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PHYSICAL ACTIVITY AND POSTURAL STABILITY AMONG INDONESIAN CONSTRUCTION WORKERS: A PRELIMINARY STUDY

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ABSTRACT

Introduction: The higher workloads experienced by construction workers reflect the higher physical demands of construction work. Prolonged workloads are responsible for up to 60% of chronic fatigue, diseases, and injuries among construction workers. Individuals need to develop their balance to support physical activity in order to improve their quality of life. Abnormalities in the balance of construction workers is associated with an increased risk of falls. **Aims:** This preliminary study aims to assess the relationship between physical activity and postural stability among Indonesian construction workers. **Methods:** A total of 118 healthy male construction workers without health problems were recruited for this study. Their physical activity levels were measured using the Baecke questionnaire for work, sports, and leisure time, while their postural balance was assessed using the one-leg standing test. **Results:** This study found a significant difference between physical activity in sports and during leisure time compared to activity at work ($F_{2.234} = 149.3$, $p < 0.0001$). In addition, this study found a weak correlation between physical activity at work and postural stability among construction workers ($p = 0.006$, $r = -2{,}498$). **Conclusion:** These preliminary findings indicated that construction workers had higher levels of physical activity at work. However, no correlation was found with postural stability. Further research is needed to investigate larger sample sizes with similar characteristics.

Keywords*:* physical activity, balance, postural stability

INTRODUCTION

The construction industry provides employment to many people around the world (Zerguine, Tamrin and Jalaludin, 2018). In developing countries, between 30 and 40 percent of the population works in the construction industry. Indonesia had 192,000 certified construction workers between 2005 and 2008, averaging 50,000 workers per year. In 2019, the number of construction workers in East Java increased significantly compared to the previous year (Statistics Indonesia, 2019). These data showed a correlation with an increase in the workload of construction workers (Hashiguchi et al., 2020). The construction industry is known to be one of the most dangerous sectors in terms of injury and death occurrences (Zerguine, Tamrin and Jalaludin, 2018). There is a correlation between prolonged workloads among construction workers and negative outcomes, such as chronic fatigue, injuries, and illnesses, that decrease productivity (Hashiguchi et al., 2020).

Construction workers with higher workloads have a higher level of physical activity (Kusumo, 2021). Physical activity refers to bodily movements that require energy and power. In addition, human physical activity is associated with quality of life, health, and well-being (Cheah et al., 2017). Individuals need to develop their balance to support physical activity in order to improve their quality of life (Kananda and Megawati, 2020). Balance refers to the ability to maintain the projection of the center of gravity in any position, such as standing, sitting, and

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walking (Jennings et al., 2015). Previous studies have shown that construction workers experience various problems, including musculoskeletal disorders due to the type and history of work (Alghadir and Anwer, 2015). In addition to musculoskeletal disorders, balance problems among construction workers have been associated with an increased risk of falls (Jebelli, Ahn and Stentz, 2016a).

Construction workers are at a high risk of falls caused by slipping, spraining, and tripping (Faude et al., 2015; Antwi-Afari et al., 2018; Cyma et al., 2018). In Australia, 23% of non-fatal falls among construction workers were due to loss of balance (Safe Work Australia, 2016). In Hongkong, falls account for 35% of the highest number of fatalities (Antwi-Afari et al., 2018). Internal factors affecting accidents include age, experience, and physical condition, while external factors include terrain and environmental conditions (Faude et al., 2015; Cyma et al., 2018; Clemson et al., 2019). Previous studies have shown that lower stability among construction workers increased the number of work-related injuries.Other factors, such as muscle imbalances, bone problems, and scars, can also affect posturalstability (Palikhe et al., 2020). To prevent falls due to instability, a report from Europe recommends assessing postural stability, neuromuscular coordination, and sensorimotor function. Assessing postural stability is highly recommended as it can help prevent work-related injuries. Workers who need to undergo balance tests include construction workers who work at heights above three meters, in outdoor areas, and on hanging boards (Zamysłowska-Szmytke and Śliwińska-Kowalska, 2012).

