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# ERGONOMIC AND USABILITY EVALUATION OF THE RAPID ESPRESSO MACHINE INTERFACE (LA SPAZIALE)

## AVALIAÇÃO ERGONÔMICA E DE USABILIDADE DA INTERFACE DA MÁQUINA DE CAFÉ EXPRESSO RAPID (LA SPAZIALE)

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Paulo Sérgio Torquato Vanucci[1]

David William Fernandes[2]

Eduardo Barbeiro Miura[3]

Kaio Marques Afonso[4]

Luciano Pires Aoki[5]

Maurilio Messias de Araujo Filho[6]

**ABSTRACT**

Coffee consumption is a widespread daily practice in both domestic and professional settings, necessitating coffee machines with efficient and safe interfaces. However, certain models exhibit ergonomic and usability limitations, revealing design flaws that hinder handling and pose risks to users. In this context, this study aims to analyze the interface of the 'Rapid' coffee machine by 'La Spaziale', identifying critical aspects related to height, grip, and usability—in compliance with Regulatory Standards (NRs)—to detect issues and propose product improvements. The research employed a qualitative, exploratory, and descriptive approach based on task analysis, photographic records, dimensional analysis, and the application of ergonomic checklists; data were compared against the Brazilian standard NR-17, following the methodological principles described by Van Kuijk et al. (2015). The results revealed significant ergonomic limitations, indicating a need for enhancements that reinforce user-centered design. Thus, the systematic ergonomic assessment demonstrates that adjustments to the interface and physical components are essential to optimize usability, reduce workload, enhance operational safety, and improve the overall user experience.

**Keywords:** Ergonomics; Usability; User interface; Coffee machines.

**RESUMO**

O consumo de café é uma prática diária disseminada tanto em ambientes domésticos quanto profissionais, exigindo máquinas de café com interfaces eficientes e seguras. No entanto, certos modelos apresentam limitações de ergonomia e usabilidade, revelando falhas de design que dificultam o manuseio e oferecem riscos aos usuários. Nesse contexto, este estudo visa analisar a interface da máquina de café 'Rapid', da marca 'La Spaziale', identificando aspectos críticos

relacionados à altura, empunhadura e usabilidade, em conformidade com as Normas Regulamentadoras (NRs), para detectar problemas e propor melhorias ao produto. A pesquisa adotou uma abordagem qualitativa, exploratória e descritiva, baseada na análise de tarefas, registros fotográficos, análise dimensional e aplicação de checklists ergonômicos, confrontando os dados com a norma brasileira NR-17 e seguindo os princípios metodológicos descritos por Van Kuijk et al. (2015). Os resultados revelaram limitações ergonômicas significativas, indicando a necessidade de aprimoramentos que reforcem o design centrado no usuário. Assim, a avaliação ergonômica sistemática demonstra que ajustes na interface e nos componentes físicos são essenciais para otimizar a usabilidade, reduzir a carga de trabalho, aumentar a segurança operacional e melhorar a experiência geral do usuário.
**Palavras-chave:** Ergonomia; Usabilidade; Interface do usuário; Máquinas de café.

## 1. INTRODUCTION

Globally, millions of people begin their day with a cup of coffee at home, in offices, and across various social settings, making the coffee maker a ubiquitous appliance in daily life. In Brazil, for instance, approximately 78% of the population consumes this beverage regularly (IBGE, 2020).

Available in diverse types and models, coffee machines vary primarily by brewing method, encompassing traditional drip filters, capsule systems, and automatic espresso machines. Investigating this theme is justified by the growing need to understand how daily interaction with these appliances impacts user well-being. Applying ergonomics to product design is crucial not only for user comfort

but also for preventing fatigue and operational errors in high-demand environments. This study is particularly vital because contemporary design frequently prioritizes aesthetics over functionality, thereby creating usability barriers.

As established by Iida (2016) and Shackel (1991), usability and efficiency are the core pillars that must sustain the user-product relationship, ensuring that technology serves human needs rather than the reverse. Within this context, the central research problem lies in the operational difficulties and physical inadequacies of professional machines used by diverse operators. Despite coffee's global popularity, comprehensive studies focusing on commercial machine interfaces through the lens of both cognitive and physical ergonomics remain scarce.

