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Body composition and physical fitness of Kung Fu practitioners – correlation between anthropometrics and motor/functional variables

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ABSTRACT

Kung Fu, a Chinese martial art widely spread around the world as a sport of combat as well as a practice for promoting health, has been referenced with the likelihood of incorporation in the Olympic games. The present study was carried out with the aim of making a preliminary approach in characterizing Kung Fu practitioners with regard to somatotype, body composition, and physical fitness. Further correlations between anthropometric characteristics and fitness components were established. Twenty-three male Kung Fu (Wing Chun style) practitioners ranging from 18 to 25 years of age were studied. The anthropometric measurements included stature, body weight, skinfolds, bony diameters, and circumferences, and the battery of fitness tests was composed of hand-grip isometric strength, flexibility, leg power, anaerobic power, abdominal endurance, arm power, running speed, and aerobic endurance evaluations. The mean BMI was 22.07±1.83 kg/m^2, having a mean relative body fat of 12.5% and a predominant mesomorphic somatotype. Relatively high scores were obtained for the power, flexibility, and endurance qualities, expressing the importance of these qualities to the Kung Fu performance. The level of aerobic fitness (45.9 ml/kg/min) was considered 'good' for individual of this range of age. Many significant correlation coefficients were found between anthropometric characteristics and physical fitness components, as well as between pairs of physical fitness qualities. In conclusion, the practitioners of the Wing Chun Kung Fu style were characterized as relatively slender and strong body holders, possessing great striking power and considerable aerobic/anaerobic fitness.

INTRODUCTION

The Kung Fu or Whu Shu (1) is a Chinese martial art that had its first historical registry at the year 2,674 B.C. (2, 3). Regardless of being, in ancient times, composed of a set of techniques developed during rough battles (4), nowadays the Kung Fu is spread worldwide mostly as a sport of combat and a popular practice for maintaining the health state and improving the physical fitness.

Composed of a countless number of methods, the Kung Fu can be classified into styles that use a wide variety of exotic weapons and styles that exploit chiefly the free-hand techniques, most of them impersonating movements of animals. In addition, there is another classification system, the formal one, in which the various Kung Fu styles are divided into internal (flexible movements) and external (hard movements) ones (4).

Apart from categorizing matters, it is well known that the popularity of the Kung Fu has increased considerably during the past few decades. Kung Fu schools exist the world over and competitions are carried out in a regular basis in regional, national, and international events. Furthermore, owing to the great number of practitioners and the existence of many well-organized associations, it has been taking into account the likelihood of incorporating the Kung Fu in the Olympic games.

Under this perspective, and transcending health-related issues, it is apparent the need of improving the fundamental physical qualities of the Kung Fu athletes by, firstly, knowing the primary requirements or capacities for this type of competitive sport, secondly, identifying an 'ideal' or desirable body type/composition for this group of athletes and, finally, applying refined training methods in order to enhance performance levels.

In spite of the above mentioned, we found there are too few experimental studies that focus on the Kung Fu. Therefore, we carried out the present study with the aim of making a preliminary approach in characterizing this group, by means of a systematized evaluation on the body composition and the fitness components of the Kung Fu practitio-

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ners. Furthermore, we also scrutinized the correlations between anthropometric characteristics and the measured fitness qualities.

Materials and methods

Subjects

Twenty-three male Kung Fu practitioners ranging from 18 to 25 years of age were randomically selected for the present study. All subjects frequented schools of the Wing Chun Kung Fu style localized in Santa Maria city, Rio Grande do Sul, Brazil. The tests only were performed after the completion of a written informed consent.

Materials

The evaluations were carried out at the exercise physiology laboratory and the track and field grounds of the Center of Physical Education and Sports of the Federal University of Santa Maria, Brazil. All apparatus, devices and instruments utilized during the assessments were examined with regard to their precision and accurately calibrated when necessary.

Physical fitness tests were evaluated with regard to their validity (if the instrument measures what it is supposed to measure) and reliability (if the instrument measures what it is supposed to measure consistently). Reproducibility and objectivity also were considered during the tests selection and protocols standardization.

