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ORIGINAL ARTICLE

Poor Trunk Flexibility is Associated with Cardiovascular Risk Factors

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Abstract

Background: Poor flexibility is a predictor of reduced physical activity. The association between trunk flexibility and cardiovascular risk factors (CVRFs) is not well understood.

Objective: To identify the prevalence of CVRFs and their association with trunk flexibility in individuals participating in a community-based health education program.

Methods: Volunteers (51 men, 48 women) aged 20-85 years old, participants in a community-based health education program in the city of Santo Antônio de Goiás, Brazil, were selected for this study. Anthropometric measures including body mass, height, body mass index (BMI), waist circumference (WC) and waist/height ratio (WHtR) were evaluated. Physical activity level was evaluated based on leisure activity participation, and trunk flexibility was evaluated by the sit and reach test. Data distribution was assessed using the Shapiro-Wilk test; Pearson's chi-square or Fisher's exact and Student *t* tests were performed for comparisons. To analyze the association between trunk flexibility and concomitant CVRFs, Spearman's correlation test and linear regression were employed. Statistical significance was defined as $p < 0.05$.

Results: 7.2% of the volunteers had no CVRF, 10.3% had only one CVRF and 82.5% had two or more CVRFs, with no differences between sexes. Increased abdominal adiposity, as assessed by WHtR ($p = 0.0097$), and systemic arterial hypertension ($p = 0.0003$) were the most prevalent CVRFs, with differences between age groups. A strong negative correlation was found between mean trunk flexibility and the number of concomitant CVRFs ($r = -0.96$, $p < 0.0028$).

Conclusion: The strong negative correlation between trunk flexibility and concomitant CVRF indicates an increased risk for cardiovascular events. Therefore, trunk flexibility measurement may be an additional tool for health promotion and prevention of cardiovascular and associated diseases in community health programs.

Keywords: Cardiovascular Diseases; Risk Factors; Abdominal Adiposity; Flexibility; Waist Height Ratio.

Introduction

Cardiovascular diseases (CVDs) are the leading cause of death in the world,[1] accounting for 18 million deaths in 2016.[2] In Brazil, CVDs cause 31% of deaths,[3] and have been considered the main cause of mortality since the 1960s.[4,5]

The cardiovascular risk factors (CVRFs) with the greatest impact on the development of CVDs are obesity, systemic arterial hypertension, insufficient physical activity, smoking and unhealthy diet.[6] Central obesity or abdominal adiposity is one of the most studied CVRFs because it is directly related to hypertension, stroke and myocardial ischemia.[7]

Abdominal adiposity can be easily determined by simple anthropometric measures that are as efficient as the most sophisticated and costly devices.[8] Waist circumference (WC) measurement is easily applicable and widely recognized as a reliable tool for estimating abdominal adiposity and predicting risks for chronic non-communicable diseases.[7] The waist-to-height ratio (WHtR) is less widely known in public health, but also a reliable anthropometric measure in the identification of CVRFs when associated with other anthropometric parameters, such as body mass index (BMI).[9,10]

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Increased abdominal adiposity and obesity are associated with various metabolic disturbances, such as type 2 diabetes, insulin resistance, hyperlipidemia, and high blood pressure,[11-13] and can negatively affect the individuals' physical fitness, including a reduced flexibility. This term is defined as the physical capacity to perform movements with adequate amplitude without risk of injury.[14-16] In the last 20 years, flexibility has gained special attention because health care institutions, such as the American College of Sports Medicine (ACSM) and the American Heart Association (AHA), started recommending flexibility training for all populations.[17,18]

Poor trunk flexibility seems to be related to arterial stiffness,[19,20] which is present in obesity[21] and CVDs,[22] and is a predictor of cardiovascular events.[23,24] In addition, some diseases in the spinal column, for example, increase the risk for CVDs due to the physical inactivity associated with the disease.[25] Increased flexibility has been shown to improve the physical function of people with these conditions.[21,25,26] Nevertheless, studies on the association between trunk flexibility and CVRFs, as abdominal adiposity and obesity, are scarce in the literature. Thus, the aim of our study was to identify the prevalence of CVRFs and to investigate the association between trunk flexibility and CVRFs in individuals participating in a community-based health education program.

