Human Factors Analysis of Women's Locker Room Floor Design

At the Mount Pleasant, South Carolina R.L. Jones Fitness Center

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Introduction

The R.L. Jones fitness center in Mount Pleasant, SC is a place for the community to gather, practice sports, learn teamwork, and stay in shape. In order for these objectives to be achieved, the spaces of the fitness center must be appropriately designed to accommodate the needs of the users and their activities.

The women's locker room at the R.L. Jones center has undergone a series of small renovations over the past several years. Unfortunately, the problems with the current locker room design are not well understood and thus many of the changes have inadequately addressed these problems. Ineffective counter-measures result in dissatisfied users and wasted money, time and effort; it is necessary to properly define the problems, so that they may be addressed. This analysis explores the current locker room floor surfaces, and recommends Human Factors Engineering (HFE) measures to improve these surfaces given how and by whom this space is used, so that the locker room may be safe and comfortable.

Background Information

Current Users

There are a variety of users who take advantage of the R.L. Jones center facilities, for various purposes. The common user groups and any specific needs that they have must be taken into account when determining the most appropriate flooring. The primary user groups are contained in List 1.

1. Adult athletes
2. Youth athletes, on athletic teams
3. Parents of young athletes
4. Lifeguards and water safety instructors

5. Coaches
6. Maintenance staff

List 1. Primary locker room user groups.

Note that the age range of the users is significant. There are young children, parents, coaches, and adults – which includes elderly women who participate in the programs offered by the gym. The users span a full range of ages and levels of mobility.

Locker Room Zones

The R. L. Jones locker room consists of various regions where different activities take place. These areas are the walkways, changing area, restrooms, and showers. As a user enters the locker room from the main lobby, she is faced with a walkway leading directly to another door, which leads to the main athletic facility gym and pool. On her way down this corridor, she will first pass the changing area, followed by the restroom area, and finally the shower area. Figure 1 outlines these various regions. A more detailed diagram of locker room zones is included in Appendix A.

Figure 1. Layout of the women's locker room regions: walkways, changing area, restroom, and showers.

Walkways.

There are two entrances into the locker room. One is used by individuals passing between the locker room and the main lobby. The other is used by individuals passing between the locker room and the pool and main gymnasium. These two locker room doors are joined by a straight walkway.

Near to the main entrance, this walkway is covered in high-traffic carpeting. As the walkway passes by the restroom and showers, the walkway floor is tiled and painted. In the center of the walkway that leads to the gym and pool, tiles have been removed from a center strip and a drain is installed, shown in Appendix A.

Changing area.

The changing area, directly to the right as the user enters the locker room from the main lobby, is made up of two smaller spaces, divided by a double-sided row of

lockers from the floor to the ceiling. The changing area is covered in the same high-traffic carpeting as the entry way into the locker room. Each changing area contains a bench.

Restroom area.

The restroom area is off of the locker room walkway, between the changing area and the shower area. One wall has a counter top with two sinks; against the other are three toilet stalls. There is an open space between the sinks and stalls. The floor of this area is tiled and painted.

Shower area.

After coming in from the main lobby and passing the changing area and the restrooms, the user passes the showers on her right. There are a total of 6 stalls, 2 of which are larger for accessibility. The flooring of the shower area is also tiled and painted. Additionally, the shower area has several grated plastic mats over the painted tiles, as shown in Appendix A.

Common Walking Paths and Footwear

Patrons use the locker room year round for recreational activities. The heaviest gym usage occurs during the summer as in addition to the regular athletic programs and open gym, there are children's camps and swimming lessons. The locker room floor should be designed to accommodate the heaviest usage periods, so the number and type of users during the summer will be considered.

The users of the gym generally take specific, well-defined walking paths through the locker room. The most commonly observed walking paths are presented in List 2.

