Daily energy expenditure and plasmatic lipid-lipoprotein levels in adolescents*

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ABSTRACT

The aim of the present study was to analyze the impact of regular practice of physical activity facing estimates of daily energy expenditure (EE_{daily}) in the plasmatic lipid-lipoprotein profile in a representative sample of adolescents. The sample consisted of 452 subjects (246 females and 206 males), age between 15 and 18 years. The plasmatic lipid-lipoprotein concentrations were established through laboratory procedures. The data concerning the regular practice of physical activity were obtained though a retrospective instrument of self-recording. Estimates concerning the EE_{daily} were established based on the caloric cost associated with the type and the duration of the activities registered by the adolescents. The sample was divided in three groups of regular practice of physical activity: the least active, < 25º percentile of the EE_{daily}; the moderately active, 25-75º percentile of the EE_{daily}; and the most active, > 75º percentile of the EE_{daily}. Cutting points for an atherogenic lipid-lipoprotein risk were also established. The results of the analysis of covariance, having the participation of the body mass index controlled, showed that the HDL-C concentrations were significantly different according to the growing groups of EE_{daily} in females ($p = 0.009$) and in males ($p = 0.010$). However, the variation behavior of the values observed was different in the two sexes. The analysis of logistic regression showed that the relative risk for lower values of HDL-C was two times higher among the least active adolescents comparing with the most active ones. In both sexes the concentrations of total cholesterol, LDL-C and triglycerides did not present significant differences among the groups of EE_{daily}. In conclusion, more intense regular practice of physical activity as well as higher EE_{daily} are associated with higher concentrations of HDL-C in adolescents of both sexes, regardless of the variations of body weight. The associations between EE_{daily} and the other plasmatic components of lipid-lipoproteins treated in the present study were weak and inconsistent.

Keywords: Physical activity. Sedentarism. Cardiovascular risk factors. Cholesterol. Triglycerides.

INTRODUCTION

Despite the trend of decline in death cases, in the industrialized societies the coronary arterial disease (CAD) is one of the main causes of morbid mortality[1]. Although reasons which effectively may lead to this decrease of the mortality rates are not conclusive, such fact has been attributed to advances concerning diagnosis, treatment and health insurance coverage concerning this pathology[2].

Nowadays, developing countries have been presenting a profile of morbid mortality which suggests an epidemiological transition. In this case, from a situation in which there was higher predominance of infectious diseases to another model in which chronic degenerative diseases linked to risk behaviors, such as CAD, start to be the dominant causes of mortality[3]. In Brazil, from 20 years of age on, it is estimated that CAD corresponds to approximately 20% of the deaths for known reasons[4]. Moreover, CAD is the main cause of expenses in medical assistance in the country[5].

CAD presents a multifactor etiology and its clinical manifestations occur almost exclusively in adulthood[6]. Nonetheless, it is well reported in the literature that the atherosclerosis process may trigger its development in childhood and adolescence as well as advance it in several stages, developing to a posterior premature coronariopathy in adulthood[7-9]. Therefore, it has been recommended that CAD primary prevention strategies, including the promotion of suitable and regular physical exercise practice, begin as early as possible[10-12].

Epidemiological evidence reveals a strong identification between a compromised plasma lipid-lipoprotein profile and morbidity cases by CVD[13-15]. Particularly in this case, in adult subjects, the available studies have tried to demonstrate that daily practice of physical activity may prevent or at least minimize the development of CAD as well as its risk factors, specifically, altered values of plasma lipids-lipoproteins. Nonetheless, in young populations the results of studies which try to show occasional association between physical activity practice and a favorable profile of plasma lipid-lipoprotein are clashing[16-25]. These results may probably present divergences due to the different research framework proposed, the statistical procedures used in the data analysis as well as the nature and specifications of the methods applied in the data collection equivalent to the daily physical activity.

Within this context, the aim of the present study was to analyze the impact of the daily physical activity practice, with data associated to the estimation of the daily energy expenditure in the plasma lipid lipoprotein of adolescents.

METHODS

Data present in the database built from the research project 'Physical Activity, Diet Composition and Risk Factors Prone to Cardiovascular Diseases in Adolescents' were used for the study's elaboration. This research includes adolescents with age between 15 and 18 years of age of both sexes[26-28].

