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ARTICLE

Body composition and performance of high-ranking female athletes of Mongolia

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Abstract: *The purpose of this study is to determine the level of morphological and functional indicators depending on sports specializations among distinguished Mongolian female athletes. Our study involved 123 athletes aged 18-34 in six sports disciplines and the body composition of the athletes were measured by anthropometry and bioelectrical impedance. Physical performance was assessed by Harvard Step Test, alongside spirometry and physical fitness tests. Sports specializations affect the indicators of physical development and body composition of athletes, which revealed significant differences between them. According to the Harvard Test, 85% (34) of team sports athletes, 53.4% (31) of martial arts athletes received good and excellent marks. High-ranking Mongolian male athletes have different body compositions according to various sports disciplines and one can create a profile of an athlete within specific sports. Many years of training can improve an athlete's performance. The cardiovascular function of athletes involved in martial arts quickly returns to normal after training.*

Keywords: *Professional Athlete, Team Sports, Human Activities, Body Composition, Anthropometry, Body Measures;*

INTRODUCTION

The current development trend of global sports is aimed at scientifically improving the training and coaching techniques of high-class athletes, who have the potential to compete for Olympic medals. In Mongolia, modern sports are organized based on the rich history and cultural heritage of the country, and in accordance with the laws and trends of global sports development, applying advanced methods suited to the nature, climatic seasons, and special features of Mongolian physical development and mentality. The selection of young people for a particular discipline in sports, and subsequent regular training for the perfect development of skills arise from the needs of the society.

The selection of young people for a particular discipline in sports, and subsequent

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regular training for the perfect development of skills arise from the needs of the society. However, in some sports, there is a lack of scientific research into the theory and methodology of sports science especially taking into consideration the demands of today's physical education and sports professionals, coaches, teachers, doctors, athletes and students.

In order to be successful in modern sports, it is extremely important to subject athletes to regular and comprehensive, and most importantly to systematic training and coaching of athletes [1, 2]. Successful physical education activities will be conducted for years with due consideration of different features of human body structure and age. On top of this, the most crucial contemporary issue in this industry is the study of changes in the physical structure and function of the next generation (children, teenagers and youth) who are growing under the influence of various ecological, social and economic factors [3,4]. In this paper, we attempted to study some features of physical structure and function, age, gender, ecology, and sports characteristics of high-ranking Mongolian athletes, in relation to the influence of various factors.

An athletes' body structure, functional characteristics, nervous system, physical agility, stamina and endurance were first studied in Mongolia at the end of the last century. Accordingly, it is important to use the above research indicators to choose professional sport types and select athletes. This is because, under the circumstance of increasing competitiveness and maximizing the strength of athletes, this study is important for detecting talents in the sport field and based on that, to select, from the very beginning, children with the ability to succeed in any type og sport [5-8]. It is also critically important to develop and use a high-level athlete model in a comprehensive study to accurately and objectively monitor the coaching process, and to modify and improve the coaching plan as needed [9].

The anthropometric and morphological characteristics of Mongolian athletes have been researched in the past. Take for example,a study carried out by Tarvaa N. et al. into some indicators of physical development of Mongolian martial artists, in which it was found that the physical development of athletes differs depending on the type of sports and coaching situation, and that the main physical indicators of athletes are better than those people who do not engage in sports [11].

Zagdsuren D. et al. compared the average physical fitness of athletes in their paper entitled “Some morphophysiological indicators of Mongolian athletes' performance” with a survey carried out by Nyamdorj Ya. et al of Mongolian men aged between 18 and 49, and they found the following differences in indicators - 10.64 cm in height, 12.58 kg in body weight and 9.76 cm in chest circumference [10].

“Study of physical development of young athletes related to sport types” conducted by Altantsetseg Ya. et al. revealed that the physical measure of 18-20-year-old university students has significantly increased as compared to 26 years ago. It has been proven that wrestler’ back strength is greater and heavier in weight, while the sport game athletes are taller, and skiers, skaters and long-distance runners have better lung capacity [12].

A“Study of some morphophysiological parameters of freestyle wrestlers aged between 16 and 19” done by Bolormaa Sh. et al compared the results of the past 5 years and found that the height, sitting height, chest circumference, back strength, chest circumference and lung capacity had decreased [13].

