Evaluation of the static and dynamic balance in single and dual tasks among active smokers and non-smokers

Yuvraj Rana,[1] Hina Vaish[2]

[1]Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation, Maharishi Markandeshwar (Deemed to be University), Mullana-Ambala, Haryana; [2]Department of Physiotherapy, School of Health Sciences, CSJM University, Kanpur, Uttar Pradesh, India

Abstract

Chronic smoking may lead to postural imbalance and there is the risk of injuries due to instability. Balance is needed to maintain posture. Literature is scarce regarding static and dynamic balance in smokers. Hence, the study aimed to evaluate the static and dynamic balance in single and dual tasks among active smokers and age-matched non-smokers.100 smokers and 100 non-smokers aged 20-50 years were selected by purposive sampling. Static balance was assessed by a single-leg stance (SLS) test. Dynamic balance was assessed by performing the time up and go (TUG) test, and 10m walk test. All the tests were performed in single and dual tasks in both smokers and age-matched non-smokers. Kolmogorov-Smirnov test was used for assessing normality. Mann-Whitney U test was used to compare the two groups. p-value $\leq$ 0.05 was considered significant. There was a significant difference in the SLS test, 10M walk test, and TUG test in single as well as dual tasks. The static and dynamic balance is impaired in chronic smokers in comparison to age-matched non-smokers and seeks further exploration in larger samples.

Introduction

Cigarette smoking is a well-known source of various chronic diseases.[1] Globally in 2019, smoking tobacco use accounted for 7·69 million deaths and was the leading risk factor for death among males (20·2% of male deaths).[2]

In this era of modernization, factors that promote the excess use of smoking are curiosity, fashion, social approval, high socioeconomic status, flavored aromatic tobacco (in hookah), the need for diversion, misperception of health hazards, and most important peer pressure among teenagers and adults.[3] The physical fitness and mental health components are affected by these habits of smoking.[4] From the previous reports it was accounted that smokers occupy more medical expenditure than non-smokers.[5]

Cigarette smoking delivers a drug named nicotine which sustains tobacco addiction. This drug has adverse effects and affects motor, sensory, cognitive, and attention abilities.[6]

There is evidence, that static postural stability is decreased in chronic smokers.[7] Chronic smoking lowers muscle strength, flexibility, and aerobic exercise level and therefore, it promotes the change in the body's organic functions.[4]

Chronic smoking can cause dizziness, unsteadiness, nausea, and some other problems and can also increase postural sway.[8] Factors controlling the body's balance and orientation consist of the vestibular, visual, somatosensory system, and motor responses.[9,10] These factors are required to maintain postural control in both static and dynamic conditions.

Dynamic postural control plays a vital role in maintaining dynamic balance because individuals perform many different tasks in daily living in a dynamic state.[11] Increased risks of falls are related to balance which leads to injuries. The injuries comprise some short- and long-term effects *i.e.* functional declination, dependent care, limitation in mobility, demotion in quality of life, and risk of early death.[12]

There is a 7.3% of reduction in bone mineral density of the lumbar spine, poorer and weak balance, a decrease in neuromuscular and physical functions, and surging bone fragility due to which there are more chances of falls and injuries in post-menopausal smokers.[13]

Nicotine affects muscles that are responsible for the instability of upright posture, also decreases the blood flow of the inner ear, and reduces the accuracy of the peripheral vestibular system.[14] Cigarette smoking may increase the risk of postural instability during the walking and standing phase. It is essential to maintain postural control in static and dynamic conditions.

The ability of the brain to organize multi-task interactions is an important component of motor control and balance.[15] During the dual task, there is a concurrent performance of a motor-motor or motor-cognitive task that is performed independently and it is tested by measuring the interference of one or both tasks in one another.[16] Maintenance of balance in dual-task is a complex outcome of trunk stability and

Correspondence: Hina Vaish, Department of Physiotherapy, School of Health Sciences, CSJM University, Kanpur, Uttar Pradesh, India.
Tel.: +91.9450124758.
E-mail: hina22vaish@gmail.com

Key words: balance, cognition, muscle strength, smoking.

Contributions: YR, experiments design, data collection, and manuscript writing; HV, experiment design, data analysis, contribution with critical intellectual content, and manuscript writing.

Conflict of interest: the authors declare no potential conflict of interest, and all authors confirm accuracy.

