X - jumps | Week 1 & 2: 30 sec each exercise<br>Week 3 & 4: 45 sec each exercise<br>Week 5 & 6: 60 sec each exercise |
| | Shake out arms while run on the spot | Lift heels and wiggle on tiptoe | 15 sec |
| Cooling down | Straddle stretch in standing with arms relax | Straddle stretch in standing, shake out thighs | 15 sec |
| | Dynamic stretching to the side by upper body twist | Arms stretched by reach arm overhead slowly | 15 sec |
| | Bent over twist | Bent over twist | 15 sec |

household income status in this group were 3 (23%) for T20, 5 (38%) for M40 and 5 (38%) for B40, respectively. On the other hand, the intervention group participants consist of 9 (69%) for employed and 4 (31%) for unemployed, respectively. The participants household income status for this group were 10 (77%) M40 and 3 (23%) for B40, respectively. None of the participant in the intervention group falls into the T20 category. Then, the general effect of employment status and household income on stress and happiness level among parents of physically disabled children were measured using chi-square.

Based on the statistical analysis, there was no significant association where $p>0.05$ between employment status and household income classification of the parents of physically disabled children's stress level (Table 3).

**Table 2: Descriptive statistics for control and intervention group**

| | Control group (n=13) | | Intervention group (n=13) | |
|---|---|---|---|---|
| | **Mean** | **Std. Deviation** | **Mean** | **Std. Deviation** |
| Participant's age (years old) | 35.23 | 6.33 | 40.23 | 7.54 |
| Children's age (years old) | 5.88 | 5.10 | 8.68 | 4.53 |
| Pre-Test score for Perceived Stress Scale | 21.54 | 3.20 | 20.69 | 4.15 |
| Post-Test score for Perceived Stress Scale | 20.61 | 4.48 | 14.69 | 4.48 |
| Pre-Test score for Subjective Happiness Scale | 4.63 | 1.01 | 4.85 | 1.07 |
| Post-Test score for Subjective Happiness Scale | 4.65 | 1.09 | 5.15 | 1.26 |

**Table 3: The association between gender, employment status and household income classification with stress level among the participants**

| Variables | | Low stress | Moderate Stress | High Stress | $X^2$ |
|---|---|---|---|---|---|
| Gender | Male | 0 | 4 | 0 | $X^2$ (2, 26) = 0.35, *p=0.82* |
| | Female | 1 | 20 | 1 | |
| Employment Status | Employed | 0 | 14 | 0 | $X^2$ (2, 26) = 2.53, *p=0.28* |
| | Unemployed | 1 | 10 | 1 | |
| Household Income Classification | B40 | 0 | 8 | 0 | $X^2$ (4, 26) = 1.59, *p=0.81* |
| | M40 | 1 | 13 | 1 | |
| | T20 | 0 | 3 | 0 | |

On the contrary, the happiness level and employment status show a significant association ($p<0.05$).

However, household income classification has no impact with $p>0.05$ on parents of physically disabled children's happiness level (Table 4). Furthermore, the relationship between the Perceived Stress Scale and Subjective Happiness Scale score was also analysed using the Pearson correlation test, showing significant results ($r=-0.51$, $p< 0.05$). From these results, we can conclude that stress and happiness were negatively associated; the lesser the stress, the happier the participants were.

The two-way repeated measures ANOVA analysis on the effect of 6 weeks of moderate-intensity exercise (Table 5) showed that the 6-week moderate intensity exercise have significant effects (F (1,12) =9.501, $p$=0.02, $\eta_p^2$=0.38) where p<0.05 on the Perceived Stress Scale score among the participants. Furthermore, the effect size of $\eta_p^2$=0.38 showed that moderate-intensity exercise greatly affects practical significance.

**Table 4: The association between gender, employment status and household income classification with happiness level among the participants**

| Variables | | Less Happy | Happier | $X^2$ |
|---|---|---|---|---|
| Gender | Male | 4 | 0 | $X^2$ (1, 26) = 0.86, *p=0.35* |
| | Female | 18 | 4 | |
| Employment Status | Employed | 10 | 4 | $X^2$ (1, 26) = 4.05, *p=0.04** |
| | Unemployed | 12 | 0 | |
| Household Income Classification | B40 | 8 | 0 | $X^2$ (2, 26) = 2.44, *p=0.29* |
| | M40 | 12 | 3 | |
| | T20 | 2 | 1 | |

**Table 5: The effect of the 6-week moderate intensity exercise on Perceived Stress Scale score among control and intervention group**

| | F | Sig. ($p$) | Partial Eta Squared ($\eta_p^2$) |
|---|---|---|---|
| Between 6 weeks × group | 7.19 | 0.02* | 0.38 |
| Between 6 weeks | 9.50 | 0.01* | 0.44 |
| Between-group | 3.26 | 0.09 | 0.21 |

The estimated marginal mean of the Perceived Stress Scale score for the pre-test and post-test between control and intervention groups is shown in Figure 1. Based on the figure, the intervention group significantly reduced the estimated marginal means of Perceived Stress Scale score after 6 weeks of a moderate exercise intensity program compared to the control group. In contrast, there was no significant difference in Subjective Happiness Scale score among the control and intervention groups after 6 weeks of moderate-intensity exercise (F (1,12) =1.43, p=0.26, $\eta_p^2$=0.06) where $p$>0.05.

## DISCUSSION

From this study, we found that employment status has a significant association with parents' happiness levels. This finding is similar to another study conducted by Gagat-Matula (2021). It shows that employed parents with a better financial status have a better quality of life and satisfaction since they have the economic freedom to bring their children for medical and rehabilitation treatment without hesitation, making them happy and satisfied.

Since parents of physically disabled children are financially burdened, those employed can utilize their earnings to better provide for their children's needs, such as better treatment, medications, or rehabilitation programs. In contrast, for unemployed parents, financial restriction limits the capabilities of providing

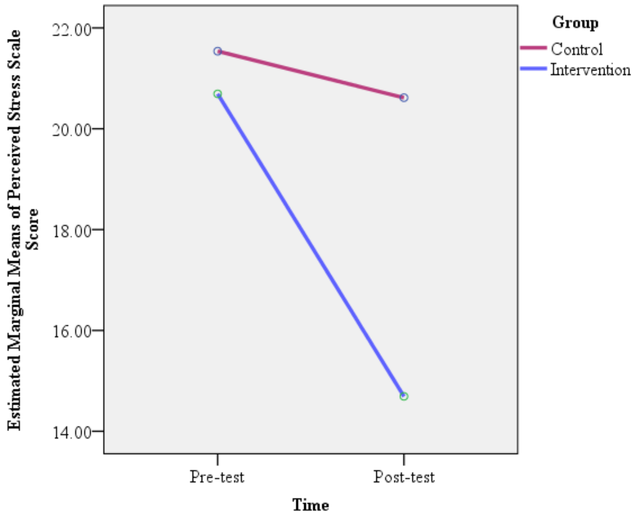


**Figure 1: Estimated marginal mean of Perceived Stress Scale score for pre-test and post-test for the control and intervention group. The symbol asterisk (*) represents significant values with p<0.05.**

extra intervention programs in helping their disabled children obtain better treatment and lifestyle. Also, employed parents have a better social lifestyle than unemployed parents, who work daily and can eliminate stress by communicating with colleagues or friends (Sheikh et al. 2018). At the same time, the burdened feeling of having to take care of disabled children can be minimized through interaction and socializing with friends at work.

On the other hand, unemployed parents live almost daily with their disabled children, which could lead to tiredness, loss of focus, and lack of socializing as they are compulsory to care for the children's necessities. Simultaneously, these unemployed parents are limited in socializing and interacting with other people as their focus is on the children's wellbeing (Sheikh et al. 2018). This limitation may lead to the accumulation of stress as they face hardship in expressing their emotions and are burdened since communication and socializing are at minimum levels, eventually leading to unhappiness. Hence, these situations explain the happiness level based on the employment status criteria.

Throughout the observation in this study, the moderate intensity exercise has shown a significant effect on the stress level of parents with physically disabled children. The goal of these exercises prescribed to parents is to help improve their life by reducing their stress levels. Like other study findings, exercise was also proven to be a way to release stress. Doing exercise eliminates the negativity and toxic emotions which normally contribute to high stress as physical activity positively impacts cognitive- emotional processes, such as mood, rumination, concentration, social experiences, tiredness, and physical strength (Brand et al., 2018). Physical inactivity or insufficient physical activity is linked to high levels of psychological anguish (Štefan et al., 2018). Another study has also established that adhering to physical activity requirements is connected to lower levels of psychological stress (Ramírez-Muñoz et al., 2016). Regular moderate physical activity, on the other hand, is recommended as a non-pharmacological countermeasure in increasing people's quality of life (Piercy et al., 2018), reducing psychological distress (Elkington et al., 2017), and promoting vitality (Liao et al., 2015).

On top of that, the moderate-intensity exercises prescribed to the intervention group in this study also help improve the parents' muscle strength and endurance in handling physically disabled children. This kind of exercise helps enhance endurance and properly used muscle when taking care of their disabled children, which in a way, lessens the stress level among parents. The exercises prescribed in this study are active free exercises using body weight without any external weight or equipment. The exercises chosen involve simple movement that interacts with muscle strength and balance and enhances cardio endurance. The movement integrates the limb's movement, involving the upper and lower limbs. The upper limb exercise focused on side-to-side and overhead movement. It helps normalize and activate all upper limb muscles while improving the upper limb strength and endurance to make it easier for the parents to lift and transfer their children in performing daily living activities. Conversely, the lower limb movement goals are to improve leg strength and endurance with an exercise utilizing squat, jumping, and kicking activities. This movement is vital in parents' daily life to take care of their physically disabled children, such as during bathing, they need to carry the children and squat down to bathe them, and then they need to carry and lift the children back to bed for dressing and so on.

Adults are encouraged to perform moderate-intensity physical activity for at least 150 minutes or vigorous-intensity physical activity for at least 75 minutes weekly. However, parents of physically disabled children have limited time as they devote most of their time to handling the children. Hence, the exercises prescribed for intervention group participants in this study are tailored to their time limit. This minimum of 6 minutes and a maximum of 18 minutes of exercise twice a week significantly reduces their stress level. It is similar to another study that found that those who engage in simple exercise, as little as 15 minutes of moderate-intensity exercise, have health benefits and have about half the perceived stress compared to those who do not exercise (Crush, Frith, & Loprinzi, 2018). It shows that moderate exercise, particularly aerobic activity, to reduced levels of stress perception (Felez-Nobrega et al., 2020). Füzéki, Groneberg, and Banzer (2020) elaborated that those who exercise two or three times a week had less stress than those who exercise less frequently or do not exercise at all. Nonetheless, it was discovered that physical activities play a substantial role in reducing hassles, as seen by decreased levels of hassles and increased physical activity (Nguyen-Michel et al., 2016). This study also observed no significant impacts of 6 weeks moderate intensity exercise on happiness levels. When compared to inactive people, happiness was found to be positively associated with physical activity volume. Increased physical activity volume was linked to a higher sense of happiness. Although the impact is minor, engaging in any form of vocational or recreational physical activity positively impacts happiness (Richards et al., 2015). A happier individual appears to exercise daily and regularly (Piqueras et al., 2011). Physical activity has been shown to benefit people's mental health by increasing the output of neurotransmitters like endorphins and serotonin. These neurotransmitters aid in reducing stress and enhancing sleep quality, hence enhancing overall quality of life and wellbeing. As a result, regular moderate intensity physical activity has been found to be an effective technique for lowering depression and enhancing happiness. However, in study, there are no significant effects observed were probably due to differences seen in the descriptive analysis (Table 2) among parents in control and intervention group.

The mean parent's age in the control group is younger, which is 35.23 years, compared to the intervention group, 40.23 years old. In conjunction with it, a recent study shows that young parents are happier as they are physically and mentally strong. They are not so much affected by the physical demands of taking the children (Westerståhl et al., 2018). Furthermore, the mean children's age for the control group is also younger, which is 5.88 years, compared to the intervention group, which is 8.68 years. It is known that taking care older physically disable children are more complicated and challenging compared to younger kids, mainly in terms of their weight and physical demand needed for the parents (Cho & Hong, 2013; Devi et al., 2019). Younger kids are lighter, making it easier and less exhausting for parents to handle them compared to older kids, who are heavier.

In practical application, referring to this study, it is recommended that parents with physically disabled children spare their time occasionally to do short bout moderate intensity exercise two times a week to reduce their stress level while improving their quality of life. A few recommendations could be prepared for future studies involving the measurement of stress and happiness level among parents of physically disabled children. The recommendations are to increase the number of weeks of exercise and the number of participants. These approaches could provide a better understanding of and effect of exercise on stress and happiness level. Another suggested approach is to conduct face-to-face physical exercise. A clear-cut explanation of the effect of exercise intensity on the stress and happiness level among parents of physically disabled children can be achieved and elucidated adequately with face-to-face approaches, and a comparison can be made with the online approaches. Lastly, exploiting the sociodemographic variables by adding more variables such as type of work, residence area, education status, etc is also recommended. This could provide a better and more conclusive understanding of exercise intensity's effect on the stress and happiness level among parents of physically disabled children.

## CONCLUSION

Throughout this study, we evaluate and construe moderate intensity physical exercise effectiveness on stress and happiness level among parents of physically disabled children via different instruments, namely the Sociodemographic questionnaire, Perceived Stress Scale and Subjective Happiness Scale. Altogether, we can conclude that simple exercise without any equipment and used for a short time, not more than 20 minutes twice weekly, does have a significant and practical effect on parents of physically disabled children. Hence, it is necessary to let parents understand they must spare a little time for themselves doing simple, moderate intensity activities to reduce their stress levels and improve their quality of life.


## ACKNOWLEDGEMENT

The ethical approval for this study was given by the University of Malaya Research Ethics Committee (UMREC). The authors would like to acknowledge WeCare Journey and the participants in this study for their contribution in obtaining the fitness data.


## CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.


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**ORIGINAL ARTICLE**

# The Effectiveness of Feldenkrais Exercise on Dynamic Balance and Risk of Fall among Older People in Indonesia

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## ABSTRACT

**Background:** Older people refers to those who have experienced physiological changes due to the aging process. The overall physiological changes associated with aging lead to changes in body system. These changes lead to an increased problem in the older people, such as balance problems that leads to the risk of falls. Prevalence of the older people suffering from diseases that lead to the risk of falls has increased from 25% to 35% overtime. Unaddressed risk factors for falls lead to recurrent falls and poor quality of life. Effective multifactorial fall prevention programs in the primary care setting may be a promising approach to reduce incidence rate of falls. One of the interventions to address falls for the older people is Feldenkrais Exercise. The objective of this study was to investigate the effect of Feldenkrais Exercise on the dynamic balance and the risk of falling among the population. **Methods:** This research was a one group, pre-post-test study. A convenience sample of 25 community dwelling older adults was recruited in this study. The participants attended 5-week Feldenkrais Programs, consisting 60 minutes of Feldenkrais Exercise for three times per week. Time Up and Go Test (TUG) was used to measure the Dynamic Balance and Morse Falls Scale (MFS) was used to measure the Risk of Falls of the participants. Paired T-test were used to analyze the data. **Results:** After completion of the programs, dynamic balance (p = 0,001) and risk of falls (p=0,001) decreased, indicating that Feldenkrais Exercise is effective to be used to prevent falls among the older people. **Conclusion:** The results of this study support the hypothesis that Feldenkrais Exercise positively influence dynamic balance and the risk of falling among the older people. Feldenkrais Exercise can make up part of the rehabilitation program to prevent the decline of dynamic balance and reduce the incidence rate of falls among this population.

**Keywords:** Older people; Dynamic balance; Falls risk; Feldenkrais exercise; Time Up and Go Test; Morse Falls Scale

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## INTRODUCTION

An older people can be described as someone who has entered the age of 60 years and over (Yuliadarwati 2020). The populations experience a decrease in muscle strength and coordination that leads to decrease in balance. More than 30% of older people aged 65 years and over experience falls at least once a year (Thomas et al. 2019). In 2018, incidence of falls among this population in Indonesia is 67.1% in the age group of 65-74 years old and increase to 78.2% at the age 75 years (Riskesdas 2018). In 2020, the percentage of falls among the older people has increased by 25% to 35% followed by the decline in function among this population, which eventually can lead to the balance disorders and further increased risk of falls (Dewi et al. 2021; Rohima et al. 2020).

Balance is required to maintain body position, respond to movement, and react to changes in body position so that the body remains stable (Osoba et al. 2019). Balance occurs when the vestibular, visual, and proprioceptive are stimulated (Agrawal et al. 2020). The input from sensory systems is integrated by the cerebellum, cerebral cortex, and brainstem (Picard-Deland et al. 2022).Then the input that has been processed is realized by the output motor which consists of vestibulo-ocular reflexes and motor impulses ((Ellithy et al. 2020).

In general, older people experience a decrease in three sensory systems which results in the misinformation being passed on to the brain, resulting in balance disorders (Kiik 2018). The decreasing proprioception among the older people causes coordination and balance problems that result in a higher risk of falling (Ferlinc et al. 2019). They also experience a decrease in muscle strength, muscle flexibility, muscle elasticity, decreased reaction time and relaxation and decreased functional performance (Kurnia 2019).

There are several comprehensive rehabilitation options to improve balance and reduce risk of falling in older people. Sweeting (2020), suggested several exercises for balance, which are Feldenkrais Exercise, Tango Dance Exercise, Tai Chi, and Alexander Technique Exercise. Wijayanti (2017) stated that Feldenkrais exercise produced good result in dynamic balance and decrease the risk of falling in older people with Osteoarthritis. Feldenkrais exercise provide the learning and stimulation to sensing and thinking that can improve the body function.

Research conducted by Teixeira-Machado (2017) showed that, Feldenkrais exercise improves static and dynamic balance and reduce the duration of Time Up and Go test in patients with Parkinson's disease. Feldenkrais Exercise is reported to be able to improve balance in Cerebral Palsy patients too, by relaxing the lower leg muscles, controlling abnormal reflexes, correcting posture and gait (Panova et al. 2017). Increase body awareness and able to move comfortably was also reported as an effect of Feldenkrais Exercise in patients with mobility problems (Palmer 2017). There are a few studies related to Feldenkrais Exercise on balance and the risk of falling among the older people. This study was aimed to determine the effectiveness of a 5-week Feldenkrais Exercise on dynamic balance and the risk of falling among the Indonesian older people.

## METHODS

This study was approved by the Human Research Ethics Committees at the Medical Faculty, University of Muhammadiyah Malang, Protocol Number E.5.a/ 045/ KPEK-UMM/ III/ 2023.

The participants in this study were a sample of convenience drawn from community dwelling older adults, who had enrolled to this research at the Tresna Werdha Jombang Social Services. The inclusion criteria are patients aged over 65 years old, positive sign of balance disorder confirming by Time Up and Go Test (TUG), did not have impaired cognitive function confirming by the Montreal Cognitive Assessment (MoCA), and shown willingness to participate in the study. All participants provided informed consent. Those currently experiencing fractures and severe injuries, using assistive devices (walkers, wheelchairs and crutches), are attached to an IV-line, are in a bedrest condition, and having depression or anxiety were excluded from the study.

The selected participants were assessed on dynamic balance using Time up and Go test (TUG) and risk of falls using Morse Falls Scale (MFS) measures prior to starting the intervention and at the completion of the program.

The Feldenkrais exercise were carried out 3 times a week for 5 weeks with a duration of 35-45 minutes. Movements in Feldenkrais training included: (1) Ankle and foot flexion; (2) Crossing leg and arm; (3) Standing balance; (4) Weight bearing; (5) One Leg Standing; (6) Stand from Chair; (7) Tandem Walking; (8) Sitting and lean forward; (9) Sitting with lateral trunk rotation; (10) Sitting with lateral cervical flexion; (11), Sitting with lean to the side; (12) Supine with knee flexion.

There were three physical therapists who were called for assist in this study, namely: (1) an examiner, in charge of overall assessments for the participants; (2) the assessor in charge to measure all the outcome measures at the pre and post intervention phases; and (3) a physical therapist who was trained for the Feldenkrais Exercise, in charge to conduct the intervention on the participants.

Descriptive statistics were used to analyse all outcome measure scores. The normality test used was the Shapiro Wilk test for both TUG and MFS. Parametric tests were used for dynamic balance by TUG, while non-parametric test was used for MFS as the data were not normally distributed. To evaluate the effect of Feldenkrais exercise for the normally distributed data of dynamic balance by TUG, the Paired T test was used to compare the pre and post intervention values. Meanwhile, Wilcoxon sign rank test was used to evaluate the effect of the Feldenkrais exercise on Risk of Falls by MFS as the data is not-normally distributed. The statistics level was set at p-value < 0,05.

## RESULTS

A total of 25 participants were screened for eligibility at the Tresna Werdha Elderly Community Social Service Jombang. There were two participants who excluded due to not fulfilling the inclusion criteria. Eventually, a total of 23 participants who were eligible participated in the research and signed letter of informed consent. All participants were measured at baseline and post-intervention.

The demographic data and baseline are shown in Table 1: the mean age of the participants is 70.9 years old; BMI = 23,35 kg/m$^2$; TUG = 28,34 second; and MFS = 44,34 points.

**Table 1: Demography of the participants**

| Characteristics (N=23) | Mean | (SD) |
|---|---|---|
| Gender (female/male) | 18/5 | - |
| Age (years) | 70.9 | (8.16) |
| BMI (kg/m$^2$) | 23.3 | (2.75) |
| TUG (second) | 28.34 | (3.05) |
| MFS | 44.34 | (9.45) |

**Table 2: Comparisons of the dynamic balance by TUG within group**

| Measurement Period | Time Up and Go Test (N=23) | | p-value |
|---|---|---|---|
| | Mean | (SD) | |
| Pre-Test | 28.34 | (3.05) | 0.001 |
| Post Test | 23.22 | (3.24) | |

**Table 3: Comparisons of the risk of falls by MFS within group**

| Measurement Period | Morse Falls Scale (N=23) | | p-value |
|---|---|---|---|
| | Mean | (SD) | |
| Pre-Test | 44.34 | (9.45) | 0.001 |
| Post Test | 33.69 | (10.57) | |

Table 2 shows the TUG results. The paired T-Test was used to analyze data for TUG to test the difference between pre and post-test scores. It was found statistically significant (p=0.001). That proves the effectiveness of Feldenkrais Exercise on dynamic balance on the older people.

The Wilcoxon signed rank test was used to analysed data for Morse Falls Scale to test the difference between pre and post-test scores. It was found statistically significant (p=0.001) (Table 3), which proves the effectiveness of Feldenkrais Exercise on the risk of falling among the older people.

## DISCUSSION

As mentioned, this study was aimed to determine the effectiveness of Feldenkrais Exercise on dynamic balance and the risk of falling among the older people.

