

## Postural and ergonomic analysis of reading habits in elderly adults: a case study

Análisis postural y ergonómico durante la lectura en adultos mayores: un estudio de caso

Nível de análise postural e ergonômica durante a leitura em idosos: um estudo de caso

### Darwin Rodrigo Revelo Ojeda

<https://orcid.org/0009-0005-0737-1087>  
University Professor and Researcher. Luis Tello  
Higher Technological Institute, Esmeraldas,  
Ecuador  
[drrevelo@insluistello.edu.ec](mailto:drrevelo@insluistello.edu.ec) (correspondence)

### ABSTRACT

**Introduction:** Proper posture is essential for preventing musculoskeletal disorders (MSDs) and ergonomic problems in elderly adults. This study aims to analyze the reading posture of elderly residents in the 'Esposos Bishara' seniors' residence, located in Tachina Parish, Esmeraldas Canton, Ecuador. **Methods:** A quantitative methodology was employed using the Rapid Entire Body Assessment (REBA) method to evaluate the reading postures of twelve elderly individuals aged between 63 and 99 years. Data were collected in designated reading spaces within the asylum. **Results:** The analysis revealed that the elderly participants exhibited medium to low risks of developing MSDs and ergonomic problems during reading activities. The predominant risk factors included neck flexion and prolonged static postures. **Discussion:** These findings align with existing literature that highlights the importance of ergonomic interventions in reducing MSD and ergonomic risks among elderly adults. The study underscores the need for ergonomic adjustments in reading environments to enhance postural health. **Conclusion:** The study concludes that while the risk levels are not alarmingly high, ergonomic modifications are necessary to mitigate potential MSDs in elderly readers. Future research should explore broader populations and varying reading environments.

**Keywords:** Posture, Elderly Adults, Reading, Ergonomics, REBA.

### RESUMO

**Contexto:** uma postura adequada é essencial para prevenir distúrbios musculoesqueléticos (DME) e ergonômicos em idosos. Este estudo visa analisar a postura de leitura dos residentes idosos no asilo 'Esposos Bishara', localizado na Paróquia Tachina, Cantão Esmeraldas, Equador. **Métodos:** Uma metodologia quantitativa foi empregada usando o método de Avaliação Rápida do Corpo Inteiro (REBA) para avaliar as posturas de leitura de doze idosos com idades entre 63 e 99 anos. Os dados foram coletados nos espaços de leitura designados dentro do asilo. **Resultados:** A análise revelou que os participantes idosos exibiram riscos médios a baixos de desenvolver DME durante as atividades de leitura. Os principais fatores de risco incluíram a flexão do pescoço e posturas estáticas prolongadas. **Discussão:** Estes achados estão em consonância com a literatura existente, que destaca a importância das intervenções ergonômicas para reduzir os riscos de DME em idosos. O estudo destaca a necessidade de ajustes ergonômicos nos ambientes de leitura para melhorar a saúde postural. **Conclusão:** O estudo conclui que, embora os níveis de risco não sejam alarmantemente altos, modificações ergonômicas são necessárias para mitigar os possíveis DME em leitores idosos. Pesquisas futuras devem explorar populações mais amplas e diferentes ambientes de leitura.

**Palavras-chave:** Postura, Idosos, Leitura, Distúrbios Musculoesqueléticos, Ergonomia, REBA

### RESUMEN

**Introducción:** una postura adecuada es esencial para prevenir trastornos musculoesqueléticos (TME) y ergonómicos en adultos mayores. Este estudio tiene como objetivo analizar la postura de lectura de los residentes mayores en el asilo 'Esposos Bishara', ubicado en la parroquia Tachina, cantón Esmeraldas, Ecuador. **Métodos:** Se empleó una metodología cuantitativa utilizando el método de Evaluación Rápida del Cuerpo Completo (REBA) para evaluar las posturas de lectura de doce individuos mayores con edades entre 63 y 99 años. Los datos se recopilaron en los espacios de lectura designados dentro del asilo. **Resultados:** El análisis reveló que los participantes mayores presentaban riesgos medios a bajos de desarrollar TME y ergonómicos durante las actividades de lectura. Los principales factores de riesgo incluyeron la flexión del cuello y las posturas estáticas prolongadas. **Discusión:** Estos hallazgos están en consonancia con la literatura existente que destaca la importancia de las intervenciones ergonómicas para reducir los riesgos de TME en adultos mayores. El estudio subraya la necesidad de ajustes ergonómicos en los entornos de lectura para mejorar la salud postural. **Conclusión:** El estudio concluye que, aunque los niveles de riesgo no son alarmantemente altos, son necesarias modificaciones ergonómicas para mitigar los posibles TME en los lectores mayores. Investigaciones futuras deberían explorar poblaciones más amplias y diversos entornos de lectura.

