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Original Research Article

Effect of 5-week training session on balance in elderly with medium risk of fall: a comparative study

Gargi M. Ray*, Pushpa R. Dhote, Amrin Rupani

Department of Neuro-Physiotherapy, VSPMS College of Physiotherapy, Nagpur, Maharashtra, India

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***Correspondence:**
Dr. Gargi M. Ray,
E-mail: gargipj@gmail.com

ABSTRACT

Background: Ageing is a process through which slow, spontaneous, and progressive changes occur in the body structure over time. Healthy ageing is also characterized by reduction in muscle mass, maximal strength, rate of force development and changes in the architectural and mechanical properties of the muscle-tendon unit, thus affecting balance in the elderly. Here, we sought to compare the effectiveness of Frenkel's and Cawthorne-Cooksey exercises on the balance in elderly within age group 60-70 years.
Methods: A comparative study was conducted on 32 geriatric people of age group 60-70 years with medium risk of fall. The risk of fall was considered using Berg Balance Scale (BBS: 21-40 score). The sample size (n=32) was divided into 16 subjects each in Group A and Group B respectively. Informed consent was taken and the procedure was explained to all the participants.
Results: The effectiveness of both the interventions on BBS was compared before and after 5 weeks of training. After 5 weeks of balance training sessions of both the groups, improvement in Berg Balance Scale (BBS) scores of the elderly group was seen.
Conclusions: The current study, conducted on Frenkel's exercises and Cawthorne- Cooksey exercises (Group A and Group B, respectively) used for the elderly with medium risk of fall of the age group 60-70 years for 5 weeks using Berg Balance Scale (BBS) shows that both the groups are equally effective in improving the balance.

Keywords: Geriatric population, Balance training, Medium risk of fall, Co-ordination exercises, Vestibular exercises

INTRODUCTION

Balance is defined as "the ability to maintain the body's centre of gravity within the base of support with minimal sway".[1] Balance is further classified into Static and Dynamic Balance. It is regulated effectively through interaction between the central nervous system, musculoskeletal system and various sensorimotor systems.[2]

Human being a bipedal animal, a major problem for standing posture is a high centre of gravity (COG) maintained over a relatively narrow base of support (BOS). Therefore, the human body has a high potential energy, leading to the priority of equilibrium control during almost all motor tasks including quiet standing.[3] The postural control system, rather than varying the pattern of muscular contractions continuously, use distinct strategies within bounded regions of the position space, such as the ankle, hip and stepping strategies (the frequent use of single and multiple steps). Ankle strategy consists of delaying activation of ankle, thigh and trunk muscles located on the same dorsal or ventral side. Hip strategy involves the delayed activation of trunk and thigh muscles radiating from proximal to distal. While the hip strategy is anticipated to be used for fast or large amplitude perturbations or when the support surface is limited and minimal ankle torque can be applied, the ankle strategy is anticipated to be used for unperturbed stance and for slow and low amplitude perturbations.[3-7]

Ageing is a process through which slow, spontaneous, and progressive changes occur in the body structure over time.[8] Healthy ageing is also characterized by reduction in muscle mass, maximal strength, rate of force development and changes in the architectural and mechanical properties of the muscle-tendon unit.[9] These changes affect the body, organs, and systems, and their functional decline may alter general abilities to carry out activities of daily living (ADLs) thus impairing independence and quality of life.[10] Research suggests that almost every area of the brain is responsible for balance. However, the cerebellum, basal ganglia, thalamus, hippocampus, and frontal and parietal lobes play important role in maintaining balance. The cerebellum is responsible for motor coordination and movement planning. Any reduction in the grey matter of the cerebellum negatively affects balance. Recently, an increasing role has been attributed to the hippocampus. It transfers information to long-term memory but also remembers spatial information. The reduction of grey matter within the basal and thalamic nuclei, placed in the brain that control motor functions, negatively affects balance. Similar conclusions were made when examining the volume of grey matter of the parietal lobe; reducing this volume worsens balance.[11] It has also been proved in recent studies, during upright standing, a decreased efficacy of primary afferent fiber to activate spinal motor neurons accompanied by increased corticospinal excitability during upright standing in elderly compared with young adults. These changes may reflect adaptations in response to the age-related alterations within the nervous and muscular systems.[12] The compensation strategy during balance impairment is sensory reweighting between visual, vestibular, and proprioceptive information. According to this strategy, the nervous system prefers reliable sensory information of one sensory system over less reliable information of other sensory systems within a continuous dynamically weighting process. Information of each sensory system is weighted by a weighting factor relative to the contribution of sensory information of the other sensory systems. The reweighting of sensory information therefore gives more insight into the contribution of the sensory systems in maintaining balance. Reweighting of sensory information also depends on environmental conditions, like standing on uneven ground or in a dark room.[13]

