

## A Review of Studies Concerning Prolonged Standing Working Posture

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**Keywords:** prolonged standing, physiological discomforts, musculoskeletal disorders, fatigue, ergonomics intervention, working posture

**Abstract.** Standing is one of the most preferred working postures in the manufacturing field as it provides a large degree of physical freedom and mobility to the human operators. In addition, the cognitive perceptions of the increase in work effectiveness and productivity rate among the human operators are the reasons this working posture is practiced. However, to stand erect for a long period of time or otherwise known as Prolonged Standing often leads to physiological discomfort, fatigue and even health issues such as Musculoskeletal Disorders (MSDs). The aim of this paper is to review on the effects resulting from Prolonged Standing and disseminates the information on the ergonomic interventions to relieve standing fatigue. Selected journals and research papers related to Prolonged Standing were reviewed and the findings showed that varying the floor conditions such as installing anti-fatigue mat and using shoes with soles would help in relieving discomfort associated with the cumulative effects of Prolonged Standing. Nevertheless, further research is needed to truly quantify the effectiveness of these suggested ergonomics interventions in real world implementations such as in the manufacturing industry.

### Introduction

Prolonged standing as a working posture for human operators is a very common sight in manufacturing plants which utilize the assembly lines concept [1, 2]. Though this particular working posture is being held responsible to the prevalence of psychological and muscles fatigue among human operators [2, 3]; the working posture is still being continuously practiced globally [1, 2]. This study suggests that this is perhaps due to the cognitive perception of the increase in productivity rate and work effectiveness among the human operators while assuming this working posture.

This study aims to review literature related to prolonged standing with a special focus on the outcomes of the ergonomics interventions in relieving the psychological and muscles fatigue closely associated with the topic as experienced by the human operators. In addition, the physiological defects from assuming the working posture and the results or the effectiveness in the implementation of the ergonomic interventions would be disseminated in the industry to elevate awareness and for counter measures to be implemented where necessary.

### Effect Resulting from Prolonged Standing

The Oxford Dictionary defined 'stand' or 'standing' as "to maintain an upright position, supported by one's feet", while, 'prolonged' is "continuing for a long time or longer than usual" [4]. Hence, based on previous literature [2,5], this study defined 'prolonged standing' as 'the working condition in which the operator continue to assume the standing working posture for over 50% of total working hours during a full work shift'.

In [2], it was noted that 'standing' is a practical working posture for the human operators when they were required to deal with heavy equipment and products, reaching materials and goods, and

pushing and pulling excessive load. However in prolonged standing cases (static standing with minimal movement), this working posture results in occupational injuries [2]. The literature [1, 3, 6, 7, 8, 9, 10] showed that prolonged standing leads to physiological discomfort, muscle fatigue, pain and could also contribute to the development of severe health hazards such as Musculoskeletal Disorders (MSDs) with special focus on regions such as the back, leg and foot of the operator. It was documented that if preventive actions are not taken once physiological discomfort is experienced as a result of prolonged standing (for example at the neck and shoulder regions of the upper extremities), the human operators would also have the tendency to later suffer from discomfort and fatigue in the lower extremities as well [8]. This is particularly in the lower limb muscles (leg and thighs), lower back and feet [8]. In addition, constrained standing work conditions such as prolonged standing work or static working posture may also cause the formation of leg edema due to muscle fatigue and discomfort [6, 11, 12].

The discomfort rating associated with various body parts may depend on several variables such as height, weight, age, and job tenure [7, 12]. These (the variables) stressed that human anthropometry would also influence the discomfort severity level as experienced by the human operators who were exposed to prolonged standing work. From an 8 hour shift assessment [7], it was noted that short stature subjects reported greater general fatigue and greater specific discomfort associated with the lower legs, knees and upper back while standing on hard floor. The same study also noted that greater discomfort at upper legs and lower backs regions were documented when the subjects were to perform prolonged standing on a mat for the following week and wearing shoes in soles for another week. It was further added that age was also an important risk factor since older subjects recorded higher discomfort ratings in their feet and hips while standing on wooden floor as well as greater leg fatigue and discomfort in their feet and low back when standing on mat [7]. King [7] continued to highlight that, in correlation with age, the bodily area most strongly affected by discomfort are the joints.

As aging is inevitable, the muscles, joints and bone also show age-related degeneration. With aging comes the shrinkage of muscles in term of size and density, hence, causing the reduction in muscles strength. This is the argument on why a senior human operator (in terms of life age) would faces higher difficulty in terms of holding the same working posture (such as prolonged standing) in comparison to younger subjects. Joints movements are facilitated by synovial fluid as a lubricant within the joints and due to the natural ageing process, the quantity of synovial fluid would decreases, resulting in stiffness and less flexible motions of the joints [13]. Due to this, senior human operators (in terms of age) tend to experience a higher level of discomfort and fatigue primarily at the joint structures as mentioned by [7].

