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Effects of 12 weeks of functional and resistance training on stress perception and sleep quality in Brazilian older people

Efeitos de 12 semanas de treinamento funcional e resistido na percepção de estresse e na qualidade do sono de pessoas idosas brasileiras

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Abstract. The study investigated the effects of a 12-week functional and resistance training program on the perception of stress and sleep quality in Brazilian older people, involving 49 participants. The Perceived Stress in older adults and the Pittsburgh Sleep Quality Index (PSQI) was used. The training protocol included a general warm-up, resistance and functional training sessions, followed by a cool-down phase, held twice a week, lasting an average of 60 minutes over the 12 weeks. Data analysis was performed using the Kolmogorov-Smirnov test, bootstrapping, t-tests and Pearson correlation, with a significance level of $p < 0.05$. The results showed a significant reduction in sleep disturbance and total sleep quality score after the intervention. Men initially had lower stress and better sleep quality in some aspects compared to women, while older people between 60 and 69 years old had improvements in sleep quality in certain aspects before and after the intervention, compared to older people aged 70 and over. Furthermore, a positive correlation was observed between the perception of stress and several components of sleep quality, such as subjective quality, duration and total score. In short, the study demonstrated that the exercise program had varying impacts on sleep quality, but not on the perception of stress among the older people, highlighting a significant improvement in sleep quality after the intervention.
Keywords: Aging. Exercise Therapy. Sleep Quality. Psychological stress. Physical education.

Resumen. El estudio investigó los efectos de un programa de entrenamiento funcional y de resistencia durante 12 semanas en la percepción del estrés y la calidad del sueño en adultos mayores brasilenos, con la participación de 49 sujetos. El protocolo de entrenamiento incluyó un calentamiento general, sesiones de entrenamiento de resistencia y funcional, seguidas de una fase de enfriamiento, realizadas dos veces por semana, con una duración promedio de 60 minutos durante las 12 semanas. El análisis de los datos se realizó mediante la prueba de Kolmogorov-Smirnov, bootstrapping, pruebas t y correlación de Pearson, con un nivel de significancia de $p < 0,05$. Los resultados mostraron una reducción significativa en el trastorno del sueño y el puntaje total de calidad del sueño después de la intervención. Los hombres inicialmente presentaron menos estrés y mejor calidad de sueño en algunos aspectos en comparación con las mujeres, mientras que los adultos mayores de entre 60 y 69 años experimentaron mejoras en la calidad del sueño en ciertos aspectos antes y después de la intervención, en comparación con los adultos mayores de 70 años o más. Además, se observó una correlación positiva entre la percepción del estrés y varios componentes de la calidad del sueño, como la calidad subjetiva, la duración y el puntaje total. En resumen, el estudio demostró que el programa de ejercicios tuvo impactos variados en la calidad del sueño, pero no en la percepción del estrés entre los adultos mayores, destacando una mejora significativa en la calidad del sueño después de la intervención.
Palabras clave: Envejecimiento. Terapia de Ejercicio. Calidad del Sueño. Estrés Psicológico. Educación Física.

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Introduction

With population aging, unique challenges arise for older adults, including financial issues, housing, living conditions, and changes in social networks and activities, factors that can contribute to a heightened perception of stress, individually and subjectively (Glover, et al., 2021). The Pan American Health Organization (PAHO) highlights that stress, depressive symptoms, and sleep disorders become increasingly relevant as aggravating factors in the aging process (Iroldi, et al., 2020).

The perception of stress can contribute to the development of chronic diseases associated with aging, such as cardiovascular, neurodegenerative, and immunosuppression conditions, emphasizing the importance of understanding the connections between perceived stress and aging (Kim, et al., 2019; Whitehead & Blaxton, 2021; Vetter, et al., 2022). Lower levels of perceived stress are associated with better quality of life and well-being. On the other hand, elevated levels are correlated with lower quality of life and well-being, as well as increased vulnerability to physical and/or cognitive issues (Whitehead & Blaxton, 2021).

Individual responses to perceived stress play a fundamental role in healthy functioning, actively influencing the pace of aging (Luo, et al., 2022). It is relevant to note that perceived stress is related to mental and cognitive overload, physical strength, and emotional tension (Guerdoux-Ninot & Trouillet, 2019; Koyanagi, et al., 2019).