Methods

Study design and sample

This was a cross-sectional study, carried out with a convenience sample composed of 99 individuals (51 men and 48 women), aged between 20 and 85 years (47.5 ± 13.9 years; mean ± standard deviation [SD]), living in Santo Antônio de Goiás, GO, Brazil. Participants were recruited during two events of a community-based health education program – "Pink October" and "Blue November" (Figure 1). All data were collected at the event site, including the administration of a sociodemographic interview to each participant.

Anthropometric evaluation

The anthropometric measures included body mass (BM), height (H), BMI, WC and WHtR. All measurements were collected according to standardized procedures.[27]

BMI was calculated by dividing BM (kg) by squared H (m), according to the equation: BMI (kg/m^2) = BM (kg) / H^2 (m), and classified according to the cut-off points proposed by the World Health Organization.[28]

WC (cm) was measured using a body measure tape (Sanny®, São Bernardo do Campo, Brazil) placed at the midpoint between the last lower rib and the iliac crest, to estimate abdominal adiposity and cardiovascular risk.[27] Lean et al.[29] proposed the use of WC as an indicator of cardiovascular risk, and respective cut-offs: men > 94 cm and women > 80 cm. From WC and H measurements, the WHtR was determined: WHtR = WC (cm) / H (m) and the cut-offs for cardiovascular risk was > 0.50 for adult and elderly men and women.[9,10]

Assessment of physical activity level

Physical activity level was assessed from data on leisure-time activity. Individuals who practiced at least 30 minutes of mild or moderate physical activity on five or more days during the week, or at least 20 minutes of vigorous physical activity on three or more days during the week were classified as sufficiently active. Those who did not reach these values were classified as insufficiently physically active.[30,31]

Blood pressure measurement

A digital blood pressure measuring device (G-Tech model MA100, Duque de Caxias – Brazil) was used for the measurements. Systolic and diastolic blood pressures were measured twice; the first measurement was taken after a resting period of at least five minutes, followed by the second measurement two minutes later. The second measurement was considered for analysis. The cutoff point for systemic arterial hypertension was a systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg, as recommended by the 7th Brazilian Guidelines of Arterial Hypertension.[32]

Assessment of trunk flexibility

Trunk flexibility was measured using the sit and reach test using a sit-and-reach box (Sanny®, São Bernardo do Campo, Brazil). The subject was instructed to sit on a mat, without shoes and with knees extended. Then, with one hand on top of the other, the volunteer flexed the trunk and reached forward along the measuring line as far as possible. Values were expressed in centimeters and the best of three attempts was included in the analysis.[33] Trunk flexibility was classified as "excellent", "above mean",

