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Prevalence of obesity in Italian adolescents. Does the use of different growth charts make the difference?

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Declarations

Ethics approval and consent to participate:

The study protocol was approved by the Ethical Committee of the University of Turin on the 11th of January 2012, and the procedures were in compliance with the Helsinki Declaration principles. Practice number was 11/01/2012.

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Abstract

Background*:* Since populations are becoming increasingly multi-ethnic, the use of local or international charts is a matter of debate.

Objectives*:* To evaluate: how the choice of cut-off thresholds affected prevalence of underweight (UW), overweight (OW), obesity (OB) in 1,200 11-12-y Italian adolescents, and how their somatic growth depended on parental origin.

Methods*:* The height, weight and BMI were expressed as SDS using Italian (ISPED-2006) and UK (UK-1990) charts. The classification of UW/OW/OB was computed with the IOTF international cut-offs, and thresholds were identified as centiles corresponding to BMI values of 18.5/25.0/30.0 kg/m^2 at 18-y in ISPED-2006 or UK-1990 references.

Results: About 30% participants had non-Italian parents, above all from North-Africa and Romania. Referring to the UK-1990 charts, all groups showed negative mean SDS for height, and positive SDS for weight and BMI. Referring to the ISPED-2006 charts, all mean SDS were negative. Percentage of UW individuals was higher in accordance with ISPED-2006 than with UK-1990 charts, whereas percentages of OW/OB were higher with UK-1990 than ISPED-2006 charts. The results obtained by using IOFT cut-offs were similar to UK-1990 cut-offs. These results were due to the different shape of age-dependent cut-off centiles. Independently by the parental origin, the percentages of adolescents classified as OW/OB were closer to the expected values by using the ISPED-2006 then the UK-1990 cut-offs. The results suggested the use of the Italian references for adolescents with immigrant parents.

Conclusions*:* The use of local charts seems more appropriate at least in Italian adolescents in the age range studied.

Key words: cut-off thresholds, immigration, overweight, underweight.

Introduction

Populations are becoming increasingly multi-ethnic owing to the increasing immigration processes. In Italy, immigration is particularly evident in North-Western regions.[1] In Turin, the percentage of immigrants has more than doubled from 2004 to 2013. Approximately 30% of a cohort of students attending the first year of secondary schools in Turin had non-Italian parents.[2-4]

A highly controversial topic is whether charts used to monitor stature and weight growth should be local or international, since growth reflects the condition of the society where individuals live.[5] The World Health Organization (WHO) children growth standards were developed on the assumption that under optimal environmental conditions, a single standard can fit all subjects, regardless of ethnicity.[6] Nevertheless, recent data showed significant differences in growth patterns among European children, and authors advocated the use of national references rather than the-WHO growth charts adoption.[7] The British-1990 body mass index (BMI) reference charts provided cut-off thresholds to define overweight, but the choice of a given cut-off centile and of cross-sectional data were criticized.[8-10] Therefore, the International Obesity Task Force (IOTF) proposed that the adult cut-off points for underweight (UW), overweight (OW) and obesity (OB) could be used also in children.[11-12] A few studies, however, raised doubts about the validity of international charts, since the same BMI centiles do not reflect the health risks in populations from different countries.[10,13-15]

In Italy, the situation is complex, owing to the prevalence of youth with OW and OB, which is the highest in Europe, and the increasing immigration rate.[5,16-17] An Italian nutrition survey promoted by the Italian Ministry of Health, involving more than 45,000 third-grade students reported a >30% prevalence of OW/OB,[17-18] according to the international cut-off thresholds proposed by Cole et al,[12] even if Italian cut-off thresholds are available.[16,19]

The aim of the present study was to evaluate how the cut-off thresholds of different growth references affect the estimate of UW, OW, and OB prevalence in a group of 1,200 adolescents, and to evaluate the extent to which somatic growth of these adolescents depends on parental origin.[12]

Methods

All the students attending the first year of middle school in Turin routinely undergo a health status and physical performance assessment.[3-4] In Italy, students attend this class at 11-12-y; however, a few individuals who failed the exams during their schooling, repeated the class and were older. Out of 7,263 students attending this class in Turin in 2011-2012, 6,876 (94.7%) participated in the assessment. Among participants, 1,200 students were selected by a simple random sampling. They received a questionnaire on health status and had a clinical examination. Their age, sex, weight, height, BMI, and percentages of individuals with UW/OW/OB were almost overlapping to those of the whole sample who participated in the assessment.[3-4]

Children's parents or legal representatives signed a consent form for the study participation. The study protocol was approved by the local Ethical Committee; the procedures were in compliance with the Helsinki Declaration principles.