Order of the measurements and tests

All procedures of the anthropometric measurements and the battery of tests were performed in two days. The physical fitness tests were organized so that preceding challenges did not affect the good fulfillment of posterior ones. First day: questionnaire, blood pressure, resting heart rate, standing height, body weight, skinfolds, bony diameters, circumferences, hand-grip isometric strength, flexibility, leg power, and lactic anaerobic power; second day: abdominal endurance, arm power, running speed, and aerobic endurance.

Protocols of the measurements and tests

Anthropometrics

The stature was measured using a stadiometer with 0.1 cm precision, and the body weight was measured using a scale with 0.1 kg precision. The subject was evaluated barefoot and dressed in underwear. During the stature measurement, the individual was instructed to take a deep breath followed by apnea before the reading was taken. The body weight was obtained in one single assessment, while the stature was the mean of three measurements (5-10).

Triceps, subscapular, suprailiac, abdominal, and medial calf skinfolds were measured using a Cescorf caliper with 0.1 mm precision. The skinfold sites were located on the right side of the body and demarcated with a surgical marking pen. Measurements were taken 2-4 seconds after the caliper pressure was released. Detailed explanation about the skinfold measurement technique can be found in reports of many authors (5-12). Two measurements were taken at each site in a rotational order and, if they varied by more than 5%, a third was taken – the final value was, then, the mean between the two measurements in which the difference was less than 5%.

Radio-ulnar, humeral, and femoral bony diameters were measured using a pachymeter with 0.1 mm precision. The measurements were taken on the right limbs using the method described by others (5-10). Each site was measured three times, and the mean was recorded as the real breadth.

The circumferences of the calf and the arm (biceps) were measured with a flexible tape measure with precision of 0.1 centimeter. Measurements were taken on the right limbs at the level of greatest girth, in a perpendicular angle. The biceps circumference was measured during a maximal isometric contraction (shoulder and elbow at 90 degrees), and the calf with the individual in standing posture. The final values were the mean of three subsequent measurements (5-10, 13).

Hand-grip isometric strength

The hand-grip isometric strength test was carried out using a Narragansett hand dynamometer. The dynamometer was firmly placed in the previously chalked palm of the subject's hand, so that its edge lain between the first and second joints of the fingers and its dial faced the palm. The subject, in standing posture, could move his arm freely during the squeezing, provided he does not touched his body with any part of his arm. Three trials were allowed for each hand, alternately, and the best reading was recorded in pounds (5, 14, 15).

Flexibility

The Wells & Dillon (16) sit and reach test was employed as an index of the individual's flexibility. The equipment consisted of a 30- × 30- × 54-centimeters box-like of plywood having a millimeter-graded scale in the form of plus sign attached on its top; the 0 of the scale started 23 cm towards the subject, from the board on which he placed his feet (12, 17). After a previous warm-up, the subject sat down at the test apparatus placing his bare feet against the board (shoulder-width apart) and keeping the knees fully extended. The subject extended the arms forward, with hands placed on top of each other, palms down, and then reached forward along the scale (holding the position of maximum reach for 1-2 seconds). Three trials were allowed and the recorded score was the farthest point the fingertips of both hands reached (5, 8, 12, 15). Reliability and objectivity coefficients for this test were reported to be 0.94 and 0.99, respectively (18).

Leg power

Leg power was measured by means of the standing long jump test, carried out at an outdoor jumping pit. Using appropriate shoes, the subject stood with feet parallel and slightly apart and behind the take-off line and, after preliminary swings with the arms and bending of the knees, took off from both feet to land on both as far as possible. Jumps followed by slipping or fall were invalidated. The measurement was made at right angles from the far edge of the take-off line to the heel or that part of the body that touched the ground nearest to the take-off line. The subject was awarded with the best score of three valid trials (5, 9, 12, 15). The standing long jump test was reported to have a reliability coefficient of 0.963 and an objectivity coefficient of 0.96 (18).

Lactic anaerobic power

The measurement of the lactic anaerobic power or capacity was accomplished by the 40-second running test. A 400-meter running track demarcated in intervals of 1 m between the 200 and 300 m was used. The subject was allowed to make a light warming up until 2 min before the test. One evaluator and one inspector holding stopwatches stood near the start line and between the 200-300 m, respectively. The evaluator instructed the subject to run as far as possible during the 40 seconds, using the track one. At the signal "Ready, Go" the subject started the sprint and the evaluator walked toward the inspector. According to the time of his stopwatch, the inspector positioned himself near the probable distance the subject will reach at the 40 seconds time-point. When the evaluator notified the end of the time by means of a whistle, the inspector observed the last foot in contact with the ground in this moment. The test was scored in meters with the result as an entire number right under the real distance covered (7, 9, 19). According to Matsudo (20), the 40-second running test has a reproducibility coefficient of 0.99 and an objectivity coefficient of 0.999 for the evaluation of the anaerobic power.