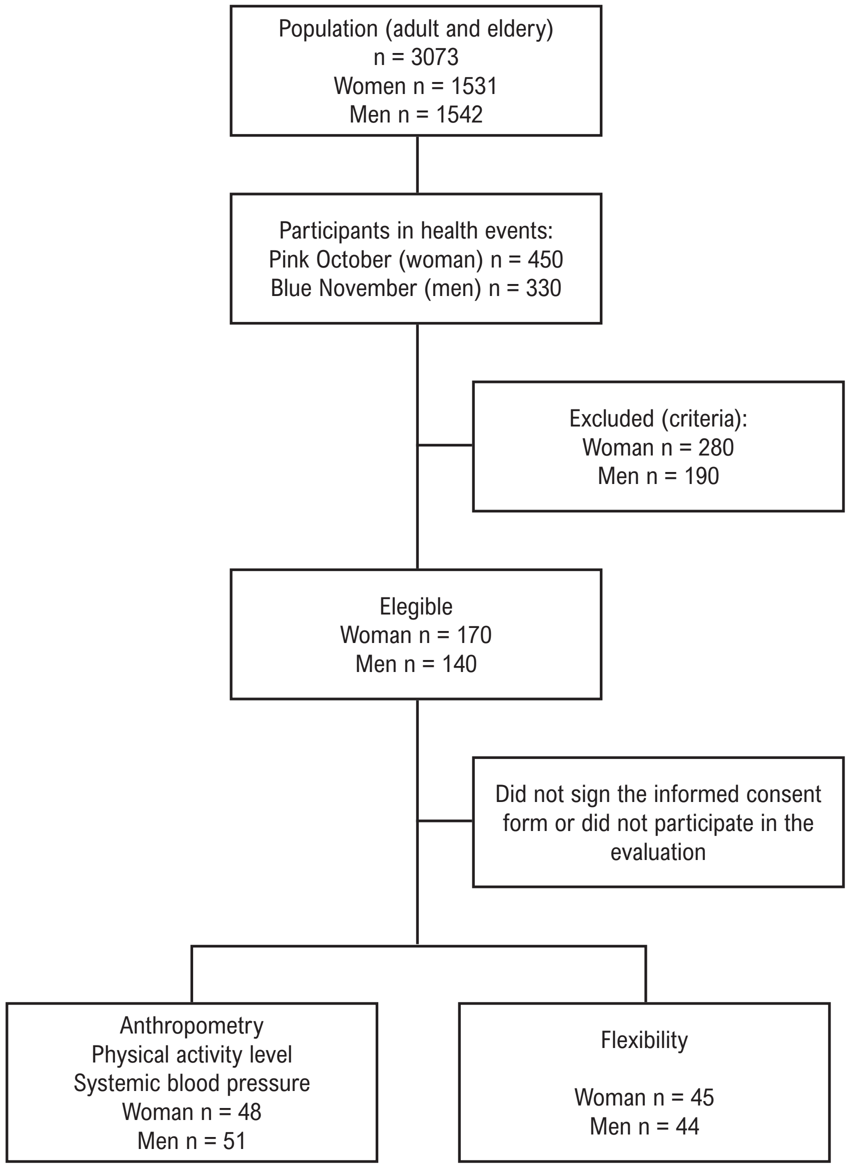

Figure 1 – Flowchart of participants' recruitment. Volunteers participating in the health education events "Pink October" and "Blue November" in Santo Antônio de Goiás city, GO, Brazil

"mean", "below mean" and "poor", by sex and age group, according to the Canadian Standardized Test of Fitness.[34]

Concomitant cardiovascular risk factors

The prevalence of single and concomitant (grouped) risk factors was determined.[35]

Statistical analysis

Categorical variables (CVRFs and classification of trunk flexibility) were presented as absolute and relative frequencies. The risk factors evaluated were obesity, abdominal adiposity (WC and WHtR), insufficient physical activity, hypertension and smoking. Pearson's chi-square test or Fisher's exact test were performed to compare the prevalence of risk factors between the age groups (20-39, 40-59 and 60+ years). Continuous variables were subjected to descriptive analysis and the Shapiro-Wilk test was applied to verify data distribution. Data were presented as mean ± standard deviation (SD) when normally distributed, and as median (interquartile range) when not normally distributed. Trunk flexibility between individuals with and without CVRF was analyzed by the Student's *t*-test for unpaired samples. Spearman's correlation test was carried out to evaluate the correlation between the number of concomitant CVRFs (discrete quantitative variable) and mean trunk flexibility, followed by linear regression analysis (the necessary assumptions were verified and met).

Statistical analysis was performed using the R software version 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria)[36]. Statistical significance was defined as $p < 0.05$.

Results

Anthropometry, trunk flexibility and blood pressure

The sample comprised 99 volunteers, with the following characteristics: BM = 71.5 (62.2 – 83.2) kg; H = 1.62 ± 0.08 m; BMI = 27.0 (24.1 – 30.1) kg/m²; WC = 91.3 ± 13.0 cm; WHtR = 0.56 ± 0.08; trunk flexibility = 22.7 ± 9.4 cm; systolic blood pressure = 129.6 ± 19.2 mmHg and diastolic blood pressure = 81.6 ± 11.6 mmHg.

Prevalence of cardiovascular risk factors by age group

Among the volunteers, 7.2% featured no CVRF, 10.3% presented only one CVRF and 82.5% showed two or more CVRFs, with no statistical difference between sexes. Increased abdominal adiposity, as assessed by WHtR ($p = 0.0097$), and systemic arterial hypertension ($p = 0.0003$) were the most prevalent CVRFs in the sample, especially in the group aged from 40 to 59 years (Table 1).

