Reference Values for Handgrip Strength Among Healthy Adults in Nigeria

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Abstract: Handgrip strength (HGS) measurements provide an objective index of the functional integrity of the upper extremity. Motivated by the paucity of reference values for HGS for an African population, this study sought to establish reference values for HGS in healthy Nigerian adults. The HGS of 745 (409 male and 336 female) healthy volunteers from the ages of 20–70 years was measured using a Takei Kiki Kogyo handgrip dynamometer in accordance with the American Society of Hand Therapists protocol. Men exhibited higher HGS than that in women in both dominant (35.2 kilogram force [kgf] *vs.* 24.9 kgf) and non-dominant (31.6 kgf *vs.* 22.8 kgf) hands. Using percentile values cut points, less than 25th (poor grip strength), 25th–75th (moderate grip strength), and >75th (good grip strength) percentile were <29.0 kgf, 29.0–34.0 kgf, and >34.0 kgf, respectively, for the dominant hand and <24.0 kgf, 24–36.0 kgf, and >36.0 kgf, respectively, for the non-dominant hand. These findings suggest that males have a significantly higher HGS than females. HGS decreases with increasing age for both dominant and non-dominant hands. The reference values derived in this study would be useful in assessing impairment in functional ability of the upper extremities in both healthy and patients' populations.

Key words: dominant hand, dynamometer, handgrip strength, healthy Nigerians, non-dominant hand

Introduction

Measurement of handgrip strength (HGS) is commonly performed by physiotherapists to measure baseline deficiency in hand muscle power, to monitor progress during rehabilitation, and to document outcome after rehabilitation [1–4]. HGS has long been used as a surrogate measure of total body strength [5–8]. Poor grip strength in middle and old adulthood has been shown in several studies to predict functional limitations and disability [5–11]. Reliable and valid evaluation of hand strength is of importance in determining the effectiveness of different treatment strategies or effects of different procedures. HGS can also be used in the clinical setting, such as rehabilitation, to determine the extent of an injury or disease process and the potential for and the progress of the individual in rehabilitation [12].

It is widely accepted that grip strength measurements provide an objective index of the functional integrity of the upper extremity [13]. Isometric dynamometry allows for the measurement and improvement of muscular performance in various muscle groups in dynamic condition [14]. Dynamometers are widely used in the assessment of muscle function in normal subjects and in patients [15,16]. According to Lagerstrom and Nordgren [17], the Jamar dynamometer has been found to give the most accurate and acceptable measures of grip strength. Other types such as the Smedley dynamometer, Martin Virgometer, and My Gripper have been reported as accurate instruments [18]. However, with recent technology many other types of dynamometers such as digital dynamometers, hydraulic dynamometers, the Lode grip dynamometer, and the Takei Kiki Kogyo dynamometer among others have also been employed and found reliable in many studies [19–21].

Incel et al [22] summarised that fatigue, hand dominance, time of day, age, state of nutrition, pain, cooperation of the patient, and presence of amputations,

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restricted motion, pain and sensory loss are among the many factors that can influence the strength of the grip. Anthropometric variables, such as height, weight, hand length and hand width, have also been reported to be positively associated with grip strength in healthy adults in many HGS studies [23–27].

Numerous studies on HGS have been published for various focus groups such as different age groups, disease groups and occupations, and from diverse populations [21,28–35]. However, there is a paucity of reference values for HGS for an African population following standardized guidelines such as those recommended by the American Society of Hand Therapists (ASHT). The aim of this study was to establish reference values for the HGS in healthy Nigerian adults. The resulting age and sex reference database serves as a basis for the proper interpretation of HGS in patients and also helps in monitoring rehabilitation outcomes for the local population.

Methods

Subjects

The study included 745 apparently healthy volunteers (409 male and 336 female) aged 20–70 years (mean, 29.3 ± 10.0 years). Participants included staff and students recruited via research advertisement and invitations from the Obafemi Awolowo University, Ile-Ife, Nigeria. Criteria for inclusion were: (1) no restriction of movement in the upper extremities, (2) no history of inflammatory joint disease, neurological disorder or injury to the upper extremity by self-report, and (3) volunteers who were not elite athletes. Dominant hand was defined as the one preferred for daily activities like writing, eating, sweeping, cutting grass, throwing a ball, and opening and closing doors and window shutters [36].