Abdominal endurance

The 60-second bent-knee sit-ups test was used to measure the abdominal muscle endurance. To start, the subject lied on the back with knees flexed to around 90 degrees and feet hip-width apart on the mat, heels around 30 cm from the buttocks. Arms were crossed on the chest, with hands on opposite shoulders. The feet were held down by an assistant to keep them on the mat. Before the start, the evaluator informed the subject that resting between sit-ups was allowed but the objective of the test was to perform as many correctly executed sit-ups as possible in a 60-second period. At the sign "Ready, Go" the subject started the abdominal movement by curling to the sitting position, touching elbows to thighs (arms on the chest), and returning to the down position until the mid-back touched the mat. Correctly executed and complete sit-ups during the 60 seconds were computed (7, 12). The reliability of the test has been satisfactory with test-retest reliability coefficients ranging from 0.68 to 0.94 (12).

Arm power

Arm power was assessed by the medicine ball put test. The test was performed outdoor, in a jumping pit, using a 2-kg medicine ball. The subject was sat in a chair with the spine erect and having a belt around his chest firmly fasten by an assistant in order to do not permit movements of the torso during the throwing. The medicine ball was held with both hands and tucked under the chin. At the sign "Ready, Go" the subject threw the ball as far as possible, in an angle so that it reached the farthest distance. The measurement was made using a tape measure, from the line of the chair (central point) to the nearest mark on the ground made by the ball. Three trials were allowed, and the mean of the scores was recorded (8, 12). This test was reported to have reliability and objectivity coefficients of 0.84 and 0.99, respectively (18).

Running speed

The 50-meter dash test was selected for the evaluation of the subject's running speed. The subject was allowed to make a light warming up until 2 min before the test, and then assumed the starting position behind the starting line. The evaluator, positioned at the finish line and holding a stopwatch accurate to one-tenth second, used the commands "Are you ready?" and "Go!" The latter was accompanied by a downward sweep of the arm, giving a visual signal to the subject, starting the watch simultaneously. The watch was stopped when the runner crossed the finish line, and the score, recorded to the nearest tenth of a second, was the elapsed time between the "Go" signal and the instant the subject crossed the finish line. Only one trial was permitted but, if necessary to repeat the test, a interval of five minutes was conceded (5, 7, 9, 12).

Aerobic endurance

The actually most popular and feasible Cooper's 12-minute run/walk test was chosen to estimate the aerobic endurance. The test was carried out in a 400-meter running track demarcated in intervals of 5 m. A brief warming up containing several stretching exercises was done before the "Start" signal. The subject was instructed that walking was allowed but the objective was to cover as great a distance as possible in 12 minutes. The evaluator stood at the starting line recording the number of laps ran and informing the time to the subject in periods of 3 minutes. The end of the test was notified by means of a whistle, and the distance covered was recorded with precision of 1 meter (5, 7-9, 12, 14, 15, 21, 22). As validity index, it was reported a correlation of 0.90 between $VO_{2\ max}$ and the distance covered during a 12-minute run/walk (23).

Calculus and statistical analysis

The body mass index (BMI), or the ratio of body weight to height squared, was calculated by means of the following equation: BMI (kg/m^2) = WT / HT^2, where WT was the subject's weight in kilograms and HT his standing height in meters (10-12, 24).

Somatotyping calculations were performed using the Heath-Carter method (25), well summarized by Mathews (5). Body composition estimations were carried out using the anatomic 4-component model, in which the body is fractioned in adipose, muscular, skeletal, and residual (including organs) constituents (10).

The anaerobic power was calculated from the score obtained in the lactic anaerobic power measurement (40-second running test). The following equation was used: AP (kg•m/sec) = [BW × D] / 40 sec., where BW was the subject's body weight in kilograms and D the distance in meters covered in 40 seconds (26).

