

Design and hygiene issues in sports facilities. A pilot study which investigates fitness centres by using a multidisciplinary tool

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Abstract

Introduction. Awareness of the benefits of the physical activity on health by the general public has increased the number of people who is practicing it in the recent years. The gyms are the primary place – as the main indoor environment – for practicing physical activity.

Methods. A multidisciplinary tool was used primarily to investigate and analyse the general aspects of fitness centres then an assessment tool was created to evaluate a specific aspect such as the location, dimension, maintenance, etc. from the design, hygiene and safety points of view. Each section of the tool consisted of a series of questionnaires where the facility managers and the researches must have answered.

Discussion. The tool was tested on various cases by analysing the critical issues which affects the quality of spaces and end users' health.

Conclusions. The critical points observed from the tool that has an impact on the design of the gyms will help to shape future of these facilities. Several design and management strategies were also highlighted to improve the hygiene and health issues of fitness centres.

Key words

- design and management strategies
- fitness centres
- evaluation tool
- indoor environment
- multidisciplinary approach

INTRODUCTION

In the most developed countries, according to recent studies, people spend more than 90% of their life in indoors including leisure time [1-3] in enclosed dwellings and workplaces making the indoor environments a major determinant of health [4-5]. The attention by the Scientific Community therefore was focused on how the environmental factors, especially the indoors, have influenced the human health, and wellness, in particular the indoor air quality [6]; in fact, the Italian Ministry of the Environment (1991), has defined the “indoor air” as the air that is present in confined non-industrial life and working spaces (homes, offices, hospitals, schools, etc.) [7].

The healthiness of confined spaces is influenced by many factors, such as pollutants due to the presence of people, human activities, air conditioning systems, and building materials [8]. Indoor pollution is defined as

the presence of different chemical, physical and biological pollutants in the air. Protracted exposure to one or more of these pollutants due to frequent and prolonged stays in confined environments may result in health issues ranging from respiratory and allergic disorders to the neoplasms [9].

In the 2000s, wellness and health were associated with the idea of fitness which was subsequently identified with an attainment and maintenance of physical fitness with constant and targeted physical activity followed by a series of healthy habits and behaviours. Avoiding excesses and unbalanced lifestyles would make it possible to lower the risks of contracting illnesses, and foster the maintenance of a good state of health and wellbeing [10]. The growing interest on health and illness prevention through exercise and physical activity further involved public administrations, which, in synergy with medical communities, to promote and underscore the

importance of the habits and behaviours listed above as the key sources of health and wellbeing.

According to the results of ISTAT survey (2006), the confined environments mostly used for physical exercise are gyms, where the activities can be grouped under the name of exercises, aerobics, fitness, etc. [11]. A sports facility is a place that can be considered as multifunctional, from the point of view of operation and consequently also from a legal one. In fact, it is first and foremost a place of sports activity [12], as well as a workplace both in the management phase and in the realization of the facility itself [13].

Gyms, indoor swimming pools, and some velodromes are defined as confined sports environments. As far as gyms are concerned, nowadays they are environments largely frequented by both athletes, for training and competitive activities, and by the general public, for recreational and/or rehabilitation purposes. To date, these structures are not regulated in their construction and management by a clear and organic national legislation, and despite the attempt of some regions to fill the existing regulatory void, a primary point of reference is missing. An exception is represented by school gyms, for which reference is still made to the now dated general regulations for school buildings [14], and some specific regional regulations for the prevention of health risks within sports buildings. The regulations analysed refer to the Italian regions Basilicata, Calabria, Liguria, Marche, Tuscany, and Umbria [15]. All these norms state project designs related to specific requirements for the opening and operation of centres for physical exercise.

A clear and updated regulatory system is a key factor in ensuring public health protection in general, and especially when dealing with indoor environments [16]. Since gyms are confined places where, due to a large number of people and the type of activity performed therein, numerous indoor pollutants can accumulate, it is very important that these environments meet requirements that allow users to carry out a physical activity without compromising their health and safety [17]. In general, scientific literature points out that in the design, implementation, and subsequent management phases, all the physical components that define climate in a confined environment (microclimate) and may directly affect the conditions of thermal well-being have to be assessed, then athletic performance and more generally the state of health [13]. As the international regulations on sporting locations indicate, for all the rooms where natural ventilation can be guaranteed the general requirements apply, while as far as the thermo-hygrometric, renewal and air quality parameters are concerned, each country, and specifically also each region, can provide restrictions.