Instrumentation and procedures

Ethical clearance was obtained from the ethics and research committee of the Obafemi Awolowo University Teaching Hospitals Complex. The aims and objectives of the study were explained and demonstrated to the participants, and their informed consent was obtained. All measurements were obtained at the same time of the day. Anthropometric measurements were performed with the participants wearing light apparel and without shoes. Body weight was measured using a portable weighing scale (Hanson bathroom weighing scale; Terraillon Deutschland GmbH, Bingen am Rhein, Germany) to the nearest 0.1 kg. Height was measured with a stadiometer to the nearest 0.1 cm. Body mass index (BMI) was computed while their ages were recorded.

HGS was measured using a standard adjustable handle dynamometer (model 84466; Takei Kiki Kogyo, Tokyo, Japan) according to a standard protocol based on the ASHT recommendations [37]. Grip strength was measured while the subject was in a sitting position with shoulder adducted and neutrally rotated and elbow in 90° flexion with no radioulnar deviation. The participants were required to squeeze the handle maximally and to sustain this for 3–5 seconds. All measurements were performed for both hands, and handedness (dominance and non-dominance) was determined based on self-report. Subjects performed three maximum attempts for each grip strength measurement, and the mean value of these trials was recorded. One-minute rests were given between each attempt, and hands were alternated to minimize fatigue effects. Results were recorded in kilogram force (kgf).

For standardization, the dynamometer was set at the second handle position. For most of the participants, the second position was considered to be the best level for grip evaluation and is also adopted by the ASHT for routine testing. No verbal encouragements were given. The calibration of both instruments was tested periodically during the study. The data were collected over a period of 10 weeks.

Statistical analysis

The SPSS version 13.0 programme (SPSS Inc., Chicago, IL, USA) for Windows was used for statistical analysis. The data were analyzed using descriptive (mean, standard deviation, median, range, and percentiles) and inferential statistics involving paired and unpaired *t* test to compare the HGS by sex, based on hand dominance and laterality. The analysis of variance (ANOVA) test was used to compare the general characteristics and HGS of the participants grouped according laterality by sex. A two-way ANOVA (mixed design; to compare sex [between-subject factor] and hand dominance [within-subject factor]) was also employed, while Pearson product moment correlation analysis was used to test the relationship between HGS and the participants' general characteristics. The α level was set at 0.05.

Results

Out of the 745 participants, 595 (79.9%) were right-hand dominant, comprising 333 (44.7%) male and 262 (35.2%) female participants, while 150 (20.1%) were left-hand dominant, comprising 76 (10.2%) male and 74 (9.9%) female participants. No participants reported ambidexterity. The general characteristics and mean HGS for the dominant and non-dominant hands of all the participants by sex are shown in Table 1. The result of the unpaired *t* test showed that there was a significant difference in the dominant ($t = 26.13$, $p < 0.001$) and non-dominant ($t = 24.41$, $p < 0.001$) HGS between the male and female participants. Likewise, a significant difference was observed in the age and weight between the male and female participants ($p = 0.05$). Paired *t* test was used to compare the HGS between the dominant and non-dominant hand for the male participants, and a significant difference was found ($t = 18.22$, $p < 0.05$). Likewise, the HGS for the dominant hand versus non-dominant hand for the female participants revealed a significant difference ($t = 18.75$, $p < 0.05$). Paired t test comparison of HGS between the right and left hand of the male ($t = 2.06$, $p = 0.04$) and female ($t = 4.70$, $p < 0.001$) participants revealed significance differences.

One-way ANOVA comparison of general characteristics and HGS of the participants grouped on basis of sex and laterality is presented in Table 2. The one-way ANOVA results indicate significant differences ($p < 0.001$) in the F ratios of the HGS of the dominant and HGS of the non-dominant hand, and the least significant difference *post hoc* analysis further probed the significant differences found in the F ratios. A two-way ANOVA was used to test whether there was a significant interaction between sex and hand dominance on HGS. Significant interactions were found between sex and hand dominance of each of the dominant HGS ($F = 366.57$, $p < 0.001$) and non-dominant HGS ($F = 123.44$, $p < 0.001$).