Availability of data and materials: the data set associated with this study is available here: Yuvraj R, Vaish H. Evaluation of static and dynamic balance in single and dual tasks among active smokers and non-smokers. Mendeley Data, V1, 2021. doi: 10.17632/9wg4t87kgg.1.

Ethics approval: the study was approved by the student project committee of the Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation, Maharishi Markandeshwar (Deemed to be University), Mullana-Ambala, Haryana, India.

Informed consent: all the participants to this study signed a written informed consent form for participating in this study.

Consent for publication: written informed consent was obtained from a legally authorized rep-patient information to be published in this article.

Funding: this research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Acknowledgments: we greatly acknowledge the support from all participants and sincerely thank all the individuals for taking part in the study.

Received for publication: 16 January 2023.
Accepted for publication: 25 June 2023.

Licensee PAGEPress, Italy
Healthcare in Low-resource Settings 2023; 11:11159
doi:10.4081/hls.2023.11159

the sensory-motor and/or automatic central function.[15] Hence, performing two tasks simultaneously strains a higher degree of attention, balancing skills, and executive function than a single-task performance. [15]

Poor attention and cognitive skills result in impaired motor-motor or motor-sensory tasks, such as maintaining static or dynamic balance.[17]

Nicotine binds to nicotinic acetylcholine receptors (nAChRs), which are pentameric ligand-gated ion channels composed of α and β subunits (α1–7, 9–10; β1–4); nAChRs are extensively distributed throughout the brain and periphery and are critical in the processes of the neuromuscular junction, neurotransmitter release, brain maturation, reward processing, and cognition.[18] To the best of our knowledge, literature is scarce regarding the static and dynamic balance during single and dual tasks in smokers. So, the study aimed to evaluate the static and dynamic balance in single and dual tasks among active smokers and to compare it with age-matched non-smokers.

Material and Methods

The study was approved by the student project committee of the Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation, Maharishi Markandeshwar (Deemed to be University), Mullana-Ambala, Haryana, India, and was conducted in accordance with the Declaration of Helsinki (Revised 2013) and National Ethical Guidelines for Biomedical and Health Research involving human participants' guidelines laid by the Indian Council of Medical Research (2017). Written informed consent was taken from the participants. For this observational study, 200 participants (100 smokers and 100 aged-matched non-smokers) were recruited through a purposive sampling method from among the university employees, students, visitors, and people residing in the nearby community. Asymptomatic individuals aged between 20-50 years of males were included. Smokers with a smoking history of ≥3 years and consumption of ≥10 cigarettes/day were included and age-matched lifetime non-smokers were also included.

The individuals were excluded if they had any acute illness or hospitalization 6 weeks preceding the study, any documented use of medications, metabolic disorders, cardiovascular, musculoskeletal, sensory, vestibular dysfunction, etc. that may affect the outcome of the study, BMI ≥ 25 Kg/m^2, systolic BP <100 mmHg or >139 mmHg, diastolic BP <60 mmHg or >89 mmHg and resting heart rate ≤ 60bpm OR ≥ 100bpm

Participants meeting the exclusion and inclusion criteria were selected for the study. A detailed description was given to all the participants about the study. Written consent was obtained from participants before the conduct of the study. After screening the participants' demographic data was collected. Weight and height were measured and then BMI was calculated. Smoking history was recorded for smokers.

We instructed the participants not to consume any heavy meal or cigarettes two hours before the test conduction and all the test was conducted between 9 am – 1 pm to avoid any intra-day variability.

Single leg stance (SLS) test was performed for the evaluation of static balance. 10m walk test and TUG (time up and go test) were performed for the evaluation of dynamic balance. To perform the SLS test, individuals were directed to stand on a single leg (dominant leg) and maintain balance.[19] To execute the 10m walk test, the 14 m track was marked and measured on the plane surface by indicating cones on both starting and ending points of the track. A 2 m distance was excluded from both sides for the acceleration and de-acceleration phase and time was recorded for a 10m distance.[20] All the participants were instructed to walk on track and time was recorded for the 10m using the stopwatch. To execute the TUG test, a chair was placed at one point and a 5m distance was marked with an indicating cone on the other side as a barrier. Participants were instructed to stand from the chair and walk 5 meters and turn around and walk back to the chair until seated.[11]

All the tests were performed in 3 different conditions *i.e.*, single task (performance of the task alone), dual manual task (performance of the task while holding a cup of water), and cognitive task (performing test while counting in decrement of 3). In between each test, 5 minutes of rest was given. For better accuracy and final analysis, each test was conducted 3 times, and an average of 3 readings was considered for analysis.