As Norman (2013) points out, poorly designed interfaces systematically induce errors and trigger user frustration. Furthermore, Kanis (2011) emphasizes that numerous usability flaws remain concealed during superficial testing, necessitating in-depth analysis to identify vulnerabilities that compromise safety and efficacy during daily handling. To investigate these issues, this study adopts a qualitative and exploratory methodology based on direct observation and technical analysis. Ergonomic checklists and photographic records were utilized to evaluate user-equipment interaction.

Methodologically, this approach aligns with the field-analysis framework described by Van Kuijk et al. (2015), which used field studies to identify user-centered design barriers across multiple markets. Through this comparative approach, this research aims to map critical interface pain points that disrupt the actual user

experience. Consequently, this article aims to analyze the interface of the "La Spaziale RAPID" coffee machine from an ergonomic perspective. By identifying critical factors such as height, grip, and equipment usability, this study proposes actionable recommendations to foster a more intuitive, safe, and comfortable user interaction.

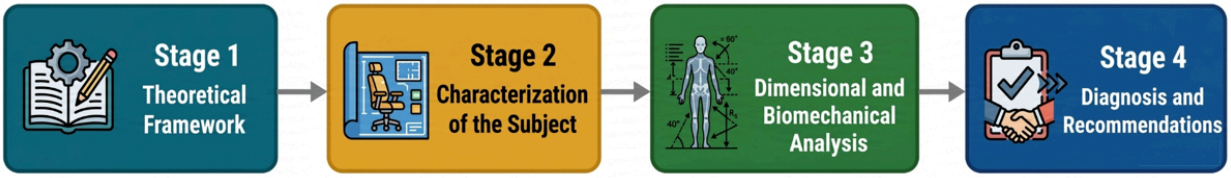
## 2. OBJECTIVES

The present article analyzes the interface of the RAPID espresso machine (La Spaziale) through the lens of ergonomics. This research investigates critical variables latent to usability, with an emphasis on anthropometric postural alignment and the graspability of the control components, resulting in the formulation of technical guidelines aimed at achieving a more intuitive and safe human interaction.

## 3. METHODOLOGY

The present research investigated usability and ergonomic challenges in commercial coffee makers, focusing specifically on the interface of the RAPID model (La Spaziale). This study is characterized as exploratory-descriptive, utilizing a qualitative approach grounded in direct technical observation and dimensional interface analysis. As a product engineering development study involving no clinical data collection, it did not require registration on the “Plataforma Brasil” platform, pursuant to Resolution No. 510/2016. The research framework comprised four main stages, synthesized in the flowchart presented in Figure 1.

**FIGURE 1 -** Flowchart of the project's methodological Stages




**Source:** Author

### 3.1. Step 1: Theoretical Framework And Literature Review

The initial stage consisted of a literature review through a systematic approach, aiming to map the ergonomic criteria applicable to professional appliances. The search process focused on the Scopus, Google Scholar, and ScienceDirect databases, using the following keywords: “ergonomics”; “coffee machine usability”; “anthropometry”; and “product design”; This selection resulted in 10 highly relevant papers (presented in Table 1); which provided the theoretical foundation for the field assessment based on the criteria of Workload; Compatibility; Guidance; and Error Prevention.

**TABLE 1 -** Set of articles resulting from a systematic review in the Scopus database regarding the topic of product ergonomics and its relationship with coffee machines.

| Author(s) | Title | Study Objective | Key Findings |
|---|---|---|---|
| Karis (2011) | *Estimating usability problems* | Estimate usability failures via systematic observation. | Short-duration tests are prone to failure; continuous observation is imperative. |
| Van Kuijk et al. (2015) | *Usability in product development* | Compare usability across diverse product categories. | Coffee maker ergonomics are frequently addressed in later development stages. |
| Tanaya (2025) | *Cognitive Ergonomics in Interfaces* | Analyze cognitive load during digital interface interaction. | Ambiguous icons increase human error rates. |
| Stranglinx (2019) | *Upper Limb Injuries in Baristas* | Evaluate repetitive strain injury (RSI) risks in professional baristas. | Manual tamping practices correlate with wrist pain. |
| Nuri (2016) | *Usability Testing: Coffee Maker* | Conduct usability testing on a domestic coffee maker with lay users. | Simple tasks generate significant errors among novice users. |
| Lee et al. (2024) | *Ergonomic Panel Angles* | Investigate the optimal inclination angle of control panels. | Panel angles between 45° and 60° enhance display visibility. |
| Setyanto (2025) | *Redesign of Coffee Machine* | Redesign a coffee machine utilizing anthropometric principles. | Height adjustment features significantly reduce back fatigue. |
| ISO 9241-11 (2018) | *Ergonomics of interaction* | Define global usability standards. | Usability depends on the context and user profile. |
| Maguire (2013) | *Kitchen Living in Later Life* | Kitchen ergonomics for diverse populations. | Small controls are access barriers. |
| Falcao (2013) | *Usability Evaluation Methods* | Review product evaluation methods. | Subjective satisfaction is crucial for quality. |

