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Perturbation exercises to improve balance and gait in older adults in rural areas

Exercícios de perturbação para melhorar o equilíbrio e a marcha em idosos em áreas rurais

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ABSTRACT

Background: Falls represent one of the main causes of activity limitation, participation restriction and deaths due to involuntary trauma in the elderly, becoming a serious socio-sanitary problem. It requires the development of preventive and curative interventions of the syndromes associated with this phenomenon. Objective: To establish the effect of a perturbation exercise program to improve balance and gait in older adults in rural areas. Methods: Balance, gait, and risk of falls were assessed with the Tinetti scale and the Times Up and Go (TUG) test. Before and after applying the perturbation exercises, they were reviewed and validated by expert judgment. Results: A clinical improvement in balance and gait of between 1 to 6 points is reflected, as well as a decrease in the risk of falls both in the Tinetti scale and in the TUG test. These were evidenced with significant differences between measures in balance (p=0.000), gait (p=0.000), risk of falls - Tinetti (p=0.000) and TUG test (p=0.000). Conclusions: Perturbation exercises improve balance and gait in older adults, reducing the risk of falls.

Keywords: elderly; accidental falls; gait; postural balance; exercise therapy.

RESUMO

Enquadramento: As quedas representam uma das principais causas de limitação de atividades, restrição de participação e mortes por traumas involuntários em idosos, tornando-se um grave problema sociosanitário. Requer o desenvolvimento de intervenções preventivas e curativas das síndromes associadas a este fenômeno. Objetivo: Estabelecer o efeito de um programa de exercícios de perturbação para melhorar o equilíbrio e a marcha em idosos em áreas rurais. Métodos: O equilíbrio, a marcha e o risco de quedas foram avaliados pela escala de Tinetti e pelo teste Times Up and Go (TUG). Antes e depois da aplicação dos exercícios de perturbação, os mesmos foram revisados e validados por julgamento de especialistas. Resultados: Reflete-se uma melhoria clínica do equilíbrio e da marcha entre 1 a 6 pontos, bem como uma diminuição do risco de quedas tanto na escala de Tinetti como no teste TUG. Estas foram evidenciadas com diferenças significativas entre medidas de equilíbrio (p=0,000), marcha (p=0,000), risco de quedas -Tinetti (p=0,000) e teste TUG (p=0,000). Conclusões: Os exercícios de perturbação melhoram o equilíbrio e a marcha em idosos, reduzindo o risco de quedas.

Palavras-chave: idosos; quedas acidentais; marcha; equilíbrio postural; terapia por exercícios.

INTRODUCTION

The aging process includes a series of changes in the body that appear over the years. They are accompanied by a gradual decline in individual physical and mental capacities in the elderly. These changes increase the risk of suffering from both acute and chronic conditions and diseases (WHO, 2022). Some examples are fragility, urinary incontinence, delirious states, falls, gait disorders, among others. They are called geriatric syndromes (Osoba et al. 2019).

The fall is the precipitation of the body towards the ground due to loss of balance (WHO, 2021). In people over 65 years of age, the prevalence of falls is one per year, which increases with age. It represents a greater risk of morbidity and mortality in the elderly (James et al. 2020). The sense of balance is achieved through the interaction of multiple complex systems, from birth; and is developed and perfected over the years (Hamstra et al, 2006; Stodden, Langendorfer & Roberton, 2009). But after 60 years, it begins to deteriorate gradually.

Worldwide, falls represent a socio-health problem, since they represent the second cause of death in geriatric patients. In addition, 80% of deaths due to falls are recorded in low- and middle-income countries, 60% in regions of the Eastern Pacific and Southeast Asia (Osoba et al. 2019). According to the United Nations, an aging population is one in which, of the total inhabitants, more than 7% are people over 65 years of age. It proposes drawing the dividing line at 60 years for developing countries (WHO, 2011). In Colombia, 26% of older adults have had a fall that led to limitations in activities of daily living and social restrictions due to fear of falling (Manrique et al. 2011).

The Ecuadorian Institute of Statistics and Censuses (INEC) in 2009 announced, through a survey, that in the Ecuadorian state there is a number of 1.2 million older adults. 53.4% are women who reach a life expectancy of 78 years compared to men who only reach the age of 72 (Menéndez et al. 2005). The Ministry of Economic and Social Inclusion (MIES) estimated that by 2050 the population of older adults would reach a proportion of 18%, so reforms must be made in health plans that can respond to new trends. (Peláez, 2005).