The mean values and percentile data for HGS of all the participants and by age stratifications for both dominant and non-dominant hands are presented in Tables 3 and 4, respectively. For this population, the percentile values cut points were used to define pattern of HGS. Less than 25^{th} (poor grip strength), 25^{th}–75^{th} (moderate grip strength), and > 75^{th} (good grip strength) percentile were < 29.0 kgf, 29.0–34.0 kgf, and > 34.0 kgf, respectively, for the dominant hand, and < 24.0 kgf, 24–36.0 kgf, and > 36.0 kgf, respectively, for the non-dominant hand. Pearson product moment correlation was used to test the relationship between HGS and age, weight, height or BMI individually among both male and female participants, as presented in Table 5. Among the male participants, HGS of the dominant hand was significantly correlated ($p < 0.05$) with age, weight, height and BMI, while HGS of the non-dominant hand showed significant correlation with age and height only. However, among the female participants, only weight and height were significantly correlated with HGS.

Discussion

Measurement of grip strength is important in hand rehabilitation. It assesses the patient's initial limitations and provides a quick reassessment of the patient's progress throughout the treatment [22]. The main objective of this study was to establish age and sex reference values for HGS based on handedness among healthy Nigerian adults. This study also investigated the influence of age and other anthropometric factors on HGS. The reference values of HGS established in this study were based on the mean of three maximum successive trials. Although the maximum value among these trials has commonly been used by many previous researchers [31–33], the average value of three consecutive trials was recommended by the ASHT [38].

Table 6 compares our findings with those of previous studies. The HGS values obtained in this study are lower than those reported among healthy American and Asian populations. This may be accounted for by racial differences between Africans, American and Asian populations. Jeune et al [34] stated that comparison of HGS across regions may provide some insight as to the historical regional differences in genetic factors, nutritional deficiencies, and/or socio-cultural environment. Variations in grip strength norms from different regions and populations are believed to be due largely to anthropometric differences [21,39,40]. Anthropometric measures are reported to be population-dependent and vary from race to race [41]. For example, hand dimensions are linked to ethnicity [42], and even within one ethnic group, there can be differences in hand sizes, making comparisons between dissimilar populations difficult [43]. Hence, reference values of HGS for the local population are needed. It is also adduced that numerous methodological variations and sample size differences from previous studies may translate into considerable discrepancies in results.

The one-way ANOVA result indicates that handedness and laterality significantly influence grip strength. From the results, the grip strength in both the dominant and non-dominant hand and grip strength in the right and left hands of males was greater than that of their female counterparts. These results are in accordance with previous findings in that grip strength was higher in men than women [13,33,44–46]. One possible explanation for this finding is the type of activity each sex is engaged in. For example, males are generally more active and take part in intense activities such as weight training, which cause increased strength and hypertrophy of muscles. However, females are more active in endurance type of activities such as aerobics in which the hypertrophy and increase in strength is not as great [47]. Also, males happen to have a higher percentage of lean body mass, which is a major determinant of strength, compared with females as a result of their physique.

From this study, the dominant hand was significantly stronger than the non-dominant hand without sex bias. Similarly, right HGS was stronger than left HGS without sex discrimination. Clerke and Clerke [48] stated that it is important to define handedness appropriately in the design of HGS studies. Some previous studies [19,30, 35,49,50] presented their data on hand dominance as dominant/non-dominant hand or major/minor hand, while other studies ignored the issue of handedness and presented their results based on laterality (right and left hand) [28,46,51,52]. Comparing the affected hand with the unaffected when estimating pre-injury grip strength for compensation and rehabilitation purposes is often

Table 1. Unpaired *t* test comparison of general characteristics and handgrip strength between male and female participants

Variable	Male ($n=409$)				Female ($n=336$)				t	p
	Mean ± SD	Median	Minimum	Maximum	Mean ± SD	Median	Minimum	Maximum		
Age (yr)	29.3 ± 10.0	26.0	20.0	70.0	27.1 ± 8.8	24.0	20.0	69.0	2.97	0.003
Weight (kg)	64.2 ± 9.3	64.0	41.0	98.0	62.2 ± 10.9	60.0	49.0	100.0	6.34	0.01
Height (m)	1.65 ± 8.91	1.66	1.40	1.92	1.67 ± 0.80	1.63	1.43	1.83	1.09	0.30
BMI (kg/m^2)	23.6 ± 4.2	23.0	15.1	40.3	23.4 ± 4.1	22.7	15.7	32.3	0.60	0.55
HGSD (kgf)	35.2 ± 8.6	34.0	11.0	99.0	24.9 ± 6.4	25.0	8.0	67.0	26.13	< 0.001
HGSND (kgf)	31.6 ± 8.7	31.0	8.0	59.0	22.8 ± 5.9	22.0	8.0	48.0	24.41	< 0.001

