Work Package: 5

Deliverable 5.2.2: Biometric Measurements

Beneficiary: SWU

This document has been created within the framework of the project “Promotion and Development of YMC(H)A-Youth Mobilization-Cultural Heritage and Athletic Valorization” (PROMO-YMC(H)A). The project is co-funded by the European Regional Development Fund (ERDF) and by national funds of the countries participating in the Cooperation Programme Interreg V-A “Greece-Bulgaria 2014-2020”. The contents of this document are sole responsibility of the South-West University “Neofit Rilski” and can in no way be taken to reflect the views of the European Union, the participating countries, the Managing Authority and the Joint Secretariat.

Del. 5.2.2 Biometric Measurements of participants

(1) Isokinetic Assessment of strength in kicking and supporting leg by isometric, concentric and eccentric protocols
(2) Determination of somatotype, body composition, and anaerobic capacity of young gymnasts
(3) Sense of knee joint force in healthy males and females
(4) *Strength characteristics of knee flexors and extensors of sports players of Mixed Martial Arts*

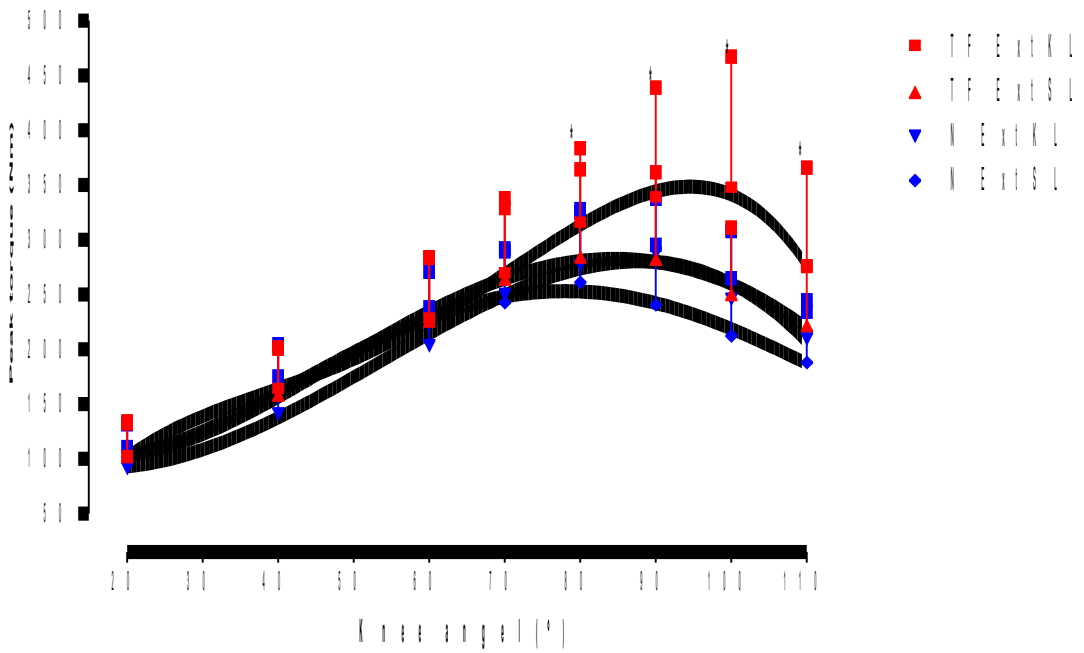
All studies were approved by University Research Ethics Committee.

(1) Isokinetic Assessment of strength in kicking and supporting leg by isometric, concentric and eccentric protocols

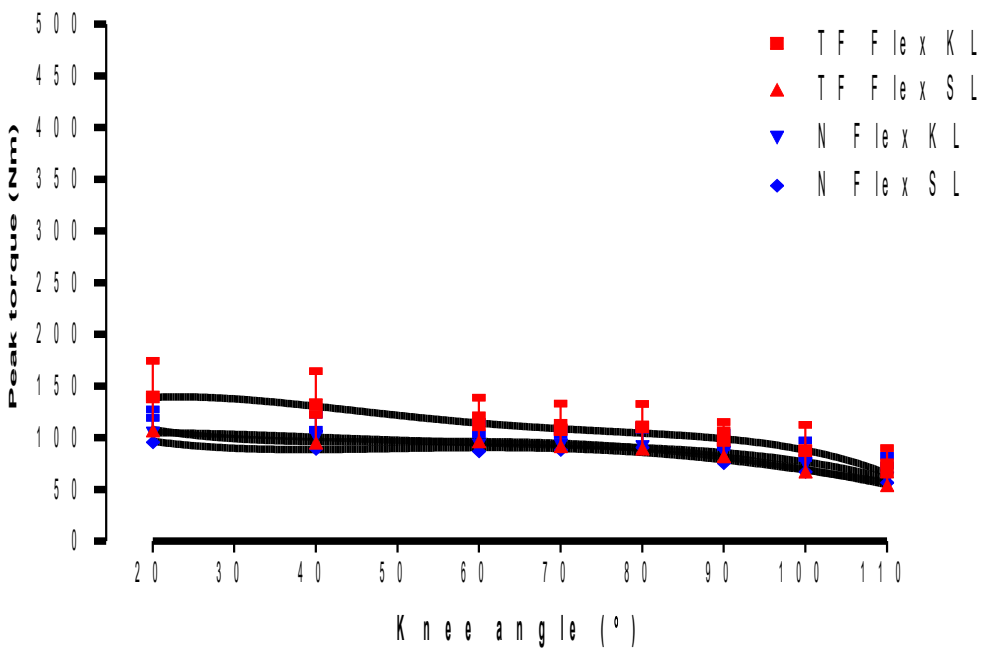
Isometric strength assessment

- **Purpose**: To investigate the knee angle of maximum isomeric torque value (Nm) of knee extensors and knee flexors of the kicking (KL) and standing leg (SL) of football players and non-athletes at 8 knee angle positions by isokinetic dynamometry (Biodex 4Pro).
- **Methods:** 16 football players (22,27±6,05y; 1,77±0,05m) and 12 non-athletes (25,36±7,42y; 1,77±0,08m) were evaluated using an isokinetic dynamometer. Participants performed maximal isometric extensions and flexions at knee angles of 20°, 40°, 60°, 70°, 80°, 90°, 100° and 110°.
- **Results:**