The maximum oxygen consumption ($VO_{2\ max}$) was estimated by means of the following equation: $VO_{2\ max}$ (ml/kg/min) = D - 504.0941662 / 44.78265098, where D was the distance in meters covered in 12 minutes, 504.0941662 the correction value in relation to the treadmill test, and 44.78265098 the constant of the O_2 consumption for 12 minutes (8).

Data analysis was performed with the StatView 5.0 software program (SAS Institute Inc., Cary, North Carolina). The Pearson's product-moment test was used to determine the correlation (r) between pairs of variables. The level of significance was analyzed by the Fisher's LSD test. A "p" value of less than 0.05 was considered significant. Data appear in the text as mean±SD.

Results and discussion

The mean resting heart rate of the twenty-three subjects was 69.8±9.1 beats per minute, and the systolic and diastolic blood pressures were 117.4±7.7 and 72.6±6.7 mm Hg, respectively. The ratio of the average body weight (68.74±7.71 kg) to the average stature (1.763±0.061 m) squared resulted in a general BMI of 22.07±1.83 kg/m^2. According to others, this level is considered normal for the studied range of age (10, 12).

The Figure 1, a simplified somatochart containing the mean values of somatotype, shows the predominance of the mesomorphic (4.50±0.84) over the ectomorphic (2.99±0.90) and the endomorphic (2.87±0.92) components. Therefore, the body type of the Kung Fu practitioners could be characterized by a square body with hard, rugged, and prominent musculature (27).

Table 1 shows the results of the estimations of body

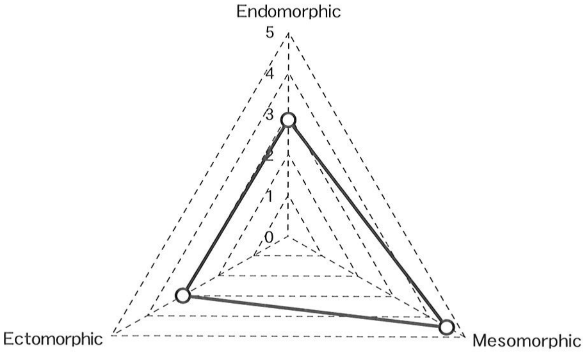

Figure 1: Simplified somatochart containing mean values.

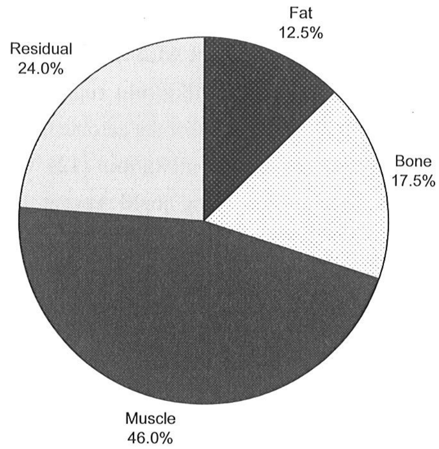

Figure 2: Percent values for the four body components.

Table 1: Body fragmentation in four components plus the fat-free body weight (in kilograms).

Fat weight	Bone weight	Muscle weight	Residual weight	Fat-free weight
8.57±3.59	12.01±1.21	31.66±4.59	16.50±1.85	60.17±7.01

Table 2: Motor and functional variables of the physical fitness.

Hand-grip isometric strength (lb)			Flexibility (cm)	Leg power (cm)	Arm power (m)	Abdominal end. (rpt)	Speed (sec)	An. power (kg·m/sec)	$VO_{2\,max}$ (ml/kg/min)
Left	Right	Left+right							
110.26	119.30	229.57	32.14	213.04	5.29	44.26	8.05	435.10	45.90
(±19.87)	(±17.04)	(±35.43)	(±9.47)	(±20.05)	(±0.61)	(±9.63)	(±0.36)	(±59.84)	(±6.41)

constituents, with fragmentation in four components plus the fat-free body weight (body weight minus fat weight), in kilograms. Additionally, Figure 2 illustrates the same findings adjusted to relative (%) values of the total body weight. It is clear the very low percentage of body fat and the predominance of the muscle mass over the other fragments, typifying the 'muscular' body. The 12.5% relative fat level was the very same as that found in post-trained men (28). Additionally, although Kung Fu and wrestling have evident differences, this rate is in agreement with previous studies on wrestlers which reported values between 10.7% (29) and 14.3% (30).

