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Association between inflammatory markers and locomotor pattern during obstacle avoidance in older adults

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Abstract

Objective: to investigate the association of inflammatory biomarkers on the locomotor pattern during obstacle avoidance with different levels of complexity manipulated by the characteristic of the obstacle (solid and fragile) in older adults. *Method*: 17 older adults (≥60 years old) were evaluated in two moments: 1) Analysis of the locomotor pattern during obstacle crossing in two conditions (solid and fragile). The variables studied for trailing and leading limbs were: speed, length, width and duration of the stride, horizontal foot-obstacle distance, horizontal obstacle-foot distance, vertical foot-obstacle distance and Maximum foot elevation. 2) Blood collection, for analysis of the inflammatory biomarkers Interleukin 6 (IL6) and C-Reactive Protein (CRP). Multiple linear regression analysis was performed to verify association between locomotor pattern and inflammatory biomarkers (IL6 and CRP) with a significance level of $p \leq 0.05$. *Results*: The regression analysis showed that Interleukin 6 was associated with the following variables: 1) stride width in the solid obstacle condition, 2) maximum foot elevation (leading limb) to avoidance the fragile obstacle, 3) horizontal foot-obstacle distance (trailing limb) in solid obstacle condition, 4) maximum foot elevation (trailing limb) to avoidance the fragile obstacle, 5) maximum foot elevation (trailing limb) to avoidance the solid obstacle. C-Reactive Protein was associated with the horizontal foot-obstacle distance (trailing limb) only for the fragile obstacle condition. *Conclusion*: Inflammatory biomarkers are associated with the locomotor pattern in older adults, regardless of the fragility of the obstacle.

Keywords: Aging. Fall. Older adults. Walking with obstacles. Inflammatory biomarkers.

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INTRODUCTION

Falls in the older population cause reduced functionality, increased morbidity and mortality, being the main cause of death in older people over 85 years[1]. In addition, there is an increase in health care costs, use of specialized services and hospitalizations[2]. Consequently, it affects the performance of daily activities due to bone fractures, as well as the fear of falling, which directly influence the quality of life. The prevalence of falls is approximately 28 to 35% in people over 65 years old, and this rate increases with advancing age and with the level of frailty of the older people[3]. Epidemiological studies with older Brazilians estimate a prevalence of falls of approximately 30%[3,4].

In this way, most of the histories of falls in older people happen during locomotion[5]. Within this context, changes in the space-time parameters of gait, such as, for example, reduction in speed, in step length and increase in double support time contribute to the increased risk of falls in older people[1,6,7] even on regular terrain. In addition, the literature suggests that worse performance in the task of overcoming an obstacle increases the risk of tripping and falls in the older population[5]. The worsening of performance is related to positioning the foot close to the obstacle during the approaching and overcoming phases, which allows greater contact with the obstacle[8,9]. The older people modulate the locomotor pattern to successfully perform this task, however, in some cases this control may not be as effective, and consequently, falls are evidenced. The literature has shown changes in the kinematic parameters in the gait of older people when overcoming obstacles, such as, for example, reduction in length and speed before overcoming the obstacle, getting closer to the obstacle before and after, and decreasing the vertical distance of the foot in relation to the obstacle, which can increase the risk of stumbling[8,10].

Gait in general, and overcoming obstacles in particular, depend on fine control of the nervous system over the locomotor system, which involves bones, joints and muscles, among other structures. Aging is associated with many changes that affect the locomotor system, including loss of bone density, sarcopenia and joint wear[11]. This last factor is associated with the implantation of a chronic inflammatory state that can be detected by the average concentration of inflammatory biomarkers in the blood[11]. Thus, the analysis of biomarkers could also be used to assess changes in the locomotor system throughout the aging process[12]. These markers would enable a diagnostic analysis of the biological processes responsible for structural and functional changes in older people. Among these markers, the inflammatory ones are the most reported in the literature to explain the motor alterations observed in the older population[13]. Thus, the increase in inflammatory biomarkers, which in aging bring with it several changes in metabolic enzymatic activities, a phenomenon called "inflammaging", a low-grade chronic systemic inflammation, but no less harmful[14]. For example, older people with frailty syndrome (weight loss, weakness and reduction in walking speed) showed high levels of inflammatory biomarkers, such as interleukin-6 (IL-6) and C-reactive protein (CRP)[15]. Likewise, high CRP levels in older people were correlated with a reduction in handgrip strength[12]. Furthermore, the increase in the inflammatory biomarker IL-6 was associated with a reduction in gait speed in older people[12]. Thus, based on these results, it can be concluded that the analysis of biomarkers is also important for diagnosing the motor condition of the older person, as the studies presented above indicated a correlation between these biological markers and the motor tests.