Several tests can be used to assess balance. These include standing on an uneven surface and standing on high or low ground (Pourkazemi et al., 2016). The way people maintain their body affects their body control. In addition, changes in postural stability are associated with changes in balance due to physiological alterations and anxiety states (Zemková and Zapletalová, 2022). Moreover, work experience is correlated with postural stability as less experienced construction workers exhibit less stability (Min, Kim and Parnianpour, 2012).

Postural control or stability can be achieved through proper balance. The sensorimotor interaction between stability and environment role is complex and requires a certain skill to achieve postural control (Ivanenko and Gurfinkel, 2018). Standing is often the dominant posture when performing motor activities (Haddad et al., 2013). Situational factors can significantly influence postural control. For instance, construction workers often face challenging physical conditions such as adjusting to heights, uneven surfaces, crouching, squatting, sitting, or sudden changes in posture. In order to cope with these challenges, they need to have stable postural and body control. Having a flexible postural control that can cope with any perturbation allows these challenges to be met (Paillard, 2019). In addition, this allows for increased activation of the motor activities. A previous study has shown that individuals who engage in long-term training possess more stable postural control (Paillard, 2017).

The study on physical activity and balance primarily focused on the elderly as a sample population. A study measured balance in healthy elderly individuals with cardiovascular diseases who engaged in physical activities (Iwakura et al., 2016). In addition, previous studies on physical activity levels have included a sample of construction workers who worked at heights (Cyma et al., 2018).

However, the study only focused on workers who worked at heights and compared the results with those of office workers. Other studies investigate the relationship between physical activity levels with postural stability, particularly on Indonesian construction workers.

According to data published by the Indonesian Ministry of Manpower and Transmigration, accidents in the construction industry are the highest among all industries (Ghuzdewan and Damanik, 2019). The construction industry had the highest accident number of accidents (31.9%), followed by the manufacturing industry (31.6%), traffic accidents (2.6%), and others (23.8%). A previous study conducted in Indonesia analyzed the causes of accidents in the construction industry and found that electrocution, falling of heavy objects, and falling from heights were the most common causes (Sholih, 2018). Despite the availability of advanced tools to assist workers, accidents remain high due to unfamiliarity and lack of skill in using those tools. Several factors, such as heavy equipment, harsh workplace environments, and mobility during work, increase physical activity levels in addition to the actual work-related activities. Furthermore, previous studies have shown a correlation between falls and unstable postural control (Jebelli, Ahn and Stentz, 2016b). The safety policy in Indonesia has been in place for a long time and the use of personal protective equipment has been a topic of discussion. However, in addition to the use of personal protective equipment, it may be necessary to improve physical condition, particularly postural control, as a preventive measure. Therefore, this preliminary study aims to investigate the relationship between the levels of physical activity and postural stability among Indonesian construction workers. Physical activity levels at work were assessed using the Baecke questionnaire, while the postural stability was assessed using the one-leg standing (OLS) test.

METHODS

Characteristics of participants

A total of 118 healthy male construction workers participated in this study. Participant were required to be between 20 and 60 years old, active construction workers with at least one year of experience, communicable, without health problems, visual problems, or lower extremity disorders, have high physical activity levels at work, and willing to participate (Cyma et al., 2018). Informed consent was obtained from all participants and the details of the study were explained to them. This study received ethical approval from the Health Research Ethics Committee of the Faculty of Medicine, University of Muhammadiyah Malang with a certificate number E.5.a/074/KEPK-UMM/V/2022.

Procedures

A sheet was prepared to identify the data of the participants andtheir experiences as construction workers. To measure physical activity levels at work, the Baecke questionnaire that had been tested for reliability and validity was used to evaluate habitual physical activity not only at work, but also during sports and leisure time (Cyma et al., 2018). The questionnaire, which has been used and modified in previous studies, consists of eight questions about physical activity at work, six questions about physical activity during sports, and four questions about physical activity during leisure time (Rocha et al., 2022). To measuring physical activity levels, the following formula was used: ([6 Q2] + [Q1 + Q2 + Q3 + Q4 + Q5 + Q6 + Q7 + Q8])/8 for work; (sport score + Q10 + Q11 + Q12)/4 for sports; ([6 Q13] + [Q14 + Q15 + Q16])/4 for leisure, where Q represents the question number (Healey et al., 2020). The results of the Baecke questionnaire were interpreted in three groups: low (score less than 5.6), moderate (score between 5.6 and 7.9), and high (score greater than 7.9). After obtaining the results of the physical activity levels, a balance test was conducted to determine postural stability.