Measurements

A week before the assessment, students were given questionnaires to be filled by parents at home, indicating their country of origin. We considered as coming from North Africa parents from Morocco, Algeria, Tunisia and Libya.

Weight and height were measured in all the participants by trained researchers. Weight was measured to the nearest 0.1 kg by a mechanical column scale (SECA model 711, Hamburg, Germany), and height to the nearest 0.1 cm with a stadiometer (SECA 220 measuring rod, Hamburg, Germany) with the participants wearing light clothes and no shoes. The measurements were performed after 8-10 h fasting in the morning, after few exercises of spine stretching. The weight scale was calibrated before each measurement session.

The pubertal stages were assessed by clinical examination according to the methods of Marshall and Tanner by trained personnel, by evaluating breast maturation (girl), testicular volume (boys) and pubic hair stages.[20-21]

Statistical analyses

The BMI was expressed as SDS (Standard Deviation Score) using ISPED-2006 charts (growth reference for Italy) and UK-1990 charts (reference for UK).[19,8] Both the charts express the distribution of auxological variables in term of three age-dependent smoothing splines called L (parameter that allows for the distribution skewness), M (median) and S (coefficient of variation). This parametrization allows to compute the SDS corresponding to the value (y) of the auxological variable as $SDS=[(y/M)^{L}-1]/(L\times S)$.[22]

To provide international cut-off thresholds consistent with the WHO adult cut-offs, Cole derived from about 200,000 girls and boys from 6 countries the centiles of the age-dependent BMI distribution (IOTF-2007 cut-off thresholds) that assumed the values of 18.5 (UW), 25 (OW), and 30kg/m^2 (OB) at 18-y (i.e. the adult-thresholds by the WHO).[23] Similarly, we considered as "local" thresholds the centiles that in ISPED-2006 or UK-1990 charts corresponded to 18.5, 25.0, and 30.0kg/m^2 at 18-y.[11-12,23] The cut-off centiles strictly depend on the reference set taken into account.

The percentages of subjects classified as UW/OW/OB were computed according to the cut-off thresholds cited above. For definition, if the study population is similar to the population on which the charts were traced, the expected percentages of UW/OW/OB subjects were: the corresponding UW cut-off centile (UW subjects), [100-the corresponding OB cut-off centile] (OB subjects), and [100-the corresponding OW cut-off centile -the expected percentage of OB individuals] (OW, but not OB subjects).

Results

About 70% of our students had Italian parents (**Tab.1)**. Out of the remaining, 32.6% had parents from North-Africa, 30% from Romania, and “other” included Albania (7.6%), Peru (5.4%), Turkey (3.7%),

China (2.8%), Chile (2.0%), Nigeria (2.0%), and many others with ≤5 children each. Owing to the low number of subjects in these subgroups, we considered only students with parents from Italy, North-Africa and Romania.

For girls, the cut-off centiles for UW/OW/OB derived from UK-1990 and ISPED-2006 charts have similar grade: about the 12th centile for the UW definition, the 88th for OW, and 98th for OB (**Tab.2**). For boys, the cut-off centiles derived from UK-1990 have higher grade than those derived from ISPED-2006 charts.

Figure 1 shows how ISPED-2006, UK-1990, and IOTF cut-off thresholds vary with increasing age. The first two cut-off centiles largely differ in value and shape, even for girls where centile grade is similar. For example, for girls at 11-y, the age of most participants (**Tab.1**), the BMI values of OB/OW/UW cut-off thresholds are respectively 25.6 *vs* 29.4kg/m^2, 21.1 *vs* 23.9kg/m^2, 15.5 *vs* 16.3kg/m^2 (UK-1990 *vs* ISPED-2006). The corresponding cut-off thresholds for boys are: 24.8 and 28.4kg/m^2, 20.4 and 22.4kg/m^2, 15.2 and 15.5kg/m^2. Noteworthy, the absolute differences for girls are higher than for boys even if the cut-off centile grades are closer. The IOTF cut-off thresholds for OW and OB are close to those derived from UK-1990.