Moreover, perceived stress is associated with sleep disorders, which become more evident with aging as sleep becomes more fragmented and interrupted. This results in lower sleep efficiency, leading to daytime sleepiness, decreased alertness, and short naps during the day, reducing total sleep hours and potentially being a predictor of increased mortality risk (Kim, et al., 2019; Iroldi, et al., 2020).

Sleep disorders in the older adult population are prevalent and associated with physical and psychological factors (Ha & Kim, 2019; Kim, et al., 2019). Poor sleep quality, for example, is related to polypharmacy and overeating for stress relief, impairing tolerance to stressful situations and inhibiting healthy behaviors (Bergmans, et al., 2021).

Reducing stress, when correlated with sleep, has positive effects on sleep quality, both endocrinologically and biopsychologically, mitigating hyperarousal and symptoms associated with insomnia (Hu, et al., 2020).

In this context, physical exercise stands out as a multidimensional approach that can address both physical and psychological aspects of health. Improvements include reduced sleep latency, increased duration of deep sleep, and decreased nighttime interruptions. Furthermore, physical exercises, especially functional ones, demonstrate a positive impact on reducing insomnia and promoting more regular sleep patterns in older adults (Stefan, et al., 2018; Tseng, et al., 2020; Darraz, et al., 2021; Peixoto, 2021).

Studies have addressed the effects of functional exercises on sleep and stress in older adults. Exercises focused on improving strength, balance, and mobility are particularly relevant, aiming to enhance daily functionality and consequently quality of life (Pillat, et al., 2019; Miyazaki, et al., 2021; Solis-Navarro, et al., 2023).

In addition to sleep benefits, physical exercise plays a remarkable role in reducing perceived stress in older adults, acting as a stress-modulating agent, promoting the release of neurotransmitters and hormones related to well-being (Silva, et al., 2015; Fragala, et al., 2019). Thus, exercises enhance not only the physical health of older adults but also play a crucial role in promoting healthy sleep and reducing perceived stress, contributing to active and balanced aging (Chovanec & Gröpel, 2020; Souza, et al., 2022).

The National Health Promotion Policy (NHPP) is guided by principles, objectives, values, and guidelines that emphasize the importance of equity, better living conditions, ways of life, and rights to a healthy life, encompassing economic, political, cultural, and environmental aspects. Aligned with the Sustainable Development Goals (SDGs), especially Quality Health at all stages of life, the NHPP motivates the need for this study, aiming to highlight the impact of a 12-week functional and resistive training intervention program on stress perception and sleep quality in older adults (Brazil, 2018).

Sleep disorders are a reality in the general population, becoming more prominent with advancing age. Globally, approximately 40% of people aged 60 or older face sleep disturbances. In the national context, the prevalence of complaints related to sleep quantity and quality in older adults of this age group varies between 35% and 40%. Such sleep problems are associated with an increased risk of falls, cognitive impairment, higher incidence of hospitalizations, and mortality (Carvalho, et al., 2022). Worldwide, chronic conditions and multimorbidities are correlated with high levels of stress in older adults, especially in low- and middle-income countries, as highlighted by Stubbs et al. (2018).

Considering the potential impact of sleep and perceived stress on the lives of older adults, covering physical, emotional, psychological, biological, and economic aspects, associated with complications for public health, justifies the relevance of this study. It seeks to address the impact on the health of this older adult population through a functional and resistive training program, aiming to assess the influence on sleep quality and stress perception of these individuals.

The importance of the study also lies in the scarcity of research combining these types of training, highlighting the relevance of understanding how physical activity can impact crucial aspects of the mental and physical health of older adults. By simultaneously addressing stress perception and sleep quality, the study fills a gap in knowledge, offering practical information for health promotion in older adults. Such results may have valuable implications for the development of evidence-based intervention strategies. Thus, this study aims to investigate the effects of 12 weeks of functional and resistive training on stress perception and sleep quality in Brazilian older adults.

Material and Methods

This is a quasi-experimental intervention study with a quantitative approach, approved by the Research Ethics Committee (REC) of Cesumar University (Unicesumar), through opinion number 3,373,307.

