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Evaluating Gym Hygiene Practices and Microbial Contamination Using Protein and Fluorescence Testing Approaches

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ABSTRACT

Background: This cross-sectional study aimed to assess cleaning and disinfection practices in gyms, focusing on the safety of these collective-use environments.

Methods: The study was conducted from October to December 2023 in two gyms-one public and one private. The study involved the inspection of high-traffic and frequently-touched exercise equipment, including bars for upper and lower limb training, extension, and flexion chairs, shoulder press machine, hack squat machine, dumbbells, leg press machine, flexor table, Hammer rowing, articulated bench press, and chest fly machine. The fluorescence method, protein test, and visual inspection were used for such analyses.

Results: A total of 120 evaluations were performed, encompassing 48 visual inspections (40.0%), 48 protein tests (40.0%), and 24 fluorescence analyses (20.0%). Among the equipment with the highest protein presence were the squat bar, 8kg dumbbell, hack squat machine, and leg press machine. Positive fluorescence results were found on the leg press, 8kg dumbbell, and chest fly machine. Visible dirt was present in 95.8% of the public gym environment and 33.3% ($p < 0.001$) of the private gym equipment.

Conclusion: The cleaning and disinfection practices performed in public and private gyms were inadequate and need improvement to mitigate the risks of cross-contamination among users.

1. Introduction

Regular physical activity is crucial for preventing and controlling heart disease, type 2 diabetes, and cancer, as well as reducing symptoms of depression and anxiety, and promoting cognitive function. It is estimated that up to 5 million deaths per year worldwide could be prevented if the global population were more active (Brazil, 2021). The Pan American Health Organization (PAHO) and the World Health Organization (WHO) recommend at least 150 to 300 minutes of moderate to vigorous aerobic activity per week for adults, including those living with chronic diseases or disabilities (Brazil, 2021). Additionally, these international organizations recommend an average of 60 minutes per day for children and adolescents (Brazil, 2021). Brazil is the fourth-largest market globally for gym clients and practitioners, with over nine million members in 2019, indicating increased awareness of the benefits of regular exercise (Marques et al., 2022). The adoption of a healthier routine has been attributed primarily to the increasing number of gym-goers, whether in public spaces as a result of government initiatives or in private environments. However, such environments, due to the shared use of equipment, may pose a risk of cross-contamination and disease transmission

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if not adequately cleaned, contradicting the expected benefits of an active lifestyle among users (Browne et al., 2023). This is particularly concerning considering that gyms are frequented by diverse populations, including young people, adults, and the elderly, who may have compromised or weakened immune systems at some point in their lives. Given this observation, the scarcity of studies pointing to such risks or to the impact of cleaning these environments on users' health is noteworthy. Cleaning and disinfection measures, as well as hand hygiene, are essential for interrupting the epidemiological chain of cross-contamination. In this sense, cleaning aims to remove dirt from surfaces through mechanical, physical, or chemical means, while disinfection is the chemical or physical process that destroys present microorganisms through a disinfectant solution (Browne et al., 2023; Frota et al., 2020; Anvisa, 2020). It is worth noting that cleaning with water and soap alone is insufficient, as it only reduces the risks of contamination by removing microorganisms but does not eliminate them, requiring disinfection with chemical products (disinfectants). Shared community spaces, including gyms, are areas that potentially harbor microorganisms, whose direct contact with the skin can facilitate transmission (Cooper et al., 2021). Promoting a safe environment free of risks, which encourages hand hygiene through the availability of supplies, as well as the cleaning of equipment between different users, is necessary to avoid various factors that pose health risks. A study conducted by Silva (2021) found that 50% of gym-goers did not clean the equipment, while the other 50% only used individual towels (Silva et al., 2021). In this context, it is crucial to raise awareness among gym users about infection prevention and to develop strategies to reduce risk, including equipment surfaces, as well as hand hygiene. However, it is necessary to evaluate the structure and supplies provided by locations to prevent the cross-transmission of microorganisms (Szulc et al., 2023; Li et al., 2021). The aim of this study was to evaluate cleaning and disinfection practices in gyms, focusing on the safety of these environments as places of collective use.

2. Materials and Methods

2.1 Study design and participants

This was a cross-sectional, descriptive, quantitative study conducted in two gyms located in the region of Juiz de Fora, MG, Brazil. The first study site refers to a public gym serving students, professionals, and members of the community from a federal university. The second gym is privately managed, targeting residents of a specific neighborhood in the region, where activities focused on health promotion with active user participation are conducted. When evaluating the physical layout of the locations, the equipment available for collective use analyzed in this study was observed, with an average of 25 pieces of equipment, 24 in the public gym and 26 in the private one.