INEC, through the census carried out in 2010, announced that in the province of Tungurahua there are 42,503 older adults and 13,010 of them live in the Ambato canton. They found a proportion of 43.1% women and 40.1% men (Reyes et al. 2005). Nowadays in Ecuador, it is important to serve these priority and vulnerable groups, which in addition to improving their quality of life will also have an impact on the socioeconomic expenditure represented by the treatment of injuries due to sensoromotor alterations (Edivã Bernardo da et al. 2015).

In this way, there is an association between alterations in balance, gait and increased risk of falls, suggesting the need for programs based on activities that improve balance (Verghese et al., 2006). For this reason, this research analyzes the effect of a perturbation exercise program to improve balance and gait in older adults in rural areas. The available evidence demonstrates the broad benefit of perturbation exercises in the older adult population, especially in the prevention of falls (Kurz et al. 2016).

In the research by Bierbaum, Peper and Arampatzis (2013) on "Exercise of mechanisms of dynamic stability improves the stability state after an unexpected gait perturbation in elderly", it was found that during the gait of the elderly there are sudden changes that affect its stability, but there is also a conserved adaptive potential. In this way, by training the mechanisms of dynamic stability and muscular strength, the dynamic stability of the older adult to sudden perturbations will be improved.

On the other hand, Epro et al (2018) in their study on "Retention of gait stability improvements over 1.5 years in older adults: effects of perturbation exposure and triceps surae neuromuscular exercise", emphasize the importance of reactive steps to maintain stability in the recovery from sudden alterations in gait. So, the authors set out to discover whether the improvement of the neuromuscular capacities of the triceps surae, induced by exercise in the medium and long term, affects the ability of older adults to retain the improvements in stability reactive gait during gait perturbation.

In this context, Gimmon et al (2018) in their study "Perturbation exercises during treadmill walking improve pelvic and trunk motion in older adults-A randomized control trial", highlight that when walking, the incidence of falls is higher in older adults. It requires great stability where pelvic and trunk function is involved. Thus, they explored whether movement that incorporates an unexpected loss of balance during walking through balance recovery reactions will improve pelvic, thoracic and trunk kinematics at different speeds during walking.

Likewise, König et al (2019), in their study on "Retention and generalizability of balance recovery response adaptations from trip perturbations across the adult life span", consider the importance of adjustments to the motor system in the different environments to which human locomotion is exposed. They wonder whether age affects the adaptation of balance recovery during walking, its retention over months, and the transfer of adaptation to a reactive balance task without training. We, therefore, decided to examine acute adaptations in reactive control of gait stability due to repeated travel-like perturbations, the retention of those perturbations over several months, and their transfer to an untrained reactive balance

task.

METHODOLOGY

The research according to its design was a quasi-experimental longitudinal cohort, with an application purpose and descriptive scope. It was developed under a mixed approach and the data source was obtained through documentary and field work. It was carried out at the "A New Life" Home Care Unit, belonging to the "Aging Together" project of public policy for the period 2022 – 2025. It was promoted by the Ministry of Economic and Social Inclusion (MIES) of the Augusto N. Martínez rural parish, which belongs to the Province of Tungurahua, Zone 3 of Economic and Social Development, of Ecuador.

Authorization was requested from the "A New Life" Home Care Unit". The study population was all older adults who actively participate in the Unit, reaching 30 participants, aged between 65 and 85 years. No sampling design was applied, due to the size of the population. In such a way, the research was developed with the entire population, meeting the inclusion criteria: older adults, men and women who belong to the "A New Life" Unit, of between 65 and 85 years old, with a history of falls in the last year, static or dynamic balance deficit with independent walking with or without a walker or cane, and with an informed consent signed. The exclusion criteria were: post-surgical users in the acute phase, with neurological injuries, presence of severe hearing impairment (Vertigo) or visual impairment (Blindness), severe intellectual disability and use of a wheelchair.