Classification of trunk flexibility and its relation to CVRFs

According to the classification of trunk flexibility (Table 2), 21.7% of the volunteers showed below mean flexibility, and 43.5% had poor flexibility. In the analysis of trunk flexibility according to the presence or absence of CVRF, individuals without CVRF showed significantly higher flexibility as compared with those with elevated WC ($p = 0.0001$) and WHtR ($p = 0.0001$) (Figure 2). There was a strong negative correlation between mean trunk flexibility and concomitant CVRFs ($r = -0.96$, $p < 0.0028$). The adjustment of the original values by linear regression generated the following equation: $y = 27.2 – 1.50\,x$ (adjusted $R^2 = 0.80$, $p < 0.0040$, RSE = 1.559) (Figure 3).

Discussion

Increased abdominal adiposity was the most prevalent CVRF and it was negatively associated with trunk flexibility. In addition, we found a strong correlation between trunk flexibility and presence of CVRF, which suggests the use of this biomarker as an indicator of increased cardiovascular risk.

Table 1 – Prevalence of cardiovascular risk factors in participants of a community-based health education program in the city of Santo Antônio de Goiás, Brazil, by age group

Risk factor	Age group (years)								p value
	Total (n = 97)		20 – 39 (n = 30)		40 – 59 (n = 45)		60+ (n = 22)		
	n	%	n	%	n	%	n	%	
Obesity*	25	25.8	6	20.0	16	35.6	3	13.6	0.1071
Elevated AA									
- WC*	59	60.8	14	46.7	31	68.9	14	63.6	0.1477
- WHtR*	74	76.3	17	56.7	38	84.4	19	86.4	**0.0097**
Insufficient PA*	46	47.4	15	50.0	22	48.9	9	40.9	0.7815
Hypertension*	53	54.6	11	36.7	22	48.9	20	90.9	**0.0003**
Smoking**	14	14.4	3	10.0	8	17.8	3	13.6	0.7070

*Missing data for two volunteers. AA: abdominal adiposity; WC: waist circumference; WHtR: waist-to-height ratio; PA: physical activity. * Pearson's chi-square test; ** Fisher's exact test. Bolded values indicate statistical differences (p<0.05) between age groups.*

Table 2 – Classification of trunk flexibility of individuals participating in a community-based health education program in the city of Santo Antônio de Goiás, Brazil, by age group

Trunk flexibility	Age group (years)							
	Total (n = 92)		20 – 39 (n = 28)		40 – 59 (n = 44)		60+ (n = 20)	
	n	%	n	%	n	%	n	%
Excellent	7	7.6	2	7.1	3	6.8	2	10.0
Above mean	14	15.2	3	10.8	7	15.9	4	20.0
Mean	11	12.0	2	7.1	7	15.9	2	10.0
Below mean	20	21.7	7	25.0	10	22.7	3	15.0
Poor	40	43.5	14	50.0	17	38.7	9	45.0

Trunk flexibility according to sex and age group[34]

