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Science of Gymnastics Journal (ScGYM®)

Science of Gymnastics Journal (ScGYM®) (abrevated for citation is SCI GYMNASTICS J) is an international journal that provide a wide range of scientific information specific to gymnastics. The journal is publishing both empirical and theoretical contributions related to gymnastics from the natural, social and human sciences. It is aimed at enhancing gymnastics knowledge (theoretical and practical) based on research and scientific methodology. We welcome articles concerned with performance analysis, judges' analysis, biomechanical analysis of gymnastics elements, medical analysis in gymnastics, pedagogical analysis related to gymnastics, biographies of important gymnastics personalities and other historical analysis, social aspects of gymnastics, motor learning and motor control in gymnastics, methodology of learning gymnastics elements, etc. Manuscripts based on quality research and comprehensive research reviews will also be considered for publication. The journal welcomes papers from all types of research paradigms.

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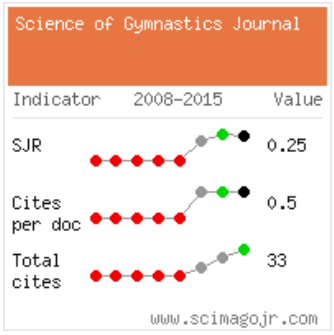

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Fundacija za šport

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CONTENTS

Acrobatic and X-treme Sports

Conference - Pre-Registration

Hosted by U.S. Ski and Snowboard Association

1 Victory Lane
Park City, UT 84060, USA

What: The US Ski and Snowboard Association (USSA) is holding a special conference May 31st - June 2nd, 2017 on Action, Acrobatic, and Extreme Sports. This is a completely new conference addressing issues and information involving – broadly defined acrobatics.

For Whom: The conference is open to all those interested in acrobatic and X-treme sports including, coaches, scientists, sports medicine staff, educators, managers, administrators and others. The preregistration website below is presented to ascertain your interest in attending (no commitment required at this juncture, just an expression of interest and request for further information). At present the agenda and program are being developed. Questions, topic areas and comments are welcome.

Where: Marriott Hotel and United States Ski and Snowboard Association, Center of Excellence in Park City, UT, USA

More Information:

https://www.eventbrite.ca/e/pre-registration-action-acrobatic-and-extreme-sports-conference-registration-26806711596?aff=affiliate1

ttaylor@ussa.org wsands@ussa.org

EDITORIAL

Since our last issue in June two major and important events signed this period of time. The first event were Olympic Games in Rio. All gymnastics competitions were of excellent quality, battles for the win were almost epic (e.g. Kohei Uchimura (Japan) versus Oleg Vernjajev (Ukraina). Some were surprises and some were disappointed. But most of all is important our sport was not part of doping issues and I'm glad FIG did not banned Russia from the gymnastics events. Afterwards Fancy Bears published some interesting documents, of which we should in near future also discus in philosophical way and to answer simple (but hard) question, is it sport proper place for those who are chronically ill? Isn't statement Mens sana in corpore sano still valid. We would be pleased if some of you readers and researchers can give more profound answers on such questions. Legal is not also legitimate.

The second important event were just finished elections for new FIG structure. Now the ex-president Bruno Grandi had a hard work how to put different aims of very different gymnastics developed countries into same direction. In his way there were many obstacles. But also many important changes, which changed our sport significantly. Fort the first, he added Trampoline, Acrobatic and Aerobic Associations under FIG umbrella. Trampoline is since 2000 also Olympic discipline (probably the most spectacular one). Sports Aerobic is part of World Games, and Acrobatic just gained to be sport discipline at next Youth Olympic Games. As a professor he did took opportunity and established Academy, which functions excellent, and also new FIG members are the result of shared knowledge in world. Perhaps new Scientific Commission did not had direct influence on Code of Points changes, but had an impact on awareness of gymnasts health, and for the first time publicly with scientific tools denied that gymnasts are small because of sport they practice. It is worth to mention open ended Code of Points, which well defines gymnast's quality, was under his presidency, where perfect 10 for execution remained (but hardly achieved). We need to thank prof. Bruno Grandi also for his support for our Journal. So for you did well prof. Bruno Grandi thank you.

I would like to congratulate new president Morinari Watanabe from Japan for his victory at presidential votes, which gave him almost unanimously support for leading our sport in future. Would be pleased if he will continue to develop our sport into most influential Olympic sport, with well defined worldwide competition system, which can serve to all countries. I believe researchers and authors of articles in our Journal will be willing to research and give answers on qustions which can arise.

Dear reader, in this issue we start with article from Ukraine research team lead by O.M. Khudolii, followed by two articles from German authors Thomas Heinen Freya Krepela and Damian Jeraj. Three more groups of authors were from Greece, lead by George Dallas, Mexico lead by H. Antonio Pineda-Espejel and Czech Republic lead by Lenka Svobodová. Anton Gajdoš added new Short historical note.