Then the informed consent document was designed, which authorized the older adults´ voluntary participation through their signature. At the same time, a review of information on perturbation exercises for balance and walking in older adults was carried out in different scientific databases. For the diagnosis, an information record sheet was structured to identify the sensoromotor alterations related to balance presented by the older adults in the study group. An initial evaluation of gait, balance and the risk of falls was carried out using the Tinetti Test, and the Timed Up and Go test:

- Tinetti Test, is a scale that measures gait and balance. It helps to early identify the danger of falls in the elderly, which begins by asking the patient: Are you afraid of falling? The scale has a duration of 8-10 minutes. The evaluator stands next to the patient at all times. When walking, the evaluator stands behind the patient and to assess balance he himself must be on the right or in front. The evaluator is the one who will answer the subscales to be evaluated. The score is completed once the patient is seated. The higher the score, the better the performance. The maximum score for the balance subscale is 16, and for gait, 12. The sum of the two scores establishes the level of risk or danger of falls. The higher the score, the lower the risk:

  - Less than 19 points: high risk of falls
  - From 19 to 24 points: lower risk of falls

The Tinetti scale has proven to be a valid and reliable tool for assessing mobility (r 0.74-0.93). In addition, it has high inter-observer reliability (0.95). (Guevara et al. 2012)

- Timed Up and Go, is a test to measure the risk of falling that is based on the ability to walk. The time will be measured when getting up from the chair (preferably without using your arms), walking to a mark located 3 meters away (both feet must exceed the mark), and turning around and sitting back down in the chair. The time begins to be measured when the evaluator gives the order. The stopwatch stops when the patient sits down. The patient will use the support product that is necessary (cane, walker, etc.) and will walk as fast as possible (without running), walking at a light but safe pace. Visualizations such as the support product used and others that may be useful will be noted. The scores range from:

  - Less than 10 seconds: low risk of falling
  - Between 10 and 20 seconds: indicates fragility (risk of falling)
  - More than 20 seconds: High risk of falling.

Timed Get Up and Go test has a specificity of 93%-96% 12 and the reported sensitivity is lower, but also acceptable for the prediction of falls 53.0%-82.5%. (Gomes et al. 2019)

These tests were applied before the intervention, to provide information, and thus, outline a program of perturbation exercises for balance and gait in older adults.

The perturbation exercise program was developed and applied, with a duration of 12 weeks, a frequency of 3 times per week and an approximate time of 75 minutes per session. For this purpose, a questionnaire was designed to confirm and validate the exercise program, based on the judgment of experts on the subject. It consisted of a questionnaire of 12 questions distributed in 4 dimensions, the expert mentioned suggestions when the rating was equal to or less than 3. The scale for the rating was structured based on the Likert recommendations where acceptance ratings of the items are

presented: 1 Very low, 2 Low, 3 Medium, 4 High, and 5 Very High. It aims at knowing the relevance in relation to the general structure, format of the document, grammar and writing, and cultural aspect of the exercise program. The experts were selected according to the experience in the field of study (neuromusculoskeletal physiotherapy), professional, research or teaching experience (greater than 3 years) and affinity with the study (acceptance to participate as an expert in the research).

The exercise tolerance of older adults is monitored through the Borg Effort Scale, which measures the perception of effort when performing physical activity that the patient perceives. It includes the parameters of vital function in each exercise session and after the intervention, through a log as an instrument and observation as an inventive technique. A document was designed to monitor and control the physiological state of older adults in response to exercise, which included:

- Heart rate: 60 to 100 bpm
- Respiratory rate: 15 to 20 rpm
- Blood Pressure: 90/60 mmHg to 120/80 mmHg
- Borg Effort Scale: which measures the patient's perception of effort when performing physical activity.

Interpreted: 0 = Rest, 1 = Very, very, light, 2 = Very light, 3 = Light, 4 = Somewhat heavy, 5 = Heavy, 6 = Heavier, 7 = Very heavy, 8 = Very, very heavy, 9 = Maximum, 10 = Extreme (Valencia et al. 2012).

And finally, there was a second evaluation, after the intervention, using the initial registration form with the Tinetti Test, and the Timed get Up and go Test.

Information processing

The processing of the information obtained from The systematic review of information was carried out based on the PRISMA recommendations (Moher et al., 2009) in the Windows Word program. The period criteria were used (years between 2014 and 2022), descriptors (perturbation and balance in the elderly), and context (worldwide articles in English and Spanish).

