GAIT PARAMETERS DURING BACKWARD WALKING IN HEALTHY ELDERLY: A COMPARATIVE STUDY DURING DIFFERENT TYPES OF DUAL TASKS.

[*]Dr. Chandan Kumar, [**]Prof. Dr Shilpi Kapoor, [***]Dr Vaibhav Chaubey.

[*]Principal, (MPT, Ph. D.), Motiwala College of Physiotherapy, Nashik, Maharashtra, India. ptchandan221@gmail.com
[**]Principal/HOD(MPT), Physiotherapy Dept., BIMR College of Professional Studies, Gwalior, MP, India
*** HOD(MPT), Department of Physiotherapy, G.R. Medical College, Gwalior, MP, India,

*Corresponding author - Dr. Chandan Kumar

ABSTRACT

Background. Gait disturbances are a common medical problem in old age. Age related changes in the gait are associated with a decrease in self-selected gait speed, cadence, stride length, and relative direction of the swing phase, accompanied by an increase in single and double time. Divided attention plays an important role in walking, multitasking and changing situation it serves as a common tool for examining the attentional demands of various tasks including walking and has clinical implications for fall risk.

Methods. This Experimental study was conducted to see the influence of various types of dual tasks in elderly during forward as well as backward walking on gait parameters & to compare the gait parameters during backward walking with different dual task in healthy elderly.

Results. It was found that there is significant difference in gait parameters including no of steps, time taken, cadence, step length, stride length. Scores of backward walking without task is 17.93±4.43, backward walking with music 23.40±2.88 and backward walking with backward counting is 23.40±2.88 respectively. Scores of backward walking without task is 16.62±2.91, backward walking with music is 21.46±4.27 and backward walking with backward counting is 26.59±3.80. Scores during backward walking without task is 1.10±.29, backward walking with music is .89±.07 and during backward walking with backward counting is .88±.08.

Conclusions. In this sample of transitionally frail older adults, counting backward while walking caused characteristic gait changes that appears to be a marker for decline in gait control; this suggests that the choice of the attention splitting task in dual task gait assessment must be made carefully.

KEYWORDS: - Gait, Dual Task, Backward walking, Elderly, Attention

INTRODUCTION

The incredible increase in life expectancy may be termed as one of the greatest triumphs of human civilization. But it has posed one of the toughest challenges to be met by modern society. Population ageing is a worldwide phenomenon, and India is no exception to the rule[1]. The population of the aged is on the increase world over as never before and holds a serious social and economic implication. India is a „mature" community and with the population of age range of 60 years and above increasing steadily, by the turn of the century it will become an ageing society [2].

In India, it is estimated that the elderly in the age group 60 and above is expected to increase from 71 million in 2001 to 179 million in 2031 and in the case of those 70 years and older, the projected increase is from 27 million in 2001 to 132 million in 2051 [3]. India has thus acquired the label of an ageing nation with 7.7% of its population being more than 60 years old [4]. Census report in 2005 indicated that the Indian population has approximately tripled during the last 50 years, but the elderly population have increased more than fourfold [1]. The trend clearly reveals that ageing has become a major social challenge and vast resources will be required towards support, care and treatment of the older persons[2].

The term "old" is always related to physical incapacity, biological deterioration and disabilities and psychological failures[1]. With advancing age, structural and functional deterioration occurs in most physiological systems, even in the absence of discernable disease [5].

These age-related physiological changes affect a broad range of tissues, organ systems, and functions, which, cumulatively, can impact activities of daily living (ADL) and the preservation of physical independence in older adults. Declination in maximal aerobic capacity (VO2max) and skeletal muscle performance with advancing age are two examples of physiological aging [6]. Advancing age is associated with declines in physical activity volume and intensity. Elderly in India mainly faces three handicaps relating to hearing, vision and mobility[7].

Mobility is further restricted by the fear of falling [8]. Mobility is defined as the ability to walk safely and independently in one's environment and is critical in maintaining independence in activities of daily living and preserving social relationships and ensuring quality of life.

Mobility is fundamental to active ageing and is intimately linked to health, status and quality of life. Physical activity relates to activities which require a measurable degree of physical exertion such as walking, lifting, standing and bending. A large proportion of falls in the elderly occurs while walking.

Walking is an important aspect of independent functioning needed for many activities of daily living and community participation [9]. As a person ages his/her walking performance starts to decline and it gradually slows down[10]. According to Bohannon RW, the manner of walking of a person, whose normal speed is about 2.5 to 3 mph, is defined as normal gait [11].

Gait disturbances are a common medical problem in old age. Age related changes in the gait are associated with a decrease in self-selected gait speed, cadence, stride length, & relative direction of the swing phase, accompanied by an increase in single & double time[12].

According to Ashton Miller in 2005 spontaneous walking speed normally decreases by about 1% per year from age 60 onwards[13]. L. Alolk, N. Vanicek in their study in 2012 stated that older adults display reduced Musculo-skeletal functions resulting from physiological and neuromuscular changes[12]. These age-related modifications contribute to reduced muscle strength and lower limb joint range of motion (ROM). Consequently, older adults display an increased stance phase and a shorter step/stride length, resulting in reduced speeds, compared to younger adults.