The aim of this investigation is to perform a pilot study to assess a multidisciplinary tool, designed to evaluate the efficiency of gyms as a health promoter.

METHODS

Development of the tool

In order to assess the quality of gyms, a multidisciplinary team, starting from previous studies concerning the topic and regulations on sports facilities, developed

a tool to understand the state of these sports facilities, and, if present, the health risks associated with indoor pollutants [18, 19].

The tool is divided into eight different sections. Each section includes questions with multiple answers or values. In order to make the instrument simple, clear and comprehensible for completion by technicians and facility managers, questions have been organized by topic with many graphical references.

Each section is described below.

- **General information** – The first section of the tool investigates general information regarding the facility, with the aim to understand its location, age, size and the number of users and employees involved. The interest of this section is to understand whether the sport facilities' proximity or distance from city centres affects their size. It could be expected that being closer to the city centres, being an area that is demographically denser, would correspond to an increase in the number of users who frequent these structures. The section also verifies whether the space is located inside a building where other activities are carried out or if the building is dedicated exclusively to fitness.
- **Gym location** – In this second section the purpose of the questions is to analyse the distribution of fitness spaces among the floors within the building (one or more floors), for the reasons described below. In the case of underground, semi-basement or ground floor spaces there may be several health hazards like humidity, due to the accumulation of moisture from various sources (i.e., rising damp, seepage or condensation), and low illumination and/or lack of natural ventilation. The resolution of all these aspects is essential to ensure adequate drying and removal of dangerous airborne contaminants like cigarette smoke and radon [20]. Exposure to radon, a radioactive noble gas, carcinogenic if inhaled (Group I according to the IARC – International Agency for Research on Cancer – classification) and recognized as the second cause of lung cancer, is higher in basements and semi-basement, and hyperventilation in gyms could increase exposure risk. If the gym is located next to the ground, the tool investigates whether a radon gas concentration measurement has ever been carried out within the premises, in order to check if the facility's management is aware of the presence of this risk, and, above all, if there are systems for its removal.
- **Gym spaces** – The third section of the questionnaire investigates the activities performed within the structure to understand the relationship between the size of the facility or the maximum number of users, and the number and type of functions and services provided by the structure. It is expected that as the facility surface area increases, as a consequence of the increasing number of users, there will be a greater number of functions than in smaller facilities or with a limited user base. In general, there are basic functions common to all facilities, like a foyer, an area with equipment, at least one locker room, and at least one room for group classes [21].
- **Functional design** – This section investigates the layout of the premises and the type of pathways

that users and employees follow to move within the structure, to enter, exit or move from one function to another. The objective is to verify the affinities and differences between the two types of paths, and to understand if there are intersections that should be avoided. Another purpose is to verify if there are overlapping flows that should be differentiated, like accessing and leaving the gym space. This configuration is not recommended as it increases the potential risk of carrying dust and dirt from the outdoors into the gym space [22]. In addition to the pathways, the accessibility of the facility by disabled users is verified. The questions in this part are intended to highlight if a structure is not accessible to some or all disabled users, the reasons for the impediments and whether they can be resolved by installing special machines for overcoming architectural barriers, or if more significant modifications are needed that may require structural changes.

- **Finishing** – The following section investigates both the interior finishing materials, as well as, although indirectly, their hygienic implications in terms of clean-ability. The purpose of the section is therefore to understand whether the materials used for covering the ceilings, floors and, if necessary, walls are suitable, or, because of their characteristics, are more prone to absorb moisture or to facilitate accumulations of dust and allergens [23-24]. These considerations are also extended to furniture and equipment for physical activity.
- **Dimensions** – The section investigates the dimensions of the activity rooms, both in terms of net surface and net height [25]. This is to understand if the relationship between the surface area of the room and the maximum number of users participating in fitness activities is acceptable, and whether the height of the premises is adequate in relation to the size and number of expected users. Temperature and humidity values of the air within these spaces are also required, if monitored. The purpose is not only to verify whether these values are constantly monitored, but also their compliance with the requirements of sports regulations [12].
- **Ventilation and air conditioning systems** – The section verifies whether spaces are adequately ventilated and if there are projections in the rooms that can potentially accumulate dust and allergens [26-27]. It also checks if the spaces are properly lit. The section aims at verifying whether the temperature and humidity values of the air are measured on a regular basis, indicating awareness of the risks associated with the presence of high values, especially in the case of dampness. Finally, the last two questions assess in detail whether ventilation by opening windows is sufficient to ensure good air exchange [28].
- **Cleaning procedures** – The last section concerns management aspects connected to cleansing procedures of activities rooms and equipment. In particular, the tool investigates if cleanliness is sufficient for the size of facilities and, above all, if the cleaning products employed are appropriate and prevent the release of volatile organic compounds responsible for poor