**Palabras clave:** Postura, Adultos Mayores, Lectura, Trastornos Musculoesqueléticos, Ergonomía, REBA.

### ARTICLE HISTORY

**Received:** 03-02-2024  
**Revised Version:** 21-04-2024  
**Accepted:** 11-05-2024  
**Published:** 26-05-2024  
**Copyright:** © 2024 by the authors  
**License:** CC BY-NC-ND 4.0  
**Manuscript type:** Article

### ARTICLE INFORMATION

**Science-Metrix Classification (Domain):**  
Economic & Social Sciences

**Main topic:**

Ergonomics of elderly reading habits

**Main practical implications:**

The study highlights the necessity of ergonomic interventions in reading environments for the elderly, suggesting actionable measures to mitigate musculoskeletal risks and enhance comfort and safety during reading activities.

**Originality/value:**

This research uniquely combines REBA analysis with a focus on elderly reading postures, providing empirical evidence into ergonomic risks and offering practical solutions to improve the quality of life for older adults. The main value lies in dealing with a case from a developing country such as Ecuador, where this type of research is very scarce in the literature.

## INTRODUCTION

The seated posture could be defined as "a position in which a considered part of the body weight is transferred to a working surface" Morales, Bonilla, & Roldán, (2021), or as that "in which the base of support of the body is halfway between that used in standing and that used during decubitus; that is, it is greater than in standing but less than in decubitus and the base of support is formed by the posterior aspect of the thighs and feet" (Tutillo, Revelo, Jiménez, & Moreira, 2020).

Different types of sitting posture are described in the literature depending on the posture adopted (anterior, middle and posterior) and the position of the spine (flexed and upright). In general, a child's sitting posture depends not only on the design of the chair, but also on his or her habits and the task performed (Guzmán, Álvarez, & García, 2022).

The anterior seated posture is the one adopted by the child in all those activities in which the object of attention is located below the horizontal line of vision (writing on the table, reading...). In this posture, the trunk is inclined forward and support is provided by the ischial tuberosities and the back of the thighs (Aldas, Chara, Guerrero, & Flores, 2021).

The middle seated posture is the one that the child adopts when the object of attention is located in the horizontal line of vision, for example, when attending the teacher's explanation or during a meeting. It is an unstable posture due to the fact that there is no support in the backrest so that the weight of the trunk rests only on the ischial tuberosities, so that the pelvis is in anteversion resulting in lumbar hyperlordosis and an increase in the dorsal and cervical curves (Martínez, Santaella, & Rodríguez, 2021).

The posterior sedentary posture is the posture that the child adopts in more restful activities in class that do not require the use of the table and when the object of attention is placed above the horizontal, providing the user with maximum comfort and convenience, for example, when watching a documentary in class on a television set on a shelf (Guzmán, Álvarez, & García, 2022). The flexed or kyphotic sitting posture is that posture in which there is increased flexion of the spine in the sagittal plane (increased dorsal kyphosis and inversion of the lumbar curve) together with retroversion of the pelvis. This flexed or kyphotic posture, if prolonged, has unfavorable repercussions on the individual by overloading the posterior ligaments of the back and increasing pressure on the anterior part of the intervertebral disc (Blümel, Aedo, Arteaga, Vallejo, & Chedraui, 2022).

As people age, alterations in postural control appear, resulting in the loss of stability and the appearance of imbalance, whose aging affects the quality of life of older adults, causing an undesired prolonged state of rest, immobility and falls, involving aging factors that will affect the cognitive, functional and sensorimotor levels. These alterations in body posture are related to aging, known as those responses to the imbalance of the body axis, adopted by the elderly when they maintain vicious postures and compensations.

However, the aging of the structures of the musculoskeletal system undergoes significant age-related changes, which may be the cause of the loss of functional independence, with the consequent reduction in participation in activities of daily living. It is important to consider that there are age-related factors that affect postural control in the elderly, particularly the loss of muscle mass, tone and function, body weight and strength, the appearance of fatigue and exhaustion, reduced walking speed, decreased flexibility of ligaments, decreased reaction capacity and impaired reflexes and slowing of movements, among others (Chalapud & Escobar, 2017).