A “Study of judo wrestlers' body structure features according to their titles and years of training” by Gerelchimeg Ch. et al.showed that higher ranking athletes with higher body mass index (BMI) have greater muscle mass but lesser amount of body water and muscle mass increases and the amount of body water decreases with each year of training [14].

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A join research by Bolorchimeg D. et al. entitled "Results of genealogical and dermatoglyphic studies of high-class athletes" had discovered that delta index, 10 finger loop patterns, loop patterns directed to little finger and the number of fingerprint are more common in high-grade athletes than in non-athletes [15].

Bat-Ireedui Kh. et al. in their research "Body Survey Structure among Mongolian National Martial Arts Athletes"" have successfully studied the body composition, which includes body muscle size, body protein and fat content, intracellular and extracellular water, minerals, body mass index, trunk and limb muscle weight relating to sport type and by monitoring coaching and training, these researchers have found that gender is significant to success in sports [16].

The afore-mentioned studies mainly focused on judokas, freestyle wrestlers and boxers. Zagdsuren D. et al. studied Mongolian national men's volleyball team, while Altantsetseg Ya. et al. studied sport games student-athletes [10, 12]. One of the advantages of our study is that the study included martial arts and team sport groups, such as basketball and football players.

Our study is a comprehensive analysis of the formation of morphological and functional characteristics of high-ranking Mongolian athletes, and depending on sports specialization, extensive desk research was done using complex modern research methods. The novelty of our study is that the external body structure of Mongolian athletes was determined with anthropometric equipment, the internal structure with bioimpendensiometric equipment, the function performance with Harvard test, and physical performance and lung function by seperately studying the sport types, sports degree and ranks.

The obtained basic parameters of athletes will be used in the designing of programs for training highly qualified young and adult athletes in Mongolia; improving the effectiveness of training control over physical development and sports preparedness of athletes; ensuring an integrated approach in the selection of individuals for professional sports; monitoring the physical condition of the population of Mongolia; and for compiling teaching aids. The basic parameterswill also be included in a number of academic disciplines. The purpose of this study is to determine the level of morphological and functional indicators depending on sports specializations among highly-ranked Mongolian male athletes.

MATERIALS AND METHODS

Research design and subjects

Prospective and longitudinal study design was applied in this study. Our study involved 123 athletes aged between 18 and 34 in six sports disciplines. 61 martial arts' athletes were from the National Team of the Department of Physical Education and Sports. 62 team sports' athletes were from the Mongolian National Basketball Association, the Mongolian Volleyball Association and the Mongolian Football Association. Our study was conducted over a span of 6 years from 2015 to 2021. On April 29 of 2015, the topic and methodology of the research were discussed and approved by the Council of Scientist of MNUMS - Mongolian National University of Medical Sciences. Material collection was organized in two summer Olympic Games in 2016 and 2021. We believe that our research results could have been better if the research i]] was conducted when the athletes are training for the Olympic Game, when they would be in the highest level of their training.

Inclusion criteria

Athletes must be a member of the national team or a premier league, have a sports degree or a rank, be relatively healthy, and agree to participate in the study.

Exclusion criteria

Athletes who are not members of the national team or the premier league, they don't have a sports degree or a rank, and are not prepared to participate in the study (due to an injury).

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Questionnaire

The survey form included questions aimed at identifying factors that affect each athlete's physical development and preparation. Athletes' age, gender, type of sports, length of training, rank, place of birth, ecological and living environment. We split the living environment into two categories, one housing with central heating system, and the other one - ger district with stoves burning coal for heating. An oft-cited problem in the ger districts in Ulaanbaatar and a number of other larger cities is the severity of air pollution (especially in winter) caused by the use of simple iron stoves for cooking and heating purposes.

Anthropometric measurement

Each athlete's standing height was measured using an anthropometric (Model 101 "GPM" manufacturers in Switzerland) and weight was measured by a digital scale. Circumferences (chest, waist, hips, arm, forearm, thigh, lower leg) were measured using a measuring tape and outside caliper; skinfold thicknesses (subscapular, over triceps, over biceps, abdominal, suprailiac) were measured with Harpenden skinfold caliper

Bioelectrical impedance analysis (BIA)

Bioelectrical impedance analysis is a method for cslculating the impedance of the body using bioelectrical impedance analyzer (ABC-01 'Medass', Russia), which uses a conventional tetrapolar method at a frequency of 50 kHz. Body composition variables, such as fat-free mass, fat mass, skeletal muscle mass and active cell mass were determined using appropriate equations provided by the manufacturer [17].