The research project had as target students regularly enrolled in the high school of the Application School linked to the State University of Londrina, Paraná State. Subjects who only went to this school were chosen due to the study's longitudinal characteristics (experimentation of health educational programs through diet interventions as well as physical exercises practice), and for its representation in the universe of high school students from the Londrina county, Paraná.

The intervention protocols in the study were approved by the Ethics Committee in Research of Londrina and followed norms of the 196/96 Resolution of the National Health Council on research

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Received in 1/3/06. Final version received in 3/8/06. Approved in 25/10/06.

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involving humans. The subjects' inclusion in the study was voluntary and with authorization from the parents or responsible ones. All students enrolled in the school year of 2003, along with their parents or responsible ones, were contacted and informed about the study's nature and aims. 452 (246 girls and 206 boys) students out of the 518 enrolled ones, agreed to participate in the study.

As additional data of the sample analyzed in the study, we can highlight that, based on the socio-economical classification criteria of the students' families, with data concerning educational background of the family's leader, housing conditions, household appliances and cars possession, as well as the number of domestic servants[29], it was observed that 22% of the students were categorized in low socio-economical status; 27% in high status and 51% in intermediate status. Concerning the classification criteria of sexual maturation suggested by Tanner[30], 10% of the analyzed girls presented breasts development equivalent to stage III, 61% to stage IV and 29% to stage V. Among the boys, 49% were in stage IV of development of pubic hair, and the remaining 51% in stage V.

In the anthropometric field, height and body weight measurements were performed from the standards suggested by Gordon *et al.*[31]. Body mass index (BMI) calculation was also established considering the ratio between the body weight and the square of the height measurements (kg/m^2).

The doses of plasma lipid lipoproteins were performed with collection of samples of 10 ml of venous blood from the elbow fold, after a period of 10-12h fasting, between 07:00 and 08:00h in the morning. The serum was immediately separated by centrifugation, being the amounts of triglycerides (TG), total cholesterol (TC) and fractions, low density lipoproteins (LDL-C) and high density (HDL-C) determined. The TC was determined by the enzymatic method cholesterol oxidase/peroxidase in a spectrophotometer instrument. The HDL-C was measured through precipitant reactive method, and the LDL-C was calculated by the Friedewald formula[32]. The TG was determined by the glycerol enzymatic method. Besides the absolute values of each plasma component, the TC/HDL-C and LDL-C/HDL-C ratios were considered. The reference values applied in order to define an atherogenic risk lipid lipoprotein profile followed the proposal presented for adolescents with the III Brazilian Guidelines on Dyslipidemias[33]: TG ≥ 130 mg/dl, TC ≥ 200 mg/dl, LDL-C ≥ 130 mg/dl and HDL-C ≤ 35 mg/dl.

In order to have the physical activity practice levels estimated, the self-record retrospective instrument of the daily activities, devised by Bouchard *et al.* was used[34]. In this case, the daily activities are classified in a continuum involving nine categories, according to estimates concerning mean caloric cost of the activities performed by humans: (1) rest in bed; (2) activities performed at sitting position; (3) mild activities performed at standing position; (4) activities which involve mild walks (< 4 km/hour); (5) mild hand labor; (6) active leisure activities and practice of recreational sports; (7) moderate hand labor; (8) active leisure activities and moderate sports practice; and (9) intense hand labor and practice of competitive sports. Since it is practical, innocuous and easy to be interpreted, the present instrument has been widely accepted and used in other studies involving young populations[25,35-38].

The retrospective instrument was filled out by the adolescents themselves in four days of the same week, two in the middle (between Monday and Friday) and two on the weekend (Saturday and Sunday). The pondered mean involving the two days of the middle and of the weekend was used for the calculation. For its administration, the day was divided in 96 periods of 15 minutes each. The study's participants received instructions and recommendations to identify the kind of activity classified between categories 1 and 9, performed in each 15-minute period, during the 24 hours of the day. A list with typical daily activities, exemplifying activities completed in the different categories, was presented to the adolescents in the trial to facilitate the completion of the instrument. Moreover, the participants were told to take additional notes if any performed activity had not been mentioned on the list specifically devised for this purpose.