In adulthood, certain alterations of postural responses in body control and balance are already evident, whose improper functioning would cause deterioration and instability when performing daily life tasks, such as feeding and dressing, in aspects such as dexterity and bimanual and hand-eye coordination, ideation, visual perception, identification, grasping, visuospatial ability, strength and grip, among others. Contextualizing this research, it is clear that nursing homes and seniors' residences are social-health centers converted into homes for millions of elderly people, where, depending on their degree of autonomy, users still have the capacity to perform basic activities of daily living (ADL) autonomously or, on the contrary, they need partial or total help from third parties to carry them out.

Generally, Guiner Aguilar, (2021) consider that the profile of users of nursing homes and seniors' residence is that of a person over 65 years of age, with multiple underlying pathologies and with initial signs of cognitive impairment or even with a confirmed diagnosis of other more advanced stages of dementia. All this means that most of the users of social and health centers have impaired cognitive ability and limitations in mobility or reduced mobility, so that many of them have a recognized degree of dependence and are assisted for some or all of the basic activities of daily living and also for most of the instrumental activities. In addition, it must be taken into account that a large number of users of these centers, due to their reduced mobility, already require some type of technical aid to move around the different rooms: manual wheelchairs, electric wheelchairs, walkers, tripods, crutches, canes. Particularly in relation to seating for the elderly, it must have an optimal distribution of pressures to offer more comfort and prevent the appearance of pressure points.

It is important that they are made of an easily washable and non-slip material to prevent falls due to sudden movements. Therapeutic chairs with side earmuffs are very suitable, the armrests on each side of the seat provide extra support to the user and are especially useful for those who have reduced mobility or little strength in their lower limbs, thus facilitating the gesture of getting up.

It is necessary to consider that Aguaysa, (2019) the backrest of the armchairs facilitates the resident to stay in a correct posture, avoiding any bad position or an overload in certain areas of the spine. If it has footrests it will allow you to rest your legs, keeping your feet slightly elevated makes the spine is supported on the backrest reducing fatigue and tension that can accumulate in this area to the maximum. Footrests are also very useful for this group, many elderly people suffer from swollen legs due to circulatory problems and the use of footrests favors blood flow and avoids discomfort. Seats with a propulsion system favor the incorporation of users with reduced mobility and considerably reduce the efforts made by health personnel during transfers in the incorporation of the load.

In order to carry out postural assessment processes, it has been found that the REBA method, which includes the following aspects, is frequently used to evaluate postural conditions in health centers:

- Trunk, neck and leg postures (Group A).
- The postures of the arms (left and right), both forearms and wrists (Group B).
- The realized load or force, whose score is added to the resultant of Group A.
- The coupling of the hands or other parts of the body with the load, which is added to the resulting Group B score.
- The muscular activity of the different parts of the body (static, repetitive or with rapid changes in posture), which is added to the C score obtained.

As for the procedure to be used for the evaluation, it is necessary to start with a detailed analysis of the task, as always when performing an ergonomic evaluation of these aspects.

Once the task is known, it is necessary to determine the moments to be observed. The method can be used both on recorded images of the activity and in the field. If it is used on recorded images, try to record from more than one angle to avoid hidden areas and to be able to visualize the angles adopted with the least possible error.

### **Overview of the literature: posture and standing of elderly in activities and REBA method approaches**

The posture of elderly individuals during various activities, including reading, has been a significant area of study due to the potential risks of musculoskeletal disorders (MSDs). Understanding these risks is crucial in developing strategies to mitigate them and improve the overall well-being of the elderly population. This section discusses relevant literature to provide a comprehensive background for analyzing reading postures in elderly adults and situates the present study within this context.

In order to identify the state of the art, a research developed by Racedo, Bonezi, & Bona, (2021) showed a significant difference between groups in the measurement of the cervical spine, where only the active older adults presented measurements within normal parameters, and the sedentary ones presented cervical hyperlordosis. The measurements of the lumbar spine presented curvature rectification values for both groups (according to the reference values in the literature). Cervical spine curvature was shown to be affected in sedentary older adults in the present study, compared to the spine curvature of active older adults. In addition, the rectification of lumbar spine curvature and changes due to this posture should be considered in the planning of physical exercise in this population.