However, from these analyses, it is evident that the biological and motor assessment are essential to describe the functional conditions of the older person, such as gait. The literature has shown that the increase in the inflammatory process in older people is related to the reduction in the length and speed of the step in gait[12,16]. However, the relationship between these biological and motor factors has not yet been analyzed in older people during the task of overcoming obstacles, which is a situation present in daily activities, such as climbing on the sidewalk or deviating from some holes, which requires locomotor adaptation. High concentrations of IL-6 and CRP are associated with less muscle mass, which can impair the execution of more complex locomotor functions[17,18]. To overcome an obstacle, muscle strength and high range of motion in the hip, knee and ankle joints are required to successfully perform the task. Still, any stumble in this situation can put the older people in a situation with a high risk of falls and they are susceptible to suffering fractures, injuries and, consequently, an increase in the number of hospitalizations. Therefore, it is still not fully elucidated in the literature how inflammatory biomarkers are associated with the locomotor pattern of the older people when overcoming obstacles and whether this influence also changes with the increase in the difficulty of the locomotor task. In this study, the locomotor pattern during obstacle crossing was investigated using the variables horizontal foot-obstacle distance, horizontal obstacle-foot distance, vertical foot-obstacle distance and maximum foot elevation, both for the approach limb and the support limb. The difficulty level of the locomotor task was manipulated by the physical characteristics of the obstacle. Based on these assumptions, the following research questions arise: Is there an association between inflammatory markers and locomotor parameters during gait with overcoming obstacles in older people? Also, does this relationship depend on the difficulty level of the locomotor task?

Therefore, the objective of the study is to investigate the association of inflammatory biomarkers in the task of overcoming obstacles with different levels of complexity manipulated by the characteristic of the obstacle (solid and fragile) in older people. The hypothesis of this study is that there is an association between locomotor parameters during obstacle overcoming and interleukin and CRP levels in older people. Thus, it is expected that the higher the levels of inflammatory markers (CRP, IL-6), the lower the speed, length and width, as well as the longer duration of the stride for the approach and support limbs for the conditions of solid and fragile obstacle. During the phase of approaching and overcoming the obstacle, it is expected that the higher the levels of inflammatory markers (CRP, IL-6) the lower the horizontal foot-obstacle distance, vertical foot-obstacle distance and foot-distance from the ground, respectively. Finally, during the landing phase, it is expected that the higher the levels of inflammatory markers (CRP, IL-6) the lower the horizontal obstacle-foot distance. Still, it is expected that these effects are evidenced for both lower limbs (approach and support) and in the most challenging condition (obstacle with fragile characteristic).

METHOD

This is a quasi-experimental study. The older people were recruited through digital dissemination (instagram and email), newspaper, television and the Exercise Guidance Service (SOE). This recruitment was carried out in the region of Greater Vitória (Vitória, Vila Velha, Serra and Cariacica) in the State of Espírito Santo. After this disclosure, 100 seniors contacted, however, 60 seniors withdrew from participating, since it was a time of social isolation due to the pandemic, where the seniors were still in the beginning of the vaccination schedule and insecure about the contact external to their family environment. Of the 40 seniors, 18 did not meet the inclusion criteria (10 had neurological diseases and 8 musculoskeletal problems that prevented them from performing the task). Thus, 22 seniors met the inclusion and exclusion criteria, however, five seniors did not complete all assessments (blood and clinical). The final sample consisted of 17 older people.

As inclusion criteria, individuals should be able to walk independently without the use of walking aids (cane/walker), preserved cognitive functions and absence of neurological and musculoskeletal health conditions that made it impossible for them to perform the task.

Measures and actions against covid-19 were strictly followed. The use of a mask was mandatory throughout the evaluation, hand hygiene and safe distance between the participant and the examiner, as well as the measurement of the participant's temperature before the beginning of the collection.

Data collection was carried out in two days. In the first, clinical evaluation and gait analysis were performed at the Laboratory of Biomechanical Analysis of Movement at the Physical Education and Sports Center of the Federal University of Espírito Santo. (Bio.Mov – CEFD/UFES). On the second day, blood collection was performed at the headquarters of Projeto Elsa located in the Graduate Program in Physiological Sciences at UFES. The processing and analysis of blood samples was performed at the Experimental Physiology and Biochemistry Laboratory (LAFIBE – CEFD/UFES).

Initially, an anamnesis was carried out to verify the general health status of the participants and the inclusion criteria. Afterwards, anthropometric measurements (height and body mass and Body Mass Index - BMI) were measured. For better characterization of the sample and screening of clinical conditions, some specific tests were applied. First, the Mini-Mental State Examination was applied for cognitive screening, which addresses issues of space and time location, memory and attention (maximum score 30 points; cutoff pattern 24 points)[19]. To quantify the level of physical activity, the modified Baecke Questionnaire for older people was applied[20]. This covers and evaluates occupational, sports and leisure activities. A score equal to or less than 9.11 points indicates a low level of physical activity, between 9.12 and 16.17 points indicates a moderate level of physical activity, and a score equal to or greater than 16.18 points indicates a high level of physical activity for the older people. To assess the static and dynamic balance of the older people, the MiniBESTest[21] was applied (maximum score 28 points), and the higher the score obtained, the better the balance of the older person. Also, to assess the fear of falling, the Efficacy Scale-International scale (FES-I) was applied[22]. In this scale, the older people indicate "I am not worried", "a little worried", "moderately worried" and "very worried" for 16 daily activities regarding the fear of falling while performing them. A score greater than or equal to 23 points suggests an association with the sporadic occurrence of falls, and a score greater than or equal to 31 points suggests a recurrent occurrence of falls. Finally, to investigate the occurrence, quantity and characteristics of falls in the last year, a Falls Questionnaire was applied.

Participants were invited to walk along a non-slip rubber walkway 9 meters long and 1.20 meters wide and perform the following conditions: 1) Walking while crossing a solid obstacle and 2) Walking while crossing a fragile obstacle (Figure 1). In an attempt to make the task similar to everyday life and following the recommendations of the Brazilian Standard for Emergency Exits in Buildings (NBR 9077)[23], which regulates stairs and sidewalks, the obstacles were 15 centimeters high. However, many obstacles in the environment are not dimensioned for the size or proportions of the individual.