quality air conditions [29]. In addition, it asks how frequently filters for forced air recycling are replaced. In fact uncleaned or unsubstituted filters might become bacteria and mould reservoirs, which are then released into the environment with negative effects on people [30]. Lastly, the tool inquired if the formation of mould colonies and the deterioration or alteration of finishing materials have ever been detected.

A pilot application of the tool was carried out in the city of Milan on different case studies (gyms and fitness centres), in order to check questions' consistency and ease of compiling. The criterion applied for the selection of gyms consisted in achieving a sample of buildings, as much as possible various and heterogeneous, which encompasses both small and large structures, in the city centre and in the suburbs, belonging to fitness chains and private providers, recently open or placed in historic or older buildings. The selection criteria applied for the enrolment included first of all the location, in order to ensure a picture of the supplies all over the city. Secondly, it distinguished private structures and fitness chains in order to get a proportional sample. The research of the centres was done through online databanks.

Once identified, 40 fitness centres were contacted. In addition to explaining the survey and its purposes, they were asked to collaborate answering anonymously to the questionnaire.

Only 18 structures showed their availability, 3 of them were excluded because they were part of the same fitness group. The pilot study was then conducted on 15 structures, as reported in *Figure 1*.

Two were the modalities for filling the questionnaire, depending on whether the structure granted or not the opportunity to make an on-site visit. In this former case, the questionnaire was filled in loco by the evaluator with the help of the manager or a member of the staff; in the latter, it was forwarded by email and then printed and completed by the manager himself who then sent it back to the evaluator. In this case, the researchers were available to support the manager for any doubt regarding the compilation, in order to avoid errors.

Data obtained from the questionnaire were inserted in an Excel database, in order to highlight structural and environmental characteristics of these facilities and to offer design indications useful for both designers and managers.

RESULTS and DISCUSSION

Almost all the investigated structures are recently constructed (as *Figure 2* shows). In fact, analysing the year of construction or inauguration of the buildings, only 3 of them (20%) became operational before 2000, one of which was located in the central urban area and two in metropolitan satellite areas. Seven gyms (46.7%) opened between 2000 and 2009, four of them were located in metropolitan satellite areas, two in semi-central areas and one in urban peripheral area; the remaining 5 gyms (33.3%) became operational between 2010 and 2014; two of them were placed in central urban areas, two in semi-central areas and one in an urban peripheral area.



Figure 1
Map of the structures contacted and analysed for a survey. The sample is various and covers the whole territory of Milan.