Along with physical decline, decline in cognitive function is a hallmark of ageing and is predictive of mortality Cognitive functions refer to an individual's perception, memory, thinking, reasoning and awareness [14]. The aged are more likely to be victims of poor mental health, which arises from senility, neurosis and extent of life satisfaction [15]. It is estimated that 20% people of age 55 years or older experience some type of mental health concern. Poor mental health produces severe debilitating impairments of memory, attention and other cognitive functioning. With ageing, structural changes of the brain occurs, especially in the prefrontal areas (regions that have been associated with the executive function and attentional systems)[16.]

According to Perry and Hodges Attention may be defined as a primary cognitive process that improves the treatment of information [17]. It is limited for any individual and that performing any task requires a given portion of capacity. Thus, if two tasks are performed together and they require more than the total capacity, the performance on either or both deteriorates[18].

Attention can be classified into separate functions, including focused or selective sustained, divided & alternating, although these distinctions are somewhat artificial. Divided attention refers to the ability to carry out more than one task at a time and alternating attention refers to the rapid shifting of attention from one task to another.

Divided attention plays an important role in walking, multitasking and changing situation it serves as a common tool for examining the attentional demands of various tasks including walking and has clinical implications for fall risk [19]. Therefore, it is not surprising that elderly subject may show difficulties in dual tasking. The attentional demand in gait has been interpreted as an involvement of the cortical level in gait control.

According to with advancing age, it is assumed that as the sensory motor information declines, the control of gait becomes more difficult for older adults and, therefore requires more attention to avoid gait unsteadiness [20,21]. Dual task methods are frequently used to test the relationship between gait and attention.[22]

According to Woollacott M Shumway-cook in 2002, Dual-task related gait changes are usually interpreted as interference caused by competing demands for limited attentional resources[23].

Dual task related gait changes have been reported to be strongly associated with the risk of falling in older adults [24,25]. A study done by Olivier Beauchet on dual task related gait changes in transitionally frail older adults in 2005, concluded that counting backward while walking caused characteristic gait changes that appear to be a marker for decline in gait control, this suggests that the choice of the attention splitting task in dual task gait assessment must be made carefully [26].

Lesley. A. Brown and Natalie de Bruin et al did a study in 2009 in which they proved that gait parameters associated with PD are exacerbated in the presence of concurrent music, an effect that is further exaggerated by the addition of a cognitive task[27].

Backward walking is a recently emerging exercise that enhances the balance and muscle strength of the lower limbs. BW provides a stronger Musculo-skeletal system and cardiovascular function[28]. Learning correctly how to walk backwards has been recommended to improve the movement components required for walking forward.BW, therefore, has been promote as a treatment strategy to improve gait [29].

Although a number of studies have been done to see the influence of various types of dual tasks in adults and elderly during forward as well as backward walking on gait parameters, but no study has been done on comparing various dual tasks during Backward walking so as to see which type of dual task possess more attentional demands on elderly.

AIMS AND OBJECTIVES

To compare the gait parameters during backward walking with different dual task in healthy elderly.

RESEARCH QUESTION

Whether there is any comparison in gait parameters during backward walking among different dual task in healthy elderly?

EXPERIMENTAL QUESTION

There is significant difference in gait parameter during backward walking among different dual task in healthy elderly

NULL HYPOTHESIS

There is no significant difference in gait parameters during backward walking among different dual task in healthy elderly.

ALTERNATIVE HYPOTHESIS

There is significant difference in gait parameters during backward walking among different dual task in healthy elderly.

PURPOSE OF THE STUDY

To find out the comparison of gait parameters among different dual task.

NEED OF THE STUDY

Backward walking is a recently emerging exercise that enhances the balance and muscle strength of the lower limbs. It provides a stronger musculoskeletal system and cardio vascular function. In recent year there has been a growing interest in the use of backward walking and running for training and rehabilitation purpose.

A lot of researches have proved that gait parameters are affected in elderly during backward walking and dual task. Since the ability to walk backward is crucial element of mobility function and might be related to greater risk for fall.

Research finding indicate that these activities are characterized by a lower peak vertical ground reaction force than are forward walking. The loading phase of the gait cycle in backward location involves a concentric contraction of the knee mechanism rather than the more stressful eccentric contraction typical of forward locomotion.

The need of the study to explore the effect of incorporating gradations in backward walking (by adding music or dual tasks) to make backward walking from less demanding task to more demanding task.

METHODOLOGY

SAMPLE SIZE

In this study, 30 subjects were selected and were instructed to do a backward walk with different dual tasks.

SOURCE OF SUBJECT

Senior citizen visited to department of Physiotherapy, Sharda hospital, society of Greater Noida, senior citizen society of Noida [ex-servicemen] & senior citizen society of Ghaziabad.

INCLUSION CRITERIA.

- Age range 60 and above 60 years old.
- Able to walk continuously for 10 meters independently without walking aid.
- Able to follow one step commands.
- MMSE should be greater or equal to 24.

EXCLUSION CRITERIA

- Any neurological, musculoskeletal and cardiopulmonary diagnosis.
- Significant visual and auditory impairments.
- Recent history of loss of consciousness or hip or knee surgery
- Color blindness
- Fracture of lower limb deformity
- Amputation of lower limb.
- MMSE less than 24.