On the other hand, Gonzales, (2018) has pointed out that the results represented in the graph and Table N° 10 show that drivers present a kyphotic attitude (kyphosis) in lateral view 63 % and in posterior view 33 %. In the case of Lordosis attitude in lateral view 13 % and in posterior view 47 % Conclusions: As a general conclusion it can be stated that people engaged in this trade are subjected to permanent loads and efforts while performing the work, the presence of postural alterations is going to be in a recurrent way.

On the other hand, Caballero, (2021) found that there is a relationship between postural alterations of the foot and their physical well-being in older adults in the home care program. In addition, the vast majority of the long-lived persons evaluated presented at least one of the three postural alterations, which generated a moderate limitation in their physical condition. These findings highlight the importance of addressing and treating postural alterations in older adults to improve their physical condition and maintain their independence.

In women aged 64 years and older, there is a decline in the resulting assessments of both the quality of balance function and postural strategy, indicating a deterioration of adaptive and neurophysiological (physiological) abilities in women aged 65-69 years. The results of the study corroborate the importance of monitoring postural balance in women over

65 years of age, as well as the introduction of preventive programs for women over 64 years of age, which will help to maintain functional balance and postural strategy in these people, reduce the risk of falls and improve mobility, having a positive impact on the quality and duration of their lives.

Gennuso et al. (2016) examined the patterns of sedentary behavior (SB) and its impact on physical function in older adults. They found that the pattern of SB, rather than the total time spent sedentary, significantly affects physical function. Prolonged periods of SB without breaks were particularly detrimental to physical function in older adults, highlighting the need for regular movement and posture variation to maintain musculoskeletal health. This study underscores the importance of examining the specific behaviors associated with sedentary activities, such as reading, to identify potential risk factors for MSDs in the elderly .

The work of Yuan (2024) contributes to this understanding by developing a digital human modeling toolset to simulate elderly postures within architectural environments. This toolset allows for ergonomic assessments, providing valuable insights into the design of living spaces that accommodate the physical needs of the elderly. By evaluating joint angles and comfort levels, the study emphasizes the need for ergonomic considerations in environments where elderly individuals perform daily activities, including reading. Such tools can inform better design practices to reduce the risk of MSDs. Moreover, Douglas and Gallagher (2017) explored the impact of different reading postures on neck and head kinematics and muscle activity. Their study revealed that reading in a semi-reclined posture significantly increased neck flexion and muscle activity, which could lead to strain on the cervical spine. This finding is critical for understanding how different reading positions can exacerbate or mitigate musculoskeletal strain, particularly in elderly populations who may already have compromised musculoskeletal function.

Vahedi et al. (2024) investigated the discomfort, neck kinematics, and muscular activity associated with smartphone usage in various postures. Their results indicated higher discomfort and increased neck flexion when using smartphones while seated, compared to standing. This study highlights the importance of posture in preventing musculoskeletal discomfort and suggests that similar considerations should be applied to other sedentary activities, such as reading. The findings are particularly relevant for designing interventions aimed at reducing MSD risks in elderly individuals .

Naito and Tochikubo (2018) developed a method for measuring balance in standing posture, which is crucial for evaluating the risk of falls among the elderly. Their approach, using head and foot pressure sensors, provided a reliable assessment of balance and stability. This methodology can be adapted to study the postural stability of elderly individuals during various activities, including reading, to better understand how different postures affect their risk of falls and musculoskeletal issues .

The ergonomic assessment of work postures among elderly farmers by Kaewdok, Sirisawasd, and Taptagaporn (2018) revealed the prevalence of awkward postures that contribute to MSDs. Their findings underscore the importance of ergonomic interventions in physically demanding occupations. Although this study focused on agricultural tasks, the principles of ergonomic assessment are applicable to other activities, including reading, where prolonged static postures can lead to similar risks.

Fitriadi et al. (2023) used ergonomic methods, including REBA, to design activity aids for the elderly. Their study demonstrated that ergonomic tools could significantly reduce the risk of MSDs by improving posture during daily activities. This approach can be extended to analyze and improve reading postures, providing practical solutions to enhance comfort and reduce strain in elderly readers.

Lastly, Lascano et al. (2020) adapted ergonomic methods to evaluate musculoskeletal risks in elderly indigenous women engaged in agricultural activities. This adaptation of the REBA method for non-industrial environments shows its flexibility and potential application in various settings, including the analysis of reading postures in elderly populations. Such adaptations can provide a more accurate assessment of posture-related risks in different activities and environments .

