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Musculoskeletal disorders in distal upper extremities among women and men: results of a study in the industry sector

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*Distúrbios musculoesqueléticos em extremidades superiores
distais entre homens e mulheres: resultados de estudo na
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This article is based on the coursework paper for the Occupational Medicine Residency Program, Federal University of Bahia, by Carolina Gomes da Silva Tolentino Gonçalves de Almeida, entitled "Gênero e Distúrbios Músculo-Esqueléticos". Part of the study was presented at the VIII Brazilian Congress of Epidemiology, 2012, São Paulo (SP), and published in the annals in the form of an abstract.

Abstract

Objective: to study the association between musculoskeletal disorders in distal upper extremities (MSDUE) and the variable sex in the plastic industry. **Method:** cross-sectional study with 577 workers. The MSDUE was defined by the presence of pain in the previous twelve months, lasting for more than one week or having a monthly frequency, causing work restrictions or search for medical care, or severity ≥ 3 (from 0 to 5), in at least one of these regions: fingers, wrists, hands, forearms or elbows. Covariates of interest were: physical and psychosocial demands at work, sociodemographic and lifestyle-related variables, physical fitness and household work. Multiple logistic regression was used in order to investigate statistical interaction and presence of confounding variables. **Results:** MSDUE occurrence was higher among women, independently of the tested work-related and outside of work demands. Physical fitness was the interaction variable, and psychosocial demands was the confounding variable. Men who referred good physical fitness presented lower prevalence compared with those with poor physical fitness. Among women, good physical fitness was not enough to significantly reduce their high musculoskeletal morbidity. **Conclusion:** differences in work-related exposure do not explain the higher morbidity among women. It is necessary to consider sex differences, either socially determined or related to biomechanics, resulting in distinct responses to work demands.

Keywords: Musculoskeletal diseases; sex; repetition strain injury; cumulative trauma disorders; occupational health.

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Introduction

Musculoskeletal disorders (MSD) are among the major public health problems that society has been facing in recent years. They represent the largest proportion of all occupational diseases registered in many countries, interfering negatively and relevantly in employability and quality of life, in addition to being responsible for a significant degree of absenteeism and disability¹⁻⁴.

In Brazil, Social Security data suggest that work-related MSDs are the most common occupational diseases in recent years. The pathologies of upper limbs and vertebral column are the most recorded ones⁵. These data concern the formally employed population, and are restricted to cases recognized and registered as work-related musculoskeletal disorders (WMSD)⁶.

The MSDs include a wide range of degenerative and inflammatory conditions affecting muscles, tendons, ligaments, joints, cartilage, peripheral nerves, and blood vessels. MSDs encompass clinical syndromes such as tenosynovitis, epicondylitis, bursitis, carpal tunnel syndrome, and osteoarthritis as well as conditions such as myalgia and low back pain. The most frequently affected regions are: lumbar spine, neck, shoulders, forearms and hands^{3,7}.

Regarding MSDs in distal upper extremities (MSDUE), the following were singled out as risk factors: repetitive or heavy physical work, prolonged work on the computer, abnormal postures, static and dynamic, low control, high psychological demand (fast pace or time pressure, without pause), dissatisfaction with work, low social support, age, female sex, smoking, and high body mass index. This shows that, as with most chronic diseases, MSDs are associated with multiple factors, work-related and not^{3,7-12}.

An important debate about MSDs concerns their higher prevalence among women (which is described by many authors), notably regarding neck and upper extremities disorders. This positive association between the female sex and symptoms in upper limbs has been described in specific occupations and also in the general working population^{4,6,10,13-20}.

What could lead to this higher prevalence of MSDs among women remains as a question not yet understood properly by scholars. Studies show that typical female tasks are related to manual labor, considered as mild and of less complexity, but that can determine a greater exposure to work that is repetitive, dull, sedentary, and of short cycles, such as on the assembly line, using fine movements under an accelerated pace as well as forced and static body postures. Given this context, one explanatory

possibility for the difference in musculoskeletal morbidity between the sexes is the greatest exposure of women to working conditions that favor the development of MSDUE. Additionally, for women, more intensely than for men, we can also add to paid work the responsibilities of the unpaid household work. The insufficient rest, more critical in women, could contribute to their illness^{4,10,18-30}.