STUDY DESIGN - Experimental Study

SAMPLING TECHNIQUE -Sample of convenience

DURATION OF STUDY - 1-year duration

INSTRUMENTATION/EQUIPMENTS/TOOLS

- Projector
- Laptop

MATERIALS REQUIRED:

- Standardized chair
- Paper walk way
- Ink for foot print
- Stopwatch
- Inch tap
- Marker

European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 07, Issue 11, 2020

Figure 1 I pod

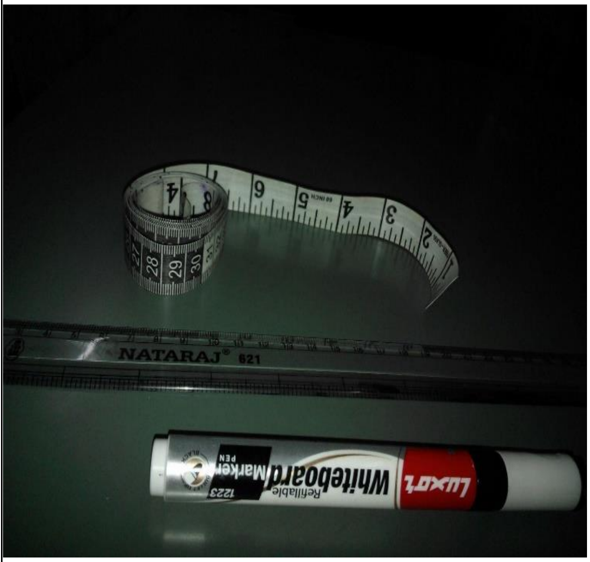


Figure 2 measuring tape, ruler, and marker

Figure 3 stop watch

Figure 4 10-meter walk way paper.

VARIABLES

DEPENDENT VARIABLES

- Gait parameters: - ,
- time taken to perform test,
- Step length,
- stride length,
- number of steps,
- cadence

Figure 5 step length

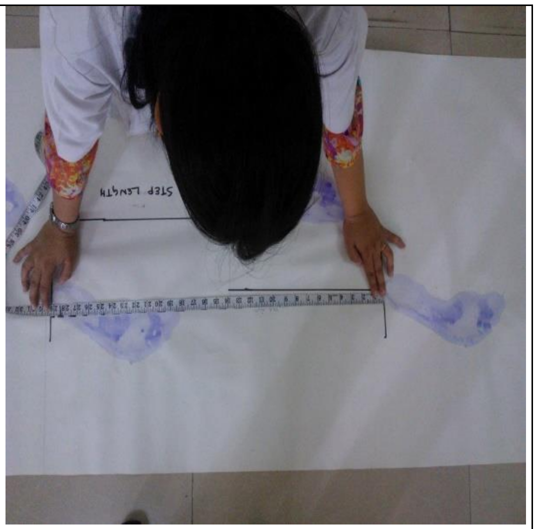


Figure 6 stride length

INDEPENDENT VARIABLES

- Backward walking without task,
- Backward walking with music,
- Backward walking with backward counting.

SAFETY MEASURES

The procedure was carried out under the complete control of the subjects and was totally according to the personal capacity of all subjects. They were assisted during backward walking. This procedure was carried out by a physical therapist (to prevent fall), but the therapist gave no assistance in the actual performance of the movements.

PROTOCOL

A sample of 30 subjects was recruited on the basis of inclusion and exclusion criteria. A brief description was given to all the subjects about the protocol and the procedure which were to be followed. An informed consent was obtained from the subjects who wanted to participate in this study. Subjects were presented with three chits mentioning

1 Backward walking without task
2 Backward walking with music
3 Backward walking with backward counting

The subjects were instructed to do a backward walk in the order in which they picked up the chits i.e., a backward walk without task, a backward walk with music and a backward walk with backward count. One subject was taken at a time. All the three readings were taken with a gap of 15min.

The demographic details of all the subjects were taken using the data collection form. Gait parameters i.e. cadence, time taken to cover six-meter distance, no of steps, step length and stride length were calculated for all three tasks.

Subjects ambulated ten meters on a paper walk away with ink patches on their shoes which left behind a foot print. Foot fall imprints are subsequently measured with a measuring tape. A stop-watch used to measure overall trial time (i.e. from start to finish line). Often requires the time to estimate when the subject broke the plane of the start and finish line.

Figure 7. shows backward walking without task. (Therapist observing time)

Figure 8 foot print of patient during backward walking with music.

Figure 9. foot print of patient during backward walking with music.

EXPERIMENTAL PROCEDURE

Space and ability

Information was given to old adults age 60 or above 60 years from senior citizens of I.T.S. Paramedical College and senior citizen society of NOIDA [ex-service man] for participation in the study. A signed consent was taken from those who volunteered and were screened using inclusion and exclusion criteria. 30 subjects were chosen depending upon inclusion and exclusion criteria.

Orientation and Consent

Prior to the participation all subjects were given consent form and brief description of the nature of the study, its aims and objectives were made clear to the subject. Their demographics and baseline measurement were taken for gait parameters variability by 10metre paper walk way.

DATA ANALYSIS

All the procedure was conducted with the SPSS version 15 software programmed.

Data were analyzed by initial assignment only individuals who completed the entire Clinical trials were counted towards the final results.

The subject's demographic details are summarized using mean values and standard deviations which include age, weight, height, leg length and MMSE.