The results of the measured motor and functional variables of the physical fitness are shown in Table 2. Only the anaerobic power and the $VO_{2\,max}$ are estimated values, the other results are the direct mean of each score obtained during field tests. Relatively high scores obtained in the power and endurance tests were in agreement with the statement that power and aerobic and/or anaerobic endurance are the most important qualities for the sports practice (31). Anaerobic endurance is said to be the physical quality correspondent to the sports of combat (31), and power is considered the quality that characterize the outstanding athletes (32). Furthermore, Dantas (31) classify power as an indispensable training element and flexibility and anaerobic endurance as important physical qualities for Kung Fu practitioners. Here, the athlete's flexibility, also called 'mobility', plays an important role in allowing large amplitude of movements (32, 33), facilitating technical performance (34), and preventing musculo-articular injuries (33-35).

Based on classification guidelines established before (23, 36), the aerobic fitness level ($VO_{2\,max}$) of the Kung Fu practitioners was found to be 'good'. In addition, the findings of the present study are consistent with maximal oxygen uptake values from 52 to 65 ml/kg/min reported for male wrestlers (28). Moreover, given that the aerobic fitness threshold for health promotion is 35 ml/kg/min (12), we are able to presume that Kung Fu training could prevent the onset of cardiac and/or metabolic related diseases (37-40).

Table 3 shows the correlation coefficients resulted from comparisons between anthropometric characteristics and physical fitness components. The level of significance is expressed by the "*z*" and "*p*" values. Hand-grip isometric strength, as well as arm power, showed to be close and

Table 3: Correlations between anthropometric characteristics and physical fitness qualities.

Variables	Correlation "*r*"	Significance "*z*"	Significance "*p*"
Body wt. / hand-grip strength	0.605	3.137	0.0017
Body wt. / arm power	0.655	3.508	0.0005
Stature / hand-grip strength	0.471	2.289	0.0221
Stature / arm power	0.526	2.613	0.0090
Stature / leg power	0.488	2.386	0.0171
BMI / hand-grip strength	0.441	2.118	0.0342
BMI / arm power	0.459	2.216	0.0267
BMI / speed	0.420	2.004	0.0451
Endomorphy / leg power	-0.442	-2.125	0.0336
Endomorphy / lactic an. power	-0.591	-3.036	0.0024
Endomorphy / speed	-0.434	-2.079	0.0376
Mesomorphy / speed	0.528	2.628	0.0086
Relative fat / lactic an. power	-0.504	-2.478	0.0132
Relative fat / $VO_{2\ max}$	-0.502	-2.470	0.0135
Bone wt. / hand-grip strength	0.497	2.437	0.0148
Bone wt. / arm power	0.422	2.012	0.0443
Bone wt. / abdominal end.	0.489	2.394	0.0167
Muscle wt. / hand-grip strength	0.632	3.330	0.0009
Muscle wt. / flexibility	0.447	2.152	0.0314
Muscle wt. / arm power	0.473	2.298	0.0216
Muscle wt. / lactic an. power	0.614	3.196	0.0014
Muscle wt. / speed	0.576	2.939	0.0033
Muscle wt. / $VO_{2\ max}$	0.446	2.145	0.0319
Residual wt. / hand-grip strength	0.605	3.135	0.0017
Residual wt. / arm power	0.655	3.507	0.0005

positively correlated to the elements of the individual's anthropometry, with particular connection to the body size and muscular content. Lactic anaerobic power and aerobic fitness revealed to be relatively strongly linked with the fat/muscle ratio, coming into accordance with a preceding report in which the degree of fatness had a great negative influence on the performance of the studied subjects (41). The scattergram (Figure 3) illustrates the inverse proportionality between maximal oxygen uptake and relative fat.

Another noteworthy correlation found in the present study was between the resting heart rate and the fat/muscle ratio and physical fitness (data not shown in the tables). The high the relative fat the elevated the resting heart rate ($r = 0.48$, $p < 0.05$); the inverse was true in comparison with the muscle weight ($r = -0.43$, $p < 0.05$). Besides, the lower the resting heart rates the better the lactic anaerobic power ($r = -0.62$, $p < 0.005$), the speed ($r = -0.46$, $p < 0.05$), and the abdominal endurance ($r = -0.53$, $p < 0.01$).