Statistical analysis

The normality of data was assessed by using the Kolmogorov-Smirnov test (n>50) and the data was found to be not normality distributed. Mann-Whitney U test was used to compare the difference between smokers and non-smokers. All analysis was done by statistical software SPSS 16.0 version. A p-value of less than 0.05 was considered statistically significant.

Results

All the participants performed all the tests completely and there were no dropouts. The demographic characteristics of the participants are described in Table 1.

The smokers recruited had a smoking history ranging from 4 years to 27 years. The smoking history of the participants is described in Table 2.

There was a significant difference in static balance in single as well as dual (motor and cognitive) tasks (Table 3); dynamic balance in single as well as dual (motor and cognitive) tasks (Table 4).

Table 1. Demographic characteristics of the participants.

Demographic details	Total population (N=200) Median (Range)	Smoker (N=100) Median (Range)	Non-smoker (N=100) Median (Range)
Age (years)	34.5 (21.0, 50.0)	34.0 (22.0-50.0)	33.0 (21.0-50.0)
Height (m)	1.70 (1.53, 1.87)	1.70 (1.55-1.85)	1.70 (1.53-1.85)
Weight (kg)	66.50 (42.0, 86.0)	67.0 (45.0-86.0)	66.0 (42.0-86.0)
BMI (kg/m^2)	22.41 (17.71, 24.98)	22.41 (17.7-24.98)	22.53 (17.98-24.98)
Systolic (mmHg)	130.0 (120.0, 138.0)	130.0 (120.0-138,0)	130.0 (120.0-138,0)
Diastolic (mmHg)	84.0 (78.0, 89.0)	84.0 (78.0, 89.0)	84.0 (78.0, 89.0)

N, number of participants.

Discussion

In the present study, the author evaluated the balance between active smokers and lifetime non-smokers by performing an SLS test for static balance. For dynamic balance, a 10m walk, and TUG test were performed. All the instructions were commanded to the participants verbally. All the tests were performed 3 times for better accuracy and in between each test 5-minute rest was given. All the tests were performed according to the standardized guidelines.

In the present study, the authors found that there was a significant difference in the SLS test, 10M walk test, and timed up-and-go test in single as well as dual (motor and cognitive) tasks.

Authors from previous studies reported that chronic smoking is related to postural instability as nicotine causes a lack of neuromuscular control and vestibular dysfunction.[7,14,21] Cigarette smoking contains a substance called nicotine, which leads to adverse effects on the neuromuscular junction, sensory nerve endings, ganglia, central nervous system, and adrenal medulla which affect the motor, sensory, cognitive, and attentional functions.[6]

Nicotine when interacts with acetylcholine receptors, it mimics acetylcholine (neurotransmitter), which has greater affinity to the acetylcholine receptor. Nicotine also interferes with the coagulation process as it increases the activity of platelets which leads to increased microvascular trauma caused due to atherosclerosis of the endothelial wall which causes impaired blood flow to the spinal cord and the brain.[22] Impaired blood flow to the brain leads to motor and cognitive deficits because the neuromuscular junction and frontal cerebral cortex were also affected by impaired blood flow in the brain. These factors lead to the initiation of a chain of oxidative injuries and activation of pro-inflammatory response that causes cellular disruption in Blood Brain Barrier (BBB) which acts as a consequence of impairment in motor and cognitive function.[22]

In the present study, we found that the time to stand on the dominant leg in smokers was significantly different from that of non-smokers under single and dual tasks. A previous study conducted by Takeshi Santo *et al.* reported that there is a relationship between balance and cigarette smoking. They reported that balance on one leg is considerably reduced in smokers as compared to non-smokers while closing their eyes.[4] However, in the present study the single-leg stance task was performed with eyes open. This indicates that smokers' balance is affected more because of musculoskeletal involvement. There are several pieces of literature available indicating that muscle force-generating capability and muscle mass are reduced in smokers in comparison to non-smokers.[23,24] A lower muscle force-generating capability has been reported in smokers by several studies. Authors from previous studies have observed that there are 25% smaller fiber cross-sectional area in the vastus lateralis muscle; "lean body mass is also lower in smokers as compared to non-smokers".[25]

