

## GAMEMOVE MOTOR SKILL ASSESSMENT MODE AND ITS APPLICATION IN THE ANALYSIS OF MOTOR PERFORMANCE IN AGING INDIVIDUALS

### MODO AVALIAÇÃO DO GAMEMOVE MOTOR SKILL E SUA APLICAÇÃO NA ANÁLISE DO DESEMPENHO MOTOR DE PESSOAS EM PROCESSO DE ENVELHECIMENTO

### MODO DE EVALUACIÓN DE GAMEMOVE MOTOR SKILL Y SU APLICACIÓN EN EL ANÁLISIS DEL RENDIMIENTO MOTOR DE PERSONAS EN PROCESO DE ENVEJECIMIENTO



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#### ABSTRACT

This study analyzed the motor performance of individuals undergoing the aging process, participants of the Gerontology Center at Feevale University, mediated by the active digital game GameMove Motor Skill. The research is characterized as exploratory, quantitative, and cross-sectional. The sample consisted of 102 aging individuals (76 females and 26 males), all participants of the Feevale Gerontology Center. Data were presented using absolute and relative frequencies, measures of central tendency, and dispersion. Normality was tested using the Kolmogorov-Smirnov test, while the Mann-Whitney test compared scores between genders, and the Chi-square test evaluated associations between motor skills and age groups. Analyses were conducted in IBM® SPSS® (v.26.0), adopting a significance level of  $p \leq 0.05$ . The analysis of motor performance in the GameMove Motor Skill revealed no significant differences between sexes in the hitting task, although results showed a favorable trend for men. In the right-leg kicking task, a significant difference was observed in favor of men. This result may be associated with cultural factors that influence oculopedal experiences and the valuation of certain motor skills in the daily lives of aging individuals. The hopping/stationary march test indicated a slight male tendency, but without statistical significance, whereas the balance test revealed significant differences favoring men on both sides, with greater discrepancies observed after the age of 70. The game proved to be a reliable instrument for assessing motor performance in individuals undergoing the aging process, providing support for understanding this performance and for the appropriate prescription of interventions.

**Keywords:** Active Video Games. Motor Skills. Aging.

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## RESUMO

Este estudo analisou o desempenho motor de pessoas em processo de envelhecimento, participantes do Centro Interdisciplinar de Pesquisas em Gerontologia da Universidade Feevale, mediado pelo jogo digital ativo GameMove Motor Skill. A pesquisa é de natureza exploratória, quantitativa e transversal. A amostra foi composta por 102 pessoas em processo de envelhecimento, 76 do sexo feminino e 26 do sexo masculino. Os dados foram apresentados por frequências absolutas e relativas, medidas de tendência central e dispersão. A normalidade foi testada pelo Kolmogorov-Smirnov, o Mann-Whitney comparou escores entre sexos e o Qui-Quadrado avaliou associações entre habilidades motoras e faixas etárias. As análises foram realizadas no IBM® SPSS® (v.26.0), adotando  $p \leq 0,05$ . A análise do desempenho motor no GameMove Motor Skill mostrou ausência de diferença significativa entre os sexos no teste de rebater, embora com melhor desempenho aos homens. No chute com a perna direita, observou-se diferença significativa em favor do sexo masculino. Esse resultado pode estar associado a fatores de ordem cultural, que influenciam a vivência óculo-pedal e a valorização de determinadas habilidades motoras no cotidiano das pessoas em processo de envelhecimento. O teste de saltitar/marcha estacionária indicou melhor desempenho masculino, mas sem significância, enquanto no equilíbrio houve diferença significativa para os homens em ambos os lados, mais acentuada após os 70 anos. O jogo demonstrou ser um instrumento confiável para a avaliação do desempenho motor em pessoas em processo de envelhecimento, oferecendo subsídios para a compreensão desse desempenho e para a adequada prescrição de intervenções.