Based on this data, the time expenditure of each study's participant in the different categories of physical activity was established. The expenditure time in categories 6 to 9 (mean energetic cost ≥ 4.8 Mets) was considered as an indicator of moderate to vigorous intensity physical activity (MVPA). The expenditure time in categories 3 to 5 (mean energetic cost between 2.3 and 3.3 Mets) was used as an indicator of low intensity physical activity (LIPA); and in categories 1 and 2 (mean energetic cost ≤ 1.5 Mets) as an indicator of physical inactivity (PHIN). Additionally, based on the caloric references suggested by the devisors of the used measurement instrument[34], the estimates of energetic expenditure by kilogram of body weight of the activities performed during the day (kcal/kg/day) were used as indicators of the daily physical activity practice (EE_{Daily}). This procedure was validated to be used in adolescents with the double marked water criterion technique. The mean difference of the EE_{Daily} between the two methods was of 1.2% with a variation coefficient of 15%[39].

The statistical treatment of the data was performed with the computer package *Statistical Package for the Social Science* (SPSS), version 13.0. Firstly, the sample was stratified in three groups of daily physical activity practice according to cut-points specific by sex and EE_{Daily}. The least physically active group had those adolescents who presented EE_{Daily} below percentile 25 (≤ 35.1 and ≤ 35.2 kcal/kg/day between girls and boys, respectively). Adolescents between 25 and 75 percentiles of the EE_{Daily} (35.2-37.7 and 35.3-39.5 kcal/kg/day between girls and boys, respectively) were considered moderately physically active, and those above the percentile 75 of the EE_{Daily} (≥ 37.8 and ≥ 39.6 kcal/kg/day between girls and boys, respectively) were considered the most physically active. Later, in order to have the anthropometric and daily physical activity practice variables selected in the study analyzed, variance analysis procedures were conducted. The comparisons between the values equivalent to the plasma lipid lipoproteins of the categorized adolescents in each of the three groups of daily physical activity practice (least active, moderately active and most active) were performed through co-variance analysis. In the trial to control the additional effects concerning surplus weight in the impact of physical activity over the lipid lipoprotein profile, the BMI values were considered as co-variables in the statistical analysis. Odds Ratio (OR) values, established through binary logistic regression analysis, also controlling the BMI values, were used in order to establish estimates concerning the related risk with adolescents who present atherogenic risk lipid lipoprotein profile due to the categorization in decreasing groups of daily physical activity practice. Reliability interval of 95% was adopted.

RESULTS

Statistical data concerning the anthropometric variables as well as daily physical activity practice are found in table 1. The cut-points equivalent to the 25 and percentiles are lower among girls, suggesting hence that boys are daily more active. In both sexes, occasional differences observed concerning age, height, body weight and BMI of the adolescents joined in the three groups of daily physical activity practice are not mentioned in statistical language. However, as expected, the mean expenditure time in the LIPA, MVPA and categories of physical activity practice and the EE_{Daily} present statistically significant differences ($p < 0.000$) favorable to the girls and the most physically active boys. The mean time of PHIN is significantly higher among least physically active adolescents ($p < 0.000$).

Results equivalent to the co-variance analysis, statistically controlling the data associated with the BMI are shown in table 2. The plasma concentrations of HDL-C ($p = 0.009$ and $p = 0.010$ for girls

TABLE 1
Mean, standard deviation and 'F' statistics values concerning the anthropometric data and routine physical activity practice of the subjects analyzed in the study

