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Effectiveness of Functional Strength Training Exercises Versus Neurodynamic Exercises on Balance and Gait of patients with Diabetic Peripheral Neuropathy

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Abstract

Diabetic neuropathy is one of the long-term complications of Diabetes Mellitus. Diabetic neuropathy symptoms include pain and numbness in the legs, feet and hands, causing decreased sensation, proprioception, reflexes, and strength in the lower extremities which affects balance and gait. Various interventions which are used by the physical therapist to minimize balance dysfunction and improve Gait in people with Diabetic Polyneuropathy. Approximately 50 percent of patients with diabetes will eventually develop neuropathy which leads to impairment in Balance and Gait. The Functional Strength Training improves the intermuscular and intramuscular synchronization through the neural control, thereby increases the muscle power by functional activities. Neurodynamic is the communication between different parts of the nervous system and mobilize the peripheral nervous system, it is a physical approach to the treatment of pain. This influences pain physiology via mechanical treatment of neural and the non-neural structures of the nervous system. Both Functional Strength Training and Neurodynamic exercises have influence on improving balance, gait and reduces the risk of fall. The aim of this study is to compare the effects of Functional strength training Versus Neurodynamic exercises on Balance and Gait of patients with Diabetic Peripheral Neuropathy. 30 patients aged 40-80 years presenting with more than 7 years who were clinically diagnosed with Diabetic Peripheral Neuropathy were selected and assigned into two groups. Experimental group A received Functional Strength Training Exercises and Group B received Neurodynamic Exercises for 40 minutes, 5 days per week for a period of 4 weeks. Balance and Gait were assessed in terms of Berg Balance Scale and Functional Gait Assessment. Paired and unpaired 't-tests' were used to determine significant differences in data among groups and between the groups. A significant improvement in the values of Berg Balance Scale and Functional Gait Assessment was observed in Functional Strength Training Exercises as well as in Neurodynamic Exercises. Functional Strength Training Exercises showed statistically significant improvement in terms of BBS and FGA than the Neurodynamic Exercises. Both Functional Strength Training Exercises and Neurodynamic Exercises were found to improve the Balance and Gait in patients with Diabetic Peripheral Neuropathy. However, the Functional Strength Training showed more significantly improvement in Balance and Gait subsequently reducing fall and fall risk injury.

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Keywords

Neurodynamic, Functional Strength Training, Diabetic Peripheral Neuropathy, Balance, Gait.

Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder which results in blood sugar level in the body which has been characterized by persistent hyperglycemia. Diabetes mellitus may be due to impaired secretion of insulin, resistance to peripheral actions of insulin, or both falls (Goyal and Jialal, 2023). The total number of people of 50.8 million affected with diabetes in 2010, and this number is predicted to increase to 87.0 million by the year 2030 (Kaveeshwar and Cornwall , 2014). Diabetic peripheral neuropathy (DPN) is the most common complication among DM patients which affects legs and feet for some people. The prevalence ranging from 18.8 to 61.9% in India (Aliya et al., 2021). Early diagnosis and screening services at the primary healthcare level can aid early diagnosis of complications and improve health outcomes among DM patients. Chronic hyperglycemia along with the other metabolic aberrations in patients with diabetes mellitus can cause damage to various organ systems and large blood vessels of the heart, brain and legs leading to the development of life-threatening health complications like neuropathy, nephropathy and retinopathy, the macrovascular complication complications lead to a 2-fold to 4-fold increased risk of cardiovascular diseases (Sanjeev, 2020).

The diagnosis of DPN for clinical practice generally depends on a combination of neuropathy symptoms, signs, and nerve conduction study (NCS). However, many factors affect dynamic balance and increase the risk of fall (Sanjeev, 2020). The implication of biomechanical abnormalities caused by DPN is leading factors to the development of foot ulceration, leg amputation and traumatic falls which require immediate medical attention. (Brown et al., 2015).