**Source:** Author

### 3.2. Step 2: Characterization Of The Object Of Study

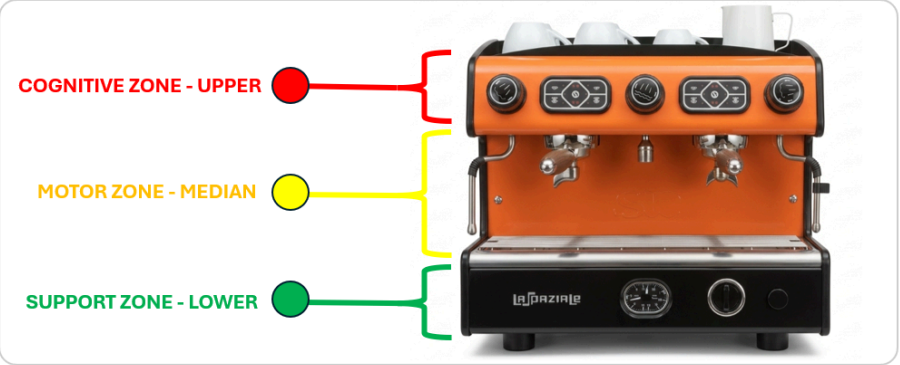
The defined object of analysis consisted of the RAPID professional coffee machine (La Spaziale), depicted in Figure 2. The aforementioned equipment was located in the UNESP university cafeteria, mounted on a fixed masonry workbench lacking features for anthropometric height accommodation. For assessment purposes, the system interface was segmented into three functional zones:

1. **Cognitive Zone (Superior):** Intended for monitoring and operating digital controls.

2. **Motor Zone (Median):** Focused on high-force execution (portafilters) and fine-motor control (steam valves).

3. **Support Zone (Inferior):** Designated for cup positioning and the residual waste tray.

**FIGURE 2 -** La Spaziale RAPID model professional espresso machine.




**Source:** Author

### 3.3. Step 3: Data Collection And Dimensional Analysis

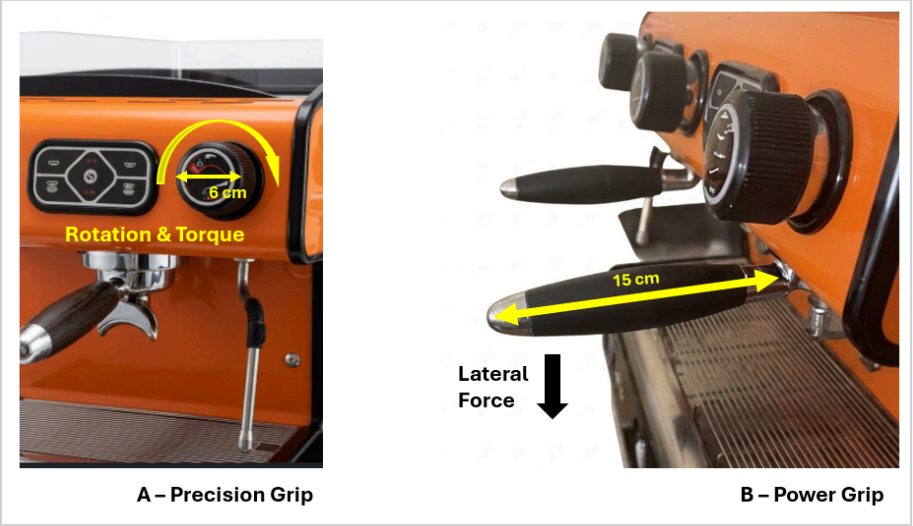
In view of the restricted access to operators during peak flow periods, a dimensional inspection method utilizing a reference scale was implemented. Technical photographic documentation was conducted with metric scales superimposed on critical interface components, thereby facilitating the assessment of grip and reach variables. The evaluation was structured around the biomechanical parameters detailed in Figure 3:

- **a) Operational Space (Base Width):** The effective width of 53 cm was assessed to determine spatial sufficiency for the concurrent performance of tasks (espresso extraction and milk vaporization) without anthropometric interference between workers;

- **b) Power Interface (Portafilter Lever):** The length of the leverage arm (15 cm) was verified to validate the accommodation of a full power grasp, essential for applying the coupling torque;

- **c) Precision Interface (Steam Knobs):** The diameter of the rotary controls (6 cm) was determined to analyze the demand for digital pinch (pulp-to-pulp grasp) and the occurrence of wrist joint deviations during the rotation cycle.

