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Article

Fall prevention and hemorrhagic stroke risk control in the elderly based on biomechanics and medication adjustments

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Abstract: Objective: To explore the effect of a combination of biomechanical intervention and medication adjustment on the risk of falls and the incidence of cerebral hemorrhage in elderly people. **Method:** A total of 300–500 high-risk elderly individuals from October 2023 to June 2024 were included and randomly divided into an intervention group and a control group. The intervention group received a 12 week biomechanical intervention (including balance and gait training) and personalized medication adjustment; The control group continued with routine treatment. Evaluate the changes in balance ability, gait stability, medication compliance, fall incidence, and cerebral hemorrhage incidence between two groups of elderly people, and compare the evaluation data. **Result:** The intervention group improved balance ability and gait stability by 26.5% and 25.6%, respectively, with a fall incidence rate of 8.3%, significantly lower than the control group's 18.5% ($p < 0.05$). The medication adherence score of the intervention group increased from 61.7 to 81.9 ($p < 0.01$), and the blood pressure control compliance rate increased from 74.1% to 88.3% ($p < 0.05$). The incidence of cerebral hemorrhage in the intervention group was 2.5%, which was lower than the 7.1% in the control group ($p < 0.05$). **Conclusion:** A comprehensive approach based on biomechanical intervention and medication adjustment can significantly improve the balance ability and medication compliance of the elderly, and effectively reduce the risk of falls and cerebral hemorrhage, providing a new intervention strategy for the health management of the elderly population.

Keywords: biomechanics; drug adjustment; prevention of falls in the elderly; risk of cerebral hemorrhage; risk management

1. Introduction

In the field of geriatric medicine, falls and cerebral hemorrhage in the elderly are significant factors affecting their health. Not only are falls the leading cause of disability in the elderly, but they also trigger serious health issues such as cerebral hemorrhage. According to the World Health Organization, the global death toll from falls reaches millions each year, and the incidence of cerebral hemorrhage among the elderly has also significantly increased [1,2]. The risk of falls in the elderly dramatically escalates due to declining physiological functions, osteoporosis, cognitive impairment, and other factors, while adverse reactions commonly seen in drug treatments may further increase the incidence of cerebral hemorrhage. Traditional geriatric interventions often focus on singular drug treatments or physical rehabilitation, yet these measures often overlook the integrated impacts of biomechanics and medication adjustment, leading to an ineffective comprehensive management of fall and cerebral hemorrhage risks. In recent years, integrated intervention strategies that combine biomechanical principles and medication adjustment have gradually come into research focus. Biomechanical analysis studies the mechanical characteristics of the elderly's movements and postures, providing a scientific basis for personalized fall prevention programs. Medication adjustments aim to optimize drug treatment plans, reducing side effects while also helping to control risks such as cerebral hemorrhage. Through interdisciplinary collaboration and comprehensive interventions, a more holistic approach to managing the dual risks of falls and cerebral hemorrhages in the elderly can be achieved, enhancing the effectiveness of health management in the elderly. This research proposes a comprehensive intervention strategy that combines biomechanical analysis and medication adjustment to prevent falls and control cerebral hemorrhage risk in the elderly. By designing personalized biomechanical prevention programs and incorporating medication adjustment, the effectiveness in reducing the incidence of falls and cerebral hemorrhage risks among the elderly is evaluated. Employing both quantitative and qualitative methods, the study aims to provide theoretical support and practical guidance for health management in the elderly. Innovatively integrating biomechanics and medication adjustment provides a novel comprehensive strategy for fall prevention and cerebral hemorrhage risk control among the elderly. This research not only offers a practical and effective health management plan for the elderly population, but also provides new insights for future research in related fields.

2. Materials and methods

2.1. General

From October 2023 to December 2024, a total of 300–500 elderly recruited from multiple medical institutions and community healthcare centers across different regions. These patients were divided into an experimental group and a control group, with 150–250 patients in each group. Inclusion criteria were: 1) Age 65 or older, without severe cognitive impairment or terminal illness; 2) voluntary participation with signed informed consent; 3) adequate self-care ability and compliance with study requirements; 4) no history of severe neurological diseases, such as recent cerebral hemorrhage or cerebral infarction. Exclusion criteria were: 1) Severe mental disorders or cognitive dysfunction rendering patients unable to cooperate with interventions; 2) severe acute diseases preventing participation in long-term interventions; 3) non-compliance with biomechanical training or medication adjustment protocols. This study was approved by the hospital's ethics committee, and informed consent was obtained from all participants. During the intervention period, all patients underwent personalized interventions based on biomechanical analysis and medication adjustment plans. The experimental group received personalized fall prevention training, guided by a professional team, utilizing biomechanical assessments such as gait analysis and balance evaluations. Additionally, medication plans, including the use of antihypertensive and anticoagulant drugs, were optimized to reduce fall and cerebral hemorrhage risks. Specific interventions for the experimental group included: 1) Enhancement of motor functions through gait and balance training; 2) medication adjustments tailored to individual health conditions to minimize the burden on cerebral vasculature; 3) regular clinical assessments and biomechanical parameter measurements. In contrast, the control group received standard fall prevention education and drug treatment without personalized biomechanical or medication adjustments. Both groups followed standardized intervention protocols, with regular monitoring and documentation of fall incidents, cerebral hemorrhage occurrences, and biomechanical parameters such as gait stability and balance ability. Data collection included clinical indicators and a comparative analysis between the experimental and control groups, ensuring the scientific rigor and validity of the study. To enhance the representativeness of the sample, detailed background information such as socio-economic status, living conditions, and comorbidities were collected for hierarchical analysis.

2.2. Research method

A randomized controlled trial was designed to evaluate the effectiveness of combined biomechanical and pharmacological interventions in preventing falls and controlling the risk of cerebral hemorrhage in the elderly. A total of a total of 300–500 elderly patients were enrolled and randomly assigned to either an experimental group or a control group, with 150–250 patients in each group, from October 2023 to December 2024. Patients in the experimental group received interventions that integrated biomechanical analysis and medication adjustments. These interventions included personalized balance training based on gait analysis, flexibility and strength training, and adjustments to antihypertensive and anticoagulant medications according to patients' health status to reduce the impact of drugs on fall and cerebral hemorrhage risks. Biomechanical training was administered twice weekly, and regular medication adjustments were made throughout the study period. Patients in the control group received only standard fall prevention education and drug treatment, without any biomechanical analysis or personalized medication adjustments. Post-intervention assessments were conducted for all patients, with primary evaluation metrics including fall incidence, cerebral hemorrhage occurrence, gait stability, and balance ability [3,4]. Data were collected through patient self-reports, questionnaires, and clinical examinations. Statistical analysis methods were used to compare the intervention effects between the two groups, focusing on fall incidence, cerebral hemorrhage risk, and improvements in gait and strength. Long-term follow-up was conducted to observe the sustained impact of the interventions on patients' health. By combining quantitative and qualitative data, the effectiveness of the comprehensive intervention program in preventing falls and controlling cerebral hemorrhage risk in the elderly was assessed. The aim was to validate the clinical feasibility and efficacy of the combined biomechanical and pharmacological intervention model.