The Common symptoms of neuropathy can cause symmetrical paresthesia, painful lower limbs, altered sensation such as numbness, burning, and tingling in lower limbs, reduced or absent deep-tendon reflexes and weakness in lower limb muscles which result in the impairment of balance and gait further leading to high risk of falls and thereby reducing the person's quality of life (Armstrong et al., 2017). Patients with diabetic peripheral neuropathy have reduced gait speed, increased stance time, decreased cadence, short stride length, and higher variability in step lengths as compared to healthy individuals (Allet et al., 2010). Allet et al., 2010; have also found that spatiotemporal gait alteration helps in the reduction of lower limb strength and sensory issues. Due to these gait and balance impairments, patients with diabetes tend to suffer from the risk of detrimental falls (Trivedi et al., 2017). The balance exercises are feasible and safe, & have the potential to improve balance and gait, consequently, reducing the risk of falls & fall-related injuries. (Ahmad et al., 2017).

Javed et al. (2015) "there is an alteration in lower limb proprioception, vibration sense, and kinesthesia, which affects tactile sensitivity which leads to irritation of skin and insufficiency in locomotor functions in individuals with long-standing diabetes." Lower limb muscle weakness leads to an increase in postural sway in standing which further manifolds the fall risk. (Jernigan et al., 2012.)

Exercise interventions in the form of strength training (ST), endurance training (ET), resistance training, balance training, Swiss ball exercises, etc., have been used in the earlier studies to managethe complications of diabetic neuropathy (Javed et al., 2015). The strengthening for lower limbs functional positions in diabetic neuropathy may lead to faster foot reaction time to visual stimuli, improves the strength of leg, less sway, and reduce risk of falling. The musculoskeletal system in diabetic neuropathy which exerts a non-uniform stresses and movement in neural tissues, depends upon the local anatomical and mechanical characteristic patterns of body movement. Thus, it helps in the activation of an array of mechanical and physiological responses in neural tissues. These responses include neural sliding, pressurization, elongation, tension & changes in intraneural microcirculation, axonal transport & impulse traffic (Cauza et al., 2005; Atre et al., 2020; Sartor et al., 2012).

Neurodynamic of the nervous system reduces the musculoskeletal tension and pain thereby it increases the muscular endurance and strength to improve balance and reduced falls (yang Dikawal et al., 2020; Nasr et al., 2017; Boyd et al.,2017; Domingues, 2018). Since the evidence available for the use of Neurodynamic exercises and Functional strength training in diabetic neuropathy is deficient, the objective of this study was to compare two interventions, namely Neurodynamic exercises Versus functional Strength Training and their effect on balance and gait in patients with diabetic neuropathy.

Materials and Methods

The present study was an experimental study conducted on 30 participants. The Primary data will be collected from 30 samples who are clinically diagnosed with diabetic peripheral neuropathy from the department of Jaya college of Paramedical sciences, College of Physiotherapy. Based on inclusion and exclusion criteria, the subjects were selected. The purpose of the study was explained to all subjects and informed consent was obtained from each subject.30 participants who met the inclusion and exclusion criteria were randomly allocated into the two study groups with 15 participants in each group.

The participants who scored <3 as per the Michigan Neuropathy Screening Instrument (MNSI) were included in the study (Moghtaderi et al., 2006). The inclusion criteria as follows: (i) Clinically Diagnosed with type I and II diabetes, (ii) males as well as females between the age group of 40–80 years, (iii) duration of diabetes more than 7 years, (iv) minimum of grade 3 strength in lower limbs according to Medical Research Council grading, and (v) able to stand and walk without assistance. Exclusion Criteria: (i) any musculoskeletal disorders affecting lower limbs, (ii) diagnosed with peripheral vascular diseases, (iii) suffered from common peroneal nerve injury, and (iv) diagnosed with any other neurological disorder like Stroke, Parkinson's Disease (v) Visual defects (vi) Vestibular defects (vii) Lower Limb Fracture (viii) comprehensive deficits

Procedure:
Participants clinically diagnosed with diabetic neuropathy between the age group of 40–80 years were screened using the inclusion and exclusion criteria. An ethical clearance from the ethical committee (EC/JCP/ 08/ 2022**)** was obtained for conducting the study. Written consent was obtained from the participants. Outcome measures assessed were Balance using the Berg Balance Scale

(Miranda- Cantellops, 2023; Patel and Shah, 2019) and Gait using Functional Gait Assessment (FGA) (Wrisley et al., 2004) in both the groups. The scores of the scales (BBS and FGA) were compared at baseline and after intervention for within groups as well as between groups.