Falls are defined as unintentional events that result in a person coming to rest inadvertently on the ground, floor, or other lower level, without any specific physical forces coming into play.[14] As the age advances, gait pattern and mobility are altered too, because of postural changes.

Many previous studies suggested that, various interventions like balance training program, Yoga, exercises using Swiss ball, Tai-Chi training, endurance training, aquatic therapy, strength training, virtual training etc.[14-34] help to improve balance in elderly, thus, reducing risks of fall.

Frenkel’s exercise uses the intact sensory systems to compensate the impaired kinaesthetic sensation to maintain balance. Hence, these exercises are also termed co-ordination exercises. It has been studied that Frenkel’s exercise also helps to improve static and dynamic balance in elderly.[11,20]

Cawthorne-Cooksey exercises provide feedback for new peripheral sensory information which allows formation of new vestibular stimulation patterns which improves balance reactions, and, consequently reduces the risks of falls.[8,35]

Neuroplasticity is the ability of the nervous system to respond to intrinsic or extrinsic stimuli by reorganising its structure, function and connections.[35-38] As age advances, this ability of the nervous system slows down but is not completely hampered. Hence, this phenomenon can be used to create an ideal environment for motor re-learning which may determine a significant improvement of overall function. It has also been proved that, practising a motor function or mental practice improves neural processing in elderly as well. Therefore, when considering these two techniques while treating elderly, concentration and repetition are considered to be the key to success.[35] The functional balance test considered in this study is the Berg Balance Scale (BBS).

METHODS

Study design

The research design used for this study was a comparative study.

Data collection tools

The materials used for data collection were: chair with and without armrests, stop watch, step stool, inch tape, colourful chalks, pen, paper, cones for obstacle walking, sponge ball, berg balance scale sheet, consent form.

Participants

The participants (n=32) included in this study were elderly subjects of age group 60-70 years. The sample size was determined as per the previously published study.[35] The participants from the community and the old age home in the vicinity of 20 km from the study place (VSPMS college of Physiotherapy and Lata Mangeshkar Hospital, Nagpur) were selected, if they were willing to participate, were able to communicate with the researcher and with medium risk of fall (score:21-40 according to

Berg Balance Scale). This study was conducted between May 2019 to February 2020.

Both males and females were included in this study. The paticipants unwilling to participate, with known conditions leading to balance impairments like, neurological, musculoskeletal deformities; fractures in lower limbs, neoplastic disorders, uncorrected visual impairments, uncorrected auditory impairments were excluded from this study. Subject withdrawal criteria were also considered if the participants were unwilling to continue further or if diagnosed with above mentioned conditions, during the study. The participants were divided into two groups, Group A (n=16) and Group B (n=16), using block randomisation (refer to Figure 1). After assignment of intervention groups, the participants were blinded and further procedure was carried out. The Ethical clearance was obtained from the Institutional Ethical Committee. The participants were explained in details about the study and they provided written informed consents. All the data obtained were kept confidential with no direct reference to the identity of the participants. Data was documented in the excel sheet.

Statistical methods

Graph Pad (Prism v8.0) software was used to build graphs and perform statistical analyses presented throughout this study. The Grubbs test also called the ESD method (Extreme Studentized Deviate), to determine whether any value represented in the list is a significant outlier from the rest. Since the data showed no significant outlier, the Shapiro–Wilk method, the D'Agostino and Pearson normality test was performed to assess whether the data showed normal distribution (A $p<0.05$ was considered significant). As the data values are not normally distributed, following tests were performed: (1) comparison of pre-and post-intervention within the group- paired test (non- parametric with Wilcoxon matched-pairs signed-rank test), (2) comparison of pre-and post-intervention between the groups- unpaired test (non-parametric with Mann Whitney test).

