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Identification of Potential and Mitigation of Ergonomic Hazards in Stairs

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Abstract: Every job, even activity, has the potential for danger. Therefore, it is necessary to control hazards by looking for potential hazards that exist in work, work tools, workplaces and work environments, in order to reduce the risk of hazards occurring. Therefore, the aim of this research is to identify other Ergonomic Hazards to balance Job Demands and Worker Abilities. Occupational Safety and Health is not only carried out preventively by using Personal Protective Equipment but can be anticipated early by paying attention to design errors so that repairs, redesign or special handling are needed in an effort to reduce or even eliminate risks. This research will produce an Ergonomic Hazard List and mitigate the risk of danger to workers who are carrying out their work or people who are carrying out activities in a certain place. Not only when working, when doing activities you also need to pay attention to ergonomic dangers. Activities in public areas, including confined areas such as schools or campuses, must also pay attention to the potential ergonomic dangers involved. Of the many places to do activities, one of them is the stairs which have been identified as having the potential to be dangerous and pose a risk of injury. Therefore, a List of Potential Ergonomic Hazards on Stairs was designed.

Keywords: Ergonomic hazards; List of potential hazards; Mitigation of injury risk; Stairs

Introduction

Every job has potential dangers. If potential dangers are not paid attention to and controlled, they could potentially cause fatigue, injury, and possibly even work accidents (Ghahramani & Amirbahmani, 2022). Therefore, it is necessary to control hazards by finding potential hazards that exist in the work, workplace, and work environment, then identifying the hazards. Major Types of Potential Hazards in the Workplace; Potential Physical Hazards; Potential Chemical Hazards; Potential Biological Hazards; Potential Ergonomic Hazards; Potential Psychological Dangers; Potential Dangers of Work Procedures. Work, workplace, and work environment must not only be healthy and safe for workers but must be human-centered design (Nguyen Ngoc et al., 2022). Companies must not only carry out activities to protect Occupational Safety and Health through efforts to prevent work accidents and occupational diseases (PP No. 50 of 2012), but also establish K3 norms, standards, guidelines, criteria (NSPK) related to Ergonomics and the Environment Work (Permenaker No. 5 of 2018) (Lestari et al., 2022).

Therefore, it is necessary to identify problems resulting from Ergonomic Hazards (Teixeira et al., 2022). However, the newly identified Ergonomic Hazards are those that impact Musculoskeletal Disorders, even though the Ergonomics aspect is still broad (Macdonald & Oakman, 2022). So, his research will identify other Ergonomic Hazards based on other aspects to balance between Job Demands and Worker Capabilities. So that Occupational Safety and Health is not only carried out in a preventive way by using Personal Protective Equipment but can be anticipated early by paying attention to Design Errors in the workplace so that redesign or special handling is needed in an effort to reduce or even eliminate sources of Ergonomic Hazards (Bauchner et al., 2020). So that the workplace is not only

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safe and healthy but comfortable as well as effective and efficient (Voordt & Jensen, 2023).

This research will produce a list of ergonomic hazards to humans or workers who are doing their work in the workplace. This list of Ergonomic Hazards can be used as a basis for preventing unhealthy conditions and accidents for workers who are doing their work in the workplace, both in Indonesia and in any country (Sukapto et al., 2019). The Ergonomic Hazard List can also be used as a basis for redesigning or even designing new workplaces and work methods (Quiroz-Flores et al., 2023). This research is included in the category of producing new concepts in dealing with the Occupational Health and Safety of workers who are doing their work in the workplace, especially on stairs.

The workplace in question is not only the production floor in the factory but also includes offices. Not only when working, but when doing activities, you also need to pay attention to Ergonomic Dangers. Activities in public areas, including limited areas such as schools or campuses, must also be considered regarding the potential ergonomic hazards therein (Jacquier-Bret & Gorce, 2023). Therefore, as a pilot project, this research will be carried out at the Pasundan University Campus, Faculty of Engineering Building, Jalan Setiabudi Number 193, Bandung City, to answer: How to identify and create a list of Potential Ergonomic Hazards and Risk Mitigation for activities on stairs? The aim of this research activity is to create a list of potential ergonomic hazards on stairs. After having a List of Potential Ergonomic Hazards, you can then analyze the risks and find ways to prevent the risk of activities on stairs for humans from occurring. Before the risk of danger harms or even injures humans, it must be ended by anticipating or mitigating the danger by using protective equipment and even redesigning or designing new stairs.

Method

The following are the stages of identifying potential dangers: Identify the object to be researched, Check the initial conditions, check records of accidents that have occurred, review potential dangers, Record information on potential hazards; Analyze the risk of danger Stairs, which relate to the length of the stairs, width of the stairs, the height of the stairs, height of the banister, the width of the banister. Slippery floors on stairs can cause someone to slip and fall down the stairs. Cracked or chipped floors on stairs can cause someone to trip and fall down the stairs. Insufficient lighting can cause the steps of the stairs to be invisible and can cause falls.