Both obstacles were made of gray foam and, in order to handle the complexity of the task, the properties of the obstacles were inferred. Thus, the solid obstacle was made of a single piece, offering a perception of stability. The fragile obstacle was made of four columns of stacked foam blocks, offering the perception of instability in an attempt to increase the complexity of the task.

The starting point of locomotion was adjusted by the experimenter in order to guarantee the crossing of the obstacle comfortably with the dominant limb. For analysis of the locomotor pattern, the participants wore black non-slip socks where 04 passive reflective markers made of 1.5 cm diameter Styrofoam spheres were positioned at the following anatomical points: fifth metatarsal and lateral aspect of the calcaneus of the right lower limb and first metatarsal and medial aspect of the calcaneus of the left lower limb. Also, two passive markers were positioned on the obstacle, one at the base and the other at the top of the obstacle, which allowed the calculation of variables related to overcoming.

Thus, 3 randomized trials were performed for each condition. When an error occurred (example: overcoming with the non-dominant leg, bumping into the obstacle or knocking it down), the attempt was repeated at the end of each block. Participants were not informed about any errors. For analysis purposes, the average value of three trials of each condition was considered.

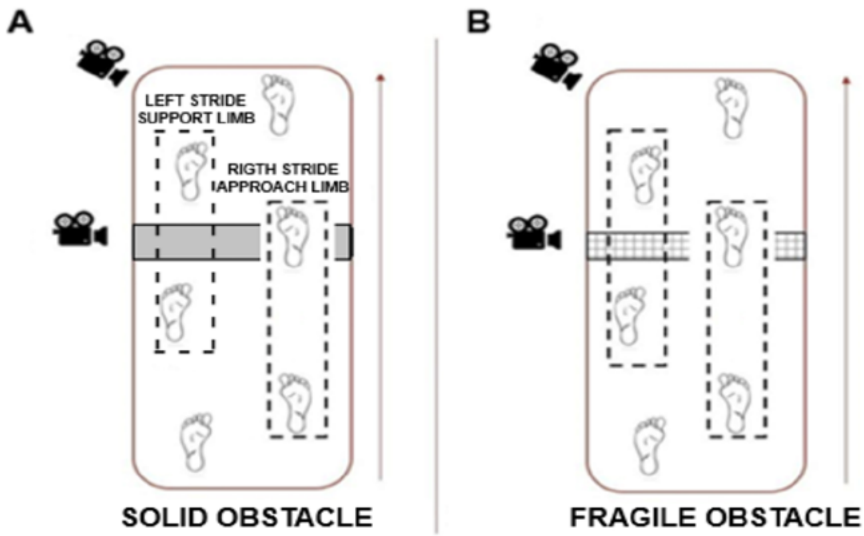

Figure 1. Experimental Design of Solid Obstacle (A) and Fragile Obstacle (B) conditions. The right and left steps represent the approach and support limb, respectively.

In the second moment, blood collection was performed. 10 mL of venous blood was collected by puncture of the forearm in the morning for analysis of inflammatory biomarkers. The older people were fasting for 10 to 12 hours and informed the use of routine medications, as well as diagnosed comorbidities. Then, the sample was centrifuged at 10,000 rpm to separate the plasma, which was stored at -80°C. To proceed with the IL-6 analysis, the samples were removed from the freezer and placed on a bench until they reached room temperature (25°C). Small samples were distributed with the pipette in microplates in a duplicate scheme and the Immunoenzymatic Assay (ELISA) method was applied using Kit R&D Systems (USA) according to the manufacturer's instructions. IL-6 analysis was performed using a microplate reader at a wavelength of 450nm, which showed the best IL-6 concentration for that standard curve, also established by the manufacturer. The closer the relationship between the standard curve and the curve presented by the sample is to 1, the more sensitive the test and the more realistic the IL-6 value obtained. CRP analysis by the Immunoturbidimetry method, according to the manufacturer's instructions, and according to the value obtained, the individuals were classified as: Low risk (less than 1.0 mg/L), medium risk (between 1.0 and 2.0 mg/L), high risk (between 2.0 and 10.0 mg/L) and very high risk (greater than or equal to 10.0 mg/L).

To capture the images in the experimental gait tasks, two digital cameras (GoPro brand, Hero 7 Black model) were used, which were positioned in order to visualize all the markers on the participant's foot and on the obstacles. The captured images were stored in AVI (Audio Video Interleaved) files for further processing. Space calibration was carried out using nine points marked on the floor (x and y axes) and seven points marked on a topographic wand (z axis), forming a large cube that served to accurately inform Dvideow of the measurements of the space through which the participant performed the task. This enabled the three-dimensional reconstruction of the markers' trajectories. Data were analyzed using routines written in Matlab language (Version 7.0 – Mathworks, Inc.) and filtered with a low-pass filter, Buttherworth.

The three-dimensional coordinates of the markers were filtered with zero phase delay, 4th order digital Butterworth filter with a cutoff frequency of 6 Hz. To determine the analyzed cycle, the contact of the heel on the ground was determined through visual inspection of the video cameras.