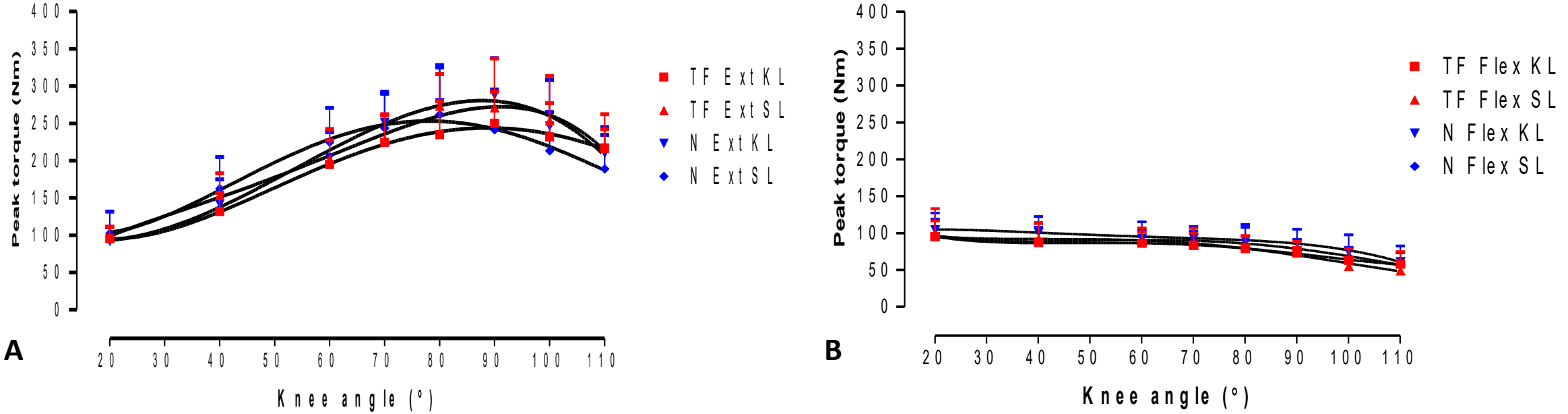
A



B



Torque-angle relationships of the peak torque and knee angle in football players with stronger KL compared with non-athletes. Graph A. Peak torques during isometric extensions at knee angles of 20°to 110°. Graph B. Peak torques during isometric flexion at knee angles of 20° to 110°. TF – football players; N – non-athletes; Ext- extension; Flex-flexion; KL-kicking leg; SL – standing leg.



Torque-angle relationships of the peak torque and knee angle in football players with stronger SL compared with non-athletes. Graph A. Peak torques during isometric extensions at knee angles of 20°to 110°. Graph B. Peak torques during isometric flexion at knee angles of 20° to 110°. TF – football players; N – non-athletes; Ext- extension; Flex-flexion; KL-kicking leg; SL – standing leg.

Conclusions:
- **Football players with a stronger KL predominate ~70 % to 30%.**
- **Angle of maximum torque of the KL extensors is shifted toward a larger muscle length.**
- **Football players with stronger KL generate higher peak torque values during extensions with KL compared to SL (statistically significant differences , $p<0.05$).**
- **Football players with stronger SL show no statistically significant difference between KL and SL extension peak torque values.**

Isokinetic strength assessment – concentric/eccentric mode

- **Purpose**: To generate torque-velocity curves of peak torque values obtained at different angular velocities in the eccentric and concentric mode of knee extension and flexion in football players and non-athletes with isokinetic dynamometer.
- **Methods**: 12 football players (22,50±4,06y; 1,74±0,08m) and 10 non-athletes (26,55±6,64y; 1,78±0.06m) were assessed with isokinetic dynamometer (Biodex 4Pro) to examine strength of knee extensors and flexors at 60°/sec, 90°/sec, 120°/sec, 180°/sec, 240°/sec and 300 °/sec in concentric and eccentric mode, to measure peak torque of KL and SL.
- **Results:**

Table 1. Mean peak torque values and standard deviation (SD) of football players (TF) in concentric (CON) and eccentric (ECC) mode of kicking (KL) and standing leg (SL) extension (Ext) and flexion (Flex) measured and angle velocity of 60 to 300 °/sec.

	TF CON Ext KL		TF CON Ext SL		TF CON Flex KL		TF CON Flex SL		TF ECC Ext KL		TF ECC Ext SL		TF ECC Flex KL		TF ECC Flex SL	
Speed	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
60°/sec	209.8	39.3	211.2	40.2	110.2	25.1	101.5	17.9	265.4	79.7	216.5	78.8	127.4	38.6	115.1	35.8
90°/sec	187.0	37.3	189.9	37.8	98.9	22.9	89.6	16.9	258.6	77.2	258.5	65.2	123.5	32.4	129.2	35.9
120°/sec	164.8	35.4	169.8	31.1	88.9	21.9	83.0	15.8	240.4	83.4	254.3	58.4	128.0	37.7	127.0	28.4
180°/sec	125.5	27.4	141.6	29.0	74.6	26.6	70.3	15.3	247.8	60.9	245.5	62.0	139.3	32.9	114.8	29.5
240°/sec	109.6	23.2	115.8	25.2	65.1	22.7	59.8	12.9	211.3	43.1	228.0	48.8	137.1	41.3	119.4	21.75
300°/sec	99.3	21.3	103.5	21.4	61.4	18.7	61.2	13.1	223.9	60.7	209.0	71.4	138.1	26.4	115.0	21.9

Table 2. Mean peak torque values and standard deviation (SD) of non-athletes (N) in concentric (CON) and eccentric (ECC) mode of kicking (KL) and standing leg (SL) extension (Ext) and flexion (Flex) measured at angular velocities of 60 to 300 °/sec.