The plastics industry in the metropolitan region of Salvador (MRS) uses, predominantly, mechanized and non-automated work, which requires strength in the upper limbs, repeatability and psychosocial demands (low control and high psychological demand such as fast-paced work)^{22,23}.

An investigation of MSDs and work was carried out in this industry, resulting in one doctoral thesis, one master's thesis and one coursework for the Occupational Medicine Residency program. From these academic products, among others, some epidemiology articles were published on epidemiological prevalence of MSDs in this population⁶; interaction between physical and psychosocial demands on the occurrence of low back pain³¹; leisure physical activities and MSDs³²; interaction between physical fitness and physical demands at work on the occurrence of MSDs³³; validity and reproducibility of self-registration of the physical demands at work³⁴; and factors associated with MSDs in workers of this industry²¹. This latest exploratory study found an association between these diseases and female sex, psychosocial demands, and job dissatisfaction. Based on the findings of this investigation, as well as on the scientific literature, the specific hypothesis of the present study was devised: women have a higher prevalence of MSDUE than men as a result of their greater exposure to work demands. This confirmatory study was carried out in order to investigate the association between the sex variable and MSDUE among plastic industry workers of the MRS.

Methods

Data from an epidemiological cross-sectional study were analyzed. The target population was 1,177 workers of operation and maintenance activities of 14 factories of the plastic industry in the MRS. The sampling was of the random stratified proportional type, in such a way that the same proportion of individuals found in each factory in the target population was kept. A minimum sample of 567 individuals was calculated, considering a degree of absolute precision of four, 95% confidence level, expected prevalence of MSDs of 50%, and a design effect of 1.4.

A previously tested questionnaire was used for data collection. The questionnaire was applied by trained interviewers in the year of 2002, in

each individual's workplace, ensuring privacy. Musculoskeletal morbidity was assessed through a translated and expanded version of the Nordic Musculoskeletal Questionnaire, with the inclusion of questions aimed to assess severity, duration, and frequency of symptoms^{6,35,36}. The referred instrument, which was previously validated in Brazil³⁷, is the most used in epidemiological studies on MSDs worldwide. Sociodemographic data, occupational history, work links, working hours, hours worked during the previous week, smoking, use of drugs, alcohol intake, physical and sports activities, household activities, and other health information were also investigated.

Physical demands at work were measured by self-reporting, by eleven questions. The response scale was numerical, with six points (from 0 to 5), having as extreme verbal explanatory qualifiers the words "never" (0) and "all the time" (5), for variables measured by duration, or the words "low" (0) and "very strong" (5), for variables measured by intensity. The analyzed questions included repetitive movements of the hands; force applied with arms or hands; sitting, standing or walking work posture; arms raised above shoulder height; trunk tilted forward or rotated; and load-lifting. The questionnaire (from which the questions on physical demands were extracted) as well as the description of its development can be found in a previous publication³⁸.

Psychosocial demands at work were evaluated by the JCQ (Job Content Questionnaire)³⁹, addressing psychological demand, control, and social support. Exposure to at least two of these situations was considered as high psychosocial demand: high demand, low control or low social support, with median cut for analysis purposes. Job dissatisfaction was also assessed by the JCQ.

Physical fitness was assessed according to self-report, with the question: "How would you assess your physical fitness?". An ordinal scale of 0 to 5 points was used, with verbal explanatory qualifiers at the ends (0 = poor, 5 = excellent). Those that scored three or more points were considered as having good physical fitness, and those that scored less than three were considered as having poor physical fitness. This cutoff point corresponded to the median.

Data analysis

MSDUE was the dependent variable, while sex was the main independent variable of the study. Covariates of interest were: physical demands at work, psychosocial demands at work, job dissatisfaction, working time, weekly working hours, overtime, double shifts, marital status, education level, age, physical fitness, overweight/obesity, smoking, alcohol intake, having or not children aged under two years, and household work.

The case of MSDUE was defined by the report of pain in at least one of the following regions: fingers, wrists, hands, forearms and elbows in the previous 12 months, lasting more than a week or with a minimum monthly frequency, not caused by acute injury and presenting gravity ≥ 3 (ordinal scale of 0 to 5, with extreme verbal explanatory qualifiers, 0 = no pain, 5 = unbearable pain), or determining seeking of medical attention, or absence (official or not) to work or even change of job³⁵.