The present study aligns with the existing literature by focusing on the posture of elderly individuals during reading activities. Utilizing the REBA method for an anthropomorphic study of reading postures, this research aims to identify the levels of risk for musculoskeletal disorders among elderly residents of the 'Esposos Bishara' seniors' residence in the city of Esmeraldas, Ecuador. This approach not only contributes to the broader understanding of posture behaviour in the elderly but also offers practical insights for ergonomic interventions to enhance their well-being.

## **METHODOLOGY**

The type and level of research corresponds to a non-experimental, descriptive design which implies not manipulating the independent variable. This approach consists of observing the fact or manifestation, as it is present in the real situation

with the purpose of analyzing it (Buendía, Colás, & Hernández, 1998). The sample of 12 people aged between 63 and 99 years who expressed their desire to participate in the study (Alonso, 2016).

The data collection technique was to allow the analysis of postural characteristics through the REBA (Rapid Entire Body Assessment) method, which is a postural analysis tool especially sensitive to tasks that involve unexpected changes in posture, usually as a consequence of handling unstable or unpredictable loads. Its application warns the evaluator about the risk of injuries associated with a posture, mainly of a musculoskeletal type, indicating in each case the urgency with which corrective actions should be applied. It is, therefore, a useful tool for risk prevention, capable of alerting about inadequate working conditions.

The method allows the joint analysis of the positions adopted by the upper body members (arm, forearm, wrist), trunk, neck and legs. In addition, it defines other factors that it considers determinant for the final assessment of posture, such as the load or force handled, the type of grip or the type of muscular activity developed by the worker. It allows both static and dynamic postures to be evaluated, and incorporates as a novelty the possibility of indicating the existence of sudden changes in posture or unstable postures.

The scoring of the activity will result in the REBA decision, which is expressed in 5 levels ranging from risk 1, negligible, to a range between 11 and 15 for a very high risk level, and describes the priority of the intervention parallel or equivalent to the risk level.

**Figure 1.** Description of the REBA scoring method

Score	Level of MSD Risk
1	negligible risk, no action required
2-3	low risk, change may be needed
4-7	medium risk, further investigation, change soon
8-10	high risk, investigate and implement change
11+	very high risk, implement change

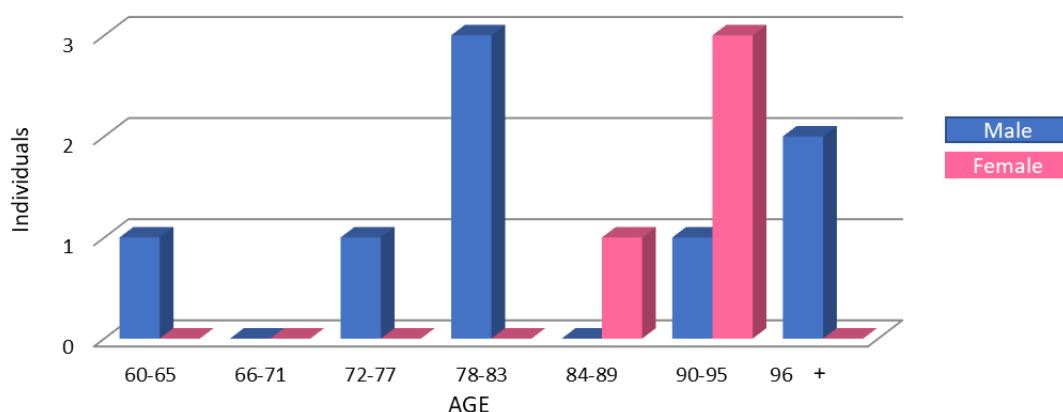
**Source:** Qutubuddin, Hebbal & Kumar (2013)

**Table 1.** Distribution of the population according to age and sex

AGE	M	F
60-65	1	0
66-71	0	0
72-77	1	0
78-83	3	0
84-89	0	1
90-95	1	3
96 and over	2	0

**Note:** Prepared by the authors. **Source:** Data collection instrument

**Figure 2.** Distribution of the population according to age and sex



**Note:** Prepared by the authors. **Source:** Data collection instrument

## RESULTS AND DISCUSSION

When analyzing the results obtained through the REBA method to older adults through direct observation of the execution of performance while performing reading activities, which are carried out in the courtyard under a structure that protects them from the sun. The type of reading is active in the morning and passive reading in the afternoon, these are scheduled 3 to 4 times per week. The researcher and collaborators were in charge of collecting the necessary data to carry out the research.

