ORIGINAL ARTICLE

Hand-grip strength as an indicator for predicting the success in martial arts athletes

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C Statistical Analysis
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Abstract

Background & Study Aim: One main scientific practical tasks in sports is increasing an efficiency and forecasting the sportsmanship growth. The purpose of this work is answer the question whether based on the hand grip strength of different martial arts' athletes it is possible of their successfulness prognostication.

Material and Methods: We examined 28 martial arts athletes: group I (11 of age 18.45 ± 0.39 years, specializing in Greco-Roman and free style wrestling, judo, sambo); group II (17 of age 18.12 ± 0.26 years, specializing in hand-to-hand combat, karate, taekwondo). The level of sportsmanship in groups was approximately the same and varied from beginners to candidate master of sports and masters of sports. We used a battery of tests, which included 41 indicator sportsmen's physical and functional condition. We studied anthropometrical indicators of general physical condition, the state of upper and lower limbs; we carried out tapping test and measured maximal frequency of grip in impulse mode.

Results: The closeness of sportsmen's physical condition at the account of absence of significant difference in most of indicators was proved. Sportsmen of the group I had greater circumferences of arm and forearm, hand dynamometry. Analysis of correlations showed significant higher quantity of important and confident correlations of grip maximal frequency in impulse mode in sportsmen of group I. These sportsmen's contribution in system formation of grip strength indicators was 1.5-4 times bigger.

Conclusions: We have proved the importance of studying of grip strength as factor of martial arts sportsmen's successfulness specialising in throws and grips of immobilisation of opponent's body (judo, sambo, wrestling etc.).

Key words: battery of tests • division of the combat sports • functional condition (fitness) • hand-to-hand combat

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Introduction

One main scientific practical tasks in sports is increasing an efficiency and forecasting the sportsmanship growth. The basis for its solution is study and analysis of sportsmen's morphological functional indicators at different stages of training. For this purpose functional tests and methodic for assessment of physical qualities' level can be used. For example, some authors recommend methodic of Dushanin [1] for control over sportsmen's current condition. It is based on analysis of initial condition's dynamic and reaction to physical load (training load), characteristic for some kinds of sports. The methodic expands opportunities of prompt responding to changes of sportsmen's functional condition (functional fitness [2]), training process's rational organization owing to integral assessment, intrinsic to it.

Analysis of tests for selection and successfulness prognostication in sports was studied in different directions [3, 4] including wrestling [5]. Main advantages and disadvantages of such approach were researched; conclusion about demand in complex scientific-practical approach to solution of this task was made.

Other authors estimated informational potential of tests with the help of discriminant and dispersion analysis, when studying peculiarities of physical condition, fitness and coordination in different kinds of sports. They marked out the most important physical qualities. Characteristic for certain kind of functioning [6, 7].

The approach, based on marking out of qualities of successfulness prognostication is rather widely spread in sports. One of such indicators is strength of hand grip. For example, Orvanová [8] analysing characteristics of physical condition and fitness in winter kinds of sports sportsmen determined the most important indicators for successfulness. They included height, weight, somatic type, percentage of fat and hand grip strength. In other research [9] when mastering technique of grip it is recommended for junior judo athletes to use methods of strictly regulated exercise and games (taking away of ribbons, clips and bands, fixed on opponent's judogi). In such cases it is very important to pay attention to training of hand grip strength [10, 11].

On example of other kinds of sports and health related trainings it was found: dependences of secular strength trend on age and presence of positive correlation with body mass; dependence of grip strength indicator for general assessment of health; factors, influencing on of rock climbers' successfulness (hand grip strength and fingers' grip strength); morphological peculiarities of sportsmen, connected with specificities of trainings and sports selection in rock climbing. As functional tests they used determination of fingers' strength in different grips. It was found that elite sportsmen had significantly higher indicators. It was offered to practice exercises for training of strength in different grips [12].

Grip strength is important in many kinds of sports: grip of golf putter determines effectiveness of strike; battery of special tests permits to prognosticate successfulness in sleigh and bobsleigh; grip strength permits to increase accuracy of archery; grip strength is an informative factor of successfulness and sportsmanship prognostication in hockey; simulation of different grip variants permits to find dependence between strength, area of contact and kind of grip; construction of models permits to prognosticate maximal grip strength; in analysis of mountaineers' physical fitness electric myographic study of grip strength is rather effective [13, 14].