From the perspective of this study, it is very disadvantageous to work in a prolonged static standing working posture since a person's total body weight would be fully supported by the lower extremities. This will results in static loading on the lower extremities such as the knee joints and especially the feet, thus leading to the prevalence of discomfort and fatigue. Prolonged exposure to such working conditions might lead to injury due to the case of ischemia [14]. In addition, Chester et al., added that in comparison with sitting or sit/stand conditions; prolonged standing was found to cause the highest severity of discomfort, fatigue and overall tiredness [3]. In another study, it was also recorded that prolonged standing during monotonous task may lead to stiffness in active muscles [1].

In terms of job tenure, King highlighted the positive relations between the duration of time spent in a standing working posture in various flooring conditions and the discomfort ratings of certain body regions [7]. For instances, for the duration of one week time period, the higher rating of discomfort was obtained in the hip area while standing on a hard floor, while greater discomfort ratings for the feet and knees were recorded for standing on a mat [7]. Hence, this study emphasized that the exposure time to prolonged standing job was related to the operator's discomfort, most probably due to the relationship between muscular strength exertion and endurance [14]. Kromer et al., further noted that the exertion of strength given by a muscle was inversely proportional to time; the higher amount of strength exertion by a given muscle results in shorter time period the strength

could be maintained [14]. Therefore, this study concluded that performing a task in the prolonged standing working posture would reduce muscle strength due to the need to endure continuous muscle exertion.

Nevertheless, it were revealed that age and job tenure only have small negative relations between lower leg volumes while exposed to three different flooring conditions [7, 12]. Zander et al., found that the increment of lower leg volume was proportional to the individual's weight in a test where the subjects were assessed in three standing surface conditions comprising of wooden block floor, anti-fatigue mat and shoe in-soles for an 8 hours shift [12].

As prolonged standing had been found to be related with low back pain symptoms in the working population, the effects of prolonged standing to individuals with chronic low back pain in comparison to healthy individuals was highlighted in another study [15]. The study showed the increased in the center of pressure (COP) root mean square (RMS), COP speed and COP frequency in the quiet standing trial (stand as still as possible for 60-s) after prolonged standing task compared to the COP RMS, COP speed and COP frequency before prolonged standing quiet standing trial indicated that chronic low back pain subjects were influenced by the prolonged standing task [15].

Additionally, Lafond et al., observed that chronic low back pain subjects presented a greater rate of fatigue and poor performance in back endurance extension test, though showing less postural changes in the antero-posterior direction with decreased postural sway during prolonged standing task compared to healthy subjects [15]. Lafond et al., also mentioned that individuals with chronic low back pain might have altered sensory-motor function for being unable to generate responses similar to those healthy subjects during prolonged standing [15]. This may contribute to chronic low back pain persistence or increased risk of recurrent back pain [15]. Nevertheless, in a more general perspective, lower back pain was consistently reported to be a common effect resulting from prolonged standing [2, 7, 11, 16].

Furthermore, aside from experiencing several body regions of discomfort, it was also founded that prolonged standing may contribute to severe health problems such as chronic venous disorders, circulatory problem, possibility of increased in the risk for stroke, difficulty in pregnancy, and degenerative damage to the joints of the spine, knee, hip and feet [8]. Halim et al., stressed that prolonged standing may results in performance decrement (such as low productivity and efficiency), increased medical costs and demoralized human operators. In short, based on these findings, this study concluded that long term exposure to prolonged standing job is very hazardous as it leads to occupational injuries [2]. Thus, this study emphasizes that it is best to minimize, if not totally avoid, prolonged standing.

## **Review on Ergonomics Interventions**

Frank et al., defined “ergonomic interventions” as “a way in reducing both the incidence of initial work-related musculoskeletal disorders (WMSDs) and/or reducing disability from injuries, their personal costs and the monetary costs associated with them effectively” [17]. With regards to prolonged standing exposure, ergonomic interventions were widely used to handle standing fatigue as well as to improve human operator's health. Among the most common ergonomics interventions being utilized with respect to prolonged standing were varying the floor conditions such as installing anti-fatigue mat and using shoe in-soles [6, 7, 8, 12].

### **Anti-Fatigue Mat.**

Julia and Zawiah, and King found that the level of stress and fatigue resulting from standing working posture could be reduced with the use of padding over the floor such as utilizing carpets, cushioned mats or so called “anti-fatigue” mats or even card board especially in the lower extremities of the body such as the lower leg and foot [7, 11, 12]. Soft mat generally reduces worker perceived discomfort during prolonged standing in comparison with those human operators standing on a hard floor; and prolonged standing on a mat was always more comfortable than standing on the hard floor whether barefooted or wearing shoes [6]. Although softer floors provide

less muscle fatigue and more comfort especially for lower back and other lower extremities, it should be noted that floor material that is too soft could also affect the level of standing stability, hence, may increase muscle demands [9]. This in return would eventually result in muscular fatigue [9].