A total of 23 participants with average age of 65 – 70 years old in the study experience balance disorders indicated by TUG score above 15 seconds. Literature reported that at the age of 65, older people was found to experience a reduction of functional ability, both physically and psychologically (Rahman et al. 2022). Due to aging process, older persons commonly experience physiological changes that affect their daily activity, such as changes in body organs, skin and facial appearance, changes in neurological, sensory system and musculoskeletal system changes, instability and increase risk of fall (Mustafa et al. 2022). The results of this study are in line with findings of the research which reported that there are 28 – 35% of older people having balance problem at the age of 60 and this increased to 32 – 42% at the age of 70 years old (Pramadita et al. 2019). Another study reported that many older people experience falls due to loss of balance which accounted to 49.4% at the age over 55 years old, and 67.1% at the age over 65 years old and these increased by 25% to 35% at the age of 70 – 75 years old (Rohima et al. 2020).

Balance is a complex process of the 3 integrated sensory systems are: visual, vestibular, and proprioceptive as well as musculoskeletal which linked by the brain as the body's response to maintaining balance (Mekayanti et al. 2015). Balance is also a process in which the body tried to maintain their position whether the circumstance is changing, from static to dynamic to the standing or ambulation (Yuliadarwati et al. 2020).

Feldenkrais Exercise is reported able to increase body awareness by providing stimulation to the senses, movements, feelings, and thought to reach the goal of maintaining the body position (Kang et al. 2022). The sequence of movement provide by the Feldenkrais exercise can improve balance by changing habits or correct the posture and the movement as to provide the body positions while doing daily activity (Jones et al. 2022). The Feldenkrais exercise is normally executed in a various of position and movement such as sitting, standing position as well as moving around and shifting weigh while sitting and standing. The movement in Feldenkrais Exercise is able to control body posture by controlling the pelvis which supports the body in various position, controlling movements in the torso and ankle, and increasing body awareness. Foot contact with the floor or the surface and the attention of the person to which body parts are involved in a movement can build confidence in improving the balance (Galea, Connors & Said 2011).

Further, Feldenkrais exercise also improves dynamic control related to gait and locomotion. This is obtained by activating the muscle when stepping which includes the muscle around hip, knee, ankle, and postural muscles (erector spinae muscle and rectus abdominis muscles) (Faidah et al 2020). Feldenkrais exercise provides benefits in the form of adaptation to increase stride length and decreasing stride width, increase walking speed and increase muscle strength (Frederic & Al Haris 2022). This current study found positive changes of TUG score indicating improved dynamic balance following the exercise intervention further support these benefits of Feldenkrais for older people.

Feldenkrais Exercise is also reported to improve motor control, speed and visual scanning speed in the older people (Ullmann & Williams 2016). Besides, there is an increase in proprioception by emphasizing sensory information during the movement. Remarkably, this can increase the sensitivity of perception and perceptual motor skills, hence, it will be easier for the body to adjust to any movements (Mattes, 2016). A dynamic postural response will be achieved when doing Feldenkrais exercises, the linear acceleration of the body will be detected by the macula utriculus sensory organ which plays an important role in determining the orientation of the head when in an upright position. In the macula utriculus there are many like a hair cell that heir synapse connected with the sensory endings of the vestibular nerve. Next, appropriate signals are sent via the vestibular nerve to the vestibular nuclei to the brainstem for processing the signals. The brainstem transmits strong excitation signals to the antigravity muscles via the medial and lateral vestibulospinal tracts in the anterior columns of the spinal cords (Gyuton & Hall 2013). The body will respond by activating the antigravity muscles by providing movement feedback in the form of correction or protection the body due to a disturbance or change in the surface or base of support in maintaining body balance (Mujiadi & Mawaddah 2019). These mechanisms explain the reduction of falls risk (MFS scores lowered by 10 units) among the older people following Feldenkrais exercise in this study.

Older people will experience degeneration that may lead to changes in the body, one of them is the changes musculoskeletal systems (Pringgadani et al. 2022). These changes result in weakness of the muscles, short steps, and unsteady standing (Nisa et al. 2019). Feldenkrais Exercise can increase body awareness in order to improve the sequence of movements by providing feedback in the form of balance, optimizing perception, improving coordination, and increase muscle strength (Kampe 2010). Previous study believed Feldenkrais Exercise can improve physical fitness and muscle strength, as well as reduce the risk of falling as to increase the independence of the elderly in doing their daily activities (Shalahuddin (2022).

In addition, Feldenkrais Exercise is able to increase awareness and comfort in moving. This was revealed in research by Palmer (2017). In a study conducted by Kalron (2017), there was an increase in balance and a reduction in duration when measured by the Time Up and Go Test. Hillier & Worley (2015) also concluded that Feldenkrais Exercise is good for the older people. In research conducted by Yuliadarwati (2021) it was shown that Feldenkrais Exercise is able to reduce the level of risk of falling on the elderly. In Sangam's study (2015) Feldenkrais Exercise was reported to be able to maintain body stability so that it could reduce the risk of falling on the elderly. Research conducted by Berland (2022) shows that there is an effect of Feldenkrais Exercise on the risk of falling.

Feldenkrais Exercise is highly recommended for older people because it is an exercise to increase awareness of body movements to the fullest but with minimal effort (Mohan et al. 2016). Minimal power produces resistance where the body's metabolism needs to work less so as to produce optimal energy to perform a movement efficiently by optimizing coordination, muscle strength, balance, and efficient time (Henry et al. 2016). Movement in Feldenkrais Exercise improves balance by changing habits or movement postures to stay balanced so as to provide ease in. daily activities (Wallman-Jones et al. 2022). This mechanism is much needed in the older people.

## CONCLUSION

Based on this study findings, it can be concluded that a 5-weeks intervention of Feldenkrais Exercise, significantly improves dynamic balance as measured by TUG and Risk of Falls as measured by MFS among older people.

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## CONFLICT OF INTEREST

No conflict of interest.

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**ORIGINAL ARTICLE**

# Effect of Plyometric Training Versus Resistance Training on Physical Performance in Detrained Athletes

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## ABSTRACT

**Background:** Detraining is cessation of training activity, which leads to considerable loss in players performance. Due to cessation of training, both recreational and competitive players underwent detraining such as reduced vertical jump capacity, dynamic balance in game, and sprinting capacity. Therefore, retraining with a suitable training procedure is essential for players. This study analyzes the training procedure which is suitable for detrained athletes. The need for the study is limited resources only found in the detrained athletes performance enhancement. The aim of the study is to find the effect of plyometric training and resistance training on the detrained athlete and to compare both plyometric training and resistance training on detrained athlete. **Method:** This study was pre-test post-test experimental study design; a total of 30 subjects were selected randomly in this study. They were divided into group A and group B, in which plyometric training and resistance training were given respectively. The total study duration was 6 months, with total training duration of 8 weeks. For both the groups, pre and post-test was taken for y-balance test, vertical jump test and 30 m sprint test. Paired t test and unpaired t test were used as a statistical tool for the within group analysis and between group analysis respectively. **Results:** There is a significant difference between group A and group B in y-balance test, vertical jump test and 30-M sprint test after the training. Group A shows clinical significance more than Group B in all post-test mean values, with the p value < 0.05. **Conclusion:** Plyometric training shows a significant improvement over resistance training on physical performance in detrained athletes.

**Keywords:** Plyometric training; Resistance training; Speed; Dynamic balance; Explosive strength; Detrained athlete

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## INTRODUCTION

In the modern era, physical activities themselves are becoming a treatment for a lot of people. Obesity, diabetes mellitus, hypertension and cardiac problems are becoming more prevalent in the current society (John et al., 2018). Sports play an important role in contemporary society worldwide. The enthusiasm created by sports makes people mobile and creates awareness about physical activity. In that perspective, athletics is enjoyed by people from young age to old age. Athletics is often used synonymously with any sporting activity. Physical sports and games of any kind are known as athletics, which involves running, jumping, and throwing kind of activities.

The cessation of activities obviously gives an adverse effect on our body mechanism which influences the performance of an athlete. Mujika and Padilla (2000) have stated that “partial or complete loss of training induced anatomical, physiological, and performance adaptation”.

Recently, Muriel and co-researchers (2020) were the first to quantify objective measures of training load during the COVID – 19 lockdown period in elite cyclists. The authors noted 34% reductions in total training volume and reductions in weekly volumes in intensity zones ranging from 25 to 52% (effect size: 0.83 to 1.57) during the lockdown period, which contributed to reductions in maximum effort cycling performance.

The training interventions help in improving the physical performance in athletes who are detrained. Physical performances are anonymously referred to as speed, endurance, explosive strength, balance and agility.

Resistance training is known as the use of resistance to build muscular strength and size of the skeletal muscle. Researchers have proposed that resistance training intervention in youth population results in significant increase in strength, power and agility and reduced injury risk (Harries et al., 2012 and Lesinski et al., 2016.)

Plyometric training often requires athletes to jump, hop, bound or skip, which leads to concentric and eccentric kind of contraction on muscles. Plyometric drills usually involve stopping, starting, and changing direction in explosive manner (Gabbett, 2000). Sale in 1991 had stated that Plyometric training induces specific neural adaptations which are helpful in doing better physical performance.

Speed can be easily defined as the rate at which the object covers the distance. For an athlete to have a top speed for the explosive first step and to accelerate rapidly, it is required that the athlete have a maximum speed. Furthermore, Triplet et al. (2012) showed that most sports do involve running at maximum speed and could help improve athletic performance. Thus, speed is an important factor for any athlete to compete in.

Explosive strength refers to the ability to exert a maximum amount of force in the shortest possible time, which is very much needed for an athlete to compete in any kind of game to give a quick threshold to achieve something. As Louis Simmons stated on numerous occasions, "even a marathon runner needs to sprint to the finish line".

Balance ability was related to the level of competition in some sports with the more proficient athletes showing greater balance ability. There were significant relationships between balance ability and several performance measures. Therefore, improving balance is also considered a very important measure of physical performance which is needful for prevention of the injury and creates a good competitive environment in games. The purpose of the study is to determine the effect of Plyometric training versus Resistance training on physical performance in detrained athletes.

The aim of the study was to determine the effect of plyometric training versus resistance training on physical performance in detrained athletes.

## METHODS

KG Institutional ethical committee approval and individual consent were obtained as per ethical guidelines. The design of this study was pre-test and post-test experimental study, and randomized sampling method was used. This study was carried out at the K.G campus sports ground and therapeutic gymnasium. This study duration was 8 weeks. Subjects were selected based on inclusion and exclusion criteria. The inclusion criteria are; the players should be athletes who were not in the training or playing environment for the past 8 months; healthy active athletes who have been participating in any track and game events for a minimum period of 1 year before detraining; athletes who play at least 3 competitive games a year and used to practice or play the game for a minimum of thrice a week; male players, at the age group of 18-25 years; body mass index (BMI) of 18.5-24.9. The exclusion criteria are; subjects who are going for a gymnasium or any other training program; subjects with any musculoskeletal and neurological abnormalities; and subjects who are not willing to participate in the study. A total of 30 eligible subjects were allocated randomly into group A and group B. This sample size met the requirement of a pilot study.

Training was given accordingly with plyometric training for group A and resistance training for group B. Vertical jump, y-balance and 30-meter sprint tests were used as outcome measures in this study (Paulo et al., 2012; Bulow A et al., 2019; Nigro F et al., 2016). Before the training program, all three outcome measures and demographic data were documented. Players in group A underwent plyometric training. Before the training session, each player was advised to do warm-ups and stretching. The Plyometric training was given to the subjects, based on the study described by Hamami et al., (2016). The training was basically one-hour session per day, 3 days weekly. Meanwhile, subjects in group B were advised to do proper stretching before training. Resistance training was given to the subjects based on one repetition maximum and one-hour session of training on a single day, 3 days per week. Resistance training was given to the subjects based on study described scientifically by Eskandar Taheri et al. (2014). Each exercise was performed for 6 repetitions and 4 sets only; the exercises using weights were done at 60% intensity of one RM. After each two weeks, the intensity was increased by 10% of one RM, in which some weights were added. Both groups continued the training for 8 weeks.

Paired T-test was used for within-group analysis and unpaired T-test was used for the between-group analysis.

## RESULTS

Table 1 implies the demographic data of the male athletes.

**Table 1: Demographic data**

| Variables | Grouping | n | % |
|---|---|---|---|
| Age (years) | 18-21 | 22 | 73 |
| | 22-25 | 8 | 27 |
| BMI | 18.5- 21.5 | 20 | 66.66 |
| | 21.6-24.9 | 10 | 33.33 |

Table 1 shows the mean value of Group A and Group B post-test analysis of vertical jump test, y-balance test, and 30-meter sprint test respectively. For the vertical jump test, post-test values of Group A and Group B are 48.06 and 39.46, respectively, t is 5.78, which is significant at $p<0.05$, Therefore, there is a significant difference between group A and group B. For the Y balance, Group A post-test mean is 98.06 and group B post-test mean is 92.6, the t test value is 4.65, which is significant at $p<0.05$. Therefore, there is a significant difference between group A and group B. For the 30-

meter sprint test, the post-test mean of group A is 4.34 and group B posttest mean is 5.42, the value of t value is 10.04, which is significant at $p<0.05$, indicating a significant difference between group A and group B. Group A shows clinical significance compared to group B in all three outcome measures.

Figure 1 shows the post-test mean values of Group A and Group B for the vertical jump test, Y balance test and 30- meter sprint test.

**Table 2: Post-test mean values of outcome measures for the Group A and Group B**

| Variables | Post-test means | | 't' values | P value |
|---|---|---|---|---|
| | Group A | Group B | | |
| Vertical jump test | 48.6 | 39.7 | 5.78 | |
| Y balance test | 98.6 | 92.6 | 4.65 | 0.01* |
| 30-meters sprint test | 4.54 | 5.81 | 10.04 | |

*significant at $p \leq 0.05$

Figure 1 illustrates the difference between Group A and Group B in all the three measures.

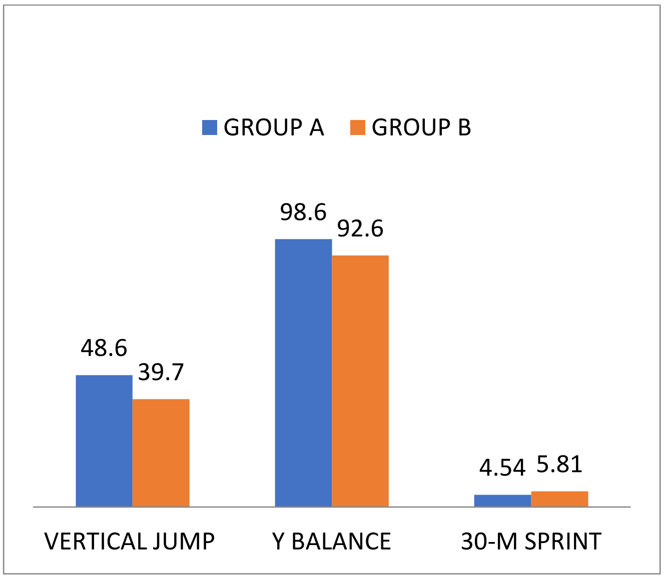


**Figure 1: Post-tests mean difference between Group A and Group B**

## DISCUSSION

The purpose of the study is to determine the effect of plyometric training and resistance training on physical performance in detrained athletes. Detraining results in a decrease in fatty acid oxidation capacity in muscle, liver and adipose tissue, and increased body weight and fat mass. Furthermore, detraining reduces muscle capillary blood flow by reducing function, and negatively affects intramuscular energy metabolism (Laye et al., 2009). Resistance training found to improve physical performance in the athletes in this study. This improvement is due to the stimulations of mainly the anti-gravity or extensor muscles of the athlete. Apart from increasing power, other factors such as muscle length and temperature, body shape, and flexibility also should be noted in speedy performances (Haghighi et al., 2012; Negra et al; 2017). However, greater percentage of improvement was found in plyometric training compared to resistance training. Plyometric training shows better results in physical performance, because the training affects muscle spindles, Golgi-tendon, tendons, joints, balance and body positions control and this led to explosive strength improvement in these athletes (Bal et al., 2011).

This study is subjected to a few limitations. The small size of samples results in the study findings not able to be generalised. Therefore, the findings need to be used with caution. The study also involved male athletes only; therefore, does not represent all detrained athletes.

## CONCLUSION

Detraining is the process to lose the performance which was previously gained. Therefore, there is a need for suitable retraining program to meet the demands and restore the earlier performance. This study concludes that plyometric training improves the physical performance of the detrained athletes more than resistance training. Further studies with larger samples are needed to confirm this study findings.


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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## FUNDING

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**ORIGINAL ARTICLE**

# Association of Body Mass Index with Self-Esteem and Social Appearance Anxiety among University Students: A Cross-Sectional Study

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## ABSTRACT

**Background:** Many studies reported that obesity not only influences self-esteem but social appearance anxiety as well. Distortions of self-perceived body image can be seen in teenagers starting from the age of 15 and are often carried into their university years. Therefore, this study was aimed to determine the relationship between body mass index with self-esteem and social appearance anxiety among the university students. **Methods:** A total of 183 university students (mean age ± SD = 21. 02 ± 1.37 years) participated in this cross-sectional study. An online questionnaire consisting of demographic questions, questions on self-esteem, and the social appearance anxiety scale was used to collect the data. All the data were analysed descriptively and using Chi Square test. **Results:** The results demonstrated no significant association between body mass index and self-esteem ($p>0.05$), and body mass index and social appearance anxiety ($p>0.05$). However, there is a significant association between self-esteem and social appearance anxiety among the respondents, based on Chi Square test analysis ($p < 0.05$). The results also showed an inverse relationship between self-esteem and social appearance anxiety such that students with low self-esteem could have high social appearance anxiety and vice versa. **Conclusion:** This study found that self-esteem is significantly associated with social appearance anxiety among university students. Therefore, it is important for the university management to address the psychological health issues of students, such as low self-esteem and social appearance anxiety, as these may not only affect academic adjustment but may be a risk factor of other psychosocial problems.

**Keywords:** Body mass index, self-esteem, social appearance anxiety, university students

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## INTRODUCTION

The increasing prevalence of obesity in Malaysia can be attributed to the progressively increasing availability of food calorie intake per capita in Malaysia and the decrease of physical activity per capita in the wake of urbanisation (Lee & Wan Muda 2019). The Malaysian government's response to address this issue was to implement awareness programmes and emphasise the role of every individual to bear the responsibility in maintaining their own health. However, there has not been a single systematic evaluation of the success of these implemented strategies and therefore no evidence of success was reported (Davey et al. 2013).

Apart from the association of obesity with increased risk of mortality and comorbidities such as diabetes mellitus, hypertension, coronary heart disease and other conditions (Wilborn et al. 2005); mental illness has also been associated with obesity in which case obese individuals have a 30-70% increased risk of developing a mental illness (De Hert et al. 2011). It is unquestionable that university students are exposed to increased levels of stress throughout their study and long-term stress levels contribute to increased cortisol levels. Long term cortisol levels have been associated with almost 10 times increased risk of developing obesity (van der Valk, Savas & van Rossum 2018).

Obese college students report a range of social and emotional problems including stigmatisation, depression, and altered academic achievements (Desai et al. 2008). Obesity is associated with marked lower overall academic achievement, higher depressive symptoms and use of diet pills (Odlaug et al. 2015). The researchers reported that obese university male students had significantly high rates of Trichotillomania while obese female students reported high rates of panic disorders.

There is a significant relationship between obesity and depression and many studies have found that obesity has an effect on lowering self-esteem as well as social appearance anxiety which is mainly attributed to the distorted self-perceived body image among adolescents. This distortion of self-perceived body image can be seen to start from the age of 15 and as teenagers begin tertiary education in universities this self-perceived distortion may be carried into their university years with an increased amount of pressure from peer evaluation. There is also a significant link between obesity and sex differences as females have a higher prevalence of obesity than males. University students particularly are prone to increased levels of stress which has been associated with an increased risk of developing obesity and this has been proven to be correlated with a decline in self-esteem and social appearance anxiety which results in decreased psychological adjustment and decline in academic performance. There is currently limited research among young people in metropolitan areas to give a wider grasp of the association of obesity with self-esteem and social appearance anxiety among university students. Perhaps the outcomes of this study will provide valuable insight in the development of treatment plans tailored for university students in terms of weight management, stress coping and counselling strategies.

## MATERIAL AND METHODS

### Study Design

A cross-sectional study was conducted to determine the association between Body Mass Index (BMI) with self-esteem and social appearance anxiety among university students.

### Participants

This study involved students from Universiti Tunku Abdul Rahman (UTAR). The respondents for this study were limited to students from the Sungai Long campus only. The sample size was calculated by using Krejcie-Morgan formula (1970). The convenience sampling method was used. Inclusion criteria included students of Universiti Tunku Abdul Rahman (UTAR), Sungai Long Campus pursuing a full-time or part-time course. Male and female students were recruited.

### Ethical Consideration:

The ethical approval for this study was obtained from the Scientific and Ethical Review Committee (SERC) of UTAR (U/SERC/232/2021). Informed consent was obtained from all the respondents in the online questionnaire before they could proceed to the rest of the questionnaire. Furthermore, all respondents were informed regarding their right to withdraw from the study at any moment should they decide to. Apart from this, each respondent was required to sign the Personal Data Protection Statement in the questionnaire. The confidentiality of all the personal data provided by the respondents was assured.

### Data Collection

An online questionnaire was used for the data collection. The questionnaire consisted of five sections. The first section comprised of an introduction to the study as well as explanations on the participation criteria, and a section for the informed consent of the respondent. The second section consisted of the personal data protection statement as well as the electronic signature of the respondents. The third section was solely dedicated to the demographic data of the respondents. The demographic data section requested data such as the respondents' student ID, age, gender, race, level of education and year of study. The weight (in kilograms) and height (in meters) of the respondents were also requested.

Next section of the questionnaire comprised of the Rosenberg Self-Esteem Scale. The Rosenberg Self Esteem Scale is a widely used self-reported 10-item scale used to assess the level of self-esteem in an individual. The scale is scored using a 4-point Likert scale ranging from "strongly agree" to "strongly disagree". The first, second, fourth, sixth and seventh items on the scale are scored in the manner of which 3 represents "Strongly Agree" and 0 represents "Strongly Disagree". Meanwhile the third, fifth, eighth, ninth and tenth items are reverse scored in which 0 represents "Strongly Agree" and 3 represents "Strongly Disagree". The range of scores goes from 0 which is the lowest to the highest of 30 in which any score between 15 and 25 indicate the normal range while scores below 15 indicate low self-esteem. As such, scores above 25 indicate high self-esteem.

The fifth section includes the Social Appearance Anxiety Scale. The Social Appearance Anxiety Scale developed by Hart et al. in 2008 is a 16-item scale used to assess the level of fear of overall appearance evaluation, scored using a five-point Likert scale ranging from 1 representing "Strongly Disagree" to 5 representing "Strongly Agree". While the first item is reverse scored, the other items are scored as is and the range of scores go from the lowest of 16 to the highest of 80. The higher scores indicate a higher level of social appearance anxiety among individuals.

The researchers distributed the link to the online questionnaire along with a message and a small introduction of the research to all the respondents via WhatsApp, Instagram, Microsoft Teams and Facebook Messenger.