Just to remind you, if you quote the Journal: its abbreviation on the Web of Knowledge is SCI GYMN J.

I wish you pleasant reading and a lot of inspiration for new research projects and articles,

Ivan Čuk
Editor-in-Chief

COMPUTER SIMULATION OF JUNIOR GYMNASTS' TRAINING PROCESS

Khudolii O.M.[1], Ivashchenko O.V.[1], Iermakov S.S.[1], Rumba O.G.[2]

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Original article

Abstract

The purpose of the research is to develop methodological approach to creation of an algorithm of informational provisioning of children's and adolescents' training of motor actions. The research was conducted in compliance with a plan of factorial experiment of 2^2 type. The received materials were used for simulation of gymnast training process. At initial stage of training, we analyzed 530 sessions (92 gymnasts of 7-10 years old age). At the stage of basic training, we analyzed 580 trainings (78 gymnasts of 11-13 years old age). For determination of different training modes' influence on change of functional state of cardio-vascular and nervous-muscular systems we conducted a five-year longitudinal prospective research (60 gymnasts). We produced an algorithm of informational provisioning of child and adolescent training to motor actions. The algorithm is based on computer simulation of a training process. We found that the progress in fulfillment of exercise depends statistically significantly on the group of following indicators: level of fitness, organization of load and orientation of training. We provide data about change of training results and pulse frequency. We show that factorial experiment's results were reliable and effective in determination of different working modes' influence on functional state and gymnast ability for mastering of motor actions. Algorithm of calculation of normative loads for gymnasts was worked out. The offered algorithm of computer simulation of training process's simulation permits receiving new information about fitness, organization of load and orientation of training influence on effectiveness of motor skill formation.

Keywords: *gymnast, information, motion, training, load, schoolchildren, training.*

INTRODUCTION

Application of computer programs in schoolchildren's physical education and sport training enables a control of pupils' physical condition, corrections in educational and health related processes, individualization of training, automatization of analysis and assessment of received results (Shandrigos', 2000, 2002, 2004; Vovk, 2002; Lucenko, 2003; Meng & Li, 2013). Data in scientific literature witnesses about urgency of problem of physical culture trainings' informational provisioning. Vovk (2002), Ashanin, Golosov and Gorbatenko (2010), Ashanin, Filenko and Nesterenko (2011), Goncharova, Yukhno and Lukjantseva (2012), Borysova and Vlasyuk (2014), point to demand in implementation of automatization in information technology (IT) and creation of data base about children

and adolescent physical condition. Saptsin and Tsipoviaz (2009) offer approaches to objective assessment of sport results and pedagogic testing. These are always subjected to random component and depend on external, internal and subjective factors. The authors give analysis of uncertainty considering new concepts and mathematic approaches, based on physical and quantum-mechanical analogies.

At the present time research in development of methodological approaches for creation of applied programs in the field of physical education and sports (Hong, 2013) is being carried out. The efforts are directed to produce the programs for taking decisions in the planning of training (Wu, 2013), simulations in the field of bio-mechanics (Merala & Piziali, 1996; Kirk, 1999) and assessment of pupils' functional state (Wright, 1999; Lucenko, 2003; Rink, Jones, Kirby, Mitchell, & Doutis, 2007). The data has been accumulated about schoolchildren physical education's effectiveness depending on the scope and orientation of motor functioning. On the basis of discriminant analysis equations have been developed which permit the control of child and adolescent fitness (Milić, Milavić, & Grgantov 2011; de Brujin & Gartner, 2011; Dorita, Pienaar, & Truter, 2011; Lulzim, 2013; Khudolii & Ivashchenko, 2014; Ivashchenko, Yermakova, Cieslicka, & Muszkieta, 2015). The value of application of metrical assessment of measurements' reliability has been proved – stability, co-ordination and self-description of control results. With these, certain quantitative information permits individualization of junior sportsmen's training according to requirements of controlled processes (Zaporozhanov & Boraczynski, 2012). It was recommended to assess reliability of measurements by calculation of linear correlation between consequent results in series. Stability of measurements should be assessed with the same method between results of accuracy in the first and seventh attempt (Zaporozhanov, 2013).