Repetitive measure of ANOVA used to evaluate the difference between 3 dual tasks for Number of steps, time taken, cadence, step length stride length

Pair wise post hoc [bone forming comparison done to find out pair wise difference between dual task.

Significant level set at 95% and p value set at 0.05

RESULT

DEMOGRAPHIC DETAILS OF THE PATIENT

Table 1 Details with mean and standard Deviation

	Mean ± SD
AGE	*67.66±5.44 years*
WEIGHT	*63.80±8.67 kg*
HEIGHT	*159.65±7.21 cm*
LEG LENGTH	*96.70±10.46 cm*
MMSE	*24.76±1.65*

GAIT PARAMETERS

TABLE 2 Numbers of step/ minutes with different task

	BWWT Mean ±SD	BWWM Mean ±SD	BWWBC Mean ±SD	F value	P value	1/2	1/3	2/3
Num of steps/ Minutes	17.93±4.43	19.06±3.44	23.40±2.88	75.75	.00	.004	.00	.004

Backward Walking Without Task*, Backward Walking with Music**, Backward Walking with Backward Counting***

The mean value and standard deviation of backward walking without task is 17.93±4.43, backward walking with music 23.40±2.88 and backward walking with backward counting is 23.40±2.88 respectively. The comparison between no. of steps and different dual task revealed significant difference with p ≤0.01 of F- value75.75.

The post hoc analysis of number of steps between backward walking without task and backward walking with music revealed significant difference. (p=.004)

The post hoc analysis of number of steps between backward walking without task and backward walking with backward counting revealed significant difference. (p=. oo1)

The post hoc analysis of number of steps between backward walking with backward counting and backward walking with music revealed significant difference. (p=.004)

Chart .1 Graphical representation of no. of steps with different dual tasks

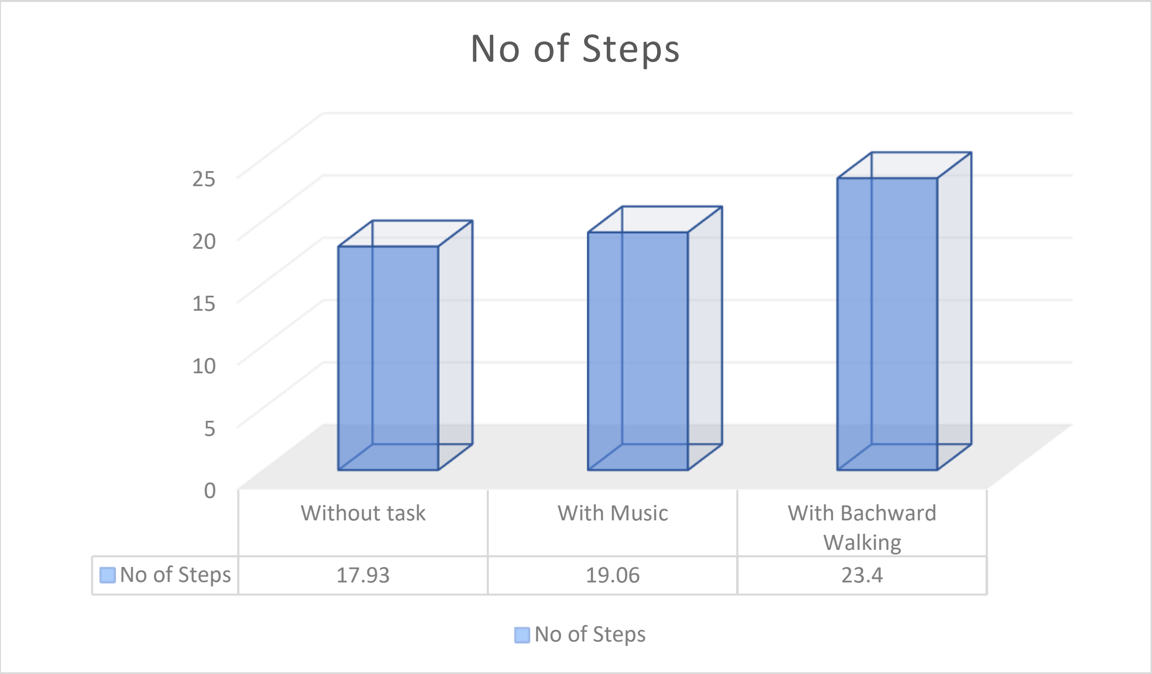
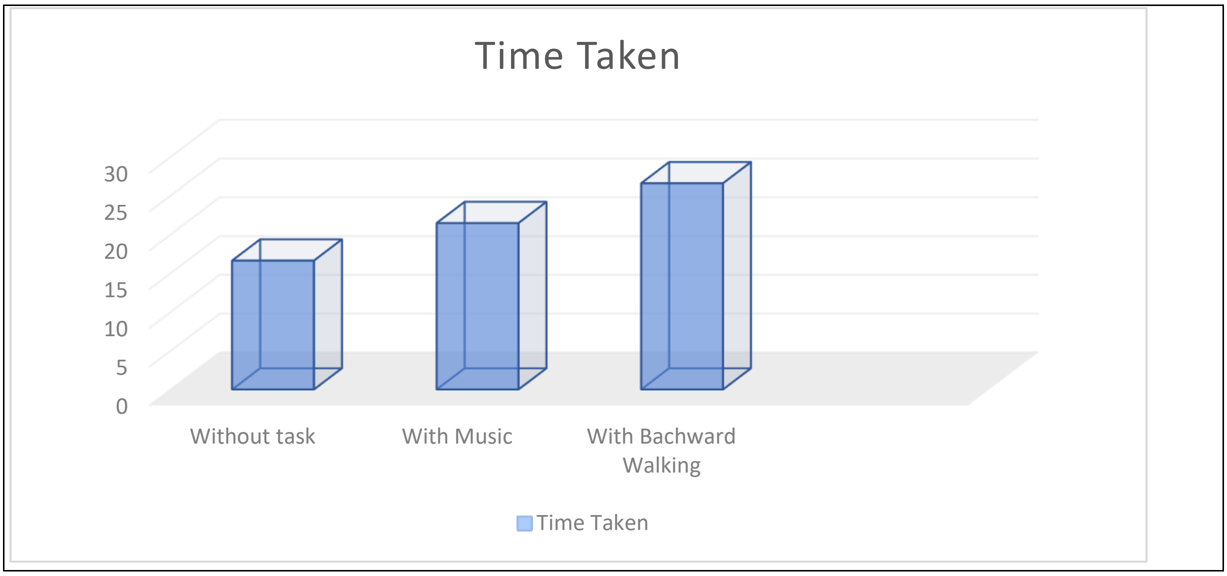