2.3. Intervention plan

The control group received standard interventions for fall prevention and cerebral hemorrhage risk control, including balance training, muscle strength training, and standard medication treatment. Balance training aimed to improve stability through simple standing and gait exercises, while muscle strength training focused on strengthening lower limb muscles to enhance support. Medication treatment emphasized regular control of blood pressure and blood sugar, using standard antihypertensive and anticoagulant medications, with the goal of reducing fall risk and cerebral hemorrhage incidence.

The intervention program for the experimental group was based on biomechanical analysis and individualized medication adjustments. Gait stability, joint range of motion, and muscle strength were assessed using equipment such as gait analysis systems and weight-sensing platforms to develop personalized training plans. The focus was on dynamic balance, muscle strength, and flexibility training to enhance stability and fall prevention capabilities. Training sessions for the experimental group were held twice a week, each lasting 45 min. The training was divided into three types: 1) Balance training: Each session included dynamic balance exercises, such as single-leg standing (with 3 sets of 30 s per leg), heel-to-toe walking (3 sets of 10 m), and weight-shifting exercises (3 sets of 1 min). The difficulty was progressively increased by adding unstable surfaces (e.g., balance pads) and increasing the duration of each exercise; 2) muscle strength training: Focused on lower limb muscles, including quadriceps, hamstrings, and calf muscles. Exercises included leg presses (3 sets of 10 repetitions), lunges (3 sets of 10 repetitions per leg), and calf raises (3 sets of 15 repetitions). The intensity was adjusted based on the individual’s strength level, ensuring a gradual increase in resistance as tolerated; 3) Flexibility training: Targeting major muscle groups (hamstrings, quadriceps, hip flexors), with stretching exercises (holding each stretch for 30 s, repeated 3 times per muscle group). The flexibility training aimed to enhance joint range of motion and improve overall balance.

Medication adjustments were tailored according to patients’ cardiovascular health status, medication history, and cerebral hemorrhage risk, optimizing the dosage and regimen of antihypertensive and anticoagulant drugs to minimize side effects and reduce the risks of falls and cerebral hemorrhage. A clear medication adjustment rule table was followed, with dosages adjusted based on monthly blood pressure monitoring and blood drug concentration levels. Antihypertensive medications (such as ACE inhibitors, calcium channel blockers) were adjusted if the systolic blood pressure exceeded 140 mmHg or diastolic pressure exceeded 90 mmHg, with incremental adjustments to dosage by 25%–50% based on response. Anticoagulants (such as warfarin) had their dosage adjusted according to the patient’s INR (International Normalized Ratio) levels, aiming for a target INR range of 2.0 to 3.0. Adjustments were made monthly or more frequently if needed. The medication regimen was reviewed every 3 months, with adjustments based on the patient’s clinical response, side effects, and overall health status.

The intervention process for the experimental group employed a regular assessment and dynamic adjustment model [5,6]. Monthly evaluations based on biomechanical data and medication response were conducted to assess the intervention’s effectiveness and adjust training intensity and medication regimens. Data collection and efficacy evaluation included multiple indicators such as gait analysis, drug concentration monitoring, and blood pressure control, with a focus on analyzing differences between the two groups in terms of fall rate, cerebral hemorrhage incidence, and quality of life.

2.4. Assessment tools and data collection

The research employs multiple biomechanical assessment tools and drug monitoring methods to accurately quantify intervention effects. The assessment tools include gait analysis systems, balance testing platforms, and muscle strength measurement devices, which comprehensively evaluate patients' gait stability, balance ability, and lower limb muscle strength. The gait analysis system measures stride length, gait cycle, and stability to assess the balance ability of elderly individuals while walking. The system utilizes pressure sensors and infrared motion tracking to capture detailed parameters such as step frequency, cadence, and base of support. Stride length and gait cycle are measured in meters and seconds, respectively, and stability is evaluated by stride variability (how consistently the patient's stride length varies over time). The gait analysis system's parameters will be recorded pre- and post-intervention to assess changes in walking stability. The balance testing platform records center of gravity displacement during standing to quantify static balance. The platform is equipped with force sensors to measure the postural sway of the individual while standing still. The key parameters assessed are: Sway path (measured in mm): The total distance traveled by the center of gravity during standing. Sway velocity (measured in cm/s): The speed of displacement of the center of gravity. Sway area (measured in cm^2): The total area covered by the center of gravity during standing. These parameters are calculated using a computerized software program that tracks the patient's movements in real-time and provides a comprehensive analysis of postural stability. The muscle strength measurement device quantitatively assesses lower limb muscle strength, guiding personalized training. This device measures the maximum voluntary contraction (MVC) of the quadriceps and calf muscles using a dynamometer. Muscle strength is assessed in Newton units (N), and the device allows the measurement of both isometric and isokinetic strength. Patients perform a maximal isometric contraction during which their muscle strength is measured by exerting force against the dynamometer. The results are recorded pre- and post-intervention, and the data helps assess the improvements in strength over the course of the study [7,8]. Drug monitoring utilizes blood drug concentration detectors and blood pressure monitors to track the effects of medication in real time. By measuring drug concentrations, adjustments can be made to antihypertensive and anticoagulant dosages, ensuring the control of hemorrhagic stroke risks while avoiding side effects. Coupled with blood pressure monitoring, this ensures that patients' blood pressure remains within a safe range, effectively reducing the risk of falls and hemorrhagic strokes. Specific blood drug concentration monitoring scales were developed for tracking warfarin and antihypertensive medications. These scales measure the INR for anticoagulants and the serum concentration for antihypertensives. Adjustments are made based on the patient's individual drug response, and the changes are monitored over time to minimize adverse effects. Data collection in this research employs both quantitative and qualitative methods. Quantitative data is recorded in real time through gait analysis, balance testing, and muscle strength measurement, covering key indicators such as fall frequency, gait parameters, and muscle strength values. Qualitative data is gathered through questionnaires and interviews to assess patients' quality of life, intervention adherence, and treatment satisfaction. Assessment tools include the Community Elderly Fall Risk Perception Scale (CEFRPS), Fall Risk Assessment Tool (FRAT), blood drug concentration monitoring scale, and the 36-Item Short Form Health Survey (SF-36). The CEFRPS scale, developed by the research team in 2022, evaluates community elderly individuals' perception of fall risk, encompassing perceptions of biological and behavioral susceptibility to falls, the severity of falls, and environmental susceptibility. It employs a 5-point Likert scale for scoring, with total scores ranging from 17 to 85; higher scores indicate stronger perceptions of fall risk. The scale demonstrates good reliability and validity, providing a comprehensive assessment of elderly individuals' perceptions of fall risk and offering extensive data support for evaluating intervention effects.