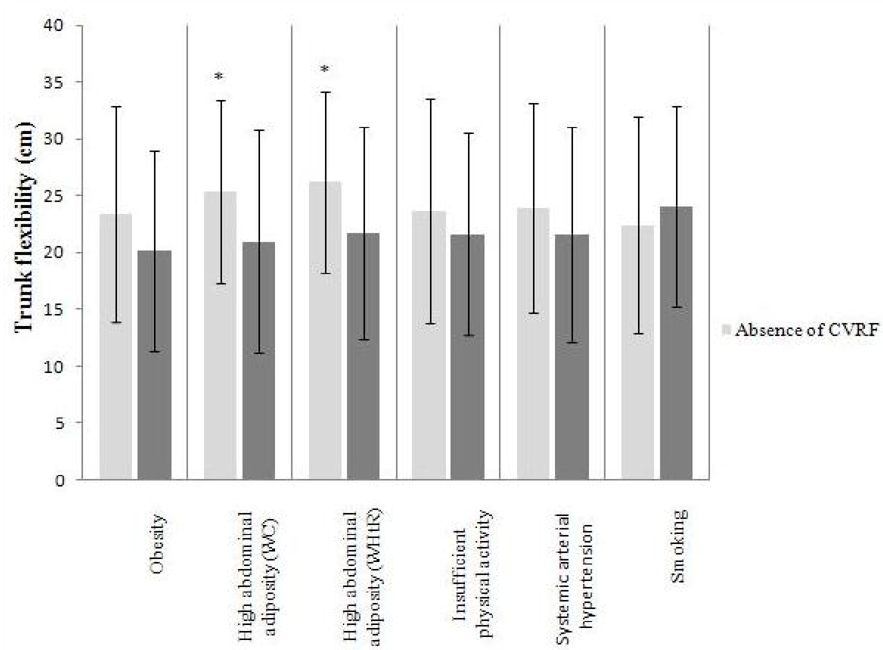

Figure 2 – Trunk flexibility (mean ± SD) of individuals with (dark gray bars) and without cardiovascular risk factors (light gray bars); *p < 0.05, Student's t-test; CVRF: cardiovascular risk factor; WC: waist circumference; WHtR: waist/height ratio

We observed a high prevalence of increased abdominal adiposity according to the WHtR (76.3%). Some studies[9,37-39] have shown that the WHtR has high accuracy in the identification of abdominal adiposity and could be a more efficient indicator than the WC, the waist-to-hip ratio (WHR) and the BMI in the cardiovascular risk assessment. Considering that excess abdominal fat is associated with CVD, WHtR is an important and useful tool for professionals in basic health care to identify individuals at increased risk.[40]

The prevalence of systemic arterial hypertension was 54.6%. The Surveillance of Risk Factors and

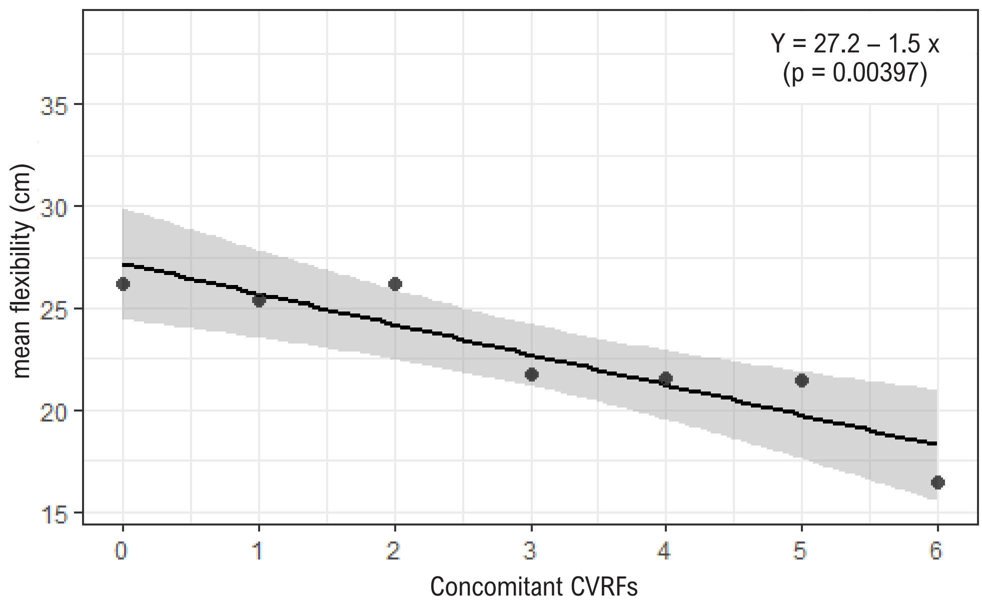

Figure 3 – Linear regression between number of concomitant cardiovascular risk factors and mean trunk flexibility (y = 27.2 – 1.5 x, adjusted R^2 = 0.80; p = 0.00397); CVRFs: cardiovascular risk factors

Protection for Chronic Diseases by Telephone Inquiry (VIGITEL, *Vigilância de Fatores de Risco e Proteção para Doenças Crônicas por Inquérito Telefônico*), conducted in all capitals of the 26 Brazilian federal states and the Federal District, registered a prevalence of hypertension of 25.7% in Brazil.[3] Our results were approximately twice as high as the prevalence found in the Brazilian population.[3] Considering that the prevalence of hypertension is increasing every year, it is necessary to implement programs focused on its reduction and prevention.