Table 3 Time taken during different dual task

	BWWT	BWWM	BWWBC	F Value	P Value	½	1/3	2/3
Time Taken (Seconds)	16.62±2.91	21.46±4.27	26.59±3.80	13.34	. 001	.001	. 001	.0

Chart 2 graphical representation of time taken and different task



The mean and standard deviation of backward walking without task is 16.62±2.91, backward walking with music is 21.46±4.27 and backward walking with backward counting is 26.59±3.80. Data is showing significant difference with p .001 and f =13.34.

The Post hoc analysis of time taken between backward walking without task and backward walking with music revealed significant difference. (p=. 001).

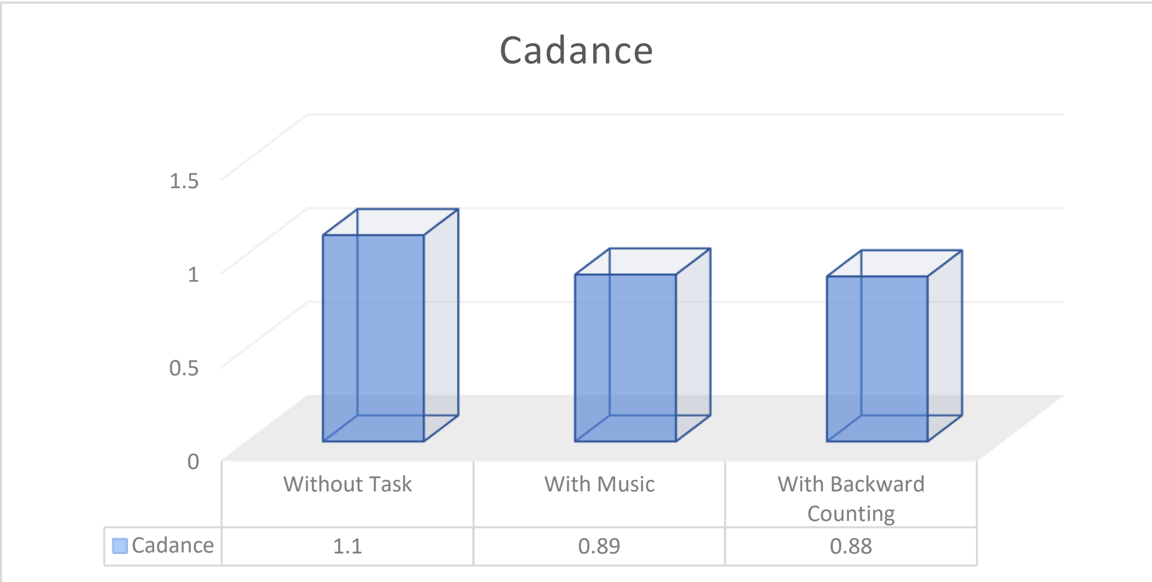
The Post hoc analysis of time taken between backward walking without task and backward walking with backward count revealed significant difference. (p=. 001).

The Post hoc analysis of time taken between backward walking with music and backward walking with backward count significant difference (p=.001) i.e., significant as p≤.05.

Table 4 Time taken during different dual task

	BWWT	BWWM	BWWBC	F Value	P value	½	1/3	2/3
Cadence/Second	1.10±.29	.89±.07	.88±. o8	23..39	.00	. 002	. 002	1.00

Chart 3 The cadence with different dual task during backward walking.



The mean and standard deviation during backward walking without task is 1.10±.29, backward walking with music is .89±.07 and during backward walking with backward counting is .88±.08. This data is showing significant result with p ≤.05.

The post hoc analysis of cadence between backward walking without task and backward walking with music revealed significant difference. (p=.002).