Harvard Step Test

Harvard Step Test (HST) is a test for measuring the physical fitness (cardiovascular endurance) of a human by using a mathematical formula for determining an Index Number, called the Physical Efficiency Index (PEI). The athlete steps up and down on a box at a rate of 30 steps per minute (every two seconds) for 5 minutes or until the athlete is fully exhausted. Exhaustion is defined as when the athlete cannot maintain the stepping rate for 15 seconds. The athlete immediately sits down on completion of the test, and the total number of heartbeats is counted between 1 to 1.5 minutes after finishing.

Physical fitness test

We determined the level of physical development of adults by a test method that assesses five physical qualities (speed, strength, flexibility, endurance and balance).

Statistical analysis

Frequencies, percentages and independent t-tests were used to examine the difference among groups. A p-value of < 0.05 was used as the cut-off point for determining the statistical significance. Statistical analysis was done using One-WayANOVA. SPSS 23.0 and Microsoft Excel 2013.

Ethical statement

The study was approved by the Research Ethics Committee of the Mongolian National University of Medical Sciences on April 29, 2015 (No. 14-15/21 (02)). All athletes were provided with written informed consent form before they participated in the study.

RESULTS AND DISCUSSION

Our study involved 123 female athletes aged 18-34 in six sports disciplines. In Mongolia, athletes are awarded 1st and 2nd degrees, as well as titles of Master of Sports and Master of International Sports. In our study,185 (52%) of the athletes are Masters of Sports and above, and 121 (70%) participants were non-smokers (Table 1).

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Table 1. General characteristics of athletes

Characteristics	Number	Percentage
Sports group		
Basketball	22	17.9%
Volleyball	21	17.1%
Football	19	15.4%
Judo	21	17.1%
Wrestling	20	16.3%
Boxing	20	16.3%
Rank		
Degree	59	48.0%
Master	40	32.5%
International Master	24	19.5%
Living environment		
Housing	75	60.9%
Ger district	48	39.1%

Physical development and body composition measurement

Mongolian athletes involved in various sports have objectively existing morphological and functional features, in addition to the values of skin folds (Table 2). In terms of external structure of high-ranking female athletes, volleyball and basketball players have higher body length ($p<0.001$), and martial arts athletes have higher body circumference measurements($p<0.05$). In terms of internal body structure, judo and freestyle wrestlers have less fat mass and more active cell mass($p<0.05$).

Table 2. Body composition measurement by sports group

Features	Basketball	Volleyball	Football	Judo	Wrestling	Box	F	*p-value
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD		
Height (cm)	167±5.1	169±8.8	159.9±5.5	161±6.5	158.4±7.4	159±6.4	9.148	0.000
Weight (kg)	64.3±10.8	63.6±9.9	57.9±6.8	66±12.8	63.1±10.2	54±8	4.192	0.002
Chest circumference (cm)	86.7±6.2	85.5±5.7	84.9±6.3	91.4±7	90.7±6.1	83.6±5.8	5.400	0.000
Waist circumference (cm)	73.6±6.7	73.4±5.6	72.1±5.8	75.5±8.7	77.6±8.8	69.2±5.3	3.429	0.006
Hip circumference (cm)	94.5±6.3	94.2±6.7	92.7±4.5	95.7±8.5	93.8±6	89.8±5.5	2.048	0.077
Right wrist circumference (cm)	27.8±3.4	25.5±2.4	27.1±2.7	29.5±2.6	29.1±2.4	26.2±2.4	7.314	0.000
Left wrist circumference (cm)	26.6±3.3	25±2.3	26.5±2.6	29.5±2.5	28.9±2.4	25.8±2.8	9.173	0.000
Tight circumference (cm)	55.8±4.1	54.7±4.6	56.1±4.3	56±5.3	57.1±4.1	53.1±4.5	1.945	0.092
Average of skinfold (cm)	1.62±0.4	1.4±0.34	1.62±0.32	1.37±0.62	1.39±0.55	1.42±0.36	1.347	0.250
Fat mass (kg)	19.6±7.5	17.7±5.9	16±4.7	18.9±9.3	15.4±6.5	12.8±4.7	2.933	0.016
Fat-free mass (kg)	45.6±3.7	46.1±4.3	41.8±3.9	47±7	47±5.1	41.6±4.6	5.041	0.000
Active cell mass (kg)	25.7±2.2	26.3±2.6	25.4±4.3	29.2±3.1	27.9±2.7	24.5±3.2	6.721	0.000
Skeletal muscle mass (kg)	22.6±1.7	23.2±2.5	20.7±2.4	23.5±4.6	24±3	20.7±2.9	4.555	0.001
Body fluids (L)	33.4±2.7	33.7±3.2	30.6±2.9	34.4±5.2	33.9±3.3	30.5±3.4	4.868	0.000
Extracellular fluid (L)	14.6±1.4	14.7±1.7	13.3±1.2	14.8±2.2	14.7±2	13.6±2.3	2.530	0.033
Basal metabolism (kcal)	1429±68	1447±82	1417±136	1539±98	1498±8.4	1390±102	6.702	0.000
Surface metabolism (kcal)	830.9±47.6	840.7±59.4	901.4±102.3	925.4±66.7	938.4±53.6	908.5±50	9.694	0.000