Forty-nine older adults participated in the study, comprising 34 women and 15 men, aged 60 to 83 years. The non-probabilistic sample was intentionally and conveniently chosen. Men and women with the following characteristics were included: (1) aged ≥ 60 years; (2) physically fit for moderate to vigorous exercise; and (3) available to participate regularly in the project activities, with an absence not exceeding 25%. The older individuals were participants in an Older Exercise Group at Unicesumar in the year 2022, and they were already capable of performing physical exertion.

Exclusion criteria were: (1) participants with debilitating neurological diseases (e.g., Alzheimer's, Parkinson's, plegias; with reduced intellectual capacity); (2) with chronic or acute diseases that contraindicate physical exercise in general and/or alter the response to intervention (e.g., incapacitating atherosclerotic disease; congestive heart failure class 4); (3) active rheumatoid arthritis; (4) advanced kidney or liver disease; and (5) undergoing chemotherapy for cancer.

Sociodemographic data were obtained from a semi-structured questionnaire, including information such as sex, age, skin color, age group, education level, retirement and income in minimum wage(s).

To measure Perceived Stress in older adults, that is, to measure the degree to which the sample perceives situations as stressful, the Perceived Stress Scale (PSS) was used, validated in Brazil by Luft et al. (2007). This scale consists of 14 questions about feelings and thoughts during the last month. For each question, respondents could choose one of the following options: 0 = never, 1 = almost never, 2 = sometimes, 3 = almost always, 4 = always. The total scale score is the sum of the scores of the 14 questions, ranging from 0 to 56. The higher the score, the higher the perceived stress, and vice versa (Luft, et al., 2007).

To evaluate sleep disturbances, the Pittsburgh Sleep Quality Index (PSQI) was used, validated in Brazil by Bertolazi et al. (2011). This questionnaire assesses sleep quality over a one-month period and consists of 19 self-assessment questions. These questions are divided into seven components: C1 = subjective sleep quality; C2 = sleep latency; C3 = sleep duration; C4 = habitual sleep efficiency; C5 = sleep disturbances; C6 = use of sleep medication; C7 = daytime dysfunction. After completion, the overall score is obtained by summing these seven components, ranging from 0 to 21 points, with higher scores indicating worse sleep quality. A score above five indicates significant difficulty in at least two components or moderate difficulties in more than three evaluated components (Bertolazi et al., 2011).

The study recruitment was conducted through a previously prepared artwork at the Interdisciplinary Laboratory for Health Promotion Intervention (ILHPI) of Unicesumar, including all essential project information. The artwork was printed and distributed in health units near Unicesumar, as well as being promoted through social networks (Instagram, Facebook, WhatsApp groups), radio, and television.

Interested participants enrolled by filling out a form available on Google Forms. Subsequently, the applicants were selected and contacted for interviews at ILHPI. The initial interview was conducted by interns and laboratory professionals. After a general health analysis by the medical team, older adults were included or excluded from the research.

The interventions consisted of practical activities conducted by physical education professionals. These activities were carried out at Unicesumar facilities on Tuesdays and Thursdays, from eight o'clock in the morning until nine o'clock in the morning, with a new group of older adults starting at nine o'clock in the morning until ten o'clock. In the afternoon, the activities started at three o'clock and ended at four o'clock, over 12 weeks of intervention. The exercises were conducted using the concurrent method, incorporating functional and resistance exercises.

The physical training protocol implemented during the program intervention was structured as follows: General Warm-up (10 minutes), including walking on the university sports court; Resistance Training Sessions (20 minutes), involving exercises such as Low Row, Bipedal Plantarflexion, Leg Extension, French Triceps, Rowing or Treadmill, Smith Machine Squat, Push-ups, Dumbbell Bench Press, Total-body Resistance Exercise (TRX) Rowing; Functional Training Sessions (20 minutes), comprising exercises such as Bench Squats with lateral elevation, TRX or Super Band Rowing, Pelvic Lifts, Agility ladder, Box or wall push-ups, Dynamic wall squats; and Cool Down (10 minutes), involving active, static, upper and lower limb, and trunk stretches.

The training sessions were held twice a week, with an approximate duration of 60 minutes, taking place at Unicesumar facilities. Over the 12 weeks, the training effort and rest protocol were modified according to training progression: from the first to the third week - three sets of 30 seconds, with 30 seconds of recovery; from the fourth to the sixth week - three sets of 40 seconds, with 20 seconds of recovery; from the seventh to the 12th week - three sets of 50 seconds, with 10 seconds of recovery.