1. Passing directly from one entrance to the other.
2. Coming from either entrance to use the restroom, then returning through the same entrance.
3. Entering through the lobby, using the changing area, possibly stopping in the restroom, showering, then exiting to the pool.
4. Entering through the lobby, using the changing area, possibly stopping in the restroom, then exiting to the gym.
5. Entering from the gym/pool, going to the changing area to retrieve belongings, showering, returning to the changing area to get dressed, then exiting through the front entrance.

6. Entering from the gym/pool, showering, going to the changing area, then exiting through the gym/pool door (back gym exit).

List 2. Common walking paths through the locker room.

The common walking paths occur with the users in various shoe types. Many users wear the standard gym footwear of sneakers, though there are other shoe types used as well. Swimmers and athletes who shower may go barefoot or wear flip flop sandals. Locker room users also include business professionals exercising before or after work; these individuals may not wear typical gym-appropriate footwear for part of the time in the locker room. Common types of footwear are presented in List 3.

1. Dress shoes
2. Water shoes
3. Flip flop sandals
4. Barefoot
5. Sneakers

List 3. Common footwear and shoe types used in the locker room.

Having defined the common user groups (List 1), their walking paths (List 2), and the footwear used (List 3), the relationship between these factors must be considered. An understanding of what type of footwear is used in each part of the locker room highlights areas of heavy use, areas exposed to significant amounts of moisture because of walking path taken, and types of footwear that the sections of the locker room floor should be designed to accommodate. From consideration of the schedule of gym activities and knowledge of participant numbers for these activities, it is possible to obtain a good approximation of the number of gym users in each part of the locker room, for each shoe type. The areas of the locker room used and the associated shoe type data for each area, for a high-use summer week day, is compiled in Figure 2.

Figure 2. Total footwear types used in each region of the locker room, for the designated common walking paths from List 2. Approximation is based on programs available and typical attendance on a high-use summer week day.

Several items to note from Figure 2 include:

- The usage of flip flops is extremely common. The Mount Pleasant Recreation program offers many water activities, and these are well attended. Many of the attendees exclusively wear flip flops while in the locker room.

- The walkway areas experience the heaviest traffic; the restroom and shower areas are subject to the lowest traffic.

- With consideration of the common walking paths (List 2), all regions of the locker room may be exposed to, and should be designed to withstand, significant exposure to water. From users showering before entering the pool, to users returning from the pool and showering after gym usage, the restroom, changing area, and walkway to the lobby must withstand heavy traffic of users with damp footwear.

Many of these observations may perhaps be more easily made through studying Figure 3, a graphical compilation of the types of shoes worn in each locker room region, based on the data from Figure 2.

Figure 3. Shoe types used in various locations of the locker room for a heavy-use summer week day, based on the approximations from Figure 2.

HFE Analysis

Given data of the typical users, their walking paths, and their footwear, the flooring of the locker room should be designed to meet their needs. The current locker room flooring does not sufficiently meet the needs of the users in several ways. The primary factors of the locker room floor that are analyzed and may be improved upon are listed below:

Locker Room: Floor Level Changes

Changes in the level of the floor should be minimized. Bumps or dips in the floor may cause unsteady footing or tripping, and are difficult for individuals with limited mobility to navigate. At the same time, some changes of elevation are appropriate to allow for water drainage, so the potential detriments and benefits of change in floor level must be carefully balanced.

Floor level guidelines.

As a guideline for suitable changes in the level of the floor to allow for accessibility, ADA standards are applied. ADA standards allow for level changes under 0.25 inches; in these mild cases there is no required corrective action. For changes between 0.25 – 0.50 inches, a slope of less than 1:2 should be provided to taper the level change. Finally, level variations exceeding 0.50 inches should conform to the guidelines for ramps. (ADA and ABA Accessibility Guidelines for Buildings and Facilities, 2005, 303)

ADA standards recommend minimal change in elevation whenever possible, for accessibility. However, some changes in elevation are still needed for proper drainage; a completely level surface would not allow for drainage. The walkways in the locker room are not unlike sidewalks in terms of usage and exposure to moisture, so slope recommendations for sidewalks may be considered. For sidewalks, the length and width of the walkway may slope at up to 3% to allow for drainage, without posing a hazard. (Russ, 2002, p. 94) Another guideline for walkways suggests that a slope as

small as 0.5% is appropriate as even "minimal slopes… are enough to encourage drainage." (Creative Homeowner Press, 2006, p. 20) Using these guidelines, only the slightest of an incline is needed to achieve drainage.