The dependent variables analyzed in the full stride while passing the obstacle were length, width, duration and speed of the stride. The stride started with the heel of the right foot touching the ground before the obstacle and ended with the next touch of the right foot after the obstacle. The length of the overtaking stride was calculated by subtracting the values of the points on the x-axis of the marker on the lateral surface of the right calcaneus and the medial surface of the left calcaneus, at the moment of overtaking, expressed in seconds (s). The width of the overtaking stride represents the distance between the markers of the right and left heels in the mediolateral direction added to the width of the left foot, when it was before the obstacle and the right foot after the obstacle, expressed in centimeters (cm). The duration of the overtaking stride was calculated by the frame difference between the heel contact divided by the sampling frequency, expressed in seconds (s) Finally, the speed of the overtaking stride was calculated by dividing the length by the duration of the stride, expressed in cm/s.

Still for analysis of the locomotor pattern, the variables horizontal foot-obstacle distance (DHPO) before overtaking, vertical foot-obstacle distance (DVPO) and Maximum foot elevation (ME) during overtaking and horizontal obstacle-foot distance (DHOP) after overtaking for the approach (MA – right lower limb) and support (MS – left lower limb) limbs. DHPO corresponds to the value obtained, expressed in centimeters (cm), by the linear distance in the x coordinate (horizontal in the anteroposterior direction of movement) between the metatarsal marker, when it left the ground to overtake, and the obstacle marker (Figure 2A). DVPO expresses the vertical distance, in centimeters (cm), between the metatarsal marker and the upper edge of the obstacle, when the foot was on the obstacle (Figure 2B). ME, expressed in centimeters (cm), is the ratio between the vertical distance between the metatarsal marker and the lower edge of the obstacle when the foot is on the obstacle (Figure 2C). Finally, the DHOP, expressed in centimeters (cm), corresponds to the value obtained by the distance in the x coordinate (horizontal in the anteroposterior direction of movement) between the calcaneal marker when coming into contact with the ground, after overtaking, and the marker on the obstacle; expressed in centimeters (cm) (Figure 2D).

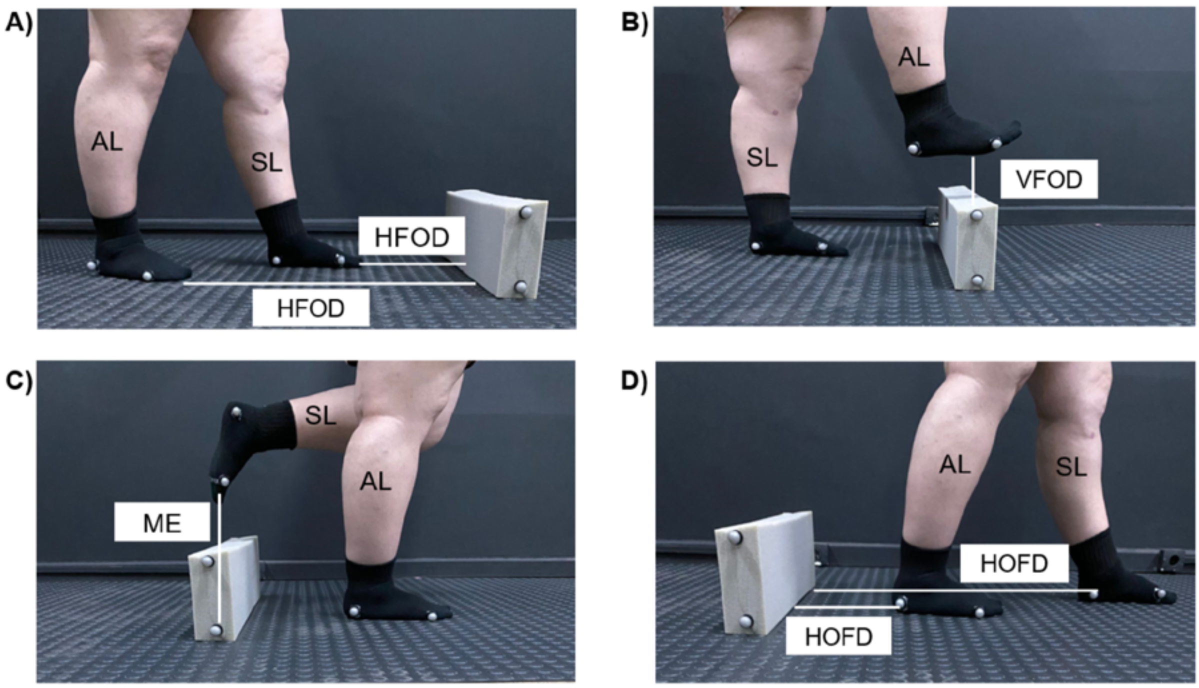

Figure 2. Side view of a participant when approaching, overcoming the obstacle to visualize the calculation of variables. A) Horizontal Foot-Obstacle Distance (HFOD); B) Vertical Foot-Obstacle Distance (VFOD); C) Maximum Foot Elevation (ME); D) Horizontal Obstacle-Foot Distance (HOFD) for the approach (AL) and support (SL) limbs.