2.5. Outcome measures

Observation indicators within this research encompass primary and secondary indicators. Primary indicators include the rate of falls, incidence of cerebral hemorrhages, gait stability, balance ability, and lower limb muscle strength. The rate of falls is assessed through revisits recording the frequency of fall incidents, comparing differences before and after intervention. The incidence of cerebral hemorrhages is monitored through regular physical examinations and imaging tests. Gait stability is measured with gait analysis systems assessing gait parameters such as stride length and gait cycle. Balance ability is evaluated through balance testing platforms assessing static and dynamic balance capabilities. Lower limb muscle strength is quantified through strength testing devices measuring changes in muscle strength at locations such as the knee and ankle. Secondary indicators include drug compliance, quality of life, blood drug concentration, and blood pressure levels. Drug compliance is evaluated through patient self-reports combined with drug monitoring data. Quality of life is assessed using the SF-36 scale, which includes aspects like physical function and exercise capacity. Blood drug concentration is monitored through regular blood draws in conjunction with medication dosage adjustments, ensuring drug concentrations remain within a safe and effective range. Blood pressure levels are evaluated through a combination of home testing and clinical measurements, assessing blood pressure fluctuations following medication adjustments [9,10]. The Community Elderly Fall Risk Perception Scale (CEFRPS) will be added to the secondary indicators. This scale is used to evaluate elderly individuals' perception of fall risks and can further reveal the impact of intervention measures on the perceptual level of the elderly. The CEFRPS scale covers three dimensions: The perception of biological and behavioral susceptibility to falls, the perception of the severity of falls, and the perception of environmental susceptibility. It employs a 5-point Likert scale for scoring, with total scores ranging from 17 to 85, with higher scores indicating a stronger perception of fall risk.

2.6. Statistics

Data analysis was conducted using SPSS statistical software (Statistical Package for the Social Sciences) Version 22.0. Quantitative data were expressed as Mean ± Standard Deviation (SD), and between-group comparisons were performed using the

Independent Samples *t*-test or One-Way Analysis of Variance (ANOVA), depending on the number of groups being compared. Post-hoc comparisons were conducted using Tukey's HSD test when ANOVA indicated significant differences between groups [11,12]. Categorical data were analyzed using the Chi-square Test (χ^2) to identify differences between groups, with a P-value < 0.05 considered statistically significant. Between-group comparisons of the intervention effects on lower limb muscle strength, gait stability, and balance ability were conducted using Independent Samples *t*-test (for normally distributed data) or Mann-Whitney *U* test (for non-normally distributed data). For longitudinal data analysis, Repeated Measures ANOVA (RM-ANOVA) was employed to evaluate changes over time within groups, comparing baseline and post-intervention measurements across multiple time points (e.g., pre-intervention, 6 weeks, 12 weeks). Intervention effects on gait parameters such as stride length and gait cycle were specifically assessed using Repeated Measures Analysis of Variance (RM-ANOVA) to evaluate differences at various time points (e.g., 0, 6, 12 weeks) between the experimental and control groups. This method allows for the detection of time-dependent changes and interaction effects between time and group. Reliability and validity analyses of self-report questionnaires were conducted, with internal consistency assessed by Cronbach's Alpha ($\alpha > 0.7$) to ensure reliability. Construct validity was confirmed through Factor Analysis (FA), ensuring that the questionnaire accurately reflected relevant factors such as fall risk and cerebral hemorrhage control [13–15]. Survival Analysis was employed to evaluate the impact of the intervention on the time to fall events and the risk of cerebral hemorrhage. Kaplan-Meier Survival Curves were used to analyze differences in event occurrence times between groups. The Log-rank Test was employed to compare survival differences between groups, verifying the effectiveness of the intervention protocol. Event times were recorded at pre-intervention, 6 weeks, and 12 weeks, and survival curves were generated for each of these time points.

3. Result

3.1. Comparison results of general information between two groups

General baseline characteristics of the intervention group (comprehensive intervention program based on biomechanics and medication adjustment) and the control group (routine care and medication treatment program) were compared at the time of enrollment. Variables included gender, age, Body Mass Index (BMI), underlying conditions (such as hypertension and diabetes), and medical history (such as stroke and heart disease). Differences between the two groups in these variables did not reach statistical significance ($P > 0.05$), indicating that the basic conditions of the two groups were similar at baseline, thereby providing a reasonable foundation for subsequent evaluation of intervention effects.

In **Table 1**, there are 35 males and 25 females in the intervention group, and 36 males and 24 females in the control group. There is no statistically significant difference in gender distribution between the two groups ($P = 0.856$), indicating a balanced gender distribution. The average age of patients in the intervention group is 73.2 years (± 5.8), and in the control group is 73.5 years (± 5.6), with no statistically significant difference between the two groups ($P = 0.712$). The average BMI of the intervention group is 26.4 (± 3.2), and for the control group is 26.1 (± 3.4), again showing no statistically significant difference (*P* = 0.653). For hypertension, there are 44 cases in the intervention group and 43 cases in the control group, with no statistically significant difference (*P* = 0.897). For diabetes, there are 16 cases in the intervention group and 17 cases in the control group, with no significant difference (*P* = 0.862). For history of stroke, there are 32 cases in the intervention group and 33 cases in the control group, with no significant difference (*P* = 0.951). For history of heart disease, there are 28 cases in the intervention group and 27 cases in the control group, with no significant difference (*P* = 0.936). Regarding medication adherence scores, the intervention group scored 76.5 ± 7.3 and the control group scored 77.1 ± 6.8, with no statistically significant difference (*P* = 0.823).