Result and Discussion

Based on the results of observations and data collection, all the stairs of Buildings A, B, and C at the Pasundan University Faculty of Engineering Campus, Jalan Setiabudi number 193 Bandung City are functionally fulfilled, because they function to climb to the upper floor and descend to the lower floor with Good. In terms of ergonomics, the anthropometric aspect of all stairs is in accordance with the standard specifications for making stairs, but this does not mean that there are no deficiencies or problems in other aspects as follows:

Visual Factors

Visual factors are considered to play a major role in successfully utilizing the function of stairs (Errida & Lotfi, 2021). Where visual input is required at some phases: The first phase of initial conceptual scanning for sensory input is to look at the ladder from the first moment before taking a step to the last rung. The second phase is detecting danger, where the eye needs to be more careful about where it is when finding potential danger. For example, in the location in Figure 5 Stairs, Side-2 Right of Building C, where there is no handrail, you need to be more careful when going up and down the stairs further to the side to hold on to the wall. The third phase is route choice, where generally the left-hand route is for going up and down, but if a danger or irregularity is identified, such as water or a cracked or broken surface, a safe route can be created.

The fourth phase is the visual perception of step location, where it is ensured that the foot will be placed in a specific location on the Run (step). To ensure that the footrest is the support for the body's mass. The fifth phase is a continuous monitoring scan. Continuous monitoring scans will determine the success of traversing the stairs. The monitoring scan must be done until both feet land on the ground floor (Elgrishi et al., 2018). Because accidents at the end of the journey on the stairs are the most common. Including what happened several times at the location in Figure 1. Middle Front Stairs of Building C. This possibility is for all stairs, including those on the Unpas Faculty of Engineering Campus. Disruptions to this process place users at increased risk of falls.

Focal and ambient vision are differentially affected by retinal image degradation (Luu et al., 2021). Focus functions such as sharpness and contrast sensitivity are quickly degraded by blur and by reduction of luminance below photopic (daylight) levels. For example, the location in Figure 1 Middle Front Stairs of Building C above and Figure 3 Left Side Stairs-1 of Building C with dark gray color on all areas of the stairs with the same

material, makes it impossible to focus because there is a reduction in sharpness and contrast sensitivity is quickly degraded by blur and by reducing the luminance so that it looks like a flat plane. Disruptions to this process also place users at increased risk of falls.

Experiments have shown that the distance between the swinging leg and the edge of the ladder can be as little as 3.7 mm in healthy individuals. It has also been shown that visual challenges, such as reduced illumination or blurring of the visual field, will result in increased clearance and thus uncontrollability. Disruptions to this process also place users at increased risk of falls.

Somatosensation (Biomechanics)

It is well known that the ability to perceive vibration and light touch pressure decreases along with other peripheral sensory functions such as joint proprioception (mainly due to muscle spindle output). During normal aging due to what is generally considered age-related peripheral neuropathy (Yuan et al., 2018). The functional result of this is performance degradation in tasks that depend in part on sensory feedback. A significant decrease in stability when standing still may result in more falls. So, people who are elderly or who have had a stroke are more at risk of falling when moving on stairs.

Cardiovascular Demands (Physiology)

Going downstairs is much less metabolically demanding than climbing stairs (Xu et al., 2023). Estimates of the magnitude of stair propulsion energy, like most other physiological and biomechanical variables, are highly dependent on gait speed and stair dimensions. Bassett et al. (1997) have reported that the gross energy cost of climbing stairs at 70 steps (20.3 cm, or 8-in, step height) per minute for 20 healthy young men and women is approximately 8.6 METs (a multiple of resting metabolic rate: 1 MET -3.5 ml 02/kg/min) while the down cost is about 2.9 MET. This compares with a typical value of 2.53 METs when walking at 2 miles per hour (3.6 km/h, 0.9 m/sec). It has also been stated that the absolute energy cost for climbing one step is about 0.15 kcal and for descending the same step at 0.05 kcal. So, when you climb stairs it is much harder, and you need more energy, therefore you need to be prepared to climb the stairs so you don't run out of energy and then become limp and unbalanced and fall.

Musculoskeletal Factors (Gotrak)

The range of motion of the lower extremity joints required for climbing and descending stairs is very large. Based on a simple kinematic model, (McCabe et al., 2023) estimated that the knee joint would flex through a range of between 70 and 98 degrees on stairs with an angle to the horizontal of 200–250 degrees, respectively, with 90 degrees of flexion required at an optimal stair angle of 300 degrees. So, you need to have flexibility in your knee joints when walking up stairs.