Procedure for intervention:

This study was conducted for 5 days a week for 4 weeks on individuals with diabetic neuropathy. A brief warm-up period of 5 min was given to the patients that included stretching of Achilles tendon and Hamstrings and Range of Motion Exercises for lower limbs. Ten repetitions of ankle dorsiflexion and plantar flexion movements were given followed by knee flexion and extension and hip flexion and abduction for both the lower limbs. The entire warm-up exercise sessions were performed actively by the participants (Ramalingam et al., 2023).

The Functional Strength Training group received training for 30–35 min per session for 5 days a week for 4 weeks (Janhavi Jagdish Atre et al .,2020): Sit to stand (10 repetitions from chair for 3 sets), (Figure 1), walking up and down a ramp (6 laps), stair climbing (1 stair Case-12 steps, 6 laps) (Figure 2), and mini hops (10 repetitions) (Figure 3).

The Neurodynamic group received 3 sets of 30 repetitions in 2 min with 1 min break in between for 3 times/ week for 4 weeks (Nasr and Zafereo, 2019; Boyd et al., 2017; Domingues, 2018). All the participants will receive neural mobilization of Tibial & Common Peroneal nerves (Nasr and Zafereo, 2019), and Femoral nerve (Buttler, 1991).

Peroneal nerve: Hip flexion/Knee Flexion / Plantar flexion (Figure 4) / Inversion to knee Extension (Figure 5). Tibial Nerve: Dorsiflexion/ Eversion (Figure 6) and Slump with Neck Flexion (Figure 7). Femoral nerve: Half pushup + neck slight extension (Figure 8) and Knee Flexion

Figure 1
Sit to Stand

Figure 2
Stair Climbing

Figure 3
Mini Hops

Figure 4
Peroneal Nerve Stretch

Figure 5
Peroneal nerve Stretch

Figure 6

Figure 7
Tibial Nerve Stretch

Figure 8
Femoral Nerve Stretch

Results

Statistical analysis was done using the "paired t-test" was used to compare before and after intervention results of each group. The "independent t-test" was used to compare changes in results between the groups by using SPSS Version software. There is significant effect of treatment A in increasing the value of Berg Balance Scale (t = -29.44, p = 2.71>0.05). In addition, the mean value of BBS has increased from 48.133 to 53.73, which confirms that Treatment A is significantly effective in increasing the value of BBS (Figure 9). There is significant effect of Treatment A in decreasing the value of Functional Gait Assessment (t = -11.93, p = 1.01>0.05). In addition, the mean value of FGA has decreased from 21.33 to 28.27, which confirms that Treatment A is significantly effective in decreasing the value of FGA (Figure 10). There is significant effect of Treatment B in increasing the value of Berg Balance Scale (t = - 14.79, p = 3.07>0.05). In addition, the mean value of BBS has increased from 47.6 to 49.87, which confirms that Treatment B is significantly effective in increasing the value of BBS (Figure 11). There is significant effect of Treatment B in decreasing the value of Functional Gait Assessment (t = - 16.04, p = 1.05 > 0.05). In addition, the mean value of FGA has decreased from 21.07 to 25.27, which confirms that Treatment B is significantly effective in decreasing the value of FGA (Figure 12)

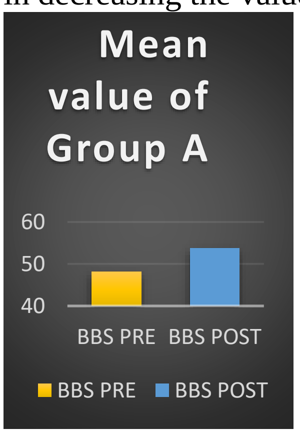

Figure 9 (BBS for Group A)

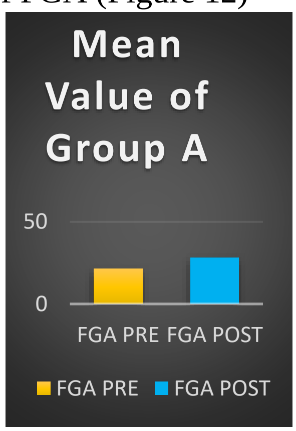

Figure 10(FGA Group A)

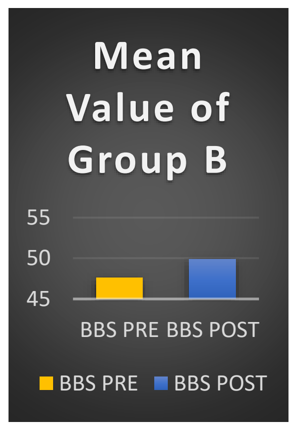

Figure 11 (BBS for Group B)