One-way ANOVA

As the rank increases, the body composition of the athletes becomes better. When comparing the training years with their rank, athletes with a master's degree or above have an average of 8 ± 4 years of training. This shows that after many years of training, the body composition of athletes changes for the better (Table 3).

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Table 3. Body composition measurement by ranks

Features	Degree	Master	International Master	F	*p-value
	Mean ± SD	Mean ± SD	Mean ± SD		
Height (cm)	163.8±8.5	161.2±6.6	161.9±7.6	1.523	0.222
Weight (kg)	60.6±11.2	62.6±11.1	62.3±8.4	0.489	0.615
Chest circumference (cm)	85.6±6.4	87.8±7.3	90±5.5	4.266	0.016
Waist circumference (cm)	71.9±6.3	75.4±8.3	74.5±7.3	3.019	0.053
Hip circumference (cm)	93.5±6.9	93.6±6.9	93.6±5.2	0.004	0.996
Right wrist circumference (cm)	26.8±3.1	28.1±3.2	28.5±1.8	3.997	0.021
Left wrist circumference (cm)	25.9±3.1	27.8±3.2	28.5±2	8.301	0.000
Tight circumference (cm)	55.1±5	55.7±4.3	55.9±4.2	0.344	0.710
Average of skinfold (cm)	1.56±0.36	1.5±0.53	0.12±0.43	5.797	0.004
Fat mass (kg)	16.7±7.2	16.8±7.3	16.8±5.7	0.004	0.996
Fat-free mass (kg)	44.1±4.7	45.7±5.3	45.7±6.5	1.437	0.242
Active cell mass (kg)	25.7 ±3.3	26.8±3.3	28.2±3.2	5.094	0.008
Skeletal muscle mass (kg)	22± 2.7	23.1±3.1	22.7±4.3	1.330	0.268
Body fluids (L)	32.3 ±3.5	33.2±3.7	33.4±4.7	1.148	0.321
Extracellular fluid (L)	14±1.8	14.6±1.9	14.6±2	1.497	0.228
Basal metabolism (kcal)	1427±104	1462±106	1507±101	5.197	0.007
Surface metabolism (kcal)	873.1±85.8	896.5±60.3	921.8±63.8	3.862	0.024

One-Way ANOVA test

Harvard Step Test result

Athletes' performance indicators or adaptation of post-workout cardiovascular function were tested by the Harvard Step Test method. Out of the 123 athletes surveyed, 98 (79.7%) athletes completed the Harvard Step Test, while 25 (20.3%) athletes failed the test due to various reasons (stopping the test, health deterioration). According to the test results, 66.3% or 65 out of 98 athletes were rated as excellent, 26.5% (26) were rated as good, and 7.1% (7) were rated as average. Within sport groups athletes in the martial arts group (judo, wrestling, boxing) have higher average test scores (F=6.863, p=0.01, Independent Samples T-test) than those in the sport games group (basketball, volleyball, football). The cardiovascular function of athletes involved in martial arts returns quickly to normal after training (Figure 1).