Results of our researches proved importance of grip strength as indicator of successfulness determination in arm wrestling [15]. In our other researches we substantiated approaches to assessment of tests' informational potential [16, 17]. In such cases determination of optimal physical loads in training of techniques on example of judo is of the same importance [18, 19], as well as determination of optimal coefficients of certain sportsmen's body parts' length [20-22].

The purpose of this work is answer the question whether based on the hand grip strength of different martial arts' athletes it is possible of their successfulness prognostication.

Material and methods

Participants

We examined 28 athletes practicing martial arts in two groups (among the three groups based on the division of the combat sports under forms of the direct confrontation accordance with the theory of combat sports [23]): group I throws and grips of immobilisation of opponent's body (n = 11, age

Combat – *noun* a physical struggle between opposing individuals or forces combat sport [39].

Combat sport – *noun* a sport in which one person fights another, e.g. wrestling, boxing and the martial arts [39].

Martial arts – *plural noun* any of various systems of combat and self-defence, e.g. judo or karate, developed especially in Japan and Korea and now usually practised as a sport [39].

Martial Arts – are systems of fight practices (practiced in many reasons: self-defence, competition, self-improvement, physical health and fitness, mental and physical development).

Main relationship between combat sport and martial arts – every combat sport is martial arts but not vice versa [23].

Division of the combat sports under forms of the direct confrontation – workings of weapons; hits (strokes); throws and grips of immobilisation of opponent's body [23].

Training load – "A simple mathematical model of training load can be defined as the product of qualitative and quantitative factor. This reasoning may became unclear whenever the quantitative factor is called 'workload volume' or 'training volume' interchangeably with 'volume of physical activity'. Various units have been adopted as measures i.e. the number of repetitions, kilometres, tons, kilocalories, etc. as well as various units of time (seconds, minutes, hours) (...) As in the real world nothing happens beyond the time, the basic procedure of improvement of workload measurement should logically start with separation of the time factor from the set of phenomena so far classified together as '*workload volume*'. (...) Due to the fact that the heart rate (HR) is commonly accepted as the universal measure of workload intensity, the product of effort duration and HR seems to be the general indicator of *training load* defined as the amount of workload. It is useful in analyses with a high level of generality. (...) In current research and training practice the product of effort duration and HR was referred to as conventional units' or further calculations have been made to convert it into points." [40, p. 238].

18.45 ±0.39 years, specializing in Greco-Roman and free style wrestling, judo, sambo); group II hits/strokes (n = 17 of age 18.12±0.26 years, specializing in hand-to-hand combat, karate, taekwondo). The level of sportsmanship in groups was approximately the same and varied from beginners to candidate master of sports and masters of sports.

The design of the research

Implied determination of 41 indicators of physical and functional condition. We studied anthropometrical indicators (somatic metrical and physical metrical), reflecting characteristics of general physical condition, anatomic status of upper and lower limbs. Tapping tests' results illustrated lability of nervous system. Grip strength was assessed in static mode by hand dynamometry as per commonly accepted methodic.

Dynamic grip strength was found by maximal frequency of hand grips in impulse mode with the help of electronic device, produced by *KEPAI* company (China). This device is designed for determination of hand grips' quantity and works on principle of hand dynamometer. In the body of the device there is a spring and electronic counter. The counter registers quantity of hand grips. During testing wrist and elbow joints were in position "hand is a little aside from torso". Strength of one grip was 10 kg. Sportsmen made maximally possible quantity of grips during 10 seconds. This quantity was registered by electronic counter. 10 seconds' interval is used also in other research in measurement of maximal isometric hand grip strength of judo sportsmen [24].

Statistical analysis

The received data was fulfilled with the help of licensed electronic tables Excel. We determined indicators of descriptive statistic: mean arithmetic, standard deviation and error of mean value [25]. Confidence of differences in groups was determined with the help of parametrical (Student's criterion) and non-parametrical: Mann–Whitney–Wilcoxson indicator U; Rosenbaum indicator Q.

On the base of the received results we built correlation matrixes, including Pearson's coefficients, which reflect interconnection between the studied indicators. For analysis we chose only significant and confident dependences.