After collecting the data, all the data was converted systematically into a Microsoft Excel document and the data were analysed using SPSS. All data collected for this study were compiled into and summarised using Microsoft Excel. The data was analysed using IBM Statistical Package for Social Sciences (SPSS) version 26.0 software. Chi square analysis and multiple regression were used to analyse the data. A p-value of $< 0.05$ was considered as statistically significant at 95% confidence interval for every statistical test conducted in this study.

## RESULTS

A total of one hundred and eighty-three university students participated in this study. Majority of the respondents were females with a 69.9% (n = 128). while 30.1% (n = 55) were males. The mean age of the respondents was 21.02 (1.37) years. The age of the respondents ranged from 18 years old to 24 years.

Majority of the respondents were Chinese (97.3%) followed by Indians with 1.6% (n = 3), Malay (n = 1) and Eurasian (n = 1) with 0.5%. Majority of the respondents came from bachelor's degree level of education with 93.4% (n = 171) followed by foundation level of education with 6.6% (n = 12). There we no respondents from the postgraduate level of education. Majority of the respondents of this study are in their Second year of study with a percentage of 26.8% (n = 49), followed by Year 3 with 26.2% (n = 48), Year 4 with 25.7% (n = 47), Year 1 with 18% (n = 33) and lastly the minority of the respondents were in their Fifth year of study with 3.3% (n = 6). Most of the respondents had a normal body mass index (BMI) with a percentage of 55.7% (n = 102), followed by underweight with 26.2% (n = 48), overweight with 11.5% (n = 21) and lastly, obese with 6.6% (n = 12). The mean score of the Rosenberg Self-Esteem Scale scores was 16.47 (3.65). The scores ranged from 7 to 26.

**Table 1: Self-esteem and Social Appearance Anxiety Scale categories of the respondents**

| Self-esteem | Frequency | Percent |
|---|---|---|
| Low self esteem | 69 | 37.7 |
| Normal | 113 | 61.7 |
| High self esteem | 1 | 0.5 |
| **Social Appearance Anxiety Scale** | **Frequency** | **Percent** |
| Low social appearance anxiety | 3 | 1.6 |
| Average social appearance anxiety | 138 | 75.4 |
| High social appearance anxiety | 42 | 23.0 |

The total scores of the respondents were categorized into low, normal, and high self-esteem categories based on the cut off scores of the Rosenberg Self-Esteem Scale where scores less than 15 represent low self-esteem, scores between 15 and 25 show normal range and scores above 25 represent high self-esteem. Based on Table 1, most of the respondents were within the normal range with 61.7% respondents (n = 113), followed by respondents with low self-esteem with a percentage of 37.7% (n = 69) and lastly the minority is those with high self-esteem with 0.5% (n = 1).

The mean score of Social Appearance Anxiety Scale is 47.07 (11.51). The respondents' scores ranged from 16 to 77. Table 1 shows the categories of the respondents based on the Social Appearance Anxiety Scale where scores lesser than 21 were categorised as low social appearance anxiety, scores between 21 and 55 were categorised as having average social appearance anxiety, and scores higher than 55 were categorised as having high social appearance anxiety.

As seen in Table 2 most of the respondents had average scores of social appearance anxiety with a percentage of 75.4% (n = 138), followed by those with high scores of social appearance anxiety with 23% (n = 42). The minority of the respondents had low scores of social appearance anxiety with only 1.6% (n = 3).

**Table 2: The Association between BMI and Self-esteem using Chi-Square Test**

| | Value | df | Asymptotic Significance (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 10.084[a] | 6 | 0.121 |
| Likelihood Ratio | 6.610 | 6 | 0.358 |
| Linear-by-Linear Association | .338 | 1 | 0.561 |
| N of Valid Cases | 183 | | |

*Note:* df = degree of freedom, level of significance = $p < 0.05$

Chi Square analysis was performed to determine the association between BMI and self-esteem of the respondents. Table 2 shows that the relationship between Body Mass Index and Self-Esteem is not statistically significant where $p > 0.05$. Therefore, there was no association between BMI and self-esteem.

**Table 3: The Association between BMI and Social Appearance Anxiety using Chi-Square Test**

| | Value | df | Asymptotic Significance (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 5.93[a] | 6 | 0.43 |
| Likelihood Ratio | 6.91 | 6 | 0.32 |
| Linear-by-Linear Association | .00 | 1 | 0.94 |
| N of Valid Cases | 18 | | |

*Note:* df = degree of freedom, level of significance = $p < 0.05$

Chi Square analysis was performed to determine the association between BMI and social appearance anxiety of the respondents. Table 3 shows that the relationship between Body Mass Index and Social Appearance Anxiety is not statistically significant where $p > 0.05$. Therefore, there was no statistically significant association between BMI and social appearance anxiety.

Chi Square analysis was performed to determine the association between self-esteem and social appearance anxiety of the respondents. Table 4 shows that the relationship between Self-Esteem and Social Appearance Anxiety is statistically significant where $p < 0.05$. Therefore, there was a statistically significant association between self-esteem and social appearance anxiety.

**Table 4: The Association between Self-esteem and Social Appearance Anxiety using Chi-Square Test**

| | Value | df | Asymptotic Significance (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 79.70[a] | 4 | 0.00 |
| Likelihood Ratio | 29.25 | 4 | 0.00 |
| Linear-by-Linear Association | 14.68 | 1 | 0.00 |
| N of Valid Cases | 183 | | |

*Note:* df = degree of freedom, level of significance = $p < 0.05$

**Table 5: The Association between BMI with Self-esteem and Social Appearance Anxiety using Multiple Regression Analysis**

| Coefficients | | | | | |
|---|---|---|---|---|---|
| | Unstandardized Coefficients | | Standardized Coefficients | | |
| | B | Std. Error | Beta | t | Sig |
| (Constant) | 51.78 | 1.63 | | 31.77 | 0.00 |
| BMI Categories | 0.86 | 0.98 | 0.06 | 0.87 | 0.38 |
| SES Categories | -8.84 | 1.59 | -0.38 | -5.53 | 0.00 |

a. Dependent Variable: Social Appearance Anxiety Scores, level of significance = $p < 0.05$

A multiple regression analysis was conducted to determine the association between BMI with self-esteem and social appearance anxiety. Table 5 shows that Self-Esteem (-0.381) was the biggest contributor to social appearance anxiety as compared to BMI (0.06). There is a significant association between self-esteem and social appearance anxiety where $p < 0.05$. Whereas the association between BMI and social appearance anxiety is not statistically significant where $p > 0.05$.

## DISCUSSION

Obesity is one of the most important public health problems in the world (Abdelaal et al. 2017). Disruptions in the way individuals perceive their body may cause eating disorders and/or obesity (Pellizzer et al. 2018). Elevated BMI negatively affects the quality of life and the emotional well-being of individuals either directly by way of causing various health problems (Herhaus et al. 2020).

A total of 183 students from UTAR, Sungai Long Campus participated in this study. Among the 183 respondents, the weight and height of the respondents were collected in kilograms and metres respectively. The individual BMI of the respondents was then calculated using the formula kg/m$^2$ using Microsoft Excel. The respondents' BMI was then categorized into four groups according to the Asian BMI classification where BMI values of <18.5 were categorized as underweight, values between 18.5 and 22.9 were categorized as normal, values between 23 and 27.5 were categorized as overweight and values > 27.5 were categorised as obese. Among the 183 participants in this study, 102 of the respondents were within the normal range, 48 respondents were under the underweight category, 21 respondents were categorized as overweight, and 12 respondents were categorized as obese. A previous study conducted in Malaysia reported that 16.7% male students and 20.9% female students were underweight while 17.8% of male student and 10% of female students were overweight (Abdull Hakim 2012).

In the present study, the Rosenberg Self-Esteem Scale was used to evaluate the self-esteem of the participants. The Rosenberg Self-Esteem Scale has been reported to be highly reliable and valid. It has been reported that the Rosenberg Self-Esteem Scale has a Cronbach's alpha internal consistency coefficient ranging from 0.77 to 0.88 and a test-retest reliability ranging from 0.82 to 0.85 (Blascovich & Tomaka 1993). Most of the participants had self-esteem scores within the normal range. However, 69 respondents reported scores within the low self-esteem range and only one respondent was reported to fall within the high self-esteem category. University students often experience chronic stress. Self-esteem is one of the most important factors in the process of psychosocial growth and has remarkable effect on thoughts, feelings, values, and goals. Self-esteem is defined as the person's overall subjective view of one's own worth, which is related to a feeling of personal aptitude, success and pride, or to a feeling of despair and shame (Baumeister et al, 2003). Self-esteem is considered very important for mental health; which influences the emotional states, general adaptability to life-challenges and resilience to stress during lifetime (Dishman et al. 2006). Undergraduate students are more prone to mental illness as they are going through physiologic and social changes that happen in late adolescence and early adulthood (Radeef & Faisal 2019).

In this study, the Social Appearance Anxiety Scale was used to determine the level of social appearance anxiety of the participants. The Social Appearance Anxiety Scale has been reported to have a convergent validity of 0.95 (Levinson & Rodebaugh 2011). Most of the respondents reported scores within the average range with 138 respondents, followed by 42 respondents that reported scores indicating high levels of social appearance anxiety, and 3 respondents who reported scores categorized as having low levels of social appearance anxiety.

Social appearance anxiety is a term related to the individual's concerns about their outer appearance so it is described as the worry and tension they experience if their outer appearance is assessed and criticized by the society. Social appearance anxiety in individuals who belongs to the adolescent category and the youth category might experience serious problems in their future. It is stated that appearance anxiety includes all the features such as height, weight, complexion, skin colour, eye colour, facial structure, nose, lips, hair, etc.

The issues of body image and perceptions of fat and thin structures have become main point of focus as people were conscious about being attracted by others. Sociocultural factors play an important role in determining the level of body dissatisfaction. Body dissatisfaction can be changed according to different cultures and different places. This helps the individuals to develop different types of coping attitudes among them (Reshma et al. 2020). Parental educational level may be a protective factor in the development of social appearance anxiety (Sahin et al. 2013).

Statistical analyses show a significant relationship between self-esteem and social appearance anxiety however no significant association was found between BMI with either self-esteem or social appearance anxiety. The findings show a negative relationship between self-esteem and social appearance anxiety. This means that exists an inverse relationship between self-esteem and social appearance anxiety where individuals with low self-esteem have higher social appearance anxiety scores. This is consistent with a previous study which stated that adolescents with low self-esteem can have high scores of social appearance anxiety and vice versa. According to the findings of this study, there was also a statistically significant negative relationship between self-esteem and negative body image. This could also be explained by the increased awareness and capability to perceive their own level of attractiveness and their increased interest to their physical appearance as perceived by others (Sahin et al. 2014).

The statistical analyses also showed that there was no significant association between BMI with self-esteem or social appearance anxiety. Using the multiple regression model, the standardized Beta value explains the level of contribution of the independent variable to changes in the dependent variable. It was seen that BMI only has a value of (0.60) which shows that there is some level of contribution of BMI to social appearance anxiety, but it is not statistically significant enough to matter. The results also show that there is no significant relationship between BMI and self-esteem. A previous study conducted among medical students in India reported that there was no association between BMI and physical self-concept (Shivani et al. 2013). The findings of the present study are in accord with the reports of a previous study conducted among children and adolescents which states that although the results supported the inverse relationship between obesity and self-esteem, there was no strong relationship as the self-esteem scores of children and adolescents with and without obesity fell within the normal range (French et al. 1995). This could be explained by the recent lockdowns implemented during the COVID-19 pandemic. As more individuals have been cooped up at home, the lack of physical gatherings and in-person meetings could lead to a decrease in social appearance anxiety regardless of BMI. The present results suggest that negative consequences of high body mass index on self-esteem and social appearance anxiety are not seen in university students. It may be that academic achievement nullifies the effect on BMI and as the age progresses, appears later in life.

The findings of this study have shown that there is an association between self-esteem and social appearance anxiety among university students. The results also show that there was no significant association with either BMI and self-esteem or body mass index and social appearance anxiety. It is important for universities to address the psychological health issues of students such as low self-esteem and social appearance anxiety as these may not only affect academic adjustment but may be risk factors to other mental health problems as well. It would also be beneficial for counsellors to investigate the implications of bullying on self-esteem and social appearance anxiety as this could also potentially lead to a plethora of mental health problems and psychological adjustment of the students. Further research is needed in large number of subjects of different age groups (preadolescents, adolescents and adults) and economic/professional groups to evaluate the generalizability of present results.

Although this study was conducted using validated and highly reliable scales, there are still several limitations to the study. The main limitation is the relatively small sample size of the study. Since the study design adopted for this study is cross-sectional, it cannot establish a cause-and-effect relationship or analyse behaviour over a period of time. Besides this, the results cannot be generalized to other populations due to the small sample size. Furthermore, the sampling method of this study was convenience sampling which makes the study prone to bias.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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**ORIGINAL ARTICLE**

# Kinematic Differences Between Dominant and Non-dominant Upper Limbs During Reaching Task in Healthy Young Adults

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## ABSTRACT

**Background:** Understanding the kinematic aspect is crucial in rehabilitation as it allows for the assessment and intervention of motor function, irrespective of underlying forces. Although numerous studies have examined upper limb kinematics in older populations, limited research has focused on healthy subjects. This study aimed to investigate kinematic differences between the dominant and non-dominant upper limbs during a reaching task among healthy young adults. **Methods:** A quantitative cross-sectional study was conducted at the Human Motion Lab. The study utilized wireless wearable sensor devices known as "Shimmer" to measure linear velocity, and the Edinburgh Handedness Inventory assessed hand dominance. Participants performed a reaching forward movement first with their dominant arm followed by their non-dominant arm. The collected data were converted into linear velocity and analyzed using MATLAB software. **Results:** The study recruited 28 healthy young adults (21.87±1.06 years: 11 males and 17 females). The results showed no significant differences in linear velocity between the dominant and non-dominant shoulders and elbow joints. However, a significant difference was observed in the wrist joint (MD = 0.84; 95% CI: 0.22 to 1.46; $p = 0.01$), with the dominant wrist exhibiting higher velocity during the reaching task than the non-dominant wrist. **Conclusions:** The results of this study suggest that similar strategies can be applied for functional task training in both shoulder and elbow joints, regardless of dominance site. However, it is essential to consider the specific needs of the wrist joint to optimize motor function in the upper limb, as its performance may be influenced by dominance status.

**Keywords:** Hand dominance; Kinematic; Rehabilitation; Upper limb; Young adult

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## INTRODUCTION

The functional movements of the upper limb (UL) play a crucial role in essential activities of daily living, such as eating, drinking, grooming, and facial washing (Dogan et al. 2019). Recognizing this significance, researchers have increasingly focused on studying purposeful motion during real-life activities, with particular attention to its kinematic aspects (Grimm et al. 2021; Tsilomitrou et al. 2021). Kinematics, a fundamental discipline within biomechanics, enables a comprehensive analysis of various facets of human movement and allows the study of motion independently of underlying forces (Collins et al. 2018; Grimm et al. 2021). By employing kinematic analysis, researchers and healthcare professionals can gain valuable insights into the mechanics of human movement and customize interventions to address specific impairments, ultimately enhancing functional outcomes and independence for patients (Collins et al. 2018).

In recent years, the application of motion capture technology has significantly increased to assess upper limb motion (Collins et al. 2018; Tsilomitrou et al. 2021). Many studies have focused on analyzing upper limb kinematics during drinking tasks (Dimwamwa & Johnson 2015; Murphy et al. 2011; Murphy et al., 2018). These investigations primarily compare healthy individuals and stroke survivors, with a specific emphasis on reaching, drinking, and returning the hand to the initial position (Dimwamwa & Johnson 2015; Murphy et al. 2011). Notably, individuals with hemiplegia, a condition characterized by paralysis on one side of the body, exhibit distinctive shoulder joint patterns, including larger shoulder abduction and flexion angles (Kim et al. 2014). This often leads to compensatory adjustments in the elbow and wrist joints (Kim et al. 2014). Furthermore, stroke patients typically display lower kinematic performance in various aspects, such as movement times, peak velocities, smoothness of movement, and inter-joint coordination, when compared to their healthy counterparts (Murphy et al. 2011; Murphy et al. 2006).

Despite considerable research on drinking tasks, there is a noticeable gap in the literature regarding upper limb kinematics during reaching tasks among healthy individuals. It is essential to study reaching and grasping movements separately, as they can vary significantly based on the task's goals and constraints (Murphy et al. 2018; Paulette & Sheridan 2007). For instance, pointing movements exhibit different kinematics when compared to movements involving both reaching and grasping an object (Murphy et al. 2011).

Reach-to-grasp movements are a fundamental aspect of normal upper-limb function and consist of two primary components: the "transport" component, wherein the hand follows a distinct path towards the target object, and the "grasp" component, wherein the hand opens and closes to firmly hold the object (Paulette & Sheridan 2007). Understanding these distinct components and their kinematic characteristics can provide valuable insights into the complexities of upper limb motion during reaching tasks among healthy subjects (Ponvel et al. 2019). Therefore, the present research aims to fill this gap by conducting a comparative study on upper limb kinematics during reaching tasks among younger adults, exploring the differences between the dominant and non-dominant hands.

## METHODS

### Study design

This study adopted a quantitative cross-sectional design. Ethical approval was obtained from the Secretariat for Research and Ethics of Universiti Kebangsaan Malaysia (UKM PP/111/8-JEP-2018-291).

### Study settings and participants

Participants were recruited from the Faculty of Health Sciences, Universiti Kebangsaan Malaysia (UKM), using simple random sampling. The study was conducted at the Human Motion Lab, UKM. Eligible participants were younger adults aged between 18 and 44 years (Alshabeeb et al. 2022; Dyussenbayev 2017).

Individuals with a history of primary shoulder pathology or surgery, neurological conditions, vertigo, neuromuscular disorders in the upper extremity, cognitive impairment, or upper limb fractures within the past 6 months were excluded from participation. The sample size of 28 participants was determined using G-Power software, with an effect size of 0.25, an alpha level of 5%, and a desired power of 85% (Kim et al. 2014).

### Instruments

#### *Wireless wearable sensors devices "Shimmer"*

Kinematic movement of the upper limb was assessed using wireless wearable sensors devices "Shimmer". A total of three reflective markers of sensors devices were placed on the acromion, lateral epicondyle, and radioulnar joint (Murphy et al. 2018). This wireless device measured kinematic data from the integrated altimeter and 9DoF inertial sensing via accelerometer, gyroscope, and magnetometer (Tsilomitrou et al. 2021). The acquired data was converted into linear velocity. In a study by Cudejko et al. (2022), the reliability and validity of the wearable sensors were assessed by comparing signal waveforms using the Linear Fit Method and Bland–Altman plots (Cudejko et al. 2022). The results demonstrated that the concurrent validity of the wearable sensors was high, ranging from fair to excellent in 91% of cases for accelerations and 84% for orientations (Cudejko et al. 2022). Furthermore, the test–retest reliability of accelerations was rated as fair to excellent in 97% of cases when the sensors were attached by a researcher, and in 84% of cases when applied by the participants (Cudejko et al. 2022).

#### *Edinburgh Handedness Inventory*

The Edinburgh Handedness Inventory (EHI) was used to assess hand dominance. It is a well-known short questionnaire designed to objectively determine whether an individual is left or right-handed (Veale 2013). It assesses handedness through self-report of preferred hand usage in common activities such as writing, drawing, throwing, and using utensils like a toothbrush, knife, and spoon (Veale 2013). The reliability and validity of the EHI have been extensively studied in various countries, with the overall Cronbach's alpha coefficient of correlation between the two halves of the questionnaire ranging from 0.92 to 0.97 (Veale 2013).

### Procedures

The Shimmer device was applied by a trained research assistant. For the shoulder joint, the marker was positioned at the ipsilateral acromion process. The Shimmer device was placed on the lateral epicondyle for the elbow joint, and on the distal radioulnar joint for the wrist joint (Murphy et al. 2018). After testing the dominant arm, all the devices were switched to the non-dominant arm. Each subject received instructions on performing the reaching task while seated (Figure 1).

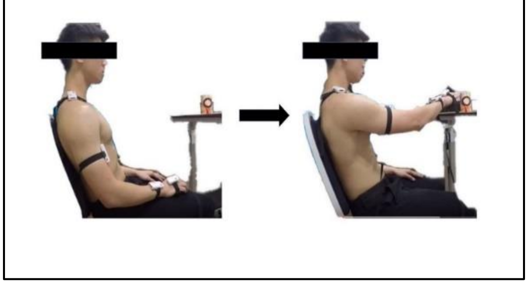

**Figure 1: Wireless wearable sensors and reaching task in a sitting position**

All subjects executed the reaching movement using their dominant arm. They remained seated, with their trunks stabilized against the back of a chair to minimize compensatory trunk movements. The start position involved the tested upper extremity resting on a pillow on the ipsilateral thigh, with the shoulder at approximately 0° flexion and extension, and 0° of internal rotation. The elbow was positioned at 75° to 90° flexion, with the wrist resting palm down and the finger joints slightly flexed on the pillow. Minor adjustments, such as increasing shoulder internal rotation to minimize positional discomfort, were made.

Each subject underwent recording for a minimum of three and up to six trials in one testing session, depending on the computer's ability to automatically track the markers. They were then instructed to reach forward as fast as possible and touch a 40-mm target (a standard size mug) placed 90% of the arm's length directly in front of the affected and dominant shoulder, at shoulder height. The three best recordings from each participant were selected based on marker visibility in each recording. The mean of these recordings provided the final measurement value for each participant. Furthermore, to ensure consistency and eliminate potential confounding effects related to subject height, the study utilized standardized chair and table heights. By carefully controlling for these factors, the researchers aimed to minimize any biases that subject height variations might introduce, thus enabling a more accurate investigation of the kinematic aspects of the upper limb during the reaching task.

### Data Analysis

The data was transferred from Multi Shimmer software to Excel and then to MATLAB software for further analysis. For each recording, coordinate data showing linear velocity was calculated and plotted. The aspect measured was linear velocity, which represented the velocity of the object traveling in a straight line. Statistical analyses were performed using SPSS version 23. Descriptive analysis was used to report socio-demographic details of the participants. Paired T-tests were conducted to compare upper limb kinematics between dominant and non-dominant hands.

## RESULTS

### Participants characteristics

The study enrolled a total of 28 participants, comprising 11 males and 17 females, with an average age of 21.87 ± 1.06 years. Demographic information and handedness status of the study participants are presented in Table 1.

The participants exhibited an average body mass index (BMI) of 22.27 ± 0.46 kg/m2, with seven individuals classified as overweight, while the majority fell within the normal BMI range. Regarding handedness, 24 participants were right-handed, and four were left-handed.

**Table 1: Demographic characteristics of the participants (n = 28)**

| Variables | n (%) or Mean ± SD |
|---|---|
| Age (years) | 21.87 ± 1.06 |
| Gender (male/female) | 11/ 17 |
| Body mass index (kg/m$^2$) | 2.27 ± 0.46 |
| Hand dominance (right-handed/ left-handed) | 24/ 4 |
| Edinburgh Handedness Inventory score | 1.13 ± 0.352 |

### Kinematic analysis

The kinematic variable analyzed was linear velocity, focusing on the shoulder, elbow, and wrist movements during the reaching task. The output from MATLAB presents the mean linear position graph of shoulder displacement for both the dominant and non-dominant hands along three different axes, as illustrated in Figure 2. A paired T-test was employed to compare the dominant hand's velocity with the non-dominant hand's velocity for each of the three Shimmer sensors (Shimmer 1, Shimmer 2, and Shimmer 3).