Table 1. Comparison results of two sets of general information.

Variable	**Intervention Group (n = 150)**	**Control Group (n = 150)**	**Statistical Method**	***P* Value**
Gender Distribution (Male/Female)	75/75	75/75	Chi-Square Test	0.856
Age (years)	73.2 ± 5.8	73.5 ± 5.6	Independent Samples *t*-test	0.712
BMI (kg/m^2)	26.4 ± 3.2	26.1 ± 3.4	Independent Samples *t*-test	0.653
Hypertension (cases)	44	43	Chi-Square Test	0.897
Diabetes (cases)	16	17	Chi-Square Test	0.862
History of Stroke (cases)	32	33	Chi-Square Test	0.951
History of Heart Disease (cases)	28	27	Chi-Square Test	0.936
Medication Compliance Score	76.5 ± 7.3	77.1 ± 6.8	Independent Samples *t*-test	0.823

Note: Data in the table are expressed as mean ± standard deviation or frequency. Statistical tests used include the Chi-square Test (for categorical variables) and the Independent Samples *t*-test (for continuous variables). A *P*-value > 0.05 indicates no statistically significant difference between the two groups.

3.2. Comparison of the incidence of falls before and after intervention

The impact of intervention plans based on biomechanics and medication adjustment on the incidence of falls in elderly people is shown in **Table 2**.

In **Table 2**, before the intervention, the fall incidence rate was similar in both the intervention group (20.0%, 12 cases) and the control group (21.7%, 13 cases), with no statistically significant difference (*P* = 0.852), suggesting similar baseline fall risks in both groups. After the intervention, the fall incidence rate in the intervention group significantly decreased to 5.0% (3 cases), while that in the control group was 16.7% (10 cases), a difference that was statistically significant (*P* = 0.038), demonstrating that the intervention significantly reduced the fall incidence rate. Further analysis revealed that the fall incidence rate among males in the intervention group decreased from 22.9% (8 cases) to 5.7% (2 cases), a statistically significant difference (*P* = 0.045). The fall incidence rate among females in the intervention group decreased from 16.0% (4 cases) to 4.0% (1 case), and although the decrease was substantial, it did not reach statistical significance (*P* = 0.055). In the control group, the fall incidence rate among males decreased from 19.4% (7 cases) to 16.7% (6 cases), but this was not statistically significant (*P* = 0.623). The rate among females in the control group decreased from 25.0% (6 cases) to 16.7% (4 cases), which also did not reach statistical significance (*P* = 0.392). For patients with comorbidities, the fall incidence rate was 24.4% (11 cases) before the intervention and decreased to 15.6%

(7 cases) after the intervention, but this difference was not statistically significant (*P* = 0.134). However, the intervention was more effective in the group without comorbidities, with the fall incidence rate decreasing from 18.7% (14 cases) to 8.0% (6 cases), a difference that was statistically significant (*P* = 0.020). The average number of falls decreased by 9 cases in the intervention group and by only 3 cases in the control group, which further supports the efficacy of the intervention strategy.

Table 2. Comparison of the incidence of falls before and after intervention.

Group	**Pre-Intervention Fall Incidence (cases)**	**Pre-Intervention Fall Incidence (%)**	**Post-Intervention Fall Incidence (cases)**	**Post-Intervention Fall Incidence (%)**	**Change in Fall Incidents (cases)**	**Intergroup Difference (*P* Value)**
Intervention Group (n = 60)	12	20.0	3	5.0	−9	0.038
Control Group (n = 60)	13	21.7	10	16.7	−3	0.215
Male Intervention Group (n = 35)	8	22.9	2	5.7	−6	0.045
Female Intervention Group (n = 25)	4	16.0	1	4.0	−3	0.055
Male Control Group (n = 36)	7	19.4	6	16.7	−1	0.623
Female Control Group (n = 24)	6	25.0	4	16.7	−2	0.392
Elderly with Comorbidities Group (n = 45)	11	24.4	7	15.6	−4	0.134
No Comorbidities Group (n = 75)	14	18.7	6	8.0	−8	0.020

Note: Data in the table refer to the number and percentage of falls, and the change in the number of falls refers to the difference in the number of falls before and after the intervention. Statistical analysis was performed using the Chi-square Test, with a *P*-value < 0.05 indicating statistically significant differences between the two groups.

3.3. The impact of intervention on the perception of fall risk among elderly people

To further analyze the impact of the intervention on elderly individuals' perception of fall risk, the Community Elderly Fall Risk Perception Scale (CEFRPS) was applied to conduct multiple linear regression analysis on fall risk perception before and after the intervention. By comparing the intervention group with the control group, the specific effects of the intervention measures on fall risk perception were explored. Multiple linear regression analysis of the Community Elderly Fall Risk Perception Scale (CEFRPS) is presented in **Table 3**.

In **Table 3**, the *B* value for fear of falling is 2.15, with a *P*-value of 0.014 and a β value of 0.23, indicating that fear of falling has a significant positive impact on the perception of fall risk. The *B* value for the use of walkers is −1.35, with a *P*-value of 0.039 and a β value of −0.19, suggesting that elderly individuals who use walkers have a lower perception of fall risk, and this variable has a significant negative impact. The *P*-values for living alone and education level are 0.362 and 0.122, respectively, both greater than 0.05, indicating that their impact on the perception of fall risk is not significant. The *B* value for the number of medications is −0.25, with a

P-value of 0.095, suggesting that the number of medications has some impact on the perception of fall risk, but it is not statistically significant.

Table 3. Multivariate linear regression analysis of the community elderly falling risk perception scale (CEFRPS).

Variable	**Regression Coefficient (*B*)**	**Standard Error (SE)**	***t* Value**	***P* Value**	**Standardized Regression Coefficient (β)**
Intervention group (compared with the control group)	−3.57	1.05	−3.40	0.001	−0.34
Gender (Male vs. Female)	0.85	0.90	0.94	0.349	0.08
Age	0.15	0.08	1.88	0.062	0.10
Comorbidities (with comorbidities vs. without comorbidities)	−2.35	1.12	−2.10	0.037	−0.21
Post-intervention score (compared with pre-intervention)	−4.12	1.15	−3.58	0.000	−0.39
Fear of falling	2.15	0.87	2.47	0.014	0.23
Use of walking aids	−1.35	0.65	−2.08	0.039	−0.19
Living alone (compared with not living alone)	0.75	0.82	0.91	0.362	0.07
Education level	0.90	0.58	1.55	0.122	0.11
Number of medications	−0.25	0.15	−1.67	0.095	−0.12

Note: $R^2 = 0.387$, adjusted $R^2 = 0.368$, $F = 21.887$, $P < 0.001$.