2.2 Sample size and sampling method

The sample for this study was selected using simple random sampling, ensuring that each part of the population had an equal opportunity to be chosen, with a unique identification assigned to select some of these elements. Equipment intended for user training, with high turnover and frequently touched by hands, was included. The selection of equipment was carried out by the researchers themselves, based on observations made at the study sites. This included bars for upper and lower limb training, extension, and flexion chairs, shoulder press machines, hack squat machines, dumbbells, leg press machines, flexor tables, hammer rowing, articulated bench press, and chest fly machines.

2.3 Data Collection

Data collection was conducted from October to December 2023 by the researchers themselves, during the afternoon period. The aim was to characterize the location, including the quantity of available equipment, the number of alcohol preparation dispensers, the number of handwashing sinks, the number of paper towel holders, and the presence (or absence) of this hand hygiene supply, as well as the number of surface disinfectant dispensers. Additionally, the checklist regarding the frequency of equipment cleaning, types of cleaning/disinfection products used, the presence of labels (according to sanitary requirements), the opening and expiration dates, and the location of products intended for this purpose were analyzed. Based on this characterization, the study stages were conducted, including visual inspection to identify the presence of dirt, fluorescence evaluation, and protein tests. Variables related to the quality of surface cleaning and disinfection were also assessed, including the name of the equipment evaluated, the presence of foam/padding, the existence of holes or tears in the area, visible dirt, and the results of protein tests, considering qualitative results (positive/negative). Additionally, fluorescence testing was conducted as it constitutes a fluorescent marker, using a transparent liquid, quick-drying, which when applied to highly touched surfaces, allows the visualization of residues with the use of ultraviolet (UV) light. The product application was conducted at a specific time, between 1 and 5 PM, and its reading was set for 24 hours when the researchers returned to the site for evaluation. This period was considered to verify whether the equipment was cleaned by the users or not (Figure 1).

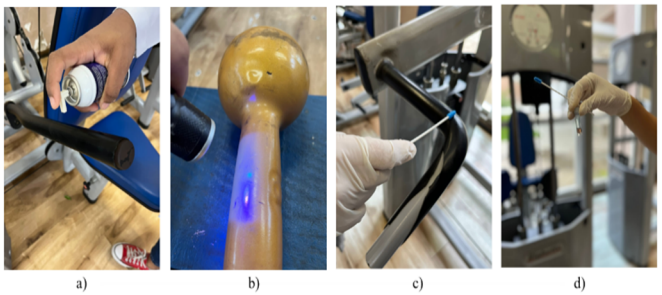

Figure 1. Photographic documentation of data collection conducted in gyms, Juiz de Fora, MG, Brazil. Note: a) Application of Optiglow® solution; b) Fluorescence verification after 24 hours of product application; c) Randomly swab different points for protein testing; d) Qualitative reading and interpretation of the protein test, evaluated by two researchers for consensus.

2.4 Statistical Analysis

Data analysis employed simple descriptive statistics to present absolute and relative data related to the variables in the form. The chi-square test was utilized, and when necessary, Fisher's exact test was employed to verify the relationship of independent variables with the response variable (type of gym: public/private). Additionally, multiple logistic regression was applied to explore more complex relationships between the properties of the measures. A Pareto diagram was developed in Microsoft Excel® to evaluate the highest cumulative percentage of positivity occurrences regarding protein and fluorescence tests.

3. Results and Discussion

In relation to the demographic characteristics of the spaces in the evaluated gyms, it was found that in the public gym, there was only one dispenser of alcohol preparation for hand hygiene, highlighting the absence of a sink. On the other hand, in the private gym, there were 17 alcohol preparation dispensers and three sinks, all equipped with stocked paper towel holders. For the cleaning of equipment between users, it was observed in the private gym that 70% alcohol-based disinfectant products were available; however, without identification labels or expiration dates. Similarly, in the public gym, in the single container provided, there was no identification of the product's date or expiration. Both public and private locations presented a daily cleaning and disinfection checklist; however, this practice was not evident during the data collection period. Table 1 shows the distribution of the equipment included in this study. A total of 48 (100%) samples were selected, with the highest frequency attributed to the rowing bench (8.3%), triceps bench (8.3%), and free squat bar (8.3%).