Also, AORN noted that anti-fatigue mats were designed to cause a slight postural sway that induced minor activation of leg muscles, improving blood flow and thus, decreasing fatigue and reducing blood pooling in the lower leg feet which causes swelling [9]. This was supported by Halim et al. who stressed that the application of anti-fatigue mat could be an alternative solution to minimize the risk of discomfort and muscle fatigue associated with prolonged standing [2].

Additionally, another study has agreed that the application of anti-fatigue mat was capable in releasing muscle fatigue in the feet as well as improving body comfort and occupational health during prolonged standing task [8] and King [7] indicated that floor mats tended to be widely used throughout the assembly plant.

The application of the anti-fatigue mat is quite feasible as it is a usual choice if the human operators would stand in a single workstation. However anti-fatigue mat usually wears out after being installed for quite some time and needs to be replaced. Therefore, it is recommended to investigate on the best shock absorbing materials and the longevity time of the anti-fatigue mat once installed. This will help the management to provide better standing workstations especially for prolonged standing jobs.

### **Shoes In-soles.**

Another potential ergonomics intervention in reducing pain and discomfort in prolonged standing conditions among human operators is wearing shoes in-soles. It was perceived that shoe in-soles as a mobile mat and wearing shoe in-soles are more comfortable than standing on a hard floor [7] and shoe in-soles have been proven to effectively improve comfort and reduce back, leg and foot pain in individuals who must stand throughout their working day [18].

In contrast, Zander et al. emphasized that shoe in-soles were less often used as an ergonomic intervention technique to reduce pain and discomfort in the feet and lower leg among human operators, perhaps, due to the company's policy which allowed their employees to wear their own choices of footwear [12]. Prat found that viscoelastic material for shoe in-soles had been found to have the best long-term ability to maintain a cushioning effect since the material's shock attenuating properties performed well after 1 year of usage [19]. Also, Redfern and Chaffin as cited in Zander et al., emphasized on the positive outcomes of reducing subjective body fatigue and discomfort in a field study during an 8 hour work shift of wearing a viscoelastic shoe in-soles and mats of mid hardness [20]. In addition, it was revealed that subjects generally experience less discomfort when wearing shoe in-soles or the combination of mats and shoe in-soles condition in contrast to only standing on floor mats [7].

This study concluded that the use of shoes with in-soles are more suitable for mobile staff such as engineers and supervisors where the application of anti-fatigue mat does not suit them as anti-fatigue mat could only suit human operators who work in a fixed workstation. The engineers and supervisors are commonly known to be highly mobile during their working hours as experienced by the author. The management should include in their policy to provide shoes with in-soles in their Personal Protective Equipment (PPE) to all of the human operators especially for those who are involved with prolonged standing jobs.

### **Overview and Combined Use of Ergonomics Interventions**

The effectiveness of these interventions has yet to be validated especially in the industry. Further research is needed to establish the relationship between prolonged standing effects and ergonomics interventions. Although Lin et al. [6] had a limited exposure time of 4 hour shifts and Zander et al. [12] studied on the exposure of 8 hour shift; both studies agreed that modifying the floor condition might control and alleviate leg edema for standing human operators whether it were in a laboratory

or industry settings. Even so, it was reported that the implementation of ergonomic interventions such as floor mats, in-soles and shoes played little role in reducing discomfort and fatigue due to prolonged standing [6, 12]. King also found that for individuals with high duration job tenure, standing on a hard floor surface or standing on a mat (anti-fatigue) were still unsuitable since it would still cause physiological discomfort especially in the body joints such as knees, hips and feet [7]. This study concluded that it is still necessary for the management to pay close attention on the duration of time being spent by the worker in assuming the prolonged standing posture. Based on these findings, this study suggested that to minimize physiological discomfort resulting from prolonged standing, there is a need to view the issue from the overall perspective, for instance, from the perspective of the condition of the workstation (flooring condition), the job (duration of work) and the operator (age, fitness, anthropometry).

## Conclusion

In conclusion, prolonged standing working posture could lead to physiological discomfort, fatigue and even health issues such as Musculoskeletal Disorders (MSDs). Thus, it is not recommended to assume the particular working posture for over 50% of total working hours during a full work shift. Variables such as weight, height, age and job tenure need to be taken into consideration as these variables are related to the discomfort rating associated with prolonged standing. The implementation of ergonomic interventions such as modifying the floor condition, utilization of anti-fatigue mats and to wear shoes with in-soles are still inconclusive in minimizing the risk of standing fatigue and discomfort among the human operators. Therefore, this review urges for further in-depth research to be conducted in quantifying the effectiveness of these suggested ergonomics interventions in the real world implementation such as in the industry.

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