To determine postural stability, the one-leg standing(OLS) test was used. This clinical test measures static balance and is

designed to be performed with andwithout visual control (Cyma et al., 2018). The validity and reliability of this test have been well-established. The participants were asked to stand straight on one dominant leg without footwear, with their arms down along their hips. In addition, they were instructed to focus on a single point at eye level in front of them. A stopwatch was required to count down the time and stopped when the participant's leg touched the ground or when the participant's arm moved away to stabilize the body. The test results were interpreted in several conditions: low (less than 10 s), moderate (less than 30 s), and high (more than 45 s) (Blodgett et al., 2022).

Statistical analysis

All statistical analyses were performed using GraphPad Prism version 7 (GraphPad Software 2365 Northside Dr. Suite 560 San Diego, CA 92108). A one-way analysis of variance (ANOVA) was used to analyze the physical activity levels of construction workers at work, during sports, and during leisure time. In addition, the Pearson correlation coefficient was used to analyze the correlation between physical activity and postural stability in each group. The two-tailed correlational significance level was set at 0.05 ($p < 0.05$).

RESULTS

Figure 1 shows the characteristics of the participants in this study. Specifically, 26% of the participants were between 20 and 30 years old (n = 31), 31% were between 31 and 40 years old (n = 36), 28% were between 41 and 50 years old (n = 33), and 15% were between 51 and 60 years old (n = 18). These results suggested that the construction workers recruited for this study had a wide range of ages, with a dominant productive age group and a smaller proportion of older workers (Figure 1A). According to the job description, 78 participants (67%) were categorized as laborers, while fewer than 5 participants (2%) were categorized as operators (Figure 1B). The characteristics of the participants were divided based on their work experience, with less than 10 years in the LE group and more than 10 years in the ME group (Figure 1C). In this study, 48 the participants (41%) were included in the LE group, while 70 participants (59%) were included in the ME group.

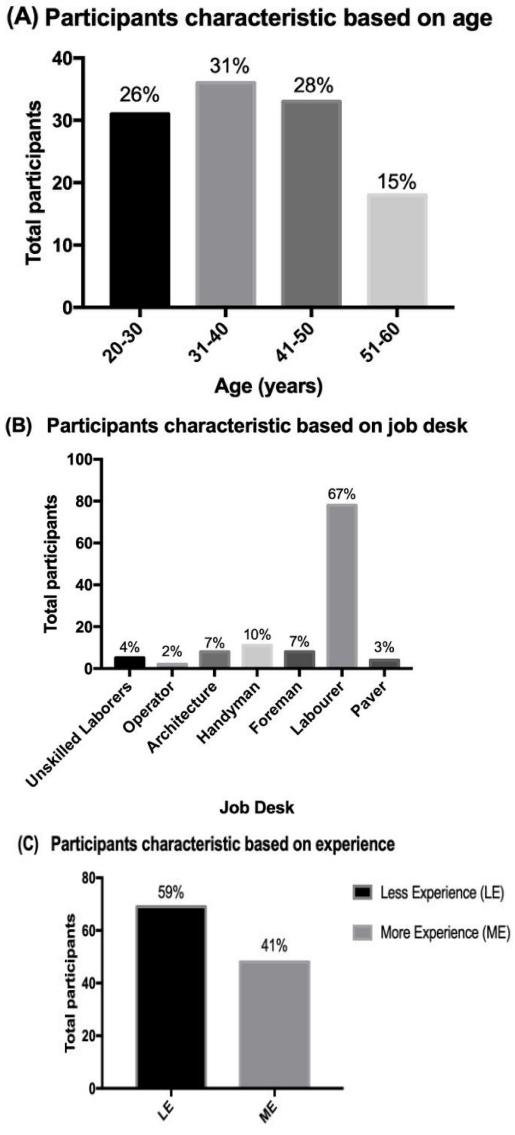

Figure 1. Characteristics of the participants in this study

The participants were characterized according to (A) age; (B) job description; and (C) work experience.