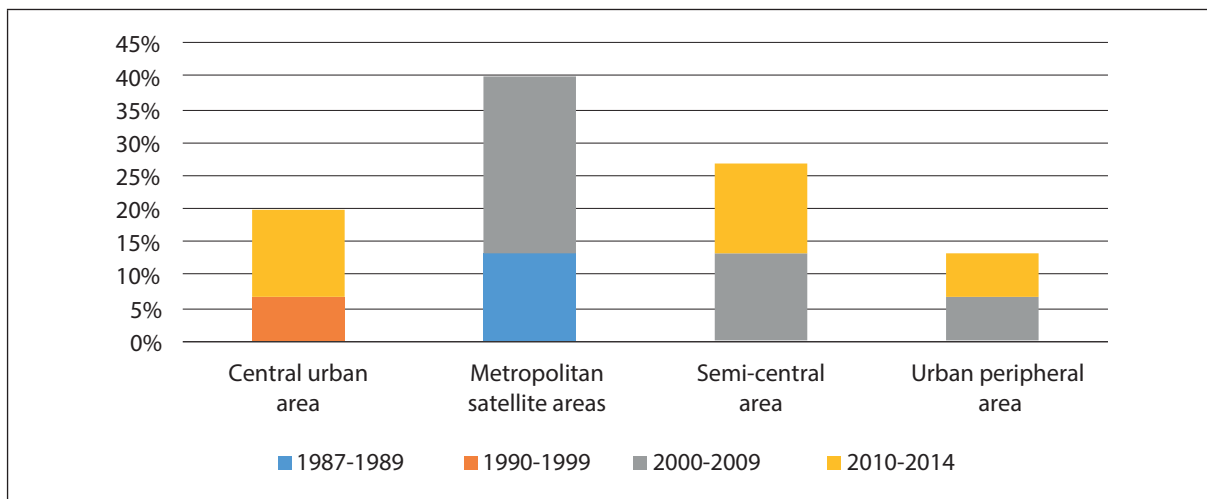


Figure 2
Distribution of the analysed gyms by age and area.

In terms of sizing, the structures are divided into three categories according to the total area: small-sized gyms (<500 sqm); medium-sized gyms (between 500 sqm and 1500 sqm) and large-sized gyms (>1500 sqm). Among the analysed structures, 20% have an area of fewer than 500 sqm, 40% between 500 and 1500 sqm, whereas 40% over 1500 sqm, which usually correspond to big fitness centres.

In the study sample, only 4 (26.7%) of the analysed structures are for gym use only. The remaining 11 (73.3%) are located in buildings with other functions:

offices, private residences (53.0%), commercial activities (13.3%), and tertiary services (6.7%).

Thirteen gyms (86.7%) have part of their spaces in the basement. In relation to the risk of the presence of Radon gas inside the activities' rooms, the owners of these 13 structures were asked if they were aware of the ground attachment modalities of the building. Indeed, the most effective ways for removing this threat from the structure is to provide a crawl space, or, alternatively, a cavity, so that air recirculation can help reduce concentrations in closed environments. These

solutions are easier to find in recent constructions. Regarding the investigated gyms only 3 (23.1%) knew they had crawl spaces, 2 (15.4%) were not able to answer and 8 (61.5%) declared they didn't have any mean of radon reduction. Overall, it emerges that most of the centres have never measured radon levels.

The survey shows that in structures sized less than 500 sqm many functions are lacking and changing rooms for customers and employees are unified. By contrast, gyms with a floor area ranging from 500 and 1500 sqm present a larger number of spaces and services, even though only structures larger than 1500 sqm are equipped with modern and cutting-edge services such as swimming pool, spa, solarium, food services, etc. [10].

Dimensional profile strongly influences also the layout organization and users' routes, as reported in *Figure 3*.

In smaller sports centres both the categories of people who use these spaces follow the same path, which is a basic path, not further simplified, that leads from the entrance to the changing room and then to the gyms. The

organization of the routes grows together with the size of the structure: the paths are distinguished by the type of locals they link, and by the people who walk them down (customers or employees). During the on-site visits, it was possible to notice that, with regard to the routes, there is a critical issue linked to the input and output flows in the structure. In fact, in many structures, people who go into the changing rooms before doing physical activity walk the same path of those who leave from fitness practice. Such a situation is not recommended because it potentially increases the risk of carrying dust and pollutants from the outdoor environment into the spaces for physical activity [22]. In general, it would be better to keep different routes or, alternatively, to organize the changing room as a filter zone between the entrance and the area where all the fitness activities are performed, and where it is possible to benefit from all the services that the structure provides.

The sample also shows that in 2 (13.3%) gyms disabled users may not be able to access the structure. Out