Considering that the variables that measured physical demands at work could be linked, the correlation array was analyzed. Then, factor analysis was carried out with eleven physical demand variables in order to identify the underlying factors, reduce the number of variables and avoid redundancy⁴⁰. The analysis captured two factors, characterizing dynamic work with load handling and correlates (factor 1: load-lifting, standing posture of work, using muscle strength with arms or hands, working with arms raised above shoulder height, working with trunk rotation, physical pressure with both hands on the work's object, and inclined torso) and static work with repeatability (factor 2: general motionless posture of work, not walking, repetitive movements with the hands, and sitting posture). Both factors presented high theoretical plausibility and were used as the independent variables of physical demands at work³¹.

Initially, a descriptive approach of the data was conducted, thus presenting the distribution of the covariates according to the strata of the main independent variable. After this, the stratified tabular analysis was carried out, obtaining the Prevalence Ratios (with the Mantel Haenszel Chi-square test).

The multivariate analysis by binary unconditional logistic regression (LR) was used to investigate the association between sex and MSDUE, with backward-type modeling. The selection of independent variables for modeling was based on the theoretical and biological plausibility of the associations involved and on the results of the bivariate analysis. The covariates associated with the dependent variable, in the initial exploratory stage ($p < 0.17$), were then tested as effect modifiers or confounders of the main association: physical demands and repeatability, physical demands and load handling, psychosocial demands at work (PSD), job dissatisfaction, fitness, and smoking⁴¹.

Statistical interaction was identified by comparison of the models adjustment with and without the product terms (interaction terms). Interaction variable were those whose products improved the model adjustment in statistically significant levels ($\alpha = 0.20$), by the likelihood ratio test⁴¹.

Once the statistical interaction was established, the end results of the measurement of the main

association were presented by the extracts of the interaction variable – that is, the results of the main association measure controlled by the effect modifier or interaction variable were presented. When a variable was established as of interaction, it was not evaluated as a confounding variable.

Confounding variables were those that, once removed from the complete model, produced a change of 15% or more in the main association measure or in the range of their confidence interval⁴¹.

The final model was presented using an alpha of 0.05. Covariates that were not of interaction or that did not confounded the results of the main association, according to the criteria previously described, were not maintained in the final model.

Data analysis was done using the Epi-Info 6.04 version and SPSS 17.0 software. The study was approved by the Research Ethics Committee of the Collective Health Institute of the Federal University

of Bahia, under protocol number 002/CEP/ISC. There was no conflict of interest.

Results

The study population was composed of 577 workers, 179 (31%) women and 398 (69%) men. MSDUE prevalence among women was 34.6%, and among men, 11.6%.

The distribution of the studied covariates according to the main independent variable (sex) is shown in **Table 1**. It is possible to notice that there was statistically significant difference between men and women for some covariates. In this table, it is possible to see that the women were more exposed to repeatability and psychosocial demands at work, and reported greater job dissatisfaction, as well as more weekly work hours. On the other hand, men presented more time of insertion in the labor market. Poor physical fitness was more referred to by women, who also devoted more hours per week to household work.

Table 1 Work-related and life habits variables, according to sex, in the population of plastic material industry workers in Salvador, BA, Brazil

<i>Variables</i>	<i>Men n=398 (%)</i>	<i>Women n=179 (%)</i>
Factor 1: Dynamic work with load handling		
Yes	205 (52)	80 (45)
No	187 (48)	97 (55)
Factor 2: Static work with repetitive movements of the hands*		
Yes	162 (41)	123 (69)
No	230 (59)	54 (31)
Psychosocial demands*		
Yes	161 (43)	117 (71)
No	210 (57)	48 (29)
Dissatisfaction*		
Yes	155 (39)	88 (49)
No	243 (61)	91 (51)
Years of work*		
≥ 13	218 (55)	78 (44)
< 13	180 (45)	101 (56)
Working hours/week*		
≥ 45	177 (44)	106 (59)
< 45	221 (56)	73 (41)
Physical fitness*		
Poor	59 (15)	54 (31)
Good	338 (85)	123 (69)
Hours of household work*		
≥ 7	104 (26)	136 (76)
< 7	294 (74)	43 (24)

* p<0,05.

