NATIONAL SPORTS ACADEMY
VASSIL LEVSKI, SOFIA
DEPARTMENT OF PHYSIOLOGY & BIOCHEMISTRY

ASSESSMENT OF THE NUTRITION AND PHYSICAL FITNESS IN PRE-SCHOOL AND PRIMARY SCHOOL CHILDREN PRACTISING ARTISTIC GYMNASTICS

Doctoral programme: Physical Education

Doctoral Candidate:
Stefan Kolimechkov

Doctoral Supervisor:
Assoc. Professor Albena Alexandrova, PhD

AIM OF THE STUDY

The aim of this PhD thesis was to assess the physical fitness and health status, as well as the impact of nutrition, physical activity and sport, on pre-school and primary school children practising artistic gymnastics.

OBJECTIVES OF THE STUDY

1. To choose, approve, and adapt an appropriate system of tests to assess nutrition, physical fitness and physical activity in children;
2. To assess nutrition, physical fitness and physical activity in a controlled group of children;
3. To assess nutrition, physical fitness and physical activity in pre-school and primary school children practising artistic gymnastics;
4. To assess the influence of the dietary regime, physical activity and sport on the physical development and health status of children practising artistic gymnastics, based on the analysis of the obtained results.

METHODS

Participants were divided into 3 groups

(a total of 102 participants: 12 pre-school and 90 primary school children)

- Pre-school children from Bulgaria (5 girls and 7 boys) between the ages of 4 and 6, who were doing artistic gymnastics at the Levski Gymnastics Club in Sofia.
- Primary school children who were doing artistic gymnastics in the United Kingdom (30 girls and 19 boys), between the ages of 7 and 11.
- Primary school children from the United Kingdom (23 girls and 18 boys), between the ages of 7 and 10, who were not engaged in any sports more than 1 time a week.

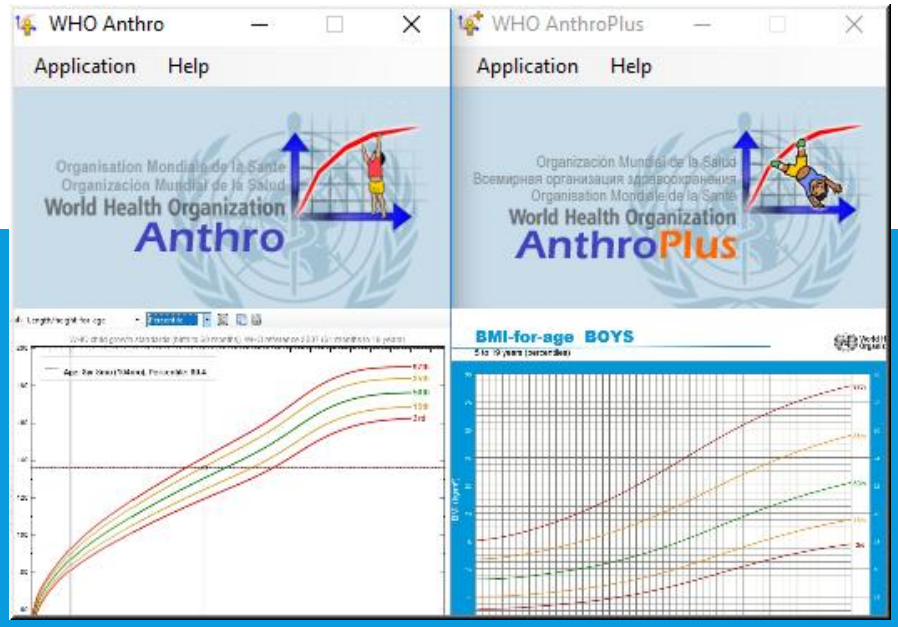
ANTHROPOMETRY

- **Height** (cm)
  by using the Leicester Height Measure.
- **Weight** (kg)
  by using the children's body fat monitor - Tanita BF-689.
- **Upper-arm & waist circumferences** (cm)
  by using the Lufkin W606PM tape measure.
- **Skin folds**: triceps, subscapular (mm)
  by using the Lange Skinfold (Cambridge).

ANTHROPOMETRY

- BMI (kg/m^2)
- Upper-arm muscle area (cm^2)
- Relative upper-arm muscle area (cm^2/kg BW)
- % Body Fat
- Lean body mass (kg)
- Waist-to-height ratio

BODY COMPOSITION ASSESSMENT



Percentile and Z-scores of height, weight, and BMI

The WHO norms for children between 5 and 19 were applied to assess BMI results.

Overweight > 1SD
Obese > 2SD
Underweight < -2SD
Severe underweight < -3SD

NUTRITION

The food frequency questionnaire (FFQ), published by Zaikova et al., 2010, was applied with a few modifications:

FFQ Modifications:

- the McCance & Widdowson's - Public Health England, PHE, 2015 nutrition reference data values were applied.
- the average portions of the foods included in the FFQ were adjusted for children.
- frequency tables for fruit and vegetable consumption were added.
- an English version of the questionnaire was prepared and edited by David Page, English Teacher at the London Meridian College.