To characterize the sample, mean and standard deviation were calculated for age, anthropometric characteristics (height, body mass), clinical (Mini-Mental, MiniBESTest, Baecke and FES-I evaluation scores), locomotor characteristics (length, width, duration and speed of the stride, DHPO, DHOP, DVPO, MH) and IL-6 and CRP levels. Multiple linear regression analyses, forced entry method (enter), were performed to investigate the association between inflammatory markers and locomotor parameters during obstacle crossing. Also, since falls can be considered a confounding variable in locomotor performance in older people, the regression model was adjusted for the number of falls. The multicollinearity test was performed by the IVF (Inflationary Variance Factor) which provides an index that measures how much the variance of an estimated regression coefficient is increased because of collinearity. If IVF is equal to 1, there is no multicollinearity between the factors and values greater than 5 indicate possible multicollinearity problems (Marôco, 2010). The confidence interval was also calculated for these analyses. These confidence intervals were calculated for unstandardized β values which are bounds constructed such that in 95% of these samples these bounds will contain true β values[24]. The significance level adopted in all analyzes was $p \leq 0.05$.

This study was approved (opinion number: 2,706,643) by the Research Ethics Committee of the Federal University of Espírito Santo (CAAE: 88258218.8.0000.5542). After consenting to participate in the study, individuals signed a Free and Informed Consent Form (TCLE) in accordance with the norms established in Resolution No. 466/12 of the National Health Council.

RESULTS

The study included 17 older people (68.9±4.7 years, 1.61±6.3 m, 68.7±11.3 kg), 15 females and 2 males living in Vitória/ES (n=16) and Cariacica (n=2). The older people had preserved cognitive function (26.6±2.11 points) and balance (21.8±5.22 points), number of falls (0.78±0.53 falls), moderate fear of falling (25.4±7.83 points) and low level of physical activity (5.3±5.3 points), which was expected since the data were collected during the covid-19 pandemic. The comorbidities reported by the patients were confirmed upon presentation of medical prescriptions with the prescription of medications. The older people were clinically healthy, as the laboratory tests did not detect anemia, acute inflammation or lack of glycemic control (Table 1). Among them, 14 used some medication. A total of 27 medications were surveyed, divided into antihypertensives (13), oral antidiabetics (6), hypolipidemic agents (5) and antiplatelet agents (3). Among these older people, some used antihypertensive drugs (n=11) associated with antiglycemic agents (n=5), antilipidemic agents (n=11) and anticoagulants (n=5).

Table 1 presents the mean and standard deviation of inflammatory biomarkers (IL-6 and CRP), laboratory tests and spatiotemporal parameters during the overcoming of obstacles in conditions of different physical characteristics (solid and fragile) for approach and support limbs.

For the multiple regression analyses, an IVF of 1 was found, which indicates that there is no multicollinearity between the factors. The regression analysis showed that Interleukin 6 was associated with the following variables: 1) stride width in the solid obstacle condition (R^2=0.88, β=0.96, p=0.03 | B=331.4 CI= [45.7–617.02]) (Figure 3A), 2) maximum elevation of the foot (support limb) to overcome the fragile obstacle (R^2=0.91, β=0.97, p=0.02, B=83.2 CI= [34.09–132.35]) (Figure 3B), 3) horizontal foot-obstacle distance (approach limb) in the solid obstacle condition (R^2=0.88, β=0.88, p=0.03, B=-165.7 CI= [-308.51– -22.88]) (Figure 3C), 4) maximum elevation of the foot (approach limb) to overcome the fragile obstacle (R^2=0.94, β=0.98, p=0.01, B=73.9 IC= [19.45–128.44]) (Figure 3D), 5) maximum elevation of the foot (approach limb) to overcome the solid obstacle (R^2=0.90, β=0.96, p=0.03, B=82.5 CI= [18.6–146.40) (Figure 3E). C-Reactive Protein was associated with the Horizontal Foot-Obstacle Distance variable (approach limb) only for the fragile obstacle condition (R^2=0.91, β=0.97, p=0.02, B=31.3 CI= [7.80–54.25]) (Figure 3F).

Table 1. Mean and standard deviation of biomarkers and locomotor variables during overcoming obstacles (solid and fragile) for approach and support limbs in older people.

	Biomarkers	
	Mean	Standard deviation
IL6 (pg/ml)	29.2	5.6
CRP (mg/L)	2.2	0.5
	Laboratory Tests	
Red blood cells (millions/mm3)	4.44	0.32
Hematocrit (%)	40.42	2.18
Hemoglobin (g/dL)	13.15	0.83
Leukocytes (thousands/mm3)	6.10	1.41
Platelets (thousands/mm3)	268.71	78.11
Fasting Glycemia (mg/dL)	108.00	26.93
Total Cholesterol (mg/dL)	182.53	46.95
LDL cholesterol (mg/dL)	100.53	43.17
Triglycerides (mg/dL)	130.88	68.72
Uric Acid (mg/dL)	4.37	1.13
Locomotive Variables		
	(Solid Obstacle|Fragile Obstacle)	
Length (m)	1.25 | 1.28	0.22 | 0.20
Width (m)	0.11 | 0.10	0.08 | 0.05
Duration (s)	1.16 | 1.18	0.16 | 0.14
Speed (m/s)	1.12 | 1.10	0.27 | 0.25
HFOD (m) – Approach	0.80 | 0.77	0.30 | 0.21
HOFD (m) – Approach	0.28 | 0.21	0.02 | 0.05
VFOD (m) – Approach	0.34 | 0.34	0.03 | 0.03
MH (m) – Approach	0.38 | 0.35	0.08 | 0.06
HFOD (m) – Support	0.36 | 0.54	0.03 | 0.02
HOFD (m) – Support	0.73 | 0.72	0.18 | 0.17
VFOD (m) – Support	0.33 | 0.35	0.05 | 0.04
MH (m) – Support	0.36 | 0.38	0.05 | 0.07

Subtittles: IL6 (interleukin-6), pg/ml (picogram per milliliter of blood), CRP (C-reactive protein), mg/L (milligram per liter), million/mm^3 (million per cubic millimeter), g/dL (gram per deciliter), thousands/mm^3 (thousands per cubic millimeter), m(meters), s (seconds), m/s (meters per second), DHPO (horizontal foot-to-obstacle distance), DHOP (horizontal obstacle-to-foot distance), DVPO (vertical foot-obstacle distance), MH (maximum elevation).