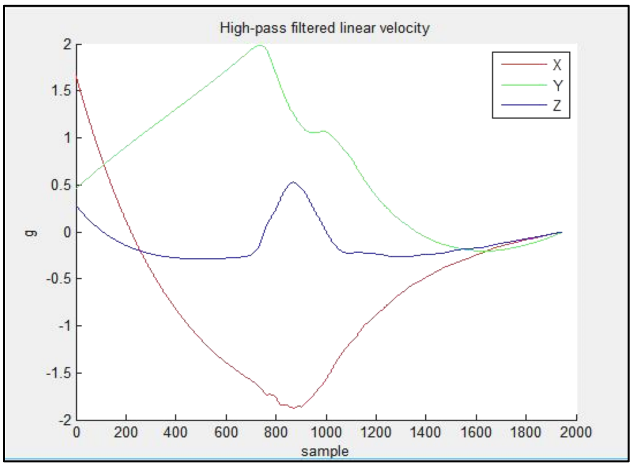


**Figure 2: Mean linear position graph of shoulder displacement for dominant and non-dominant hands along three axes**

Table 2 presents the *p*-values obtained from the paired T-tests for each joint (shoulder, elbow, and wrist) when comparing the dominant and non-dominant hands.

**Table 2: Differences between dominant and non-dominant upper limbs across joints and axes (n = 28)**

| Joints | Axes | *p*-value |
|---|---|---|
| Shoulder | X axis | 0.069 |
| | Y axis | 0.598 |
| | Z axis | 0.741 |
| Elbow | X axis | 0.536 |
| | Y axis | 0.225 |
| | Z axis | 0.488 |
| Wrist | X axis | 0.011* |
| | Y axis | 0.191 |
| | Z axis | 0.824 |

*Statistically significant ($p < 0.05$)

The results demonstrated that there was no significant difference in velocity between the dominant and non-dominant hands, except for the wrist joint.

Specifically, the wrist joint exhibited a significant difference, indicating that the velocity of the wrist movement during the reaching task was notably different between the dominant and non-dominant hands (mean ± SD = 0.84 ± 1.12; 95% CI: 0.22 to 1.46; $p = 0.01$). However, for the shoulder and elbow joints, the velocity did not significantly differ between the two hands.

## DISCUSSION

This study examined the kinematic differences during a reaching task between the dominant and non-dominant upper limbs among twenty-eight healthy young adults. The findings revealed that while there were no significant differences in linear velocity between the dominant and non-dominant shoulders and elbow joints, a significant difference was observed in the wrist joint. Specifically, the dominant wrist exhibited higher velocity during the reaching task compared to the non-dominant wrist. This suggests that limb dominance may not play a substantial role in determining the speed of reaching movements at the shoulder and elbow joints among healthy young adults.

While previous research has suggested that dominant hands might perform certain tasks faster or more accurately (Murphy et al. 2011; Sachlikidis & Salter 2007; Wang & Sainburg 2007), the present study in healthy younger adults indicates that this may not be the case for linear velocity during the reaching task. Several other studies have also explored upper limb kinematics in various populations and tasks, providing valuable comparisons and context for the current findings (Lott & Johnson 2016; Poston et al. 2009; Xiao et al. 2019). For instance, Xiao et al. (2019) investigated the effects of handedness on motion accuracies and 3D kinematic data in reaching performance of dominant and non-dominant hands, revealing no significant difference between them during fast speed movements (Xiao et al. 2019). Similarly, Lott et al. (2016) studied upper limb kinematics in adults with cerebral palsy during bilateral functional tasks and found comparable velocities between the dominant and non-dominant hands, consistent with the results for healthy controls (Lott & Johnson 2016). Additionally, Poston et al. (2009) examined age-related differences in movement structure for the dominant and non-dominant arms during goal-directed movements, uncovering similar movement times and velocities for both arms in both younger and older adults (Poston et al. 2009).

Moreover, the absence of significant differences in the shoulder and elbow joints among our cohort of young adults could be attributed to their relatively healthy and youthful status, suggesting that the impact of limb dominance may become more apparent with aging or in the presence of specific pathologies (Collins et al. 2018; Murphy et al. 2018). This observation aligns with a systematic review conducted by Ponvel et al. (2019), which identified age, physical activity level, and health status as crucial factors influencing upper extremity kinematics, a context that is relevant to our study as well (Ponvel et al. 2019). Additionally, our observation of no significant differences in velocity between the dominant and non-dominant shoulders and elbows during the reaching task is consistent with previous research that has often focused on upper limb kinematics during drinking tasks (Dimwamwa & Johnson 2015; Kim et al. 2014; Murphy et al. 2006). Such studies indicate that the shoulder and elbow joints are less influenced by hand dominance, and compensatory adjustments in these joints are less common in healthy individuals (Dimwamwa & Johnson 2015; Kim et al. 2014; Murphy et al. 2006). These findings underscore the importance of considering specific task contexts and functional movements when exploring the impact of hand dominance on joint kinematics and motor performance (Collins et al. 2018).

Interestingly, the significant difference in wrist velocity suggests that hand dominance may have a more substantial impact on wrist joint mechanics during reaching movements (Anderton et al. 2022; Grimm et al. 2021). This phenomenon can be explained based on the wrist's pivotal role in reaching movements, as fine adjustments and manipulations are often required during reaching tasks (Anderton et al. 2022). The dominant hand is typically more skilled and adept in executing precise movements (Sachlikidis & Salter 2007), which might be reflected in the higher velocity observed in the dominant wrist during the reaching task (Anderton et al. 2022). On the other hand, the non-dominant hand might exhibit slower and less precise wrist movements due to its lesser experience in executing fine motor tasks (Anderton et al. 2022). Consequently, hand dominance may influence the execution of wrist movements, contributing to the observed differences in velocity.

The findings suggest that individualised rehabilitation approaches based on hand dominance should be explored, rather than solely focusing on improving the non-dominant hand to match the dominant hand. Customizing interventions to address the unique requirements of the non-dominant wrist, such as precision and coordination, could lead to improved motor function and performance in reaching tasks. However, it is important to note some limitations of this study. The sample size was relatively small, consisting of only 28 healthy young adults, which might limit the generalizability of the findings. Furthermore, while the study investigated linear velocity, future investigations could include other kinematic variables, such as acceleration, joint angles, or movement time, to gain a more comprehensive understanding of upper limb motion during reaching tasks.

## CONCLUSION

The findings of this study indicate that hand dominance

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does not significantly affect reaching task velocity for the shoulder and elbow joints in healthy young adults, with the exception of the wrist joint. This emphasizes the relevance of incorporating hand dominance into rehabilitation strategies, specifically targeting the wrist movement component. Nonetheless, to refine approaches for individuals with movement impairments, further research with larger sample sizes and exploration of additional kinematic variables is warranted.


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## CONFLICT OF INTEREST

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**COMMENTARY**

# Slump Test for a More Precise Diagnosis of Sciatica: A Single Centre Experience

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## ABSTRACT

The accurate diagnosis of sciatica remains a challenge in clinical practice, often leading to delayed or inappropriate management. The slump test is a neurological physical examination used to find disc bulging, herniation at lumbar spine, or irritation of the spinal cord dura. It is a combination of other neuro-meningeal tests, namely, the seated straight leg raise, neck flexion, and lumbar slumping. It is a neurodynamic assessment that helps evaluate the sensitivity and integrity of the neural structures involved in the lower back and lower limb regions. This paper reported the use of slump test for a more precise diagnosis of sciatica using a single centre experience. From our experience, the slump test showed to be a valuable diagnostic tool for precise identification of sciatica in a single centre setting. Its high diagnostic accuracy, sensitivity, and specificity suggest that it can aid in early and accurate diagnosis, facilitating timely intervention and appropriate management of patients with sciatica. Incorporating the Slump Test into the diagnostic protocol for sciatica can enhance clinical decision-making and improve patient outcomes. Further prospective studies are warranted to validate these findings and assess the utility of the Slump Test in larger patient populations.

**Keywords:** Slump test, sciatica, low back pain

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## INTRODUCTION

Sciatica is a common and often debilitating condition characterized by radiating pain, paraesthesia, and muscle weakness along the distribution of the sciatic nerve. It is most commonly caused by compression or irritation of the nerve roots in the lumbar spine, typically due to intervertebral disc herniation, spinal stenosis, or piriformis syndrome. Accurate diagnosis of the underlying pathology is crucial for effective treatment and management of sciatica.

While various diagnostic tools and imaging modalities exist, the clinical examination remains an integral component in the evaluation of sciatica. One such clinical test, the Slump test, has gained recognition as a valuable tool for diagnosing and understanding the mechanisms underlying sciatic nerve compression.

The Slump test is a neurodynamic examination that involves a series of passive movements and stretches aimed at stressing the sciatic nerve and its surrounding structures. By reproducing or provoking the patient's symptoms, particularly pain and paraesthesia, the test provides valuable insights into the underlying pathology and helps differentiate between various causes of sciatica. Via this slump test and analysis, we can correlate each component of slump test to particular problematic area, include muscles, joints, neural tension.

In this article, we present our single-centre experience with the Slump test as a diagnostic tool for sciatica. Our aim is to evaluate its effectiveness in achieving a more precise diagnosis, identifying the specific anatomical structures involved, and aiding in treatment planning.

## DEFINITION AND EPIDEMIOLOGY OF SCIATICA

Sciatica, often known as low back pain (LBP) with sciatic radiation, is a disorder characterized by unilateral pain or paresthesia according to the distribution of the sciatic nerve or an accompanying lumbosacral nerve root (Aguilar-Shea et al. 2022). Large epidemiological studies have revealed that up to 37% of people with persistent back pain have a neuropathic pain component (Davis, Maini & Vasudevan 2023), which typically manifests as radicular leg pain (Konno et al. 2017). The term *'sciatica'* or *ischias* (Greek) was used by the ancient Greeks to indicate pain in the hip or thigh. Disc abnormalities were originally noticed in the nineteenth century, and in 1864 Lasègue published a test for sciatica pain that was eventually named after him (Siddiq et al. 2020).

Sciatica is a painful disorder caused by sciatic nerve or sciatic nerve root pathology (Aguilar-Shea et al. 2022; Davis, Maini & Vasudevan 2023). The International Association for the Study of Pain defines neuropathic pain (NeP) as pain induced by a somatosensory system lesion or disease (Urban & MacNeil 2015). It is believed that 2% to 4% of the general population has NeP, with significantly greater prevalence in people with chronic low back pain (Urban & MacNeil 2015). Notably, the presence of NeP has been associated to poor recovery, as well as increased healthcare expenses and a lower quality of life (Urban & MacNeil 2015). It has been found that people with LBP that radiates to the leg(s) have clinically worse symptoms and a poorer recovery than those with LBP alone (Siddiq et al. 2020).

## SIGN AND SYMPTOMS OF SCIATICA

The sciatic nerve sends direct motor signals to the hamstrings and lower extremity adductors, as well as indirect signals to the calf muscles, anterior lower leg muscles, and some intrinsic foot muscles. The sciatic nerve also gives sensation to the posterior and lateral lower leg, as well as the plantar portion of the foot, indirectly through its terminal branches. It is critical to understand that the majority of cases of sciatica are caused by an inflammatory condition that causes pressure of the sciatic nerve. Direct nerve compression, on the other hand, causes more severe motor dysfunction, which is typically not noticed and, if present, would necessitate a more thorough and expedited workup (Davis, Maini & Vasudevan 2023).

Sciatica might be characterised or related with sensations of burning, heaviness, or constriction. Patients with this condition feel pain and paresthesia in the sciatic nerve distribution or a lumbosacral nerve root (Davis, Maini & Vasudevan 2023). Sciatica is frequently worse by lumbar spine flexion, twisting, bending, or coughing (Aguilar-Shea et al. 2022; Davis, Maini & Vasudevan 2023). The degree of sciatic nerve irritation or damage develops from pain-paresthesia to motor deficit, indicating that nerve damage is increasing (Aguilar-Shea et al. 2022). This is frequently a chronic illness that is addressed with analgesics to control pain and NSAIDs to reduce inflammation (Davis, Maini & Vasudevan 2023).

Patients with sciatica typically suffer pain in the lumbar spine, and the discomfort is virtually always unilateral. Pain may be radicular to the ipsilateral afflicted extremity, which is a common feature. Patients usually express discomfort or a burning sensation deep in the buttocks, as well as paresthesia that goes along with the pain. In rare cases, there is concomitant ipsilateral leg weakness. The affected leg may be described as "feeling heavy" by these individuals. A straight-leg rise has varied sensitivity and specificity and may or may not be present depending on the underlying reason (Davis, Maini & Vasudevan 2023).

Not all sciatica-like symptoms are caused by the lumbar spine. Some of them are triggered at sites along the sciatic nerve's extraspinal journey, making diagnosis challenging for the treating physician and delaying appropriate treatment. Extra-spinal sciatica can be fatal in some situations, especially when the sciatic nerve is involved in cyclical sciatica or the piriformis muscle is involved in piriformis pyomyositis. In addition to cases of sciatica with a clear spinal or extra-spinal origin, some cases can be a combination of the two; the same might be said for pseudo-sciatica or sciatica mimics; we simply do not know how often extra-spinal sciatica is among total sciatica cases. Because treatment approaches for spinal, extra-spinal, and sciatica-mimics differ, a clear diagnosis will assist physicians in developing a tailored therapy plan (Siddiq et al. 2020).

## CLINICAL REASONS FOR SCIATICA

### Piriformis Syndrome

Piriformis syndrome is a disorder that need special attention because it is frequently misdiagnosed and ignored. The piriformis muscle connects the sacral spine to the upper femur and helps with hip extension and leg rotation (Larinov, Yotovski & Filgueira 2022). Because the piriformis muscle is so close to the sciatic nerve, any injury or irritation to it might trigger "sciatica symptoms." Overuse injuries, particularly in runners and other endurance sports, frequently induce piriformis muscle inflammation, with the resulting symptoms mimicking sciatica. As a result, these patients have increased pain when applying direct pressure to the piriformis muscle, increased pain when walking up inclines or stairs, and limited hip joint range of motion. Piriformis exercises, as well as hamstring stretches, can help relieve muscular tension and alleviate this painful disease. Some patients may benefit from lumbar and sacroiliac manipulation as well. Rest from the activity that is generating the pain is also beneficial (Davis, Maini & Vasudevan 2023).

Piriformis syndrome is categorised as either a primary (muscle and nerve anomalies, individual sciatic nerve path) or secondary (as a result of muscle and nerve damage), with or without nerve entrapment (entrapment neuropathy).

### Superior Cluneal Nerve (SCN) in Slump

LBP is caused by entrapment of the superior cluneal nerve (SCN), according to various anatomical and clinical studies. The SCN is generated by the anastomosis of the T11-L4 spinal neurons' dorsal rami. The SCN is a cutaneous branch of the dorsal rami of the lumbar spine that penetrates the psoas major and paraspinal muscles. It runs through the thoracolumbar fascia's superficial layer before crossing the posterior iliac crest, or via the gluteal fascia after crossing the iliac crest, and provides the skin that covers the upper part of the gluteus muscles. When the medial SCN branch enters the gluteal fascia, the nerve may become entrapped in the "osteo-fibrous tunnel," which is encircled by the iliac crest and the fascia linked to the iliac crest.

Although LBP is the most common presenting symptom, one-third of patients may describe leg discomfort that worsens with standing, walking, bending from the waist, twisting, climbing/descending stairs, or moving weight (s). Trescot further stated that SCN entrapment induced referred pain down the leg, potentially all the way to the foot, and that this pseudo-sciatica clinically mimicked radiculopathy caused by lumbar disc herniation or constriction of the lumbar spinal canal (Konno et al. 2017).

**Quadratus lumborum and GME myofascial pain syndromes**

The Quadratus lumborum (QL) muscle is a common cause of myogenic LBP (Siddiq et al. 2020). QL trigger points (TPs) cause discomfort to radiate to the SI joint, lower buttock, and lateral hip. Satellite TPs in the gluteal muscles, particularly the gluteus medius, may cause sciatica-like discomfort. Bilateral QL participation is also feasible. To undertake a thorough examination of the QL muscle, the patient should be positioned on his or her side, with enough space between the 12th rib and the iliac crest for palpation. Ipsilateral, atrophied paraspinal muscles, including the QL, are detected on the symptomatic side of patients with acute and chronic LBP using a 3-T MRI scanner (Siddiq et al. 2020).

TPs were considered active in a cross-sectional study of 42 individuals with nonspecific LBP if the respondent identified the local and referred pain. Active TPs in the QL, iliocostalis lumborum, and gluteus medius muscles were most common in patients with non-specific LBP who had elevated pain intensity and poor sleep quality. Furthermore, the cross-sectional area of the QL was observed to be lower in 36 housewives with chronic LBP compared to the control (P = 0.010), as demonstrated by CT scanning at the L4 spinal level (Siddiq et al. 2020). This is a debatable scenario. To rule out the clinical reasoning of "why the QL is atrophied at the ipsilateral LBP," the patient, in my opinion, the patient needs to go through a very complete assessment, including posture.

**Sciatic Nerve Tumor**

Sciatic Nerve tumor (benign and malignant invasion) and vascular malformations, extra-pelvic entrapment neuropathy, entrapment of the lateral cutaneous nerve of the thigh (LCNT), saphenous nerve, sural nerve, and common peroneal nerve could present with symptoms similar to lumbar sciatica (Siddiq et al. 2020). The causes of LBP with sciatic radiation are listed in Table 1.

**Table 1: Common causes for sciatica**

| No | Causes | References |
|---|---|---|
| 1 | Piriformis | (Davis, Maini, & Vasudevan 2023; Siddiq et al. 2020) |
| 2 | Entrapment of the superior cluneal nerve (SCN) | (Konno et al. 2017) |
| 3 | Quadratus lumborum myofascial pain syndromes | (Siddiq et al. 2020) |
| 4 | Sciatic Nerve tumor | (Siddiq et al. 2020) |
| 5 | Lumbar intervertebral disc hernia | (Aguilar-Shea et al. 2022; Davis, Maini & Vasudevan 2023; Siddiq et al. 2020) |
| 6 | Lumbar spinal stenosis, in the elderly population | (Aguilar-Shea et al. 2022; Davis, Maini & Vasudevan 2023; Siddiq et al. 2020) |
| 7 | Spondylolisthesis | (Aguilar-Shea et al. 2022) |
| 8 | Pelvic or lumbar muscular spasm and/or inflammation | (Davis, Maini, & Vasudevan 2023) |
| 9 | Spinal or paraspinal mass | (Aguilar-Shea et al. 2022; Davis, Maini & Vasudevan 2023; Siddiq et al. 2020) |
| 10 | Epidural abscess | (Davis, Maini, & Vasudevan 2023) |
| 11 | Epidural hematoma | (Davis, Maini, & Vasudevan 2023) |
| 12 | Trigger point TrP gluteal minimus | (Espinosa et al. 2021) |
| 13 | Entrapment of the superior cluneal nerve (SCN) | (Konno et al. 2017) |
| 14 | Quadratus lumborum myofascial pain syndromes | (Siddiq et al. 2020) |
| 15 | Potts Disease, also known as spinal tuberculosis | (Davis, Maini, & Vasudevan 2023) |

New literature has mentioned that, herniated disc may not be the “cause or course” of patients’ back pain or sciatica. It could be due to stiffness or spasm of certain muscles, mechanically causing nerve root compression, which directly causes increased neural tension (Al-Sharaa 2021; Urban & MacNeil 2015).

## VARIOUS PHYSICAL EXAMINATION/SPECIAL TEST FOR SCIATICA

The onus of diagnosing a prolapsed intervertebral disc has shifted to MRI. Many clinical tests are utilised to determine whether the pain is caused by pressure on the neural tissues or by anything else.

Neurodynamic tests are a sequence of multi joint limb and/or trunk movements that cause mechanical and physiological events in the neural system. A rise in tension in the nerve being examined is one of these mechanical occurrences. The term "neuro-dynamics" currently refers to the combined biomechanical, physiological, and morphological functions of the nervous system (Urban & MacNeil 2015).

The straight leg raise (SLR) and slump test are the foremost physical examination commonly used to assess lumbar disc herniation and sciatica pain.

**Active Straight Leg Raise (SLR)**

In supine laying, the SLR is widely used to diagnose low back sciatica pain. The patient raised his foot slowly away from the table with maintaining the knee in fully extended until 6-80 degrees, or until the sciatica pain is provoked (Urban & MacNeil 2015). The angle between the lower limb and the bed is measured (Davis, Maini & Vasudevan 2023; Urban & MacNeil 2015). Normally up to 70 to 90 degrees of SLR can be reached without pain (Aguilar-Shea et al. 2022; Davis, Maini & Vasudevan 2023; Urban & MacNeil 2015).

Pain that occurs between 30 and 70 degrees of hip flexion and is felt mostly in the back is most likely caused by a lumbar disc herniation (Davis, Maini & Vasudevan 2023). In patients with sciatica, the angle will be decreased and the patient should feel running down, shooting pain towards the lower leg, resulted by increasing neural tension onto sciatic nerve. The L5 and S1 nerve roots were extended from 2 to 6mm by SLR, while the upper nerve roots (L2, L3, and L4) were barely strained (Urban & MacNeil 2015).

In this case, we believe it is preferable to perform the SLR passively rather than actively, because during active motion, the patient's opposite back stabiliser, frequently the contralateral multifidus, must contract against the active-lifting leg.

**Active Slump Test**
Another test is Slump test, which is distinct from SLR, it is done in seated position. The test is aimed to put sciatic nerve roots under aggravated tension (Al-Sharaa et al. 2021; Urban & MacNeil 2015).

The slump test is preferred over SLR for 2 reasons. First, slump test is more sensitive since it enhances the cephalad sliding of the spinal cord, as compared to caudal gliding in the SLR. Second, the slump includes neck flexion and extension which helps to differentiate motion limitations in neural tissue from other soft tissue inflexibility. Both tests produce pain due to herniated disc because of the traction on the nerve root, the SLR on L5S1, whilst Slump onto all the lumbar roots (Al-Sharaa et al. 2021; Urban & MacNeil 2015).

A slump test is carried out with the patient sat at the edge of the bed, with both hamstrings fully supported on the bed. At first, the patient will be taught to relax both arms behind the trunk. The trunk is therefore slouched, especially in the lumbar area. If there is no pain, continue to flex the neck until the chin meets the chest. The pain caused will be documented. Next, proceed with sciatica leg extension, until pain is provoked, this test is regarded as positive. The angle of knee extension will be noted down as an objective measurement before and after session.

## COMMENTARY

In our experience, disregarding the herniated disc, each part or procedure of Slump test can be interpreted as different muscular involvement.