For comparative analysis of the data is used method of correlation structures [26]. It allows to give quantitative characterization of the functional system, which depends on the ratio of stable and unstable bonds in it. For this purpose is used specific weight of meaningful and reliable ties and indicator of system formation (IS).

Significant thought communication, whose strength was greater than 0.3, reliable – for group I with force not less than 0.476, for group II – not less than 0.389. Specific weight was found as the ratio of the absolute number of such bonds to the total amount, expressed as a percentage, its error by the formula:

$$S_p = [p(100 - p)/N]^{-1/2}$$

where: p – specific weight of ties (%); N – number of indicators.

Comparison of specific weight was performed using Student's t test.

It is a relative value, so it is expressed in % and can be calculated its error by standard formulas and accuracy using Student's test.

Contribution of definite criterion in system was estimated by indicator of system formation (IS). This criterion was offered for analysis of correlation matrixes. Zosimov [26] and reflects the quantity of connections, which are created by the studied indicator, and their strength. This indicator is expressed in convenient units (conv. Un.) and is calculated by formula:

$$IS = \Sigma rj \times n$$

where:

Σrj – sum of values of significant correlation coefficients, created by the given indicator;

n – number of significant connections of this indicator of structure.

Results

Empirical data prove the absence of significant differences between most of the studied indicators (Table 1).

Sambo – is a Russian martial art and combat sport. The word "SAMBO" is an acronym for *SAMozashchita Bez Oruzhiya*, which literally translates as "self-defense without weapons". Sambo is relatively modern since its development began in the early 1920s by the Soviet Red Army to improve their hand-to-hand combat abilities It was intended to be a merger of the most effective techniques of other martial arts. The pioneers of Sambo were Viktor Spiridonov and Vasili Oshchepkov. Oshchepkov died in prison as a result of the Great Purge after being accused of being a Japanese spy. Oshchepkov spent several years living in Japan +and training in judo under its founder Jigoro Kano [*Wikipedia*].

Freestyle wrestling – is a style of amateur wrestling that is practiced throughout the world. Along with **Greco-Roman**, it is one of the two styles of wrestling contested in the Olympic games.

Condition – *noun* 1. the particular state of someone or something 2. a particular illness, injury or disorder; *verb* to undertake a fitness plan to improve general health, appearance or physical performance [39]

Functional fitness – ability to perform everyday activities safely and independently without fatigue; requires aerobic endurance, flexibility, balance, agility, and muscular strength [2].

Hand grip – *noun* a resistant piece of equipment used to develop hand strength [39].

Judogi – is the formal Japanese name for the traditional uniform used for judo practice and competition [Wikipedia] .

Table 1. Morphological condition of martial arts' sportsmen

Variable (indicator)	Group I (n = 11)	Group II (n = 17)
Body length (cm)	175.91 ±2.17	177.12 ±2.66
Body mass (kg)	77.00 ±4.60	68.24 ±2.78
Chest circumference (cm)	94.09± 3.92	90.03 ±1.70
Width of shoulders (cm)	42.50 ±1.50	40.21 ±0.73
Circumference of right arm (cm)	**35.36 ±1.64***	**30.53 ±0.90***
Circumference of right forearm (cm)	**30.23 ±1.04***	**27.09 ±0.68***
Circumference of left arm (cm)	**34.50 ±1.50***	**30.00 ±0.85***
Circumference of left forearm (cm)	**29.23 ±1.10***	**26.66 ±0.70***
Circumference of right wrist (cm)	17.09 ±0.34	16.38 ±0.32
Circumference of left wrist (cm)	16.91 ±0.37	16.29 ±0.30
Right hand dynamometry (kg)	46.55 ±4.39	35.59 ±2.96
Left hand dynamometry (kg)	**43.82 ±3.80***	**33.53 ±2.77***
Maximal right hand grip frequency in impulse mode (number of repetitions)	27.09 ±1.99	25.63 ±2.17
Maximal left hand grip frequency in impulse mode (number of repetitions)	25.82 ±2.86	23.31 ±2.01
Tapping test results: 1 sub test (number of repetitions)	53.73 ±4.41	52.94 ±4.60
Tapping test results: 2 sub test (number of repetitions)	49.91 ±4.76	42.29 ±3.62
Tapping test results: 3 sub test (number of repetitions)	47.36 ±4.59	40.88 ±3.48
Tapping test results: 4 sub test (number of repetitions)	47.64 ±4.88	42.82 ±3.49
Tapping test results: 5 sub test (number of repetitions)	45.36 ±4.74	45.18 ±4.58
Tapping test results: 6 sub test (number of repetitions)	47.36 ±4.76	44.41 ±3.48
Systolic blood pressure (mm Hg)	124.35 ±5.33	119.41 ±3.48
Diastolic blood pressure (mm Hg)	76.36 ±3.10	71.18 ±2.45