SD = standard deviation; BMI = body mass index; HGSD = handgrip strength for dominant hand; HGSND = handgrip strength for non-dominant hand.

Table 2. One-way analysis of variation and least significant difference *post hoc* comparison of general characteristics and handgrip strength of the participants grouped on basis of sex and laterality*

Variable	Male ($n=409$)		Female ($n=336$)		F ratio	p
	Right hand ($n=336$)	Left hand ($n=76$)	Right hand ($n=263$)	Left hand ($n=74$)		
Age (yr)	29.0 ± 9.9†	30.5 ± 10.7‡	27.5 ± 9.3†	25.9 ± 6.7§	4.04	0.007
Weight (kg)	64.1 ± 9.3†	64.3 ± 9.6†	62.2 ± 10.9‡	62.0 ± 10.9‡	2.39	0.07
Height (m)	1.66 ± 0.09†	1.65 ± 0.09†	1.63 ± 0.07‡	1.64 ± 0.08‡	5.58	0.001
BMI (kg/m^2)	23.5 ± 4.1	23.9 ± 4.3	23.5 ± 4.1	23.2 ± 4.2	0.36	0.78
HGSD (kgf)	37.6 ± 11.1†	35.9 ± 8.2‡	25.8 ± 6.0§	23.5 ± 7.0$^{\|}$	123.74	< 0.001
HGSND (kgf)	32.4 ± 9.6†	30.3 ± 7.4‡	22.0 ± 6.8§	22.0 ± 5.3$^{\|}$	120.04	< 0.001

*Data are presented as mean ± standard deviation; $^{\dagger,\ddagger,\S,\|}$for a particular variable, mode means with different superscript symbols are significantly ($p < 0.05$) different. Mode means with same superscript symbols are not significantly different ($p > 0.05$). The pair of cell means that is significant has different superscript symbols. BMI = body mass index; HGSD = handgrip strength for dominant hand; HGSND = handgrip strength for non-dominant hand.

Table 3. Baseline mean and percentile data for dominant handgrip strength (in kilogram force) of all the subjects by age and sex (n=745)

Age (yr)	Sex	n	Mean ± SD	Minimum	25th percentile	75th percentile	Medium	95th percentile	Maximum
20–29	M	280	36.3 ± 8.4	11.0	30.0	35.0	42.0	52.0	99.0
	F	262	25.1 ± 6.4	8.0	20.0	29.0	25.0	38.0	67.0
	All	542	31.0 ± 9.6	8.0	27.0	34.4	34.5	50.8	99.0
30–39	M	79	35.0 ± 6.2	21.0	30.0	40.0	35.0	46.1	49.0
	F	47	24.5 ± 6.1	14.0	20.0	27.0	24.0	39.0	39.0
	All	126	30.7 ± 8.0	14.0	26.0	34.0	31.5	47.6	49.0
40–49	M	28	33.6 ± 7.3	20.0	26.5	38.0	35.0	49.1	52.5
	F	12	22.4 ± 6.9	13.0	16.3	26.5	21.0	37.0	37.0
	All	40	30.2 ± 8.8	12.0	21.0	31.4	32.3	45.0	52.5
50–59	M	15	27.6 ± 5.4	20.0	24.0	33.0	27.0	38.0	38.0
	F	10	24.8 ± 6.9	16.0	20.5	27.3	23.5	39.0	39.0
	All	25	25.9 ± 7.9	14.0	22.0	31.0	31.0	46.0	48.0
60–69	M	7	22.8 ± 5.6	16.0	18.5	27.0	21.0	34.0	34.0
	F	5	26.2 ± 3.0	22.0	23.0	28.5	28.0	29.0	29.0
	All	12	20.7 ± 3.4	15.0	20.0	30.0	20.0	44.0	25.0
All	M	409	35.2 ± 8.6	11.0	29.0	40.0	34.0	49.0	99.0
	F	336	24.9 ± 6.4	8.0	20.0	29.0	25.0	38.0	51.0
	All	745	30.1 ± 6.4	8.0	29.0	34.0	34.5	49.0	99.0

SD = standard deviation; M = male; F = female.