NUTRITION

The basal metabolic rate (BMR kcal/24h) was calculated by using the equations of HarrisBenedict. The estimated daily energy needs (kcal/24h) were derived by employing the following formula: BMR x coeficient of physical activity.

The following parameters were calculated:

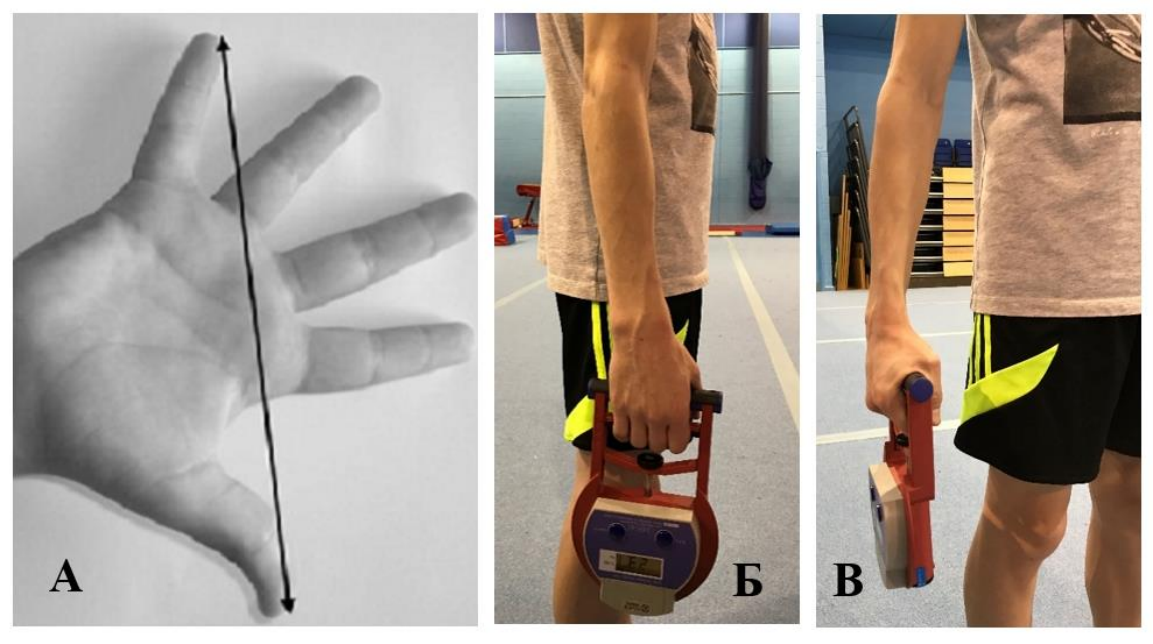
- daily intake of proteins, carbohydrates and fats per kg body mass (g/kg/24h)
- total daily energy intake per kg body mass (kcal/kg/24h)
- the energy contribution of each nutrient (E%)

PHYSICAL FITNESS

The **Alpha-fit health-related physical fitness test battery** was applied to assess the physical fitness of the participants.

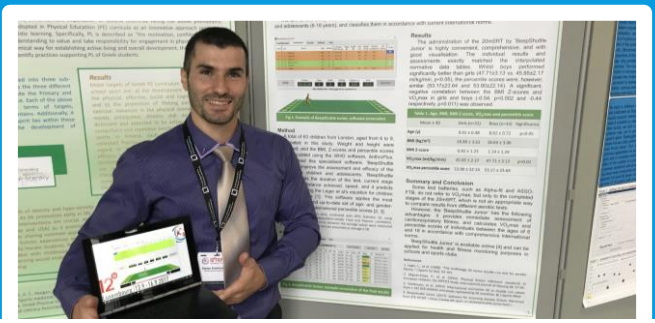
Tests:

- anthropometry described earlier;
- 20m Shuttle Run Test (Beep Test);
- Handgrip strength;
- Standing long jump;
- 4 x 10 m Shuttle Run Test.



PHYSICAL FITNESS

For the administration of the 20m SRT, we created a specialized software, BeepShuttle Junior.



PHYSICAL FITNESS

ASSESSMENT OF THE RESULTS

Reference: Miguel-Etayo P, L. Gracia-Marco, F. Ortega, et al. (2014) Physical fitness reference standards in European children: the IDEFICS study. International journal of Obesity 38: 57-66.
Reference: Ortega, F., E. Artero, J. Ruiz, V. España-Romero, D. Jiménez-Pavón, G. Vicente-Rodriguez, . . . Castillo, M. (2011). Physical fitness levels among European adolescents: the HELENA st

PERCENTILES FOR HANDGRIP STRENGTH IN EUROPEAN CHILDREN AND ADOLESCENTS (Average of right and left handgrip strength)