	N CON Ext KL		N CON Ext SL		N CON Flex KL		N CON Flex SL		N ECC Ext KL		N ECC Ext SL		N ECC Flex KL		N ECC Flex SL	
Speed	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
60°/sec	182.5	52.6	171.6	43.2	80.0	21.0	82.3	18.1	210.3	71.6	223.6	73.2	102.9	33.0	105.9	12.7
90°/sec	158.9	47.3	156.6	41.8	69.4	21.2	73.4	13.3	214.9	84.9	226.2	56.3	103.8	18.9	109.4	21.6
120°/sec	140.5	49.2	138.7	39.7	63.7	19.5	66.6	14.9	216.3	74.8	234.8	51.1	108.3	20.2	106.8	16.5
180°/sec	119.3	36.7	117.5	34.7	56.0	15.0	57.5	14.2	203.6	64.9	215.0	68.6	106.9	23.0	112.3	21.7
240°/sec	101.5	32.7	97.9	29.7	52.4	9.6	51.0	16.8	214.4	73.4	202.7	53.2	105.3	30.5	107.8	18.9
300°/sec	90.7	32.4	91.3	28.7	55.2	10.7	52.6	15.3	183.5	50.6	163.6	29.2	113.0	35.1	96.0	15.6

(2) Determination of somatotype, body composition, and anaerobic capacity of young gymnasts

Gymnastics requires explosive sprinting, jumping, pushing and pulling skills, together with balance and artistry. On the vault, balance beam and floor, explosive leg power plays an important role in connecting elements and acrobatic series.

Aim

The aim of the present study is to determine the somatotype and body composition of young gymnasts and to evaluate their anaerobic power using two methods.

The data will be used to track changes as a result of training and athletes' growth.

Materials and methods

- The study includes 14 gymnasts (14.47±6.68 years, 149.90±14.36 cm, 44.38±12.61 kg) from gymnastics club PIRIN 2011, Blagoevgrad, Bulgaria
- Their antropometric data and body compositions were measured using body mass analyser IOI353.
- Heath-Carter somatotype method
- Wingate anaerobic test involved 30 sec of pedaling as fast as possible on a Monark bicycle ergometer against an external force. The amount of workload in the Wingate test was 0.075 kg per kg body weight of the subject.
- To measure the blood lactate concentration with biochemical analyzer (Biosen - C line, EKF Diagnostic), blood samples were collected at rest (before warm-up) and at 1^{st}, 3^{rd} and 5^{th} minutes after the end of the Wingate test.
- Sargent vertical jump test

Anthropometric data

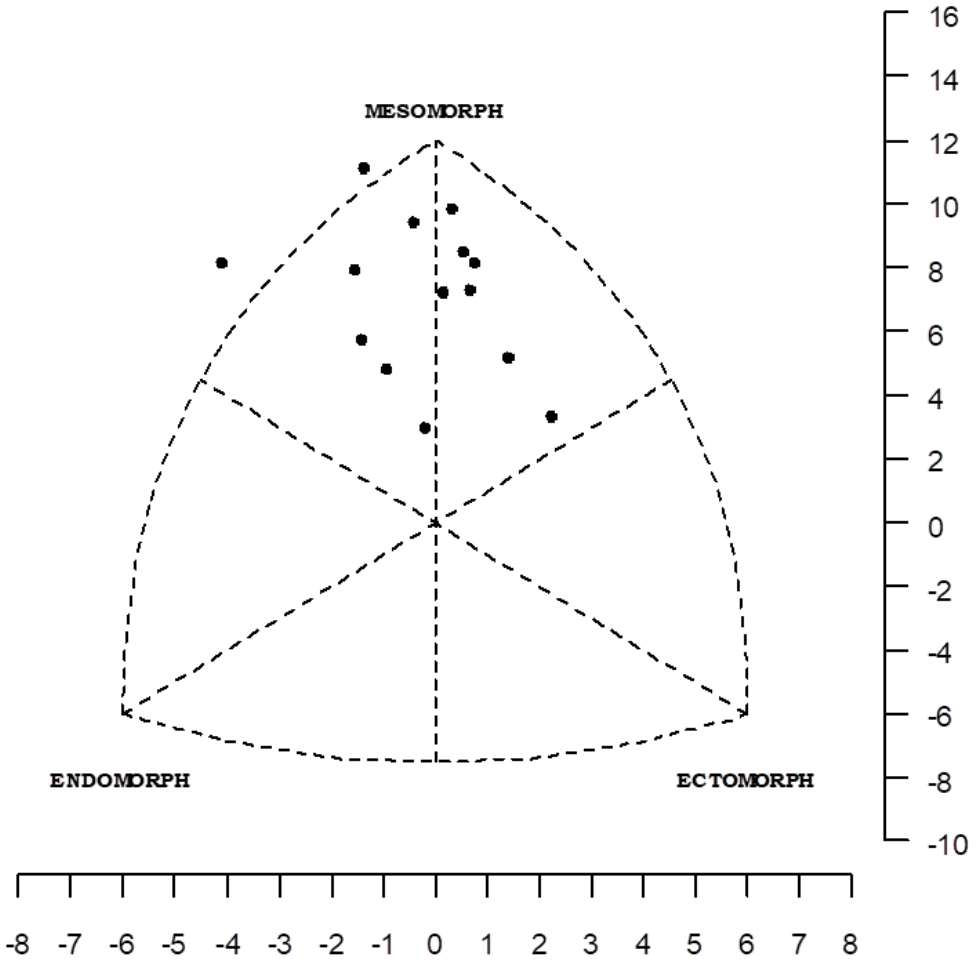
ID	Age	Height	Weight	M.B.F.	L.B.M.	S.L.M.	B.M.I.	Fatness
G2	8.0	128.0	27.4	1.9	25.5	23.9	16.7	-23.9
G16	8.0	127.0	25.4	1.2	24.2	22.7	15.7	-28.5
G4	10.0	143.0	40.2	4.6	35.6	33.2	19.7	-10.7
G5	10.0	143.0	36.2	3.2	33.0	30.9	17.7	-19.6
G11	10.0	128.0	25.7	1.4	24.3	22.8	15.7	-28.6
G22	10.0	153.0	44.6	8.3	36.3	33.7	19.1	-13.4
G3	12.0	155.0	50.2	7.9	42.3	39.4	20.9	-5.1
G9	12.0	149.0	40.5	6.9	33.6	31.2	18.2	-17.0
Mean	10.0	140.8	36.3	4.4	31.9	29.7	18.0	-18.4
±SD	1.5	11.6	9.3	2.9	6.6	6.1	1.9	8.5