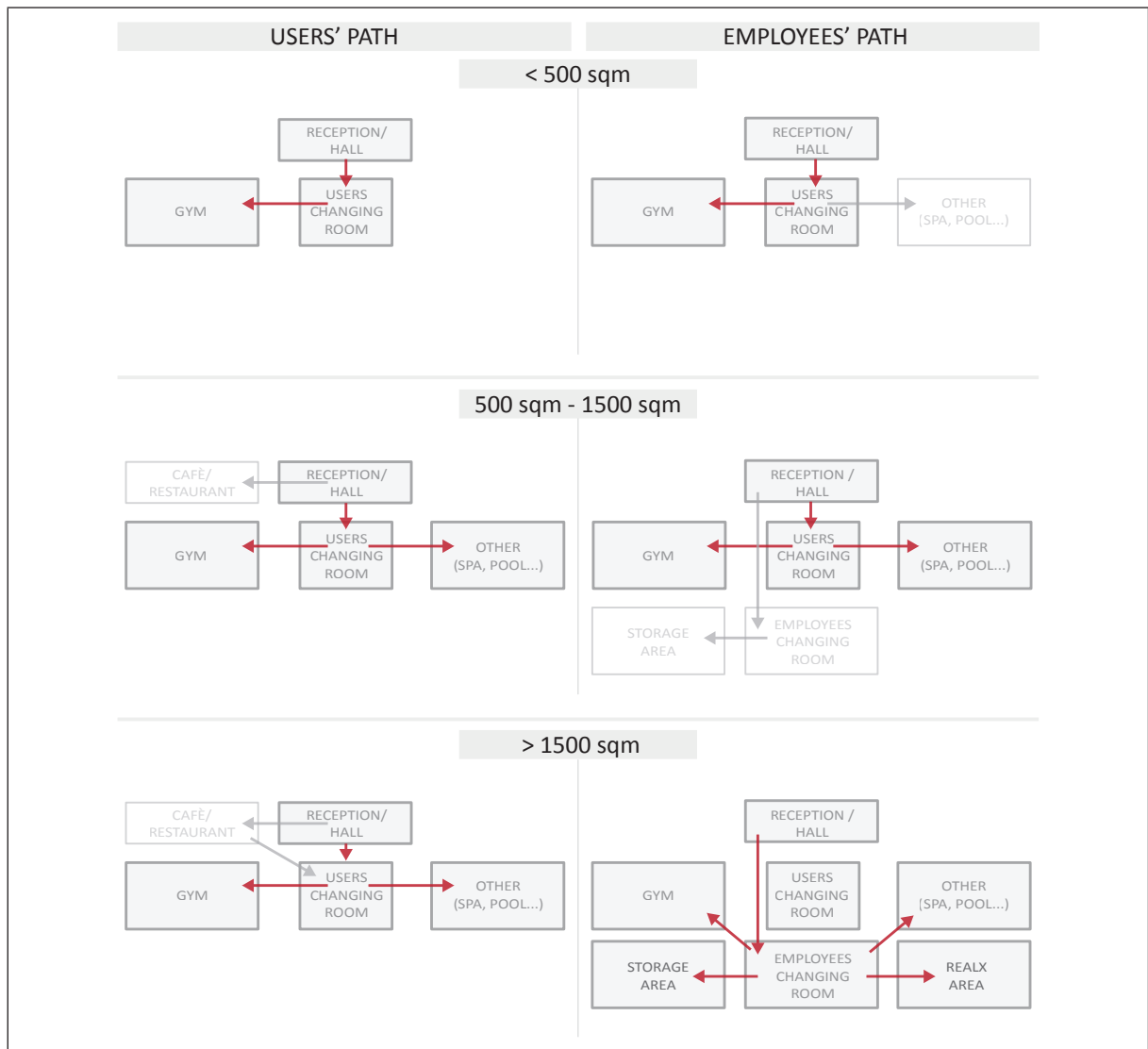


Figure 3
Customers-employees routes in the analysed structures divided by size.

of the 86.7% of structures accessible to disabled users (13 gyms), in 26.7% (4 gyms) the access is limited to some areas.

In terms of design, the section related to materials used for making the finishing of the gyms has the aim of verifying they are not dangerous for customers and employees' health. Building products can indeed worsen living conditions by directly releasing polluting or dangerous substances, by absorbing and then releasing substances from other sources or by favouring the build up of dirt and the growth of microorganisms, which may increase the risks of incurring in one or more building-related diseases. With respect to finishing, materials that can cause these effects are glues, cladding for paving and revetment, carpet, varnishes, dyes, panels, false ceilings, and furniture. In almost all the analysed centres it was possible to notice that the materials were suitable, as *Table 1* shows. Particularly the cladding, often realized in plastic laminate for both flooring and walls, proved to be in good state, smooth and easily cleanable. The sole exceptions are two cases where it was found the presence of exposed brick and wooden ceiling. Both these materials, being very porous, are more likely to accumulate microorganisms because of the imbibition, which favours their proliferation [31]. It is possible to prevent indoor air pollution caused by building products with a wise choice of materials, methods of laying and installation and finishing processes.