The training sessions were monitored using perceptual scales, such as the Rating of Perceived Recovery (RPR) proposed by Laurent et al. (2011) before sessions and the Borg Rating of Perceived Exertion (RPE) proposed by Foster et al. (2001) after sessions. All participants were properly instructed on these scales in a meeting before starting physical exercises.

Data analysis was performed using SPSS 25.0 software, employing descriptive and inferential statistics. Frequency and percentage were used as descriptive measures for categorical variables. For numerical variables, data normality was analyzed using the Kolmogorov-Smirnov test and skewness and kurtosis coefficients. Bootstrapping procedures (1000 re-samplings; 95% BCa CI) were also performed to increase result reliability, correct potential deviations from normality in data distribution, and differences between group sizes, and to provide a 95% confidence interval for means (Haukoos; Lewis, 2005).

The Bootstrap dependent t-test (two time points) was used to compare anxiety symptoms and sleep quality before and after the physical exercise program. The Bootstrap Independent t-tests (two groups) were employed to compare stress perception and sleep quality of older adults before and after a physical exercise program based on sex, age group, monthly income, and ethnicity. Zhao et al. (2021) demonstrated that bootstrap t test outperforms Student's t test, and it is recommended to replace Student's t test in data analysis regardless of sample size. Pearson correlation was used to analyze the association between stress perception and sleep quality of older adults before and after the physical exercise program. A significance level of $p < 0.05$ was adopted.

Results

Forty-nine older adults, of both sexes (34 women and 15 men), participated in the research, aged between 60 and 83 years (M = 69.30; SD = 5.16). Table 1 demonstrates that the majority of older adults were aged between 60 and 69 years (55.1%), were retired (87.8%), had a monthly income of more than three minimum wages (71.4%), were white (75.5%), and had completed high school or higher education (75.5%).

Table 2 presents the comparison of older adults' perceived stress and sleep quality before and after the physical exercise program. A significant difference was found between the time points only in the sleep disturbance component ($p = 0.019$) and the total score of sleep quality ($p = 0.022$). It is noteworthy that there was a significant reduction in the mean of the sleep disturbance component and the total score of quality.

Table 1.
Profile of the older participants in the research. Maringá, Paraná, Brazil, 2023.

VARIABLES	F	%
Gender		
Female	34	69.4
Male	15	30.6
Age group		
60 to 69 years	27	55.1
70 years or older	22	44.9
Retirement		
Yes	43	87.8
No	6	12.2
Monthly Income		
1 to 3 MW	14	28.6
More than 3 MW	35	71.4
Color		
White	37	75.5
Black	12	24.5
Education		
Completed Elementary School	8	16.3
Completed Middle School	4	8.2
Completed High School	17	34.7
Completed Higher Education	20	40.8

MW: Minimum Wages

Table 2.
Comparison of perceived stress and sleep quality among older adults before and after the physical exercise program. Maringá, Paraná, Brazil, 2023

Variables	Moments		p
	Pre-intervention (n=49)	Post-intervention (n=49)	
	M (SD)	M (SD)	
Perceived Stress	21.51 (7,72)	20.73 (7,81)	0.501
Sleep Quality Components			
Subjective Quality	1.14 (0,79)	1.06 (0,77)	0.543
Latency	1.35 (0,99)	1.20 (0,86)	0.181
Duration	1.04 (0,95)	1.00 (0,97)	0.766
Efficiency	0.80 (1,15)	0.59 (1,09)	0.285
Disturbance	1.61 (0,63)	1.45 (0,57)	0.019*
Medication Use	1.29 (1,39)	0.92 (1,25)	0.051
Sleepiness and Daytime Dysfunction	0.71 (0,73)	0.67 (0,85)	0.749
Total Score	7.93 (4,03)	6.89 (3,70)	0.022*

* Significant difference: p < 0.05 - Dependent t-test.
M: mean; SD: standard deviation.

Table 3.
Comparison of stress perception and sleep quality in older adults before and after functional physical exercise program by sex. Maringá. Paraná. Brazil. 2023.