ID	Age	Height	Weight	M.B.F.	L.B.M.	S.L.M.	B.M.I.	Fatness
G13	13.0	158.0	46.7	5.5	41.2	38.5	18.7	-14.9
G14	14.0	155.0	48.1	10.5	37.6	34.8	20.0	-9.1
G1	18.0	161.0	55.0	8.7	46.3	43.1	21.2	-3.5
G24	18.0	170.0	56.0	7.0	49.0	45.7	19.4	-11.9
G23	19.0	159.0	61.6	17.7	43.9	40.4	24.4	10.8
G21	22.0	169.0	63.7	10.8	52.9	49.2	22.3	1.4
Mean	17.3	161.0	51.5	7.9	43.5	40.5	19.8	-9.9
±SD	3.3	6.5	4.7	2.2	5.1	4.8	1.1	4.9

M.B.F – mass body fat, **L.B.M.** – lean body mass, **S.L.M.** – soft lean mass, **B.M.I.** – body mass index

The study participants are divided into two groups depending on age: 8 are in the younger age group (8-12) and 6 in the older group (13-22). In the first group the height was 140.8 ± 11.6 cm, weight - 36.3 ± 9.3 kg, BMI - 18.0 ± 1.9. The group is not homogeneous in terms of height and weight, as at this age, the most common differences are encountered, but BMI varies the least. In the second group these indices are height - 161.0 ± 6.5 cm, weight - 51.5 ± 4.7 and BMI - 19.8 ± 1.1. Here again the same trend is observed - large differences in height and weight and small variations in BMI. Although gymnastics are generally weak and with a low body mass index, it is noticeable that it increases over the years and this is due to an increase in both the muscle mass as a result of the training but also the percentage of body fat. If the percentage of body fat is -18.4 ± 8.5% in children 8-12 years of age, then it is larger in older group -9.9 ± 4.9%, ie the increase is on average about 9%.

Somatotype



Despite of the increase of body fat percentage, the group of gymnasts is distinguished by its low percentage of fat, and high percentage of muscle mass. This observation is also confirmed by the obtained somatogram. The general somatogram shows clearly that the subjects studied have a pronounced mesomorphic type, most of which are ecto-meso, and only few of them are endo-meso. The mesomorphic type is the type that is characteristic of gymnastics, as shown in a number of studies.

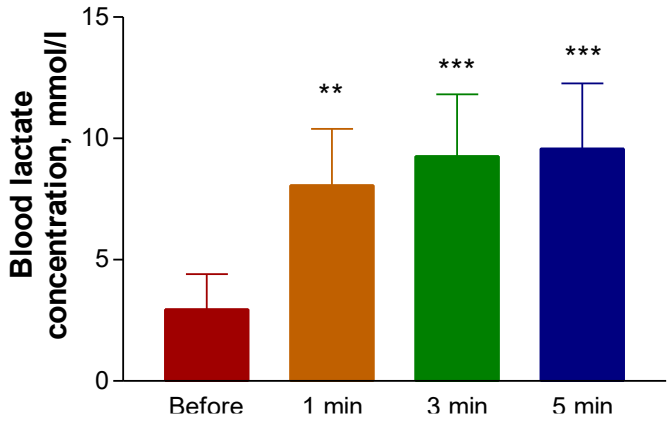
Wingate test results

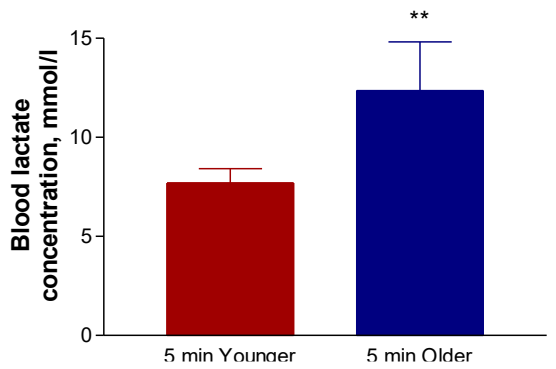
ID	Age	PP (W)	LP (W)	AF (%)
G1	18	465.2	252.22	45.78
G2	8	116.26	73.78	36.53
G3	12	247.01	184.87	25.15
G4	10	217.95	159.1	27.00
G5	10	139.38	90.78	34.86
G9	12	178.58	123.52	30.83
G11	10	88.85	66.08	25.62
G13	13	322.81	169.28	47.56
G14	14	265.61	208.43	21.52
G16	8	80.38	45.86	42.94
G21	22	616.07	283.18	54.03
G22	10	210.34	128.17	39.06
G23	19	428.01	269.63	37.00
G24	18	391.92	256.22	34.62