**Palavras-chave:** Jogos Eletrônicos de Movimento. Destreza Motora. Envelhecimento.

## RESUMEN

Este estudio analizó el rendimiento motor de personas en proceso de envejecimiento, participantes del Centro Interdisciplinario de Investigaciones en Gerontología de la Universidad Feevale, mediado por el juego digital activo GameMove Motor Skill. La investigación es de naturaleza exploratoria, cuantitativa y transversal. La muestra estuvo compuesta por 102 personas en proceso de envejecimiento, 76 mujeres y 26 hombres. Los datos se presentaron por frecuencias absolutas y relativas, medidas de tendencia central y dispersión. La normalidad se probó mediante Kolmogorov-Smirnov, Mann-Whitney comparó las puntuaciones entre sexos y Chi-Cuadrado evaluó las asociaciones entre habilidades motoras y grupos de edad. Los análisis se realizaron en IBM® SPSS® (v.26.0), adoptando  $p \leq 0,05$ . El análisis del rendimiento motor en GameMove Motor Skill mostró una ausencia de diferencias significativas entre los sexos en la prueba de bateo, aunque con un mejor rendimiento en los hombres. En la patada con la pierna derecha, se observó una diferencia significativa a favor del sexo masculino. Este resultado puede estar asociado a factores de orden cultural, que influyen en la experiencia óculo-pedal y en la valoración de determinadas habilidades motoras en la vida cotidiana de las personas en proceso de envejecimiento. La prueba de saltar/marcha estacionaria indicó un mejor rendimiento masculino, pero sin significación, mientras que en el equilibrio hubo una diferencia significativa para los hombres en ambos lados, más acentuada después de los 70 años. El juego demostró ser un instrumento confiable para evaluar el desempeño motor en personas en proceso de envejecimiento, ofreciendo información para comprender este desempeño y prescribir intervenciones adecuadas.

**Palabras clave:** Juegos Electrónicos de Movimiento. Destreza Motora. Envejecimiento.

## 1 INTRODUCTION

The world's population is in an aging process, configuring one of the most relevant demographic phenomena of the twenty-first century. According to recent estimates by the World Health Organization (WHO, 2024), by the year 2030, one in six people will be 60 years of age or older, totaling approximately 1.4 billion individuals in this age group. Projections also indicate that by 2050 this contingent could reach 2.1 billion people, evidencing the magnitude and urgency of discussions on population aging on a global scale.

The United Nations predicts that by 2050, people over the age of 65 will make up 15.9% of the world's population, up from 9.3% in 2020. In Europe, this age group is projected to reach 28.1%, from the current 19.1%, while the population over 80 years of age is expected to practically double, from 5.3% to 10.1% in the same period (United Nations, 2023).

The proportion of people in the process of aging has been increasing consistently in both developed and developing countries, a direct result of the combination of declining mortality and fertility rates and the progressive increase in life expectancy. In this context, it is essential to understand and identify the priority problems that affect the aging population, understood as the contingent of individuals who enter more advanced age groups as a result of the increase in longevity and the reduction in fertility and mortality rates. Such understanding is essential to support the formulation of actions aimed at ensuring the safety of the aging population and providing the necessary health care (Torre, 2022).

In this sense, it is imperative to consider the physiological and functional changes typical of aging, since reduced levels of physical activity, decreased gait speed, and progressive loss of muscle strength are associated with a more accelerated decline in mobility, predisposing to functional limitations and greater vulnerability (Martins et al., 2020).

Among the most critical factors, deficits in postural control stand out, which have repercussions on physical functioning and are significant predictors of falls in the elderly. Postural control should be understood as a complex and dynamic skill, resulting from the interaction between sensory, perceptive and motor processes, whose proper integration enables postural orientation and the maintenance of balance. From this perspective, functional balance is a central element, as it represents the ability of the elderly to sustain stability, both in static and dynamic situations, during daily activities. The impairment of this ability compromises not only functional independence, but also the quality of life of individuals in the aging process (Medeiros et al., 2024).

Flores et al., (2024) argue that technological devices, such as television, smartphones, computers, and video games, are associated with the promotion of sedentary lifestyle patterns. However, Pacheco et al (2020), Ha et al (2025) and Chen et al (2020) indicate that

technological advances can also offer new possibilities for the practice of physical exercise, contributing to the improvement of physical activity levels, well-being and learning.

In this sense, exergames (a term derived from the combination of the words exercise and game) can be defined as active digital games (JDAs) that require body movement to be played, providing an interactive experience that works as a form of physical exercise (Van Santen et al., 2018). These resources cover multiple motor and cognitive skills by integrating sensory feedback, adjustable ranges of motion, variations in speed and precision, as well as diversified tasks that simulate everyday situations (Schneider; Berlese; Barbosa, 2023).

Exergames or JDAs are recognized for enabling not only the real-time practice of motor activities, but also for promoting engagement in meaningful actions related to the interests of daily living (Maggio et al, 2025). Huang et al. (2017) highlight that this type of game can positively influence both the subjective experience and the behaviors of players by articulating entertainment with functional goals.

In the field of rehabilitation, there is a growing body of scientific evidence on the potential benefits of JDAs for people with cognitive-motor deficits. Nuic et al (2024) and Fernandes et al (2025) point to positive impacts on specific populations, such as patients with Parkinson's disease or in the post-stroke rehabilitation phase. Chen et al. (2021) point out that these tools have significant potential for improving postural control and balance, fundamental aspects for functional autonomy.