Joint Diseases and Surgery (Gotrak)

Given the large range of motion and considerable strength demands mentioned previously, stair activity can clearly be a very demanding task for individuals with joint disease or those recovering from injury (Fletcher et al., 2001). It is significant that the Knee Society Clinical Rating System devotes 50 points out of a total of 100 in its functional component to the ability to walk up and down stairs without the use of handrails or assistive devices. So, at the location Stairs Side-2 Right of Building C, where there is no handrail (banister), you need to be more careful by going down and up the stairs further to the edge to touch the wall so that there is balance support and pressure reduction.

Cognition

Cognitive function is another aspect of stair descent that has received little attention despite numerous studies showing that cognitive impairment contributes to an increased risk of falls (Charette et al., 2020). Templer has predicted that cognitive function is a key factor in successful stair navigation due to the need to integrate multiple forms of sensory input received during this complex locomotor task (Sienko et al., 2018). This may be especially true in public stairs, where the frequency of unexpected events is greater and the geometry of the stairs is unknown. So before going up and down the stairs, you must begin the process of orientation towards the stairs.

Neurological Disorders (Gotrak)

Disorders associated with stroke, Parkinson's disease (PD), or other neurological disorders are common and may be characterized by decreased strength, loss of coordination, delayed muscle responses, cognitive and emotional difficulties, and deficits in vision and somatosensation (Gandolfi et al., 2019). After a stroke, reduced strength is often compounded by abnormal and variable muscle synergies, making gait and activities of daily living very difficult (Seo et al., 2020). Moreover, using stairs can be very dangerous because reduced, let alone loss of muscle response coordination, will cause falls.

Risk Mitigation

Activities to determine the level of possibility or frequency of risk occurrence as well as the level of impact on achieving goals or targets by considering control activities called Risk Analysis that have been

carried out (Aven, 2016). Next is mitigating reducing or even eliminating the possibility of risk occurring by designing or redesigning to eliminate potential dangers. Recommended designs or design improvements (Ahmed, 2017): Replace the stair material, especially the run section, so that it is not slippery, especially if exposed to rainwater. Use wet anti-slip material, such as rough ceramic or coated with rubber (Sudoł et al., 2021); Add a trim at each end of the steps, especially the Run (step) part of a different color to the Run (footing) color so that it is not blurry but the end is clearly visible, making it easier to get the right time to swing or step onto the next Run (step); Use another base color and with the symbol number Zero (0) for the field or ground floor after passing the last Run (step) when descending the stairs (Gascon et al., 2017).

For example, the last run (footing) is given the number One symbol, then the field or ground floor is given the number Zero symbol with a green base. So that no one will ever assume or assume that the last Run (footing) is the field or ground floor (Dwivedi et al., 2023); Provide bright enough lighting in the stair area so that each step is clearly visible, especially in the afternoon or evening (Ticleanu, 2021); Provide a handrail (banister) on each stair, both for going up the stairs and for going down the stairs; Create maintenance procedures for the stair area so that it is always clean and there are no cracked, broken or peeling surfaces of the steps.

This includes cleaning handrails so that hands remain clean and checking handrails so that there is no potential for injuring hands; Make it a rule that when descending or climbing stairs you must use the path on the left side, including keeping your luggage from touching other people; Make an agreement that when an elderly person or someone who has had a stroke uses stairs, someone must supervise or accompany them; Warn people who are going up the stairs to prepare their energy so they don't run out of energy and then become weak before reaching the top of the stairs; Help hold hands or provide support for people who experience stiff knee joints; Develop a culture so as not to force people to rush when going down and up the stairs.

Conclusion

Meanwhile, after the List of Potential Hazards and Risks of Injury on stairs is designed, it can be used by people who will design activities in certain locations or areas to pay attention to these potential dangers so that in the design the potential dangers are non-existent or minimal. People who own or provide activities in certain locations or areas, must repair or modify them so that the potential dangers are not as sensitive or are reduced or even eliminated so as not to cause injury to people carrying out activities in that location or area. People doing activities in certain locations or areas can be more alert or careful so as not to have an accident and then get injured. This list of Potential Hazards and Injury Risks can be used anywhere in the world because a list like this does not yet exist.

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Author Contributions

Conceptualization, C. H. S. A, P. M. Z, T. R, R. A. E, M. N. S.; methodology, C. H. S. A.; validation, P. M. Z. and T. R.; formal analysis, R. A. E.; investigation, M. N. S., and C. H. S. A.; resources, P. M. Z. and T. R.; data curation, R. A. E.: writing-original draft preparation, M. N. S and C. H. S. A.; writing—review and editing, P. M. Z.: visualization, and T. R.and R. A. E. 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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