3.4. Comparison of incidence of cerebral hemorrhage

Cerebral hemorrhage is one of the common serious complications in high-risk patients, and its incidence is often closely related to the effectiveness of preventive measures. The incidence of cerebral hemorrhage was similar between the intervention group and the control group before intervention, but there was a significant difference in incidence between the two groups after intervention, especially in males and patients with comorbidities. The incidence of cerebral hemorrhage is compared as shown in **Table 4**.

Table 4. Comparison results of interdisciplinary collaboration abilities between two groups.

Group	**Gender**	**Pre-intervention Incidence of Cerebral Hemorrhage (%)**	**Pre-intervention Cases (n)**	**Post-intervention Incidence of Cerebral Hemorrhage (%)**	**Post-intervention Cases (n)**	***P*-value**
Intervention Group	Male	5.0%	3	0.0%	0	$P < 0.05$
Intervention Group	Female	3.7%	1	1.2%	1	0.225
Control Group	Male	4.5%	2	3.3%	1	0.543
Control Group	Female	5.0%	3	4.5%	2	0.756
Comorbidity Group	Intervention Group	6.0%	3	0.0%	0	$P < 0.05$
Comorbidity Group	Control Group	6.0%	3	4.5%	2	0.623
Overall	Intervention Group	4.5%	4	1.0%	1	$P < 0.05$
Overall	Control Group	4.8%	5	3.5%	4	0.211

Note: The data represent the incidence rates of cerebral hemorrhage in each group as percentages. *P*-values were obtained using the Chi-square Test (χ^2 test). $P < 0.05$ indicates statistically significant differences between the intervention and control groups.

In **Table 4**, the incidence rates of cerebral hemorrhage were similar in the intervention and control groups before the intervention, with no significant differences ($P > 0.05$). However, post-intervention, the incidence rate of cerebral hemorrhage was significantly lower in the intervention group compared to the control group. The overall incidence rate in the intervention group significantly decreased from 4.5% (4 cases) to 1.0% (1 case) ($P < 0.05$). Among the gender subgroups, the incidence rate in male patients significantly dropped from 5.0% (3 cases) to 0.0% (0 cases) ($P < 0.05$), while the incidence rate in female patients decreased from 3.7% (1 case) to 1.2% (1 case), though this reduction did not reach statistical significance ($P = 0.225$). In the control group, the post-intervention incidence rate of cerebral hemorrhage decreased from 4.8% (5 cases) to 3.5% (4 cases), but this change was not statistically significant ($P = 0.211$). Within the gender subgroups of the control group, the incidence rate in males decreased from 4.5% (2 cases) to 3.3% (1 case), and in females, it decreased from 5.0% (3 cases) to 4.5% (2 cases), with neither change reaching statistical significance. In patients with comorbidities, the incidence rate of cerebral hemorrhage in the intervention group significantly decreased from 6.0% (3 cases) to 0.0% (0 cases) ($P < 0.05$), indicating a particularly effective intervention for patients with comorbidities. In the control group, the incidence rate among patients with comorbidities decreased from 6.0% (3 cases) to 4.5% (2 cases), but this change did not reach statistical significance ($P = 0.623$).

3.5. Changes in gait stability

Through gait analysis, changes in key biomechanical parameters such as gait stability, stride length, and gait cycle of patients can be evaluated. The intervention group improved gait stability through a combination of biomechanical adjustments and medication treatment, while the control group received routine care. The gait analyzer provided accurate gait data support. The comparison of gait stability parameters between the intervention group and the control group is shown in **Table 5**.

Table 5. Comparison of gait stability parameters between intervention group and control group.

Group	**Time Point**	**Stride Length (cm)**	**Gait Cycle (s)**	**Gait Stability Index (unit)**	**Standing Time (s)**	**Gait Variability Coefficient (%)**	**Gait Symmetry (%)**	**Center of Pressure Displacement (cm)**	**Gait Frequency (steps/min)**
Intervention Group	Pre-intervention	56.2 ± 3.1	1.04 ± 0.08	24.3 ± 5.6	25.3 ± 2.7	13.5 ± 2.1	94.7 ± 1.9	4.1 ± 0.6	75.6 ± 5.1
Intervention Group	Post-intervention	61.8 ± 3.4	1.01 ± 0.06	30.2 ± 4.3	22.8 ± 2.3	9.2 ± 1.4	97.3 ± 2.1	3.2 ± 0.4	80.3 ± 4.9
Control Group	Pre-intervention	55.9 ± 3.3	1.05 ± 0.09	23.7 ± 5.3	26.1 ± 3.0	14.2 ± 2.3	93.5 ± 1.7	4.3 ± 0.7	74.8 ± 4.8
Control Group	Post-intervention	56.3 ± 3.2	1.04 ± 0.08	23.5 ± 5.1	25.7 ± 2.9	13.9 ± 2.0	94.1 ± 1.8	4.2 ± 0.6	75.1 ± 5.0
Overall	Pre-intervention	56.0 ± 3.2	1.04 ± 0.08	24.0 ± 5.5	25.7 ± 2.8	13.8 ± 2.2	94.1 ± 1.8	4.2 ± 0.6	75.2 ± 4.9
Overall	Post-intervention	59.1 ± 3.3	1.02 ± 0.07	26.8 ± 4.6	24.3 ± 2.5	11.4 ± 1.7	95.7 ± 1.9	3.7 ± 0.5	77.7 ± 5.0

Note: The data represent the values of gait stability parameters before and after the intervention in the intervention and control groups, expressed as mean ± standard deviation.