However, despite the already recognized benefits of Active Digital Games (JDAs), there is still a relevant gap in the scientific field regarding the proof of their effectiveness in assessing motor performance (Leal et al., 2023). This gap highlights the need for research to validate the applicability of these technological resources in order to promote health and the prevention of functional disabilities.

In this sense, the definition of adequate motor parameters, combined with the systematic monitoring of Physical Education professionals, is a fundamental condition to ensure the effectiveness of interventions. This process not only guides the adaptation of the JDAs to the particular demands of the aging population, but also ensures the creation of contextualized virtual environments that respect individual singularities and promote dynamic, safe, and socially meaningful motor experiences. Thus, the Physical Education professional plays a central role in articulating technology, health and inclusion. In view of this scenario, the present study aims to analyze the motor performance of people in the aging process, participants of the Interdisciplinary Center for Research in Gerontology of Feevale

University, mediated by the active digital game GameMove Motor Skill.<sup>6</sup>

## 2 METHOD

The present research is characterized as being exploratory, descriptive, quantitative and cross-sectional. In order to contemplate the objectives of the study, the instruments and procedures were organized and carried out in phases and stages. The procedures and instruments for data collection or production were established according to the development phase, which followed a process structured in phases according to the model proposed by Baba and Tschang (2001). In Phase 1, the theoretical and pedagogical foundations for the improvement of the game were established. Phase 2 focused on creating the game's layout, rules, narrative, and characters, as well as implementing motion capture via webcam, and in Phase 3, developing the game itself. After the judges' validation (phase 4) and data collection, adaptations were made to the game and validation with the target audience (phase 5).

We investigated 102 aging people, of both sexes (76 females and 26 males), aged between 50 and 80 years, participants at the Feevale Gerontology Center, in Rio Grande do Sul, Brazil. Inclusion in the study was conditional on their consent. The exclusion criteria were guaranteed through the information contained in the registration form made available by the Feevale Gerontology Center, ensuring the standardization of the sample and the possibility of interaction of the participants with the game. Individuals in the aging process who had uncorrected physical, cognitive, intellectual or visual disabilities, whose conditions could compromise the adequate execution of the proposed tasks, were excluded from the study. Among the physical criteria, significantly reduced mobility, severe spasticity, and relevant musculoskeletal restrictions were considered exclusion factors. In the cognitive field, situations of severe developmental delays or marked attentional deficits were excluded. Regarding intellectual limitations, substantial comprehension difficulties were considered, capable of directly interfering with the performance of game activities.

In addition, the investigation had the participation of 02 Physical Education professionals, whose contribution was fundamental for the performance of the analog motor assessment through observation of movements (process-oriented assessment). The process-oriented evaluation, conducted by experts in the field, enabled detailed analysis of movement patterns, allowing comparisons between the data obtained in the JDA GameMove Motor Skill and the motor parameters. This complementary approach strengthens the validity

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<sup>6</sup> For the initial validation of the game with children (children from 6 to 11 years old), see: SCHNEIDER, Guilherme Theisen; et al. Development and validation of an active digital game to stimulate motor skills: application of the GameMove Motor Skill. In: *Anais...* (proceedings of the SBGames Extended 2023 conference, Brazilian Computer Society). 2023. Available at: [https://sol.sbc.org.br/index.php/sbgames\\_estendido/article/view/27856](https://sol.sbc.org.br/index.php/sbgames_estendido/article/view/27856).

of the results, ensuring a methodological triangulation that improves the reliability of the results and enables a more comprehensive understanding of the motor development of people in the aging process.

All evaluations were performed after signing the Informed Consent Form, in accordance with the determinations of resolution 466, of December 2012, of the National Health Council. Participants were provided with information regarding their right to participate and guarantees of anonymity. The study was approved by the Research Ethics Committee CAEE No. 78383024.6.0000.5348, Registration No.: 206426/2024.

To meet the need for a tool with a more precise evaluative focus, such as game improvement, a new stage was developed that introduced a differentiated dynamic to provide a more accurate and standardized motor evaluation. The main modifications included an introduction (instruction phase), with detailed feedback on motor actions, combining visual and auditory instructions. The objective was to improve the execution and understanding of the movements by the participants. This feedback offered immediate guidance, ensuring that movements were performed with greater precision. In addition, the evaluation phase has been adjusted to cover all age groups at a single level, with modifications such as reducing obstacles and increasing the intervals between tasks. These changes ensured a more reliable evaluation of motor parameters. By simplifying the dynamics of the game and adjusting variables such as the complexity of the tasks, the time and the number of obstacles, reliable results were obtained on the motor performance of people in the aging process.