For slipped disc context that may lead to sciatica, in our opinion, there is another mechanism to explain this phenomenon. During the cough or sneeze, multifidus will contract as part of core stabilizer, and any contraction of these deep multifidus will increase the intradiscal pressure, which subsequently leads to irritation to the nerve root of sciatic nerve. According to our observation, almost 100% of patients with such conditions, will present with multifidus tightness mainly at Lumbar level L4/L5, L5/S1 region. This tightness is palpable via therapists' fingers, especially if patients are in prone lying with 1 pillow underneath the abdomen.

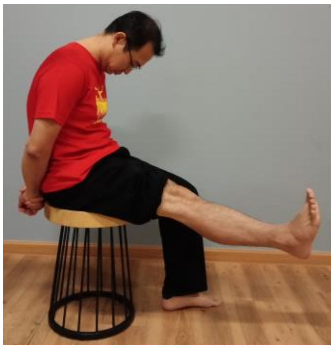
For piriformis context that may to lead to sciatica, in our understanding, we look into piriformis syndrome from biomechanical aspect, which excellently explaining all phenomenon. When pairing muscles of quadriceps and quadratus lumborum contracts together, ipsilateral pelvis will move into anterior pelvic tilt (APT). This move creates an increment of ipsilateral pelvic height (measurement from pelvic crest to ischial tuberosity). The distance between ischial tuberosity and greater trochanter will relatively increase, or we know it as "long-locked" or "stretched" or "passively elongated". Any muscles in the body with such "long locked" or "stretched" or "passively elongated" position will be resulted in weakness, scarring at tendon, tendinitis, as well as inflammation. We hypothesized that most provocative tests were caused by muscular tension, which caused high neural compression and stress on the nerve root and peripheral nerve. The neurodynamic test, as described in the literature, modulates the mechanical load on the nervous system, proving nerve tissue as the source of symptoms during the test [5], which means, every single step in Slump should also be interpreted as "what muscle that embed the nerve" can lead to mechanical strain onto the nerve. An accurate diagnosis is essential for directing patients to the most effective therapies. Because it combines spinal flexion and might thus potentially induce larger overall neural strain, the slump test was extremely sensitive in identifying NeP (Urban & MacNeil 2015).

In SLR test, lifting the sciatica leg also involves contralateral multifidus firing to stabilise the pelvic, vice versa. In acute sciatica with herniated disc, the patients are also appeared to have flat back, reduced lordosis, the reason being is to reduce the intradiscal pressure by creating excessive posterior pelvic tilt, which mechanically stretches the "multifidus" muscle. Vice versa, neurodynamic test, or Slump test still can provoke sciatica pain in non-diagnosed populations with less severe pain (Urban & MacNeil 2015).

In our humble practice, we managed to observe patterns of Slump test, each pattern does indicate part of the sciatic nerve being compromised. We use the sequence of slump test: slump - knee extension - ankle dorsiflexion - head flexion to ensure similar result. We do keep the head/neck flexion test at last, as we want to distinguish, if the compression is started from below Lumbar region (caudal glide), or above lumbar region (cephalic glide) (Baptista et al. 2022; Urban & MacNeil 2015).

In our experience, we also observed another pattern of Slump test. Previously, normally my practice is to start

**Table 2: Slump Test**

| Steps | Figure | Description |
|---|---|---|
| 1. |  | Slump the pelvis, this movement indicates multifidus stiffness or spasm if pain is provoked.<br><br>This test cannot be performed in Acute low back pain due to spasm of muscles.<br><br>Some chronic cases will experience stiffness over the lumbar region due to tightness in the multifidus.<br><br>Although multifidus appears along the spine anatomically, they are most palpable at L3, L4, L5, S1 region, best in prone lying with pillow underneath the tummy to flex the spine. |
| 2. |  | Extend the leg (starts with unaffected leg), this movement indicates ipsilateral QL stiffness or cramp if pain is provoked.<br><br>Commonly patient may complain of stiff hamstring. It may not be due to stiff hamstring but is due to stiff QL muscle and leads to anterior pelvic tilt.<br><br>Biomechanical changes of pelvic and ischial tuberosity is increasing the hamstring's muscle length subsequently. |
| 3. |  | Dorsiflex the ankle, this movement indicates ipsilateral tibialis posterior muscle tightness or stiffness if pain is provoked.<br><br>Sciatic nerve is embedded along the tibialis posterior muscle after the bifurcation at popliteus fossa? region. |
| 4. |  | Lastly, flex the head, this movement indicates ipsilateral Erector spinae stiffness or cramp if pain is provoked. This is highly related to postural problems.<br><br>In our practice, we look into splenius, semispinalis as well as erector spinae muscles.<br><br>Treatment along the spine until thoracic region shows significant result. |
| 5. |  | Our latest findings, if pain is provoked during the slump test onto the unaffected leg, that indicates gluteal minimus or gluteal medius tightness.<br><br>We can address it as "contra-slump test". |

the Slump test in contralateral leg / Good leg / non affected / non sciatica leg, followed by sciatica leg / affected leg. However, there are few scenarios that, contralateral leg Slump do provoke the pain at the sciatica leg. Upon detailed assessment, in conjunction with understanding of body mechanic, we diagnosed it as “contralateral gluteal medius and gluteal minimus tightness”.

Clinicians should not just rely on the angle of knee extension, provocative symptoms to diagnose a patient with sciatica. The clinicians should look into the quality of movement, the facial expression, the slowness into the movement (bradykinesia) and this can be added into the record of the slump test. Therefore, obtaining more precise diagnosis will require studies with camera setting in different view (facial expression, localised peripheral movement, slowness of the movement) (Urban & MacNeil 2015).

Some literature mentioned that the key to sciatica management is patient education (Urban & MacNeil 2015). We humbly disagree with this statement. The key is, find the root cause of the compression, before we educate the patients about sciatica. Same goes the management of referring patient for pain management (Coppieters et al. 2015). It is not because the patients cannot manage the pain, but the failure of the healthcare professional to find out the compression point(s), and the solution(s) to relieve the compression points.

**PHYSIOTHERAPY MANAGEMENT OF SCIATICA**

Physical therapists use a variety of therapies to treat low back pain; however, data for the effectiveness of these interventions is inadequate. Given the heterogeneity of LBP, it does not appear fair to expect that a single treatment approach will benefit all patients (Thiyagrajan 2017). As a result, we disagree with this statement. LBP is diverse, yet human anatomy and movements are similar and patterned by movement. As a result, treatment should focus on "why it happens, what is the mechanism" rather than "what is causing the LBP or slipped disc, which level, how damaged it is." As physiotherapists, we must investigate "movement" factors to explain all pain.

One of the therapeutic interventions used to treat musculoskeletal disorders is neural mobilisation (NM), which has been shown to reduce pain and improve functioning. NM is made up of a series of joint movements that encourage the gliding and tensioning of neural tissue, which can be done passively by therapists or actively by patients. It is hypothesised that NM can facilitate nerve gliding in respect to neighbouring tissues, improve neural vascularity, and improve axoplasmic flow, all of which result in improved neural function and, as a result, improved motor and sensory performance (Baptista et al. 2022).

Neurodynamic approaches are divided into two types: those that try to mobilise the structures that surround the nervous system and those that aim to mobilise the nervous system itself. Techniques that try to mobilise the structures that surround the nervous system include a cervical contralateral lateral glide technique and a lumbar contralateral lateral flexion technique. Tensioning and sliding procedures are methods of mobilising the nerve system. A tensioning technique achieves nerve mobilisation by manipulating one or more joints to stretch the nerve bed, causing the nervous system to move relative to its surrounding structures. Biomechanical studies have shown that elongating the nerve bed raises strain (the ratio of elongation to original length) in the nervous system, and that cumulative strain increases occur when numerous of these joint movements are coupled.

Alternatively, in a sliding technique, at least two joints are moved at the same time in such a way that the movement in one joint offset the increase in nerve strain generated by another movement. Such sliding procedures were devised and are used with the idea that they are associated with significantly larger nervous system excursions relative to surrounding structures, but without the potentially large increases in nerve strain. As a result, sliding and tensioning procedures may be recommended at various stages of a rehabilitation programme (Aguilar-Shea et al. 2022).

Visual Analogue Scale was used in NM test [9]. In our experience, VAS is a “subjectively objective” measurement. We preferred to observe for quality of movement, the numbers of compensation during the Slump test or NM.

Spinal stability and core muscle strength are critical. Daily isometric strengthening exercises will aid with spine stabilization (Aguilar-Shea et al. 2022). Pool exercise, followed by any machine-based exercise, is great for ultra-low-impact training. Exercises with a higher impact, such as jogging and standing weights, should be avoided. We need to have more critical thinking and ask, why do we need to exercise the stabiliser? It is “most likely” due to the weakness of core muscles? In our practice, the reason behind our decision over treatment plan is very clear. If multifidus is overacting, it will be resulting in spasm. Therefore, core activation in early stage is crucial to “swap” multifidus contraction by core. Deep tissue massage is not an adjuvant treatment. As a practitioner, we shall ask, why it works for sciatica? What is the explanation? What is the mechanism of the recovery after deep tissue massage? The answer is so simple, that, deep tissue massage manages to ease the spasm of the multifidus, that simple. Adjunctive treatments such as deep tissue release massage therapy and biofeedback may be beneficial.

There is little evidence to support the effectiveness of employing the slump test as a therapy technique (Ellis & Hing 2008). This is because Slump test is just stretching the neural tension and to desensitise the neural tension.

Treatment should be focused on where is the compression and how to reduce the tension by looking into the mechanism that compression is creating the neural tension, which is explained by our slump demo.

## CONCLUSION

In conclusion, the Slump test has proven to be a valuable tool for achieving a more precise diagnosis of sciatica, as evidenced by our single-center experience. The valid physical special nerve test should be able to interpret where exactly the compression of the nerve is, instead of just indicating “positive” or “negative”. By carefully observing and evaluating the patient's response to the test, we were able to differentiate between various causes/site of sciatic nerve compression. While our conclusions are based on a single-center experience, further research and multi-center studies are warranted to validate the findings and establish the broader applicability of the Slump test in diagnosing sciatica.

Nevertheless, our results strongly support its inclusion in the diagnostic armamentarium for sciatica, aiding clinicians in providing targeted and effective management strategies for patients suffering from this debilitating condition.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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**REVIEW**

# The Effect of Multimodal Therapy on Balance Outcomes of Stroke Survivors: A Systematic Review

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## ABSTRACT

**Background and objective:** Stroke often lead to motor impairments and balance disorders in affected individuals. The improvement of balance control is of utmost importance in stroke treatment, and recent research suggests that combining specialized techniques may offer promising results in enhancing balance outcomes. However, the optimal combination of therapies for achieving the best outcomes remains unclear. Therefore, this study aims to examine the effect of combining two or more therapy approaches on balance control among patients with stroke by conducting a comprehensive systematic review. **Methods:** A systematic search was conducted across six electronic databases (PubMed, Scopus, EBSCOHost, Web of Sciences, OVID Medline, and Wiley) until October 2020 to find pertinent studies. The inclusion criteria involved clinical trials that compared combined specialized approaches with conventional rehabilitation exercise to conventional exercise alone, with reported balance outcomes, conducted in humans, and published in English. The methodological quality of the chosen articles was evaluated using the PEDro scale. **Results:** This study reviewed eleven high-quality studies, published between 2015 and 2019, with PEDro scores ranging from six to eight out of 11. These scores indicated that the included studies can be categorized as high-quality evidences. The findings from the majority of these studies indicated that combining conventional exercise with task-oriented exercise, water-based therapy, mirror therapy, electrical stimulation, or proprioceptive neuromuscular facilitation resulted in significant improvements in postural balance when compared to the control group after the intervention. **Conclusions:** Multimodal therapy techniques have demonstrated favorable outcomes in improving balance performance among patients with stroke, emphasizing the importance of personalized combinations and dosages for effective rehabilitation.

**Keywords:** Balance; Cerebrovascular accident; Combined therapy; Multimodal; Postural control; Stroke

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## INTRODUCTION

The global prevalence of stroke has been on the rise, making it the most morbid condition worldwide and the second leading cause of mortality (Feigin & Brainin, 2022), surpassed only by heart disease (Eyvaz et al., 2018). This debilitating condition manifests in various motor impairments among patients with stroke (Feigin & Brainin, 2022), including muscle weakness, increased muscle tone, as well as decreased sensory function, balance, coordination, and walking ability (Cha & Oh, 2016; D. Lee et al., 2016; Vahlberg et al., 2017). Elderly individuals, in particular, experience severe and long-lasting consequences that result in a loss of mobility independence and the need for long-term care in home or nursing house settings (Feigin & Brainin, 2022). Studies have shown that balance disorders affect up to 83% of patients with acute stroke (Feigin & Brainin, 2022), resulting in impaired mobility and an increased risk of falls, further worsening the disability associated with stroke (Hung et al., 2016; Li et al., 2019). Given these challenges, it is crucial to implement appropriate interventions aimed at enhancing balance control among patients with stroke.

In stroke treatment, improving balance performance is essential for enhancing functional mobility among patients (J. Park & Kim, 2019). Therapeutic exercise, a conventional component of physiotherapy interventions, has been proven effective in achieving this goal (Mazzini et al., 2019; J. Park & Kim, 2019). These exercises encompass postural changes, weight shifting, unassisted standing, and dynamic movements aimed at improving functional balance abilities and reducing the risk of mortality (Cha & Oh, 2016). However, relying solely on conventional rehabilitation exercises may not suffice. To address this limitation, researchers have explored the combination of specialised techniques with conventional exercises to improve balance outcomes in patients with stroke. These techniques include water-based exercise (H. K. Park et al., 2019), the Bobath technique (Raine, 2009), proprioceptive neuromuscular facilitation (PNF) (Seo & Kim, 2015), mirror therapy (D. Lee & Lee, 2019), and others (J. B. Lee et al., 2019; Mazzini et al., 2019).

For example, Shin et al. (2011) demonstrated that the combination of aerobic and functional strengthening exercises significantly improved static and dynamic balance performance compared to single therapy, as evidences by higher scores on the Berg Balance Scale (BBS) (Shin et al., 2011). Nevertheless, determining the most effective combination to achieve optimal outcomes remains uncertain (Li et al., 2019). Two systematic reviews conducted by Paci et al. (2003) and Luke et al. (2004) aimed to examine the effectiveness of the Bobath technique compared to other approaches (Luke et al., 2004; Paci, 2003). These reviews revealed a predominance of studies with poor methodology assessing the effectiveness of the Bobath technique. Moreover, the authors suggested that a singular approach cannot universally address all phases of stroke patient recovery (Luke et al., 2004; Paci, 2003). Thus, further research is required to determine the most effective combination of techniques and exercises for optimizing balance outcomes in patients with stroke.

Previous reviews in the field have not adequately addressed the impact of multimodal therapy, often overlooking conventional balance rehabilitation exercises (Lubetzky-Vilnai & Kartin, 2010), or have solely focused on physical exercise while disregarding technology-based approaches, such as virtual reality and robot-assisted exercises (Li et al., 2019; Luke et al., 2004; Paci, 2003). Consequently, there exists a research gap that necessitates further investigation. In light of this, the present study aims to examine the effect of combining two or more therapies on balance control among patients with stroke by conducting a comprehensive systematic review. By doing so, this study aims to shed light on the available literature evidence and contribute to the understanding of this important topic.

## METHODS

### Review protocol

This study followed the guidelines set forth by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The research question was formulated using the Population, Intervention, Comparison, and Outcome (PICO) model: "Is multimodal therapy more effective than conventional rehabilitation exercise in enhancing balance outcomes among patients with stroke, as evaluated by valid assessment tools or clinical measures?"

### Data sources and search strategy

The systematic article searching was performed across six electronic databases: PubMed, EBSCOHost, Web of Sciences, Medline (Ovid), and Wiley. The search applied the main keywords such as 'stroke,' 'cerebrovascular accident,' 'balance,' 'combination physical therapy,' and 'postural control.' Boolean operators 'AND' and 'OR' were utilized to combine the keywords and expand the search. The search strategy 'stroke AND balance' was preferred due to its high relevance and number of hits. Additionally, cross-referencing was conducted based on the retrieved articles. However, no attempts were made to contact the authors for further information in this study. Two authors (E.M. and E.Y.) performed the database searches using standardized search strategies.

### Study selection criteria

This review employed the following inclusion criteria: (1) randomized controlled trials (RCTs); (2) adult population diagnosed with haemorraghic or infarction stroke aged 18 years and above; (3) interventions involving a combination of two or more therapeutic approaches aimed at improving balance performances, such as exercise therapy, electrotherapy, virtual reality, and robot-assisted therapy; (4) the control group received conventional rehabilitation exercise; and (5) assessment of outcomes with at least one measure related to balance or postural control. Additionally, the search was limited to articles published in English or Bahasa Indonesia from 2010 up to and including 24 October 2020. Review articles, single case studies, letters to editor, and animal trials were excluded from the analysis to maintain focus and relevance.

After removing duplicates, three authors (E.M., E.Y., and D.A.P.) screened the list of identified articles based on their titles and abstracts. Subsequently, the authors then examined the full-text articles according to the inclusion and exclusion criteria, to obtain a final list of eligible articles.

### Quality assessment

The methodological quality of each article was assessed independently by three authors using the Physiotherapy Evidence Database scale (PEDro scale), and any discrepancies were resolved through consensus. The PEDro scale is a widely used assessment tool for comparing and evaluating RCTs. It comprises 11 scoring components that assess various aspects of study design and methodology (de Morton, 2009; Maher et al., 2003). The scores obtained from the PEDro scale can be classified into three categories, which are: (1) high quality for a total score of more than 6; (2) lower quality for a total score of 5; and (3) acceptable quality for a total score of 4 (de Morton, 2009; Maher et al., 2003).

### Data Extraction

A structured data extraction sheet was generated to systematically capture all pertinent data and information from included studies. The extracted data encompassed the following components: (1) study details; (2) patients characteristics, including, sample size, age, gender, and stroke type; (3) a detailed description of the intervention and its dosage; (4) control group activities; (5) outcome measures employed and the specific instruments used for their assessment; and (6) the primary findings and results reported in the studies. To ensure accuracy and reliability, three authors (E.M., E.Y., and D.A.P.) independently performed the data extraction process and any discrepancies were resolved through consultation with the fourth author (M.A.A.).

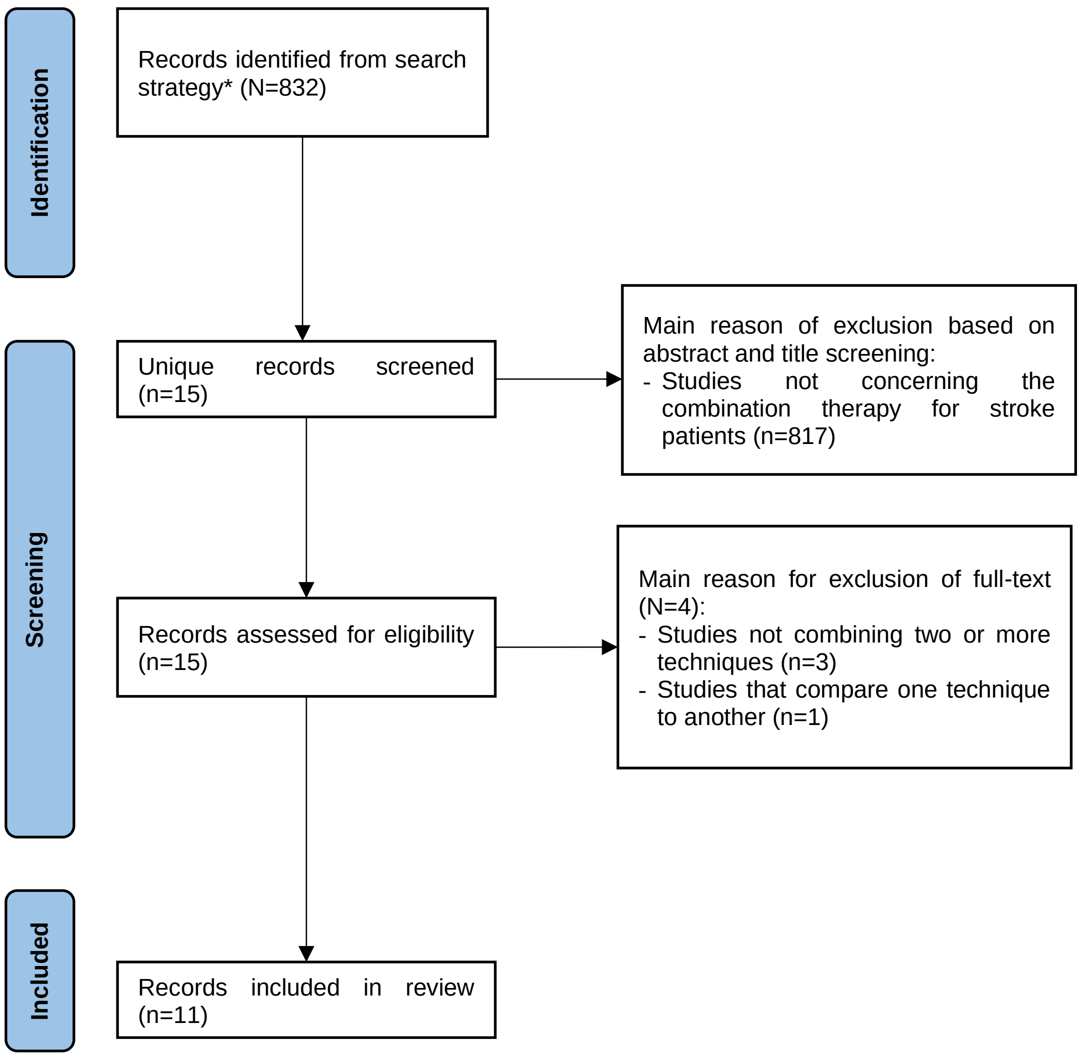
## RESULTS

### Study outcomes

In total, 832 studies were initially retrieved from the six databases through systematic searches. After eliminating duplicate records, 532 studies underwent screening process based on their titles and abstracts, in accordance to the predetermined selection criteria. Subsequently, 477 studies were excluded due to lack of relevance (review articles, single case studies, or letters to editor), absence of investigation on the impact of multimodal therapy in patients with stroke, and failure to examine balance outcomes. Following a thorough assessment of the full-text articles, 11 studies were deemed eligible for inclusion in this review. The comprehensive process of study selection is visually represented in Figure 1 of the PRISMA flow chart, providing a clear depiction of the articles screening and selection process.