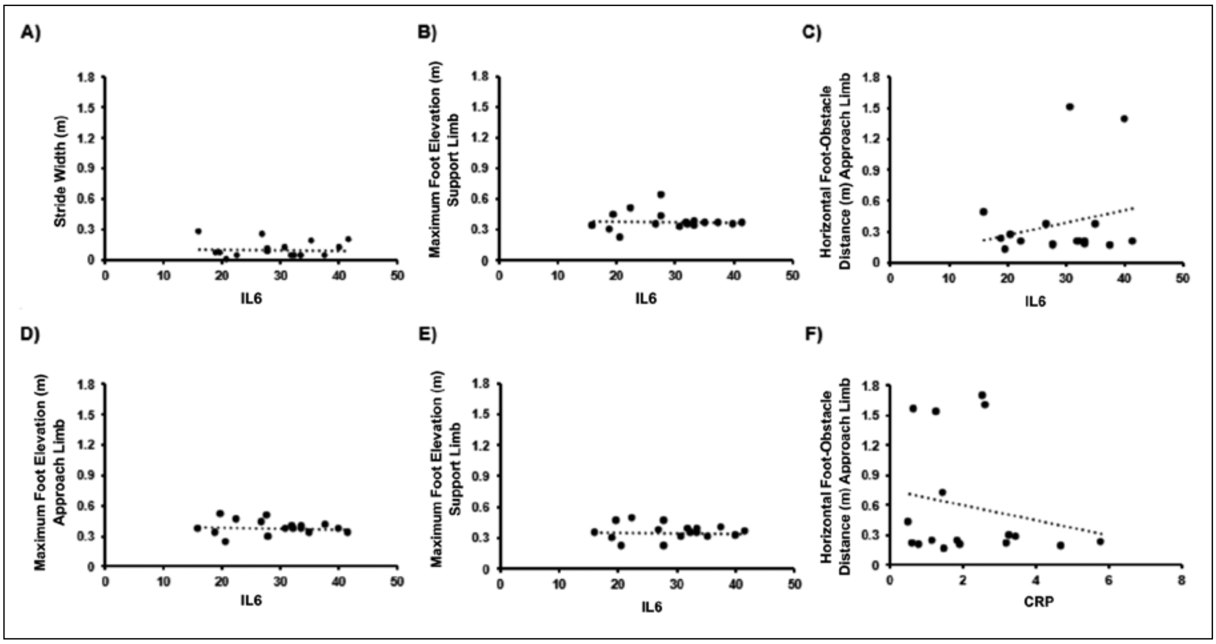

Figure 3. Association between IL6 and the variables stride width (A), maximum elevation of the support limb foot (B) and horizontal foot-obstacle distance of the approach limb (C) in gait with solid obstacle, maximum elevation of the foot of the approach limb (D) and maximum elevation of the foot to the support limb (E) in gait with overcoming a fragile obstacle and the relationship between CRP and horizontal foot-obstacle distance for the approach limb (F) in gait with overcoming a fragile obstacle.

DISCUSSION

The general objective of the study was to investigate the association between inflammatory biomarkers in the task of overcoming obstacles and the different levels of complexity manipulated by the characteristic of the obstacle (solid and fragile) in older people. The first hypothesis of the study was partially confirmed, as there was an association only between the IL-6 biomarker and the left stride width when overcoming a solid obstacle. The second hypothesis was also partially confirmed, as there was an association between the inflammatory biomarkers with the variables horizontal foot-obstacle distance for the approach limb in both obstacles and maximum elevation of the support limb foot for both obstacles and approach limb for a fragile obstacle. These associations were found for both types of obstacle fragility, solid and fragile.

Regarding inflammatory biomarkers (CRP and IL6), the older people can be classified into a medium and high risk of inflammation, according to the reference values. The literature shows that these high inflammatory patterns cause oxidative stress that directly interferes with muscle response and decreases functional fitness[17,18]. However, the lower CRP values are due to the older people in the sample not presenting, at the time of data collection, any process of acute inflammation, as CRP is a precursor of IL-6 in the inflammation cascade and both characterize healthy aging individuals. Although the two proteins are considered important inflammatory biomarkers in the aging process, CRP is a precursor signaling of IL-6, being more indicative of the existence of an inflammation process, than indicative of the time that this process began[17,18].

In this way, a reduction in muscle response and a decrease in functional fitness can influence the performance of daily activities, such as overcoming an obstacle. The literature shows that older people have a conservative pattern in relation to overcoming obstacles that put them at risk of falls, such as shorter horizontal obstacle-foot distance, stride length and speed, and vertical foot-obstacle distance[8,9]. Our results showed that the inflammation process is closely related to locomotor performance in older people when overcoming obstacles. A possible explanation for these results is that inflammatory cytokines have a catabolic effect on muscle[25]. Furthermore, the moderate and high degree of inflammation (high concentration of IL6 and CRP in the blood) may be associated with a reduction in muscle mass and musculoskeletal changes, which may generate or lead to a reduction in the production of muscle strength and power[26]. In this way, due to this reduction in muscle function, the older people get closer to the obstacle and, when overcoming, position the foot closer to the obstacle, compromising locomotor performance with consequent risk of stumbling and falls, leading to an increased risk of fractures and impacting directly quality of life in a negative way.