**FIGURE 3 -** Dimensional analysis: (A) 15 cm filter holder; (B) 6 cm handle.




**Source:** Author

### 3.4. Step 4: Diagnosis And Recommendations

In the final phase, the collected dimensional data were cross-referenced with the guidelines of ***Regulatory Standard 17 (NR-17)*** and anthropometric data of the Brazilian population. Incompatibilities were identified between the machine's dimensions (especially the ***105 cm*** working height and the handle designs) and the users' biomechanical capacities. Based on this diagnosis, design

recommendations and workplace interventions were developed to mitigate the risks of fatigue and musculoskeletal injuries.

## 4. RESULTS

Data collection was conducted through the direct observation of a single worker operating the "***espresso machine"*** in a university cafeteria, combined with a dimensional assessment of the user interface, and subsequent compliance cross-referencing with ***NR-17 ergonomic standards***.

### 4.1. Technical Specifications Of The Equipment

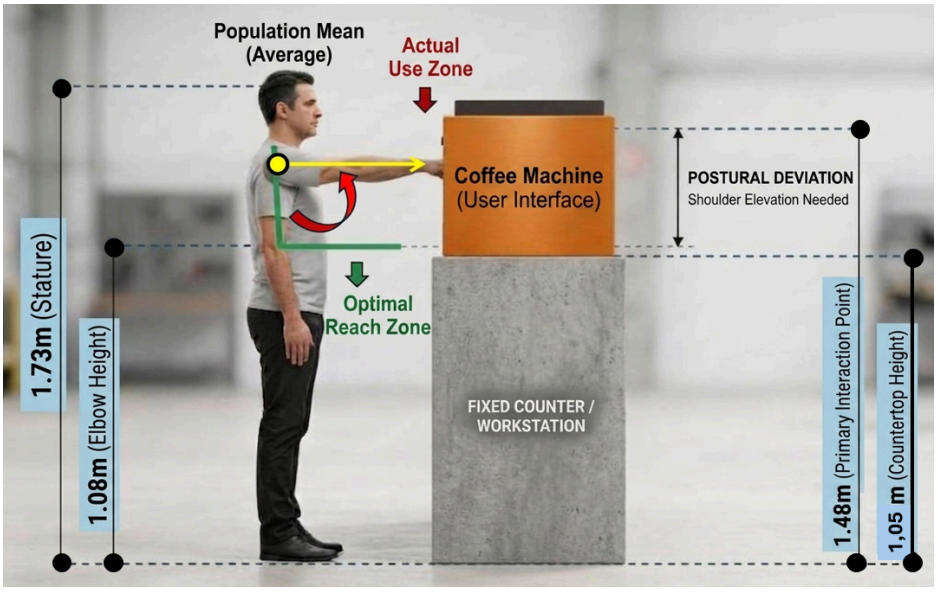
The RAPID line espresso machine by LA SPAZIALE BRASIL & AMERICA is a medium-to-large professional equipment capable of simultaneous extraction for 3 to 4 coffees, yielding up to 140 cups per kilogram of coffee beans, and characterized by its distinct ORANGE casing. Its dimensions and specifications indicate intensive utilization in commercial food service environments, such as cafeterias. The integration of a dual-scale pressure gauge, multiple outlets, and specialized controls establishes a complex interface designed for trained operators.

From a technical standpoint, the machine is available in two primary configurations: the RAPID EK and the manual-stop RAPID EP model. The equipment features a built-in volumetric pump, an automatic boiler refill system, and electric heating with a power consumption of 2,700 W on a 230V/60Hz grid.

### 4.2. Working Height And User Interface Analysis

Given that this is a professional-grade machine with a 10-liter boiler and a robust structure, its total working height significantly exceeds 105 cm. This elevated position imposes substantial ergonomic challenges for operators of varying statures. The dual-scale pressure gauge, a critical element for espresso quality control, must be positioned at a height and angle that facilitate quick and effortless monitoring, thereby preventing excessive neck flexion or extension.