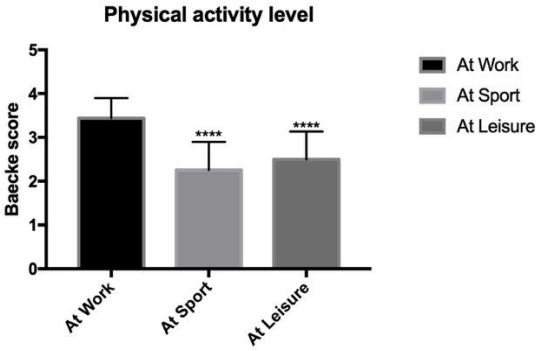

Figure 2. The differences in physical activity levels among different activities

**** $p < 0.0001$ based on one-way ANOVA on the comparison of physical activity levels between work-related activities and other activities

Figure 2 shows the significant difference in the physical activity levels of the construction workers during sports and leisure time compared to work-related physical activities as determined by the one-way ANOVA ($F\ 2.234 = 149.3$, $p < 0.0001$). Specifically, the participants showed high levels of physical activity (70%, n = 83) and moderate levels of physical activity (30%, n = 35). Furthermore, the results suggested that the participants engaged in high levels of (70%, n = 99) and moderate levels (30%, n = 19) of physical activity at work. In terms of sports, the majority of participants engaged in moderate levels of physical activity (88%, n = 104), with a smaller percentage engaging in high (11%, n = 13) or low (1%, n = 4) levels of physical activity. Similarly, the majority of participants engaged in high levels of physical activity during leisure time (19%, n = 22) and a smaller percentage engaging in moderate levels of physical activity (81%, n = 9).

The participants were categorized based on the results of the OLS test. Nine participants were categorized into grade 2, 38 participants were categorized into grade 3, and 71 participants were categorized into grade 4. Figure 3 shows the postural stability grades of participants in this study. The grades reflect the participants endurance during the test. Nine participants (7%) received a low grade, indicating less than 30 seconds of stability. In addition, 38 participants (41%) received a moderate grade, indicating less than 44 seconds of stability. The remaining 71 participants (52%) received a high grade, indicated more than 45 seconds of stability.

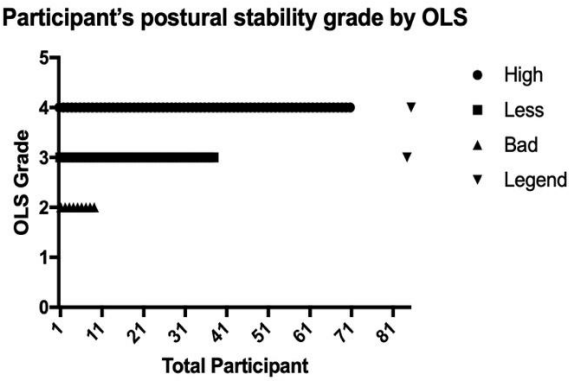

Figure 3. Postural stability of the participants based on the OLS test

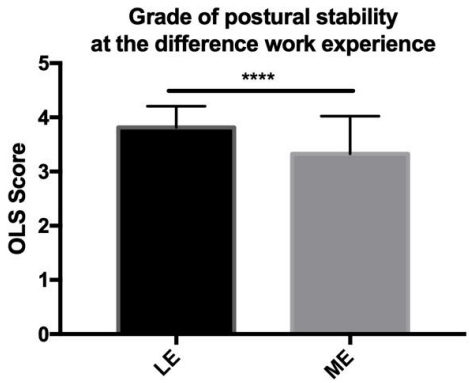

Figure 4. Postural stability of the LE and ME groups based on the OLS test

**** ($p < 0.0001$)

Subsequently, an unpaired t-test was used to analyze the postural stability of the LE and ME groups as shown in Figure 4. The results indicated a significant difference in postural stability scores based on the OLS test between the LE and ME groups ($p < 0.0001$). The OLS score of the LE group was higher than that of the ME group.

Table 1. Results of the Pearson analysis

Variable	Result
Physical activity at work and postural stability	r = -2.498
	p = 0.006
Physical activity during sports and postural stability	r = -0.104
	p = 0.25
Physical activity during leisure time and postural stability	r = 0.059
	p = 0.520
Total index of physical activity and postural stability	r = -0.142
	p = 0.124

Table 1 shows the results of the Pearson correlation coefficient between physical activity at work and postural stability, which showed a significant but low correlation ($p < 0.01$). Another variable analyzed using the Pearson correlation coefficient showed no significant correlation ($p > 0.05$).