With respect to dimensional aspects, the tool inspects the relationship between the size of activities rooms and the number of users. No difference between the size of

specific areas and the number of clients expected to use them has emerged from the comparison of case studies.

In parallel with the maximum number of users each room can hold, air temperature and humidity values in those rooms were also asked. As per existing prescriptions, the air temperature inside the activities room must vary between a minimum of 16 °C and a maximum of 20 °C with humidity values not lower to 50%. In fact, higher values of air temperature and humidity may favour the proliferation of germs, bacteria, and microorganisms which, scattering in the air, may lead to inadequate conditions of the spaces. The values recorded from the sample are for most out of the standard.

With respect to ventilation systems, it emerges that, in most cases (14/15), the whole building, or only a part, is equipped with implants projecting from the ceiling, which increases the probability of dirt and determines a worsening of indoor air quality [32]. The designer should, therefore, prefer lighting fittings integrated with the ceiling and ventilation systems on top of the false ceiling. Regarding the air exchange implant, almost all the structures are equipped with a forced air system.

This is positive because in this way the exchange is mechanically controlled by the specific equipment which enables the manager to set different values according to the needs.

The regular monitoring of air humidity and the temperature inside the gyms is another aspect investigated by the survey, which asked if these values are regularly measured. Confirming data emerged in the previous section, the temperature is monitored more often than humidity (respectively 85% and 35%) and structures seem to be indeed very little interested in keeping its value within certain standards. Once again, the manager is responsible for the constant monitoring of air temperature and humidity in order to intervene if these values rise or fall excessively.

Eventually, the last two questions of the section connected to ventilation system asked if in the spaces for activities there is some form of air turnover – even through windows opening – and if so, how long they are kept open. While the feedback was positive in the 55% of the cases (in total 8) for the first query, not even a structure was able to answer to the second question, impeding to define if the windows opening is sufficient for ensuring an appropriate air exchange.

Anyway, it is always good to flank the forced air recycling with a natural air turnover but being careful to respect the established time limits to avoid an excessive fall of relative humidity and temperature and the formation of airflows disturbing the users in the activities spaces.

The cleaning is strictly related to the size of the fitness centre: while smaller ones do the cleaning only two or three times a week, in the larger ones the cleaning staff is always present inside the activities spaces and cleans continuously during the daily opening (as long as the size of the structure increases the cleaning modality becomes extensive and more careful).

In almost all the cases, the cleaning activity is performed by a specialized external agency and, for what concerns the equipment used, this can be done either

Table 1
Finishing materials analysis in case studies detected

Ceiling	Number (%)
Cement	2 (13.3)
Drywall false ceiling	1 (6.7)
Modular false ceiling	6 (40.0)
Plaster	5 (33.3)
Wood	1 (6.7)
Total	15 (100.0)
Floor	Number (%)
Ceramic	1 (6.7)
Laminate	7 (46.7)
Parquet	7 (46.7)
Total	15 (100.0)
Wall	Number (%)
Plaster, exposed brick	1 (6.7)
Mural paint	2 (13.3)
Washable paint	9 (60.0)
Glass	3 (20.0)
Total	15 (100.0)

by the cleaning staff, the structure's personnel and the customers themselves. This is another important datum because reveals constant hygiene of tools which should not be underestimated considering that these ones sometimes have parts which can easily absorb sweat and humidity creating an ideal environment for microorganisms [31].

The maintenance of the ventilation system is another relevant issue. Just like finishing materials and equipment inserts, the filters of the ventilation system can turn into germs and allergens reservoirs and, if they are not regularly clean or substituted, they can make the ventilation system a source of biological risk [33]. Thus, it is really important to undertake routine maintenance of the system and to replace the filters. The survey highlights that in the majority of gyms (55%) the filters are cleaned or substituted monthly but, in other cases (15%), the structures declared that they replaced them only once in a year, or even that they've never changed them. Naturally, it depends on the dimensions of the gym and the number of hours of the functioning of the implant itself.