*differences between groups are confident at $p<0.05$

We have also determined some distinctions in physical condition of sportsmen. For example, we found significant increase of arm's and forearm's circumferences, left hand dynamometry in group I ($p<0.05$). By value of right hand dynamometry we confirmed the tendency to confidence of differences ($p<0.1$). Not large samples served as the basis for usage of non-parametrical indicators Rosenbaum's criterion (Q) proved significant increase of left and right hand dynamometry in group I ($p<0.05$). Wilkinson-Manna-Whitney indicator (U) showed increase of both arm's and forearm's circumferences and hand dynamometry in this group ($p<0.05$).

The data of significant and confident correlations' specific weight are given in table 2.

Noticeable increase of correlations quantity by maximal right hand grip frequency in throw kinds martial arts' sportsmen has been proved ($p<0.05$). By other indicators no significant differences have been found.

In group I maximal right hand grip frequency correlated with body length (r = 0.815), body mass (r = 0.536), shoulder width (r = 0.543), right arm length (r = 0.706) and forearm (r = 0.788), chest circumference (r = 0.620), right biceps circumference (r = 0.497), forearm (r = 0.699) and wrist (r = 0.753), hip length (r = 0.564). Rather significant correlation was found with maximal left hand grip frequency (r = 0.692). Dependence on tapping test results had reverse character. Confident correlation was registered with results 1 (r = –0.527), 4 (r = –0.499) and 6 (r = –0.666) sub tests. Rather expressed correlation with maximal right hand rip frequency was with systolic blood pressure (r = 0.717) and right hand (r = 0.658) and left hand (r = 0.730) dynamometry.

Table 2. Specific weight of significant and confident correlations of martial arts' sportsmen's grip strength (%)

Indicator	Group I (n = 11)	Group II (n = 17)
Maximal frequency of right hand grip		
Confident correlations	**62.50 ±7.56***	15.00 ±5.58
Significant correlations	**80.00 ±6.25***	45.00 ±7.77
Maximal frequency of left hand grip		
Confident correlations	62.50 ±7.56	55.00±7.77
Significant correlations	77.50 ±6.52	62.50±7.56
Right hand dynamometry		
Confident correlations	57.50±7.72	67.50±7.32
Significant correlations	82.50±5.93	70.00±7.16
Left hand dynamometry		
Confident correlations	60.00±7.65	67.50±7.31
Significant correlations	77.50±6.52	62.50±7.56

* differences between groups are confident at p<0.05

Maximal left hand grip frequency of throw kinds martial arts' representatives correlated practically with the same criteria: body length (r = 0.769), body mass (r = 0.748), shoulder width (r = 0.793), left arm (r = 0.532) and forearm (r = 0.551) length, chest circumference (r = 0.784), left biceps circumference (r = 0.658), forearm (r = 0.668) and wrist (r = 0.874). Dependence on tapping test results had reverse character. Confident correlation was found with results 2 (r = –0.495), 5 (r = –0.584) and 6 (r = –0.646) sub tests. Maximal left hand grip frequency was also connected with systolic blood pressure and hand dynamometry results. Strength of correlation for blood pressure was less, while for hand dynamometry – bigger. It was accordingly 0.581, 0.763 and 0.812.

Confident correlations with right hand dynamometry were found for body length (r = 0.876), body mass (r = 0.806), shoulder width (r = 0.912), right arm (r = 0.640) and forearm (r = 0.800) length, chest circumference (r = 0.897), right biceps circumference (r = 0.729), forearm (r = 0.801) and wrist (r = 0.867), right hand grip frequency (r = 0.658) and left hand grip frequency (r = 0.753), right shin circumference (r = 0.656). Dependence on tapping test results also had reverse character. Confident correlation was found only with results of 6^{th} (r = –0.493) sub test. Correlation strength for systolic blood pressure was 0.681, and for left hand dynamometry was practically functional 0.905.