In addition, another possible explanation for the relationship between biomarkers and locomotor pattern when overcoming obstacles may be associated with a high concentration of IL-6, which may lead to a reduction in corticospinal tract activity[27]. Consequently, this alteration in cortical activity suggests that the pattern of coordination of muscle activity between lower limbs can be influenced during the positioning of the foot when overcoming obstacles in older people.

However, from these analyses, it is evident that the evaluation with inflammatory biomarkers and overcoming obstacles and motor skills are essential to describe and diagnose the clinical condition of the older people, which can be used as a complement to the clinical batteries (MiniBESTest, MiniMental, Baecke and Fear of Falling). Thus, the association between inflammatory biomarkers and locomotor performance during overcoming obstacles allows understanding that high inflammation can impact locomotor parameters. This result deserves attention, as it may put these older people at risk of falls, as they are susceptible to fractures, injuries and, consequently, an increase in the number of hospitalizations in the SUS. Thus, the present study carried out a diagnosis of gait and inflammatory biomarkers in the older people with the aim of developing guidelines and interventional strategies so that this index is reduced, such as physical exercises to improve muscle function and motor coordination.

This study has some limitations, data collection took place during the pandemic, when restrictive measures were severe, especially for the older people, who were considered a risk group. Also due to the pandemic, we had to ensure a safe environment for the participant, with minimal movement of people. Some individuals, because they did not have vaccination coverage, were also insecure about completing the survey. These limitations directly affected the total study sample with a small number of older people. In addition, it is suggested for future studies that the clinical batteries are also included in the regression model to verify how these variables are related to the locomotor pattern and the inflammatory profile of the older people.

CONCLUSION

The inflammatory biomarkers IL-6 and CRP are associated with locomotor parameters during obstacle crossing, regardless of the fragility condition of the obstacle, in older people. It should be noted that, from these analyses, it is evident that the evaluation with inflammatory biomarkers and overcoming obstacles are essential to describe and diagnose the functional condition of older people, which can be used as a complement to clinical batteries.

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AUTHORSHIP

- Juliana Amaral da Silva – article writing, data analysis and interpretation.
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- Milena Razuk – data analysis.

- André Soares Leopoldo – article writing, data analysis and interpretation.
- José Geraldo Mill – article writing, data analysis and interpretation.
- Natalia Madalena Rinaldi – responsible for all aspects of the work, ensuring that issues relating to the accuracy or completeness of any part of the work and approval of the version to be published.

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REFERENCES

1. Ambrose AF, Paul G, Hausdorff JM. Risk factors for falls among older adults: a review of the literature. Maturitas 2013; 75(1):51-61. Available at: https://doi.org/10.1016/j.maturitas.2013.02.009
2. Wilkinson I, Harper A. Comprehensive geriatric assessment, rehabilitations and discharge planning. Medicine 2021; 49(1):10-16. Available at: https://doi.org/10.1016/j.mpmed.2020.10.013
3. Siqueira FV, Facchini LA, Piccini RX, Tomasi E, Thumé E, Silveira DS, et al. Prevalência de quedas em idosos e fatores associados. Rev. Saúde Pública 2007;41(5):749-56. Available at: https://doi.org/10.1590/S0034-89102007000500009
4. Salari N, Darvishi N, Ahmadipanah M, Shohaimi S, Mohammadi M. Global prevalence of falls in the older adults: a comprehensive systematic review and meta-analysis. J. Orthop. Surg. Res 2022; 17(1):334. Available at: https://doi.org/10.1186/s13018-022-03222-1
5. Timsina LR, Willetts JL, Brennan MJ, Marucci-Wellman H, Lombardi DA, Courtney TK, Verma SK. Circumstances of fall-related injuries by age and gender among community-dwelling adults in the United States. PLoS One 2017; 12(5), e0176561. Available at: https://doi.org/10.1371/journal.pone.0176561
6. Kwon M, Kwon Y, Park Y, Kim J. Comparison of gait patterns in elderly fallers and non-fallers. Technol. Health. Care 2018; 26:427-436. Available at: https://doi.org/10.3233/THC-174736
7. Skiadopoulos A, Moore E, Sayles HR, Schmid KK, Stergiou N. Step width variability as a discriminator of age-related gait changes. J. Neuroeng. Rehabil 2020; 17(1):41. Available at: https://doi.org/10.1186/s12984-020-00671-9
8. Muir BC, Bodratti LA, Morris CE, Haddad JM, Emmerik REA, Rietdyk S. Gait characteristics during inadvertent obstacle contacts in young, middle-aged and older adults. Gait Posture 2020; 77:100-104. Available at: https://doi.org/10.1016/j.gaitpost.2020.01.020
9. Raffegeau TE, Kellaher GK, Terz MJ, Roper JÁ, Altmann LJ, Hass CJ. Older women take shorter steps during backwards walking and obstacle crossing. Exp. Gerontol 2019; 122(15):60-66. Available at: https://doi.org/10.1016/j.exger.2019.04.011.
10. Yamagata M, Tateuchi H, Pataky T, Shimizu I, Ichihashi N. Relation between frontal plane center of mass position stability and foot elevation during obstacle crossing. J. Biomech 2021; 116:110219. Available at: https://doi.org/10.1016/j.jbiomech.2020.110219
11. Pinheiro SCB, Barrena HC, Macedo AB. Articular altitudes caused by aging and its impacts in the autonomy of the elderly. Arqu Mudi 2019; 23(3): 35-45. Available at:https://doi.org/10.4025/arqmudi.v23i3.51510
12. Arts MH, Collard RM, Comijs HC, Zuidersma M, Rooji SE, Naarding P, et al. Physical frailty and cognitive functioning in depressed older adults: findings from the NESDO study. J. Am. Med. Dir. Assoc 2016; 17(1):36–43. Available at: https://doi.org/10.1016/j.jamda.2015.07.016
13. Ramakrishman P, Alyousefi N, Abdul-rahman PS, Kamaruzzaman SB, Chin AV, Tan MP. A systematic review of studies comparing potential biochemical biomarkers of frailty with frailty assessments. Eur. Geriatr. Med 2017; 8(6):397-407. Available at: https://doi.org/10.1016/j.eurger.2017.07.010
14. Franceschi C, Garagnani P, Morsiani C, Conte M, Santoro A, Grignolio A, Monte D, Capri M, Salvioli AE. The continuum of aging and age-related diseases: Common mechanisms but different rates. Front. Med 2018; 5:61. Available at: https://doi.org/10.3389/fmed.2018.00061
15. Milan-Mattos JC, Anibal FF, Perseguini NM, Minatel V, Rehder-Santos P, Castro CA, et al. Effects of natural aging and gender on pro-inflammatory markers. Braz. J. Med. Biol. Res 2019; 52(9): e8392. Available at: https://doi.org/10.1590/1414-431X20198392