Handgrip Strength (kg) for GIRLS

Percentiles

Age	1	3	10	20	25	30	40	50	60	70	75	80	90	97	99	100
5.0	4.2	4.5	5.0	5.3	5.4	5.6	5.9	6.3	6.7	7.1	7.3	7.7	8.4	10.1	10.8	11.2
6.0	5.0	5.5	6.2	6.7	7.0	7.2	7.7	8.1	8.6	9.1	9.3	9.7	10.6	12.1	13.2	13.8
6.5	5.4	6.0	6.8	7.5	7.8	8.0	8.5	9.0	9.5	10.0	10.3	10.8	11.7	13.1	14.4	15.1
7.0	5.8	6.4	7.4	8.1	8.5	8.8	9.3	9.8	10.4	10.9	11.2	11.7	12.7	14.2	15.4	16.0
7.5	6.1	6.9	8.0	8.8	9.2	9.5	10.0	10.6	11.2	11.9	12.2	12.7	13.7	15.3	16.5	17.1
8.0	6.5	7.3	8.6	9.5	9.9	10.2	10.9	11.5	12.1	12.8	13.1	13.6	14.7	16.3	17.6	18.3
8.5	6.7	7.7	9.1	10.1	10.6	10.9	11.6	12.3	13.0	13.7	14.1	14.6	15.7	17.4	18.6	19.2
9.0	7.8	8.7	10.1	11.2	11.7	12.1	12.8	13.6	14.3	15.1	15.5	16.1	17.3	19.2	20.4	21.0
10.0	10.0	10.7	12.1	13.4	13.9	14.4	15.2	16.1	16.9	17.8	18.3	19.0	20.4	22.8	24.0	24.6
11.0	12.1	12.8	14.1	15.5	16.2	16.7	17.7	18.6	19.6	20.6	21.2	21.8	23.5	26.4	27.6	28.1
12.0	14.3	14.8	16.1	17.7	18.4	19.0	20.1	21.1	22.2	23.3	24.0	24.7	26.7	30.0	31.2	31.7
13.0	16.5	16.8	18.1	19.9	20.6	21.3	22.5	23.6	24.8	26.0	26.8	27.6	29.8	33.7	34.8	35.3
14.0	18.3	18.6	19.8	21.5	22.2	22.9	24.1	25.2	26.4	27.7	28.5	29.2	31.5	35.4	36.5	37.1
15.0	19.1	19.4	20.7	22.5	23.2	23.9	25.1	26.2	27.4	28.7	29.5	30.3	32.6	36.7	37.9	38.5
16.0	19.7	20.0	21.2	22.9	23.6	24.3	25.4	26.6	27.8	29.1	30.0	30.8	33.2	37.8	39.1	39.7
17.0	20.7	21.0	22.2	23.9	24.6	25.2	26.4	27.6	28.9	30.3	31.2	32.1	34.8	40.3	41.9	42.7
18.0	21.7	22.0	23.2	24.9	25.5	26.1	27.4	28.6	30.0	31.5	32.5	33.4	36.4	42.9	44.8	45.7

Handgrip Strength (kg) for BOYS

Percentiles

Age	1	3	10	20	25	30	40	50	60	70	75	80	90	97	99	100
5.0	4.4	4.8	5.5	6.0	6.3	6.5	6.9	7.3	7.7	8.2	8.4	8.8	9.5	10.4	11.5	12.1
6.0	5.4	6.0	6.9	7.6	7.9	8.1	8.6	9.1	9.6	10.1	10.4	10.8	11.7	13.0	14.1	14.7
6.5	5.9	6.6	7.6	8.3	8.7	9.0	9.5	10.0	10.6	11.1	11.4	11.9	12.8	14.3	15.4	16.0
7.0	6.4	7.2	8.3	9.0	9.4	9.7	10.3	10.9	11.5	12.1	12.4	12.9	13.9	15.5	16.8	17.5
7.5	7.0	7.8	8.9	9.8	10.2	10.5	11.1	11.7	12.4	13.1	13.4	14.0	15.1	16.8	18.1	18.8
8.0	7.5	8.3	9.6	10.5	11.0	11.3	12.0	12.6	13.3	14.0	14.4	15.0	16.2	18.0	19.5	20.3
8.5	8.0	8.9	10.3	11.2	11.7	12.1	12.8	13.5	14.3	15.0	15.4	16.0	17.3	19.3	20.8	21.6