Height-, weight- and BMI-SDS derived from UK-1990 and ISPED-2006 charts are reported by country of parental origin (**Tab.3**). When referred to the UK-1990 charts, all groups show negative mean (and median) SDS for height, and positive for weight and BMI, suggesting that these students differ in body shape from their UK peers, i.e., on average, they are shorter and heavier. On the contrary, when referred to ISPED-2006 charts, all mean (and median) SDS are negative. Standard deviations (SD) for height-SDS are close to 1 (the expected value), but slightly higher for weight- and BMI-SDS. The dispersion of SDS values derived from ISPED-2006 charts is lower than that of SDS derived from UK-1990. The 1st centile is lower than expected (i.e. -2.33), except for height-SDS (UK-1990) of adolescents with North-African parents, and for the SDS (UK-1990) of all the traits adolescents of Romanian children (**Tab.2**). The 99th centile is always lower than expected (i.e. +2.33) for height-SDS (both charts), and higher for weight- and BMI-SDS (UK-1990), but lower for weight-SDS of adolescents with Italian and Romanian parents (ISPED-2006).

The differences in height-SDS and weight-SDS between stages of breast maturation, testicular volume < or ≥4mL, and pubic hair stages (both sexes) are negligible (results not reported).

Table 4 reports the percentage of UW/OW/OB subjects in accordance with the different cut-off thresholds. From Table 2, we can derive that the expected percentages of UW, OW -but not OB-, and OB adolescents are 12.3%, 10.3% and 1.7% (girls), and 6.3%, 15.8% and 2.3% (boys), respectively, with ISPED-2006, and 12.2%, 10.5% and 1.2% (girls), and 11.0%, 8.7% and 0.9% (boys), with UK-1990 cut-offs.

In both sexes, the percentage of UW subjects is about 2-fold higher than expected adopting the ISPED-2006 reference. According to UK-1990, the percentage of UW boys, independently of parental origin, and UW girls with Romanian parents are less than expected, whereas the percentage of UW girls with Italian or North-African parents is similar to the expected value. The differences between observed and expected percentages of OW/OB subjects in accordance with ISPED-2006 are rather small, with the exception of boys with North-African parents, whose prevalence of OB is 2-fold the expected value. When defined in accordance with UK-1990, the prevalence of OW girls is about twice than expected, whereas the prevalence OW boys ranges from 1.6 (Romanian parents) to 2.9 (Italian and North-African parents) times than expected; the prevalence of OB girls ranges from 2 (North-African parents) to 6.5 (Italian parents), and that of OB boys ranges from 8.6 (Italian parents) to 11.3 (Romanian parents) times the expected value.

As it could be anticipated from **Figure 1**, the percentages of UW, OW and OB defined in accordance to IOTF cut-off thresholds are similar to those derived from UK-1990.

Discussion

The present study indicates that UK-1990 cut-off thresholds applied to a group of Italian adolescents, identified more subjects as OW or OB than ISPED-2006 cut-off thresholds, independent of parental origin. By contrast, UK-1990 identified less UW subjects than ISPED-2006. These results remained substantially unchanged considering also the pubertal status.

The observed differences derived from the different shape of the centiles used as cut-off thresholds. The UK-1990 centiles are steeper and do not reach a plateau, whereas ISPED-2006 centiles reach the plateau within 16-y (girls) and 18-y (boys). Moreover, from 6 to 18-y, ISPED-2006 thresholds are consistently higher than UK-1990 thresholds. Similar differences in growth shape, i.e. in the velocity to approach adult body proportion, emerged between Italy and UK or USA, and between Northern (Continental) and Southern (Mediterranean) Italy.[16,19] Although, on the average, Italian adolescents show higher BMIs, the prevalence of OW/OB in adulthood is lower than in Northern Europe and USA.[24]

A possible explanation for these differences may be the age of the "adiposity rebound", i.e. the normal rebound in BMI after it reaches its lowest point, usually occurring after 4-6 years,[25] which is critical for the adult development of chronic diseases.[26] An early adiposity rebound (before 5-y) is associated with obesity, hypertension and metabolic syndrome in adulthood.[27-28] The BMI rebound reaching the 50th centile occurs between 5-6 years in UK-1990 and between 3.5-4.5 years in ISPED-2006 charts.[8,19] The earlier adiposity rebound of Italian children may account, at least in part, for the higher percentage of OW/OB subjects according to the UK-1990 or IOTF cut-off threshold, but not for the slowdown in BMI growth of Italian individuals approaching adulthood.