Data are presented as Mean±SD unless otherwise stated. A $p<0.05$ was considered significant.

Methodology of intervention

Two groups were formed, Group A and Group B. The sample size (n=32) was divided into 16 and 16 subjects in Group A and Group B respectively (Figure 1). Informed consent was taken and the procedure was explained to all the participants.

Total number of 32 participants were considered, and divided in two groups using block randomisation method. Eight permuted blocks were formed. Blocks were randomly chosen to determine the assignment of participants into the groups.

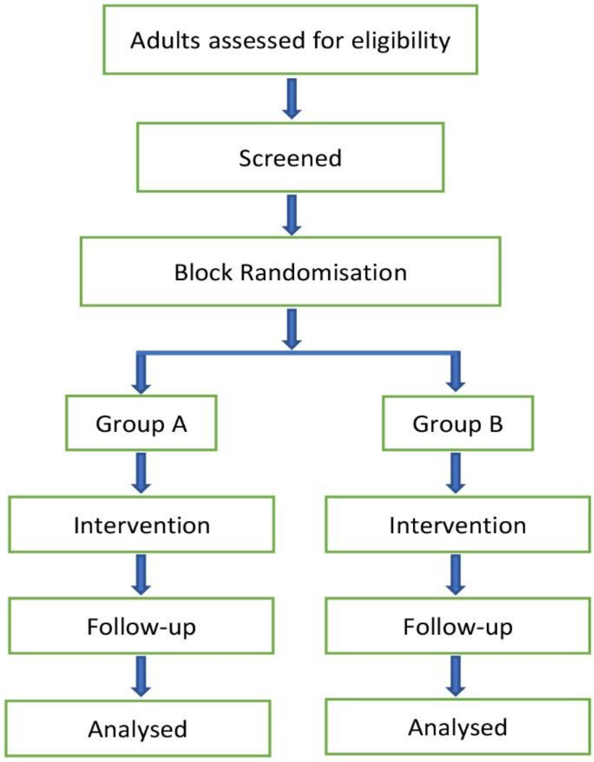

Figure 1: Block randomisation method used in this study.

According to the group allocated to the participants, the intervention was planned and exercises were prescribed to the participants of respective groups for 5 weeks, thrice a week. At the end of intervention period, follow-up of participants from both the groups were done. The post-intervention berg balance scores were assessed and statistical analysis of the data obtained was carried out.

The treatment session included warm-up exercise (walking), a training session with 1-minute rest for every 5 minutes of exercise, cool down exercises including stretching of muscles involved in balance exercise (erector spine, hamstring, rectus femoris, gastro-soleus, and pectoral muscles).

Group A: The participants in this group were treated with Frenkel's exercise. These exercises were performed for 5 weeks, 3 times per week. In the first week, the duration of each session was 10 minutes and then increased by 5 minutes per week and hence, duration of the last session was 30 minutes.[20]

Exercises for legs in sitting: patient should be able to see foot-markings on floor.[11] Exercises for legs in sitting, slide heel to a position indicated by a mark on floor, sitting by alternate leg stretching and lifting to place heel or toe on specified mark and sitting by change to standing and sit down again, support may be required.

Exercise for the legs in standing: Some support may be necessary, but patient should be able to see his feet, and foot-markings on floor. Standing by axial rotation, stride standing by transfer weight from foot to foot, stride standing by walk sideways placing feet on marks on the floor, standing by walking placing feet on marks, standing by turn round, standing by walking and changing directions to avoid obstacles, heel to toe walking (tandem walking).[11,39]

Group B: The participants in this group were treated by Cawthorne-Cooksey exercises. Cawthorne-Cooksey exercises are based on a series of exercises of increasing complexity involving first eye and head movements and then movements of the whole body while sitting, and in the upright position both with eyes open (EO) and eyes closed (EC). The full set of these exercises were administered to the patients: each exercise was repeated 5 times, first in the EO condition and then in the EC condition.[40] These exercises were performed for 5 weeks, 3 times per week.

Eye and head movement, sitting down: first slowly, then faster by look up and down, look to the right and to the left, bring your fingers closer and farther, looking at it, move your head (slowly and then faster) to the right and the left, with open eyes, move your head (slowly and then faster) up and down, with open eyes, repeat moving head to the right and left, and up and down with closed eyes.