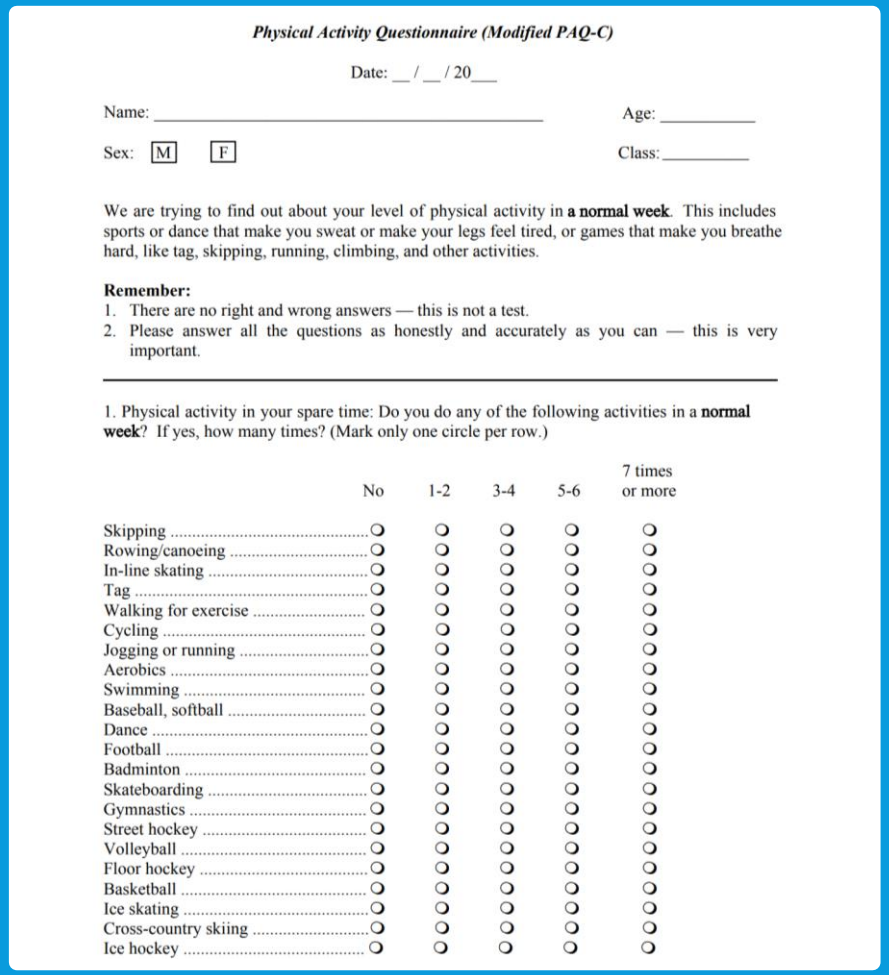
The percentile scores recommended for the Alpha-Fit test battery were applied to assess the results of the participants:

- 6 to 9 years old (Miguel-Etayo et al, 2014)
- 13 to 17 years old (Ortega et al, 2011).
- 9 to 12 years: calculated by a linear interpolation (highlighted in yellow).

PHYSICAL ACTIVITY

The PAQ-C (Kowalski et al, 2004) questionnaire for children was applied to assess physical fitness.

The cut-offs 2.9 for boys and 2.7 for girls (Voss et al, 2013), which categorize students as sufficiently active and low-active in England, were used to evaluate the physical activity results.



Physical Activity Questionnaire (Modified PAQ-C)

Date: __ / __ / 20___

Name: _____ Age: _____

Sex: M F Class: _____

We are trying to find out about your level of physical activity in **a normal week**. This includes sports or dance that make you sweat or make your legs feel tired, or games that make you breathe hard, like tag, skipping, running, climbing, and other activities.

Remember:
1. There are no right and wrong answers — this is not a test.
2. Please answer all the questions as honestly and accurately as you can — this is very important.

---

1. Physical activity in your spare time: Do you do any of the following activities in a **normal week**? If yes, how many times? (Mark only one circle per row.)

	No	1-2	3-4	5-6	7 times or more
Skipping	○	○	○	○	○
Rowing/canoeing	○	○	○	○	○
In-line skating	○	○	○	○	○
Tag	○	○	○	○	○
Walking for exercise	○	○	○	○	○
Cycling	○	○	○	○	○
Jogging or running	○	○	○	○	○
Aerobics	○	○	○	○	○
Swimming	○	○	○	○	○
Baseball, softball	○	○	○	○	○
Dance	○	○	○	○	○
Football	○	○	○	○	○
Badminton	○	○	○	○	○
Skateboarding	○	○	○	○	○
Gymnastics	○	○	○	○	○
Street hockey	○	○	○	○	○
Volleyball	○	○	○	○	○
Floor hockey	○	○	○	○	○
Basketball	○	○	○	○	○
Ice skating	○	○	○	○	○
Cross-country skiing	○	○	○	○	○
Ice hockey	○	○	○	○	○

STATISTICAL ANALYSES

The data was analysed by using Excel spreadsheets and SPSS Statistics 19, IBM USA Software