Tabular analysis results indicated possible interaction of the physical fitness variable with the sex variable in the occurrence of MSDUE, as shown in **Table 2**. This table presents prevalence, prevalence ratio, and 95% confidence intervals (95%CI) for combined effects of fitness and sex in the occurrence of MSDUE. It is possible to notice that women presented, in all strata, more prevalence of MSDUE than men. Among those who reported good fitness, men had pain prevalence of 9.2%, while for women, this value was 30.9%. Among those who reported poor physical fitness, the prevalence among men was 25.4%, and among women 44.4%. That is, among those with good physical fitness, women had 3.37 times the prevalence of men. However, among those with poor physical fitness, that ratio was 1.75. It is possible to observe in this table that the increase in the prevalence among men in the presence of poor physical fitness was different from that among

women, whose prevalence of MSDUE, always very high, varied little according to fitness. This analysis result suggests an interaction between sex and physical fitness for the occurrence of MSDUE, which was tested by the multivariate analysis.

Table 3 shows the models, crude and adjusted, by psychosocial demands (PSD), according to poor and good physical fitness. The PSD variable confounded the main association, while the variable physical fitness was a modifier of the effect of sex on the occurrence of pain. Therefore, in this table, it is possible to observe the final results of the main association with adjustment by PSD, and the strata according to fitness. Among those who reported poor physical fitness, the association between sex and MSDUE was 2.35 (adjusted to 2.00), while it was 4.43 (adjusted to 3.36), among those with good physical fitness.

Table 2 Prevalence, prevalence ratio (PR), and confidence interval (95%CI) for the combined effects of female sex and physical fitness for the occurrence of musculoskeletal disorders in the distal upper extremities in plastic industry workers in Salvador, BA, Brazil

<i>Variables</i>	<i>n</i>	<i>Prevalence (%)</i>	<i>PR</i>	<i>95%CI</i>
Good physical fitness + man	338	9.2	1.00	-
Good physical fitness + woman	123	30.9	3.37	2.20 – 5.16
Poor physical fitness + man	59	25.4	2.77	1.60 – 4.81
Poor physical fitness + woman	54	44.4	4.85	3.09 – 7.59

Table 3 Results of the Logistic Regression for the association between female sex and musculoskeletal disorders in upper distal extremities according to physical fitness, in plastic industry workers in Salvador, BA, Brazil

<i>Models</i>	<i>Physical fitness (n = 577)</i>			
	<i>Poor (n = 113)</i>		<i>Good (n=461)</i>	
	<i>OR</i>	<i>95%CI</i>	<i>OR</i>	<i>95%CI</i>
Model 1				
Female sex	2.35	1.06 – 5.20	4.43	2.60 – 7.54
Model 2				
Female sex (adjusted for PSD)	2.00	0.85 – 4.71	3.36	1.90 – 5.92

OR: Odds ratio.

95%CI: 95% confidence interval.

PSD: Psychosocial demands.

Discussion

This study investigated the association between sex and MSDUE, which remained consistent after multivariate analysis, including sociodemographic, work-related and non-work-related variables. Therefore, a positive and independent association exists between female sex and MSDUE. Although work-related exposure and occurrence of MSDUE are associated, among men and women, the latter present more MSDUE, despite this exposure.

The hypothesis of differential exposure confirms that the difference in the prevalence of MSDs among men and women could be explained by different working conditions. Thus, this difference could disappear with the adjustment for exposure, and the risk of illness would be equal for men and women subjected to the same conditions^{4,19,20,42}.

In some studies that adjusted work-related exposure, the greater risk of MSDs among women practically disappeared^{4,42}. Strazdins and Bammer¹⁸ attribute the difference in prevalence of MSDs among men and women to different exposure to risk factors at work and at home, since this difference became non-significant when these variables were controlled. On the other hand, in accordance with the results of this study, some authors found a musculoskeletal morbidity consistently greater among women, even after adjustments for work-related exposure, both in the general working population and among various occupations^{10,43}. In this perspective, Messing et al.²⁸ also admit that the difference in symptoms among men and women could be partly explained, but not entirely, by the working conditions.