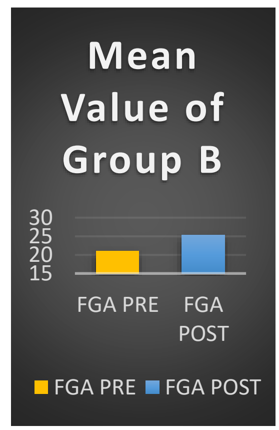

Figure 12(FGA Group B)

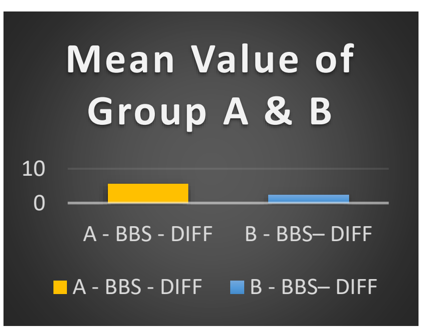

Figure 13 (BBS between Group A& B)

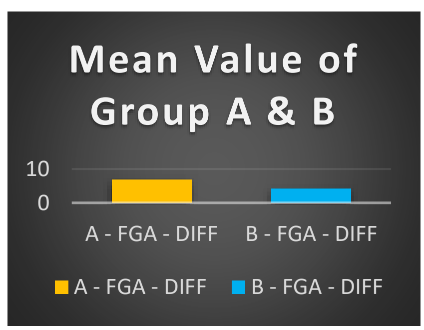

Figure 14(FGA between Group A&B)

There is significant difference between two treatments (A and B) in terms of average increase in BBS (t = 13.64, p = 3.4 > 0.05). In addition, the mean increase in the value of BBS by Treatment A is greater than that of Treatment B. Hence, we conclude that Treatment A is significantly effective than Treatment B in terms of mean increase in the value of Berg Balance Scale. (Figure 13).

There is significant difference between two treatments (A and B) in terms of average improvement in FGA (t = 4.29, p = 9.7 > 0.05). In addition, the mean improvement in FGA by Treatment A is greater than Treatment B. Hence, we conclude that Treatment A is effective than Treatment B in terms of mean improvement in FGA (Figure 14).

Discussion

The prevalence of neuropathy symptoms is more in diabetes patients when the duration of diabetes is more than 5 years (Trivedi, 2017), which further leads to affect the nerve conduction velocity, leads to the impairment of Balance and Gait function. Patients with Diabetic Polyneuropathy show a high risk of fall because of impaired Balance, loss of sensation and Proprioception. (Brown et al., 2015) Therefore, designing an appropriate intervention is to overcome the complications of diabetic neuropathy and improving their function is essential.

Atre and Ganvir (2020) "In standing position, there is co-contraction of agonist and antagonist muscles, leading to balancing of the body. In diabetic neuropathy, due to the injury of sensory and motor nerves, there is impairment in balancing forces of the lower limbs which leads to fall and loss in proprioception. Thus, Functional Strength Training impose demands on lower limbs in standing to have influence on balance training. The muscles may have counteracted for loss of proprioception that leads to improve the balance. Functional Strength Training involves the activities in everyday life given with the focus of improving the strength of muscles.

Functional Strength Training improves intermuscular and intramuscular synchronization through neural control by preventing the muscle loss and improves the stability and gait. Functional Strength Training have positive effects on insulin resistance may increase number of glucose transporter (GLUT) proteins. In skeletal muscle cells, GLUT4 is thought to be responsible for insulin and contraction-stimulated glucose transport in adipose tissues and skeletal muscle. In addition, Total muscle mass will ultimately result in an increase in total insulin-mediated glucose up-take. FST exercises increases muscle work in lower limbs, which can be considered a key factor in reducing gait alterations in diabetic people. The present study will focus on improving the intermuscular and intramuscular synchronization through the neural control, thereby increasing the muscle power by functional activities improving balance, gait and reduced risk of fall.