The data obtained from the expert review questionnaire were processed through the creation of a database in the Windows Excel program, and in the same way for the calculation of the coefficient or content ratio (CVC) recommended by Hernández-Nieto. (2011). It reflects the agreement between the experts' criteria, through a ratio or coefficient of agreement between experts; where if the value obtained from CVC is greater than 0.70, the content can be accepted and the document applied. While if this is lower, the criterion can be restructured according to the experts' suggestions, or eliminated, to later apply the questionnaire for a new CVC calculation (36). Recommended CVC values and interpretation are 0 to 0.60 = unacceptable; greater than 0.60 and less than or equal to 0.70 = poor, greater than 0.70 and less than or equal to 0.80 = acceptable; greater than 0.80 and less than or equal to 0.90 = good and greater than 0.90 = excellent. (Hernández et al., 2011)

Regarding the information collected from the evaluations before and after the intervention, these were processed and described using the SPSS V21 statistical system, through descriptive contingency tables corresponding to the measures of the clinical variations of the sensoromotor state of the elderly. To determine the significant differences between these measurements, the Student's t test for related samples was used in quantitative variables that behaved normally. They were determined by the Shapiro-Wilk Test ($p>0.05$). On the other hand, for qualitative variables or variables that did not behave normally, the Wilcoxon rank test was used. The significance for the two tests was 95% and a margin of error of 5% (0.005) (Moher et al., 2009).

Bioethical Considerations

This project has the approval of the "Bioethics Committee for Research on Human Beings of the Faculty of Health Sciences, Technical University of Ambato", with code 026-CEISH-UTA-2023. It approves and indicates that it complies with the methodological and legal ethical requirements. The methodology was socialized, the informed consent detailing the research process was signed.

TREATMENT PLAN

Biosafety measures for direct in-person care

- Use of triple layer surgical mask or KN95

- Use of anti-fluid fabric uniform
- Hand washing before and after each session
- Alcohol-based hand disinfection.

Conditions under which the older adult must attend the session

- Wearing comfortable clothing that allows movement
- Drink water or fluids before and after exercise
- Do not consume food 30 minutes before exercise
- Have a good attitude and willingness to perform the exercises

Treatment parameters

Table 1. Parameters and description

Parameters	Description
Type of exercise	Sitting perturbation Perturbation at four points Perturbation in standing Perturbation while driving
Frequency	3 times a week (Monday, Wednesday and Friday)
Intensity	Gentle: 5 repetitions of each exercise Moderate: 10 repetitions of each exercise Strong: 15 repetitions of each exercise
Session duration	45 min
Schedule	Morning
Total length	12 weeks of the program
Prescription of the exercise	Gentle intensity: 4 weeks Moderate intensity: 4 weeks Strong intensity: 4 weeks

Source: the authors

Considerations before exercise

Prior to the intervention, the physiological parameters of all patients must be assessed and recorded in their log, to maintain control of vital signs in relation to exercise tolerance, which will be carried out by the physiotherapist.

Table 2. Parameters and indicators

Parameters	Indicators	Normal	Materials
Blood pressure	Measures oxygen saturation levels in the blood.	90/60 mmHg to 120/80 mmHg	blood pressure monitor
Heart Rate	It measures the number of times the heart beats per minute.	60 to 100 bpm	Stopwatch/ Pulse oximeter
Breathing frequency	Measures the amount you breathe per minute	15 to 20 rpm	Stopwatch
BORG scale	Measures the patient's perceived effort when exercising	0 to 10	Recording log

Source: the authors

Description of the exercises

Soft intensity

Table 3. Description Soft intensity

No.	Description
1	Patient sitting in a chair, with arms hanging at the sides, legs raised at least 30 cm alternately
2	Patient in 4-point position, one extended arm raised above his head, hold for 5 seconds and alternate with another arm
3	Patient standing, behind a chair supported with their hands; one leg raised by bending the knee, alternately
4	Patient standing, behind a chair supported with one hand; extend one leg backwards, and raise the extended arm on the same side laterally, hold for 5 seconds and return to the starting position, alternating with the other leg and arm
5	Patient standing, legs slightly apart, with arms hanging at the sides, perform short, quick swinging movements of the arms, maintaining the hip position for 20 seconds.
6	Patient standing, with legs open at shoulder level and arms resting on the back of a chair, perform a light squat with a straight back and raising the arms forward, hold for 5 seconds and return to the starting position.
7	Patient standing leaning against a wall, with legs open at shoulder level and arms parallel to the body, raise one leg to the side and the arms to the side at 90°, hold for 5 seconds and return to the starting position and alternate with the other leg.
8	Patient standing near a wall walking forward placing the heel of one foot in front of the toes of the other foot touching each other
9	Patient standing, leaning on a wall, walking to the side, one foot next to the other, in short steps
10	Patient standing, walking backwards, leaning on a wall, trying to follow a straight line with short steps

Source: the authors.