**FIGURE 4 –** Height Diagram.




**Source:** Author

The total height of the work surface (counter combined with the espresso machine) places the cup-warming area and the upper controls at a threshold exceeding 115 cm from the floor. Based on Brazilian anthropometric averages, the optimal working height for light manual tasks (such as button actuation) should be positioned between 5 and 10 cm below elbow height (1.08 m). In the observed environment, this height is excessive, forcing the operator to sustain shoulder abduction and elevation exceeding 30 degrees or 40 cm during handling. Figure 4 schematically illustrates this discrepancy between the ***Comfort Zone*** recommended by NR-17 and the ***Actual Zone*** imposed by the equipment.

### 4.2.1. Biomechanical Overload At Grip Interfaces

Analysis of the actuation components identified two critical points of musculoskeletal strain:

a. **Steam Knobs (Ø 6 cm):** This diameter requires an operational torque ranging from ***10 N·m to 16 N·m*** for male populations. Field observations and user reports regarding machine usage indicate that the valve's mechanical resistance demands high torque—approaching ***16 N·m***—which induces significant stress on the wrist joint. Consequently, the repetitive nature of this motion poses a high risk to the distal upper extremities, potentially leading to ***Work-Related Musculoskeletal Disorders (WRMSDs / RSIs).***

b. **Portafilter Handle (15 cm):** Although the component's length accommodates a power grip (full palmar grasp), observed operations show that the horizontal locking mechanism requires substantial perpendicular force. The absence of tactile feedback regarding the precise "locking point" leads operators to exert excessive force, resulting in unnecessary muscle fatigue (the maximum perpendicular force an adult can exert at the end of a ***15 cm lever ranges from 26 N to 106 N).***

### 4.2.2. Ergonomic Design And Operational Considerations

For this category of professional equipment, ergonomic recommendations must comply with the provisions of ***NR-17, ISO 14738, and NHO 11*** (Assessment of Glare and Illuminance Levels), establishing the following workstation criteria:

- ***Height-adjustable workbenches (90–110 cm)*** to accommodate diverse operator percentiles;
- Non-slip platforms designed for shorter statured operators;
- A spatial layout optimized to minimize unnecessary reach and movement;
- Adequate illuminance targeting the control panel and pressure gauge;
- Specific training programs on proper posture during prolonged operational periods.

#### 4.2.3. Physical Workspace Characterization

The physical environment is characterized by high pedestrian traffic and spatial constraints regarding operation and circulation. The espresso machine is positioned on the service counter. This layout requires precise manual control from the user during equipment handling to prevent spills and operational accidents, particularly during peak hours.

#### 4.2.4. Layout And Spatial Arrangement Analysis

The physical arrangement of the workstation must facilitate rapid and safe access to the machine controls and the beverage dispensing area. It was observed that the spatial configuration allows for comfortable hand positioning during capsule insertion, cup placement, and beverage retrieval, satisfying the parameters of NR-17.

### 4.2.5. Assessment Of Adopted Postures

Due to operational constraints, photographic recording of the worker during equipment handling was restricted. Consequently, non-intrusive observational methods were employed to monitor the operator, supplemented by technical field notes on postures and machine dimensions. During operation, the worker maintained a standing posture, exhibiting slight trunk flexion and forward shoulder protraction to reach the controls. The hands performed repetitive movements of pinching, rotation, and pushing, which are typical for manipulating buttons, levers, and capsules. Biomechanical stress was primarily concentrated in the joints of the index finger and thumb, as well as on the palmar support surfaces. If the base height were inadequate, prolonged postural discomfort would occur, violating the ergonomic criteria established by NR-17.

### 4.2.6. Identification Of Motor, Sensory Activities And Furniture Functionality

The motor activities involved in the coffee preparation process included: (1) **Capsule or powder insertion;** (2) **Closing the upper lid** using manual pressure; (3) **Actuating the brewing buttons;** (4) **Positioning and removing** the cup.

The base of the coffee machine must provide stable support for both hands and cups during operation. However, it was observed that the cafeteria counter, which is frequently designed for multi-purpose functions, has an average height of ***0.80 m***. This dimension may be inadequate relative to the users' stature. In accordance with Regulatory Standard 17 ***(NR17)***, it is recommended that furniture be

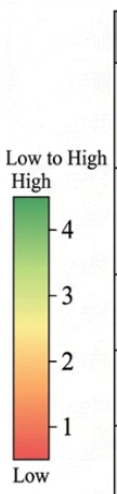
adjusted to the average working height to ensure a natural flexion angle of the arms and wrists.