The last section dealt with hygienic and sanitary matters. In fact, it was asked if moulds were ever been found in the implants, or if finishing materials have ever shown signs of alteration or decline. While for questions regarding moulds negative answers predominated, positive answers prevailed about material alterations (60%). In both cases, the problem is connected with standing water, which penetrates finishing materials or furniture, creating a favourable environment for microorganism potentially dangerous for human health [34, 35]. Thus, it is up to the designer to realize a waterproof system of ground attachment and an efficient implant suitable for rainwater disposal. On the other hand, it is the duty

of the manager to make sure that the implants in the structure work synergistically in order to ensure a correct air recycling and to keep optimal environmental and thermo-hygrometric conditions.

CONCLUSIONS

The multidisciplinary tool allowed us to verify potential critical issues related to the collection of information needed for carrying out a complete and exhaustive investigation, to be potentially extended to wider contexts. The time for filling the questionnaire is reasonable (roughly 60 minutes). The questions seem to be appropriate, but the answering modality showed some difficulties, which can be overcome using closed-ended questions. The questionnaires sent by email and filled by the managers of the structures were not complete, thus it was necessary to verify ex-post all the questions on site.

A potential limit can be deducted from the tool itself, which needs to be filled by a competent evaluator or, at least, by someone instructed about its use and supported by the manager of the structure.

The main deficiencies are observed in the section related to spaces' sizing in contrast to the scheme reported in the questionnaire. In this respect, a question regarding the volume of the environment and the layout of the room will be included in case it does not correspond to the scheme references.

Planned modifications include a clearer definition of the number of users, which has to refer to the mean number of people who attended the gym in the previous 6 months. This will make it easier to quantify the air volume needed. In the light of the survey we carried out and the results we obtained, it was possible to make some considerations and draw indications useful

Table 2

Design and management strategies for gyms and fitness centres

Design / maintenance strategies	Avoided side effects	References
Proper sealing and protection of groundwork structures	The rise of radon gas and humidity	Signorelli <i>et al.</i> , 2016 [9]
Appropriate functional layout	The overlap of customers and employees' routes	Braniš and Šafránek, 2011 [22]
Internal finishing materials smooth, easily cleanable and free from gaps	Settlement and growth of microorganisms	Buonanno <i>et al.</i> , 2012 [36]
Suitable mechanical air ventilation system	Air pollution and thermal discomfort	De Antonellis <i>et al.</i> , 2016 [37]
Openings for natural lighting and ventilation	Air pollution, thermal discomfort, growth of microorganisms	Popov VI <i>et al.</i> , 2016 [38]
Furniture and ventilation system components not protruding from the walls and the ceiling	Settlement and growth of dirt, dust, bacteria and allergens	Braniš <i>et al.</i> , 2009 [39]
Appropriate sizing of activities rooms, avoiding rooms with excessively high ceiling	Formation of convective motions of the air	De Antonellis <i>et al.</i> , 2016 [37]
Structure equipped for ensuring accessibility to disable people, if only to a minimum number of rooms, and participation to selected typology of courses.	Accessibility forbidden for disable users	Brandizzi and Carbone, 2004 [21]
Monitoring air temperature and humidity	Microclimate discomfort	Sacks and Shendell, 2014 [40]
Programming cleaning measures and maintenance of force air recycling systems	Settlement/growth of bacteria and microorganism and air pollution	Bouzgarou <i>et al.</i> , 2013 [26]
Cleaning locals and equipment with specific products which limit the dispersal of polluting agents in the air	Air pollution inside the environments	Alves <i>et al.</i> , 2014 [29]

for the designer who needs to plan this kind of structure, as summarized in *Table 2*. Furthermore, the results achieved show how poor indoor air quality is often not due to an incorrect design or a careless choice of materials and furniture, but to inadequate maintenance and management of the structure operated by the manager. For this reason, it was possible to obtain some management indications useful for keeping locals in good conditions of indoor comfort.

In conclusion, the tool has shown to be very useful on at least two aspects: on one hand as a mean for understanding designer trends (and typologies of structures) on the territory, and on the other as a tool for the surveillance of the quality of health promotion spaces.

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Authors' contribution

All authors contributed equally in the preparation of this manuscript.

Conflicts of interest statement

The authors declare that there is no conflict of interest regarding the publication of this paper.

Data availability statement

The data used to support the findings of this study are included in the article.

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