Test of normality

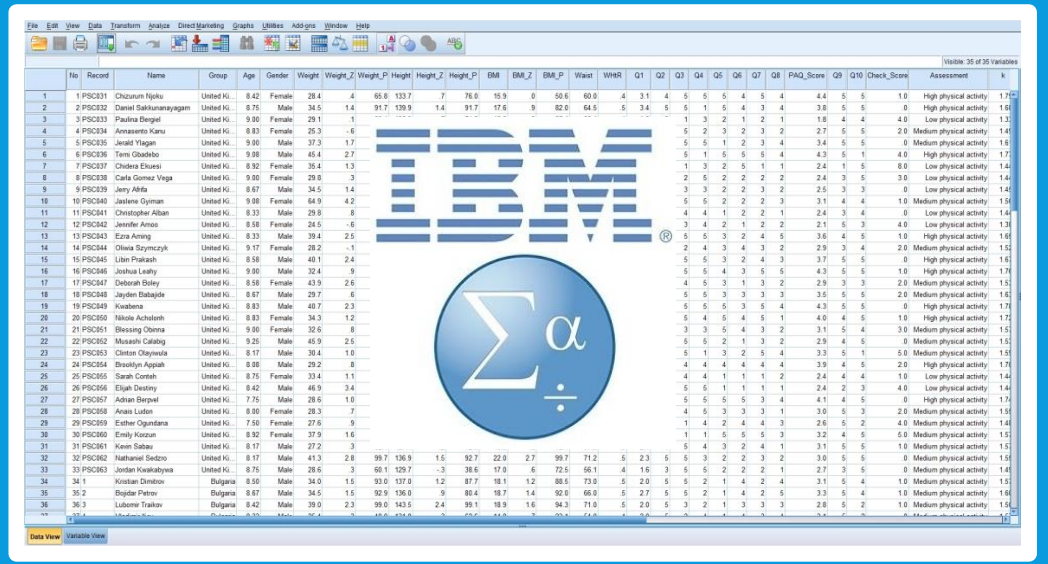
- Kolmogorov-Smirnov

Comparison of parameters

- T-test for independent samples
- Mann-Whitney U test for independent samples

Correlation between parameters

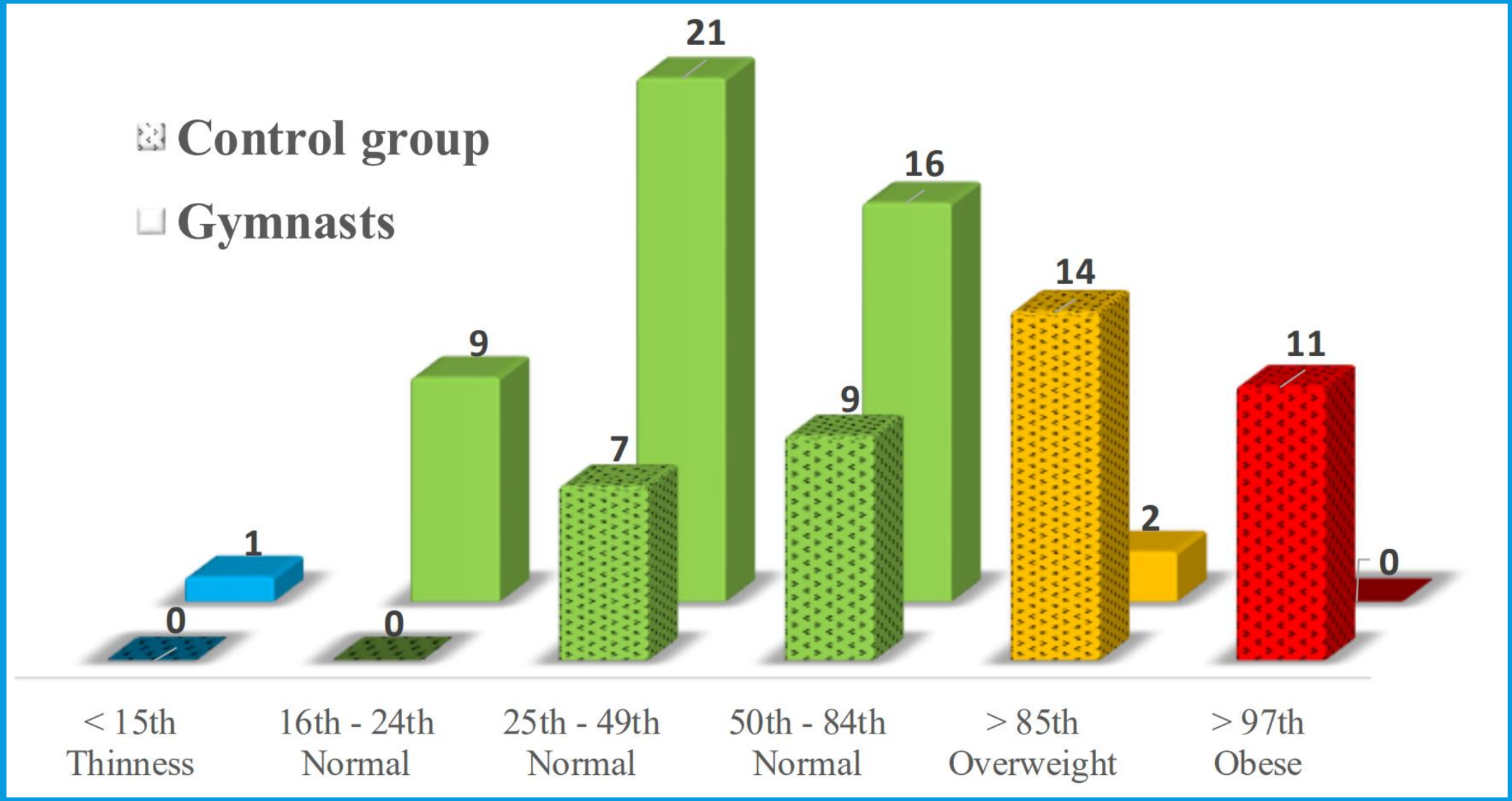
- Pearson correlation coefficient (r)
- Multiple correlation analysis