Exertion during machine operation is primarily concentrated in the joints of the index finger and thumb, as well as on the supporting surfaces of the palm. The barista's activity combines elements of light work—such as monitoring the extraction process and cleaning—with periods of precision work, such as tamping (coffee compaction) and fine-tuning machine interface parameters, including buttons and pattern matching.

In the analyzed context, the 105 cm high countertop is elevated for most of the population, considering average elbow heights, which range between 95 cm and 110 cm for men, and 90 cm to 105 cm for women. This height may force baristas to work with elevated shoulders and their arms above a comfortable position, particularly during tamping, which requires the application of controlled downward force. As described by Iida et al. (2016), "for precision work, a slightly higher surface is suitable (up to 5 cm above elbow height)."

### 4.3. Ergonomic Evaluation Matrix

To quantify the usability analysis of the coffee machine, the identified issues were classified according to the Criteria of Bastien and Scapin (1993) and scored on a severity scale (1 = Critical to 5 = Excellent). The consolidated data are presented in Table 1.




| Criterion | Score | Detailed Analysis |
|---|---|---|
| Conduction | 2 | System feedback is deficient. The analog manometer features a hard-to-read display due to poor contrast and low positioning, hindering real-time pressure monitoring. |
| Workload | 2 | Fixed height demands static scapular waist exertion. Manual operation, lacking automatic stop, increases cognitive load and requires continuous visual attention. |
| Control | 3 | Button responsiveness is immediate, but a critical lack of redundant safety measures (e.g., easily accessible emergency stop) lowers the rating. |
| Adaptability | 1 | Rigid system architecture. Complete absence of user-accessible height, panel tilt, or temperature adjustments for the end-user. |
| Compatibility | 2 | Handle sizing disregards anthropometric data for smaller hands (below the 5$^{th}$ percentile female hand size), obstructing ergonomic operation for this demographic. |
| Error Prevention | 3 | Button grouping is purely spatial, with no differentiation by color or texture, leading to high potential for accidental activation of adjacent functions (e.g., mistaking short x long coffee). |
| Average | 2.1 | Classification: Critical Usability. |

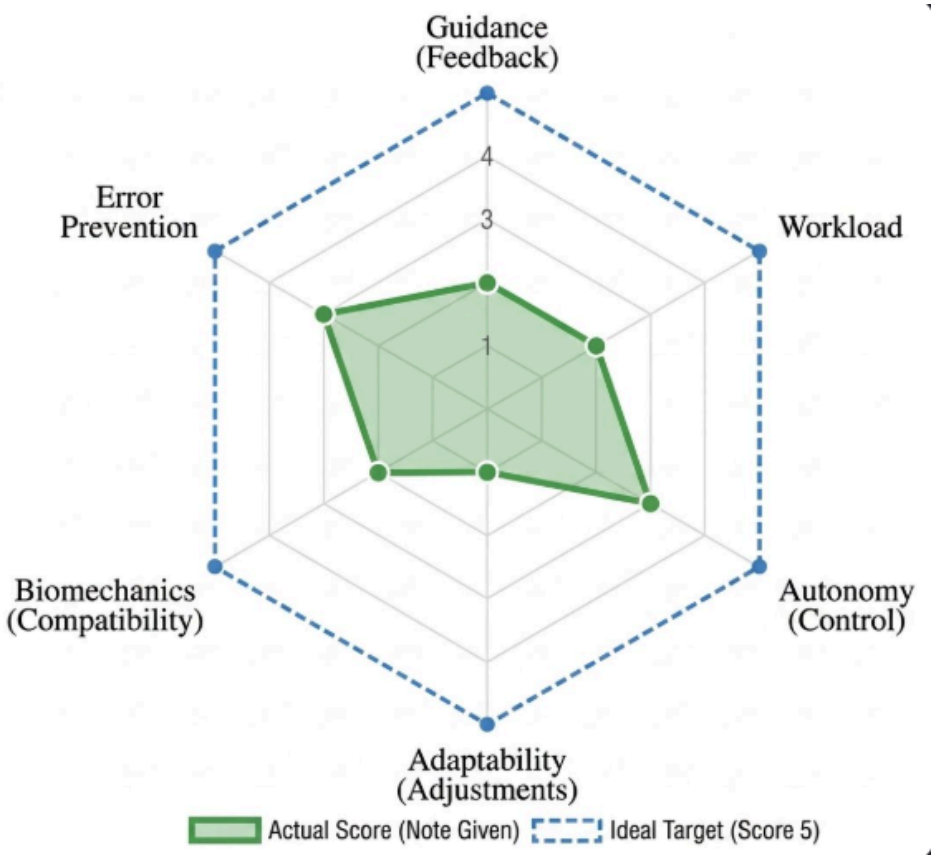
**TABELA 1.** Matriz de Pontuação Ergonômica.