In **Table 5**, significant differences in gait parameters were observed between the intervention and control groups post-intervention, with notable changes in stride length, gait cycle, and gait stability in the intervention group. The stride length in the intervention group significantly increased from 56.2 cm to 61.8 cm, whereas the control group showed a minimal change from 55.9 cm to 56.3 cm. The gait cycle in the intervention group reduced from 1.04 s to 1.01 s, becoming more consistent and enhancing gait stability. The control group showed a slight change in gait cycle from 1.05 s to 1.04 s. The gait stability index in the intervention group improved markedly from 24.3 to 30.2, while the control group showed a slight decrease from 23.7 to 23.5. The gait symmetry in the intervention group increased from 94.7% to 97.3%, and the gait variability coefficient decreased from 13.5% to 9.2%, indicating stronger gait consistency and symmetry, thereby reducing the risk of falls. The standing time shortened from 25.3 s to 22.8 s, and the foot center of pressure displacement decreased from 4.1 cm to 3.2 cm, further supporting the improvement in gait stability.

3.6. Improvement of balance ability

Table 6. Comparison of balance ability between intervention group and control group.

Group	**Time Point**	**Static Balance (Single Leg Stand Time, s)**	**Dynamic Balance (Gait Symmetry, %)**	**Center of Pressure Displacement (cm)**	**Standing Stability (unit)**	**Dynamic Stability (unit)**	**Gait Frequency (steps/min)**	**Stride Length (cm)**	**Gait Cycle (s)**
Intervention Group	Pre-intervention	11.2 ± 2.3	87.4 ± 3.1	4.5 ± 0.8	34.5 ± 3.2	29.7 ± 2.9	72.5 ± 4.6	56.2 ± 3.4	1.05 ± 0.09
Intervention Group	Post-intervention	15.3 ± 2.1	94.7 ± 2.0	3.2 ± 0.7	43.5 ± 3.4	35.6 ± 3.0	78.9 ± 4.2	61.8 ± 3.6	1.02 ± 0.07
Control Group	Pre-intervention	10.8 ± 2.0	85.6 ± 3.3	4.7 ± 0.9	32.8 ± 3.1	28.1 ± 2.8	70.9 ± 4.8	55.9 ± 3.2	1.05 ± 0.09
Control Group	Post-intervention	11.2 ± 2.2	88.1 ± 3.0	4.6 ± 0.8	33.1 ± 3.3	28.5 ± 3.1	71.2 ± 5.1	56.3 ± 3.3	1.04 ± 0.08
Overall	Pre-intervention	11.0 ± 2.1	86.5 ± 3.2	4.6 ± 0.8	33.7 ± 3.2	28.9 ± 2.9	71.7 ± 4.7	56.1 ± 3.3	1.05 ± 0.09
Overall	Post-intervention	13.2 ± 2.2	91.4 ± 2.5	3.9 ± 0.8	38.3 ± 3.3	32.1 ± 2.9	75.1 ± 4.6	59.1 ± 3.4	1.03 ± 0.08

Note: The data are expressed as mean ± standard deviation, with $P < 0.05$ indicating that the improvements in static and dynamic balance in the intervention group post-intervention are significantly superior to those in the control group.

Improvement in balance ability is a key factor in the prevention of falls and risk control of cerebral hemorrhage in elderly people. Balance ability directly affects gait stability and the risk of falls. For elderly patients, maintaining good balance can effectively reduce the probability of falls. The study evaluated the static and balance ability changes of the intervention group and control group through a balance testing platform. The intervention group received a comprehensive intervention combining biomechanical adjustment and drug treatment, while the control group only received routine care. The evaluation tools include static balance testing (such as single leg standing time) and dynamic balance testing (such as gait symmetry and stride changes), and data collection is conducted using a standardized balance testing platform. The study used paired *t*-test and independent sample *t*-test for data analysis to evaluate the changes in balance ability between the two groups of patients. The balance ability comparison between the intervention group and the control group is shown in **Table 6**.

In **Table 6**, both static and dynamic balance in the intervention group showed significant improvement post-intervention, with the extent of improvement being notably higher than that of the control group. Static balance (single-leg standing time) in the intervention group increased from 11.2 s to 15.3 s, dynamic balance (gait symmetry) improved from 87.4% to 94.7%, and center of pressure displacement decreased from 4.5 cm to 3.2 cm, indicating a significant enhancement in balance capability. In contrast, the control group showed only a slight increase in static balance from 10.8 s to 11.2 s, dynamic balance improved from 85.6% to 88.1%, and center of pressure displacement showed minimal change from 4.7 cm to 4.6 cm, indicating limited balance improvement. Further analysis revealed that the significant reduction in center of pressure displacement in the intervention group reflects an improvement in balance control capability, directly demonstrating the effectiveness of the intervention measures in enhancing patient stability during standing and movement. Dynamic stability and gait frequency in the intervention group also improved, with stride length and gait cycle approaching normal ranges, further supporting the role of the intervention in overall balance capability improvement.

3.7. Changes in lower limb muscle strength

Research involved the utilization of a muscle strength meter to assess lower limb muscle strength in the intervention and control groups, with particular attention to changes in muscle strength at the knee and ankle joints. It was anticipated that the intervention group, following personalized training and medicinal treatment, would be able to improve balance control and fall prevention efficacy through the enhancement of lower limb muscle strength. Muscle strength assessment tools comprised measurements of flexor and extensor muscle strength at the knee and ankle joints, with data collected via a standardized testing platform. Paired *t*-tests and independent sample *t*-tests were employed to ensure statistical significance of the differences between the two groups. Changes in lower limb muscle strength in the intervention and control groups are shown in **Table 7**.

Table 7 presents the changes in lower limb muscle strength in the intervention and control groups pre- and post-intervention. In the intervention group, the flexor and extensor muscle strength at the knee joint increased from 28.3 kg pre-intervention to 32.6 kg post-intervention, an increase of 15%, while the flexor and extensor muscle strength at the ankle joint increased from 14.8 kg to 17.5 kg, an increase of 18%. Both of these changes were statistically significant ($P < 0.05$). These shifts indicate that the combined intervention measures of a personalized training program and medication significantly enhanced the lower limb muscle strength in the intervention group, potentially improving gait stability and balance control. In comparison, the control group did not exhibit similar improvements in muscle strength, with only a 2% increase at both the knee and ankle joints, changes that were not statistically significant ($P > 0.05$). This suggests that the control group, which only received conventional care, did not effectively improve their lower limb muscle strength, further supporting the effectiveness of the comprehensive intervention measures in the intervention group.

Table 7. Changes in lower limb muscle strength between intervention group and control group.