Head and body movement, sitting down: place an object on the floor. Take it and bring it above and place it on the floor again (look at the object the whole time), shrink your shoulders and make circular movements, turning head and trunk alternately to left and right.

Standing up exercises: sit down and stand up; initially with eyes open and stand up again; initially with eyes open and then with closed eyes, throwing a small ball from one hand to the other (overhead) and following it with eyes, throwing a small ball from one hand to another while bending forward, behind the knees.

Exercises while walking: throwing and catching ball above the head while walking, walking up and down a flight of stairs, walking around the room initially with eyes open and then with eyes closed and playing any game involving stretching, bending and aiming the ball.[35]

RESULTS

An assessment form was designed in which: name, age, gender, history of any associated illness, was considered. The pre-intervention BBS score was taken on the first day of commencement of the protocol and the post-intervention BBS score was taken on the last day of the exercise protocol. The Berg Balance Scale (BBS) consists of 14 functional tasks commonly performed in day-to-day life. Tasks ranges from sitting or standing unsupported, to movement transitions which involves; sit-to-stand and vice versa; variations in standing position. The scoring system involves scores from 0-4 which indicates that, 4-person performs independently and meets time and distance criteria, whereas, 0-unable to perform. The maximum score of 56 is possible.[41] The score are as follows 41-56= low fall risk, 21-40= medium fall risk, 0-20= high fall risk, <36 fall risk close to 100%.[41,42]

The difference between pre- and post-intervention BBS scores were noted on the assessment form. The mean of Berg Balance scores pre-and post-intervention of both the groups is calculated to show that there is no difference in pre-intervention values in both groups as shown in Table 1. The authors strictly adhered to the planned protocol to maintain the fidelity of the study. The intervention adherence was assessed by the authors and two other physiotherapists.

Table 1: Pre-and post-intervention Mean Berg Balance scores with the standard deviations.

Mean of Berg Balance scores	Pre-intervention Mean±SD	Post-intervention Mean±SD
Group A	37.5±3.20	50.06±3.75
Group B	37.43±4.66	51.25±2.64

Interpretation

Paired test (non-parametric with Wilcoxon matched-pairs signed-rank test)

Comparing the mean of pre-and post-intervention berg balance scores of Group A and B, statistically, using paired test (non-parametric with Wilcoxon matched-pairs signed-rank test), i.e., within the same group (Figure 2). It shows significant difference in pre-and post-intervention Berg Balance scores in both groups with the 95% confidence level.

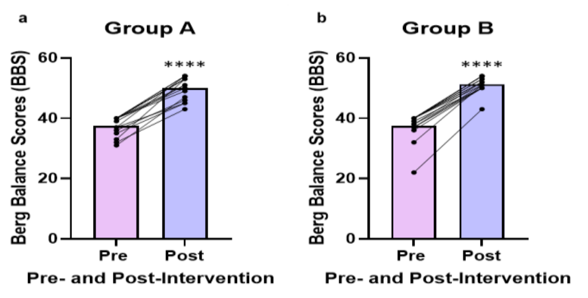

Figure 2: Pre-and Post-intervention Berg Balance Scores (BBS) in Group A and B. (a) Represents the pre-and post-intervention BBS of Group A. (b) Represents the pre-and post-intervention BBS of Group B. Each symbol (dot) on the bar graph represents the individual BBS within the groups' A and B, while the lines represent pre-and post-intervention BBS of the individual participant in this study.

No data was excluded. Data represented as mean±SD, ****p<0.0001. Mean±SD of the post-treatment scores are represented in Table 1 (Group A=50.062±3.75, Group B=51.25 ±2.64).

Unpaired test (non-parametric with Mann Whitney test)

Comparing the pre-and post-intervention berg balance scores of Group A and B between the groups was done statistically, using an unpaired test (non-parametric with Mann Whitney test). It shows no statistically significant difference between Group A and B in pre-and post-intervention Berg Balance Scores in both groups with the 95% confidence level (Figure 3).