A relevant issue that still restricts the comparison between studies is the weakness in the definition of work-related exposure and in the epidemiological analysis process, in which the demonstration of results adjustment procedures can be absent. In this investigation, the measures we used to assess physical and psychosocial demands at work enabled an assessment of individual exposure through posture, load handling, repeatability, use of strength with upper limbs and psychosocial aspects. The measurement of work-related exposure to physical demands aimed that the self-reported exposure incorporated different experiences and perceptions, overcoming the use of the title of the occupation as a proxy for exposure, which would not allow the incorporation of exposure variability, neither consider the dynamic and changeable character of the working hours. Therefore, the assessment of exposure to physical demands in this study can be considered a strong point, considering the incorporation of many variables, as well as the

factorial structure of the set of questions having presented strong theoretical plausibility. This type of exposure assessment is still hardly found in studies of this nature, which has been criticized by epidemiologists who study the theme³⁴.

The results of this study allow us to question the model of differential exposure between men and women as sufficient explanation for the differences in prevalence of MSDUE^{18,42}. In this perspective, the higher prevalence of physical symptoms among women in general, regardless of the work, leads to the argument that non-work-related factors would also be involved in differences between the sexes¹⁰.

Regarding aspects of the body's biomechanics, there are differences related to muscular strength and resistance that may have a role in the susceptibility to MSDUE between sexes. Women have less strength than men of the same size, which appears to be more pronounced for the upper limbs, and achieve less muscle hypertrophy results with training. For the same task, women use increased muscular activity than men, almost reaching their maximum capacity. Women also have a higher proportion of type 1 muscle fibers, which are weaker, but present a higher resistance to fatigue. This could increase the risk of overload, one of the mechanisms for the development of MSDs. In addition, muscle activity produced due to a repetitive task demonstrated a pattern of less variability of movements in the female sex, which points to different control and compensation mechanisms between men and women, which could have a role in the increased prevalence of MSDs among women^{20,44,45}.

Studies suggest that the response to stress would be more regulated by the nervous system in men and by the metabolic system in women, and that women would present a smaller variety of strategies of adaptation to muscle pain than men. Studies involving pain account and threshold found smaller inhibitory control effects of modulation of pain in the spinal cord of women, and they showed lower pain threshold and more intense responses to induced muscle pain than men, which suggests that some endogenous controls of pain are less robust for females^{10,16-18,44-48}.

Some scholars argue that women have a greater selective attention to the body, and that would be the reason why they have a greater tendency to notice muscle tension and stress. Women would also have a greater predisposition to assign somatic sensations to physical diseases, as well as to report symptoms and health problems presented by them, as they would face less social constraints than men when assuming a sick and/or of health care behavior. All these factors might contribute to the higher prevalence of musculoskeletal pain among women^{4,9,10,17,20,28,49-51}.

Given this, a model of differential vulnerability has been proposed to explain the higher prevalence of MSDUE in the female sex, which involves biological and sociocultural factors, the meaning of family and work-related demands, and a possible smaller capacity of women to cope with these demands. Thus, exposure to similar risks in the workplace would result in different impacts on men and women, generating greater stress to the latter^{18,30,42,44}. Therefore, it is important that this possible vulnerability of the female workforce is considered in the development of public policies for the prevention of occupational diseases and promotion of healthy work environments for both men and women.

This study also showed that the association between sex and MSDUE is not homogeneous for all men and women of the population, i.e., a variable that modifies the effect of sex on the musculoskeletal illness (physical fitness) as well as a confounding variable (psychosocial demands) were found.

The confounding of the association between female sex and MSDUE by the PSD at work variable is explained by the fact that this is a variable associated with the MSDUE and of unequal distribution between women and men in the study population, as women are more exposed than men to high PSD at work. However, even after adjusting this variable, the association between female sex and MSDUE remained, suffering only a small decrease in strength.

As to interaction found between sex and physical fitness in determining MSDUE, it is possible to say that, for both men and women, reporting good physical fitness had different repercussions. Although the women always presented higher prevalence of musculoskeletal pain than men, this result is modified by physical fitness. Good physical fitness was more protective among men, as those who reported good physical fitness presented a much lower prevalence than those with poor physical fitness (from 25.4% to 9.2%). Among women, on the other hand, having good physical fitness was not enough to substantially change the high musculoskeletal morbidity (from 44.4% to 30.9%).