Thus, Figure 1 illustrates the set of images in the tutorial (instruction phase) referring to the four movements selected for initial learning at the beginning of the evaluation phase. The tutorial was structured in such a way as to present each movement through the silhouette of an individual performing the actions of balancing, jumping (stationary gait), batting and kicking. To ensure adequate assimilation by the participants, the movements were programmed to be performed at a reduced speed, allowing a clearer and more detailed visualization of the actions by the participants. This strategy aimed to facilitate the understanding and correct execution of the movements, aligning with the pedagogical and evaluative objectives of the game.

**Figure 1**

*Set of Tutorial Images in the four moves of the GameMove Motor Skill*



Source: GameMove Motor Skill game tutorial images.

The digital evaluation was conducted using the GameMove Motor Skill, under the direct supervision of the principal investigator. Initially, the data of each participant, such as name, age and gender, were recorded in the game's identification menu. After this registration process, the system went through a calibration phase, designed to adjust the capture and mimicry of the body movements of the evaluated, ensuring the accuracy of the interactions. Each participant was submitted to an introductory stage, in which they practiced the game's tutorial. This phase aimed to promote familiarization with the movements required in each game mode, ensuring an adequate understanding of the proposed activities.

During the execution of the game, the Physical Education professionals filled out a specific analog motor assessment questionnaire aimed at people in the aging process, based on motor protocols applied to the elderly population and guided by the movement development guidelines proposed by Gallahue, Ozmun and Goodway (2013). This approach enabled an analysis of motor skills, respecting the particularities of aging and ensuring scientific rigor in the interpretation of the results. This instrument documents the motor skills observed, providing process-oriented data of the movements requested in the game (product).

The results were described as absolute (n) and relative (%) frequencies, minimum and maximum values, arithmetic mean, standard deviation, median, percentile ranks (P25, P75) and interquartile range. Kolmogorov-Smirnov was applied to test adherence to the normal distribution in all experimental variables (game and observation). Mann-Whitney was used to

compare the scores between genders. Chi-square ( $\chi^2$ ) was used to assess the existence of associations between the levels of motor skills classification as a function of age groups. All statistical procedures were performed using the IBM® SPSS® software (Version 26.0), adopting a significance level of  $p \leq 0.05$ .

### 3 RESULTS

The results presented in this study came from two complementary sources: the data collected automatically by the active digital game GameMove Motor Skill (product of motor actions) and the observations conducted by Physical Education professionals (process of motor actions). As an instrument to evaluate the motor action process, an assessment for older people adapted from the protocol originally proposed by Schneider (2025) was used. The data from the game provides objective and standardized information about the performance (product) of the participants, capturing precise metrics such as time, accuracy and efficiency of the movements. On the other hand, the observations of Physical Education professionals allowed a process-oriented analysis that considers more subtle and contextual aspects of motor performance, such as functional motor organization of movement, posture, coordination and adaptability. This perspective was essential for interpreting nuances that were not completely captured by the webcam.

The integration of these two data sources is justified by the need for a process- and product-oriented evaluation of motor performance, also encompassing the contextualized interpretation of its implications. This hybrid approach enabled a triangulation of information, ensuring that the study's findings incorporate both the precision and advances offered by the technology and the analytical depth and interpretive richness afforded by the expert observation of a qualified professional.

### 4 ANALYSIS OF DATA FROM THE JDA GAMEDOVE ENGINE SKILL

Before the presentation of the results, the procedure adopted for the statistical analysis of the data from the GameMove Motor Skill Active Digital Game (JDA) is highlighted. Comparisons were made using the two-way model, considering the factors age and sex, in order to verify the need or not for different classifications between men and women. In total, 21 variables were analyzed, distributed in three age groups (50–59 years, 60–69 years, and 70–80 years), which allowed a precise understanding of the effects of aging on motor performance, as well as the possible interactions between age and sex that will be presented in Table 1.

**Table 1**

*Comparison between the sexes by age profile in the ability to balance the game*

Age Group	Variable	Gender		P
		Female (n=76)	Male (n=26)	
50-59 years (n = 18)	Right Balance	58,0	60,0	0,100
	Left Balance	58,0	60,0	0,164
	Total Balance	117,0	120,0	0,100
60-69 years old (n = 58)	Right Balance	58,0	59,0	0,701
	Left Balance	57,0	58,0	0,522
	Total Balance	114,0	118,0	0,403
70-80 years (n = 26)	Right Balance	45,0	52,5	*0,017
	Left Balance	50,5	56,5	*0,015
	Total Balance	97,0	109,0	**0,003
All (n = 102)	Right Balance	57,0	58,0	0,480
	Left Balance	56,0	57,0	0,189
	Total Balance	112,0	114,5	0,211

(\*)  $p \leq 0.05$ ; (\*\*)  $p \leq 0.01$ ; (\*\*\*)  $p \leq 0.001$ .