Table 4. Baseline mean and percentile data for non-dominant handgrip strength (in kilogram force) of all the subjects by age and sex ($n = 745$)

Age group (yr)	Sex	n	Mean ± SD	Minimum	25th percentile	75th percentile	Medium	95th percentile	Maximum
20–29	M	280	32.2 ± 9.1	8.0	26.5	37.0	31.0	47.0	63.0
	F	262	23.0 ± 5.9	8.0	19.0	26.0	23.0	34.4	48.0
	All	542	27.9 ± 9.0	8.0	6.0	36.0	47.0	46.2	63.0
30–39	M	79	32.2 ± 6.5	20.0	28.0	36.0	32.0	44.6	47.0
	F	47	21.9 ± 5.5	12.0	18.0	26.0	21.0	31.6	35.0
	All	126	28.0 ± 7.9	12.0	24.0	35.0	27.5	43.5	47.0
40–49	M	28	29.8 ± 6.3	18.0	25.3	33.0	28.5	45.3	45.5
	F	12	20.3 ± 6.0	12.0	14.3	25.9	20.0	30.0	30.0
	All	40	27.0 ± 7.5	12.0	22.2	33.5	26.7	42.8	45.5
50–59	M	15	27.4 ± 8.4	14.0	21.0	32.0	27.0	48.0	48.0
	F	10	23.6 ± 7.0	16.0	19.5	26.8	21.5	39.0	39.0
	All	25	25.9 ± 7.9	14.0	22.0	31.0	31.3	40.5	48.5
60–69	M	7	21.9 ± 5.1	15.0	17.0	24.0	22.0	32.0	32.0
	F	5	20.9 ± 3.9	15.0	17.5	24.5	20.5	25.0	25.0
	All	12	20.7 ± 3.4	15.0	21.0	29.5	20.0	37.8	25.0
20–70	M	409	31.6 ± 8.7	8.0	26.0	36.0	31.0	45.8	59.0
	F	336	22.8 ± 5.9	8.0	19.0	26.0	22.0	33.2	48.0
	All	745	27.2 ± 6.6	8.0	24.0	36.0	47.0	45.8	63.0

SD = standard deviation; M = male; F = female.

Table 5. Relationship between handgrip strength and age, height, weight, and body mass index (BMI)

Variables	Age	Weight	Height	BMI	HGSD	HGSND
Male participants						
Age	1.00	0.173	–0.053	0.176	–0.267	–0.178
		0.000	0.483	0.000	0.000	0.000
Weight		1.000	0.110	0.772	0.140	0.076
			0.026	0.000	0.005	0.127
Height			1.000	–0.536	0.179	0.140
				0.000	0.000	0.000
BMI				1.000	0.007	–0.042
					0.893	0.402
HGSD					1.000	0.676
						0.000
HGSND						1.000
Female participants						
Age	1.00	0.160	0.031	0.151	–0.022	–0.060
		0.003	0.570	0.005	0.682	0.271
Weight		1.000	0.281	0.863	0.253	0.217
			0.000	0.000	0.000	0.000
Height			1.000	–0.236	0.252	0.261
				0.000	0.000	0.000
BMI				1.000	0.127	0.085
					0.020	0.118
HGSD					1.000	0.723
						0.000
HGSND						1.000

HGSD = handgrip strength for dominant hand; HGSND = handgrip strength for non-dominant hand.

employed in clinical practice. However, significant differences in grip strength based on handedness and laterality found in this study and corroborated by other investigators [28,33,46] have further stressed the importance of establishing normative databases for HGS.

The results of this study also showed that grip strength peaked in the 20–29 year age category for both males and females. This result corroborates the report of Tsang [33] who reported that grip strength peaked between the ages of 21 and 30 years. We found HGS to decline with advancing age among both sexes. This is consistent with previous reports that HGS decreases with increasing age [28,33,46]. In this study, a significant inverse correlation was found between age and grip strength among male participants only. This corroborates previous studies that have reported that there is a relationship between hand strength and age [28,44, 51,53]. Age-related decline in grip strength can be attributed to decreasing physical activity, loss of muscle mass, alterations in muscle fibres, decreasing hormone levels, and chronic diseases that come with advancing age [7,54–56].