Variables	Gender		p
	Female (n=34)	Male (n=15)	
	M (SD)	M (SD)	
Stress Perception Pre	23.35 (6.81)	17.33 (8.26)	0.010*
Stress Perception Post	21.85 (8.46)	18.20 (5.50)	0.133
Sleep Quality Components			
Subjective Quality Pre	1.23 (0.69)	0.93 (0.96)	0.221
Subjective Quality Post	1.09 (0.71)	1.00 (0.92)	0.717
Latency Pre	1.59 (0.99)	0.80 (0.77)	0.009*
Latency Post	1.47 (0.82)	0.60 (0.63)	0.001*
Duration Pre	1.08 (0.90)	0.93 (1.09)	0.607
Duration Post	0.97 (0.96)	1.07 (1.03)	0.755
Efficiency Pre	0.88 (1.20)	0.60 (1.06)	0.436
Efficiency Post	0.50 (1.02)	0.80 (1.26)	0.384
Disturbance Pre	1.70 (0.62)	1.40 (0.63)	0.124
Disturbance Post	1.47 (0.61)	1.40 (0.50)	0.699
Medication Use Pre	1.32 (1.40)	1.20 (1.42)	0.779
Medication Use Post	1.03 (1.26)	0.67 (1.23)	0.357
Daytime Sleepiness/Disfunction Pre	0.85 (0.78)	0.40 (0.50)	0.046*
Daytime Sleepiness/Disfunction Post	0.76 (0.85)	0.47 (0.83)	0.263
Total Score Pre	8.68 (4.33)	6.27 (2.68)	0.023*
Total Score Post	7.29 (4.01)	6.00 (2.77)	0.264

* Significant difference: p < 0.05 - Dependent t-test.
M: mean; SD: standard deviation.

When comparing the perceived stress and sleep quality of older adults before and after the physical exercise program by sex (Table 3), a significant difference was found between the groups in the perception of stress before the intervention (p = 0.010), in the sleep latency components at pre (p = 0.009) and post-intervention (p = 0.001) moments, in the sleepiness and daytime dysfunction component pre-intervention (p = 0.046), and in the total sleep quality score pre-intervention (p = 0.023). It is noteworthy that men (M = 17.33) had a lower stress score before the intervention compared to women (M = 23.35). Additionally, men showed better quality in sleep latency pre and post-intervention, in sleepiness and daytime dysfunction pre-intervention, and in the total sleep quality score pre-intervention.

In comparing the perceived stress and sleep quality of older adults before and after the physical exercise program by age group (Table 4), a significant difference was found between the groups only in the sleep disturbance component before (p = 0.041) and after (p = 0.010) the intervention and in the sleepiness and daytime dysfunction component after the intervention (p = 0.049). It is noteworthy that older adults in the age group of 60 to 69 years showed better quality in the sleep disturbance component at both time points compared to older adults aged 70 years or older. However, older adults aged 70 years or older exhibited better quality in the sleepiness and daytime dysfunction component after the intervention.

Table 4.
Comparison of stress perception and sleep quality among older adults before and after the physical exercise program based on age group. Maringá. Paraná. Brazil. 2023.

VARIABLES	Age group		p
	60 to 69 years (n=27)	70 years or older (n=22)	
	M (SD)	M (SD)	
Stress Perception Pre	22.74 (7.19)	20.00 (8.25)	0.220
Stress Perception Post	20.63 (8.21)	20.86 (7.47)	0.918
Sleep Quality Components			
Subjective Quality Pre	1.11 (0.75)	1.18 (0.85)	0.759
Subjective Quality Post	1.11 (0.84)	1.00 (0.69)	0.623
Latency Pre	1.26 (0.98)	1.45 (1.01)	0.498
Latency Post	1.15 (0.76)	1.27 (0.98)	0.621
Duration Pre	0.93 (0.95)	1.18 (0.95)	0.357
Duration Post	0.89 (1.01)	1.14 (0.94)	0.384
Efficiency Pre	0.67 (1.07)	0.95 (1.25)	0.391
Efficiency Post	0.56 (1.12)	0.64 (1.09)	0.801
Disturbance Pre	1.44 (0.64)	1.82 (0.59)	0.041*
Disturbance Post	1.26 (0.52)	1.68 (0.57)	0.010*
Medication Use Pre	1.48 (1.42)	1.05 (1.36)	0.283
Medication Use Post	1.07 (1.38)	0.73 (1.07)	0.342
Daytime Sleepiness/Disfunction Pre	0.78 (0.75)	0.64 (0.72)	0.509
Daytime Sleepiness/Disfunction Post	0.89 (0.89)	0.40 (0.73)	0.049*
Total Score Pre	7.67 (3.99)	8.27 (4.16)	0.607
Total Score Post	6.92 (4.11)	6.86 (3.22)	0.954

* Significant difference: p < 0.05 - Dependent t-test.
M: mean; SD: standard deviation.