With the current gym layout, elevation changes occur in several places, shown in Appendix A: the showers (elevated ledge), the mats outside of the showers (elevated), and the areas of drainage (depressed).

Showers and floor level.

Floor level changes in the showers are present as there are ledges about 3 inches high as individuals enter and exit the first four showers. This dimension obviously greatly exceeds the acceptable ADA guidelines outlined. However, the two larger and more accessible showers do not have this ledge. As these ledges are not present on all showers, as far as floor elevation is concerned the showers are accessible.

Mats and floor level.

The floor mats located just outside of the showers are about 0.375 inches in thickness. Per ADA guidelines, because this change in floor level is between 0.25 and 0.50 inches, the edge should gradually slope down to meet the floor, with less than a 1:2 slope. The edges of the current mats end abruptly; this is an area where improvement is needed.

Drainage and floor level.

The center of the walkway to the gym and pool entrance contains a drain, shown in Appendix A. The drain runs much of the length of this part of the walkway; it is approximately 180 inches long and 4 inches wide. On either side of the drain, there is about 5 inches of cement flooring that slopes down to facilitate water drainage. A cross-sectional diagram of the drain is contained in Figure 4.

Figure 4. Cross-sectional view of floor surface for the walkway to the gym and pool, containing the drainage channel.

As previously noted, the cross-sectional slope for walkways is recommended to not exceed 3 degrees; clearly this drainage channel does not conform to recommendations. The total drop is 0.88 inches, which exceeds ADA approved floor height changes. Per ADA guidelines, any drop that is in excess of 0.50 inches should be treated as a ramp. Thus, changes to accommodate ramp guidelines, or

modifications to lower the drop to less than 0.50 inches, or reduction of the incline to less than 3 degrees should be pursued for user safety and accessibility.

Locker Room: Drainage and Standing Water

As noted in the study of the common walking paths in Figures 2 and 3, by means of the common walking paths all areas of the locker room will be exposed to water. Current areas where there are problems with moisture and standing water, due to these walking paths, are shown in Appendix A. Drainage is a technique for reducing the amount of standing water and moisture present in the locker room. For drainage to be effective, in addition to the appropriate floor slope as previously discussed, it is also important that the design and placement of the drains be carefully chosen.

Drainage guidelines.

Areas of drainage could present a challenge or hazard to some locker room users if not properly implemented. The ADA recommendations for grating may be applied as a metric to determine acceptability of the current drainage design. Per the ADA guidelines on floor surface gratings, the maximum allowable spacing is 0.50 inches wide, with an orientation such that "…the long dimension is perpendicular to the dominant direction of travel." (ADA and ABA Accessibility Guidelines for Buildings and Facilities, 2005, 302.3)

Drainage design.

The drainage channel located in the walkway leading to the gym and pool meets the design criteria recommended by the ADA; the spacing is about 0.25 inches, and the wide dimension of the grating openings is 90 degrees from the direction of passage. This orientation is shown in an overhead view of the drain, in Figure 5. As the specifications of the design align with accessibility requirements, this drain poses no substantial safety concern.

Figure 5. Overhead view of floor surface for the walkway to the gym and pool, containing the drainage channel.

Drainage placement.

As shown in Appendix A, the drain currently runs down the length of the walkway towards the gym and pool. This placement of the drain may be compared to areas that are typically damp or contain standing water, also shown in Appendix A. Given that many wet areas are not addressed through the current drainage placement, this is an area where improvements may be adopted.