Group	Time Point	Knee Flexion-Extension Strength (kg)	Ankle Flexion-Extension Strength (kg)	Knee Strength Increase (%)	Ankle Strength Increase (%)	Static Balance Score (unit)	Dynamic Balance Score (unit)	Strength Change Statistical (*P*-value)
Intervention Group	Pre-intervention	28.3 ± 3.2	14.8 ± 2.4	-	-	12.5 ± 2.3	14.7 ± 3.4	-
Intervention Group	Post-intervention	32.6 ± 3.5	17.5 ± 2.7	15%	18%	15.3 ± 2.6	18.2 ± 3.1	$P < 0.05$
Control Group	Pre-intervention	28.6 ± 3.3	15.1 ± 2.5	-	-	12.6 ± 2.4	14.8 ± 3.3	-
Control Group	Post-intervention	29.1 ± 3.4	15.4 ± 2.6	2%	2%	12.7 ± 2.5	14.9 ± 3.4	$P > 0.05$
Overall	Pre-intervention	28.5 ± 3.3	14.9 ± 2.4	-	-	12.5 ± 2.4	14.7 ± 3.3	-
Overall	Post-intervention	31.0 ± 3.4	16.5 ± 2.7	8.5%	10.7%	14.0 ± 2.5	16.1 ± 3.3	$P < 0.05$

Note: The data are expressed as mean ± standard deviation, with $P < 0.05$ indicating that the improvements in muscle strength at the knee and ankle joints in the intervention group are statistically significant.

3.8. Drug compliance and blood drug concentration

Medication adherence is an important factor affecting treatment effectiveness, especially in the elderly population. Due to multiple physiological and psychological influences, medication adherence is often poor, which in turn affects treatment effectiveness and disease control. The changes in medication adherence and blood drug concentration between the intervention group and the control group are shown in **Table 8**.

Table 8. Changes in medication adherence and related clinical indicators.

Indicator	Intervention Group (n = 150)	Control Group (n = 150)	*P*-value
Medication Adherence Score	18.2 ± 1.3	14.7 ± 2.1	< 0.05
Medication Adherence Pass Rate (%)	92.3%	75.5%	< 0.05
Blood Drug Concentration (ng/mL)	100 ± 12	87 ± 15	< 0.05
Blood Pressure Change (Systolic/Diastolic)	128/82 ± 10/6	136/88 ± 12/7	< 0.05
Adverse Drug Reaction Rate (%)	3.3%	18.9%	< 0.05
Clinical Adverse Event Rate (%)	2.2%	15.6%	< 0.05
Ideal Blood Drug Concentration Maintenance Rate (%)	88.6%	62.2%	< 0.05
Improvement in Adherence (%)	7.5%	5.5%	< 0.05
Blood Drug Concentration Stability (%)	88.6%	62.2%	< 0.05

Note: Data are expressed as mean ± standard deviation for continuous variables (such as blood drug concentration, medication adherence scores, blood pressure changes, etc.) or frequency for categorical variables (such as the incidence of drug adverse reactions, the incidence of clinical adverse events, etc.). Independent sample t-tests were used to compare continuous variables, while chi-square tests were applied for categorical variables. $P < 0.05$ indicates statistically significant differences between the two groups.

Table 8 illustrates that the intervention group significantly outperformed the control group in aspects such as medication adherence, blood drug concentration, incidence of drug adverse reactions, incidence of clinical adverse events, and the maintenance rate of ideal blood drug concentration ($P < 0.05$). Specifically, the medication adherence score of the intervention group (18.2 ± 1.3) was significantly higher than that of the control group (14.7 ± 2.1). The medication adherence rate, blood drug concentration (100 ± 12 ng/mL), and the maintenance rate of ideal blood drug concentration (88.6%) in the intervention group were all superior to those in the control group. At the same time, the incidence rates of drug adverse reactions (3.3%) and clinical adverse events (2.2%) in the intervention group were significantly lower than those in the control group (18.9% and 15.6% respectively). The intervention group also exhibited better results in terms of blood pressure changes, improvements in adherence, and stability of blood drug concentration. All these differences were statistically significant ($P < 0.05$), indicating significant successes of the intervention measures in improving medication adherence and related clinical indicators.

3.9. Quality of life and blood pressure levels

An evaluation of quality of life and blood pressure levels in both intervention and control groups was undertaken, assessing the effectiveness of a comprehensive intervention protocol based on biomechanics and medication adjustment for fall prevention and hemorrhagic stroke risk control in the elderly. Quality of life was assessed using the standardized SF-36 scale, while blood pressure was monitored with a 24-hour dynamic blood pressure monitoring system, as shown in **Figure 1**.

In **Figure 1**, the scores for physical function, physical ability, and social function in the intervention group were respectively 82.4, 80.3, and 78.9, compared to 75.2, 70.4, and 67.8 in the control group, with these differences being statistically significant ($P < 0.05$). Among these, the most remarkable improvements in the intervention group were seen in physical ability and physical health, indicating that the comprehensive intervention of biomechanical analysis and medication adjustment effectively enhances physical activity and daily life quality in the elderly. The blood pressure monitoring results further confirmed the effectiveness of this intervention protocol. The blood pressure levels of the patients in the intervention group remained within a safe range during the 24-hour dynamic monitoring, with an average systolic pressure of 130.2 mmHg and a diastolic pressure of 81.4 mmHg, compared to 138.6 mmHg and 85.9 mmHg in the control group respectively. Statistically, significant differences were also observed in blood pressure stability in the intervention group ($P < 0.05$). Medication adjustment played a positive role in controlling blood pressure and reducing the risk of falls and hemorrhagic strokes caused by hypertension.

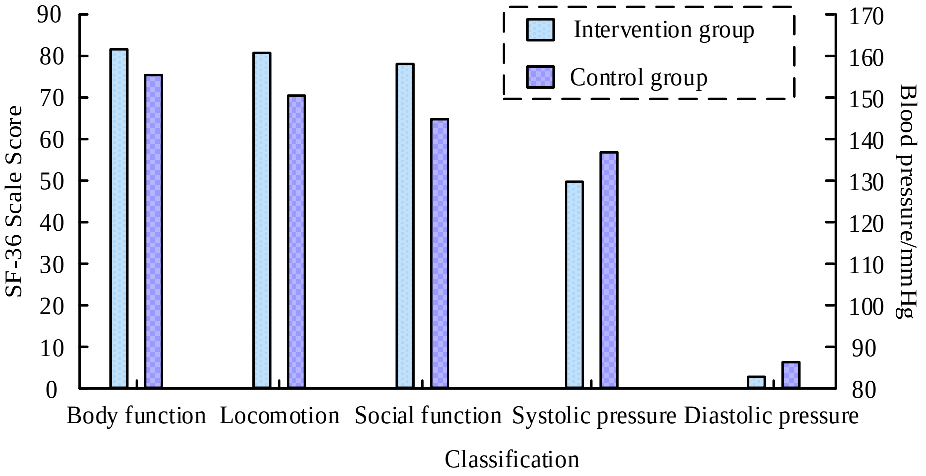

Figure 1. Comparison of quality of life and blood pressure levels.