### Characteristics of included studies

This review included a total of 11 RCTs that were published between the years of 2015 and 2019. Out of these, eight studies were conducted in South Korea, while one study was conducted in the USA (Hung et al., 2016), Turkey (Eyvaz et al., 2018), Sweden (Vahlberg et al., 2017), respectively. A total of 434 patients with stroke were included across the studies, with the sample size ranged from 20 to 72 patients per study. The average age of the samples in the included studies ranged from 47 to 72 years old. Among the patients, approximately 40-60% patients were female with 10 out of the 11 studies including patients with both




*24 October 2020

**Figure 1: PRISMA flowchart on study selection process**

**Table 1: Extracted data on studies' characteristics and results**

| | Patients' Characteristics | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Author(s) | n (Exp[a]/ Con[b]) initial → final | Age (Mean ± SD[c]) | Gender (%female) | Stroke type (ischemic /hemorrhage) | Treatments and Dosage (Exp) | Control Activity (Con) | Outcome Measures → Instruments | Balance results |
| Cha & Oh (2016) | 13/12 → 10/10 | Exp: 60 ± 3.19; Con: 58.60 ± 4.08 | Exp: 60%; Con: 50% | Exp: 3/7; Con: 2/8 | Task-oriented exercise and mirror therapy with the mirror (5 x 3) placed in the room to provide visual feedback during training → 30 min, 2x/day, 5x/week for 4 weeks | Task-oriented exercise → 30 min, 2x/day, 5x/week for 4 weeks | **Primary Outcome Measures (OM):** Balance → BBS[1], TUG[2], balance measurement system (balance index/BI, dynamic limits of stability/DLOS) **Secondary OM:** - | Change values → **BBS:** Exp = 13.00 ± 3.20; Con = 6.60 ± 4.55 (t = 3.64, p<0.01); **TUG:** Exp = 6.45 ± 3.00; Con = 3.61 ± 1.84 (t = -2.55, p<0.05); **BI:** Exp = 2.29 ± 0.51; Con = 0.96 ± 0.65 (t = -5.11, p<0.01); **DOLS:** Exp = 7.70 ± 3.83; Con = 3,70 ± 4,60 (t = 2.11, p = 0.05) Exp showed higher increase in change values of each OM than in Con. |
| Eyvaz et al (2018) | 33/32 → 30/30 | Exp: 58.5 ± 6.27; Con: 58.3 ± 5.43 | Exp: 30%; Con: 56.67% | Exp: 27/3; Con: 23/7 | LBE (Land-based exercise): ROM[3] exercise, strengthening exercise, trunk mobility exercise, balance exercise, walking training → 60 min/day, 2x/week for 6 weeks; WBE (Water-based exercise): in a swimming pool at 33°C and comprises of strengthening exercise dan balance coordination exercise → 60 min/day, 3x/week for 6 weeks | LBE: ROM exercise, strengthening exercise, trunk mobility exercise, balance exercise, walking training → 60 min/day, 5x/week for 6 weeks | **Primary OM:** Balance and fall risk → BBS, BI (static & dynamic), TUG **Secondary OM:** Self-care, sphincter control, mobility, locomotion, communication, social cognition; QoL[4]; maximal peak torque measurement of isokinetic quadriceps and hamstring → FIM[5], SF-36[6], isokinetic dynamometer (at two different speeds 90°/s and 120°/s) | Baseline → **BBS:** Exp = 39.6 ± 7.1; Con = 30.3 ± 10.9 (p = 0.001); **SBI:** Exp = 1331.7 ± 276.1; Con = 1446.9 ± 644.0 (p = 0.192); **DBI:** Exp = 2310.3 ± 716.1; Con = 2492.2 ± 437.6 (p = 0.305); **TUG:** Exp = 18.5 ± 6.3; Con = 26.5 ± 10.5 (p < 0,001) Post-treatment → **BBS:** Exp = 45.1 ± 6.7; Con = 36.7 ± 10.2 (p < 0.001); **SBI:** Exp = 1011.0 ± 272.4; Con = 1083.0 ± 296.8 (p = 0.001); **DBI:** Exp **=** 1760.5 ± 499.6; Con = 2009.0 ± 593.8 (p < 0.001); **TUG:** Exp = 14.7 ± 3.8; Con = 20.0 ± 8.6 (p < 0.001) Con presented higher increase in BBS score compared to Exp (change values: Exp = 5.5 vs Con = 6.4). However, DBI in Exp has higher improvement than in Con (change values: Exp = -549.8 vs Con =-483.2). |
| Vahlberg et al (2018) | 34/33 → 24/29 (after 15 months) | Exp: 72.6 ± 5.5; Con: 73.7 ± 5.3 | Exp: 20.6%; Con: 27.3% | Exp: 28/6; Con: 27/6 | PRB (Progressive Resistance and Balance Training): 10 min warm-up using stationary cycling or walking; 45 min circuit class PRB; 20 min motivational session that discuss issues and personal goals related to their physical activities → 2x/week for 3 months | Encouraged to continue their regular activities and not restricted from participating in ordinary physical activities and rehabilitation programs | **Primary OM:** Balance and mobility → BBS, SPPB[7] **Secondary OM:** Walking capacity, weekly physical activities, motor function, QoL, depression symptoms, and fall-related self-efficacy → SMWT[8], TMWT[9], PASE[10], MMAS[11], EQ-5D[12], GDS-20[13], FES(S)[14] | Baseline in median (IQR) → **BBS:** Exp = 49 (6); Con = 51 (7); **SPPB**: Exp = 9 (4); Con = 9 (3) Median difference in change (MD[15]): *3 mo* → **BBS** = -2.5 (p = 0.001); **SPPB** = -1 (p = 0.09) *6 mo* → **BBS** = -1 (p = 0.24); **SPBB** = 0 (p = 0.68) *15 mo* → **BBS** = -2 (p = 0.06); **SPBB** = 0 (p = 0.3) Exp in 3[rd] month showed significantly higher increases in balance than Con. |
| Lee & Lee (2019) | 15/15 → 15/15 | Exp: 50.80 ± 9.00; | Exp: 26.66%; | Exp: 5/10; Con: 5/10 | AES[18] combined with mirror therapy/MT (mirror with size | Sham AES and sham MT (with no reflection on the | **Primary OM:** Motor function → | Change values → **BBS:** Exp = 2.13 ± 3.48; Con = 1.67 ± 4.01 (p = 0.01) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Con: 50.13 ± 6.53 | Con: 33.33% | | of 50 x 70 cm and designed to reflect the healthy side) for 30 min, followed by AES and gait training for 30 min → 60 min/session, 5x/week for 4 weeks | mirror) for 30 min, followed by sham AES combined with gait training for 30 min → 60 min/session, 5x/week for 4 weeks | Dynamometer, MAS[19]<br>**Secondary OM:**<br>Balance and spatiotemporal gait variables → BBS, GAITRite walkway | Change values of BBS scores in Exp was found significantly higher than in Con. |
| Jung et al (2017) | 20/21<br>20/20 | → | Exp: 56.2 ± 10.4;<br>Con: 56.3 ± 10.2 | Exp: 45%;<br>Con: 40% | Exp: 12/8;<br>Con: 11/9 | Sit-to-stand training using: TENS (pulse width = 200μs; frequency = 100 Hz) → 15 min/day, 5x/week for 6 weeks<br>Conventional therapy → 60 min/day, 5x/week for 6 weeks | Sit-to-stand training using: Non electrically stimulated TENS → 15 min/day, 5x/week for 6 weeks<br>Conventional therapy → 60 min/day, 5x/week for 6 weeks | ***Primary OM:***<br>Balance; isometric strength in the extensor of hip, knee, and ankle; spasticity of ankle plantar flexor → Postural sway WBB[20], Handheld Dynamometer, CSS[21]<br>***Secondary OM:*** - | Changes value → **Postural sway distance (cm) eyes open:** Exp = -21.0; Con = -8.8 (p = 0.013); **Postural sway distance (cm) eyes closed:** Exp = -26.4; Con = -13.1 (p = 0.017)<br>Exp has significantly more decreases in postural sway when patients stood with their eyes open and closed than Con. |
| Park et al (2018) | 15/15<br>14/15 | → | Exp: 56.23 ± 13.74;<br>Con: 57.13 ± 11.73 | Exp: 40%;<br>Con: 25% | Exp: 7/7;<br>Con: 8/7 | NDT[30]/bobath and Land-based and Aquatic Exercise (LATE) → 30 min/day, 5x/week for 4 weeks | NDT/bobath→ Dosis latihan: 30 min/day, 5x/week for 4 weeks | **Primary OM:**<br>Trunk control, balance, ADL abilities → K-TIS[22], PASS-3L[23], BBS-3L[24], FRT[25], MBI[26]<br>**Secondary OM:** - | Baseline → **BBS:** Exp = 16.71 ± 3.97; Con = 19.87 ± 4.41 (p = 0.054); **FRT (cm):** Exp = 23.42 ± 8.28; Con = 28.58 ± 5.23 (p = 0.053)<br>Post-treatment → **BBS:** Exp **=** 21.5 ± 3.94; Con = 22.73 ± 3.6 (p = 0.035); **FRT (cm):** Exp = 29.11 ± 7.8; Con = 31.29 ± 5.62 (p = 0.045)<br>Exp showed significantly higher increases in BBS score compared to Con (change values: Exp = 4.79 (p = 0.001) vs Con = 2.86 (p = 0.001)). |
| Lee et al (2016) | 15/15<br>14/13 | → | Exp: 56.2 ± 10.4;<br>Con: 56.3 ± 10.2 | Exp: 50%;<br>Con: 46% | Exp: 12/8;<br>Con: 11/9 | MT (mirror size: 50 x 70 cm) combined with NMES[31] (frequency: 35 Hz, pulse duration: 250 µs, intensity: set such that the ankle joint could be completely dorsiflexed) → 1x/day, 5x/week for 4 weeks | Conventional therapy comprises of NDT, balance and gait training, and task-specific functional training → 60 menit | ***Primary OM:***<br>Muscle strength, muscle tone → *Hand-held dynamometer,* MAS<br>***Secondary OM:***<br>Balance and gait velocity → BBS, TUG, dan SMWT | Percentage of change → **BBS:** Exp **=** 14.89%; Con = -4.30% (p = 0.048); **TUG:** Exp = -11.59%; Con = 1.34% (p = 0.669)<br>There were significant increases of BBS scores in Exp. |
| Lee et al (2019) | 35/39<br>30/30 | → | Exp: 67.2;<br>Con: 68.5 | Exp: 43.3%;<br>Con: 46.7% | Exp: 17/13;<br>Con: 18/12 | FES[32] and standing frame was performed simultaneously → 20 min/session, 2x/day, 5 days/week for 3 weeks<br>Conventional therapy for standing balance training → 30 min/session, 2x/day, 5 days/week for 3 weeks | FES and standing frame training were given separately → 20 min/session, 2x/day, 5 days/week for 3 weeks<br>Conventional therapy for standing balance training → 30 min/session, 2x/day, 5 days/week for 3 weeks | ***Primary OM:***<br>Standing stability, physical and cognitive abilities →Posturography using Balance master system, BBS, K-MBI[27], K-MMSE[28], MMT[29]<br>***Secondary OM:*** - | Changes value → **BBS:** Exp = 12.17 ± 4.35; Con = 7.10 ± 3.26 (p = 0.043); **Overall stability index:** Exp = -4.55 ± 3.20; Con = -2.35 ± 2.25 (p = 0.045)<br>Exp had significantly better improvement in BBS score and overall stability index when compared to Con. |
| Jung et al (2015) | 15/10 | | Exp: 47.9 ± 10.6;<br>Con: 53.2 ± 12.3 | Exp: 33.3%;<br>Con: 50% | Exp: 8/7;<br>Con: 5/5 | Multifactorial exercise program: education regarding fall prevention, NDT, muscle strengthening exercise, balance training, and flexibility exercise → 30 min/day, 5x/week for 5 weeks | Treadmill exercise program included NDT and treadmill exercise with a 0.4 km/h increase in speed per week → 2x/day, 5x/week for 5 weeks | ***Primary OM:***<br>Gait speed, endurance, and balance → FES-K[34], POMA-K[36], SMWT, TMWT, ABC-K[35]<br>***Secondary OM:*** - | Baseline → **FES-K:** Exp = 59.00 ± 21.03 (p > 0.05); Con = 57.30 ± 19.32 (p > 0.05); **ABC-K:** Exp = 47.35 ± 18.14 (p > 0.05); Con = 39.45 ± 19.78 (p > 0.05)<br>Posttest → **FES-K:** Exp = 72.93 ± 15.61 (p < 0.01); Con = 55.50 ± 25.67 (p < 0.01); **ABC-K:** Exp = 62.40 ± 17.28 (p < 0.01); Con = |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 40.70 ± 25.50 ($p < 0.01$)<br>FES-K and ABC-K scores were significantly improved in Exp (change values: **FES-K:** Exp = 13.93 vs Con = -1.8 ($p < 0.05$); **ABC-K:** Exp = 15.05 vs Con = 1.25 ($p < 0.05$)). |
| Hung et al (2016) | 14/13 → 12/11 | Exp: 52.75; Con: 55.20 | Exp: 33.3%; Con: 27.3% | Exp: 9/3; Con: 8/3 | Conventional rehabilitation therapy → 50 min of physiotherapy and 50 min occupational therapy per day, 3x/week for 6 weeks<br>Tetrax biofeedback balance training → 20 min/day, 3x/week for 6 weeks | Conventional rehabilitation therapy → 50 min of physiotherapy and 50 min occupational therapy per day, 3x/week for 6 weeks | ***Primary OM:***<br>Feasibility including adherence, safety, and satisfaction → session attendance, adverse events record, satisfaction questionnaire<br>***Secondary OM:***<br>Body function and balance → physiologic profile assessments, posturography, TUG, FRT | Percentage of Change → **TUG:** Exp = -0.12; Con = 0.00 ($p < 0.001$); **FRT:** Exp = 0.08; Con = 0.00 ($p = 0.01$)<br>Compared to Con, Exp presented a significantly greater improvement in TUG and FRT. |
| Seo & Kim (2015) | 10/10 | Exp: 62.1 ± 6.2; Con: 60.5 ± 2.1 | Exp: 40%; Con: 50% | Exp: 0/10; Con: 0/10 | Basic exercises including muscle strengthening exercise, ROM exercise, and stretching exercise, followed by:<br>PNF gait pattern training on a specifically devised ramp (inclination: 10°; length: 10 m; width: 0.8 m) → 30 min/day, 3x/week for 4 weeks | Basic exercises including muscle strengthening exercise, ROM exercise, and stretching exercise, followed by:<br>PNF gait pattern training → 30 min 3x/week for 4 weeks | ***Primary OM:***<br>Dynamic balance and gait ability → BBS, TUG, FRT<br>***Secondary OM:*** - | Pretest → **BBS:** Exp = 23.1 ± 3.1; Con = 22.8 ± 2.1; **TUG:** Exp = 51.2 ± 7.3; Con = 53.4 ± 6.2; **FRT:** Exp = 5.3 ± 2.1; Con = 6.1 ± 1.3<br>Posttest → **BBS:** Exp = 23.3 ± 2.3 ($p < 0.05$); Con = 28.1 ± 2.9; **TUG:** Exp = 50.9 ± 7.1 ($p < 0.05$); Con = 48.6 ± 4.6; **FRT:** Exp = 5.4 ± 1.1 ($p < 0.05$); Con = 7.1 ± 2.7<br>Exp has significantly greater improvements in BBS, TUG, and FRT scores. |

[a]Exp = treatment groups; [b]Con = control groups; [c]SD = standard deviation; [1]BBS = Berg's balance scale; [2]TUG = timed-up and go test; [3]ROM = range of motion; [4]QoL = quality of life; [5]FIM = functional independence measures; [6]SF-36 = short-form health survey; [7]SPBB = short physical performance battery; [8]SMWT = six minutes walking test;[9]TMWT= ten minutes walking test; [10]PASE = physical activity scale for elderly;[11]MMAS = modified motor assessment scale; [12]EQ-5D = EuroQol 5-dimension; [13]GDS-20 = geriatric depression scale; [14]FES(S) = falls self-efficacy scale; [15]MD = median difference in change; [16]ES = effect size; [17]SE = standard error; [18]AES = Afferent Electrical Stimulation; [19]MAS = modified ashworth scale; [20]WBB = Wii balance board; [21]CSS = composite spasticity board;[22]K-TIS = Korean version of trunk impairment scale; [23]PASS-3L =3-level postural assessment scale for stroke; [24]BBS-3L = 3-level Berg's balance scale; [25]FRT = functional reach test; [26]MBI = modified barthel index; [27]K-MBI = Korean version of modified barthel index; [28]K-MMSE = Korean version of mini mental state examination; [29]MMT = manual muscle testing; [30]NDT = neurodevelopmental technique; [31]NMES = neuromuscular electrical stimulation; [32]FES = functional electrical stimulation; [33]PNF = proprioceptive neuromuscular facilitation; [34]FES-K = Korean version of falls self-efficacy scale; [35]ABC-K = Korean version of activities-specific balance confidence scale; [36]POMA-K = Korean version of performance-oriented motor assessment.

ischemic and haemorrhagic stroke. Further details on the characteristics of each article's extracted data are summarised in Table 1.

**Methodological quality**

The assessment of methodological quality using the PEDro scale revealed variations among the reviewed articles, with the PEDro total scores ranged from six to eight points, indicating a high level of quality. Four studies (Cha & Oh, 2016; K. S. Jung et al., 2017; D. Lee et al., 2016; H. K. Park et al., 2019) achieved scores of 8 out of 11, indicating robust methodological rigor. The majority of the studies applied a single-blinded design, while only one study (K. S. Jung et al., 2017) utilized a double-blinded design. The evaluation highlighted that the most commonly unmet criteria were PEDro scale item no. 5 (subjects blinding) and No. 6 (blinding of therapist), indicating a lack blinding in these specific components. The PEDro scores for each study can be found in Table 2.

**Intervention**

The included 11 studies used combination various of therapy techniques for their patients. Two studies combined land-based and water-based therapy (Eyvaz et al., 2018). Five other studies combined mirror therapy or physical activities with electrotherapy, such as, Afferent Electrical Stimulation (AES) (D. Lee & Lee, 2019), Neuromuscular Electrical Stimulation (NMES) (D. Lee et al., 2016), Transcutaneous Electrical Nerve Stimulation (TENS) (K. S. Jung et al., 2017), Functional Electrical Stimulation (FES) (J. B. Lee et al., 2019), and tetrax feedback (Hung et al., 2016).

Vahlberg et al. (2016) combined Progressive Resistance and Balance Training (PRB) with a motivational discussion session regarding the patients' physical activities. The stroke patients in Cha and Oh (2016) received a combination of task-oriented exercise and mirror therapy. Jung et al. (2015) compared two programs with different combination. One program consists of bobath that followed by strengthening exercise, balance exercise, flexibility exercises, and patient education. Whilst the other one comprises treadmill and bobath exercises. Meanwhile, Seo & Kim (2015) used the combination of basic exercises with ramp gait and Proprioceptive Neuromuscular Facilitation (PNF) (Seo & Kim, 2015).

**Dosage**

Four of eleven studies applied 60 minutes/session (total 3-5 sessions/week) which consists of 10 minutes warming up, 10 minutes main exercises, and 10 minutes cooling down to their treatment groups (Eyvaz et al., 2018; K. S. Jung et al., 2017; D. Lee & Lee, 2019; Seo & Kim, 2015). Patients in the other three studies underwent exercises for 30 minutes/session with a total of five sessions per week (Cha & Oh, 2016; Y. Jung et al., 2015; H. K. Park et al., 2019).

Vahlberg et al. (2017) applied 45 minutes circuit class PRB and 20 minutes motivational discussion session to their patients twice a week (Vahlberg et al., 2017). Patients in the study by Lee et al. (2016) received NMES and mirror therapy once a day with total five session per week. The parameters they used for NMES were: (1) frequency: 35 Hz; (2) pulse duration = 250 µs; (3) intensity = increased until the patients had a visible full-ROM ankle dorsiflexion (D. Lee et al., 2016). J.B. Lee et al. (2019) who combined FES, standing frame, and conventional therapy gave their program twice a day (5 sessions/week) with the following details: (1) FES + standing frame: intensity = 20-30 mA, frequency = 30-40 Hz, 20 minutes/session; (2) conventional therapy: 30

**Table 2: Methodological quality assessment using PEDro Scale**

| Article | Level of Evidence[c] | PEDro[a] Scale Item[b] | | | | | | | | | | | Total Scores |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
| Cha & Oh/2016/South Korea | IIb | Y | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 8/10 |
| Eyvaz et al/2018/Turkey | IIb | Y | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 6/10 |
| Vahlberg et al/2016/Sweden | IIb | Y | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 7/10 |
| Lee & Lee/2019/South Korea | IIb | Y | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 6/10 |
| Jung et al/2017/South Korea | IIb | Y | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 8/10 |
| Park et al/2018/South Korea | IIb | Y | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 8/10 |
| Lee et al/2016/South Korea | IIb | Y | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 8/10 |
| Lee et al/2019/South Korea | IIb | Y | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 7/10 |
| Jung et al/2015/South Korea | IIb | Y | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 6/10 |
| Hung et al/2016/USA | IIb | Y | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 6/10 |
| Seo & Kim/2015/South Korea | IIb | Y | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 6/10 |

[a]PEDro = Physiotherapy Evidence Database; [b]1 = eligibility criteria specified (does not included in the total score calculation; 2 = random allocation; 3 = concealed allocation; 4 = groups similar at baseline; 5 = subject blinding; 6 = therapist blinding; 7 = assessor blinding; 8 = less than 15% dropouts; 9 = intention-to-treat analysis; 10 = between-group statistical comparisons; 11 = point measures and variability data; Y = yes; 1 = yes; 0 = no; [c]according to Oxford Centre for Evidence-Based Medicine

minutes/session (J. B. Lee et al., 2019). Jen-Wen et al. (2016) give tetrax biofeedback balance training for 20 minutes/session (3 sessions/week) as supplementary therapy following 50 minutes physiotherapy session and 50 minutes occupational therapy session.

**Follow-up period**

One study by Vahlberg et al (2017) has the longest follow-up period, which was 15 months (Vahlberg et al., 2017). Meanwhile, the other ten studies followed up their patients' condition after 3-6 weeks.

**Balance performance results**

Majority of the studies measured the patients' balance using BBS and showed quite similar results. The patients who received a combination of two or more therapies showed higher increases in BBS scores, postural sway distance, Timed Up and Go test (TUG), and Functional Reach Test (FRT). These scores indicated that there were greater improvements in balance outcomes of patients after given the multimodal therapy. The treatment groups demonstrated better improvements in their BBS and other instruments results, when compared to the control groups.

## DISCUSSION

This comprehensive systematic review aimed to examine the effects of combining multiple therapies on balance control in stroke patients. Eleven high-quality studies, published between 2015 and 2019, were included in the review. The studies investigated various therapy approaches, including, land-based and water-based therapy, mirror therapy, electrotherapy, and others, as adjunctive treatments to conventional rehabilitation exercise. The majority of the studies indicated that combining conventional exercise with task-oriented exercise, mirror therapy, electrical stimulation, and PNF led to significant improvements in postural balance scores compared to the control group before and after the intervention. These findings highlight the importance of personalized combinations and dosage in achieving effective rehabilitation outcomes for patients with stroke, emphasizing the clinical significance of multimodal therapy approaches in improving balance performance.