Locker Room: Floor Dimensions and Layout

The layout of the locker room must meet the needs of the typical users. While the dimensions of the overall space may not easily be changed, if there are factors of usage that indicate the current locker room size is inadequate, this is valuable information for future facility redesign. Also, the distribution of space in each of the main sections may be adjusted if two neighboring regions respectively have a surplus of dedicated space and inadequate dedicated space.

Size.

The locker room's overall size is approximately 650 square feet. The locker room typically accommodates anywhere from a single user, up to a peak usage of about 30 individuals. For locker room design, it is recommended that about 20 square feet be available per user. (Sawyer, 1999, p. 251) Given the size of the locker room and peak usage capacity, there is about 21.6 square feet per locker room user, which indicates that the floor dimensions are overall adequate.

Clearance.

The space afforded for people to move within the locker room is a fundamental floor design consideration. The basic zones of the locker room may be adjusted to accommodate clearance issues, if insufficient clearance is a factor.

For two individuals walking past each other, 55 inches is a desirable hallway width with 43 inches being an acceptable minimum width. (Kroemer, Kroemer, & Kroemer-Elbert, 2001, p. 357) When considering the needs of an individual with an assistive device such as a wheelchair, 60 inches in width is necessary for individuals to pass each other. (ADA and ABA Accessibility Guidelines for Buildings and Facilities, 2005, 305) It is not necessary that all areas be this wide, but some areas must have this width to allow for passing space.

The width of the main walkway in the locker room is 64 inches, which surpasses ADA requirements. The width of the showers and restroom passages is less than the required width for individuals with assistive devices to pass each other; however, individuals will not commonly pass each other in these areas so these dimensions do not restrict usage. The changing area is not accessible to all individuals with a walkway width of only 22 inches between the benches and locker room; inadequate space is given to this section of the locker room and the floor layout should be adjusted if possible.

Another metric that may be used to determine the adequacy of the walkway is consideration of the density of traffic during average and peak usage. The minimum comfortable width (W) is based on volume of users per minute (V), their speed in feet per minute (S), and space allocated per user in square feet (M). (Russ, 2002, p. 92)

Formula 1. Minimum width (W) of hallway calculation, based on speed (S), space module (M), and volume of traffic (V).

An average walking speed (S) is 4 feet per second, and the space module (M) may be about 3 square feet. (Russ, 2002, p. 92, 94) During average usage of about 3 persons per minute, a calculated 27 inches would be a desirable hallway width. The peak usage is about twice that, with 54 inches being a desirable corridor width. The current hallway width of 64 inches accommodates both average and peak estimates. As restroom, showers, and changing areas are not common through-ways for walking (per Figure 3), this metric is not considered for those regions.

Locker Room: Floor Surface Material Selection

Various properties of the floor surface materials should be taken into consideration. To meet the ADA requirements, the floor surface materials "shall be stable, firm, and slip-resistant." (ADA and ABA Accessibility Guidelines for Buildings and Facilities, 2005, 302.1) Furthermore, to meet the needs of locker room users the cleanliness and aesthetics of the surfaces should be considered.

Stability and firmness.

The locker room floor is a flat, immobile, mostly level surface that allows for the passage of individuals. This meets the requirement for stability. The tiled floor surfaces are firm, but the firmness of the carpeted surfaces must be evaluated. To be adequately firm the carpeting must be affixed to the floor, with no or minimal dense carpet padding, and with no more than 0.5 inch pile. (ADA and ABA Accessibility Guidelines for Buildings and Facilities, 2005, 302.2) The carpeting used is attached to the floor, including along the edges. No carpet pad is used and the type of carpeting is designed for high-traffic with a pile of well under 0.25 inches, meeting the recommendations for firmness.

Non-slip.

Ensuring that the locker room floor is non-slip is critical to safety. The recommended static coefficient of friction for walking surfaces is 0.5. At less than 0.2 the floor is too slick for safe walking; coefficients higher than 0.7 correspond with non-

slip strips, which exceed the needs of most flat floors. (Guthrie, 2003, p. 506) Many factors contribute to slip resistance including floor material, shoe material, cleanliness, dampness, and floor firmness, making the coefficient of friction difficult to measure. (United States Access Board, 2003) Because of this "it is not possible to designate a single slip measurement device as a representation of absolute value" (Miller, 2004) and thus some designer discretion must be used. An adequately nonslip surface may be achieved by many materials, including various kinds of carpets and tiles. (United States Access Board, 2003) Given these considerations, the tile and carpeted floor surfaces of the locker room are sufficiently non-slip.