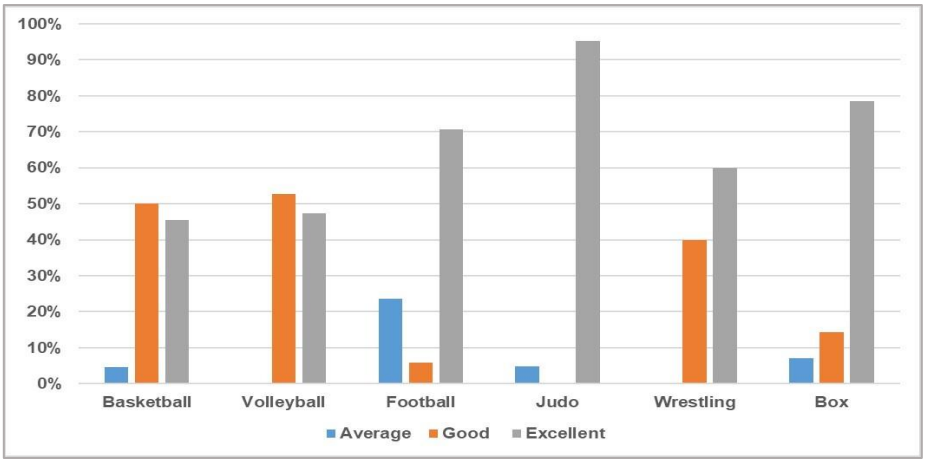

Figure 1. Harvard Step Test result by sports group

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Physical performance

The Harvard Step Test is a method to assess the 5 physical qualities, that is, the level of physical development and fitness, of an athlete. Among the sport groups, the best result **(**p<0,001**)** was shown by the martial art sports group and especially female judokas and wrestlers. Mongolia has won 21 out of 30 medals in the Olympic Games in judo and wrestling, which shows that Mongolian judo and wrestling athletes are better than those in other disciplines of sports. (Table 4)[19].

Table 4. Physical performance by sports group

Features	Basketball	Volleyball	Football	Judo	Wrestling	Boxing	F	*p-value
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD		
Right hand grip strength (kg)	22±4	27±7	21±4	35±6	26±7	24±6	15.021	0.000
Left hand grip strength (kg)	21±5	26±7	20±4	32±7	26±8	23±5	11.721	0.000
Speed (times/10sec)	42±6	42±6	43±7	41±3	39±9	41±10	1.017	0.411
Push-ups (times/30sec)	27±6	26±9	24±10	33±9	29±7	24±7	3.709	0.004
Crunch (times/30sec)	20±5	22±4	19±5	27±4	25±5	21±6	8.280	0.000
Flexibility (cm)	15±7	18±6	15±8	20±5	21±6	17±6	3.071	0.012
Balance (cm)	24±27	37±32	21±29	19±21	16±21	14±21	2.085	0.072
Endurance (sec)	21.97±10.5	20.33±7.87	15.61±4.2	20.93±9.52	15.25±4.6	14.08±4.81	4.332	0.001
Broad jump (cm)	188±20	216±20	172±17	196±17	191±24	171±22	13.883	0.000
Agility shuttle run (sec)	7.73±0.65	7.74±0.57	8.6±0.89	7.9±0.54	8.27±0.57	8.56±0.88	6.716	0.000

One-Way ANOVA test.

Physical performance is the same as body composition and performance becomes better as the rank increases. This means that after many years of training, the body composition of athletes improves and the performance gets better (Table 5).