According to trunk flexibility classification, we found 64.1% of the individuals with trunk flexibility below the recommended values.[34] A similar result was found in the evaluation of 46 workers at the Federal University of Viçosa, MG, Brazil, including men and women aged around 40 years old, in which 66.5% of them had trunk flexibility below the recommended values.[41] Flexibility is important for athletes as well as for sedentary and/or physically active people, as less mobility of the hip joint, for example, can contribute to back pain and compromise work, sports and/or daily life activities.[15]

When comparing trunk flexibility between individuals with and without CVRF, we found a significant difference in the flexibility of individuals with adequate WC compared to those with WC above the recommended values. We also observed significant difference in flexibility of individuals with adequate WHtR compared to those with elevated WHtR.

Studies evaluating the relationship between trunk flexibility and CVRFs are scarce in the literature. However, studies have shown that poor trunk flexibility has been associated with arterial stiffness in young and elderly individuals.[19,20,42] Thus, flexibility may be a predictor of arterial stiffness, regardless of other physical fitness components.[19,20] In addition, after only four weeks of flexibility training, a reduction in arterial stiffness was observed,[19] thereby suggesting flexibility as an indicator of cardiovascular health and cardiorespiratory fitness.[43] These findings reinforce the importance of flexibility training and the inclusion of this measure in community health programs.

Cardiovascular risk factors can occur simultaneously and represent a greater risk for cardiovascular events when compared with isolated risk factors.[35,44] When the risk factors were grouped, 82.5% of the subjects were found to be at increased risk for CVD. A previous study reported that concomitant CVRFs were found in 72.5% adults and elderly in the city of Salvador, Brazil.[45]

We found a strong negative correlation between the number of concomitant CVRFs and mean trunk flexibility. Therefore, flexibility seems to be a sensitive indicator of increased cardiovascular risk. According to the equation obtained by linear regression analysis, we observed that for each additional risk factor, flexibility was reduced by 1.50 cm, or each 1.50 cm reduction in trunk flexibility indicated the addition of one CVRF (Figure 3). Accordingly, it is possible to estimate cardiovascular risk by the measurement of trunk flexibility using the sit-and-reach test, which is simple and easy to apply. Trunk flexibility, therefore, may be an additional tool to be applied in the detection and control of CVDs.

One limitation of our study was the inability to perform blood biochemical tests to identify other risk factors, such as dyslipidemia and glycemic disturbances. However, studies in the literature about the relationship between flexibility and CVRFs are scarce. Thus, our study is important as a basis for future research on trunk flexibility and CVRFs, including analysis of metabolic biomarkers in larger samples, to provide a better understanding of the association between the variables studied.

Conclusion

Increased abdominal adiposity was the most prevalent CVRF and it was negatively associated with trunk flexibility among participants in a community-based health program in the city of Santo Antônio de Goiás, located in the mid-west of Brazil. Moreover, there was a high prevalence of concomitant CVRFs, which were strongly and negatively correlated with trunk flexibility. Considering these findings and that flexibility training can reduce arterial stiffness, trunk flexibility is suggested as an indicator of increased cardiovascular risk. Therefore, trunk flexibility measurement may be an additional tool for health promotion and prevention of cardiovascular and associated diseases in community health programs.

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Author contributions

Conception and design of the research: Silva MS, Cominetti C, Naves MMV. Data acquisition: Cardoso RF, Silva MS. Data synthesis, analysis and interpretation: Cardoso RF, Silva MS, Cominetti C, Naves MMV. Statistical analysis and manuscript writing: Cardoso RF. Critical review of the writing and the intellectual content of the manuscript: Cominetti C, Naves MMV.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

There were no external funding sources for this study.

Study Association

This study is associated with Rafael Felipe Cardoso's master thesis.

Ethical approval and informed consent

The study was approved by the Research Ethics Committee of the Federal University of Goiás (protocol number 784.446/2014). All procedures involved in this study were in accordance with the Declaration of Helsinki, 1975, updated in 2013. All participants included in the study signed an informed consent form.

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