Diabetes affects the microcirculation of the body from kidney to eyes and skin. Large and small occasionally the small and large veins, by inducing sclerosis of walls of blood vessels. The most commonly affected are the longest peripheral nerves which are carries the proprioceptive feedback which it affects the balance and gait. The nerve damage can be produced by a disturbance in local pressure-flow relationships combined with epineural mechanical constraint, which in turn affects the balance and gait among the Diabetic Polyneuropathy patients.

Neural Mobilization or Neurodynamics is a physical approach to the treatment of pain. This method depends on influencing pain physiology via mechanical treatment of neural tissues and the non-neural structures surrounding the nervous system (Nasr and Zafereo, 2019). After neural mobilization, tissue mobility, blood circulation, and axonal transport, all of which are necessary for a neuron's usefulness and mechanical integrity, will be increased Neurodynamics of the nervous system is to reduce musculoskeletal tension and pain and thereby increase the muscular endurance and strength improved balance and reduced falls (Goyat et al., 2022). The present study will focus on improving the improving the Neuro-physiologic function of tibial, common peroneal and femoral nerves that has impact the motor symptoms of diabetic neuropathy and will improve balance and reduced risk of fall.

Conclusion

Both Functional Strength Training Exercises and Neurodynamic Exercises were found to improve the Balance and Gait in patients with Diabetic Peripheral Neuropathy. However, the Functional Strength Training showed more significant improvement in Balance and Gait subsequently reducing fall risk and fall related injury. Therefore, Functional Strength Training can be used as effective adjunctive and supportive therapy in the management Diabetic Peripheral Neuropathy patients.

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References

Ahmad, I., Hussain, E., Singla, D., Verma, S., & Ali, K. (2017). Balance training in diabetic peripheral neuropathy: A narrative review. *JSM Diabetology and Management*, *2*(1), 1002.

Aliya Jasmine, Akila, G. V., Vanitha Durai, Anitha Rani, M., Vanishree Shriraam, Samya, V., Gayathri, T., & Shriraam, M. (2021). Prevalence of peripheral neuropathy among type 2 diabetes mellitus patients in a rural health centre in South India. *International Journal of Diabetes in Developing Countries*, *41*, 293–300.

Allet, L., Armand, S., de Bie, R. A., Golay, A., Monnin, D., Aminian, K., et al. (2010). The gait and balance of patients with diabetes can be improved: A randomized controlled trial. *Diabetologia*, *53*(3), 458–466. https://doi.org/10.1007/s00125-009-1592-6

Armstrong, D. G., Boulton, A. J., & Bus, S. A. (2017). Diabetic foot ulcers and their recurrence. *New England Journal of Medicine*, *376*(24), 2367–2375. https://doi.org/10.1056/NEJMra1615439

Atre, J. J., & Ganvir, S. S. (2020). Effect of functional strength training versus proprioceptive neuromuscular facilitation on balance and gait in patients with diabetic neuropathy. *Indian Journal of Physical Therapy and Research*, *2*(1), 47–51.

Boyd, B. S., Nee, R. J., & Smoot, B. (2017). Safety of lower extremity neurodynamic exercises in adults with diabetes mellitus: A feasibility study. *Journal of Manual & Manipulative Therapy*, *25*(1), 30–38.

Brown, S. J., Handsaker, J. C., Bowling, F. L., Boulton, A. J., & Reeves, N. D. (2015). Diabetic peripheral neuropathy compromises balance during daily activities. *Diabetes Care, 38*(6), 1116–1122. https://doi.org/10.2337/dc14-1982

Butler, D. (1991). *Mobilization of the nervous system: Diagnosis and management of physical* *dysfunction of the nervous system in a pain sciences and clinical reasoning framework* [Course workbook]. NOI Group.

Cauza, E., Hanusch-Enserer, U., Strasser, B., Ludvik, B., Metz-Schimmerl, S., Pacini, G., ... & Haber, P. (2005). The relative benefits of endurance and strength training on the metabolic factors and muscle function of people with type 2 diabetes mellitus. *Archives of Physical Medicine and Rehabilitation*, *86*(8), 1527–1533.