DISCUSSION

Work in the construction industry requires physical and mental strength (Kong et al., 2018). It is a high-risk job as workers are tasked with assembling, lowering, modifying, and carrying heavy objects to construct buildings (Mousavi, 2015). Falls in the workplace are a major concern as they can cause injury, disability, and even death. To prevent work-related injuries, it is important to maintain good coordination between sensorimotor and neuromuscular functions in controlling postural stability (Palikhe et al., 2020). Therefore, the relationship between physical activity levels and postural stability is investigated in this study.

Age is an important factor in determining productivity at work. Physical activity levels also vary with age (Graf and Cecchini, 2017). In this study, the largest age group of participants was between 31 and 40 years old, while the smallest age group was between 51 and 60 years old. Construction workers commonly come from a wide range of age groups (Idrees, Hafeez and Kim, 2017). In the United States of America, the age range of construction workers is typically between 42 and 67 years old. It is estimated that the number of construction workers aged 55 years old and older will increase by 11.9 to 24.8 percent between 2004 and 2024. In addition, it is estimated that the average age of construction workers will be between 42 and 45 years old between 2016 and 2026 (Sokas, Dong and Cain, 2019). This study found that the majority of construction workers fall into the productive age category, which is associated with higher levels of activity compared to the elderly (Lontoh, Kumala and Novendy, 2020).

In addition to identifying the age, this study also identifies the job description of construction workers. Each job has a different level of physical activity, with construction work being the largest contributor to daily activity. More than half of the daily activity comes from the workplace (Arias et al., 2015). As a result, the participants of this study, particularly laborers, exhibited moderate to high levels of physical activity. This finding is consistent with previous findings that workers in the field have the highest levels of physical activity. Among construction workers, there were various positions with different levels of difficulty (Alghadir and Anwer, 2015). In addition, this study found that more experienced workers were dominant compared to novice workers although no significant difference was found in terms of physical activity levels between them. This finding suggested that the physical activity of construction workers was consistent and not affected by work experience.

The Baecke questionnaire was used to identify the highest and lowest levels of physical activity at work, during sports, and in leisure time among construction workers (Cyma et al., 2018; Rocha et al., 2022). The results showed significant difference between the levels of physical

activity at work, which turned out to be higher than the levels of physical activity during sports and leisure time. However, the differences in work experience among the participants were unlikely to affect the levels of physical activity since they achieved similar results. This study found that the lower levels of physical activity during sports and leisure time were due to the high workload at work, resulting in less activity during their free time. A study conducted among office workers found that higher levels of physical activity during sports and leisure time were associated with lower levels of physical activity at work (Chau et al., 2012). In fact, regular exercise could be done during their free time (Clemes, Oêconnell and Edwardson, 2014).

A previous study revealed that construction workers had higher levels of physical activity and postural stability than office workers (Cyma et al., 2018). Postural stability is also influenced by job description in the workplace, such as indirect balance training and duties. In addition, a comparative study between construction workers andfirefighters found that construction workers had better postural stability. However, both groups were found to engage in high levels of physical activity at work. It is possible that the higher physical activity among construction workers may exercise specific muscle groups, especially in the lower extremities, and increase their postural stability (Gatti, Schneider and Migliaccio, 2014). Unfortunately, this study found no correlation between higher levels of physical activity and improved postural stability.

Another previous study suggested that older construction workers with long experience exhibited better postural stability compared to novice workers (Min, Kim and Parnianpour, 2012). Experienced workers were found to be more comfortable working at heights without handrails and no cardiovascular stress was observed. However, this study found that older workers with more experience did not exhibit improved postural stability compared to younger workerswith less experiences. Therefore, it is important to note that age is not the only factor affecting postural stability, as workplace and experience also play a role (Remaud, Thuong-Cong and Bilodeau, 2015). Furthermore, while better postural control can reduce the risk of falls in the workplace, it can also increase the risk of postural strain.