Table 5 presents the comparison of perceived stress and sleep quality of older adults before and after the physical exercise program based on income. A significant difference was found between the groups only in the sleep efficiency (p = 0.043) and use of sleep medication (p < 0.001) components before the intervention, indicating that older adults with a monthly income of more than three minimum wages reported better sleep efficiency (M = 0.54) and used less sleep medication throughout the week (M = 0.86) compared to older adults with an income of one to three minimum wages (M = 1.43 and 2.36, respectively).

Table 5.
Comparison of stress perception and sleep quality among older adults before and after the physical exercise program based on monthly income. Maringá, Paraná, Brazil, 2023.

VARIABLES	Monthly income		p
	1 to 3 MW (n=14)	More than 3 MW (n=35)	
	M (SD)	M (SD)	
Stress Perception Pre	22.28 (8.76)	21.20 (2.38)	0.662
Stress Perception Post	22.71 (7.34)	19.94 (7.95)	0.266
Sleep Quality Components			
Subjective Quality Pre	1.07 (0.82)	1.17 (0.78)	0.694
Subjective Quality Post	1.14 (0.86)	1.03 (0.74)	0.646
Latency Pre	1.29 (0.91)	1.37 (1.03)	0.788
Latency Post	1.29 (0.82)	1.17 (0.89)	0.681
Duration Pre	1.14 (1.16)	1.00 (0.87)	0.642
Duration Post	1.14 (1.23)	0.94 (0.87)	0.524
Efficiency Pre	1.43 (1.39)	0.54 (0.95)	0.043*
Efficiency Post	0.93 (1.26)	0.46 (1.01)	0.177
Disturbance Pre	1.71 90.46)	1.57 (0.69)	0.486
Disturbance Post	1.57 (0.51)	1.40 (0.60)	0.355
Medication Use Pre	2.36 (1.15)	0.86 (1.26)	<0.001*
Medication Use Post	1.29 (1.43)	0.77 (1.16)	0.198
Daytime Sleepiness/Disfunction Pre	0.64 (0.84)	0.74 (0.70)	0.672
Daytime Sleepiness/Disfunction Post	0.64 (0.92)	0.69 (0.83)	0.875
Total Score Pre	9.64 (3.60)	7.26 (4.04)	0.061
Total Score Post	8.00 (4.62)	6.46 (3.23)	0.191

* Significant difference: p < 0.05 - Dependent t-test.
M: mean; SD: standard deviation.
MW: Minimum Wages

A significant difference was found in the comparison of perceived stress and sleep quality of older adults before and after the physical exercise program based on the color of the older adults (white or black) only in the sleep latency component (p = 0.032) after the intervention (Table 6), indicating that older adults of white ethnicity (M = 1.05) showed better quality in this sleep component compared to older adults of black ethnicity (M = 1.67).

Table 6.
Comparison of stress perception and sleep quality among older individuals before and after the physical exercise program as a function of skin color. Maringá, Paraná, Brazil. 2023.

VARIABLES	Skin color		p
	White (n=37)	Black (n=12)	
	M (SD)	M (SD)	
Pre-Stress Perception	21.24 (7.32)	22.33 (9.17)	0.676
Post-Stress Perception	20.40 (6.48)	21.75 (11.28)	0.713
Sleep Quality Components			
Pre-Subjective Quality	1.11 (0.84)	1.25 (0.62)	0.594
Post-Subjective Quality	0.95 (0.70)	1.42 (0.90)	0.067
Pre-Latency	1.30 (1.02)	1.50 (0.90)	0.544
Post-Latency	1.05 (0.81)	1.67 (0.88)	0.032*
Pre-Duration	0.89 (0.87)	1.50 (1.08)	0.055
Post-Duration	0.89 (0.96)	1.33 (0.98)	0.177
Pre-Efficiency	0.62 (1.03)	1.33 (1.37)	0.063
Post-Efficiency	0.54 (1.01)	0.75 (1.35)	0.571
Pre-Disturbance	1.68 (0.57)	1.42 (0.79)	0.227
Post-Disturbance	1.43 (0.55)	1.50 (0.67)	0.730
Pre-Medication Use	1.19 (1.37)	1.58 (1.50)	0.402
Post-Medication Use	0.86 (1.25)	1.08 (1.31)	0.606
Pre-Daytime Sleepiness/Dysfunction	0.70 (0.74)	0.75 (0.75)	0.849
Post-Daytime Sleepiness/Dysfunction	0.65 (0.82)	0.75 (0.96)	0.724
Total Score Pre	7.49 (3.76)	9.33 (4.67)	0.171
Total Score Post"	6.38 (3.32)	8.50 (4.48)	0.085