Source: Prepared by the author, 2025.

Table 1 shows that, up to the age of 69, there were no significant differences between men and women in the motor ability of balance. However, in the 70 to 80 age group, women had significantly lower performance on the right ( $p = 0.017$ ), left ( $p = 0.015$ ) and total ( $p = 0.003$ ) balance measures. These results may be related to physiological factors such as sarcopenia, lower muscle mass and strength, reduced bone mineral density, and postmenopausal hormonal changes, which contribute to a steeper decline in body stability in this age group.

**Table 2**

*Comparison between the sexes by age profile, ability to jump/stationary gait in the game*

Age Group	Variable	Gender		P
		Women	Male	
50-59 years (n = 18)	Click-through Rate/Hits S01	1,7	1,5	0,130
	Click/Hit Rate S02	1,4	1,4	0,498
	Click/Hit Rate S03	1,3	1,3	0,738
	Click/Hit Rate S04	1,3	1,3	0,574
	Overall Click-through / Hit Rate	1,4	1,4	0,824
	Total Time Bouncing	33,0	23,0	0,056
60-69 years old (n = 58)	Click-through Rate/Hits S01	1,5	2,2	*0,018
	Click/Hit Rate S02	1,4	1,4	0,764
	Click/Hit Rate S03	1,3	1,3	0,588
	Click/Hit Rate S04	1,3	1,3	0,624
	Overall Click-through / Hit Rate	1,4	1,6	0,069
	Total Time Bouncing	28,0	38,0	0,254
70-80 years (n = 26)	Click-through Rate/Hits S01	1,7	2,2	*0,046
	Click/Hit Rate S02	1,4	1,4	0,403
	Click/Hit Rate S03	1,5	1,3	0,560
	Click/Hit Rate S04	1,3	1,4	0,322
	Overall Click-through / Hit Rate	1,6	1,6	0,274
	Total Time Bouncing	49,0	27,5	0,403
All (n = 102)	Click-through Rate/Hits S01	1,7	2,1	**0,006
	Click/Hit Rate S02	1,4	1,4	0,479
	Click/Hit Rate S03	1,3	1,3	0,735
	Click/Hit Rate S04	1,3	1,3	*0,048
	Overall Click-through / Hit Rate	1,4	1,5	*0,021
	Total Time Bouncing	33,0	27,5	0,969

(\*)  $p \leq 0.05$ ; (\*\*)  $p \leq 0.01$ ; (\*\*\*)  $p \leq 0.001$ .

Source: Prepared by the author, 2025.

Table 2 shows that, for the group between 50 and 59 years of age, there were no significant differences between men and women in the click/correct answer rates (S01 to S04) or in the overall rate, although the total time of jumping showed a trend of difference in favor of women ( $p = 0.056$ ), without statistical significance. In the 60-69 and 70-80 age groups, there was a significant difference in the click/correct answer rate S01 ( $p = 0.018$  and  $p = 0.046$ , respectively), with superior performance of men, in addition to a favorable trend in the overall rate between 60 and 69 years ( $p = 0.069$ ). In the sample as a whole ( $n = 102$ ), men had significantly higher performance in S01 ( $p = 0.006$ ), S04 ( $p = 0.048$ ) and in the overall rate ( $p = 0.021$ ).

**Table 3**

*Comparison between the sexes by age profile, ability: Batting in the game*

Age Group	Variable	Gender		P
		Women	Male	
50-59 years (n = 18)	Bounce Right	5,0	4,0	0,498
	Left Batting	5,0	5,0	1,000
	Total Bounce	10,0	9,0	0,654
60-69 years old (n = 58)	Bounce Right	4,0	5,0	0,209
	Left Batting	5,0	4,0	0,468
	Total Bounce	9,0	9,0	0,831
70-80 years (n = 26)	Bounce Right	4,0	4,0	0,667
	Left Batting	3,5	4,5	0,403
	Total Bounce	7,0	8,5	0,560
All (n = 102)	Bounce Right	4,0	5,0	0,666
	Left Batting	5,0	4,0	0,778
	Total Bounce	9,0	9,0	0,903

Source: Prepared by the author, 2025.

Table 3 shows that, in all age groups analyzed (50–59, 60–69, and 70–80 years), there were no statistically significant differences between men and women in the ability to hit, either with the right or left hand, or in the total number of repetitions. Although small variations were observed, there is a trend towards higher performance of the right hand in men and the left hand in women between 60–69 years of age, and slightly higher values for men between 70–80 years of age, without statistical significance. Thus, the overall average performance remains similar between the sexes.