Table 1. Distribution of analyzed equipment in the study, Juiz de Fora, MG, Brazil (n = 48)

Equipment	n	Percentage
Rowing bench	04	8.3
Triceps bench	04	8.3
Free squat bar	04	8.3
Smith squat bar	02	4.2
Bench press bar	02	4.2
Free bar	02	4.2
Squat bar	02	4.2
Leg extension machine	02	4.2
Leg curl machine	02	4.2
Shoulder press development	02	4.2
Gravitron	02	4.2
Hack machine	02	4.2
4kg dumbbell	02	4.2
5kg dumbbell	02	4.2
8kg dumbbell	02	4.2
Leg press machine	02	4.2
180° leg press machine	02	4.2
45° leg press machine	02	4.2
Flexor table	02	4.2
Hammer rowing machine	02	4.2
Articulated bench press	01	2.1
Fly machine	01	2.1

A total of 120 evaluations were conducted, encompassing 48 visual inspections (40.0%), 48 protein tests (40.0%), and 24 (20.0%) using the fluorescence method. Regarding the condition of the shared furniture in the equipment with upholstery, 16.7% and 33.3% in the public and private gyms, respectively, showed tears, indicating difficulty in cleaning and greater susceptibility to dirt retention. In visual inspection, the presence of dirt in the public gym was confirmed with positive tests in 95.8%, while in the private one, it was 33.3% ($p < 0.001$). In the application of protein tests, both presented unsatisfactory results, ranging from 58.3% to 83.3% ($p = 0.050$). The applied fluorescence method revealed poor equipment hygiene (Table 2).

Table 2. Variables related to cleaning and disinfection of surfaces in the participating gyms of the study, Juiz de Fora, MG, Brazil

Variables	Responses	Evaluated Gym n (%)		Bivariate Analysis	Multivariate Analysis
		Private (n = 24)	Public (n = 24)	*p-value*	*p-value*$^{\psi}$
Presence of holes or tears in the area*	No	12 (50.0)	10 (41.7)	0.401**	0.406
	Yes	04 (16.7)	08 (33.3)		
Presence of visible dirt in the area	No	16 (66.7)	01 (4.2)	0.000¥	<0.001
	Yes	08 (33,3)	23 (95.8)		
Result of the protein test	Negative	10 (41.7)	04 (16.7)	0.490**	0.050
	Positive	14 (58.3)	20 (83.3)		
Result of the fluorescence test***	Negative	02 (16.7)	04 (33.3)	0.641¥	0.383
	Positive	10 (83.3)	08 (66.7)		

Note: *Considering only equipment with upholstery present (private gym n = 16/public gym n = 18); **Chi-square test; ¥Fisher's exact test; ψMultiple logistic regression; ***Evaluation performed after 24 hours (n = 12/gym).

There were 34 (100%) equipment positive for the protein test. The Pareto chart showed that the squat bar, the 8kg dumbbell, the hack squat machine, and the leg press machine were responsible for the highest cumulative frequency (41%) (Figure 2).

Regarding the equipment positive for fluorescence, a total of 18 (100%) are observed, where three were responsible for the highest cumulative frequency (39%), namely: the leg press machine, the 8kg dumbbell, and the chest fly machine (Figure 3).