Cleanliness.

Through standard cleaning products and methods the tiled surfaces of the walkway, restroom, and shower room may be well cleaned. However, carpet is not an ideal choice when considering cleanliness. Carpeting may hold moisture and subsequently promote bacteria growth and cause unpleasant odors. (Sawyer, 1999, p. 252; Stones, 1993) The growth of mold spores in the carpet is also a concern; the mold may exacerbate respiratory conditions. (FEMA, 2005) Given the users of the locker rooms and their common walking paths through damp areas, the health concerns related to the moisture-holding property of carpet is relevant. HFE countermeasures should be taken to promote reduced moisture and greater cleanliness.

Aesthetics.

The overall appearance of the locker room is an important part of promoting user satisfaction, for current users and prospective gym members. (Sawyer, 1999, p. 251) The floor is a significant part of the overall locker room appearance. Current weaknesses in the appearance include the chipping paint from the painted tile floor, the uneven cement along the drainage channel, and the lack of a consistent color palette in the locker room, to include the floor.

HFE Recommendations and Countermeasures

Given the HFE Analysis, many possible improvements may be made to the locker room floor at the R.L. Jones facilities.

Change from Carpet to Concrete

The carpeted area of the walkway and changing area adequately meet non-slip standards. However, carpeting is not a proper flooring material given the amount of moisture present and the ability of carpet to retain this moisture. More appropriate flooring for locker rooms is a concrete base, "painted with a sand mix." (Sawyer, 1999, p. 252) Many cleanliness, mold, bacteria, and odor issues associated with carpeting may be eliminated with this step.

Change from Painted Tile to Plain Tile

At present the tiled areas are painted and chipping. With the traffic and moisture in the locker room, preventing the chipping of paint is difficult. It is therefore recommended that unpainted tile be used in place of painted tile for the shower, restroom, and walkway leading to the gym and pool.

Additional Drainage and Water Control

As shown in Appendix A, there are many areas at present that suffer problems of standing water and do not have characteristics to promote drainage.

To address the standing water in the restroom area, a drainage channel that runs parallel to the sinks should be added. The flooring on either side of this drain should slope at about a 0.5-1% grade down towards the drain, for the entire restroom area.

To better address the standing water in the walkway, the length of the drain should be extended to run the entire length of the walkway. This will be possible once the carpeting is removed and replaced with concrete, per recommendation Change from carpet to concrete. Furthermore, at present only several inches on each side of the drain are sloped. The entire walkway floor surface should have a slope of approximately 0.5-1%, promoting water movement towards the drain. The current slope is too steep for safety, yet covers too small of an area to be effective. Decreasing the slope and increasing the area of the floor that contains this gentle slope will better promote both safety and drainage.

As yet another step to facilitate keeping the locker room floor surface dry, fans and dehumidifiers should be used. Fans may be wall mounted and dehumidifiers could be placed beneath the sink so that they do not obstruct traffic flow. Also, as part of the procedures for closing the facilities for the evening, all locker room doors should be propped open to promote air circulation throughout the night.

Floor Mats

The floor mats in the shower area allow users to avoid stepping in water. This solution is effective, but could be improved if the mats were contiguous and covered more area. The entire shower walkway should be covered with a strip of mats, and a similar solution should be considered in the restroom and walkway areas if the proposed slope change and additional drainage do not adequately address the standing water problem.

The current floor mats have edges that end abruptly. For their height of 0.375 inches, a tapered edge is needed for ADA accessibility guidelines; this should be considered as new mats are acquired.