PP – peak power, LP – low power, AR – anaerobic fatigue

AF = 100*(PP – LP)/PP

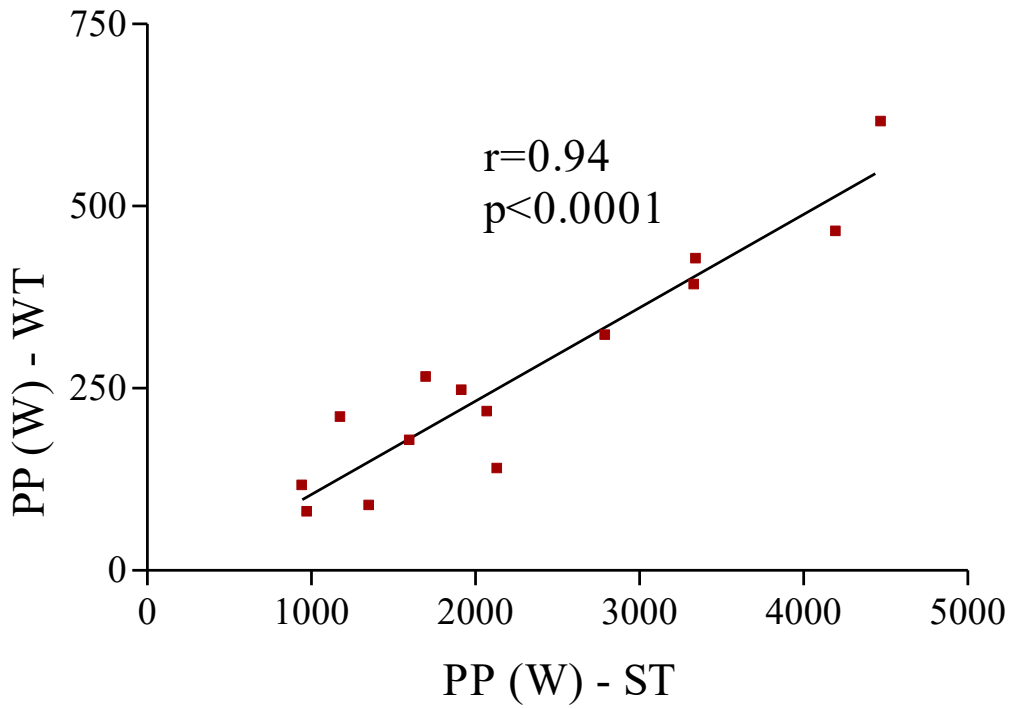
Children are more aerobic than adults but the results showed that after the appropriate training they could develop their anaerobic capacity. Gymnasts age 8-12 have relative peak power lower than older gymnast but their fatigue indexes (45 to 54 % older and 21 to 36 % younger) were higher which proves again that children have faster oxygen uptake kinetics during high intensity exercise than do adults and a 30-s test with children is likely to include a significant contribution from aerobic metabolism, so their blood lactate concentration is significantly lower.





Correlation between Wingate anaerobic test and Sargent test results

ID	Vertical jump, cm	PP(W) - ST	PP (W) - WT
G1	62	4199.9	465.2
G2	29	946.52	116.26
G3	28	1918.66	247.01
G4	38	2072.66	217.95
G5	42	2134.26	139.38
G9	30	1600.65	178.58
G11	37	1355.11	88.85
G13	45	2792.01	322.81
G14	26	1702.13	265.61
G16	31	977.32	80.38
G21	60	4472.61	616.07
G22	20	1179.38	210.34
G23	43	3345.58	428.01
G24	47	3334.7	391.92



PP (W) – ST – peak power determined by Sargent test,
PP (W) – WT – peak power determined by Wingate test

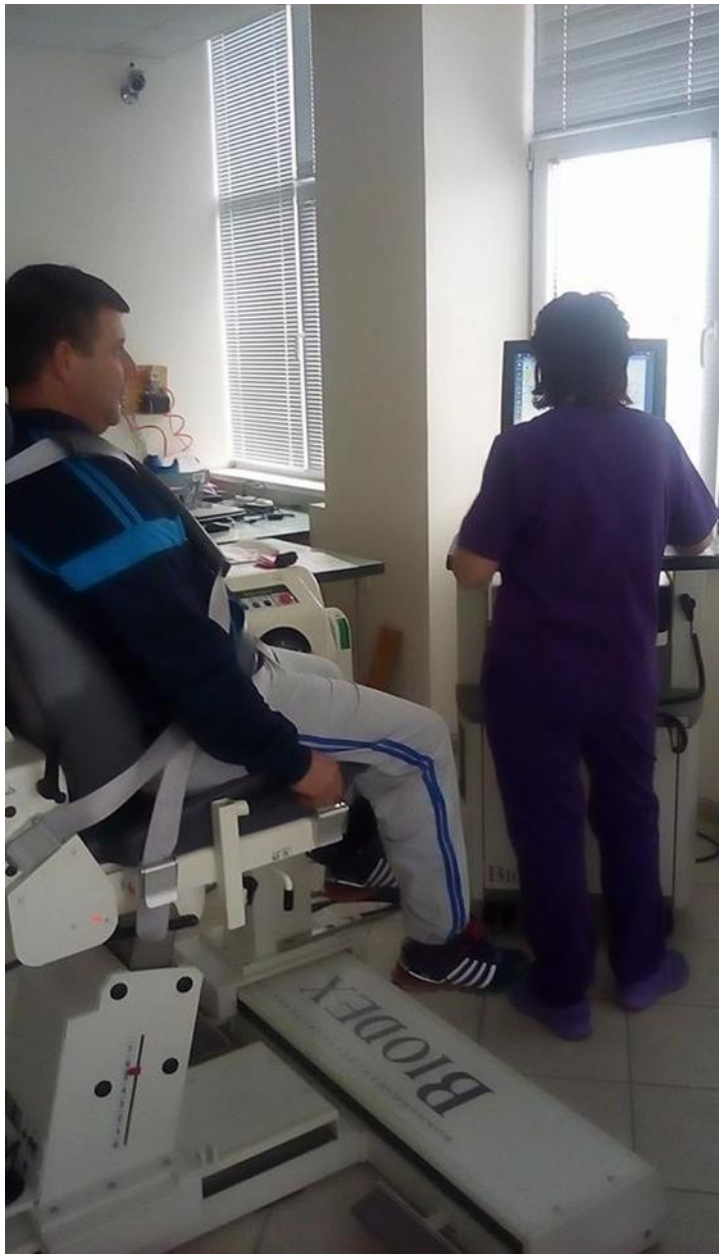
The Sayers Equation:
Peak power (W) = 60.7 x VJ (cm) + 45.3 x mass(kg) – 2055

Conclusions

- The percentage of body fat of gymnast is very low (-18.4 ± 8.5% of 8-12 year-old gymnasts and -9.9 ± 4.9% of 13-22 year-old gymnasts);
- Mesomorphy is are main characteristics of gymnasts (its value ranges from 4.5 to 8.2);
- Anaerobic capacity of gymnasts is relatively high and training helps in its development as it could be seen in older group of gymansts.