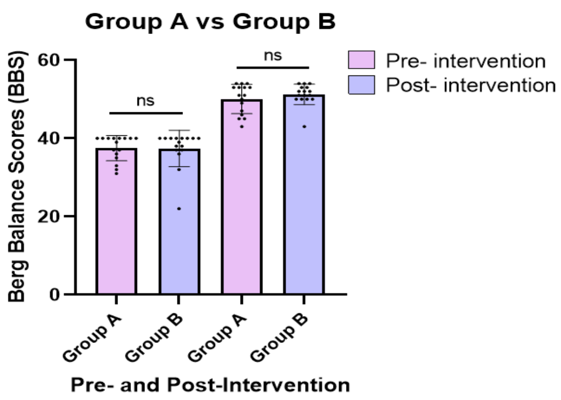

Figure 3: Comparison of Pre-and Post- Intervention Berg Balance Scores of Group A and B. The dots on the bar diagram represent individual scores pre- and post-intervention in both the groups. No data was excluded. Data represented as mean±SD where, ^{ns}p=non-significant.

Compares the pre-and post-intervention data of Group A and B. The dots on the bar diagram represent individual scores pre-and post-intervention in both the groups. No data was excluded. Data represented as mean±SD where, nsp=non-significant.

As represented in the graph above, the difference in the results of post-intervention means of Berg balance scores is minimal. The pre-and post-intervention mean score of Group A and B are as represented in Table 1. Thus, the difference in pre-and post-treatment mean score of Group A=12.56, and that of Group B=13.82. Also, as seen in the graph above, the individual score improvement is better in Group B.

Therefore, the graph represents, the overall improvement is seen effectively, when considering the change in individual scores post-intervention, in Group B, though, statistically, the results prove that there is no significant difference in both the intervention techniques to improve the Berg balance scores. Thus, proving the null hypothesis, i.e., there is no significant difference in the effect of 5-week training sessions of Frenkel's exercise and Cawthorne-Cooksey exercise on improving berg balance score in elderly of age-group 60-70 years with medium risk of fall.

DISCUSSION

In this study, the purpose was to assess the berg balance score using Frenkel's exercises and Cawthorne-Cooksey exercises. Also, to see if they generated motor learning and contributed to improving balance and reducing the possibility of falls in the elderly with medium risk of fall.

The study results showed that both techniques were effective in improving the berg balance score. The statistically significant differences were observed in statistical analysis of pre-and post-treatment in both groups (Group A and Group B), i.e., Wilcoxon matched-pairs signed-rank test in both the groups showed statistically significant differences. Whereas, Mann-Whitney U test analysis proved that there was no significant difference in the statistical analysis of post-treatment results of both the groups. The graphical representation signifies the individual improvement in berg balance scores post-treatment to be more effective in Group B than Group A (refer Figure 3).

With age, balance and gait control decline because of changes in sensory acuity, motor control, neural, and cognitive functions. Consequently, impairments in mobility tasks including stair climbing and standing from a seated position are seen in this population which results in low levels of physical activity, reduced independence, and poorer quality of life.[43]

Falls and fall-related injuries are now the growing public health concern in many regions of the world with rapid population ageing. It is particularly due to ageing related balance deficits and poor postural stability. Balance and gait rely on an internal sensory representation of the body in space (proprioception) to plan and coordinate movement. Multisensory information allows instantaneous assessment of the posture and its relationship to the environment. A repetitive firing of the sensory information is necessary to control balance. However, this repetitive firing reduces in older age and may be further reduced by pathology or inactivity-related deconditioning, affecting one or more systems.

These health and lifestyle factors, as well as considerable variability in the rate of normal ageing, result in great heterogeneity in older people, such that some have a sensorimotor function, balance, and gait abilities similar to young adults while others are markedly impaired.[43]

Physiology of the techniques

Cawthorne-Cooksey exercises

The vestibular system is the absolute referential for the maintenance of balance. Ageing can result in balance disturbance and an increase in likelihood of falls thus leading to functional deficits. The vestibular exercises as described by Cawthorne and Cooksey, may support the new arrangements of peripheral sensorial information, thus, allowing new vestibular stimulation patterns necessary for new experiences to become automatic. This practice would be capable of promoting improvement in reactions of balance and, consequently, reducing falls.

The clinical recovery aided through these exercises is thought to rely on the following mechanisms:

Adaptation

Modification of the gain of the relevant vestibulo-oculomotor and vestibulospinal circuits.