	Less active	Moderately active	More active	p < F
Girls				
n	57	135	54	ns
Age (years)	16.64 ± 0.83	16.64 ± 0.90	16.63 ± 1.00	ns
Height (cm)	163.88 ± 7.26	162.72 ± 5.41	162.97 ± 6.77	ns
Body weight (kg)	56.79 ± 9.16	56.65 ± 8.16	54.86 ± 10.07	ns
BMI (kg/m²)	21.12 ± 2.60	21.37 ± 2.73	20.59 ± 3.23	0.000
PHIN (min/day)	1,303.17 ± 42.34	1,200.17 ± 59.25	1,054.58 ± 68.37	0.000
LIPA (min/day)	136.25 ± 33.12	218.44 ± 46.08	338.40 ± 71.21	0.000
MVPA (min/day)	0.47 ± 3.23	23.07 ± 9.20	48.29 ± 14.29	0.000
PA_{Daily} (kcal/kg/day)	34.15 ± 0.80	36.35 ± 0.88	39.85 ± 0.92	0.000
Boys				
n	51	102	53	
Age (years)	16.42 ± 0.85	16.50 ± 0.90	16.68 ± 0.75	ns
Height (cm)	174.48 ± 5.64	173.39 ± 0.67	174.72 ± 7.46	ns
Body weight (kg)	66.74 ± 12.24	64.52 ± 10.28	64.40 ± 10.39	ns
BMI (kg/m²)	21.88 ± 3.84	21.45 ± 2.93	21.06 ± 2.81	ns
PHIN (min/day)	1,328.35 ± 41.51	1,196.03 ± 87.41	1,096.16 ± 96.09	0.000
LIPA (min/day)	107.19 ± 40.34	220.19 ± 43.24	246.34 ± 47.08	0.000
MVPA (min/day)	5.27 ± 9.13	25.29 ± 12.54	98.17 ± 39.05	0.000
PA_{Daily} (kcal/kg/day)	34.08 ± 0.79	37.23 ± 1.28	42.25 ± 2.36	0.000

BMI: body mass index; PHIN: physical inactivity; LIPA: low intensity physical activity; MVPA: moderate to vigorous intensities physical activity; PA_{Daily}: daily physical activity practice.

TABLE 2
Statistics data concerning the covariance analysis, controlling the data associated with the BMI, concerning the plasma lipid lipoproteins concentrations according to the daily physical activity practice

	Less active	Moderately active	More active	p < F
Girls				
TC (mg/dl)	153.03 ± 26.51	144.92 ± 21.66	137.97 ± 23.44	ns
HDL-C (mg/dl)	41.32 ± 11.05	52.04 ± 11.94	56.94 ± 14.04	0.009
LDL-C (mg/dl)	84.68 ± 27.20	76.05 ± 20.40	74.48 ± 22.13	ns
TG (mg/dl)	87.44 ± 28.63	84.60 ± 39.17	77.90 ± 33.86	ns
TC/HDL-C	3.46 ± 0.80	2.84 ± 0.67	2.58 ± 0.57	ns
LDL-C/HDL-C	1.96 ± 0.62	1.51 ± 0.49	1.34 ± 0.52	ns
Boys				
TC (mg/dl)	142.69 ± 18.52	135.17 ± 25.88	128.67 ± 21.75	ns
HDL-C (mg/dl)	38.45 ± 7.29	45.21 ± 6.09	55.00 ± 7.27	0.010
LDL-C (mg/dl)	76.66 ± 17.93	71.05 ± 23.25	65.17 ± 18.62	ns
TG (mg/dl)	87.48 ± 37.74	81.71 ± 36.65	78.54 ± 39.09	ns
TC/HDL-C	3.73 ± 0.82	3.06 ± 0.74	2.39 ± 0.64	ns
LDL-C/HDL-C	2.02 ± 0.65	1.60 ± 0.55	1.23 ± 0.54	ns

TC: total cholesterol: HDL-C: high density lipoproteins; LDL-C: low density lipoproteins; TG: triglycerides; CT/HDL-C: ratio between total cholesterol and high density lipoproteins; LDL-C/HDL-C: ratio between low and high densities lipoproteins.

and boys, respectively) of the adolescents analyzed in the study present differences according to the increasing groups of daily physical activity practice; however, the variation behavior of the values observed is different in the two sexes. While in the boys the most remarkable differences are observed in the most active group in comparison with its moderately active and least active pairs, in the girls this phenomenon is observed in the moderately active group in relation to the least active one. The values observed concerning TC, LDL-C, TG and the TC/HDL-C and LDL-C/HDL-C ratios did not present statistical differences among the three daily physical activity practice groups.