Confident correlations with left hand dynamometry were found for body length (r = 0.864), body mass (r = 0.740), shoulder width (r = 0.885), arm (r = 0.592) and forearm (r = 0.700) length, chest circumference (r = 0.840), right biceps circumference (r = 0.664), forearm (r = 0.826) and wrist (r = 0.833), maximal right hand grip (r = 0.730) and left hand grip (r = 0.812) frequency. Confident correlation with tapping test results was found for 4 (r = –0.491), 5 (r =–0.588) and 6 (r = –0.592) subtest. Correlation strength for systolic pressure was 0.673.

In group II there were much less confident correlations of right hand grip maximal frequency. We proved dependences on hand length (r = 0.428), chest circumference (r = 0.426), wrist circumference (r = 0.484), maximal left hand grip frequency (r = 0.768) and hand dynamometry (r = 0.479).

Maximal left hand grip frequency had more confident correlations. They are proved for body mass (r = 0.404), forearm length (r = 0.566), wrist length (r = 0.504) and width (r = 0.562), chest circumference (r = 0.485), forearm (r = 0.399) and wrist circumference (r = 0.604); left hand dynamometry (r = 0.479).

Values of hand dynamometry in group II had much more confident correlations than maximal grip frequency. For example for right hand dynamometry we found correlations with body length (r = 0.673), body mass (r = 0.518), shoulder width

(r = 0.634), right arm (r = 0.515) and forearm (r = 0.660) length, wrist length (r = 0.434) and width (r = 0.464), chest circumference (r = 0.569), circumference of right biceps (r = 0.605), forearm (r = 0.750) and wrist (r = 0.620), maximal frequency of left hand grip (r = 0.609). Correlation strength for systolic blood pressure was 0.587, and with left hand dynamometry 0.872.

Left hand dynamometry correlated with body length (r = 0.772), body mass (r = 0.662), shoulder width (r = 0.708), left arm (r = 0.654) and forearm (r = 0.768) length, wrist length (r = 0.468), chest circumference (r = 0.704), left biceps circumference (r = 0.522), forearm (r = 0.680) and wrist (r = 0.815), maximal frequency of right hand grip (r = 0.479) and left hand grip (r = 0.649).

Calculation of IS indicators for hand dynamometry and maximal grip frequency showed noticeable distinctions in groups. For example, in group I IS of maximal right hand grip was 605.37; in group II 134.08. For maximal frequency of left hand grip in group I it was 537.36; in group II 316. 84. For right hand dynamometry, accordingly, 713.43 and 449.71. For left hand dynamometry it was 628.48 and 469.45.

Discussion

The closeness of sportsmen's physical condition at the account of absence of significant difference in most of indicators was proved. Besides main anthropometrical indicators this assumption is proved by values of wrist circumference. This indicator used for determination of somatic type and witnesses that among participants there prevails sportsmen with normosthenic body composition. Tapping test results also permit to say that participants had similar features of nervous system.

The received results witness about importance of strength grip for sportsmen of throw kind martial arts and prove available literature data. It also illustrates differences in values of arm's and especially forearm's circumferences. Muscles of which ensure grip strength. In this context increase of hand dynamometry in group 1 becomes logical and it is proved by parametrical and non-parametrical criteria. The received data are analogous to results of Hiroshi Arakawa et al. [27]. The authors studied anthropometrical characteristics of Japanese women –elite wrestlers. It was proved that well developed muscles of upper limbs and forearms are an important factor of successfulness. It is also confirmed by results of our previous studies [28-30].

For I group sportsmen grip, as the basis of effective technique fulfilment, is very important. It is proved by analysis of Judo competitions' results, which was carried out by Parkhomovich [31]. Grip permits to realize effort in required direction and in required moment for fulfilment of technique. Aliev [32] underlines that struggle for grips is an important element of modern judo tactic in elite sportsmen. With equal physical and tactic fitness just grips ensure high efficiency.