Significant Difference: p < 0.05 - Dependent Student's t-test.
SD: standart deviation.

When analyzing the correlations between perceived stress and sleep quality of older adults before and after the physical exercise program (Table 7), it is noted that a significant (p < 0.05) and positive correlation was found between perceived stress and sleep quality components of subjective quality (r = 0.46), latency (r = 0.33), sleepiness (r = 0.39), and total sleep quality score (r = 0.42) before the intervention. After the intervention, a significant (p < 0.05) and positive correlation was found between perceived stress and sleep quality components of subjective quality (r = 0.30), duration (r = 0.44), and total sleep quality score (r = 0.42). Positive and weak/moderate correlations (r between 0.29 and 0.69) were found between sleep quality components in both moments.

Table 7.
Correlation between perceived stress and sleep quality of older adults before and after the physical exercise program. Maringá, Paraná, Brazil, 2023.

Pre Post	1	2	3	4	5	6	7	8	9
1. Perception of Stress	-	0.30*	0.19	0.44*	0.13	0.35	0.12	0.27	0.42*
2. Subjective Quality	0.46*	-	0.32*	0.39*	0.20	0.31*	-0.02	0.35*	0.57*
3. Latency	0.33*	0.41	-	0.12	0.11	0.35*	0.23	0.43*	0.60*
4. Duration	0.07	0.24	0.12	-	0.50*	0.22	0.10	0.18	0.63*
5. Efficiency	0.17	0.24	0.26	0.57*	-	0.36*	-0.03	0.12	0.57*
6. Disturbance	0.20	0.19	0.45*	0.26	0.29*	-	0.14	0.22	0.57*
7. Medication Use	0.22	0.19	0.14	0.07	0.15	0.34*	-	0.33*	0.50*
8. Sleepiness/Dysfunction	0.39*	0.36*	0.45*	0.19	0.35*	0.34*	0.14	-	0.63*
9. Total Sleep Score	0.42*	0.58*	0.63*	0.56*	0.69*	0.60*	0.56*	0.61*	-

Pearson Correlation.
* The correlation is significant at the 0.05 level.

Discussion

The main findings of the study indicate that the resistance and functional exercise program improved sleep disturbances and quality in older adults. This happens because moderate-intensity physical exercise can improve sleep quality, and when associated with routine and regular physical exercise practice, it leads to mood improvement and cognitive abilities (El-Kader & Al-Jiffri, 2019). Sewell et al. (2021) suggest that physical activity can help reduce the negative impact of sleep deficiency on older individuals. Furthermore, the randomized controlled trial by Souza et al. (2022) showed that 12 weeks of resistance training brought significant improvements to older adults: increased muscle strength and measurable advances in sleep quality, including reduced sleep onset latency, increased stage N3 (the deepest stage of sleep), and improved subjective sleep perception in individuals aged 65 or older (Manzoli, et al., 2018).

We found that men showed better sleep latency quality post-intervention compared to women. Differences in body composition, such as muscle and fat, can affect how men and women respond to training (Beckner, et al., 2023), possibly influencing sleep differently. Additionally, different hormone levels such as testosterone and estrogen between sexes can have important impacts on post-exercise recovery (Collado-Boira, et al., 2021; Lewis, et al., 2022) and on sleep pattern regulation (Hammes & Levin, 2019; Beekly, et al., 2023), which could explain this observed difference. Fank et al. (2022) systematic review pointed out that the overall effect of physical exercise in older adults was to improve overall sleep quality and its subjective components such as quality, duration, and latency in both sexes. Meanwhile, Gupta et al. (2022) clinical trial concluded that resistance training yielded better results for sleep duration and latency in individuals aged 60 and above of both sexes.