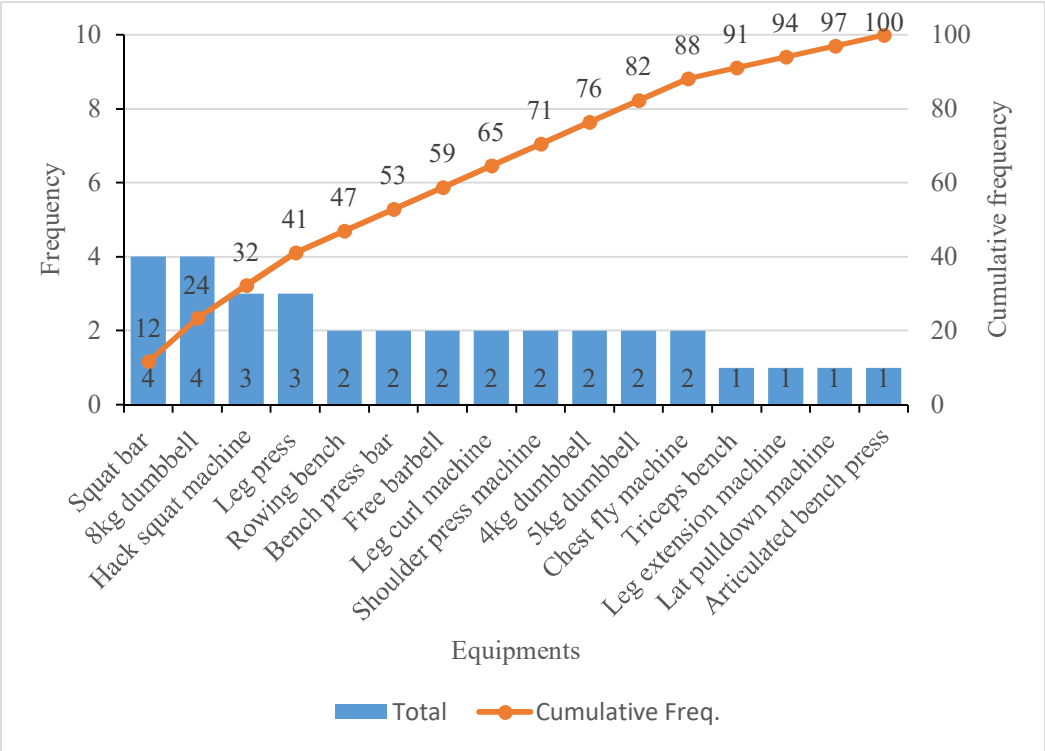

Figure 2. Distribution of equipment positive for the protein test, Juiz de Fora, MG, Brazil (n = 34)

This study has revealed that the quality of cleaning and disinfection of surfaces in both public and private gyms is unsatisfactory, as visual inspection, protein test analysis, and fluorescence method have produced unsatisfactory results. These findings emphasize the necessity for developing protocols and implementing improvements in the cleaning process to prevent the spread of microorganisms among gym-goers. Moreover, the limited availability of supplies in the public gym for patrons' use warrants consideration, with only one dispenser of alcohol preparation on-site and an absence of handwashing sinks. These aspects highlight the importance of training and educating cleaning professionals on the proper way to disinfect equipment, as well as the necessity of providing adequate infrastructure and supplies for this purpose. Training sessions are imperative to discuss the risks associated with shared equipment use, the condition of their upholstery, and user health. An experimental study conducted by Rodrigues *et al.* (2022) in a private educational institution's gym evaluated the quality of cleaning by assessing the effectiveness of disinfection with 70% alcohol before and after its application on weightlifting equipment during three shifts of the same day. The results showed that, despite a significant reduction after disinfection, bacterial colonies were still present on the evaluated surfaces. This demonstrates that while cleaning contributes to reducing the microbial load on equipment, proper disinfection following protocols recommended by national guidelines is still necessary (Rodrigues et al., 2022). Researchers who evaluated 16 gyms in Ohio, United States, demonstrated that 38.2% of environmental surfaces were contaminated with Staphylococcus aureus. However, these researchers did not assess the structure and supplies used in the context of cross-contamination prevention. It is necessary to investigate not only the presence of microorganisms on surfaces but also the effectiveness of cleaning and disinfection practices to ensure safe environments, considering other aspects that influence the cleanliness of these locations (Dalman et al., 2019). The data from this study revealed visible dirt, identified by visual inspection, which was confirmed by the protein test. Researchers investigating the effectiveness of disinfection in a gym indicated that specific disinfectant products can reduce and inactivate fungi and bacteria. The results promote safety in the environment, particularly in the elimination of Escherichia coli, provided that the product is used in sufficient quantity and for the recommended action time (Boonrattanakij et al., 2021). The protein test assesses surfaces to quickly detect contaminant residues, offering a metric to verify the efficiency of cleaning procedures. However, the literature advises the use of additional complementary tests. Adenosine Triphosphate (ATP) bioluminescence testing is a promising alternative, reliable, and reproducible in quantifying values related to dirtiness. Although widely used in hospitals and undervalued in gyms, its cost is still high as it reflects the quantity in relative light units of all organic material (Alvim et al., 2023; Wang et al., 2022; Van Arkel et al., 2020; Assadian et al., 2021). Regarding the fluorescence method, it stands out as a strategy incorporated in this study to verify the poor hygiene of the equipment. A similar study emphasized that utilizing this

method to analyze cleaning effectiveness is a promising option, but it cannot be used as the sole indicator (Van Arkel et al., 2020). From another perspective, researchers who evaluated the persistence of Sars-CoV-2 genetic material on gym equipment surfaces emphasized that indoor spaces pose a higher risk and have a higher incidence compared to open areas, reaffirming the need to value well-elaborated, evidence-based protocols, using fluorescence methods to ensure the safety of the environment intended for physical activities (Nascimento et al., 2023). This study did not proceed with a microbiological analysis of the surface. However, despite the absence of this analysis, the employed testing methods were sufficient to show that the protocols, hand hygiene encouragement, and shared seating surfaces were not adequately clean. Furthermore, the study findings suggest that the same testing approaches could be viable for regular adoption in such environments, through the institution of appropriate protocols.