Table 3 shows the OR dimensions followed by the reliability intervals of 95% equivalent to the relative risk of the adolescents analyzed in the study present atherogenic risk lipid lipoprotein profile due to the classification in daily physical activity practice groups. The results of the logistic regression analysis show that the OR dimensions for dislypoproteinemia are higher in girls and among adolescents of lower daily physical activity practice when compared with the remaining groups. Nevertheless, in the present investigation, only in the HDL-C case the adolescents with lower EE_{Daily} demonstrate higher relative risk statistically significant of presenting compromising amounts in comparison with their pairs of higher EE_{Daily} (girls – OR = 2.18; 95% IC 1.31-3.11; boys – OR = 1.96; 95% IC 1.26-2.75). In the other three plasma components (TC, LDL-C and TG) it was verified that the found OR values are not relevant in statistical language.

TABLE 3
Odds Ratio values and reliability interval of 95% between cutting points of plasma lipid lipoproteins and indicators of daily physical activity practice

	Girls	Boys
TC		
More active	1.00	1.00
Moderately active	1.21 (0.60-1.86)	1.28 (0.68-1.93)
Less active	1.65 (0.95-2.40)	1.47 (0.81-2.16)
HDL-C		
More active	1.00	1.00
Moderately active	1.42 (0.75-2.19)	1.37 (0.69-2.17)
Less active	2.18 (1.31-3.11)	1.96 (1.26-2.75)
LDL-C		
More active	1.00	1.00
Moderately active	1.28 (0.87-1.71)	1.34 (0.65-2.07)
Less active	1.67 (0.99-2.44)	1.53 (0.82-2.25)
TG		
More active	1.00	1.00
Moderately active	1.39 (0.79-2.04)	1.27 (0.67-1.92)
Less active	1.62 (0.96-2.48)	1.51 (0.87-2.19)

TC: total cholesterol: HDL-C: high density lipoproteins; LDL-C: low density lipoproteins; TG: triglycerides.

DISCUSSION

The main finding of the present study revealed that, in adolescents, high EE_{Daily}, induced by daily physical activity practice, is associated with higher serum concentrations of HDL-C. Moreover, the EE_{Daily} and the highest amounts of HDL-C present specific behavior in each sex. The OR also showed significant higher risk of finding atherogenic risk HDL-C values in the least active adolescents group compared with its pairs joined in the most physically active group. The associations observed between the EE_{Daily} and the remaining plasma components of lipid lipoproteins treated in the present study were weak and inconsistent. Corroborating with the expectations found in the literature, the results found here agree with the data provided by studies previously conducted, involving other measurement indicators aimed at monitoring physical activity[16-25].

Sometimes the modifications in the plasma lipid lipoprotein profile of adolescents are tried to be justified by the concomitant alterations in their body weight[17,25]. In the present study, the values of BMI were statistically controlled with the co-variance analysis. In that case, even in the lack of participation of the BMI values, the results found showed that the adolescents who belonged to the group with higher EE_{Daily} presented significantly higher values of HDL-C compared with its pairs which belong to the groups of lower EE_{Daily}.

It has been proved in studies involving adults that a less physically active lifestyle is a risk behavior clearly identified with altered values of plasma lipid lipoproteins [40-43]; however, this association has not been confirmed with the same potential in young populations, which has been intriguing the researchers of the field.

The justifications which possibly explain the observed differences in the magnitude of the associations between physical activity and

lipid lipoproteins plasma concentrations of adults and adolescents are still obscure. Nonetheless, the less discriminatory ability concerning the daily physical activity practice and lipid lipoprotein profile of adolescents compared with adults, besides implications concerning the biological maturation process, deserved attention.

The fact that adolescents are naturally more active in their routine compared with adults has been a widely used argument by some researchers[16-17,19] once the occasional variations in the plasma lipid lipoproteins amount in a higher level of daily physical activity practice do not present the same sensibility than in adults. However, based on the found results in the present study, such hypothesis should be discarded, taking into consideration that the expenditure time of the most active adolescents in MVPA was significantly higher than its moderately active and least physically active pairs. As an illustration, we can say that the mean expenditure time in MVPA (≥ 4.8 Mets) in boys considered the most physically active was 98.17 minutes/day; that is, higher than the 30-60 daily minutes recommended for adolescents by the public health organs[44-45], which was not the case of boys considered moderately active (25.29 minutes/day) and least active (5.27 minutes/day). Among the girls, those considered most active spent a mean time in MVPA of 48.29 minutes/day, while the least active ones, in average, remained only 0.47 minute/day in this category of physical activity. Therefore, both most active and least active adolescents in the groups of daily physical activity as well as the EE_{Daily} were represented in the sample selected for the study.