In the present study, we found that there was a significant difference in the 10M and TUG tests (functional balance test) in smokers when compared to non-smokers. 10M walk test is used to assess the gait speed, coordination, and functional balance of an individual.[26] The TUG test is used for assessing participants moving ability and strength during dynamic as well as static balance by evaluating the time taken from standing from the chair, walking 5m, turning back from the barrier, and sitting back to the chair. These test findings could be related to gait variability and parameters. Smoking is related to impaired gait parameters and gait velocity.[27] Lower gait velocity is linked with more pack-years of smoking. More pack year of smoking is related to decreased speed and rhythm. Smoking components like nicotine is having adverse effects on the nervous system, cardiovascular system, and musculoskeletal system. This correlation shows that smoking may associate with gait parameters which are comprised of slow pace, velocity, and rhythm.[27] Lamoth *et al.* stated that while performing cognitive task gait variables and trunk coordination is diminished.[28]

In the present study, we found that there is a difference during attention-demanding tasks in smokers and age-matched non-smokers. These findings suggest that the maintenance of static balance requires attention. In the present study, we noticed that the time to stand with difficulty in the secondary task was comparatively different in smokers. A previous study showed that smokers have impaired cognitive function and there is a decrease in psychomotor speed in smokers.[29] These impairments may cause imbalance and make it difficult to maintain stability and perform tasks.[30]

The study had few limitations. We could not enroll female participants. The study was singly cantered with participants from the same geographical location. The sample was small and was collected by non-probability method though strict inclusion and exclusion criteria were followed. We did not record the level of physical activity and dietary patterns of the participants subjectively. We did not record the time when the last cigarette was smoked.

Table 2. Smoking history of participants.

Variables	Median (Range)
No. of cigarette smoking per day	11.5 (10.0, 18.0)
No. of years the participant is smoking	10.0 (4.0, 27.0)

Table 3. Comparison of static balance in smokers and non-smokers.

Test	Smoker (Median)	Non-smoker (Median)	Z value	p-value
SLS in Single task	26.5	30	-5.226	0.0001*
SLS in the dual cognitive task	25	30	-6.350	0.0001*
SLS in dual manual task	25	30	-6.476	0.0001*

SLS, single leg stance; *p<0.05 was considered significant.

Table 4. Comparison of dynamic balance in smokers and non-smokers.

Test	Smoker (Median)	Non-smoker (Median)	Z value	p-value
10-meter walk test in Single task	6.5	6	-4.968	0.0001*
10-meter walk test in the dual cognitive task	7.1	6.8	-5.092	0.0001*
10-meter walk test in dual manual task	7.2	6.7	-4.121	0.0001*
TUG test in Single task	7	6.5	-4.088	0.0001*
TUG test in the dual cognitive task	7.5	7	-4.112	0.0001*
TUG test in dual manual task	7.5	7.15	-3.778	0.0001*

TUG, time up and go; *p<0.05 was considered significant.

Conclusions

The present study concluded that static and dynamic balance is impaired in chronic male smokers as compared to non-smokers and seeks further exploration in larger samples. Hence, it is reasonable to promote the prohibition of smoking and develop exercise habits focusing on muscle strengthening and balance measures.