Differences in dietary habits, social factors, genetic determinants or in puberty-onset age might be other explanations. In Europe, pubertal age shows a North-South gradient with menarche occurring at a mean age of 12-y in Italy and 13-y in UK.[29] As a consequence, the weight target is reached earlier in the Italian youths. An association has been suggested between early puberty and obesity.[30] However, it is unclear whether the early sexual maturation influences the fat depot or vice-versa.[31]

Our participants were slightly shorter than those on which ISPED-2006 charts are based. This may be due to the earlier pubertal age of Southern-Mediterranean adolescents. Our participants with North-African and Romanian parents showed a similar distribution of height-, weight- and BMI-SDS than those with Italian parents, suggesting that anthropometric characteristics of these adolescents resembled those of their Italian peers. Analogously, height growth of Maghreb infants living in France showed no significant difference than those of their French peers.[32] By contrast, Moroccan children

living in Netherlands showed substantially shorter height and increased BMI than Dutch children, and North-African children living in Sweden had higher odds of being OW/OB than Swedish children.[33-34] These findings suggest that immigration to Europe may be associated with higher OW risk.[35] An increasing prevalence of OW/OB has been reported in children of Moroccan and Middle Eastern/North African origin living in Europe than the native children.[36] The prevalence of OW/OB in Moroccan children living in Rabat was much lower than that of Moroccan children living in the Netherlands.[33,37] Socio-cultural factors such as the westernization of eating habits, the body image perception and the level of physical activity have been suggested to play an important role in this phenomenon.[38] We found the percentage of OW/OB subjects by the ISPED-2006 cut-off thresholds similar to the one expected independent of parental origin. Therefore, for the largest groups of children of immigrants in Italy, it might be advisable to employ the same charts used for their Italian peers, at least in this age-range.

Identifying appropriate growth charts is of paramount importance, since growth charts determine the cut-off thresholds used in clinical guidelines to monitor growth, with consequences for public healthcare. Our results showed that using non-Italian references likely overemphasizes the problem of OW/OB, whereas understates that of UW. The existence among adolescents of the double burden of OW and UW is proven, even if only the former is, at present, a recognized and publicized problem in Italy.[18]

The prevalence of UW subjects in Italy varied among studies: 1.2% (age range 8-9-y);[18] 13% (6-19-y);[39] 10.1% (11-y);[40] 2% (6.5-11.5-y).[41] In Italy, from 2008 to 2014, UW prevalence increased in 8-9-y children, while OW (23.2 to 20.9%) and OB (12.0 to 9.8%) decreased, although remained alarmingly high.[17-18,42] The proportion of UW children is increasing also in other countries, such as Spain, France, Sweden.[43-45] Possible explanations for this trend may be sociocultural factors associated with beauty standards and media exposure to images of ideally thin models, and the increment in adolescent body dissatisfaction.[46]

Limitations and strengths

A main weakness of the study was the narrow participants' age-range, which limited the generalizability of the results. The limitations of the BMI in assessing body fatness have been suggested,[47,13] but the reported high specificity of BMI as a measure of fatness at 11-12-y, and the high correlation between BMI and percent body fat, when appropriate cut-offs are chosen, are reassuring.[13-15,48] In the present report, the ISPED-2006 charts have been used, instead of those specific for Central-North Italy, because a high proportion of residents in Turin migrated from Southern Italy.[2]

The study strengths were the measurement of all the anthropometric variables by trained researchers, and the similarity of our participants to all the adolescents living in Turin with the same age-range, as previously shown.[3-4]

Conclusions

In adolescents from North-Western Italy in the age range studied, the use of local charts seems to be more appropriate to monitor growth. It would be important that rates and SDS values among countries using their local growth charts will be compared, in order to develop international growth charts best suited for the populations not previously included.