ANTHROPOMETRIC PARAMETERS OF THE PRIMARY SCHOOL CHILDREN

	Female gymnasts (n=30)	Control group females (n=23)
Age (years)	9.37 ± 1.35	9.03 ± 0.54
Sports experience (months)	44.90 ± 17.96	-
Sessions/week	2.93 ± 1.05	-
Height (cm)	130.60 ± 7.36	139.92 ± 9.07
Height – percentile score	28.88 ± 23.45	75.07 ± 30.76
Weight (kg)	27.18 ± 4.61	37.81 ± 10.01
Weight – percentile score	37.71 ± 22.81	80.93 ± 25.94
BMI (kg/cm^2)	15.83 ± 1.45	19.08 ± 3.51
BMI - percentile score	39.18 ± 23.55	74.37 ± 26.37
Waist-to-height ratio	0.41 ± 0.03	0.47 ± 0.06
Body Fat (%) (Slaughter)	13.21 ± 2.47	22.13 ± 5.99
Body Fat (%) (Slaughter) percentile score	12.02 ± 14.00	63.31 ± 33.98
Upper-arm muscle area (cm^2)	24.42 ± 4.42	27.18 ± 6.38
Relative upper-arm muscle area (cm^2/kg)	0.91 ± 0.12	0.73 ± 0.09

	Male gymnasts (n=19)	Control group males (n=18)
Age (years)	9.69 ± 1.49	8.79 ± 0.52
Sports experience (months)	48.42 ± 21.01	-
Sessions/week	3.05 ± 1.08	-
Height (cm)	133.26 ± 7.62	136.56 ± 6.96
Height - percentile score	33.94 ± 18.60	73.13 ± 19.38
Weight (kg)	28.88 ± 4.39	37.09 ± 6.86
Weight - percentile score	41.01 ± 19.97	88.58 ± 14.45
BMI (kg/cm^2)	16.17 ± 1.02	19.83 ± 2.97
BMI - percentile score	43.42 ± 21.26	86.94 ± 17.63
Waist-to-height ratio	0.42 ± 0.04	0.49 ± 0.05
Body Fat (%) (Slaughter)	10.69 ± 2.85	23.72 ± 8.63
Body Fat (%) (Slaughter) percentile score	23.04 ± 20.20	82.82 ± 23.29
Upper-arm muscle area (cm^2)	25.95 ± 3.85	27.12 ± 5.41
Relative upper-arm muscle area (cm^2/kg)	0.91 ± 0.08	0.77 ± 0.17



Distribution of the BMI percentile scores in the artistic gymnasts (boys and girls together, n=49) and the control group (n=41)

NUTRIENT INTAKE OF THE ARTISTIC GYMNASTS (BOYS AND GIRLS TOGETHER, n=49) AND THE CONTROL GROUP (n=41), (MEAN ± SD)

	Gymnasts (n=49)	Control group (n=41)	p
BMI Z-score	-0.29 ± 0.72	1.30 ± 1.14	p < 0.001*
Energy needs/kg BW (kcal/kg/24h)	59.08 ± 10.02	43.45 ± 6.96	p < 0.001^{x}
Energy intake/kg BW (kcal/kg/24h)	63.24 ± 13.60	39.57 ± 16.51	p < 0.001*
Energy needs/Energy intake	1.09 ± 0.27	0.90 ± 0.30	p < 0.01*
Proteins/kg BW (g/kg/24h)	2.59 ± 0.56	1.74 ± 0.68	p < 0.001*
Protein (E%)	16.41 ± 1.80 %	17.90 ± 2.33 %	p < 0.01^{x}
Fat/kg BW (g/kg/24h)	1.92 ± 0.49	1.19 ± 0.58	p < 0.001*
Fat (E%)	27.65 ± 4.99 %	26.32 ± 4.38 %	p > 0.05^{x}
Carbohydrates/kg BW (g/kg/24h)	8.58 ± 2.31	5.26 ± 2.22	p < 0.001*
Carbohydrates (E %)	53.98 ± 5.45 %	53.39 ± 4.92 %	p > 0.05^{x}
Animal Protein (%)	51.88 ± 9.69 %	55.51 ± 9.09 %	p > 0.05*
Animal Fat (%)	62.80 ± 12.49 %	62.10 ± 8.25 %	p > 0.05*