Moderate intensity

Table 4. Description Moderate intensity

No.	Description
1	Patient sitting in a chair, with arms hanging at the sides, raise the right leg and the left arm, alternately
2	Patient in a 4-point position, raise an extended arm above their head, bending both knees at the same time, maintain the position for 5 seconds and alternate with the other arm.
3	Patient standing behind a chair supported by a single finger; raise one leg by bending the knee, alternately
4	Patient standing, with legs slightly apart, stand on tiptoe, raising the arms forward at 90°, hold for 5 seconds and return to the starting position, alternating with heels
5	Patient standing, with legs together, with arms hanging at the sides, perform short, quick swinging movements of the arms, maintaining the hip position for 20 seconds.
6	Patient standing, with legs open at shoulder level and arms parallel to the body, perform a 90° squat with a straight back and raising the arms forward, hold for 5 seconds and return to the starting position.
7	Patient standing, with legs open at shoulder level and arms parallel to the body, raise one leg to the side and both arms to the side at 90°, hold for 5 seconds and return to the starting position and alternate with the other leg.
8	Patient standing, walking forward taking long steps alternately
9	Patient standing, walking to the side, one foot next to the other, heel and toe
10	Patient standing, walking backwards, leaning on a wall, trying to follow a straight line with short steps

Source: the authors.

Strong intensity

Table 5. Description Strong intensity

No.	Description
1	Patient sitting in a chair, holding a bar or stick with arms separated and on the legs, raise the arms straight to the midline of the head, hold for 5 seconds and return to the starting position
2	Patient in a 4-point position, raise the extended right arm above the head and the extended left leg at the same time, maintain the position for 5 seconds and alternate with another arm and leg.
3	Patient standing, raise one leg by bending the knee, and raising the lateral arms to 90°, hold for 5 seconds and alternate the leg.
4	Patient standing, raise one leg by bending the knee, alternately.
5	Patient standing, with legs together, with arms hanging at the sides, perform short, quick swinging movements of the arms, maintaining the hip position for 20 seconds.
6	Patient standing, with legs open at shoulder level and arms parallel to the body, perform a squat greater than 90° with a straight back and raising the arms forward, hold for 5 seconds and return to the starting position.
7	Patient standing, with legs open at shoulder level and arms parallel to the body, raise one leg laterally, flexing it against the other and raise both arms forward at 90°, hold for 5 seconds and return to the starting position.
8	Patient standing, walk forward, raising one bent leg alternately and raising the arms with each step.
9	Patient standing, walking to the side, crossing one foot over the other in front of each step
10	Patient standing, walking backwards, trying to follow a straight line with short steps on toes and heel

Source: the authors.

RESULTS

Initial evaluation of balance, gait and risk of fall

Table 6. Initial evaluation of balance, gait and risk of falling

Variables	Average	Upper limit	Lower limit
Balance/16	10	15	6
March /12	7	10	6
Tinetti/28	18	24	11
Falling risk*(Tinetti)*	High risk	Medium risk	High risk
TUG	12	14	9
Risk of falling (TUG)	Risk of falling = Fragility	Low risk of falling	Risk of falling = Fragility

Source: the authors.

In the initial evaluation of balance, gait and risk of falling through the application of the Tinetti Scale, an average of 10/16 points was obtained in balance, with values higher than 15 and lower than 6. As for gait, an average value of 7/12 points was achieved, with maximum values of 10 and minimum values of 6 points. Likewise, in the risk of falls, an average of 18/28 was achieved, which corresponds to a high risk of falls, with upper limits of 24 and lower limits of 11. In the same way, with the application of the Timed Up and Go test (TUG), to measure the risk of falls, an average of 12 seconds was obtained, which corresponds to the risk of falling or fragility, with an upper limit of 14 seconds and a lower limit of 9 seconds. These data refer to a considerable alteration of balance and gait in older adults, translating into a high risk of falls in this population. The integration of therapeutic strategies that mitigate this problem is necessary.