Domingues, M. (2018). Diabetic peripheral neuropathy and neurodynamics. *International Physical Medicine & Rehabilitation Journal*, *3*(2). https://doi.org/10.15406/ipmrj.2018.03.00101

Goyal, R., & Jialal, I. (2023). Diabetes mellitus type 2. In *StatPearls*. StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK148852/

Goyat, M., Saxena, A., & Goyal, M. (2022). Study protocol titled as "Effectiveness of neural mobilization in improving the ankle ROM and plantar pressure distribution in patients with diabetic peripheral neuropathy: A single group, pre-post, quasi-experimental study protocol." *Journal of Diabetes & Metabolic Disorders*, *21*(2), 2035–2041. https://doi.org/10.1007/s40200-022-01068-z

Javed, S., Petropoulos, I. N., Alam, U., & Malik, R. A. (2015). Treatment of painful diabetic neuropathy. *Therapeutic Advances in Chronic Disease*, *6*(1), 15–28. https://doi.org/10.1177/2040622314554431

Jernigan, S. D., Pohl, P. S., Mahnken, J. D., & Kluding, P. M. (2012). Diagnostic accuracy of fall risk assessment tools in people with diabetic peripheral neuropathy. *Physical Therapy*, *92*(11), 1461–1470. https://doi.org/10.2522/ptj.20110374

Kaveeshwar, S. A., & Cornwall, J. (2014). The current state of diabetes mellitus in India. *Australasian Medical Journal*, *7*(1), 45–48. https://doi.org/10.4066/AMJ.2014.1979

Miranda-Cantellops, N. (2023). Berg balance testing. In *StatPearls*. StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK574602/

Moghtaderi, A., Bakhshipour, A., & Rashidi, H. (2006). Validation of Michigan neuropathy screening instrument for diabetic peripheral neuropathy. *Clinical Neurology and Neurosurgery*, *108*(5), 477–481.

Nasr, A. J., & Zafereo, J. (2019). The effects of dry needling and neurodynamic exercise on idiopathic peripheral neuropathy: A case report. *Journal of Bodywork and Movement Therapies*, *23*(2), 306–310.

Patel, B., & Shah, S. (2019). Test-retest reliability of Berg Balance Scale in subjects with diabetic neuropathy: A pilot study. *Journal of Emerging Technologies and Innovative Research*, *6*(6), 272–275.

Prentice, W. E. (2017). *Therapeutic modalities in rehabilitation* (5th ed.). McGraw-Hill Education.

Ramalingam, V., Jagatheesan, A., & Suganthirababu, P. (Eds.). (2023). *Proceedings of International Physiotherapy Conference – Stride'23*. *International Journal of Physiotherapy and Occupational Therapy*, 1–143. https://ijpot.com/conference.html

Rojhani-Shirazi, Z., Barzintaj, F., & Salimifard, M. R. (2017). Comparison of the effects of two types of therapeutic exercises—Frenkel vs. Swiss ball—on the clinical balance measures in patients with type II diabetic neuropathy. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *11*(Suppl 1), S29–S32.

Saleh, M. S., & Rehab, N. I. (2019). Effect of ankle proprioceptive training on gait and risk of fall in patients with diabetic neuropathy: A randomized controlled trial. *International Journal of Diabetes Research*, *2*(1), 40–45.

Sanjeev, K. (2020). *Diabetic peripheral neuropathy and clinical practice* (1st ed.). Springer

Sartor, C. D., Watari, R., Pássaro, A. C., Picon, A. P., Hasue, R. H., & Sacco, I. C. N. (2012). Effects of a combined strengthening, stretching and functional training program versus usual care on gait biomechanics and foot function for diabetic neuropathy: A randomized controlled trial. *BMC Musculoskeletal Disorders*, *13*(1), 36. https://doi.org/10.1186/1471-2474-13-36

Trivedi, S., Pandit, A., Ganguly, G., & Das, S. K. (2017). Epidemiology of peripheral neuropathy: An Indian perspective. *Annals of Indian Academy of Neurology*, *20*(3), 173–184. https://doi.org/10.4103/aian.AIAN_61_17

Wrisley, D. M., Marchetti, G. F., Kuharsky, D. K., & Whitney, S. L. (2004). Reliability, internal consistency, and validity of data obtained with the Functional Gait Assessment. *Physical Therapy*, *84*(10), 906–918.

yang Dikawal, M. W. M. U., Rawak, S., Ramalingam, V., Sundar, V., & Joseph, S. (2020). Effect of neuro-dynamic technique on repetitive inward ankle rolls among young Malaysian athletes: A randomized controlled trial. *Sains Malaysiana*, *49*(6), 1323–1332. https://doi.org/10.17576/jsm-2020-4906-04