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Figure 1. Cut-off centiles for underweight (UW), overweight (OW) and obesity (OB) derived from UK-1990 (dots) and ISPED-2000 (dashed line) charts. Continuous lines are the IOTF-2000/7 thresholds cut-off.

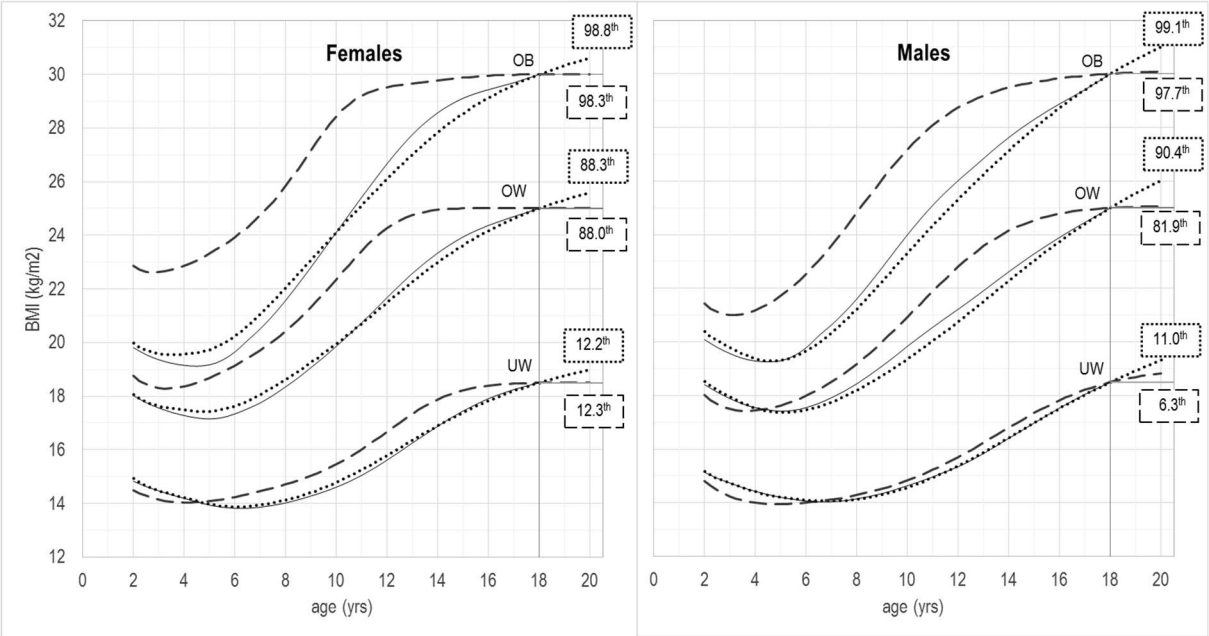

Table 1. Distribution of the participants by age, sex and country of parental origin

Age (years)	Country of parental origin								Total
	Italy		North Africa*		Romania		Others**		
	F	M	F	M	F	M	F	M	
11	35	17	2	3	1	1	5	4	68
12	378	369	36	57	34	35	41	52	1002
>12	21	27	3	14	12	23	16	14	130
Total	434	413	41	74	47	59	62	70	1200

*North Africa includes Moroccans, Algerians, Tunisians, and Libyans

**Other countries of origin, grouped as "other" included Albania (7.6%), Peru (5.4%), Turkey (3.7%), China (2.8%), Chile (2.0%), Nigeria (2.0%), Senegal (1.4%), Moldavia (1.1%), and many others with 3 or less children each.

Table 2. Cut-off centiles for underweight (UW), overweight (OW) and obesity (OB) derived from UK-1990 and ISPED-2006 references

	UK-1990		ISPED-2006	
	F	**M**	**F**	**M**
UW	12.2	11.0	12.3	6.3
OW	88.3	90.4	88.0	81.9
OB	98.8	99.1	98.3	97.7

In accordance with IOFT, the adolescent cut-off centiles for UW, OW and OB were computed by using the centiles corresponding to the BMI values respectively of 18.5 kg/m^2, 25 kg/m^2, and 30 kg/m^2 at 18 years.