**Source:** Author

### 4.4. Visual Performance Analysis (Radar Chart)

In order to illustrate the ergonomic imbalance of the interface, the radar chart presented in Figure 5 was constructed. It displays a substantially constrained coverage area (red) relative to the ideal polygon (dashed green line). Notably, the device prioritizes mechanical robustness at the expense of human interaction, yielding its lowest ratings in Adaptability (Score 1) and Compatibility (Score 2). These results align with Van Kuijk et al. (2015), who state that usability in industrial coffee makers is often compromised to ensure hardware durability.

**FIGURE 5 –** Comparative profile of the RAPID (RED) vs. Ideal NR-17 (green) coffee makers, demonstrating retraction in the Adaptability and Workload areas.




**Source:** Author

Using the data obtained from the ergonomic matrix in Table 1, a Pareto chart was constructed focusing on the ergonomic deficit of the La Spaziale RAPID espresso machine (Figure 6). The chart illustrates the variance between the ideal score (5.0) and the actual score assigned in the ergonomic matrix. The criteria with the highest cumulative negative impact account for 76.5% of the usability issues across the dimensions of Adaptability, Guidance, Workload, and Compatibility.

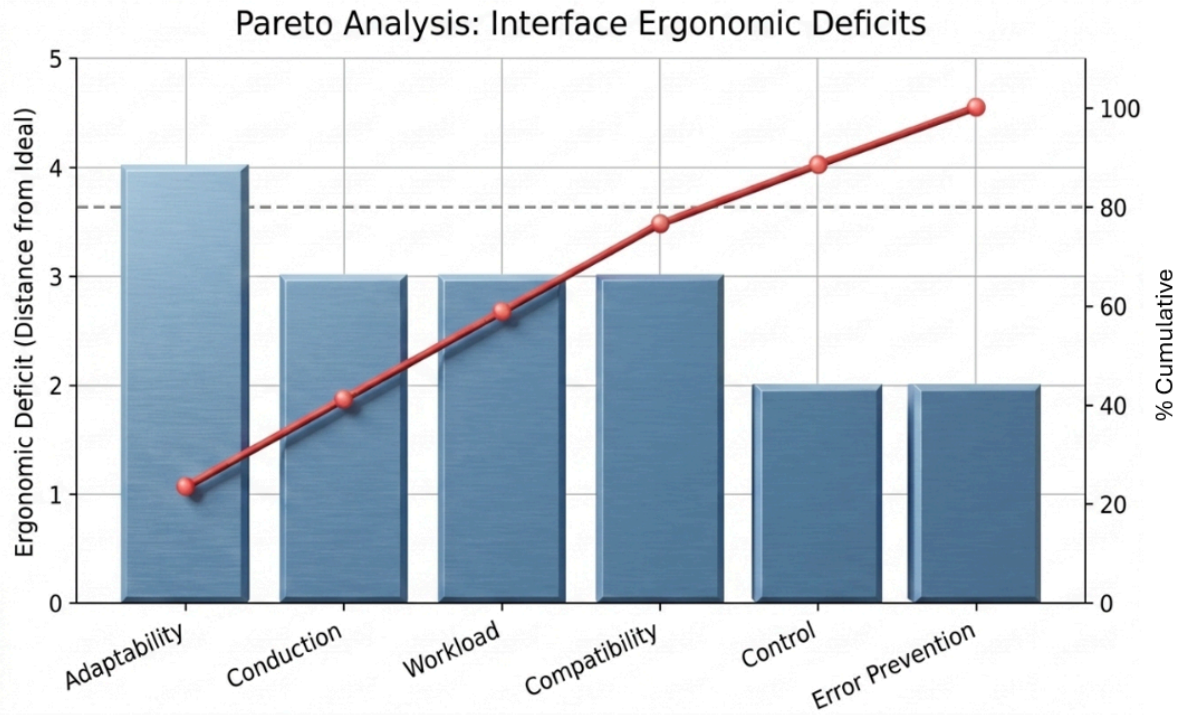
The Pareto principle (the 80/20 rule) indicates that approximately 80% of problems stem from 20% of the causes. In the chart, the dashed gray line intersects the red curve immediately after the Compatibility criterion, revealing that four out of the six analyzed issues account for 76.5% of the product's total usability deficit.