(3) Sense of knee joint force in healthy males and females

- The sense of skeletal muscles force is a part of proprioception. It is generated both by central mechanisms and signals by peripheral mechanoreceptors, and especially by the Golgi's tendons organ in the muscle tendons (Proske, Gandevia, 2012)
- Measurement the sense of force with an isokinetic dynamometer allows to quantify this specific sensibility and to calculate the errors - as a criteria of a proprioceptive threshold.
- It is an important part of proprioceptive sensitivity and can be studied in athletes, patients and healthy people.
- The aim of the present study is to



PARTICIPANTS AND ORGANIZATION OF THE STUDY

▪This study consisted of two parts. In part one, anthropometry and muscle strength evaluation were conducted and in part two force sense at the knee joint were evaluated. Both parts took place in the morning about 2-3 hours after the first meal and in a state of good hydration. 42 participants were selected in 2 groups (Group 19 - 23 years old and group 30 - 54 years old), 12 males and 12 females from the first and respectively the second group.

- Participants were selected to have no injury on their dominant leg.
- Anthropometric indexes:

a) “body mass index” (BMI), as a ratio of body mass to squared height; and
b) “lean body mass” (LBM), assessed according to the formula of Boer , were calculated.

- The testing procedures were approved by South-West University Ethics Committee and the participants gave written informed consent.
- Upon arrival to the laboratory, the participants performed a general warm-up consisting of 5 min cycling on a veloergometer with a load of about 120 W at 60 rounds per min to optimize the viscoelastic properties of the muscles, tendons and joints of the lower limbs and prepare the body for the measurement.
- The subjects were tested with isokinetic dynamometer (Biodex, 4 S Pro) unilaterally, on the dominant lower limb.
- Determination of the dominant leg was with so called “the push off “ test.

ISOKINETIC TESTING PROCEDURES

- Subject performed three isometric 3s maximal voluntary isometric contractions (MVC) for knee extension to estimate the angle at which the subject generates a peak torque; it is well known, that this angle varies between individuals, although in a narrow range;
- Between each repetition, participants had at least 30 s rest to reduce fatigue;
- The subject continued with training to reproduce 50% of the muscle force called target through 3 open-eye tests; Every person made 3 attempts to reproduce the target with eliminate vision (eye band) and sound (by muting of the dynamometer) signalling, but with verbal reinforcement and instructions;
- The final measurement of the deviations from the target force was through 3 independent reproduction attempts, without help and reinforcement; 3 values were generated that show how much the generated force is near or far from the target; A one-minute rest was given between trials to avoid fatigue;

Subjects' force reproducing accuracy in percentage was evaluated using three types of errors (Vafadar A.K.):

a) constant error, i.e. the measure of the deviation from the target;
b) variable error, i.e. the measure of the consistency in performance and
c) absolute error, i.e. the measure of the magnitude of the error, discounting direction;

ANTHROPOMETRIC DATA

PARTICIPANTS	MALES	FEMALES
Group 19-23	**(n=12)**	**(n=12)**
Age (years) [mean± SD]	19.3 ± 0.50#	20.1 ± 1.6#
Height (cm) [mean± SD]	175.7 ± 5.6	165.6 ± 3.6*
Body mass (kg) [mean± SD]	78.9 ± 12.3	60.1 ± 8.4*
Body mass index (kg/m2) [mean± SD]	25.7 ± 4.7	21.9 ± 3.4*
Lean body mass (kg)	59.8 ± 5.0	45.2 ± 2.4*
Group 30-54	**(n=10)**	**(n=10)**
Age (years) [mean± SD]	42.1±8	43.3 ± 7.4
Height (cm) [mean± SD]	173 ± 5.8	166.2 ± 4.8 *
Body mass (kg) [mean± SD]	84.6 ± 12.2	64.3 ± 10.2 *
Body mass index (kg/m2) [mean± SD]	28.2 ± 3.3	23.3 ± 3.6*
Lean body mass (kg)	61.4 ± 6	46.5 ± 3.8*

- The results of the anthropometric measurements, presented in Table 1, show that in the two age groups the gender characteristic differences were observed. They were expressed in a statistically significant ($p < 0.05$) higher mean in men in terms of Height, Body Mass (BM), Body Mass Index (BMI), and Lean Body Mass (LBM) than the women.
- No statistically significant differences were observed between males from group 19-23 against group 30-54 in all measured anthropometric parameters except to the age. The same results were obtained in the comparative study of the women in both groups.
- In fact, the feeling of muscle strength has been shown to become more accurate throughout childhood and adolescence, peak in young adulthood, then progressively decline after this (Goble, 2010); It is combination of peripheral and central changes that may accompany aging.

SENSE OF MUSCLE FORCE

- The results for isometric peak torque produced by knee extensors are 244 ±50Nm and 173.7±34Nm for the younger males and females and 261.5±60Nm and 159.7±23Nm for the older group respectively. Knee extensors peak torque was higher in the females from the younger group than the elder one.
- In group 19-23, males peak torque was significantly higher than the females who had a 28% decrease in strength. By comparing young and old men over the years, their strength has grown about 7% over the period of 54 years, while that of women with age decreases about 8%.
- Evaluating the feeling of muscle strength is based on the calculation of 3 types of errors. The results on their mean values are presented in Figure 1. In the reproduction of target strength (50% of MVC) in the triple measurement, higher variations in target deviation and error rate in younger subjects were observed.