16. Verghese J, Holtzer R, Oh-Park M, Derby CA, Lipton RB, Wang C. Inflammatory markers and gait speed decline in older adults. J. Gerontol. A Biol. Sci. Med. Sci 2011; 66A(10):1083–1089. Available at: https://doi.org/10.1093/gerona/glr099

17. Zembron-Lacny A, Dzuibek W, Wolny-Rokicka E, Dabrowska G, Wozniewski M. The relation of inflammaging with skeletal muscle properties in elderly men. Am J Mens Health 2019; 13(2):1557988319841934. Available at: https://doi.org/10.1177/1557988319841934

18. Amorim JSCA, Torres KCL, Carvalho AT, Martins-Filho OA, Lima-Costa MF, Peixoto SV. Inflammatory markers and occurrence of falls: Bambuí Cohort Study of Aging. Rev Saúde Pública 2019; 53(35). Available at: https://doi.org/10.11606/S1518-8787.2019053000855

19. Brucki SMD, Nitrini R, Caramelli P, Bertolucci PHF, Okamoto IH. Suggestions for utilization of the mini-mental state examination in Brazil. Arq Neuro-Psiquiatr 2003; 61 (3):777-81. Available at: https://doi.org/10.1590/S0004-282X2003000500014

20. Ueno DT. Validação do questionário baecke modificado para idosos e proposta de valores normativos. São Paulo. Dissertação [mestrado em Ciências da Motricidade] - Universidade Estadual Paulista "Júlio de Mesquita Filho"; 2013.

21. Maia AC, Rodrigues-de-Paula F, Magalhães LC, Teixeira RL. Cross-cultural adaptation and analysis of the psychometric properties of the balance evaluation systems test and MiniBESTest in the elderly and individuals with Parkinson's disease: application of the Rasch model. Braz J Phys Ther 2016;17(3):195-217. Available at: https://doi.org/10.1590/S1413-35552012005000085

22. Camargo FFO, Dias RC, Dias JMD, Freire MTF. Cross-cultural adaptation and evaluation of the psychometric Properties of the Falls Efficacy Scale - International Among Elderly Brazilians (FES-I-BRASIL). Braz J Phys 2010; 14(3). Available at: https://doi.org/10.1590/S1413-35552010000300010

23. Brazilian Association of Technical Rules. NBR 9077: Buildings - Emergency exits - Procedure. Rio de Janeiro; 1993.

24. Field, A. Discovering Statistics with SPSS. 2 ed, Porto Alegre: Artmed; 2009.

25. Tiainen K, Hurme M, Hervonen A, Luukkaala T, Jylha M. Inflammatory markers and physical performance among nonagenarians. J. Gerontol. A. Biol. Sci. Med. Sci 2010; 65(6):658–663. Available at: https://doi.org/10.1093/gerona/glq056

26. Xu Y, Wang M, Chen D, Jiang X, Xiong Z. Inflammatory biomarkers in older adults with frailty: a systematic review and meta-analysis of cross-sectional studies. Aging Clin Exp Res 2022; 34:971-987. Available at: https://doi.org/10.1007/s40520-021-02022-7

27. Fiocco AJ, Krieger L, D'Amico D, Parrott MD, Laurin D, Gaudreau P, et al. A systematic review of existing peripheral biomarkers of cognitive aging: Is there enough evidence for biomarker proxies in behavioral modification interventions? Ageing Res. Rev 2019; 52:72-119. Available at: https://doi.org/10.1016/j.arr.2019.04.008