References

1. Wang R, Jiang Y, Yao C, et al. Prevalence of tobacco-related chronic diseases and their role in smoking cessation among smokers in a rural area of Shanghai, China: a cross-sectional study. BMC Public Health 2019;19:753.
2. GBD 2019 Tobacco Collaborators. Spatial, temporal, and demographic patterns in the prevalence of smoking tobacco use and attributable disease burden in 204 countries and territories, 1990-2019: a systematic analysis from the Global Burden of Disease Study 2019. Lancet 2021;397:2337-60. Correction in Lancet 2021;397:2336.
3. Qasim H, Alarabi AB, Alzoubi KH, et al. The effects of hookah/waterpipe smoking on general health and the cardiovascular system. Environ Health Prev Med 2019;24:58.
4. Saito T, Miyatake N, Nishii K. Relationship between cigarette smoking and one leg with eyes closed balance in Japanese men. Environ Health Prev Med 2015;20:388-91.
5. Hayashida K, Murakami G, Takahashi Y, et al. Nihon Eiseigaku Zassh 2012;67:50-5.
6. Heishman SJ, Taylor RC, Henningfield JE. Nicotine and Smoking: A Review of Effects on Human Performance. Exp Clin Psychopharmacol 1994;2:345–95.
7. Schmidt TP, Pennington DL, Durazzo TC, Meyerhoff DJ. Postural stability in cigarette smokers and during abstinence from alcohol. Alcohol Clin Exp Res 2014;38:1753-1760.
8. Pereira CB, Strupp M, Holzleitner T, Brandt T. Smoking and balance: correlation of nicotine-induced nystagmus and postural body sway. Neuroreport 2001;12:1223-1226.
9. Toprak CŞ, Duruöz MT, Gündüz OH. Static and dynamic balance disorders in patients with rheumatoid arthritis and relationships with lower extremity function and deformities: a prospective controlled study. Arch Rheumatol 2018;33:328-34.
10. Bressel E, Yonker JC, Kras J, Heath EM. Comparison of static and dynamic balance in female collegiate soccer, basketball, and gymnastics athletes. J Athl Train 2007;42:42-6.
11. Hemmati L, Rojhani-Shirazi Z, Malek-Hoseini H, Mobaraki I. Evaluation of static and dynamic balance tests in single and dual task conditions in participants with nonspecific chronic low back pain. J Chiropr Med 2017;16:189–94.
12. Lesinski M, Hortobágyi T, Muehlbauer T, et al. Effects of balance training on balance performance in healthy older adults: a systematic review and meta-analysis. Sports Med 2016;46:457.
13. Wong PK, Christie JJ, Wark JD. The effects of smoking on bone health. Clin Sci 2007;113:233-41.
14. Iki M, Ishizaki H, Aalto H, et al. Smoking habits and postural stability. Am J Otolaryngol 1994;15(2):124-8.
15. Plummer P, Eskes G, Wallace S, et al. Cognitive-motor interference during functional mobility after stroke: state of the science and implications for future research. Arch Phys Med Rehabil 2013;94:2565-74.e6.
16. Fritz NE, Basso DM. Dual-task training for balance and mobility in a person with severe traumatic brain injury: a case study. J Neurol Phys Ther 2013;37:37-43.
17. Leland A, Tavakol K, Scholten J, et al. The role of dual tasking in the assessment of gait, cognition and community reintegration of veterans with mild traumatic brain injury. Mater Sociomed 2017;29:251-6.
18. Ren M, Lotfipour S. Nicotine gateway effects on adolescent substance use. West J Emerg Med 2019;20:696-709.
19. Perez-Cruzado D, González-Sánchez M, Cuesta-Vargas AI. Parameterization and reliability of single-leg balance test assessed with inertial sensors in stroke survivors: a cross-sectional study. Biomed Eng Online 2014;13:127.
20. Scivoletto G, Tamburella F, Laurenza L, et al. Validity and reliability of the 10-m walk test and the 6-min walk test in spinal cord injury patients. Spinal Cord 2011;49:736-40.
21. Chomiak T, Pereira FV, Hu B. The single-leg-stance test in Parkinson's disease. J Clin Med Res 2015;7:182-5.
22. Mazzone P, Tierney W, Hossain M, et al. Pathophysiological impact of cigarette smoke exposure on the cerebrovascular system with a focus on the blood-brain barrier: expanding the awareness of smoking toxicity in an underappreciated area. Int J Environ Res Public Health 2010;7:4111-26.
23. Seymour JM, Spruit MA, Hopkinson NS, et al. The prevalence of quadriceps weakness in COPD and the relationship with disease severity. Eur Respir J 2010;36:81-88.
24. Degens H, Gayan-Ramirez G, van Hees HW. Smoking-induced skeletal muscle dysfunction: from evidence to mechanisms. Am J Respir Crit Care Med 2015;191:620-5.
25. Montes de Oca M, Loeb E, Torres SH, et al. Peripheral muscle alterations in non-COPD smokers. Chest 2008;133:13-8.
26. Peters DM, Fritz SL, Krotish DE. Assessing the reliability and validity of a shorter walk test compared with the 10-Meter Walk Test for measurements of gait speed in healthy, older adults. J Geriatr Phys Ther 2013;36:24-30.
27. Verlinden VJ, Maksimovic A, Mirza SS, et al. The associations of alcohol, coffee and tobacco consumption with gait in a community-dwelling population. Eur J Clin Nutr 2016;70:116-22.
28. Lamoth CJ, Stins JF, Pont M, et al. Effects of attention on the control of locomotion in individuals with chronic low back pain. J Neuroeng Rehabil 2008;5:13.
29. Pushpa K, Kanchana R. Effect of cigarette smoking on cognitive performance in young adult smokers. Natl J Physiol Pharm Pharmacol 2019;9:562-5.
30. Demİr T, Balal M, Demİrkİran M. The effect of cognitive task on postural stability in cervical dystonia. Arq Neuropsiquiatr 2020;78:549-55.