Validation of the program through expert judgment

Table 7. CVC calculation for validation by expert judgment

Aspects	Items	J1	J2	J3	Sx1	Mx	CVCi	Pe	CVCt
General	Is the structure of the program clear and easy to understand?	5	5	5	Four. Five	3.0	1.00	0.0	0.96
	Are there no inconsistencies in the program's expressions?	5	5	5					
	Does the program meet the stated objective?	5	5	5					
	Total, Aspect 1	15	15	15					
Format	Is the program format appropriate?	5	5	5	Four. Five	3.0	1.00	0.0	0.96
	Are the length of the statements and paragraphs appropriate?	5	5	5					
	Is the format of the reference images appropriate?	5	5	5					
	Total, Aspect 2	15	15	15					
Grammar and writing	Is the grammatical structure clear in its concepts?	5	5	5	Four. Five	3.0	1.00	0.0	0.96
	Are there no inconsistencies in the words, or that they contain the wrong meaning?	5	5	5					
	Do the paragraphs do not contain controversies or controversies, perceived in a degrading or offensive way?	5	5	5					
	Total, Aspect 3	15	15	15					
Culture	Are the terms used appropriate to the cultural context of the population to which it will be applied?	5	5	5	Four. Five	3.0	1.00	0.0	0.96
	Does the concept or construct of the program have the same meaning and familiarity for the population?	5	5	5					
	Is the relevance of the proposal and the program in accordance with local needs?	5	5	5					
	Total, Aspect 4	15	15	15					
	CVCt								0.96

Source: the authors.

Through the data obtained from the judgment of the 3 experts who reviewed the perturbation exercise program aimed at balance training in older adults, the CVC calculation was carried out, obtaining a global and per item coefficient of 0.96; which indicates excellent agreement between experts according to the Hernández Nieto scale (38). Thus this allows the application of the program in the study population.

Measurement of physilogical parameters between stages

Table 8. Physiological parameters measured between phases

Measures	First			Second			Third		
Parameters	Average	Lower limit	Upper limit	Average	Lower limit	Upper limit	Average	Lower limit	Upper limit
F.C.	76	64	99	72	64	86	73	62	79
FR	19	17	27	18	17	20	17	16	24
Systolic P.	127	117	131	125	116	128	124	115	128
Diastolic P.	84	75	90	83	74	92	81	72	88
BORG	5	3	6	4	3	5	3	2	5

Source: the authors.

The physiological parameters of heart rate, respiratory rate, blood pressure and exercise tolerance of the older adults

were normal in each phase of the exercises, so progress could be made from phase to phase.

Clinical variation between measurements

Variation between measures of balance and gait

Table 9. Variation between balance and gait measurements

Measures	Initial Balance	Final Balance	Initial march	Final march
Average	10	14	7	10
Upper limit	15	16	10	12
Lower limit	6	12	6	8

Source: the authors.

The differences between initial and final balance and gait results demonstrate a significant improvement. Thus, in the balance, a minimum value of 6 to 9 points went from a maximum value of 12 to 16 points and an average of 10 to 14 points, demonstrating a gain of 3 to 4 points in the balance. In the same way, gait went from a minimum value of 5 to 8 points, from a maximum value of 10 to 12 points and an average of 7 to 10 points, revealing a gain of between 2 and 3 points in gait. The results after the application of the perturbation exercise program show improvement in balance from 1 to 6 points, in walking from 2 to 3 points.

Variation between measures of fall risk: Tinetti Scale

Table 10. Clinical variation between fall risk measures

Tinetti test		Initial evaluation		Final evaluation	
Punctuation	Risk of falls	Fr	%	Fr	%
25 to 28	Low risk	0	0	15	50
19 to 24	Medium risk	15	50	15	50
< 19	High risk	15	50	0	0
Total		30	100	30	100

Source: the authors.

The differences between initial and final results of the risk of falls obtained from the administration of the Tinetti scale demonstrated a significant reduction in risk after applying the program. It went from 50% of the population with high risk and the other 50% with medium risk, to 50% of the population with medium risk and the remaining 50% with low risk. It showed a considerable improvement in balance and gait of the entire population, associated with balance training through perturbation exercises.

Variation between measures of fall risk: TUG test

Table 11. Clinical variation between measurements: TUG

TUG		Initial evaluation		Final evaluation	
Punctuation	Risk of falls	Fr	%	Fr	%
> 20 sec	High risk of falls	0	0	0	0
10 to 20 sec	Risk of falls	27	90	12	40
< 10 sec	Low risk of falls	3	10	18	60
Total		30	100	30	100

Source: the authors

Likewise, in the differences between initial and final results of the risk of falls obtained from the administration of the TUG test, a significant decrease in risk was found after applying the program. It went from 90% of the population at risk of falls and 10% at low risk; 40% of the population at risk of falls and the remaining 60% at low risk. This showed considerable improvement in dynamic balance, attributed to balance training through perturbation exercises.