Table 5. Physical performance by ranks

Features	Degree	Master	International Master	F	*p-value
	Mean ± SD	Mean ± SD	Mean ± SD		
Right hand grip strength (kg)	23±6	27±7	31±8	13.093	0.000
Left hand grip strength (kg)	22±6	27±7	28±7	10.074	0.000
Speed (times/10sec)	42±7	39±7	43±7	4.183	0.018
Push-ups (times/30sec)	24±8	29±8	33±8	12.003	0.000
Crunch (times/30sec)	19±5	24±5	27±4	23.819	0.000
Flexibility (cm)	17±6	18±6	19±8	0.689	0.504
Balance (cm)	27±30	21±22	11±17	3.154	0.046
Endurance (sec)	18.89±9.12	16.76±7.04	18.66±6.06	0.914	0.404
Broad jump (cm)	185±28	190±24	197±18	1.859	0.160
Agility shuttle run (sec)	8.2±0.92	8.09±0.61	7.97±0.57	0.848	0.431

A comparison of training years with sports degree has reveled that athletes who have a sport degree have spent average 6 ± 3 years for training. In general, athletes spend 8 ± 4 years training to reach the rank of master of sports, and 11 ± 3 years on an average to obtain international sports masters degree. It therefore transpires that athletes with high sports ranks and titles, who took part in the study, had spent many years in training to reach high level of physical fitness.

Our researchers who assessed some indicators of physical development of athletes have found that the level of physical development of athletes differs depending on the type of sports and the state of training, and that the main physical indicators are higher among athletes than those who are not athletes.

We compared 18, 19, 20- year-old participants/athletes with the study “Physical development of young athletes in relation to

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sports" (Altantsetseg Ya.). Altantsetseg's study included student-athletes in different sports disciplines, such as sports games, wrestling, skiing, and long-distance running. Compared to our study 21 years later, the anthropometric parameters are greater in terms of standard deviations or wider in scope, which indicates that the physical structure of athletes in different sports varies depending on the nature of the sports ($p < 0.001$). Compared to 21 years ago, the average height of female athletes was higher (159.5±2.2cm to 161.9±7.4cm) at age 18, which, however, decreased at the age of 19, 20. Whereas, body weight, circumference measurements and the thickness of adipose tissue increased in female athletes of all ages, and the quality of strength and flexibility decreased, which are indicative of the level of physical fitness [12].

Indicators of mixed martial art athletes were compared with the studes carried out by Tarvaa N., Zagdsuren D., and Dagvasuren P. and our research result were almost identical with the study entitled "Some performance and morpho-physiological indicators of Mongolian athletes" [10, 11, 18].

Compared to the study of freestyle wrestlers (Tarvaa N., Zagdsuren D.), the rate of height (174.8±4.2cm to 169.8±7.3cm) decreased while the rate of weight (65.5±6.3kg to 73.6±4.6kg) increased. No significant differences were observed in chest circumference [10, 11]. Judo wrestlers are taller, heavierand have an increased chest circumference (94±3.1cmto 98.8±8.8cm) than athletes 21 years ago when compared with the study conducted by Zagdsuren D. [10].

Measurements of anthropometric variables can create a profile of athletes within specific sports, because different sports have different anthropometric characteristics, and this could help coaches to select players for professional level according with the playing position [20]. The results of this study are consistent with our study.

Prevalence of smoking among university athletes was relatively high, although nicotine addiction was very low and lung functions were still relatively good. In our study we did not find much difference between smokers and non-smokers and the living environment, such as air pollution, as the athlete's lung functions were still good [21].

This study had several limitations. In Mongolia, judo, freestyle wrestling and boxing are the most successful sports, while martial arts is more successful than team sports, because the results in judo, freestyle wrestling and boxing depends on the efforts of an individual, while team athletes require the efforts of all members of the team. Subsequently, in our research sample, the bulk sample of athletes with international master's degree tended to be athletes from martial artists. Today team sports is developing fast in the country and we can take the example of our athletes, who are participating in international 3x3 basketball events. We hope that this research will be expanded in the future and that we will study the athletes in each cycle of the Olympic Games and contribute to the improvement of the overall performance of Mongolian athletes.

CONCLUSIONS

Sports athletes have a tall, low muscle mass or asthenic type of physique, while martial arts athletes have a low back, wide girth, and a hypersthenic type of physique with well-developed muscles of both arms. According to bio-impedance measurement, the proportion of active cells or the number of cells capable of functioning, and the basal metabolic rate are higher in martial art athletes.

This is due to the size of the muscles used by the martial arts athletes and the load they take, and the body becomes a feature of the internal structure of the body depending on the type of sports. Many years of training can improve an athlete's performance is a fact. The cardiovascular function of athletes involved in martial arts quickly returns to normal after training.

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