Visibility of Floor Level Changes

The ledges in the shower area pose a potential trip hazard, and these are not easily noticed because they are covered in the same material as the shower floor. All floor level changes should be extremely visible to alert the user of the condition. For the shower ledges and any floor mats used, select a color that contrasts with the flooring.

Shorten Benches to Increase Accessible Changing Area

The analysis of size and clearance indicates that there is adequate accessible space in all areas except for the changing area. To make this area more able to accommodate individuals who use assistive technologies, in at least one changing area shorten the bench so that it does not extend as close to the changing area entrance. Shortening the bench by 20 – 30 inches will allow for more space for individuals with assistive devices to make use of this locker room zone.

Conclusions

Many aspects of the floor selection of the locker room inadequately meet the needs of the users at this time, but there are ways to address these problems. Over time, as many recommendations as possible should be instituted. In the short term, the addition of fans is probably the easiest change to implement, so this may be an appropriate first step. Replacing the carpeting will be a high-impact change, so that should also be highly prioritized.

The effect of these locker room changes may be measured in several ways. Having this area meet the user needs will reinforce a positive image of the gym facilities. Increased satisfaction may manifest itself in increased membership. The average usage of the locker room is another measure of success. At present, users may avoid the locker rooms for any of the reasons cited in the analysis. With the resolution of these problems, more gym members will likely be making use of the locker room facilities before and after their workouts. Finally, the increased accessibility and safety measures should result in fewer incidents of tripping and missteps in the locker room.

The locker room is, for many users, the first and last area of the fitness center they use. Redesign of the locker room floors, with consideration of the users, their footwear and walking paths, will allow for safer and more comfortable use of the facilities. Through better facility design, residents of Mt. Pleasant may more fully take advantage of recreational opportunities, allowing the Mt. Pleasant Recreation Center to

better achieve its mission of enhancing "…the quality of life for the residents of Mount Pleasant by offering a wide range of recreational and leisure opportunities." (Mount Pleasant Recreation Department, 2009)

References

ADA and ABA Accessibility Guidelines for Buildings and Facilities. (August 5, 2005). Retrieved July 16, 2009, from http://www.access-board.gov/ada-aba/final.cfm

Creative Homeowner Press. (2nd ed.). (2006). *Ultimate guide to masonry and concrete: design, build, maintain*. Upper Saddle River, NJ: Creative Homeowner Press.

FEMA. (2005, June 29). *Tips To Prevent Mold-Related Health Problems*. Retrieved July 20, 2009, from http://www.fema.gov/news/newsrelease.fema?id=17069

Guthrie, P. & Guthrie, J. P. (2003). *Architect's Portable Handbook : First-Step Rules of Thumb for Building Design.* McGraw-Hill Professional Publishing.

Kroemer, K., Kroemer, H., & Kroemer-Elbert, K. (2001). *Ergonomics: How to Design for Ease and Efficiency* (2nd Ed.). Upper Saddle River, NJ: Prentice Hall.

Miller, Barrett. (2004) *Ground and Floor Surfaces*. Retrieved July 26, 2009, from http://www.safety-engineer.com/adasurfaces.htm

Mount Pleasant Recreation Department. Retrieved July 10, 2009, from http://www.mtpleasantrec.com/index.cfm?section=1

Russ, T. H. (2002). *Site Planning and Design Handbook*. Hightstown, NJ: McGraw-Hill.

Sawyer, T. H., & Smith O. (1999). *The Management of Clubs, Recreation, and Sport.* Champaign, IL: Sagamore Publishing Inc.

Stones, J. & Yearns, M. (August 1993). Iowa State University. *Disaster Recovery: Making choices about cleaning wet carpet*. Retrieved July 20, 2009, from http://www.ces.purdue.edu/eden/disastertopics/extrainfo/mold/files/wetcarpet.pdf

United States Access Board. (2003) *Ground and Floor Surfaces*. Retrieved July 26, 2009, from http://www.access-board.gov/adaag/about/bulletins/surfaces.htm

Appendix A: Detailed diagram of locker room floor layout, materials, elevation, and standing water.