Statistical variation between fall risk measures

Table 12. Statistical variations between measures: Tinetti and TUG

	Initial Tinetti – Tinetti Final	Initial TUG – TUG Final
Z	-5,231b	-3,873b
asymptotic sig. (bilateral)	,000	,000

Source: the authors

Statistically, after applying the exercise program to older adults, it was possible to verify that, through the Wilcoxon Rank test for related samples, a significant difference in both the risk of falls measured with the Tinetti scale and with the TUG test obtained a probability of p value of 0.001 for both cases. Since these statistical values are less than the alpha for the two tests, the research hypothesis can be accept and reject the null hypothesis; affirming that there isin significant differences in the risk of falls before and after the application of the perturbation exercise program for balance training in older adults.

DISCUSSION

Scientific evidence indicates that perturbation in both static and dynamic exercises are effective in improving balance. Allin et al (2020) assessed reactive balance and incidence of falls before and after 4 perturbation sessions, revealing improvement in balance measures in the perturbation group versus reference participants. Likewise, the incidence of falls was lower. Bierbaum, Peper and Arampatzis (2013) showed significant differences with a 14-week intervention, 2 times per week, 1.5 h per session. And, Epro et al (2018), through a 14-week perturbation-based training, achieved improvement in the stability of gait reactive to perturbation. They mentioned that the neuromotor system of older adults has rapid plasticity and the ability to retain adaptations for a long period in the face of sudden repeated perturbation. In this way, an exercise program structured in three phases was designed, with a duration of 12 weeks, a frequency of 3 times per week and an approximate session time of 45 minutes. This was reviewed by expert judgment that generated a CVC of 0.96 overall and per item, allowing the application of the program with excellent agreement between experts, according to the scale of Hernández Nieto (2011). In addition, it is mentioned that to move from phase to phase, physiological parameters of heart rate, respiratory rate, blood pressure and exercise tolerance were measured in older adults. They demonstrated to maintain normal limits in each phase of the exercises, so progress was possible from phase to phase.

Regarding the differences between initial and final balance and gait results, they demonstrate a significant improvement. Thus, as for balance, a minimum value of 6 to 9 points went from a maximum value of 12 to 16 points and an average of 10 to 14 points, demonstrating a gain of 3 to 4 points in balance. In the same way, gait went from a minimum value of 5 to 8 points, from a maximum value of 10 to 12 points and an average of 7 to 10 points, revealing a gain of between 2 and 3 points in gait. The results after the application of the perturbation exercise program show improvement in balance of 1 to 6 points, and in gait of 2 to 3 points. Likewise, statistically, it was possible to verify that, through the Student's t test for related samples, a significant difference in both the balance ($p<0.001$), as well as in gait ($p<0.001$) was found. As for the risk of falls measured with the Wilcoxon rank test, in the Tinetti scale ($p<0.001$) and the TUG test ($p<0.001$) were obtained. There were significant differences between measures after the application of the program in balance, gait and the risk of falls in older adults.

CONCLUSIONS

The level of alteration in balance, gait and risk of falls in older adults was considerable since the population presented average levels in balance and gait of 6/16 and 7/12 respectively and in the risk of falls high levels, both in the Tinetti scale as in the TUG test. In this way, the elderly population should be considered vulnerable as they present a high risk of falls. They

are more prone to accidents that can compromise their physical integrity and even lead to death. This situation reveals the need to implement effective programs that improve balance and gait to reduce the risk of a fall.

The evidence indicates that the neuromotor system of older adults has rapid plasticity and the ability to retain adaptations for a long period in the face of sudden repeated perturbations. In this way, an exercise program structured in three phases was designed, with a duration of 12 weeks, a frequency of 3 times per week and an approximate session time of 45 minutes. It was reviewed by expert judgment and allowed the application of the program with excellent agreement between experts, for a CVC of 0.96 overall and per item, according to the scale of Hernández Nieto (2011)

The perturbation exercise program in older adults demonstrated improvement in balance from 1 to 6 points, and in gait from 2 to 3 points. They statistically obtained significant differences in both balance ($p<0.001$) and gait ($p<0.001$), in the risk of falls with the Tinetti scale ($p<0.001$) and in the TUG test ($p<0.001$). Thus, it can be concluded that a perturbation program improves the balance of older adults.

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