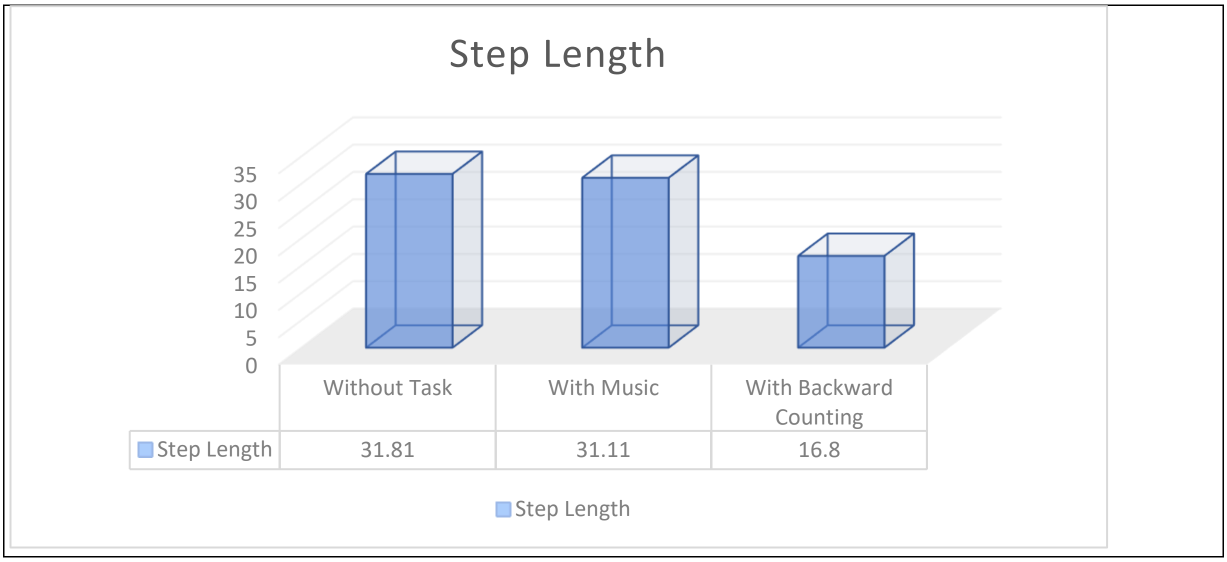
The Post hoc analysis of cadence between backward walking without task and backward walking with backward counting revealed significant difference(p=.002).

The Post hoc analysis of cadence between backward walking with music and backward walking with backward count reveals significant difference. (p=1.00) Post hoc p≥.05 in this that means it is not significant.

Table 5 Step Length of Different Dual Task

	BWWT	BWWM	BWWBC	F -Value	P Value	½	1/3	2/3
Step length(cm)	31.81±4.05	31.11±3.85	16.80±3.10	244.62	.001	.026	.001	.026

Chart 4 step length of different dual task during backward walking.



The mean and standard deviation of step length during backward walking without task is 31.81±4.05, backward walking with music is 31.11±3.85 and during backward walking with backward counting is 16.80±3.10. This data revealed significant difference. (p=.026).

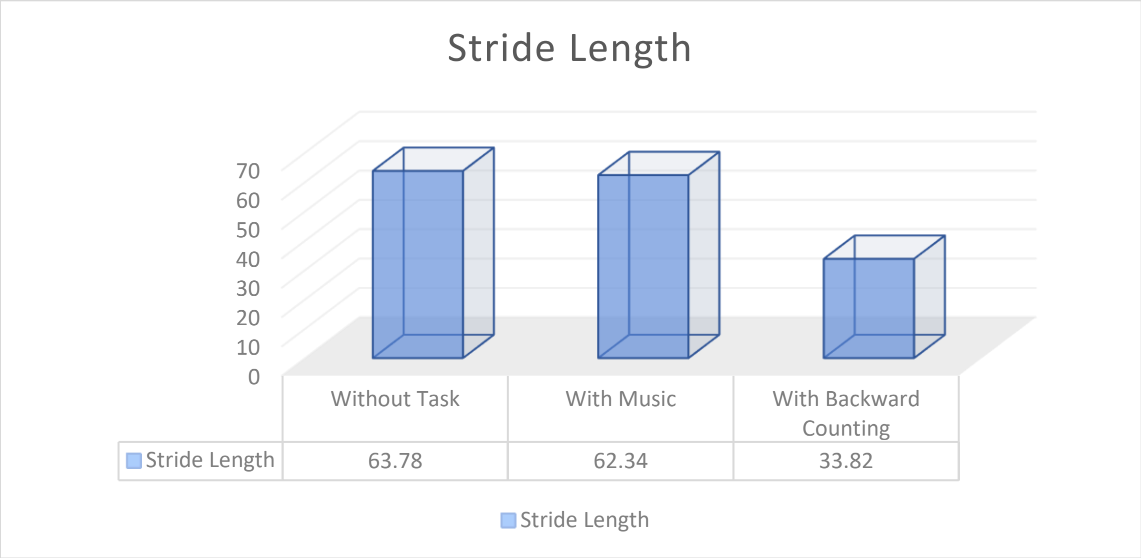
The Post hoc analysis of step length between backward walking without task and backward walking with backward count revealed significant difference. (p=.001).