Another trial of justification which could partly explain the differences observed between the magnitude of the physical activity-plasma concentrations associations of adults and adolescents is related to lower variations found in the lipid lipoproteins concentrations of younger subjects. The expectation is that the proportion of adolescents who will present altered values of plasma lipid lipoproteins is significantly lower than of adults; thus, the impact of the daily physical activity practice in the plasma lipid lipoproteins amounts should be, to begin with, due to their dimensions being already close to healthy values.

Conversely, the justification which most fulfills the differences observed between the magnitude of physical activity-plasma lipid lipoproteins concentrations associations of adults and adolescents may be related to the fact that metabolic adaptations linked with the control of the plasma lipid lipoproteins concentrations in the performance of physical exertion result from complex interactions involving hormones, enzymes and receptors and therefore, particularly occur in the young body, differently from the adult's[46]. In this context, theoretically, it is assumed that the significant associations observed in adults may not be the cause, with the participation therefore of additional effects from other non-identified metabolic variables, affecting hence, the impact of the daily physical activity practice in the plasma concentrations of lipid lipoproteins, which is not apparent in adolescents due to their lack of total biological maturation. Such fact may probably suggest that the conception that the consequences concerning least daily physical activity practice in the plasma concentrations of lipid lipoproteins may take some time to be identified.

New data presented in the present study are related with the impact of the EE_{Daily}, an indicator strongly accepted concerning the daily physical activity practice[16,25,34,39], in the atherogenic risk lipid lipoprotein profile, established through the cut-points clinically relevant for adolescents[33]. When using a conventional statistical framework aimed to identify associations between physical activity and plasma lipid lipoproteins concentrations, which is the case of the correlation coefficients, it is possible to identify that some more physically active subjects may present dyslipoproteinaemias, and, on the other hand, some less physically active subjects may present a desirable lipid lipoprotein profile. Therefore, in order to estimate the relative risk of adolescents classified in decreasing groups of EE_{Daily} who present compromising plasma lipid lipoproteins concentrations, binary logistic regression analysis was applied. In summary, with the dimensions of the OR values, higher relative risk was observed for adolescents who present atherogenic risk lipid lipoprotein profile with decrease in EE_{Daily}. Nevertheless, due to the reliability intervals breadth equivalent to the calculated values of OR, only girls and boys with low EE_{Daily} (≤ 35.1 and ≤ 35.2 kcal/kg/day respectively) demonstrated significant relative risk in statistical language and approximately of two-fold more (girls – OR = 2.18; 95% IC 1.31-3.11; boys – OR = 1.96; 95% IC 1.6-2.75) of presenting HDL-C values ≤ 35 mg/dl compared with girls and boys with high EE_{Daily} (≥ 37.8 among boys and ≥ 39.6 kcal/kg/day among girls).

The results of the present study must be interpreted with some limitations. First, the data concerning the daily physical activity practice as well as the EE_{Daily} were obtained through a retrospective instrument of self-record of the daily activities, which was filled by the adolescents themselves. Although the validity and reproducibility indications of the instrument are available and fulfill the proposed acceptance criteria[39], other measurements concerning physical activity as well as the EE_{Daily}, which is the case of the accelerometers, may offer more robust and conclusive results. Second, eating habits of the adolescents analyzed in the study have not been considered; besides that, higher ingestion of food rich in total and saturated fat may interfere in the plasma lipid lipoproteins concentrations[28,47-48], the same situation happening with smoking[28,49-50]. Moreover, the sample framework applied, involving non-randomly selection of the subjects and with specific social, economical and cultural features, may weaken the external validity of the study as well as make its results' generalization difficult.

In conclusion, the found results suggest that high EE_{Daily} is associated with HDL-C concentrations also high in adolescents of both sexes. Concerning the difficulties to obtain reliable indicators for daily physical activity practice in young populations, especially concerning the energy expenditure of the daily activities, a better understanding on the complex dose-response relationship between physical activity and plasma lipid lipoproteins concentrations is important for the proposition of physical activity practice recommendations aimed to prevention of dyslipoproteinemias in young subjects and in adult ages in the future.

All the authors declared there is not any potential conflict of interests regarding this article.

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