Several studies on HGS in healthy populations have found significant associations between grip strength and anthropometric variables such as forearm circumference and length, hand size, body mass, height, weight, BMI, hand length, and hand width [21,24–26]. The results of this study indicate that weight, height and BMI are individually correlated with grip strength among male participants, while only weight and height significantly correlate with grip strength among female participants.

A major limitation of this study was that the participants were recruited from a single university, which may affect generalizability of our results to the whole Nigerian population. Nonetheless, our university is a federal government-owned educational institution open to staff and students from every state of the federation. However, we recommend that further research on normative values for HGS be carried out to address the problem of external validity and to consider the occupational variables and other health-related factors that can affect grip strength in a local population.

Conclusion

This study established reference values for HGS according to age and sex for healthy Nigerians adults. The results suggest that age and anthropometric factors can significantly influence grip strength. It is concluded that the dominant hand is stronger than the non-dominant hand, and that the right hand is stronger than the left in both sexes. Our results also indicate that handedness

Table 6. Comparison of handgrip strength between this present study and some other studies

Author	Age range (yr)	*n*	Hand classification	Male handgrip strength (kgf)			Female handgrip strength (kgf)		
				Mean ± SD	Minimum	Maximum	Mean ± SD	Minimum	Maximum
Present study	20–70	745	DH	35.2 ± 8.6	11.0	99.0	24.9 ± 6.4	8.0	67.0
			NDH	31.6 ± 8.7	8.0	59.0	22.8 ± 5.9	8.0	48.0
Tsang [33]	21–70	544	DH	43.8 ± 8.0	21.3	65.0	28.5 ± 5.7	4.2	44.3
			NDH	40.8 ± 7.8	19.3	72.3	26.2 ± 5.5	5.5	44.3
Present study	20–70	745	RH	35.9 ± 8.2	17.0	67.0	25.8 ± 6.0	10.0	41.0
			LH	32.9 ± 9.6	8.0	57.0	22.0 ± 6.8	8.0	46.0
Mathiowetz et al [28]	20–75	628	RH	47.4 ± 12.9	14.6	80.0	28.6 ± 7.7	11.4	62.3
			LH	87.8 ± 12.6	12.3	72.7	24.5 ± 7.1	10.5	52.3
Kamarul and Ahmad [46]	18–65	412	RH	76.6 ± 8.9	10.5	57.7	18.6 ± 5.8	6.4	83.2
			LH	73.6 ± 8.3	8.2	54.1	16.9 ± 5.5	8.6	80.0

SD = standard deviation; DH = dominant hand; NDH = non-dominant hand; RH = right hand; LH = left hand.

and laterality significantly influence grip strength. Men exhibited greater HGS than women. The mean values for the HGS of male and female participants were 35.2 kgf and 24.9 kgf, respectively, for the dominant hand, and 31.6 kgf and 22.8 kgf, respectively, for the non-dominant hands; the mean values for the HGS of male and female participants were 35.9 kgf and 25.8 kgf, respectively, for the right hand, and 32.9 kgf and 22.0 kgf, respectively, for the left hand. HGS decreases with increasing age among both sexes. From this population, < 29.0 kgf was considered poor grip strength, between 29.0 and 34.0 kgf was considered moderate grip strength, and > 34.0 kgf was considered good grip strength for the dominant hand. Likewise, < 24.0 kgf was considered poor grip strength, between 24.0 and 36.0 kgf was considered moderate grip strength, and > 36.0 kgf was considered good grip strength for the non-dominant hand.

The reference values derived in this study would be useful in assessing impairment in functional ability of the upper extremities in both healthy and patient populations. Although the HGS data in this study cannot be considered as normative for Nigerians, it can serve as preliminary baseline values against which physiotherapists can compare the measurement of their patients. Furthermore, the results of this study also suggest that the usual practice where the physiotherapist compares the HGS of the limb of interest with the contralateral limb as a criterion reference may not be justified.

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