PHYSICAL FITNESS PARAMETERS AND THEIR PERCENTILE SCORES BASED ON THE ALPHA-FIT TEST BATTERY

	Female gymnasts (n=30)	Control group females (n=23)
Musculoskeletal Fitness: Upper body strength		
Handgrip strength test (kg)	14.18 ± 2.97	16.45 ± 4.13
Handgrip strength test (percentile score)	54.10 ± 29.24	75.83 ± 26.44
Relative handgrip strength (kg/kg BW)	0.52 ± 0.07	0.45 ± 0.11
Musculoskeletal Fitness: Lower body strength		
Standing long jump (cm)	154.61 ± 16.81	123.48 ± 21.70
Standing long jump (percentile score)	92.25 ± 11.65	55.55 ± 31.00
Motor Fitness		
4x10 m shuttle run test (sec)	11.97 ± 0.71	13.88 ± 1.25
4x10 m shuttle run test (percentile score)	91.01 ± 10.31	52.37 ± 28.04
Cardiorespiratory Fitness		
VO_2max (ml/kg/min)	52.06 ± 4.17	45.88 ± 2.08
VO_2max (percentile score)	89.26 ± 17.08	54.12 ± 22.34

	Male gymnasts (n=19)	Control group males (n=18)
Musculoskeletal Fitness: Upper body strength		
Handgrip strength test (kg)	16.91 ± 3.44	15.42 ± 2.90
Handgrip strength test (percentile score)	58.60 ± 18.62	66.37 ± 24.34
Relative handgrip strength (kg/kg BW)	0.58 ± 0.08	0.42 ± 0.08
Musculoskeletal Fitness: Lower body strength		
Standing long jump (cm)	176.78 ± 22.44	124.56 ± 23.04
Standing long jump (percentile score)	96.24 ± 4.36	45.72 ± 30.28
Motor Fitness		
4x10 m shuttle run test (sec)	11.18 ± 0.89	13.36 ± 1.08
4x10 m shuttle run test (percentile score)	92.41 ± 6.09	49.44 ± 25.25
Cardiorespiratory Fitness		
VO_2max (ml/kg/min)	53.98 ± 3.93	46.36 ± 2.67
VO_2max (percentile score)	88.63 ± 15.89	43.13 ± 21.56

PHYSICAL ACTIVITY OF THE GYMNASTS (n=21) AND THE CONTROL GROUP (n=21), ASSESSED BY THE SPECIALISED QUESTIONNAIRE FOR CHILDREN, PAQ-C

	Gymnasts (n=21)	Control group (n=21)	p
1. Spare-time activity: sports	1.87 ± 0.43	1.81 ± 0.62	p > 0.05*
2. Activity during physical education classes	4.29 ± 1.01	3.81 ± 1.12	p > 0.05^{x}
3. Break-time activity	3.67 ± 1.28	3.86 ± 1.62	p > 0.05^{x}
4. Lunch-time activity	3.76 ± 1.34	3.86 ± 1.39	p > 0.05^{x}
5. After-school activity	4.10 ± 0.83	2.48 ± 1.25	**p < 0.001^{x}**
6. Evening activity	3.43 ± 1.21	2.38 ± 1.28	**p < 0.05^{x}**
7. Weekend-activity	2.67 ± 0.80	2.91 ± 1.30	p > 0.05^{x}
8. Activity frequency	3.14 ± 1.20	2.24 ± 1.26	**p < 0.05^{x}**
Total PAQ-C activity	**3.36 ± 0.58**	**2.92 ± 0.59**	**p < 0.05***

CORELATION BETWEEN THE TOTAL PAQ-C ACTIVITY SCORE, RELATIVE PHYSICAL ACTIVITY AND THE OTHER PARAMETERS OF ALL PRIMARY SCHOOL CHILDREN

n=42	Total PAQ-C activity score	Relative physical activity
Total PAQ-C activity score	1	**0.692****
Relative handgrip strength	0.271	**0.593****
Standing long jump	**0.373***	**0.455****
Standing long jump (percentile score)	0.264	**0.550****
4x10 m shuttle run test	**-0.344***	**-0.491****
4x10 m shuttle run test (percentile score)	0.236	**0.552****
VO_2max	**0.378***	**0.692****
VO_2max (percentile score)	0.200	**0.593****
Body fat % (Slaughter)	-0.093	**-0.556****
Body fat % (Slaughter) (percentile score)	0.105	**-0.389***
Waist circumference	0.048	**-0.582****
BMI (kg/cm^2)	0.039	**-0.526****
BMI - percentile score	0.097	**-0.346***
Weight	0.019	**-0.648****
Weight - percentile score	0.026	**-0.665****

CONCLUSIONS

1. The body mass index (BMI) does not provide an adequate assessment regarding weight and physical development in children with greater muscle mass who are practising sport.
2. Training in artistic gymnastics helps to maintain normal levels of health as far as the weight of children is concerned.
3. The chosen Food Frequency Questionnaire (FFQ) in this dissertation provides a good estimation of the average energy intake of nutrients. This conclusion is confirmed by the relatively good consistency between the results from this dissertation and data from other studies.
4. Using this nutritional method provides parents with a greater stimulus to take interest in observing their children's diets and encourages them to seek more information about combining appropriate physical activity with a healthy diet in order to benefit the physical development of their children.