Table 3. Mean values of height-, weight-, and body mass index (BMI)-SDS derived by UK-1990 and ISPED-2006 charts

		Mean (SD)	Centile				
			1st	25th	50th	75th	99th
Italy (n=847)							
UK-1990	height	-0.34 (1.03)	-2.58	-0.98	-0.31	+0.34	+2.22
	weight	+0.16 (1.27)	-2.75	-0.79	+0.15	+1.11	+2.87
	BMI	+0.38 (1.35)	-2.86	-0.63	+0.41	+1.45	+3.03
ISPED-2006	height	-0.62 (1.02)	-2.95	-1.25	-0.58	+0.06	+1.92
	weight	-0.47 (1.15)	-2.95	-1.32	-0.52	+0.35	+2.14
	BMI	-0.27 (1.19)	-2.87	-1.17	-0.27	+0.63	+2.39
North Africa (n=115)							
UK-1990	height	-0.14 (1.05)	-2.21	-0.93	-0.18	+0.49	+2.22
	weight	+0.30 (1.31)	-2.77	-0.57	+0.22	+1.28	+3.31
	BMI	+0.44 (1.45)	-3.46	-0.70	+0.46	+1.45	+3.16
ISPED-2006	height	-0.42 (1.04)	-2.49	-1.22	-0.45	+0.27	+1.92
	weight	-0.34 (1.20)	-2.98	-1.18	-0.47	+0.53	+2.60
	BMI	-0.22 (1.28)	-3.32	-1.31	-0.28	+0.68	+2.56
Romania (n=106)							
UK-1990	height	-0.26 (1.04)	-2.11	-1.11	-0.25	+0.49	+2.02
	weight	+0.15 (1.26)	-2.28	-0.80	+0.02	+1.07	+2.81
	BMI	+0.37 (1.20)	-2.29	-0.33	+0.25	+1.26	+2.96
ISPED-2006	height	-0.52 (1.01)	-2.44	-1.31	-0.40	+0.18	+1.61
	weight	-0.48 (1.14)	-2.55	-1.31	-0.67	+0.35	+2.11
	BMI	-0.30 (1.09)	-2.45	-1.01	-0.51	+0.41	+2.18
All (n=1200)							
UK-1990	height	-0.29 (1.04)	-2.63	-0.98	-0.31	+0.41	+2.22
	weight	+0.18 (1.26)	-2.75	-0.74	+0.15	+1.11	+2.89
	BMI	+0.39 (1.33)	-2.82	-0.61	+0.37	+1.43	+3.06
ISPED-2006	height	-0.57 (1.03)	-2.91	-1.25	-0.58	+0.12	+1.92
	weight	-0.45 (1.14)	-2.95	-1.29	-0.50	+0.37	+2.16
	BMI	-0.27 (1.19)	-2.87	-1.16	-0.35	+0.59	+2.41

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Table 4. Percentage of females and males defined as underweight (UW), overweight (OW) and obese (OB) in accordance with the cut-off thresholds under comparison

	Females			Males		
	UW (%)	**OW (%)**	**OB (%)**	**UW (%)**	**OW (%)**	**OB (%)**
Italy (*n*=847)						
UK-1990	13.59	17.97	7.83	9.93	25.42	7.75
ISPED-2006	27.19	11.29	1.84	14.29	14.77	2.42
IOTF-2000/7	11.98	18.20	6.22	9.44	23.73	6.05
North Africa (*n*=115)						
UK-1990	12.20	26.83	2.44	10.81	25.68	9.46
ISPED-2006	26.83	9.76	2.44	13.51	17.57	5.41
IOTF-2000/7	9.76	24.39	2.44	9.46	25.68	6.76
Romania (*n*=106)						
UK-1990	8.51	21.28	4.26	5.08	13.56	10.17
ISPED-2006	23.40	8.51	2.13	10.17	13.56	3.39
IOTF-2000/7	8.51	21.28	4.26	5.08	11.86	8.47
All (*n*=1200)						
UK-1990	12.50	19.18	7.02	9.42	22.89	8.44
ISPED-2006	26.54	10.96	1.88	13.47	14.61	2.76
IOTF-2000/7	11.13	18.66	5.82	8.77	21.75	6.49

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