**Table 2.** Evaluation according to REBA method

ITEM	SEX	AGE	REBA
1	M	63	3
2	M	80	3
3	M	79	5
4	M	76	3
5	M	92	4
6	M	82	4
7	M	80	3
8	M	90	6
1	F	99	4
2	F	87	4
3	F	99	5
4	F	91	3

**Note:** Prepared by the authors. **Source:** Data collection instrument

**Table 3.** Interpretation according to the postures adopted

Score	Level	Risk	Performance
3	1	Under	Action may be required
4-5-6	2	Medium	Action is needed

**Note:** Prepared by the authors. **Source:** Data collection instrument

The natural lighting, which ranges from 1002 - 1485 lux, was also evaluated.

It is important to consider that the method divides into several segments - specifically, wrists, forearms, elbows, shoulders, neck, trunk, back, legs and knees - in order to evaluate them individually. Each region receives a score based on the static, dynamic and unstable postures it adopts, as well as the rapid changes in posture that occur. From the final REBA score, the risk levels corresponding to the time evaluated are obtained. The method classifies risk into five categories: negligible, low, medium, high and very high. These risk levels lead to five levels of action: from level 0 (REBA score equal to 1), which means that no action is necessary, to level 4 (score 11 to 15), which means that immediate action must be taken.

**Figure 3.** Older adults in the elderly residence



**Note:** Prepared by the authors.

Now, from the data obtained, it does not fall only to the posture due to the furniture but also to the fact that due to

age they have ailments that limit their functionality and these older adults are dependent. It has been found that the risks are medium, indicating the need for action to prevent Musculoskeletal Disorders, which corresponds to the results found in Gonzales, (2018) where people in seated position have a higher risk of musculoskeletal disorders and kyphosis in cervical spine so it was also found that mobility is reduced in them as can be seen in the photographic evidence.

The results of this study, as assessed using the REBA method, indicate varying levels of postural risk among elderly adults during reading activities. The scores ranged from 3 to 6, indicating low to medium risk levels. According to the REBA evaluation, a score of 3 suggests that action may be required, while scores between 4 and 6 necessitate action to mitigate risk (Janowitz et al., 2006).

These findings align with previous research highlighting the ergonomic challenges faced by older adults during sedentary activities. Gennuso et al. (2016) emphasized that sedentary behaviors, including reading, can negatively impact physical function, particularly when breaks are infrequent. Our study's results, showing medium risk levels, underscore the importance of addressing postural issues to prevent musculoskeletal disorders (MSDs) in the elderly. The method used in this study evaluates various body segments—wrists, forearms, elbows, shoulders, neck, trunk, back, legs, and knees—individually, providing a comprehensive assessment of the participants' postures. This detailed approach is essential, as different segments may experience varying levels of strain, and a holistic evaluation is necessary to understand the overall ergonomic risk (Douglas & Gallagher, 2017).

## CONCLUSIONS

Body posture is defined as the position of the whole body or a part of it in relation to gravity; that is, it is the result of the balance between the latter and the anti-gravitational muscular forces that may vary in relation to the situation in which it is confronted. In this sense, taking into consideration the population under study, the presence of medium and low risks for the presence of musculoskeletal disorders in older adults during reading activities was found.

To develop strategies and physiotherapeutic programs for the postural re-education of the elderly, to improve the condition of the classic physical therapy programs by others that are clearly aimed at improving posture, so that in the future this will not be a factor in the decrease of speed and thus of mobility.

### Main limitations of the study and future research

However, this study has several limitations. Firstly, the sample size was small, comprising only 12 individuals, which may limit the generalizability of the findings. Additionally, the study was conducted in a specific setting—the courtyard of the Esposos Bishara seniors' residence—where environmental factors like natural lighting (1002-1485 lux) could influence the results. Future studies should consider larger, more diverse populations and different settings to validate these findings.

To build on the findings of this study, future research should focus on the following areas: 1) *Larger sample sizes*: including a more significant number of participants to enhance the generalizability of the results. 2) *Diverse settings*: conducting studies in various environments to account for different lighting conditions, furniture ergonomics, and other contextual factors. 3) *Longitudinal studies*: Assessing the long-term impact of ergonomic interventions on reducing MSD risk in the elderly. 4) *Technology Integration*: Utilizing digital human modeling tools, as suggested by Yuan (2024), to simulate and optimize reading postures in real-time. *Intervention Efficacy*: Evaluating the effectiveness of ergonomic interventions, such as posture-corrective devices or adjusted reading schedules, in mitigating identified risks.