This study found that regardless of the work experience, postural stability remains the same among the participants. This study did not find any correlation between the levels of physical activity and postural stability. Another study showed that work experience, whether less or more, did not result in a significant difference in the levels of physical activity and postural stability. Nevertheless, older construction workers tended to have more work experience. Higher levels of physical activity characterize healthy aging (McPhee et al., 2016). This can improve stability as evidenced by higher stability grades. A previous study also found that older individuals who remain active in their communities have good postural stability (McMullan et al., 2018).

In the construction industry, young workers often have less work experience than their older counterparts. However, their levels of physical activity is similar. This study found that postural stability increased with the level of physical activity performed, which is consistent with previous research showing good postural stability in individuals of productive age (Kováčiková, Sarvestan and Zemková, 2021). At this age, postural stability may be affected, especially in the case of complex activities. To complete such tasks, individuals should possess both flexibility and stability (Paillard, 2019). Moreover, long-term training can lead to superior postural stability (Paillard, 2017).

A good balance refers to the interaction between physiological and

cognitive elements which results in a robust response to disturbances (Richardson, 2017). A comprehensive assessment can help determine the appropriate intervention to address balance problems. In addition to age-related challenges, balance problems may be related to various medical conditions of varying severity (Cuevas-Trisan, 2019). Abnormal balance is becoming increasingly common among the elderly and those in long-term care facilities. This finding is relevant to this study as it suggested that older construction workers had worse postural stability. As the body ages, several physiological changes occur that can affect many functional systems, altering quality of life and leading to problems, such as less independence, impaired postural stability, and low extremity strength, which can increase the risk of falls (Cruz-Jimenez, 2017).

A previous study on the elderly found a significant correlation between postural stability and physical activity (Taghipour, Hosseini and Pouraria, 2016). This finding supports the theory that balance or postural stability is determined by multiple systems, including visual, vestibular, somatosensory, musculoskeletal, and neuromuscular systems (Kisner and Colby, 2016). The degenerative process of aging can cause a decrease in muscle strength, bone density, endurance, and stability (Ivanali et al., 2021). However, increasing physical activity can improve postural stability and prevent the risk of falls. On the contrary, the levels of physical activity has a significant but low correlation with postural stability in construction workers (Schober, Boer and Schwarte, 2018).

Fortunately, postural stability among the participants in this study showed a good result if the grade was very stable. Furthermore, more experienced, older workers were found to have lower OLS scores than less experienced workers. Postural control is divided into two: static and dynamic. This study examines static postural control where balance is maintained in a relatively quiet environment (Macpherson and Horak, 2013). The best performance of postural control, either static or dynamic, can maintain the center of pressure above the base of support to prevent the risk of fall (Ivanenko and Gurfinkel, 2018). A previous study in the mid-1970s showed that postural imbalance in adults is associated with a higher risk of falls. The decline in postural control is influenced age and affects the decline of sensory, motor, and cognitive systems (Sá et al., 2018). The weakness of these systems corresponds to the loss of neuromuscular capacity (Zemková and Zapletalová, 2022).

This preliminary study has some limitations. First, the participants were not in the same age range and there was a wide variation in work experience. Second, this study did not collect a detailed medical history from the participants, which could have affected postural stability. Therefore, further research is needed to investigate postural stability in larger samples of construction workers with the same age range and experience. To maintain population homogeneity, further research may recruit laborers only as participants as their number is the highest among other job descriptions in the construction industry. In addition to the characteristics of the participants, postural stability may be considered as a common ability due to the complexity of the control system. This reason can be used as a background to investigate dynamic balance in future studies.

CONCLUSION

The construction industry employs a large number of workers who are involved in jobs that are physically demanding. To support their physical activity, workers need to improve their balance. Abnormalities in the balances of construction workers can increase the risk

of falls. This study found that construction workers engaged in high levels of physical activity at work, which differed significantly from their physical activity during sports and leisure time. In addition, no correlation was found between higher levels of physical activity and the stability grade based on the OLS score. These preliminary findings are consistent with previous studies that suggested that physiological changes, such as impaired postural stability, may occur as the body ages. However, further research should investigate larger sample sizes, detailed characteristics of participants, and balance under perturbing environments.

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Conflicts of interest

The authors have no conflicts of interest to declare.

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