**Table 4**

*Comparison between the sexes by age profile, ability: Kicking in the game*

Age Group	Variable	Gender		P
		Women	Male	
50-59 years (n = 18)	Kick Right	4,0	4,0	0,912
	Left Kick	5,0	4,0	0,250
	Total Kick	9,0	8,0	0,574
60-69 years old (n = 58)	Kick Right	4,0	5,0	0,365
	Left Kick	5,0	5,0	0,820
	Total Kick	9,0	9,0	0,640
70-80 years (n = 26)	Kick Right	2,5	4,0	0,053
	Left Kick	3,5	4,5	0,252
	Total Kick	6,0	8,5	*0,046
All (n = 102)	Kick Right	4,0	4,0	0,469
	Left Kick	5,0	5,0	0,903
	Total Kick	8,5	8,5	0,661

(\*)  $p \leq 0.05$ ; (\*\*)  $p \leq 0.01$ ; (\*\*\*)  $p \leq 0.001$ .

Source: Prepared by the author, 2025.

Table 4 shows that, in the 50–59 and 60–69 age groups, no statistically significant differences were identified between men and women in kicking ability, which indicates the absence of relevant effects of aging on this motor capacity at these ages. In the 70–80 age

group, however, there was a significant difference in the total number of kicks ( $p = 0.046$ ), with superior performance of men, while the right kick showed only a trend towards difference ( $p = 0.053$ ).

## 5 ANALYSIS OF DATA FROM THE EXPERT'S OBSERVATION

In order to identify inconsistencies in the evaluation provided by the *GameMove Motor Skill* game, an observational analysis (motor action process) was carried out, through motor evaluation, adapted from Schneider's proposal (2025) and conducted by a Physical Education professional.

Initially, descriptive statistics were performed, covering minimum and maximum values, median, arithmetic mean, standard deviation, percentiles (P25, P50, P75), as well as the interquartile range (IQR), in order to characterize the performance of the participants. For the comparative stage, the *two-way* ANOVA model was used, considering the factors age and sex. The purpose of this procedure was to identify possible variations between the groups and to assess the need for distinct classifications between men and women, thus ensuring the relevance of a joint analysis. In all, 12 variables were analyzed, distributed in three age groups (50–59 years, 60–69 years, and 70–80 years), allowing a detailed assessment of the impact of aging and gender on motor performance. Based on this design, the descriptive and comparative results are presented below, organized in tables in order to highlight the patterns of motor performance between the different age groups and sexes, as well as the possible interactions between these variables.

**Table 5**

*Comparison between the sexes by age profile, ability: Balance in observation*

Age Group	Variable	Gender		P
		Women	Male	
50-59 years (n = 18)	Right Balance	7,0	7,0	0,912
	Left Balance	7,0	7,0	0,250
	Total Balance	14,0	14,0	0,738
60-69 years old (n = 58)	Right Balance	7,0	6,0	0,098
	Left Balance	7,0	6,0	0,915
	Total Balance	13,0	12,0	0,342
70-80 years (n = 26)	Right Balance	5,0	6,0	0,076
	Left Balance	6,0	6,0	0,462
	Total Balance	11,0	12,0	0,131
All (n = 102)	Right Balance	7,0	6,0	0,387
	Left Balance	6,0	6,5	0,699
	Total Balance	12,0	12,0	0,811

Source: Prepared by the author, 2025.

Table 5 shows that, in all age groups analyzed, no statistically significant differences were identified between men and women in postural balance, either on the right or left sides

and on the total. Small trends were recorded with slightly higher performance of women in right balance between 60–69 years ( $p = 0.098$ ) and men between 70–80 years ( $p = 0.076$ ), but without statistical significance.

**Table 6**

*Comparison between the sexes by age profile, ability: Jumping in observation*

Age Group	Variable	Gender		P
		Women	Male	
50-59 years (n = 18)	Overall Click-through / Hit Rate	1,4	1,4	0,824
	Total Bounce	14,0	14,0	1,000
60-69 years old (n = 58)	Overall Click-through / Hit Rate	1,4	1,6	0,091
	Total Bounce	14,0	14,0	0,791
70-80 years (n = 26)	Overall Click-through / Hit Rate	1,6	1,6	0,274
	Total Bounce	13,0	14,0	0,781
All (n = 102)	Overall Click-through / Hit Rate	1,4	1,5	*0,021
	Total Bounce	14,0	14,0	0,605

(\*)  $p \leq 0.05$ ; (\*\*)  $p \leq 0.01$ ; (\*\*\*)  $p \leq 0.001$ .

Source: Prepared by the author, 2025.