With an actual score of 1.0 and an isolated deficit of 4 points, the complete lack of physical adjustments (such as panel inclination or

counter height regulation) individually represents 23.5% of the workstation's total ergonomic inadequacy. Consequently, Adaptability emerges as the primary offender in the machine's evaluation.

Concentrating redesign efforts exclusively on Adaptability, Guidance, Workload, and Compatibility represents the most efficient approach. This constitutes the Critical Intervention Zone. Resolving these four deficiencies eliminates the vast majority of biomechanical risks observed in the barista's routine, such as shoulder fatigue caused by excessive flexion and wrist strain when operating buttons and knobs.

**FIGURE 6 –** Gráfico de Pareto aplicado à matriz ergonômica da tabela 1




## 5. FINAL CONSIDERATIONS

This paper provides a significant scientific contribution to the fields of production engineering and ergonomics applied to commercial product design. A primary strength of this research lies in its well-defined methodological framework, which is grounded in the

established ergonomic criteria of Bastien and Scapin (1993). By practically articulating the regulatory mandates of NR-17 with the physical constraints of a high-demand, real-world environment—namely, a university cafeteria—this study achieves an excellent integration of normative and ergonomic factors (BRASIL, 2023). Furthermore, the dimensional mapping of the workspace and the distinct segmentation into cognitive, motor, and support zones enabled a visually transparent and well-documented diagnosis. This methodological clarity enhances the reproducibility of the study across other types of professional appliances installed in fixed workstations.

Conversely, a critical analysis reveals key methodological limitations that constrain the overall scope of the work. The primary weakness stems from the partial absence of direct empirical testing with a diverse user base, which restricted data collection to a strictly dimensional inspection and theoretical observation. Consequently, the postures and muscle fatigue of the baristas were only theoretically inferred from population averages, failing to capture the variability of actual usage and dynamic exertion. This omission contradicts the recommendations of Kanis (2011) regarding the importance of continuous testing to uncover latent usability issues. Moreover, limiting the sample to a single espresso machine model precludes a more robust generalization regarding the commercial market. The lack of clinical data or subjective discomfort questionnaires further reduces the empirical weight of the final assessment of the equipment.

When contextualized within the specialized literature, the results strongly corroborate trends identified by prior research. The prioritization of structural robustness over human usability validates

the central thesis of Van Kuijk et al. (2015) concerning the historical neglect of user-centered design in industrial machinery. Similarly, the identified flaws regarding countertop height and upper controls align directly with the findings of Setyanto (2025), who links elevated surfaces to chronic back and shoulder girdle pain in operators. Finally, the confusing clustering of buttons lacking tactile or chromatic distinction ratifies the findings of Tanaya (2025) regarding the significant increase in cognitive load and human error induced by poorly designed analog interfaces. Thus, this study establishes itself as a necessary imperative for urgent ergonomic redesign within the food service industry.

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[1] Universidade Estadual Paulista "Júlio de Mesquita Filho" - UNESP.
E-mail: acesse o artigo original para visualizar o e-mail

[2] Universidade Estadual Paulista "Júlio de Mesquita Filho" - UNESP.
E-mail: acesse o artigo original para visualizar o e-mail

[3] Universidade Estadual Paulista "Júlio de Mesquita Filho" – UNESP.
E-mail: acesse o artigo original para visualizar o e-mail

[4] Universidade Estadual Paulista "Júlio de Mesquita Filho" - UNESP.
E-mail: acesse o artigo original para visualizar o e-mail

[5] Centro de Excelência de Educação Profissional – J. F. Barreto. E-mail: acesse o artigo original para visualizar o e-mail

[6] Mestrado em Engenharia Mecânica Instituto Federal de São Paulo - Campus Araraquara - IFSP. ORCID: https://orcid.org/0009-0000-9677-4921. E-mail: acesse o artigo original para visualizar o e-mail