## REFERENCES

- Aguaysa Carrillo, P. (2019). Posturas de trabajo y su relación con la sintomatología de dolor lumbar en docentes de enseñanza Primaria General - Nivel Inicial. Ambato – Ecuador: Universidad Técnica de Ambato. Trabajo de Maestría.  
[https://repositorio.uta.edu.ec/bitstream/123456789/29218/1/Tesis\\_%20t1536mshi.pdf](https://repositorio.uta.edu.ec/bitstream/123456789/29218/1/Tesis_%20t1536mshi.pdf).
- Aldas, C., Chara, N., Guerrero, P., & Flores, R. (2021). Actividad física en el adulto mayor. *Dominio de las Ciencias*, ISSN-e 2477-8818, Vol. 7, Nº. Extra 5, <https://dialnet.unirioja.es/servlet/articulo?codigo=8383840>, pp.64-77.
- Alonso, L. (2016). Métodos de investigación de enfoque experimental. *Ciencias de la Educación Perú*.
- Blümel, J., Aedo, S., Arteaga, E., Vallejo, M., & Chedraui, P. (2022). Factores de riesgo de artrosis de rodilla, cadera o ambas en mujeres chilenas de mediana edad: un estudio de cohorte de tres décadas. *Rev. méd. Chile*;150(1):<http://dx.doi.org/10.4067/S0034-98872022000100046>, pp.46-53.
- Buendía, L., Colás, M., & Hernández, F. (1998). Métodos de Investigación en Psicopedagogía. Madrid, España: McGraw-Hill/Interamericana de España, S.A.U. Pag. 363.
- Caballero Huapaya, J. (2021). Alteraciones posturales del pie y condición física en el adulto mayor del programa de atención domiciliaria – essalud,2019. Lima - Perú: Universidad Privada Norbert Wiener. Trabajo de Especialidad.[https://repositorio.uwiener.edu.pe/bitstream/handle/20.500.13053/5831/T061\\_41849521\\_S.pdf?sequence=1&isAllowed=y](https://repositorio.uwiener.edu.pe/bitstream/handle/20.500.13053/5831/T061_41849521_S.pdf?sequence=1&isAllowed=y).

Caballero, E.; Hernández, H.; Rosete, M. (2022). Efectos de un programa de fortalecimiento físico en la condición funcional de adultos mayores. *Cienc Lat Rev Científica Multidiscip.*, 6(4):3187-99.

Chalapud, L., & Escobar, A. (2017). Actividad física para mejorar fuerza y equilibrio en el adulto mayor. *Rev Univ. Salud*; 19(1). DOI: <https://doi.org/10.22267/rus.171901.73>. <https://revistas.udenar.edu.co/index.php/usalud/article/view/2870> .

Douglas, E. C., & Gallagher, K. M. (2017). The influence of a semi-reclined seated posture on head and neck kinematics and muscle activity while reading a tablet computer. *Applied Ergonomics*, 60, 342-347. <https://doi.org/10.1016/j.apergo.2016.12.013>

Fitriadi, R., Syach, A. F., Fahmi, A. A., Muslimah, E., & Pratiwi, I. (2023, November). Ergonomic Approach: Posture Analysis and Design of Activity Aids for the Elderly. In 4th Borobudur International Symposium on Science and Technology 2022 (BIS-STE 2022) (pp. 791-805). Atlantis Press.

Gennuso, K. P., Thraen-Borowski, K. M., Gangnon, R. E., & Colbert, L. H. (2016). Patterns of sedentary behavior and physical function in older adults. *Aging Clinical and Experimental Research*, 28, 943-950. <https://doi.org/10.1007/s40520-015-0386-4>

Gonzales Villegas, B. (2018). Alteraciones Posturales de Columna en Mototaxistas de la Asociación San Pedro del Distrito Vice - Sechura 2018. Piura- Perú: Universidad San Pedro. Trabajo de titulación. [http://repositorio.usanpedro.edu.pe/bitstream/handle/USANPEDRO/13065/Tesis\\_62015.pdf?sequence=1&isAllowed=y](http://repositorio.usanpedro.edu.pe/bitstream/handle/USANPEDRO/13065/Tesis_62015.pdf?sequence=1&isAllowed=y).