Table 6 shows that, between 50 and 59 years of age, there were no significant differences between men and women in the overall click/correct rate or in the total number of jumps, indicating similar performance in coordination and locomotion tasks. However, between 60 and 69 years of age, there was a trend of male superiority in the overall click/correct answer rate (1.6 vs. 1.4;  $p = 0.091$ ), although without statistical significance, while the total number of correct answers remained equivalent between the sexes. In the 70 to 80 age group, both the click/hit rate and the total number of jumps remained similar, with no statistical differences. When considering the total sample ( $n = 102$ ), the overall click/correct answer rate showed a significant difference for males ( $p = 0.021$ ), while the total number of skipping remained balanced.

**Table 7**

*Comparison between the sexes by age profile, ability: Rebuttal in observation*

Age Group	Variable	Gender		P
		Women	Male	
50-59 years (n = 18)	Bounce Right	6,0	6,0	0,301
	Left Batting	6,0	6,0	0,301
	Total Bounce	12,0	12,0	0,301
60-69 years old (n = 58)	Bounce Right	6,0	6,0	0,241
	Left Batting	5,0	6,0	0,104
	Total Bounce	11,0	12,0	0,157
70-80 years (n = 26)	Bounce Right	5,5	5,0	0,781
	Left Batting	5,0	5,0	0,940

	Total Bounce	10,5	10,0	0,899
All (n = 102)	Bounce Right	6,0	6,0	0,704
	Left Batting	5,5	6,0	0,291
	Total Bounce	11,0	12,0	0,473

Source: Prepared by the author, 2025.

Table 7 did not identify statistically significant differences between men and women in the performance of hitting ability, either with the right or left hand, or in total. Between 60 and 69 years of age, only a slight trend of better performance of the left hand was observed in men ( $p = 0.104$ ), without, however, reaching statistical significance.

**Table 8**

*Comparison between the sexes by age profile, ability: Guessing on observation*

Age Group	Variable	Gender		P
		Women	Male	
50-59 years (n = 18)	Kick Right	6,0	6,0	0,426
	Left Kick	6,0	6,0	0,426
	Total Kick	12,0	12,0	0,426
60-69 years old (n = 58)	Kick Right	6,0	6,0	0,160
	Left Kick	6,0	6,0	0,520
	Total Kick	12,0	12,0	0,465
70-80 years (n = 26)	Kick Right	6,0	6,0	0,432
	Left Kick	6,0	6,0	0,631
	Total Kick	12,0	12,0	0,595
All (n = 102)	Kick Right	6,0	6,0	0,053
	Left Kick	6,0	6,0	0,287
	Total Kick	12,0	12,0	0,227

Source: Prepared by the author, 2025.

The data presented in Table 8 demonstrate that no statistically significant differences were found between men and women in the different age groups in the performance of kicking ability, both for the right and left legs, as well as in the total number of kicks, indicating stability and equivalence between the sexes throughout aging.

## 6 DISCUSSIONS

Aging causes significant changes in motor initiation and control, but such effects tend not to be homogeneous between the sexes. These differences are also reflected in neuromuscular structure and function. Studies such as the one by Guo et al. (2025), in which they investigated 50 elderly people (26 men and 24 women, aged between 60 and 83 years), point out that women have greater functional vulnerability compared to men, which is reflected in multiple domains, from cortical preparation to motor execution and balance, corroborating the results presented in Tables 1 and 5 (equilibrium variables).

At the level of movement initiation, Frolov et al. (2020) observed that older people resort to more complex pre-movement processes, resulting in slower execution. According to

the results of tables 2, 3 and 6, distinct patterns in motor performance are observed between men and women. Rantanen, Era and Heikkinen (2005) found that women performed better in fine dexterity tasks, such as in the Purdue Pegboard test (an assessment widely used to measure manual dexterity, fine motor coordination and speed of manipulating objects with the hands), while men exhibited greater handgrip strength and *tapping* speed, in line with the results presented in Tables 3 and 7 (rebounding variables). This result is confirmed in a more recent study proposed by Wunderle et al., (2024) in which it was identified that men obtain higher results in tapping strength and frequency, while women excel in activities of stacking pins on the *Purdue Pegboard (perforated panel)*, evidencing greater manual agility corresponding to the results in table 2, 3 and 7 (bounce and bounce variables).

In addition, Beck, Hastings, and Clark (2025), in a systematic review, reinforce that, even in older people, male muscle strength remains consistently superior, although women retain advantages in coordination and manual dexterity. This corroborates the equivalences of the results in the variables of jumping/stationary gait and bouncing, when compared between the sexes, as shown in tables 2, 3, 6 and 7. Although women have a tendency for advantages in coordination and manual dexterity, this may have been compensated by the male evaluates who have a tendency towards better results in upper limb strength and power, as observed in Tables 3 and 7.