Habituation

A central process of learning that is independent of sensory adaptation and motor fatigue.

Central compensation

A counterbalancing of any defect of structure or function, and substitution with other sensory inputs.

It is observed that the difference in balance sensorimotor strategies between eyes open (EO), eyes closed (EC) reflect the reorganisation of different components of postural control at the input level. These strategies allow an evaluation of the respective contribution of the afferent impulses involved in the postural control, their interactions in postural control and the possibility of selecting and relying on a more dependable input. Gauchard et al in 2001, proved that in an elderly population, the dependence on visual afferent impulses increases, while, other sensory impulses are used less. The individuals who are not physically trained and lead a sedentary lifestyle, show high dependency for visual afferent and alteration of proprioception. Therefore, any age-related visual deprivation generates more difficulties related to balance regulation accuracy.[44] As the age progresses, a hyposensitivity to afferent vestibular impulses develops, consequently, EC condition along with removed or altered proprioceptive impulses appears to be disruptive in the elderly. But, repetitive practice of these exercises has a positive effect on vestibular afferent which thus improves adaptation required in EC condition. Practicing these low-energy activities may produce hyperstimulation of the vestibular afferents, leading to increased insensitivity in the vestibular system as seen in vestibular rehabilitation. These exercises develop proprioception, which suggests that subjects achieve accurate sensorial choice between visual and proprioceptive-vestibular afferents, thus resulting in precise adaptation of motor response. Therefore, helping elderly subjects to retain the stable bottom-up strategy displayed in EO condition.

The vestibular system is sensitive to each acceleration movement of head, these exercises force subjects to use vestibular afferents again and prevent omission of vestibular inputs, without putting much strain on visual cues.

These exercises can also form the base for regulation of posture on vestibular referential, thus, limiting age-related postural deficits, as suggested by one study.[44]

Frenkel's exercise

Associated with high activation in visual-spatial networks in the brain of older adults. It is also known to involve an activation of the cerebellum, which is responsible for motor control and motor learning, and was found to influence a variety of higher cognitive functions, including divided attention and working memory, and verbal learning and memory.[45]

As proved in earlier studies, the cerebellum is involved in both compensatory postural reaction by means of sensory feedback mechanisms and anticipatory postural adjustments by means of feedforward mechanisms.[46] In addition, bimanual coordination movements have been shown to lead to activation in the pre-frontal cortex, specifically the medial frontal region, which is also involved in attention to demanding cognitive tasks, spatial memory, self-initiated movement, and conflict resolution.[43] Frenkel's exercise is used to retrain proprioception (conscious capacity to sense position, movement and force of body segments) and coordination, with particular focus on the lower limbs, thus assisting in improving balance.[46,47]

In previous studies, comparison of these techniques is not studied to improve balance in population of age-group 60-70 years with medium risk of fall. Moreover, according to the available literature, dosage for Cawthorne-Cooksey exercise was for 9 weeks, which was proved to be effective.[35] The other available dosage was 10 sessions for 5 consecutive days, which was not proved more effective.[40] But, this study proved that Cawthorne-Cooksey exercises are effective in improving balance after 5-week training session in elderly (60-70 years) with medium risk of fall. But further study is required to assess long term effect of both these exercises and also, to demonstrate if study based on sex differences show any variation in the results.

It has already been proved that relative inactivity in elderly people induces poor quality of balance, vestibular and proprioceptive hypo-excitability, and a high dependency upon visual afferent. Hence, proving the fact that, the regular exercises significantly improve dynamic postural control, with considerable advantages for the vestibular as well as proprioceptive sensitivity and lower contribution of visual cues, thus, limiting the harmful effect of ageing on balance.[44]

CONCLUSION

As per the statistical analysis, Berg Balance Scale (BBS) scores (pre-and post-intervention) in each group was statistically significant, thus proving that both the groups are effective in improving the balance. But, statistical analysis of Berg Balance Scale (BBS) scores (pre-and post-intervention) between the groups, are not statistically significant.

Thus, both techniques are equally effective in improving balance and also in reducing the risk of falls in elderly adults aged 60-70 years with a medium risk of fall. It also demonstrates that; Cawthorne-Cooksey exercises are effective in improving the balance in elderly people of the same age group in 5 weeks of training.

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