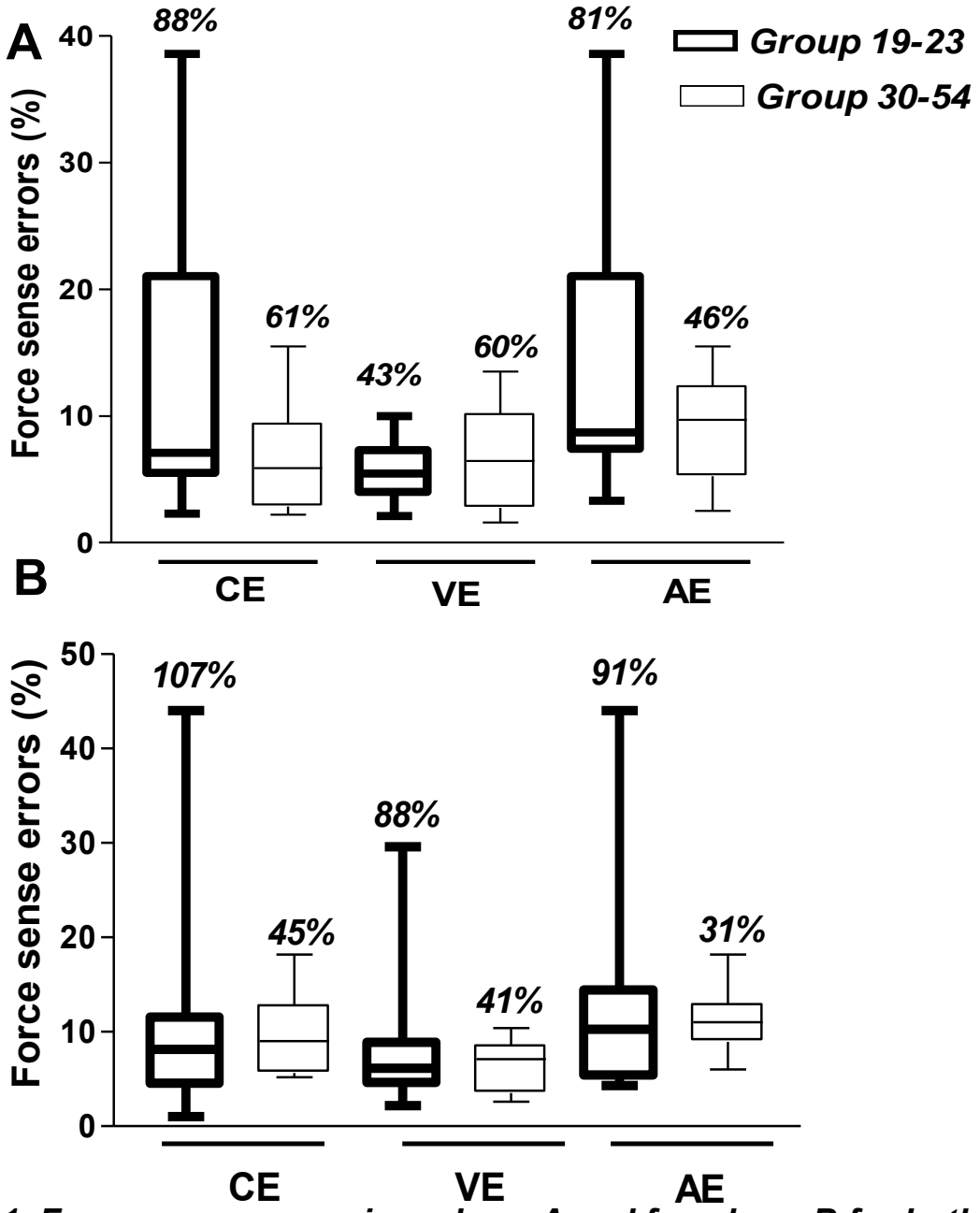


Fig 1. Force sense errors in males – A and females – B for both groups studied; CE- constant error; VE- variable error; AE- absolute error;

CORRELATION ANALYSIS

Type of error as a criteria of proprioceptive thresholds	Parameter	Pearson's correlation coefficient r $p<0.05$	Interpretation
MALES			
Group 19-23			
Variable error	BM (kg)	-0.53*	moderate,negative
Variable error	BMI (kg/m^2)	-0.52*	moderate, negative
Group 30-54			
No correlation			
FEMALES			
Group 19-23			
Constant error	Age (years)	0.59	moderate , positive
Constant error	Hight (sm)	0.51	moderate , positive
Absolute error	Hight (sm)	0.57	moderate , positive
Group 30-54			
Constant error	Age (sm)	-0.58	moderate,negative

- Correlation relationships data for men and women show significant gender differences in regard anthropometric parameters that influence the proprioceptive sense of muscle force.
- In the young males group, moderate negative correlations were found between BM and BMI with VE, which determines how much the error varies, whether it changes.
- In older men, such a correlation has not been established. Since, the means in the 2 groups do not differ significantly, it can be expected that all males with higher body mass and fat mass may be expected to have a higher level of muscle force. These data in the literature are extremely contradictory.
- It was found the moderate correlation between age and CE; height and CE/AE in the group of younger women. Moderate negative correlation relationship was found only with age in the older female group.
- Obviously, there are gender differences in anthropometric parameters that influence the proprioceptive threshold for muscle force. In the literature, the data are contradictory, but everyone believes that there are some differences between men and women.
- It was proved that age and height have a negative effect to the sense of muscle force in women.