Miarka et al. [33] analysed time characteristics of judo duels. They showed that grip time takes rather great specific weight. This indicator was used for assessment of fight effectiveness. The same results were received also in women judo athletes. The most experienced sportswomen were characterized by the highest indicators of grip time.

For II group sportsmen kicking is of main importance and it pre-determined the differences of morphological functional indicators. The researches of Hyun-Bae Kim et al. [34] showed that in taekwondo grip strength is not important for growth of sportsmanship.

The found in throw kind of martial arts' sportsmen confident correlations of longitudinal and perimeter sizes of leg with maximal grip frequency and hand dynamometry reflect peculiarities of general physical condition; direct dependences between limb muscles' condition. However, considering specific features of wrestling these results can be interpreted from positions of the research of Blais et al. [35]. The authors assessed throw technique in Judo on the base of motor bio-mechanic. They outlined main points and segments, involved in movement. The results permitted to consider lower limbs and torso to be leading in fulfilment of throws but not arms. Validity of this approach is proved also in our researches of bio-mechanical regularities of movements [36].

Analysis of correlation matrixes is performed in physiology, hygiene. It allows to assess the condition of the body's adaptive capacity, to compare the response to various stimuli. Thus, in

manuscript by Podrigalo et al. [15], its use has allowed to establish differences between the functional state of athletes in arm wrestling of different skill levels.

Different specific weight of confident and significant correlations of grip maximal frequency and hand dynamometry in the tested groups reflect different indicators for kicking and throw kinds of martial arts. For I group sportsmen grip in impulse mode and maximal wrist strength, reflecting hand muscles' condition, are important. At the same time for representatives of throw kinds of martial arts mainly hand dynamometry, depending on condition of upper limbs' muscles, is important. Dynamic grip is not very significant.

The found in groups confident correlations to large extent are similar. Correlations with body length and mass, width shoulder, chest circumference, arms' length and circumference indicators shall be assessed as reflection of grip strength dependence on general physical and limb muscles' condition. Correlations between maximal grip frequency and hand dynamometry illustrate different sides of grip – its static and dynamic component.

It is also interesting that in group I there were confident correlations of maximal grip strength and hand dynamometry with tapping test results. In group II these dependences were not substantial. In our opinion it reflects reverse correlation between strength and quickness of movements' fulfilment, which can be interpreted as dependence between sportsmen's physical and technical fitness. In this context application of the mentioned tests becomes a valuable tool for assessment of fitness and prognostication of sportsmen's successfulness. Analogous researches were conducted by Hamdi Chtourou et al. [37]. The authors used grip strength as test for assessment of judo sportsmen's biological rhythms.

Less quantity of correlations in group II, less values of IS for maximal grip frequency and hand dynamometry in kicking (hits/strokes) martial arts illustrate less significant grip strength than in different kinds of wrestling (throws and grips of immobilisation of opponent's body).

At the same time for a quick and effective fighters capture it is one of the decisive factors for the victory. This is confirmed by the results of Parkhomovich [31], Aliev [32]. The same conclusion can be drawn on the basis of the analysis of IS values. High contribution in maximal grip frequency and hand dynamometry proves their importance to the success of the athletes.

The mentioned data confirm our previous results [38]. Analysis of character, strength, orientation of maximal grip frequency and hand dynamometry correlations witnesses about high informational potential of these tests. It permits to recommend them as screening for control over sportsmen's condition in martial arts.

Conclusions

The fulfilled research proved importance of studying of grip strength as successfulness factor for sportsmen of throws and grips of immobilisation of opponent's body kinds of martial arts. Higher dynamic and static grip strength of throw kinds martial arts' sportsmen prove importance of strength of wrist and fingers muscles, which ensure sufficient strength for victory in martial arts. Indicators of maximal grip in impulse mode and hand dynamometry are characterized by correlations with indicators of general physical and upper limbs' condition. Correlations with tapping test results illustrate dependence between sportsmen's physical and technical fitness. Contribution of grip strength in system permits to consider them important for successfulness in wrestling, judo etc. At the same time in kicking martial arts these indicators are not very important and their absolute contribution in system formation is much lower. The conducted researches permit to recommend the mentioned tests as screening for assessment of sportsmen's fitness in throws and grips of immobilisation of opponent's body kinds of martial arts (judo, sambo, wrestling etc.).

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