The Post hoc analysis of step length between backward walking with music and backward walking with backward count revealed significant difference. (p=.02)

Table 6 stride length with different dual task during backward walking

	BWWT	BWWM	BWWBC	F- Value	P - Value	1/2	1/3	2/3
Stride length(cm)	63.78±8.24	62.34±7.58	33.82±6.09	248.8	.001	.032	.001	.001

Chart.5 Stride lengths among different dual task.



The mean and standard deviation of stride length during backward walking without task is 63.78±6, backward walking with music is62.34 ±7.58 and during backward walking with backward counting is 33.82±6.09. This data is showing significant result with p ≤.05.
The post hoc analysis of stride length between backward walking without task and backward walking with music revealed significant difference(p=.026)

The Post hoc analysis of stride length between backward walking without task and backward walking with backward count. Revealed significant difference. (p=.026)

The Post hoc analysis of stride length between backward walking with music and backward walking with backward count revealed significant difference. (p=.026).

DISCUSSION

In this study, when comparison of gait parameters between backward walking without task and backward walking with music is done. It was found that there is significant difference in gait parameters including no of steps, time taken, cadence, step length, stride length.

This is in agreement with study done by Lasely A. Brown et al in 2009 which stated that music adds to the cognitive load acting as a distraction from the primary task [26].

When comparison of gait parameters between backward walking without task and backward walking with backward counting was done. It also revealed significant difference in gait parameters. This is supported by study done by Beauchet O. et al in 2008, in which they stated that there are age related changes in gait parameters such as speed, time, stride length, due to simultaneous performance of a walking associated task and interpreted as interference related to competing demands for attention resources involved in both tasks [27].

Experimental and neuropsychological findings support the important role played by attention and executive function in gait control and the regulation of gait speed and variability. These neuropsychological data suggest a more specific role of cognitive function. In particular, gait may be modulated by frontal cognitive networks that use and manipulate sensory information via cortical sensory association areas, namely the parietal and occipital cortices.[28] The frontal-visuospatial network may be one of the neural substrates that regulates both velocity and gait variability, a measure of dynamic stability. This network is involved in the flexible adaptation of motor behavior, especially whenever the environmental context changes.

Consistent with findings of previous studies, which suggested that Executive function was associated with falls and gait speed slowing in older adults, we also observed that performance of a dual task reduced gait speed in healthy elderly [29-31].

There was significant difference found when we compared gait parameters between backward walking with music and backward walking with counting backward. The result of the present study shows that backward walking with counting backward is a more demanding task than backward walking with music as a cognitive task.

In another study done by Oliver Beauchet et al stated that gait control requires more attention resources with parallel activation of executive functions in older individuals [20]. Thus, Counting backward depends on the working memory, which is a system for temporary storage and processing of information that is directly related to executive functions in older individuals, it appears that combining an arithmetic task with walking created a competitive demand for executive functions in elder subjects which leads to significant difference in gait parameters of both the activities.

CONCLUSION

In this sample of transitionally frail older adults, counting backward while walking caused characteristic gait changes that appears to be a marker for decline in gait control; this suggests that the choice of the attention splitting task in dual task gait assessment must be made carefully.

ETHICAL APPROVAL

The study was registered (IEC/2016/76-A/21) and approved by Institutional Ethics Committee of Department of Physiotherapy, SAHS, School of Medical Sciences & Research, Sharda University & Sharda Hospital. Before starting the treatment, all the information related to the study was explained to all the participants and written consent form was taken.

FUNDING
This article was the result of the faculty project in the Department of Physiotherapy, School of Allied Health Sciences, Sharda University. No external funding

AUTHORS' CONTRIBUTIONS

Conception, study design, and guidance in writing: Dr Chandan Kumar;

Implementation of intervention & Writing: Dr Vaibhav Chaubey

Planning: Dr Shilpi Kapoor

CONFLICT OF INTEREST

The authors declared no conflict of interest.

REFERENCES

1. Prakash Bhattacharya Institute of Chartered Financial Analysis of India; Implications of an Aging Population in India: Challenges and Opportunities. January 12–14, 2005.

2. G. Vani Bhushanam*, K. Sreedevi** and Janaki Kameshwaran***; A Comparative Study on the Living Conditions and Nutritional Status of Elderly in Paid and Unpaid Homes of Chennai, India International Journal of Scientific and Research Publications, Volume 3, Issue 9, September 2013.

3. Krishnamachari Srinivasan, Mario Vaz & Tinku Thomas St. John‟s , Prevalence of health related disability among community dwelling urban elderly from middle socioeconomic strata in Bangaluru, India Received September 19, 2008.

4. Gopal K Ingle, Anita Nath, Geriatric Health in India: Concerns and Solutions Indian Journal of Community Medicine, Vol. 33, Issue 4, October 2008.

5. Masoro E. Handbook of Physiology Section 11. In: Masoro E, editor. New York (NY): Oxford University Press; 1995. p. 3–21.

6. Holloszy JO, Kohrt WM, Sect. 11, chat, 24: exercise in handbook of physiology of aging, Bethesda: American Physiological society ;1995, p,633-66.

7. Irudaya Rajan. (2006). Population Ageing and Health in India. esocialsciences.com, Working Papers.

8. Jorstad EC, Hauer K, Becker, C Lamb SE: Measuring the psychological outcomes of falling: a systematic review. J Am Getriatr Soc 2005; 53:501-10.