In our study, younger older adults experienced more significant improvements in sleep disturbances post-intervention compared to older ones. Younger older adults may have a greater response capacity to training stimuli, including muscular and metabolic adaptations, resulting in more pronounced improvements in sleep disturbances (Romare, et al., 2023). Another consideration is that, with advancing age, physiological and hormonal changes may occur that impact sleep quality (Lima, et al., 2019; Silva, et al., 2022), which may make it more challenging for older older adults to achieve significant improvements with training.

Older older adults showed better quality in the sleepiness and daytime dysfunction component of sleep after the intervention compared to younger ones. Different reasons can explain this finding, such as greater resilience in older older adults and possible lifelong exercise habits (Silva & Eulálio 2022; Toth, et al., 2023), greater commitment to the program, different initial health states, and distinct physiological responses to exercise.

We identified that older adults of white ethnicity exhibited better sleep latency compared to their black counterparts. Several complex factors could contribute to this finding, including genetic and racial influences that can impact the response to physical exercise and, consequently, to sleep (Jackson, 2017; Viecelli & Ewald, 2022). Additionally, socioeconomic disparities between ethnic groups may play a significant role in sleep quality (Jehan, et al., 2018; Rojanapairat, et al., 2023), as well as individual responses to physical training, specific participant characteristics, and sleep culture.

It is important to highlight that cultural differences in the approach to and importance attributed to sleep may influence how participants adopt and internalize sleep practices (Cheung, et al., 2021; Jeon, et al., 2021). This variety of elements highlights the complexity and multidimensionality of influences on sleep quality in different ethnic groups, underscoring the need for a holistic approach when interpreting such results.

After the intervention program, we observed that the lower the stress, the better the subjective quality, duration, and overall quality of sleep. Firstly, exercise is known to reduce stress and anxiety levels, promoting a physiological response that reduces stress hormones such as cortisol and increases endorphin production, improving well-being (Xie, et al., 2021; Mahindru, et al., 2023). This reduction in stress can directly contribute to a more restful and higher-quality sleep. Additionally, regular practice of physical exercises, such as functional and resistance training, can help regulate the circadian cycle, positively influencing sleep quality and duration (Alves, et al., 2021; Shen, et al., 2023). The combination of these factors may contribute to the observed association between stress reduction and sleep improvement after functional and resistance training.

Finally, it is worth noting that the intervention program with functional and resistance exercises did not significantly reduce stress in older individuals, which may be attributed to individual variations in the exercise response, influenced by factors such as initial fitness levels, health history, and genetic characteristics. Furthermore, the duration and intensity of the exercise program may play a crucial role, highlighting the complexity of physical stress responses in a diverse elderly population. These considerations emphasize the importance of personalized and adaptable approaches in intervention programs to maximize desired benefits.

Despite the important findings, this research has limitations. Firstly, the lack of a control group may compromise the ability to attribute the observed changes directly to the training program, without considering other external factors. Additionally, the sample is not representative of the diversity of the elderly population, limiting the generalization of the results. The subjective measurement of perceived stress and sleep quality may be susceptible to self-report bias. Moreover, the lack of long-term evaluations after the end of the program may limit the understanding of the long-term effects. These considerations are crucial for interpreting and applying the study results in a contextualized manner.

Conclusion

Based on the obtained results, the study revealed varied impacts of the physical exercise program on sleep quality, but not on the perception of stress among older adults. A significant reduction was observed in the average score of the sleep disturbance component and the total score of sleep quality after the intervention.

Sex-stratified analyses indicated significant differences in various components, with men showing lower stress scores before the intervention and better quality in sleep latency, sleepiness, and daytime dysfunction.

Age group also influenced the results, with individuals aged 60 to 69 showing better quality in the sleep disturbance component, while those aged 70 or older demonstrated improvement in sleepiness and daytime dysfunction after the intervention.

Based on the study's findings, several practical implications arise. Firstly, exercise programs should be tailored to meet the specific needs of different demographic groups, such as men and women, considering their distinct characteristics like sleep quality and stress levels. Moreover, it's crucial to emphasize the importance of regular moderate-intensity exercise as it can significantly contribute to improving sleep quality and reducing stress in older adults. These findings underscore the need for a personalized and adaptable approach in prescribing exercise to promote overall well-being and mental health in elderly individuals.

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