CONCLUSIONS

5. For a full assessment of energy expenditure in children, It is necessary to take into account physical activity outside of physical education lessons and sports training in order to calculate total energy expenditure in children;
6. Several years of gymnastics training in school children led to a significant improvement in their physical fitness;
7. The total PAQ-C activity score does not adequately reflect the relationship between physical activity on the one hand, and anthropometric parameters and physical fitness parameters on the other.

RECOMMENDATIONS

1. In addition to BMI, other anthropometric (% body fat) and strength parameters (muscle hypertrophy and muscle strength) should be used to adequately assess the weight and physical development of child-athletes;
2. It is recommended that the methods for assessing children's nutrition should be improved, in order to calculate the intake of vitamins and microelements;
3. The Alpha-fit test battery was recommended for the assessment of physical fitness, as it made it possible to compare the fitness levels of children from different countries practicing different physical activities;
4. The relative physical activity score was recommended to be used instead of the total PAQ-C physical activity score, as it provided logically expected correlations with anthropometric and physical fitness parameters.

CONTRIBUTIONS

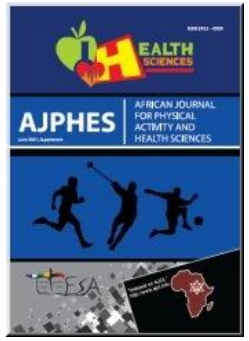
1. For the first time a comprehensive assessment was carried out on the physical fitness, physical activity and nutrition of pre-school and primary school children practising artistic gymnastics.
2. The chosen Food Frequency Questionnaire (FFQ) was adapted in order to assess nutritional levels in children generally, and those specifically practising sports. The FFQ was adapted, validated and translated into English in order to be used internationally.
3. In addition to the aforementioned Food Frequency Questionnaire used to assess children's nutrition, frequency tables for consumption of fruits and vegetables were also applied.
4. Specialised software, called BeepShuttle Junior, was created and approved (using the original Leger protocol) in order to carry out the 20m shuttle run test (beep test), which is part of the Alpha-fit health-related physical fitness test battery. This software allows for an automatic assessment of the maximal oxygen uptake (VO_2max) in children and adolescents in accordance with international norms for their age and gender.
5. A new parameter, 'relative physical activity score', was recommended in order to assess physical activity.

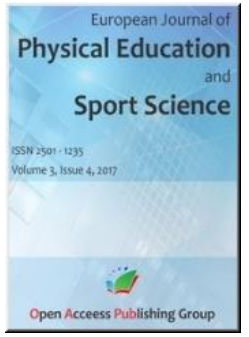
Publications used in connection with my PhD thesis

1. Kolimechkov, S., Petrov, L., Alexandrova, A., & Atanasov, P. (2016). Nutrition and physical development assessment of pre-school and primary school children practising artistic gymnastics African Journal for Physical Activity and Health Sciences (AJPHES), 22(2:2), 565-577.

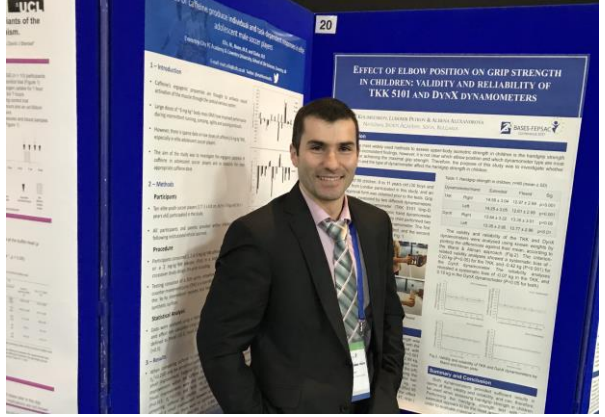
2. Kolimechkov, S. (2017). Physical Fitness Assessment in Children and Adolescents: A Systematic Review. European Journal of Physical Education and Sport Science, 3(4), 65-78.

3. Kolimechkov, S., Petrov, L., Ilinova, B., Alexandrova, A., Andreeva, L. & Atanasov, P. (2013). Assessment of the physical development of pre-school and primary school children practising artistic gymnastics. Journal of Sport Science, 4, 106-115 (in Bulgarian).





PEKTOPAT


20
EFFECT OF ELBOW POSITION ON GRIP STRENGTH IN CHILDREN: VALIDITY AND RELIABILITY OF TKK 5101 AND DynX DYNAMOMETERS

THANK YOU