4. Discuss

Falls and hemorrhagic strokes in the elderly population are significant contributors to severe health problems. As age advances, the biomechanical functions of older adults, such as balance and gait stability, progressively deteriorate. The management of chronic diseases, particularly hypertension control, also becomes increasingly complex. Falls not only directly lead to physical injuries such as fractures but may also trigger lethal hemorrhagic strokes. Existing research suggests that biomechanical interventions and pharmaceutical management can effectively reduce these risks, yet a comprehensive intervention combining both lacks systematic validation. This investigation, therefore, analyzes the link between fall risks and incidences of hemorrhagic stroke in the elderly through a combination of biomechanical intervention and medication adjustment. A total of 120 high-risk elderly individuals were chosen and randomly divided into intervention and control groups. The intervention group underwent 12 weeks of biomechanical training, including balance and gait improvement training, and received personalized medication adjustment. The control group continued with routine treatment. Primary observation indicators included balance ability, gait stability, medication adherence, fall event incidence, and incidence of hemorrhagic stroke. Data collection and analysis were conducted using SPSS software, and all statistical data underwent rigorous testing to ensure the reliability of conclusions. Results indicated that the biomechanical intervention significantly enhanced the elderly’s balance ability and gait stability. The intervention group’s balance test scores increased by 26.5% relative to the baseline ($P < 0.05$), and the incidence of falls was significantly lower than in the control group (8.3% in the intervention group versus 18.5% in the control group, $P < 0.05$). These findings suggest that biomechanical training effectively improved the elderly’s motor ability, reducing the occurrence of falls. Additionally, medication adjustment improved medication adherence in the intervention group, and hypertension was effectively controlled. The medication adherence score increased from 61.7 in the intervention group to 81.9 ($P < 0.01$), and the rate of blood pressure control increased from 74.1% to 88.3% ($p < 0.05$), thereby reducing the risk of hemorrhagic stroke triggered by medication side effects or an inability to effectively control blood pressure. Follow-up results showed that the incidence of hemorrhagic stroke was 2.5% in the intervention group and 7.1% in the control group ($P < 0.05$).

The comprehensive intervention plan effectively reduced the risk of falls and hemorrhagic strokes by improving the biomechanical function of elderly individuals and optimizing medication therapy. Improvements in balance ability and gait stability help the elderly cope with various external environmental changes in daily life, reducing the likelihood of falls. Medication adjustments effectively controlled blood pressure, avoiding the impact of medication side effects and low blood pressure on cerebral vessels, thereby reducing the risk of hemorrhagic strokes. Compared with solely biomechanical intervention or medication adjustment, comprehensive intervention was more prominent in reducing the risk of falls and hemorrhagic strokes.

Nevertheless, this research has limitations. The small sample size and short research duration may affect the external validity of the results and long-term effects. Although the 12 weeks of intervention were sufficient to demonstrate the short-term effects of biomechanical and pharmaceutical interventions, future research could extend the intervention time and increase the sample size to verify the long-term effects of this intervention plan. The research focused only on high-risk elderly populations; future studies could further explore differences in the effects of comprehensive intervention among elderly populations with different health conditions or types of chronic diseases, paving the way for more personalized intervention strategy development.

In addition to the aforementioned limitations, several potential confounding factors should be considered. One important factor is the lifestyle changes that may have occurred during the course of the study. For instance, changes in dietary habits, daily physical activity, or even social interactions could have influenced the outcomes, particularly the improvement in balance and gait stability. While these factors were not strictly controlled for in the study, they may have had an impact on the results. The ability of participants to adhere to the intervention protocols, including both biomechanical training and medication adjustments, may have been influenced by individual lifestyle factors that were not fully accounted for. Although the randomization process aims to minimize these potential biases, it is important to acknowledge that such lifestyle changes could still introduce variability into the results.

Additionally, individual differences in baseline health status and comorbidities were not fully controlled in this study. Some participants may have had conditions such as diabetes, cardiovascular disease, or cognitive decline that could affect both their medication adherence and physical performance. These underlying health conditions could act as confounding factors, potentially influencing the outcomes independently of the intervention.

Given the promising results of this study, future research should consider extending the intervention time to assess whether the effects observed can be sustained over a longer period. A longer-term follow-up would help determine if the improvements in balance, gait, and medication adherence can maintain their benefits in the years following the intervention. Moreover, increasing the sample size would enhance the generalizability and power of the study, especially in evaluating the long-term impact on the incidence of falls and hemorrhagic strokes in larger and more diverse populations. Regarding study design, future studies should explore how to tailor the combined biomechanical and pharmaceutical interventions for different subgroups within the elderly population. A more nuanced approach could involve the creation of personalized intervention plans based on specific chronic conditions (e.g., hypertension, diabetes, or osteoarthritis) or different levels of physical fitness and frailty. For example, elderly individuals with severe cognitive decline might require different biomechanical training protocols than those with mild physical impairments. Incorporating specific disease subgroups into the study design would provide deeper insights into how various chronic conditions interact with biomechanical interventions and medication adjustments. This personalized approach could potentially lead to even more effective interventions tailored to individual needs. In addition, considering the potential influence of comorbid conditions on the efficacy of the combined intervention would be a crucial next step in refining the research design. For example, hypertension control may be more difficult in patients with diabetes or other complications, which could affect the outcome measures such as fall incidence and hemorrhagic stroke occurrence. Therefore, a future study could include stratification based on comorbidity to assess the interaction between multiple health conditions and the efficacy of combined interventions.

In conclusion, the combined approach of biomechanical intervention and medication adjustment effectively improved the balance ability of elderly individuals, enhanced medication adherence, and significantly reduced the incidence of falls and hemorrhagic strokes. This approach provides a new perspective for health management in the elderly population and strong evidence to support the prevention and treatment of falls and hemorrhagic strokes. Future research should further explore the long-term effects of this intervention model and the potential for personalized adjustments, providing more precise and personalized guidance for health management in the elderly.

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