There is a gap in the epidemiological literature on the role of physical fitness in the determination of MSDs. It is known that men exercise more than women. There is some evidence, however, of the protective role of good physical fitness regarding MSDs, notably among those subjected to lighter physical work, but without reference to differences between men and women^{18,33,52,53}.

The found interaction between sex and physical fitness could be related, among other factors, to the different results of the practice of physical exercises

for men and women. For men it is easier to get results of muscular hypertrophy, strength, and endurance in response to physical activity than for women⁴⁵. Thus, men who consider themselves in good physical fitness would be better protected from MSDs than women who have this perception.

Physical fitness incorporates some attributes, as: cardiorespiratory aptitude, muscular strength, muscular endurance, body composition and flexibility. We verified that studies that evaluate physical fitness using direct measures are restricted to specific attributes, in general in an isolated way, in small population quotas. This study used as one of the independent variables the self reported physical fitness, which has the advantage of incorporating, through the global perception of the subject about his/her physical state, all possible attributes of physical fitness. It is known that both direct and self-reported measures present advantages and limitations. However, self-registration is widely used in population studies, in view of the difficulties of cost and time, among others, to obtain direct measurement for large population quotas³⁴. Only the direct measurement of all components of physical fitness could represent an alternative modality of assessment to the global perception obtained from self-reporting^{33,54,55}.

Since we are dealing with a cross-sectional study, it is not possible to rule out the possibility of reverse causality, i.e., individuals with MSDUE reported worse physical fitness due to their morbidity. However, the aforementioned found interaction shows that the more frequent report of poor physical fitness among those who referred musculoskeletal pain was not homogeneous between men and women, i.e., there was a different impact on morbidity when the interaction was considered regarding physical fitness.

Although specific adjusted estimates show a consistent association between female sex and MSDUE (3.4 and 2.0), the confidence interval shows lower precision to the result among those with poor physical fitness, a stratum that counts with fewer individuals. This limitation should be considered in the interpretation of the findings as a whole, verifying the varying amplitude of the intervals, which should reflect the sampling size. However, as Rothman⁵⁶ points out, in the article "Six persistent research misconceptions", the advantage of the confidence interval is to indicate the magnitude of the effect size and the degree of precision, and it should not be judged solely based on the limits, whether it contains or not the null value. As the author discusses in some relevant publications on this theme^{57,58}, strong associations may be incorrectly interpreted as a null finding, by the mistake of considering that lower precision implies the absence of effect (due to the

interpretation of lack of statistical significance using hypothesis testing), or still, weak associations may be incorrectly interpreted as important because they are statistically significant.

The difference in occurrence of MSDUE between men and women can be considered a multicausal phenomenon, in which biological, biomechanical, behavioral, sociocultural, and work-related factors are combined to determine it. By incorporating an expanded number of covariates for analysis of the association between the sex variable and MSDUE, this study might contribute to the debate about greater morbidity among women, including the many perspectives for its explanation.

Conclusion

Women presented higher occurrence of MSDUE, which remains even after considering the exposure to physical and psychosocial demands at work,

as well as outside work and individual factors. Even after the analysis of potential confounders and effect modifiers of the association between sex and MSDUE, the high prevalence found for musculoskeletal morbidity among women persisted.

Hence, considering the differences among men and women – either socially determined or concerning the biomechanical nature of the body and the various capabilities of physical response against work-related demands –, should be a prerogative for guiding the organization of work and the suitability of the conditions under which the work is performed. Considering these differences implies the adoption of programs that are better informed by epidemiological evidence, aimed to improving working conditions. More contributions to the debate can come from further investigations using large samples and having longitudinal designs that would expand the explanation and better delimit the relative contribution of each of the determinants for musculoskeletal morbidity of men and women at work.

Authors' contribution

Almeida CGSTG was responsible for project design, bibliographical review, data analysis and interpretation, development of the manuscript, and final approval of the version to be published. Fernandes RCP was responsible for project design, bibliographical review, data gathering, analysis and interpretation, development of the manuscript, and final approval of the version to be published.

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