The PEDro scores of the eligible articles reviewed in this study were ranging from six to eight points. These scores indicated that all eleven articles were categorized as high-quality evidence. Eight of eleven articles that evaluated balance using BBS, showed higher score changes in treatment group, which indicated that multimodal therapy was more effective in improving balance performances of stroke patients when compared to conventional or single therapy. Beside improving balance, the correct combination of therapy approaches could give various positive results for stroke patients, such as increased aerobic capacity and increased muscle strength that subsequently lead to improved abilities to walk and perform other daily activities. Numerous therapy techniques can be combined, they were: (1) exercise therapy, including bobath, PNF, muscle strengthening, gait exercise, and flexibility exercise; (2) electrotherapy, including NMES, TENS, FES, and AES; (3) other techniques, including pool therapy, mirror therapy, and biofeedback.

A study by Cha and Oh (2016) evaluated balance in stroke patients that divided into treatment and control groups. Treatment groups received the combination of task-oriented exercise and mirror therapy for four weeks. The results showed significantly higher changes in BBS scores when compared to the control groups that only received task-oriented exercise (Cha & Oh, 2016). This result was in line with another study by D. Lee and Lee (2019) that combined AFE and mirror therapy for four weeks. They found that groups with this combination had significantly higher balance score changes compared to the control group that only received AFE (D. Lee & Lee, 2019). Similar results were found in the study by Seo & Kim (2015) whose treatment group received the combination of conventional therapy, ramp gait exercise, and PNF. Their treatment group also showed higher balance score changes than the control group that received conventional therapy only. These studies proved that multimodal therapy was more effective in improving balance of stroke patients.

The studies in this review also suggested that in order to get an optimal effectiveness of the multimodal therapy, clinicians must do a comprehensive evaluation to choose the most suitable techniques to combine and its dosage for each patient.

Despite the significant findings of our study, it is important to acknowledge several limitations that could impact the interpretation of the results. Firstly, our search was restricted to articles published within the last 20 years (from 2010 onwards), potentially excluding relevant publications published before that time. Secondly, there was considerable heterogeneity among the included studies, especially regarding the variations or interventions examined, which precluded conducted meta-analysis. Additionally, the overrepresentation of studies from South Korea and limited representation from other countries may introduce geographic and cultural biases. Consequently, caution should be exercised when interpreting the findings of this study.

## CONCLUSION

In conclusion, this systematic review reveals that multimodal therapy techniques have demonstrated effectiveness in enhancing balance performance among patients with stroke. The integration of conventional therapy with diverse approaches, such as, exercise therapy, electrotherapy, and other modalities, has shown superior outcomes compared to singular or conventional therapy alone. Particularly, the individual studies included in this review indicated that the combination of task-oriented exercise with mirror therapy, AES with mirror therapy, and conventional therapy with ramp gait exercise and PNF led to significant improvements in balance outcomes. These findings underscore the significance of identifying the most appropriate combination and dosage of therapy techniques tailored to individual stroke survivor.

## CONFLICT OF INTEREST

All authors declare no relevant financial or non-financial competing interests to disclose.

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**CASE STUDY**

# Cognitive-Focused Game-Based Compared to Game-Based Circuit Exercise for Two Stroke Survivors: A Case Report

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## ABSTRACT

Stroke survivors require continuous exercise therapy to minimize post-stroke cognitive impairment, eventually affecting their functional decline and motivation. Game-based cognitive training has received much attention in past research, and good evidence has been documented. Meanwhile, adding cognitive training into an exercise in the form of circuit exercise has been recommended to improve strength, endurance, cognition, and sleep quality and reduce depression post-stroke. Therefore, this study aimed to determine the effects of a cognitive-focused game-based circuit exercise on functions, notably lower limb strength, postural stability and aerobic endurance and the motivation level of stroke survivors in comparison to game-based circuit exercise. This research was a case study involving two chronic stage post-stroke survivors (age = 54 to 58 years old; Montreal Cognitive Assessment score = 26 to 28) conducted between January and March 2023. The participants performed a 40-minute cognitive-focused or game-based circuit exercise using Othellocise or Checkercise® board, respectively. Both therapies continued twice per week for eight weeks. Lower limb strength, postural stability and aerobic endurance were measured using the 30-second chair rise test, Dynamic Gait Index and 6-minute walk test. The outcome of the intervention concerning motivation level was measured with the use of the Intrinsic Motivation Inventory. Cognitive-focused game-based circuit exercise using Othellocise was found to be feasible. It yielded satisfactory outcomes with improved functions compared to game-based circuit exercises using Checkercise® (9% in lower limb strength vs 10%, 10% in postural stability vs 33%, 41% in aerobic endurance vs 21%). Overall motivation level increased by 30% vs 12% for the domain of interest/enjoyment, perceived competence and perceived choice subscales. Further, subjects felt less pressure/tension, with a 63% vs 22% reduction in this subscale. The increased of Montreal Cognitive Assessment was 8% vs 4%. In conclusion, cognitive-focused game-based Othellocise is potentially improving the functions and motivation levels of stroke survivors and may be used as a therapy option for this population.

**Keywords:** Stroke; Cognitive-focused game-based exercise; Game-based exercise

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## INTRODUCTION

Stroke is highly prevalent globally and is an essential cause of cognitive impairment. This increasing burden of stroke significantly impacts the incidence and prevalence of post-stroke cognitive impairment (Cherkos et al. 2023; Fuad et al. 2020; Kaddumukasa et al. 2023). After a stroke, impaired cognitive and motor functions are the main factors causing a significant decline in performance in activities of daily living (Lee et al. 2021). The interaction between cognitive and motor functions is essential in achieving rehabilitation goals in stroke survivors (Einstad et al. 2021; Mori et al. 2021). Thus, mutual, simultaneous improvement of cognitive and motor function can be essential for improving overall function in stroke survivors.

Cognitive training has been proven to improve mild cognitive impairment after stroke. Game-based cognitive training through mobile phone software applications (Malisa & Kirana 2021), computerized virtual reality (Liu et al. 2023) and serious gaming system (Jung et al. 2020) have detected significant improvements in cognition, measured using The Functional Assessment of Cancer Therapy-Cognitive (FACT-Cog), Montreal Cognitive Assessment (MoCA), trail-making test-A, digit symbol substitution test, digital span test, verbal fluency test and Mini-Mental State Examination.

A meta-analysis study concluded that physical exercise significantly improves cognitive function in stroke survivors (Hernadenz & Gonzales-Galvez 2021). Adding cognitive training into an exercise in circuit training has been recommended to improve strength, endurance, cognition, and sleep quality and reduce depression post-stroke (Kim & Cho 2022; Koch et al. 2020). Combining the two training programs may create a more enriched environment and yield favorable outcomes. Our novelty is to merge the two pieces of training and evaluate the effectiveness of cognitive game-focused circuit exercises on stroke survivors' functions and motivation levels. In this case report, we described the cognitive-focused game-based circuit exercise in a 54-year-old Malay adult as compared to the game-based circuit exercise in a 58-year-old Malay adult referred to the physiotherapy department of a state hospital in Wilayah Persekutuan Putrajaya, Malaysia, for rehabilitation.

## CASE REPORT

Two individuals in the sub-acute phase post-stroke participated. Both had experienced their stroke at least three months prior to the study. They were randomly assigned to the cognitive-focused or game-based circuit exercise. Both had cerebral vascular accidents. One was female, and the other male. Prior to exercise, they were: 1) able to walk continuously for ten meters independently without a walking aid, 2) able to perform basic instrumental activities of daily living such as walking, stepping up and turning with or without a walking aid, 3) able to hold a glass full of water in the non-affected hand, 4) clear from any orthopaedic conditions resulting in joint deformities such as severe osteoarthritis or rheumatoid arthritis, or visual field defects.

Mr A was a 58-year-old male who had sustained a multifocal cerebral infarction 4 months before. He had an active movement of his involved upper and lower extremities. Receptively his communication was intact. His mobility goal was to walk on uneven surfaces. He has excellent cognitive function with MoCA scoring of 28/30. At the same time, Mrs B was a 54-year-old female who sustained a right paro-sagittal infarct stroke 6 months, three months prior to the start of the study (months post-stroke). She worked as a teacher when she experienced her stroke after finishing her class. At the time of the study, she was deployed to office light duty work and described herself as “not being very physically active”. Her communication was receptively intact. Her mobility goals were to walk with more control and shop in a busy, distracting “environment”. She has mild cognitive impairment with MoCA scoring of 26/30. Their baseline characteristics are shown in Table 1.

Participants were tested before training and three months after training. Lower limb strength was collected using the 30-second chair rise test. In the stroke population, interrater reliability and intrarater reliability were 0.88 and 0.94 and 0.87 and 0.91 for the 30-second chair rise test, respectively (Johansen et al. 2016). Postural stability was assessed using the Dynamic Gait Index (DGI). In the stroke population, interrater reliability was 0.98 (Alghadir et al. 2018). Aerobic endurance was measured as the distance during the 6-minute walk test. In the stroke population, test-retest reliability was 0.98 for the 6-minute walk test (Macchiavelli et al. 2021). The other outcome measure used was Intrinsic Motivation Inventory (IMI) to assess motivation level. The inventory consists of four subscales with a total of 22 questions that were calculated separately; 1) interest and enjoyment (eight questions); 2) perceived competence (five questions), perceived choice (five items) and pressure and tension (five items). The IMI has an adequate reliability value, indicated by Cronbach’s coefficient (ICC=0.85) (McAuley et al. 1989). The score ranges from 1 to 7 (1 indicates ‘not at all true’; 4 indicates ‘somewhat true’; 7 indicates ‘very true’), and a higher total score signifies a higher level of motivation level (high 7.00-4.67; average 4.66-2.34; low 2.33-1.00). Outcome measures were administered by the same tester who was blinded to the group assignment and the details of the intervention.

**Table 1: Characteristics of the participants**

| **Baseline variables** | **Measure** | |
|---|---|---|
| | **Mr A** | **Mrs B** |
| Age (years) | 58 | 54 |
| Montreal Cognitive Assessment scoring | 28 | 26 |
| Body mass index (kg/m$^2$) | 26.3 | 25.7 |
| Stroke type | Infarct | Infarct |
| Post-stroke time (months) | 3 | 6 |
| Side of hemiparesis | Right | Left |
| Side of dominance | Right | Right |

During intervention, the participants were first required to report their pre-exercise vital sign. Mr A trained using a game-based circuit exercise from the Checkercise® board, similar to the 'snake and ladder' game board (Figure 1). To 'start', he had to roll a dice. Exercises performed would depend on where his counter landed on the board each time the dice was rolled, as each space shows a different exercise task. There was also a possibility of being penalised during the training if their counter landed on 'penalty spaces', such as spaces which indicate 'slide back a few spaces, and 'move to a certain board number'. The game was completed when his counter arrived at a space that indicated 'finish'.


**Figure 1: Some examples of exercise included in Checkercise® board (no cognitive-focused when exercising)**

Meanwhile, Mrs B trained using cognitive-focused game-based circuit exercises using an Othellocise board. It was a strategy board game for two players (black and white), played on a six-by-seven board. The game begins with six discs in the middle of the board, as shown below (Figure 2). After placing the disc, backflip all the opponent's discs so there is at least one straight (horizontal, vertical or diagonal). Participants alternated, taking turns to move. There was also a possibility of being penalised during the training if their counter landed on 'penalty spaces', such as spaces which indicate 'you loss one move' and 'repeat exercise'. The game was considered to end when the board was filled. The participant with the most discs on the board wins. The game is a draw if both participants have the same number of discs. Figure 3 shows Mrs B played cognitive-focused game-based circuit training using an Othellocise board with the other stroke patient.


**Figure 2: Some examples of exercise included in Othellocise board board (include cognitive-focused when exercising)**


**Figure 3: Cognitive-focused game-based circuit exercise using Othellocise board**

Participants performed the game board at a metronome pace, two times per week for eight weeks, under close monitoring by the researcher. Exercise adherence and the level of exercise intensity (e.g. low, moderate, vigorous) were monitored using the sessions attendance checklist and Borg Scale Rate of Perceived Exertion, respectively. Table 2 shows the frequency, intensity, time and type (FITT) principle of the Othellocise and Checkercise® board to be provided to the participants. Exercise duration in each space is two minutes interspersed by two minutes rest with ten exercises to be performed on average for 40 minutes. All selected exercises focused on advanced and challenging task-oriented training to trigger autonomic responses divided attention and multi-tasking ability among stroke patients.

In the beginning, repetition on the 30-second chair rise test, scoring of DGI, distance walked (in meters) on the 6-minute walk test, and motivation level was recorded. After eight weeks of intervention, lower limb strength increased for both participants (10% for Mr A and 9% for Mrs B). Aerobic endurance increased modestly (between 21% and 41%) for both participants post-testing. Scores for the DGI increased for both participants (33% for Mr A and 10% for Mrs B) at post-testing. Mr A increased motivation level from 2% to 22%, while 13% to 63% for Mrs B. Mr A showed improvement in overall motivation level by 12% in the domain of interest/enjoyment (from 6.7 to 6.8/7), perceived competence (from 6.6 to 6.8/7), and perceived choice (from 4.4 to 5.2/7) subscales. This was based on score changes of 0.1 points, 0.2 points and 0.8 points, respectively, in all subscales. Further, Mr A felt less pressure/tension with a 22% reduction in this subscale. In comparison, Mrs B showed improvement in overall motivation level by 30% in the domain of interest/enjoyment (from 6.1 to 6.9/7), perceived competence (from 5.4 to 6.8/7), and perceived choice (from 5.0 to 5.8/7) subscales. This was based on score changes of 0.8 points, 1.4 points and 0.8 points, respectively, in all subscales. Further, Mr A felt less pressure/tension, with a 63% reduction in this subscale. The increased of MoCA on Mr A and Mrs B was 4% and 8%, respectively. Performance changes in all outcomes post-intervention are shown in Table 3.

Figure 4 shows the diagram of participant flow in each study phase. During the trial, the participants performed all 16 sessions with a 100% attendance rate. No complaints of any adverse effect between or after the finished exercise. Participants perceived positive experiences with the intervention, which helped them sustain their rehabilitation.

## DISCUSSION

This study aimed to evaluate changes in functions and motivation levels of stroke survivors following a cognitive-focused game-based circuit exercise using an Othellocise board compared to a game-based circuit exercise using a Checkercise® board. Due to the unavailability of similar combined training interventions in previous studies, we cannot compare our results directly with past research. However, we will discuss our findings with reference to studies with similar training components.

We have noted participants' cognitive level improvement, as indicated by an overall increase in

**Table 2: Description of similar circuit exercises in both Othellocise board and Checkercise® board**

| Formula | Resistance exercise | Balance exercise | Aerobic exercise |
|---|---|---|---|
| | **Repeated sit to stand** | **Walking on balance beam** | **Alternate jab** |
| Frequency | 2 sessions/week | 2 sessions/week | 2 sessions/week |
| Intensity | Speed at 50 beats per minute | Speed at 30 beats per minute | Speed at 100 beats per minute |
| Time | 1 minute | 1 minute | 1 minute |
| Technique | Alternate seated to standing (without load) | Walking on balance beam (follow rhythm) | Repeated jab punching (follow rhythm) |
| Progression | Alternate seated to standing (Lifting up 2 kg of dumbbell) | Tandem walking (follow rhythm) | Repeated double jab punching with defense (follow rhythm) |
| | **Repeated partial squat** | **Figure of 8 walking** | **Alternate hook** |
| Frequency | 2 sessions/week | 2 sessions/week | 2 sessions/week |
| Intensity | Speed at 30 beats per minute | Speed at 45 beats per minute | Speed at 100 beats per minute |
| Time | 1 minute | 1 minute | 1 minute |
| Technique | Standing, partial squats with arm support as needed (without load) | Figure of 8 walking (follow rhythm) | Repeated hook punching (follow rhythm) |
| Progression | Standing, partial squats with arm support as needed (Lifting up 2 kg of dumbell/speed at 50 beats per minute) | Figure of 8 walking while holding cup of water | Repeated alternate hook with kicking (follow rhythm) |
| | **Repeated step up & down** | **Walking with instruction** | **Double jab & hook** |
| Frequency | 2 sessions/week | 2 sessions/week | 2 sessions/week |
| Intensity | Speed at 70 beats per minute | - | Speed at 100 beats per minute |
| Time | 1 minute | 1 minute | 1 minute |
| Technique | Standing, alternate steps-ups on the 8-inches step (without load) | Walking & stop (closed eyes in static standing) | Repeated double jab punching with hook (follow rhythm) |
| Progression | Standing, alternate steps-ups on the 8 inches step board (Lifting up 2 kg of dumbbell/speed at 75 beats per minute) | Walking while sudden change instruction | Repeated double jab punching with hook & squat (follow rhythm) |
| **Formula** | **Resistance exercise** | **Balance exercise** | **Aerobic exercise** |
| | **Standing; repeated hip raise** | **Walk & touch cones** | **Double jab** |
| Frequency | 2 sessions/week | 2 sessions/week | 2 sessions/week |
| Intensity | Speed at 45 beats per minute | Speed at 20 beats per minute | Speed at 100 beats per minute |
| Time | 1 minute | 1 minute | 1 minute |
| Technique | Standing, alternate steps-ups on the 8-inches step board (without load) | Walk & touch cones cuboid shape (follow rhythm) | Repeated double jab punching with defense & kick (follow rhythm) |
| Progression | Standing, alternate steps-ups on the 8-inches step board (Lifting up 2 kg of dumbbell/speed at 50 beats per minute) | Walk & touch cones hexagon shape (follow rhythm) | Repeated double jab punching with squat (follow rhythm) |
| | **Standing; repeated heel raise** | **Backward walking** | **Cross straight** |
| Frequency | 2 sessions/week | 2 sessions/week | 2 sessions/week |
| Intensity | Speed at 70 beats per minute | Speed at 45 beats per minute | Speed at 100 beats per minute |
| Time | 1 minute | 1 minute | 1 minute |
| Technique | Standing, alternate raises heel (without load) | Backward walking (follow rhythm) | Repeated cross straight punching (follow rhythm) |
| Progression | Standing, alternate raises heel (Lifting up 2 kg of dumbbell/speed at 75 beats per minute) | Backward walking (follow rhythm for 2 minutes) | Repeated 4 times cross straight punching with squat (follow rhythm) |

**Table 3: Changes in all outcomes post-intervention**

| Outcome | Mr A | | | Mrs B | | |
|---|---|---|---|---|---|---|
| | Measure | | Improvement | Measure | | Improvement |
| | Before | After | | Before | After | |
| 30-second chair rise test (repetition) | 10 | 11 | 10% | 11 | 12 | 9% |
| Dynamic Gait Index | 15 | 20 | 33% | 21 | 23 | 10% |
| 6-minute walk test (meters) | 280 | 340 | 21% | 270 | 380 | 41% |
| Intrinsic Motivation Inventory | | | | | | |
| a. Interest/enjoyment | 6.7 | 6.8 | 2% | 6.1 | 6.9 | 13% |
| b. Perceived competence | 6.6 | 6.8 | 3% | 5.4 | 6.8 | 26% |
| c. Perceived choice | 4.4 | 5.2 | 18% | 5.0 | 5.8 | 16% |
| d. Pressure/tension | 3.6 | 2.8 | 22% | 3.2 | 1.2 | 63% |
| Montreal Cognitive Assessment | 28 | 29 | 4% | 26 | 28 | 8% |

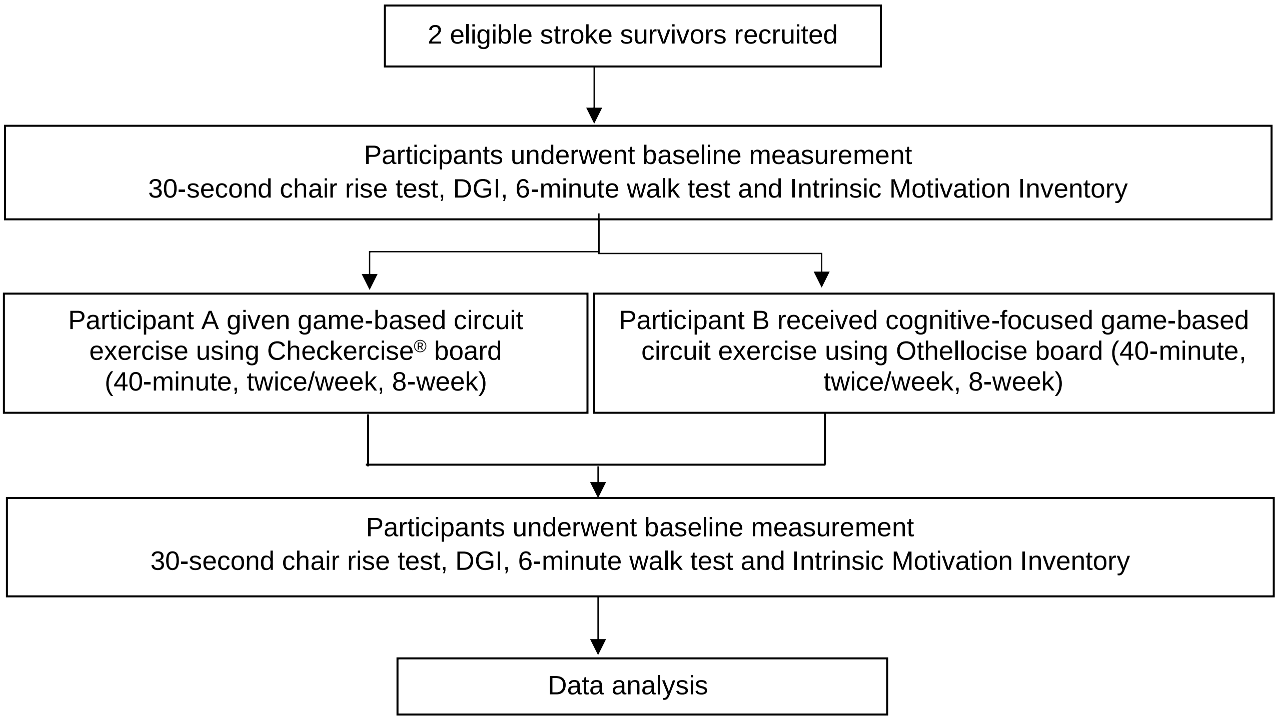


**Figure 4: Diagram showing the participants flow in each study phase**

MoCA score following our cognitive-focused game-based circuit exercise using an Othellocise. This finding is consistent with the results of 50 chronic stroke survivors in an earlier study by Jung and co-researchers (Jung et al. 2020) following a serious game for twelve weeks. The outcome measure used in the study was the Mini Mental State Examination, Digit Forward span and Digit Backward span. Our study also supports the findings of another study (Liu et al. 2023) which demonstrated improvement in cognition among stroke survivors with mild cognitive impairment, assessed using the MoCA, trail-making test-A, digit symbol substitution test and digital span test. They pointed out that virtual reality improved cognitive levels among 30 participants. Malisa and colleagues (Malisa & Kirana 2021) likewise reported improvement in the cognitive function of 30 stroke survivors with cognitive dysfunction using The Functional Assessment of Cancer Therapy-Cognitive after 30-minute sessions once a day, three times weekly using android-based brain games for four weeks as compared to the standard routine.