Significant correlations between pairs of physical fitness qualities are shown in Table 4. Contrary to the previous table, in this one the estimated anaerobic power results were used to establish the correlations. It is remarkable the sequence of direct proportionality between hand-grip isometric strength and most of the other measured physical capacities. These results are comparable to the findings of Clarke (42), in which the hand-grip readings showed a correlation of 0.80 with more general measures of muscle strength. Therefore, it seems that, if further studies can provide us with even more consistent data, enough to set up standardized norms, a simple hand-grip strength test would be accepted as an indicator of the general fitness level of a certain subject. To an analogous fashion, anaerobic power

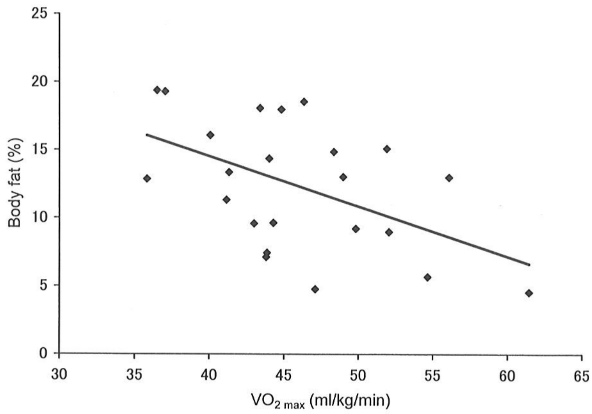

Figure 3: Maximal oxygen uptake was inversely proportional to relative body fat.

Table 4: Correlations between pairs of physical fitness qualities.

Variables	Correlation "r"	Significance "z"	Significance "p"
Hand-grip strength / flexibility	0.438	2.100	0.0357
Hand-grip strength / arm power	0.510	2.516	0.0119
Hand-grip strength / leg power	0.409	1.942	0.0521
Hand-grip strength / anaerobic	0.680	3.711	0.0002
Hand-grip strength / speed	0.539	2.696	0.0070
Flexibility / abdominal end.	0.463	2.239	0.0251
Flexibility / $VO_{2\,max}$	0.486	2.373	0.0177
Anaerobic power / flexibility	0.471	2.290	0.0220
Anaerobic power / arm power	0.673	3.654	0.0003
Anaerobic power / speed	0.567	2.879	0.0040
Anaerobic power / abd. end.	0.449	2.161	0.0307
Abdominal endurance / $VO_{2\,max}$	0.415	1.977	0.0480

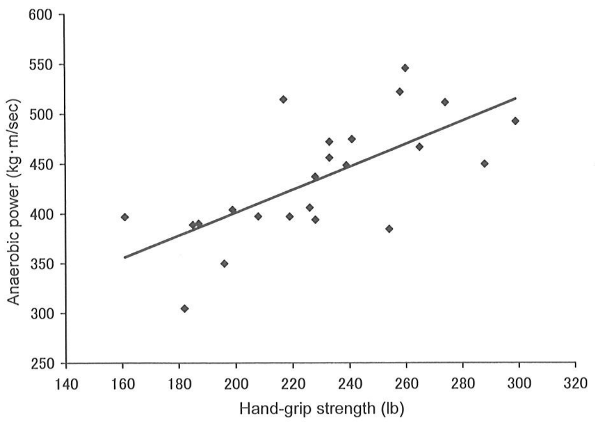

Figure 4: Anaerobic power is directly proportional to the hand-grip isometric strength.

showed significant positive correlation with five physical qualities, and flexibility with four of them. The scattergram (Figure 4) illustrates the direct proportionality between hand-grip isometric strength and anaerobic power.

In summary, the practitioners of the Wing Chun Kung Fu, a technically simple (2, 43) and one of the most popular styles of martial art in Hong Kong, Europe, and America (44), can be characterized as relatively slender and strong body holders, possessing great striking power and considerable aerobic/anaerobic fitness. Supplementary studies are needed to investigate body composition and fitness changes in Kung Fu beginners as well as to validate a battery of tests for this group of athletes.

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