9. Jack MG, Phillips CL, Coppin AK, Ciol MA,Bandinelli S, Rerucci L complex walking task performance :55(1)58-65.

10. Palmer, Katie & Thomas, Jamie & Mudge, Suzie. (2014). Activity patterns in people with neurological conditions. New Zealand Journal of Physiotherapy. 42. 9.

11. Silsupadol P, Lugade V, Donkelaar P V, Chou LS, Mayr U,Woolacott MH et al. Effects of single task versus dual task training on balance performance in older adults:Adouble blind , randomised controlled trail:Arch Phys Rehabil. 2009 march: 90(3)381-387.

12. L .Alock ,N Vanicek, T D O Brien ;Alterations in gait speed and age do not fully explain the changes in gait mechanics associated with healthy older women. Gait and posture 37[2013]586-592.

13. Ashton Miller JA: chapter 4, Age associated changes in the biomechanics of gait related falls in older adults; In Hausdorff JM, Alexander NB; Gait disorders; evaluation and management: Taylor and francis 2005 ;63-100.

14. Claire O‟Regan, Hilary Cronin and Rose Anne Kenny Mental Health and Cognitive Function, key finding reports The Irish Longitudinal Study on Ageing ,2012.

15. Gilles Allalia, b, Marian van der Meulena, c, Frédéric Assala Gait and cognition: the impact of executive function Schweizer Archiv Für Neurologie Und Psychiatrie 2010;161(6):195–9.

16. Galit Yogev, Jeffrey M. Hausedorff and nir Giladi; The role of executive function and Attention in gait, Mov Disorder ,2008 Feb 15‟23(3):329-472.

17. Perry R. J &Hodges, J R (1999). Attention and executive deficits in Alzheimer's disease. A critical review Brain ,122, 383-404.

18. Marjorie Woollacott, Anne Shumway cook; Attention and the control of posture and gait; a review of an emerging area of research. Gait & Posture 16 (2002)1-14.

19. Dubost, Veronique & Kressig, Reto & Gonthier, Régis & Herrmann, Francois & Aminian, Kamiar & Najafi, Bijan & Beauchet, Olivier. (2006). Relationships between dual-task related changes in stride velocity and stride time variability in healthy older adults. Human movement science. 25. 372-82. 10.1016/j.humov.2006.03.004..

20. Beauchet O, Najafi, B,Dubost, V, Aminian ,K Mouray, F, $ Kressing ,R. W(2003).Age related decline of gait control under a dual task condition .journal of the American Geriatrics Society ,51, 1187-118.

21. Bloem, B r, Steinjns J. A. G,$Smits Englesman, B.C.(2003).An update on falls .Current Opinion in Neurology,16 ,15-26.

22. Tsuyoshi Asai , Takehiko Doi , Soichiro Hirata , Hiroshi Ando. Dual tasking affects lateral trunk control in healthy younger and older adults. Gait $Posture 38(2013)830-836.

23. Woollacott, M., Shumway-Cook, A (2002). Attention and the control of posture and gait: A review of an emerging area of research. Gait and posture,16,1-14.

24. Lundin-Olsson L, Nyberg L Gustafson Y; Stops walking when talking as a predictor of falls in elderly people. Lancet. 1997 Mar 1;349(9052): 617.

25. Faundin-Olsson L, Nyberg L Gustafson Y;Attention, frailty, and falls ;The effect of a manual task on basis mobility.Jam Geriatric Soci 1998;46;758-761.

26. Lasely A. Brown, Natalie de Brain, Jon B Doan, Oksana 28 Sauchowersky, Novel Challenges to Gait in Parkinson’s Disease: The Effect of Concurrent Music in single – and Dual- Task Contexts.; Arch Phys Med Rehabil vol 90 Sep 2009.

27. Beauchet O, Allali G, Annweiler C, Berrut G, Maarouf N, Herrmann F, R, Dubost V: Does Change in Gait while Counting Backward Predict the Occurrence of a First Fall in Older Adults? Gerontology 2008; 54:217-223. doi: 10.1159/000127318.

28. Chow TW, Cummings J. Frontal-subcortical circuits. In: Miller BL, Cummings J, editors. The Human Frontal Lobes: Functions and Disorders. New York: The Guilford Press; 2007. pp. 25–43. (Science and Practice of Neuropsychology Series).

29. Minhyeon Lee, Jungyoon Kim Jongsang Son, Young Kim; Kinematic and Kinetic analysis during forward and backward walking.;Gait &Posture 38(2013).

30. Yee-Ru Yang ,Jyh –Geng Yen , Ray-Yau Wang ,Lu Lu Yen Fu-kong Lieu;Gait Outcomes after additional Backward walking training in patients with stroke :a randomized controlled trial ;Clinical Rehabilitation 2005 19 264 273.

31. Kearney F, C, Harwood R, H, Gladman J, R, F, Lincoln N, Masud T: The Relationship between Executive Function and Falls and Gait Abnormalities in Older Adults: A Systematic Review. Dement Geriatr Cogn Disord 2013; 36:20-35. doi: 10.1159/000350031.

32. A. Perrochon , G. Kemoun , A. Berthoz Impact of executive function on gait and balance in older adults with cognitive impairment Annals of Physical and Rehabilitation Medicine Volume 55, S1 pages e271-e272 (octobre 2012) Doi : 10.1016/jrehab. 2012.07.685.