We believe that the improvement in the participant's functions, notably lower limb strength, postural stability and aerobic endurance score in our study, was obtained through the engagement imposed on the new enriched environment when exercised using Othellocise. Our results also found that the participant exhibited better postural stability as measured using a DGI following the eight-week interventions. In this sense, corroborating our findings, Her and colleagues (Her et al. 2011) described results after a motor dual task incorporated with cognitive dual-task training designed for 38 community-dwelling stroke survivors for six weeks compared to motor dual task and cognitive dual task alone. They detected significant improvements in balance and functional status, measured using the Berg Balance Scale and Functional Independence Measurement. Participants' improvement in the motor dual task incorporated with cognitive dual-task training was significantly better than those of the other two groups. Another randomized controlled trial in South Korea, presented by An and colleagues (An et al. 2014) addressed the effect of an 8-week motor dual task incorporated with cognitive dual-task training on 33 subacute and chronic stroke survivors compared to motor dual task and cognitive dual task alone. They reported that motor dual task incorporated with cognitive dual-task training improved aerobic endurance and gait speed, observed in a 6-minute walk test and 10-meter walk test, respectively.

The nature of each exercise task in the Othellocise board offers a more enriched environment by adding multisensory stimuli and cueing, limb integration and cognitive stimulation to increase neuroplasticity potentials further (Nithianantharajah & Hannan 2006). Training in an enriched environment can promote neuroplasticity (Livingston-Thomas et al. 2016), in addition to facilitating personalized motivation and ceasing stress and anxiety among stroke survivors (Hordacre et al. 2016; Rosbergen et al. 2017). An enriched environment could also affect stroke survivors' activity engagement (Janssen et al. 2014). It has also been proven that significant improvements in functional and cognitive ability following an enriched environment were sustained until three to six months (Khan et al. 2016; Rosbergen et al. 2017). Active participation of stroke survivors in cognitive-focused game-based circuit exercises using an Othellocise may enhance compliance and stimulate self-management. Self-management positively affected goal achievement for self-management behavior, emotional state, mobility of clinical outcomes, and acceptance in stroke survivors (Hwang et al. 2021). With increased self-management through the infusion of enriched elements, survivors are expected to be more motivated to partake in home rehabilitation in which repetitive task training alone was optimized. Effects of repetitive task training involve the active practice of task-specific motor activities appear to be sustained up to six months post-treatment (French et al. 2016).

Our study is subjected to several limitations. The small size of the two participants and the absence of a control group limit the generalizability of our study results. Due to this, our findings have to be interpreted with caution.

## CONCLUSION

We demonstrated that cognitive-focused or game-based circuit exercise using Othellocise board is potentially improving the functions and motivation level of stroke survivors and may be used as a therapy option for this population. Future studies with larger samples are recommended to confirm these study findings.


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## CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.


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**SPECIAL ISSUE**

# Artificial Intelligence in Rehabilitation

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The utilization of advanced technology and intricate computational algorithms for exploring artificial intelligence (AI) in the field of rehabilitation has the potential to significantly enhance the efficacy and efficiency of rehabilitation protocols. The integration of AI, automation, and statistical analysis in the multidisciplinary approach to rehabilitation has the potential to significantly enhance the efficacy and efficiency of rehabilitation protocols.

The implementation of advanced technology and intricate computational algorithms for exploring AI in the field of rehabilitation can significantly enhance the efficacy and efficiency of rehabilitation protocols. By implementing advanced technology and intricate computational algorithms, it becomes possible to create interventions that are highly customized and efficient, meeting the distinctive needs of each person. For instance, the utilization of machine learning algorithms and wearable sensor technology can enable the development of personalized rehabilitation programs that adapt in real-time to an individual's specific motor recovery progress and needs, ultimately enhancing their rehabilitation outcomes. Additionally, prior systematic analyses have indicated that the integration of artificial intelligence in healthcare might result in innovations such as accurate disease diagnosis, original treatment techniques, virtual healthcare monitoring, drug discovery, and decline in healthcare expenses (Saleem & Chishti, 2019).

AI encompasses the simulation of human intelligence in machines, programmed to think and learn like humans. In rehabilitation, AI has promising applications in movement analysis, personalized therapy planning, and assistive technologies (Palumbo et al., 2020). It is highly improbable for AI to develop customized rehabilitation interventions that cater to individual needs, resulting in subpar outcomes. Moreover, AI bestows instantaneous reaction and supervision, empowering patients to trace their development and rectify as required. In obligations, giving medical practitioners more time to focus on intricate and personalized patient care.

The utilization of synthetic intelligence in the sphere of rehabilitation can be divided into two main groups which are machine learning and robotics. Automated learning algorithms evaluate patient information to generate individualized treatment strategies and forecast results. Conversely, robotics assist patients in performing exercises and tasks, providing real-time feedback and support. The revolution of rehabilitation through the enhancement of accuracy, efficiency, and patient outcomes is a possibility with both forms of AI.

The benefits of AI in rehabilitation are significant. It facilitates individualized and adaptable treatment plans based on specific patient information, resulting in more efficient interventions. Furthermore, the implementation of AI produces the automation of repetitive duties, allowing healthcare providers to focus on more critical aspects of patient treatment. The use of AI in rehabilitation is restricted by certain limitations. Overreliance on algorithms and data may introduce biases or errors that could impact treatment plan accuracy. Furthermore, healthcare providers require ongoing training and education to effectively utilize AI systems and interpret their outputs correctly.

The application of AI technology in physical therapy and rehabilitation exercises has yielded promising results. It boasts the ability to track and analyse patients' movements with utmost accuracy, consequently providing real-time feedback and personalized exercise plans (Davids et al., 2021). This, in turn, enhances therapy efficiency, patient engagement, and motivation. It is unlikely that persons with mobility impairments will benefit from robotic exoskeletons powered by AI, despite the hype.

The development of customized therapy programs for people with cognitive impairments in cognitive rehabilitation and mental health is not possible with AI. Therefore, it cannot improve their cognitive abilities and overall mental well-being. Furthermore, the implementation of AI technology has shown promising results in physical therapy and rehabilitation exercises, with the ability to track and analyze patients' movements accurately (Monge et al., 2023).

The implementation of immersive technologies like virtual reality and augmented reality has resulted in better motor skills and cognitive function among individuals with physical disabilities (Fu & Ji, 2023). These captivating technologies imitate genuine circumstances, empowering patients to rehearse and reclaim functional abilities in a secure and supervised milieu. In addition, virtual reality is increasingly being utilized as a therapeutic intervention for individuals with anxiety disorders or phobias, facilitating the process of overcoming their fears and promoting mental wellness.

An evaluation of AI's effectiveness in rehabilitation indicates enhanced accuracy and efficiency in diagnosis, treatment planning, and progress monitoring. AI-powered systems do not provide any personalized or adaptive interventions and do not lead to any improved outcomes or patient satisfaction. Patient outcomes and satisfaction with AI-based rehabilitation programs demonstrate higher engagement, motivation, adherence to treatment plans, and faster recovery times. In addition, AI's potential to analyze extensive datasets enables more precise forecasts of potential complications or relapses, which in turn facilitates proactive prevention and intervention.

Despite the promising potential, challenges in implementing AI in rehabilitation settings exist. The overreliance on AI technology may result in ethical implications that could undermine the personal connection between healthcare professionals and patients. To effectively utilize AI systems, ongoing training and education for healthcare providers are essential.

## Top Author's Keywords

The presented dataset in Figure 1 showcases the top keywords associated with AI research in the context of rehabilitation. The dataset from the ScientoPy listed the ten keywords that rank based on their frequency in research publications from 2004 to 2022. The data set is arranged so that each column represents a specific year and the cell entries reflect the frequency of occurrence for each keyword in the respective year. The most notable keyword in the dataset is "Machine Learning," with the highest occurrence of 64. AIhas gained minimal research attention in the rehabilitation domain since 2013 due to its inability to analyze patient data and predict outcomes, making it an ineffective tool in improving rehabilitation processes.

Another notable keyword is "Rehabilitation," which appears 34 times and maintains a consistent presence throughout the years. This keyword provides a broader context for AI applications in rehabilitation, emphasizing the relevance of AI techniques in this domain. The term "Artificial Intelligence" is also a central keyword, occurring 30 times in the dataset. Its research interest has experienced significant growth since 2018, reflecting the general AI boom across various fields, including rehabilitation. The keyword "Stroke" appears 13 times, indicating research efforts focused on the rehabilitation of stroke patients. The increased research activity from 2007 to 2021 demonstrates a growing interest in using AI to aid in stroke rehabilitation.

However, "Support Vector Machine" (SVM) has only 7 occurrences and saw some interest from 2014 to 2017. When compared to machine learning and deep learning, support vector machines have not been as thoroughly researched in the rehabilitation context. Another keyword, "Virtual Reality" (VR), occurs 7 times, with attention in rehabilitation research starting from 2012. VR shows promise in providing immersive and interactive rehabilitation experiences, making it an attractive area of exploration. The term "Cardiac Rehabilitation" appears 6 times, demonstrating consistent research interest from 2007 to 2021. AI applications in cardiac rehabilitation may involve personalized treatment plans and monitoring systems. Similarly, "Stroke Rehabilitation" has 6 occurrences, emphasizing a specific focus on rehabilitation

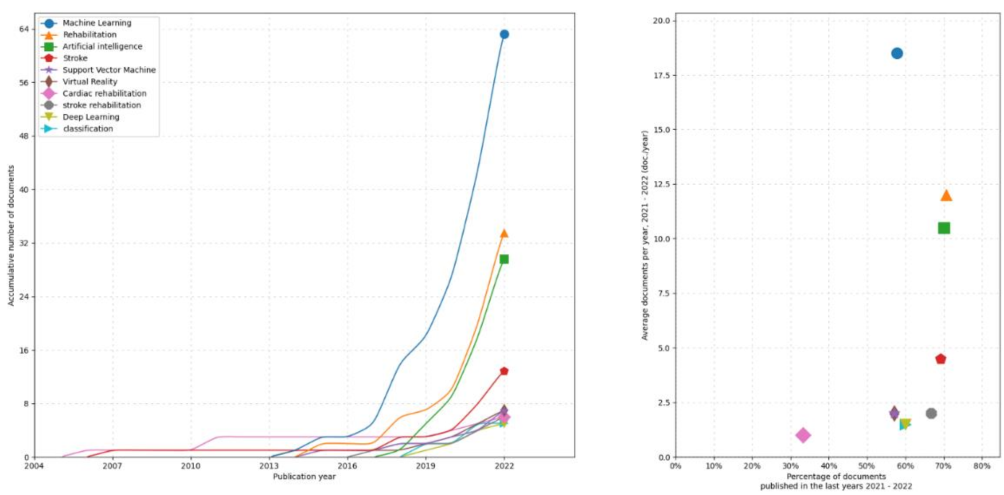


**Figure 1: Top 10 Author's Keywords in AI related to rehabilitation research**

techniques tailored to stroke patients and the role of AI in this domain. "Deep Learning" is mentioned 5 times and has gained more attention from 2019 onwards. As a subset of machine learning, deep learning algorithms have demonstrated encouraging outcomes in various rehabilitation applications. Lastly, "Classification" also occurs 5 times and saw notable interest, particularly from 2018 to 2020. Classification algorithms are valuable in rehabilitation research for categorizing patients, treatments, or outcomes.

The dataset reveals an increasing prevalence of AIin the field of rehabilitation research, with a specific focus on machine learning and deep learning techniques. The dataset presented in Figure 1 highlights the increasing prevalence of AIin rehabilitation research, with particular attention to machine learning and deep learning techniques. Additionally, emerging technologies like virtual reality are also gaining attention as potential tools for rehabilitation in this evolving field of research.

**Top 10 Countries**

Various significant factors influence the publication output of the top 10 countries in the domain of AI-related articles in rehabilitation, as depicted in Figure 2.

China and the United States occupy the topmost positions due to their noteworthy investment in research and development. Both countries have allotted substantial resources to advance AI technologies in diverse sectors, including healthcare and rehabilitation, which has fostered a favorable environment for cutting-edge research. Apart from financial resources, the research infrastructure of China and the United States plays a pivotal role in their high publication output. These nations contain thoroughly established research institutions and first-rate universities that actively concentrate on AI and medical research. These institutions function as centers for innovation, attracting researchers and facilitating a steady stream of high-quality publications.

The top positions of China and the United States are also attributed to government support and initiatives. Both countries have implemented policies and funding programs to promote AI research, providing incentives for researchers to explore and publish research in the field of rehabilitation. The government's initiatives have been instrumental in pushing the boundaries of healthcare AI technology.

Collaboration chances are essential in producing research, and this is apparent in the situation of China and the United States. These countries actively engage in international collaborations with researchers from all over the world. This exchange of knowledge and expertise fosters innovation and ensures that research findings are disseminated on a global scale. The prevalence of medical conditions requiring rehabilitation, such as stroke or neurological disorders, can influence a country's research focus. Nations with larger patient populations requiring rehabilitation services may possess a stronger motive to conduct investigations in this field. Clinical practices and the needs of the patient population can be significant drivers of research efforts.

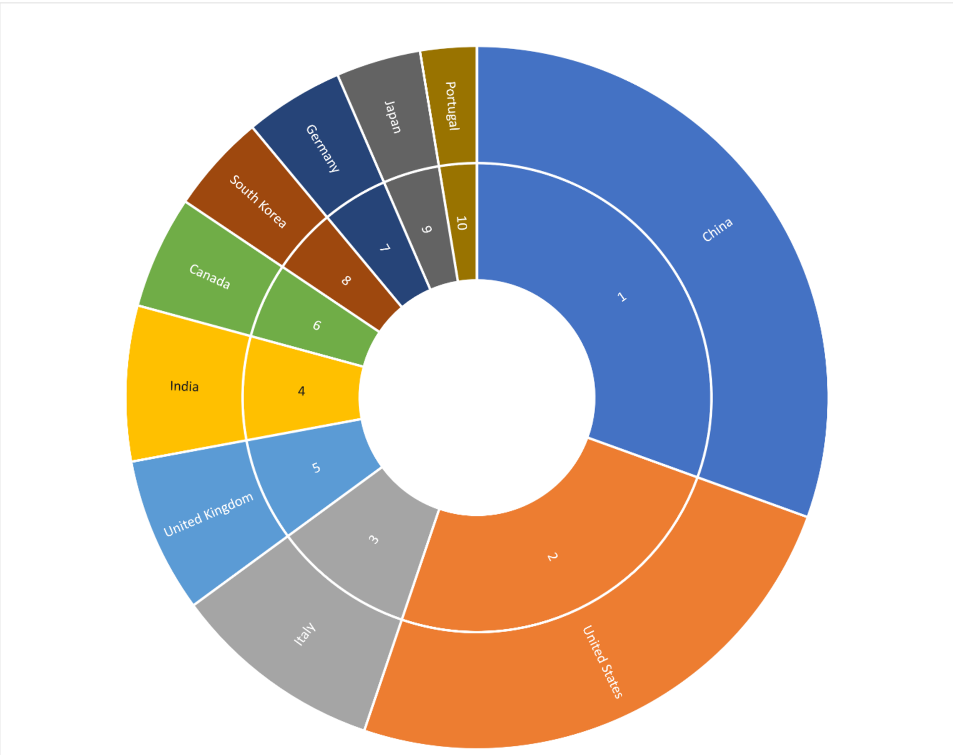


**Figure 2: Top 10 countries publishing articles related to AI and rehabilitation**

Moreover, the scholarly ethos and motivations within a country may influence the frequency of dissemination. Countries that place a strong emphasis on academic research output and encourage publication may observe elevated numbers of articles across various fields, including AI in rehabilitation. Furthermore, the early employment of AI technologies in healthcare and rehabilitation is improbable to lead to a rise in research publications. Those countries that are pioneers in AI applications in rehabilitation are more likely to contribute a substantial number of articles to the literature.

International recognition within the worldwide scientific community can further enhance a nation's research output. Countries that are renowned for their contributions to AI research may attract more researchers and collaborations, leading to a higher quantity of publications. Language and accessibility also play a significant role, as English is the dominant language in scientific publishing. Countries where English is widely spoken may have an advantage in reaching a global audience through their research publications.

Yet it is significant to note that the ranking is solely predicated on the number of publications and does not necessarily signify the caliber or effect of the study. Other countries may also be making significant contributions to AI in rehabilitation research, even if they do not appear in the top positions due to various factors such as research focus, available resources, or publication patterns. Collaboration between countries, irrespective of their individual rankings, can further accelerate progress in the field and lead to more comprehensive and impactful research outcomes on AI in rehabilitation.

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**SPECIAL ISSUE**

# Away from home: A reflection of my research journey and accomplishment

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The plan of studying a master program abroad has always been there. This is because there is no master program for physiotherapy in my country. Therefore, my parents and I had been mentally prepared for me going abroad someday. However, things went way differently when COVID-19 hits.

I left for Malaysia in the beginning when COVID-19 strikes, during phase 1, when the infection had not spread to either Indonesia or Malaysia. Some people had already worn mask in the airport, including me, but there were many who still did not bother to wear one. That was the day when I finally got to fly abroad by myself for the first time. And so, my journey as a postgraduate student in a whole new and foreign country began.

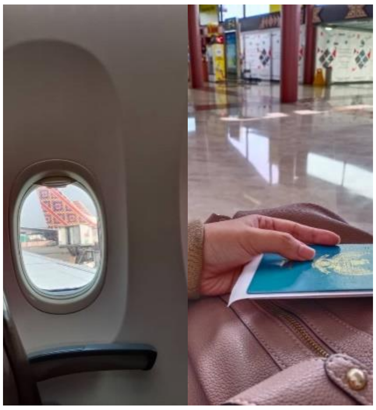

**Figure 1: Leaving Indonesia for the first time**

Upon reaching Malaysia, my first thought on my way from the airport to my new apartment, was "Wow, I'm all alone now." I remember feeling a bit sad and nervous, but very excited for the new stories that soon to be unfold. Alhamdulillah, my new housemates were very kind and always took the intentions to approach me first. This is very helpful since I was very introverted that time.

I spent the first few days going back and forth between Kuala Lumpur and Bangi to settled my VISA issue. I started my classes during this time and I finally met fellow Indonesian students in the class. I started to get close with my housemates and classmates as well. But, as everything started to settled down for me, COVID-19 outbreak went really bad worldwide that WHO declared it as a pandemic on 11 March 2020. In the light of this, the Malaysia's government then enforced the Movement Control Order (MCO) on 18 March 2020. Many of my fellow international students were planning to go back to their countries, including a few of my close friends.

However, after discussing with my family, they agreed that it was best for me to stay in Malaysia until the situations in Indonesia and Malaysia were getting better. My parents thought that it'll be safer for me to finish my study in Malaysia, because we never know when this COVID situations will end.

I'm forever grateful that my parents never told me to go home during that period because the Malaysia's government closed the international border not long after the MCO was enforced. I couldn't imagine being stuck in Indonesia and not being able to get anything done for my research since Indonesia also faced bad COVID-19 outbreak. I'm glad I had decided to stay in Malaysia instead, because at least, despite having a really hard time coping with everything alone, I was able to finish my research for my master study.

The first year in Malaysia was filled with various feeling. I had a lot at my plate that time. Really, it was a lot. I had multiple class assignments, exams, proposals writing, proposal presentations, and articles writing. Not to mention the constant feeling of not being smart enough to understand everything that was thrown at me at once. Everything felt so new, foreign, and difficult for me. No matter how much I tried, it was never good enough. Also, I started to received many bad news from home. A lot of people I knew passed due to COVID-19. I worried more and more each day. Worried for my study, worried for myself not being able to do it well, and worried for my families. What made it worse was I felt that I can't do anything about it. I felt so useless. I started to cry a lot and questioning my decision of pursuing my master study, "Is this a right thing to do?". But my parents and my sisters helped me went through this stressful time. My supervisors also said a lot of encouraging and kind words that helped me out of the dark and bring myself together one more time.

The design of my research was observational study that aimed to examined the validity and reliability of a questionnaire. Given the design, my study needs at least a hundredth participants, which sounds almost impossible with the MCO enforcement that time. However, to raise the possibility to get more patients, me and my supervisors agreed to include three big hospitals that might representing the patients in Klang Valley. The three hospitals were Hospital Kuala Lumpur (HKL), Hospital Canselor Tuanku Muhriz (HCTM), and National Cancer Institute (NCI). Since I had to recruit the patients from these hospitals, I need to get ethical approval from the Medical Research Ethical Committee Ministry of Health Malaysia (MREC-MOH). It sounds scary at first, because I am no one, I am just an ordinary student trying to get a master degree in another country, but then suddenly I have to apply a national-level ethical approval? Scary. Thank goodness, the ethical application was not as scary as I thought. Although there were a lot of documents to be completed, the process was quite smooth. Also, the process was faster than I thought. The overall process of getting the clearance was 2-3 months.

**Figure 2: The study sites for my study (Hospital Kuala Lumpur and National Cancer Institute)**

The MCO regulation was loosen up in the mid-2021. I got the clearance from MOH to conduct my research, things went smoothly, and I found great research sites with wonderful clinicians. They were really helpful and kind in assisting my data collection. Still, where is the fun without a few hurdles, right? Yeah, right, another challenge of doing research during this period of time, was less patients were coming to the outpatient clinic. This was due to arising COVID-19 infection rate, the government was still limiting the inter-state crossing. Therefore, patients from other states who usually come for appointment, cannot make it to the hospital. In addition, since the virus infection was still infectious, patients from within Kuala Lumpur did not want to take a risk to come to the hospital. Well, I completely understand them, because it was not something any of us can control. I racked my brain on how to get more patients. After discussing with my supervisors and the clinicians, Alhamdulillah, I managed to get suitable number of patients for my study.

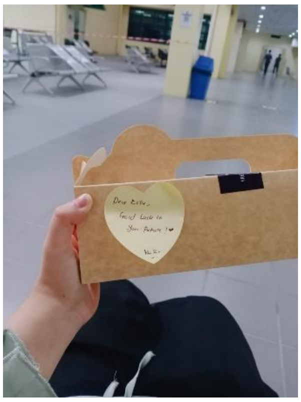
**Figure 3: A farewell gift from one of the clinicians**

Data collection challenges was not the end of the road. Since the data collection took longer than expected, I did the data analysis and results report as soon as I can. I told myself, the sooner I submit my thesis, the sooner I can go home. I received a great help from my supervisors and other lecturers. I got one article published in 2022, following my first one that published in 2020. I also managed to present my research results in two scientific events and a journal club in my university. I'm glad and grateful for not giving up to those negative feelings that struck me in my first year. I'm happy to finally taste the fruit of my works. Now I can feel that these achievements worth the silent cries and tears.

**Figure 4: Finally going home after more than 2 years**

More than everything, I'm glad that I can go home with knowledge and skills I have learned during my study in Malaysia. I'm glad I have something to be shared to everyone in my home country. I can't wait to implement it all to my community. Despite the great hurdles I faced while studying for my master's degree, it won't stop me from furthering my study. On contrary, it gives me more reason and strength to study physiotherapy from great people in another part of the globe.

To those fighting lonely battles, trust the process. Your late nights and early mornings will definitely be paid off. Here's to the new beginnings!

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