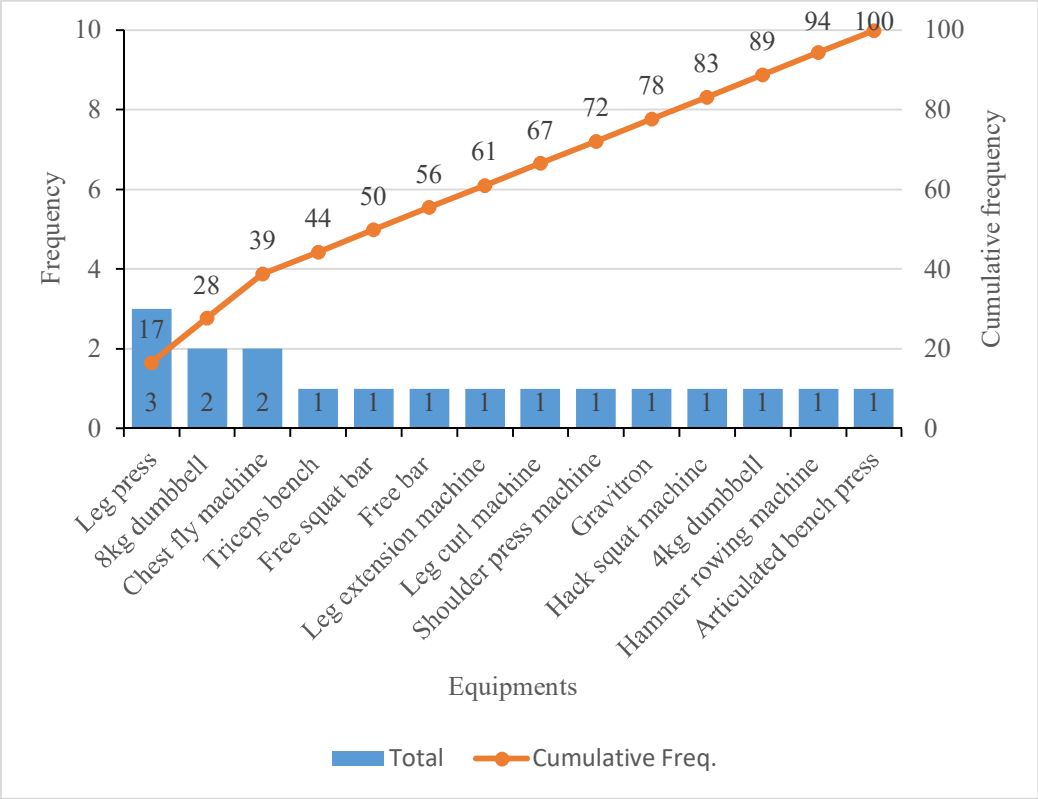

Figure 3. Equipment positive for the fluorescence method, Juiz de Fora, MG, Brazil (n = 18)

4. Conclusion

The analysis of the environment, equipment, and hand hygiene devices in the public and private gyms highlighted the need for the careful implementation of best practices. This is crucial to encourage users to mitigate the possibility of cross-transmission of microorganisms during collective use, thus offering greater safety to attendees. Especially considering that gyms are frequented by a diverse audience, including young people, adults, and the elderly, who may have compromised or weakened immune systems at some point in their lives. In this regard, the study revealed a concerning gap in the quality of surface cleaning and disinfection practices in these gym facilities. These aspects were evidenced by the high rates of positive results in protein and fluorescence tests, combined with visual inspection. The findings underscore the urgency of improving hygiene protocols to contain the spread of microorganisms among attendees, including the implementation of measures that favor the adequate provision of supplies, such as disinfectants, alcohol preparation dispensers, paper towels, and handwashing sinks.

Authors' Contributions

Daniela Santos Batista, Bianca Carolina Sobrinho Ananias: Conceptualization; Data curation; Methodology; Validation; Investigation; Resources; Writing-original draft; Writing-review & editing. Thais Vidal de Oliveira, Thiago César Nascimento, Vanessa Albuquerque Alvim de Paula, Adriana Cristina de Oliveira: Methodology; Validation; Resources; Writing-review & editing. André Luiz Silva Alvim: Conceptualization; Data curation; Formal analysis; Methodology; Validation; Formal analysis; Investigation; Resources; Supervision; Data curation; Writing-original draft; Writing-review & editing.

All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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None.

Ethical considerations

The study was approved by the Research Ethics Committee of the proposing institution, opinion number 0386.0.203.000-11 and the ethical aspects were respected. (project code: CAAE 0386.0.203.000-11).

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