Guiner Aguilar, C. (2021). Prevención de los trastornos musculoesqueléticos en residencias de tercera edad. Alicante. España: Universidad Miguel Hernández de Elche. <http://dspace.umh.es/handle/11000/27226>.

Guzmán, E., Álvarez, H., & García, M. (2022). Efectos de un programa de fortalecimiento físico en la condición funcional de adultos mayores. *Cienc Lat Rev Científica Multidiscip*; 6(4). [https://doi.org/10.37811/cl\\_rcm.v6i4.2827](https://doi.org/10.37811/cl_rcm.v6i4.2827), pp.3187-3199.

Kaewdok, T., Sirisawasd, S., & Taptagaporn, S. (2018). Work posture assessment among elderly farmers in Pathumthani Province, Thailand. *Journal of Advances in Health and Medical Sciences*, 4(1), 09-14.

Lascano, A., Antonio, T. S., Larrea, A., & Ciaccia, M. (2020). Ergonomic methods adaptation for risk evaluation associated to musculoskeletal disorders in elderly indigenous women of the Ecuadorian highlands. In *Advances in Physical, Social & Occupational Ergonomics: Proceedings of the AHFE 2020 Virtual Conferences on Physical Ergonomics and Human Factors, Social & Occupational Ergonomics and Cross-Cultural Decision Making, July 16–20, 2020, USA* (pp. 266-273). Springer International Publishing.

Martínez, N., Santaella, E., & Rodríguez, A. (2021). Beneficios de la actividad física para la promoción de un envejecimiento activo en personas mayores. *Revisión bibliográfica. Retos*, 39. <https://doi.org/10.47197/retos.v0i39.74537>, pp.829–834.

Morales, X., Bonilla, E., & Roldán, M. (2021). Evaluación del riesgo ergonómico por posturas forzadas en fisioterapeutas. *Cambios rev. méd*; 20(1). <https://pesquisa.bvsalud.org/portal/resource/pt/biblio-1292873>, pp.67-73.

Naito, T., & Tochikubo, O. (2018). Standing Posture Balance Measurement Method and Evaluation Considering the Sway of Head and Foot Pressure. *Transactions of Japanese Society for Medical and Biological Engineering*, 56(3), 65–73. <https://doi.org/10.11239/jsmbe.56.65>

Qutubuddin, S. M., Hebbal, S. S., & Kumar, A. C. S. (2013). Ergonomic risk assessment using postural analysis tools in a bus body building unit. *Industrial Engineering Letters*, 3(8), 10-20.

Racedo, A., Bonezi, A., & Bona, R. (2021). Medidas angulares de la columna vertebral de adultos mayores activos y sedentarios. *JONNPR*; Vol.6. No.1. <https://dx.doi.org/10.19230/jonnpr.3944>. [https://scielo.isciii.es/scielo.php?script=sci\\_arttext&pid=S2529-850X2021000100006](https://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S2529-850X2021000100006), pp.68-83.

Tutillo, J., Revelo, A., Jiménez, M., & Moreira, M. . (2020). Artropatías en el adulto mayor. *Revista Cubana de Reumatología*; 22 (1). <https://www.medigraphic.com/cgi-bin/new/resumen.cgi?IDARTICULO=95031>.

Vahedi, Z., Kazemi, Z., Sharifnezhad, A., & Mazloumi, A. (2024). Perceived discomfort, neck kinematics, and muscular activity during smartphone usage: a comparative study. *Human Factors*, 66(2), 437-450. <https://doi.org/10.1177/00187208221087760>

Yuan, H. (2024). Developing a digital human modeling toolset: Simulating elderly posture in Grasshopper to optimize living environments. *Journal of Building Engineering*, 90, 109308. <https://doi.org/10.1016/j.jobbe.2024.109308>

**Contribution of each author to the manuscript:**

Task	% of contribution of each author
	A1
A. theoretical and conceptual foundations and problematization:	100%
B. data research and statistical analysis:	100%
C. elaboration of figures and tables:	100%
D. drafting, reviewing and writing of the text:	100%
E. selection of bibliographical references	100%
F. Other (please indicate)	-

**Indication of conflict of interest:**

There is no conflict of interest

**Source of funding**

There is no source of funding

**Acknowledgments**

There is no acknowledgments