In this sense, Hooyman et al. (2021) showed that the manipulation of tools, highly dependent on fine motor control and cognitive functions, is more challenging for older people, with sex differences emerging mainly in manual precision tasks, with older women achieving superior results compared to men, similar to what was observed in our results. Vasylenko, Gorecka, and Rodríguez-Aranda (2018) report that elderly men were slower than elderly women in bimanual tasks, showing that sex influences not only strength, but also the quality of motor execution.

Sex differences become even more evident in postural balance. Elshorbagy et al. (2024) showed a significant increase in mediolateral oscillation in elderly women, indicating a lower efficiency of the compensatory mechanisms responsible for maintaining postural stability. Rezaei et al. (2024) point out that the single-leg stance test is a reliable predictor of aging, regardless of gender, but performance scores tend to be lower in women, corroborating the results presented in tables 1 and 5. As the study by Wu et al. (2021) demonstrates, there is a worse balance performance in Chinese elderly women. Similarly, Nascimento et al. (2023) reported a prevalence of falls almost twice as high among Portuguese women compared to men (48.7% vs. 23.6%). These data reinforce that women

are more susceptible to postural decline and falls, possibly due to factors such as lower muscle mass, hormonal differences, and greater longevity.

Muscle strength and power are crucial determinants of motor performance and also show differences between the sexes. It is estimated that there will be a progressive loss of 5 to 10% of muscle mass per decade after the age of 50, but this reduction has a greater impact on women (Rodrigues et al., 2022). Bersotti et al. (2022) showed that men preserve superior absolute torque in ankle dorsiflexion and plantar flexion, while Caçador et al. (2023) highlighted that women's lower limb strength corresponds to only 60–80% of that observed in men. This discrepancy is even more critical in muscle power, a variable strongly associated with fall prevention. This discrepancy may have been a determining factor for a better result in men in the evaluations that required greater recruitment of the muscles of the lower limbs, as observed in the results of Tables 4 and 8.

From a neuromuscular point of view, Guo et al. (2025) showed that elderly men maintain greater size and strength of the motor units of the vastus lateralis muscle, also presenting better motor control and functional performance compared to women. Although both sexes exhibit progressive decline due to aging, the functional impact is more pronounced in women, especially after the age of 70. In the same direction, Toro-Román et al. (2024) confirmed that male individuals have higher values of strength, cardiorespiratory capacity, and performance in functional tests, although decline with age is inevitable for both groups. These results corroborate the evidence that, from the seventh decade of life onwards, these differences become more pronounced, highlighting the motor superiority of men over women in most of the parameters evaluated.

Therefore, men tend to preserve better strength, power, and overall performance, while women have a higher risk of postural instability, falls, and accelerated functional decline. According to Clark, Manini, and Fielding (2023), these patterns reflect neuromuscular determinants of aging, among which greater muscle mass and the ability to generate power contribute to superior physical performance among men. Liang, Li, and Wang (2024) reinforce that women have a significantly higher risk of falls, instability, and early functional decline, as a result of an interaction between biological factors (such as lower lean mass and hormonal changes related to menopause) and behavioral and social factors, including lower engagement in physical strength activities throughout life. It is understood that the differences observed between the sexes in the aging process of motor performance should not be interpreted solely as a result of biological determinants. Such distinctions also reflect the influence of sociocultural factors, as well as inequalities in opportunities for access to and

engagement in physical activity practices throughout the course of life, which contribute decisively to the configuration of functional capacities in advanced age.

## 7 CONCLUSION

The results obtained indicate that the active digital game *GameMove Motor Skill* is a valid and reliable tool for the evaluation of motor performance in people in the aging process. There was a trend towards better male performance in the tasks of batting and jumping/stationary gait, a significant difference in favor of men in the kicking test, and male superiority in balance, especially after 70 years of age.

These results confirm that aging causes significant changes in motor control and initiation, manifesting itself differently between the sexes. Women showed greater functional vulnerability in aspects related to manual dexterity, motor execution and balance, while men showed greater preservation of strength, power and overall motor performance. This difference results not only from biological factors such as lower muscle mass and hormonal changes, but also from sociocultural conditioning factors that provide men with greater exposure to motor practices associated with strength, speed and power throughout life.

The reliability of the *GameMove Motor Skill* was evidenced by the high correlation between the metrics generated by the system and the independent evaluations carried out by Physical Education professionals, as well as by the stability of the scores in repeated measures. Thus, the instrument shows promise for application in clinical and research contexts, contributing to functional monitoring and to the promotion of health and quality of life during aging.

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