(4) *Strength characteristics of knee flexors and extensors of sports players of Mixed Martial Arts*

Methodology of the study

The aim of the study is to analyze the generated maximum torque of flexors and expanders, dynamic knee loads, MMA racers and untreated healthy men. The experiments in the current study were conducted at the Center for Functional Studies in Sport at Southwestern University "Neofit Rilski", Blagoevgrad. The participants were 8 (n = 8) middle-age Mixed Martial Arts players (22.3 + -3.5 y; M±SD) and 8 healthy untreated men of middle-aged men (24.13 ± 1.3 y; M±SD).

Study protocol.

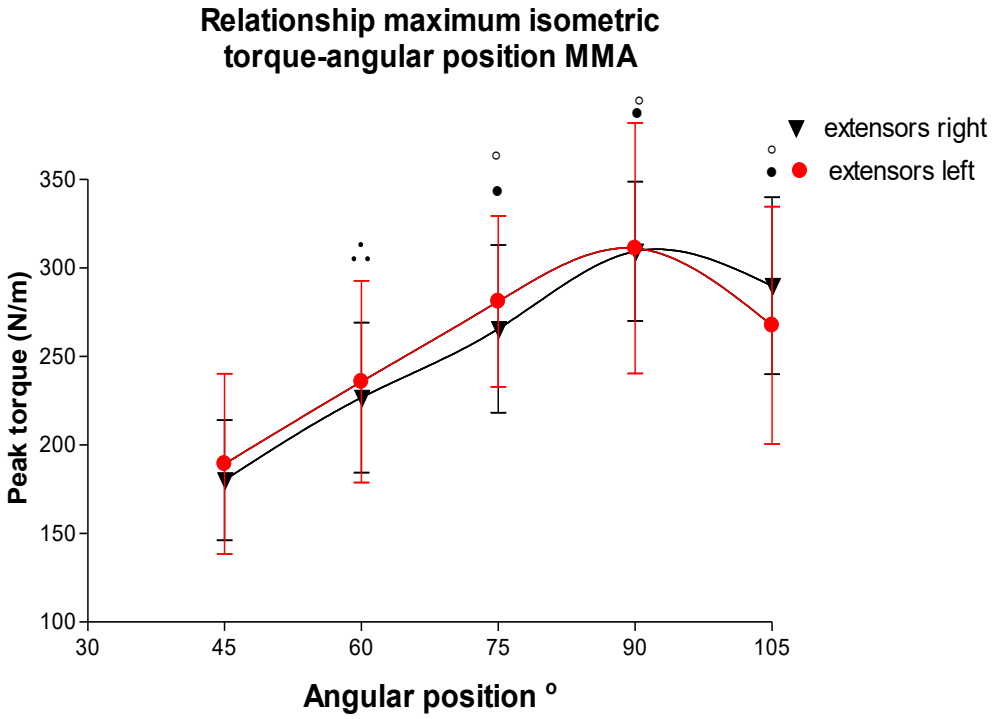
The assessment of dynamic torque at different angular velocities in concentric and eccentric mode was performed with the isokinetic system Biodex 4ProS. The angular velocities we selected were: 30, 90, 150, 210, 270 °/sec. with range of motions 120 °.

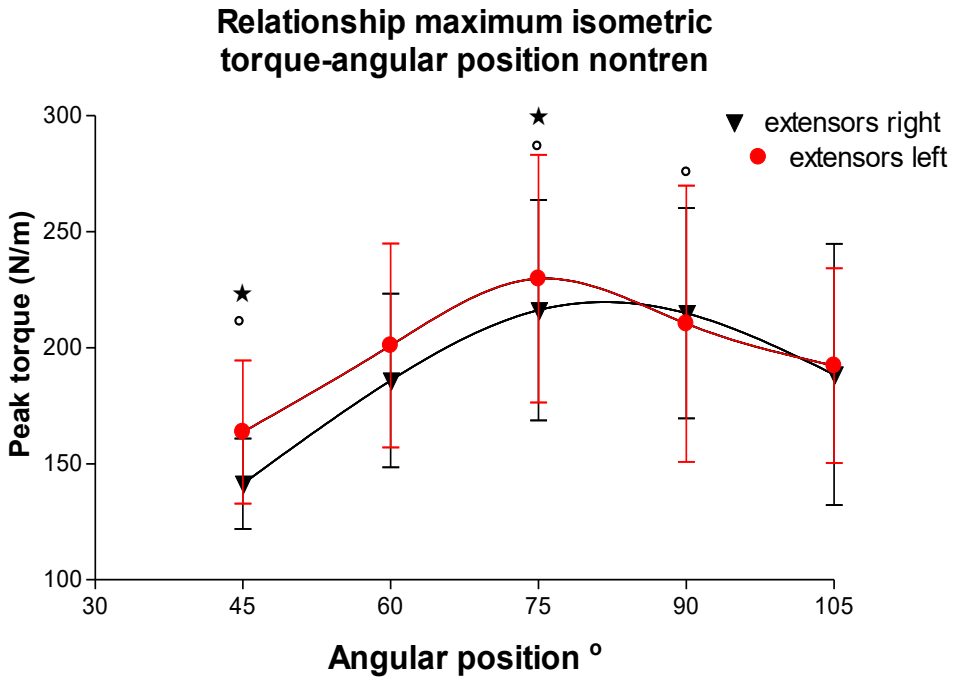
Two repeats are performed with a rest time between different angular speeds of 60 seconds. Start at the slowest speed 30 °/sec. The same procedure is applied to both legs.

The assessment of isometric muscle strength was performed at the same starting position. The angular joint positions used were 45°, 60°, 75°, 90° and 105°. the investigator performs a maximum isometric extension for 3 seconds, followed by a maximum isometric flexure for 3 seconds.

With a rest time of 10 seconds between repetitions. The Protocol for torque of angular position has been randomized. Graphics are processed on Prism 3.0 by a cubic spline.

Results of study isometric torque of extensors in knee joint





Results of study concentric and eccentric peak torque in knee joint