Analysis of mathematical models allows selection of physical exercises on the basis of kinematic movement characteristics (Iermakov, 2001, 2010); arrangement of means of orientation priority during educational term and development of movement abilities (Khudolii, 2005, 2009, 2012; Khudolii & Iermakov, 2011; Rumba, 2013; Karpenko & Rumba, 2014). Regularities of motor skills' development have been substantiated depending on adaptation processes (Platonov & Bulatova, 1995; Linec', 1997; Khudolii & Ivashchenko, 2014). Also the data about model building and their application in gymnastics have been presented: assessment of efficiency of sport task's fulfillment (LaForge-MacKenzie & Sullivan, 2014) and fulfillment of imitation exercises (Jensen, Scott, Krustrup, & Mohr, 2013); cause-effect relations of self-assessment of gymnastic exercises' fulfillment (Marsh, Chanal, & Sarrazin 2006); control of movement with feedback (Miyazaki, Sampei, & Koga, 2001); priorities of affective and cognitive training (O'Leary & Griggs, 2010); optimization of women-gymnasts' loading (Sanchez et al., 2013); exposure of mechanical and physical quantities in jumps on spring built on the basis of Hay and Reid method (Takei, Blucker, Nohara, & Yamashita 2000). Tereschenko, Otsupok, Krupenio, Levchuk, & Boloban (2013) note that the content of educational material contributes to mastering the tasks of athlete sensoric-motor coordination and is a basis for effective formation of motor skills and ability of gymnastic exercise mastering. Kozhanova (2013) proposed approaches for defining the effectiveness of female gymnastic competitive activity. Normative indicators in training of children's and adolescents' motor skills have been reported (Ivashchenko, 1988; Ivashchenko & Karpunec', 2001; Khudolii, 2005; Khudolii & Ivashchenko, 2014). Conception of simulation of children's and adolescents' motor skills' training has been worked out (Khudolii, 2005; Khudolii & Ivashchenko, 2014; Ivashchenko, Yermakova, Cieslicka, & Muszkieta, 2015; Khudolii, Iermakov, &

Ananchenko, 2015), as well as a program of scientific research in the field of simulation of motor skills' training (Khudolii & Karpunec', 2002; Khudolii & Ivashchenko, 2004).

The models of educational process and training of young gymnasts can be divided to:

a) Modification model of the effectiveness of education depending on muscular, special motive and functional training of young gymnasts;

b) Modification model of the effectiveness of education depending on the quantity of training using optimal loading that provides favorable conditions for mastering the movements;

c) Modification model of the effectiveness of competitive activity depending on competitive loadings of young gymnasts.

Logistic function has been used for creation of the models a) and b), for model c) regression equation was used from the results of an analysis of full factorial experiment of 2^k type. Thus, sufficient amount of material has been accumulated to produce the algorithm of child and adolescent training and to create the appropriate software.

Hypothesis of our research is based on the following assumptions:

- When education is done on the basis of informed processes about proceeding of adaptive reactions of an organism, the effectiveness will raise;
- Objectivity of information provided by the analysis of mathematical models.

The purpose of the research is to develop methodological approaches to creation an algorithm of informational provisioning of children's and adolescents' training in motor actions.

METHODS

The methods of the research: for solution of our tasks we used dialectic method (principle of system and causality), systemic approach, simulation, generalization, analysis and synthesis, pedagogic experiment, methods of mathematic planning of experiment and testing. Systemic approach was used to find integrative, systemic characteristics of object of the research, to determine the tasks formulated in the process of algorithms and software for informational maintenance of children's and adolescents' training of motor skills.

We used the factorial experiment of 2^2 type (see table 1). The received materials were used for simulation of junior (7-13 years old) gymnastics training. At the initial stage of training we analyzed 530 training sessions. Ninety-two gymnasts 7-10 years old participated in the research. At the stage of basic training we analyzed above 580 training sessions with 78 junior gymnasts 11-13 years old. This analysis enabled the production of a model of junior gymnast training at initial and basic stages. To determine the effect of different regimes of training exercises on the change of the functional state of the cardiovascular system and the effectiveness of the training we conducted a five-year prospective experiment where 60 junior athletes participated. Heart rate was recorded after each session on the training equipment. To assess the effectiveness of the learning process we recorded the level of exercises. The level of training is defined as the ratio of successfully performed exercises to the total number of exercies.

For evaluation of training load pulsometry is commonly used in gymnastics (Khudolii, 2005; Khudolii & Ivashchenko, 2014). When young gymnasts perform exercises on the equipment in the zone of heart rate within 140-160 beats/minute, deterioration in the quality of the execution for 0.3-0.6 points is observed; quality of exercises done in the zone of heart rate within 120-135 beats/min is not affected; training in the zone of heart rate within 100-119 beats/min improves the quality of exercises for 0.3-0.4 points (Khudolii & Ivashchenko, 2014).

The study protocol was approved by the Ethical Committee of H.S. Skovoroda Kharkiv National Pedagogical University.

In addition, children and their parents or legal guardians were fully informed about all the features of the study, and a signed informed-consent document was obtained from all the parents.

RESULTS

Systemic analysis allows to determine the following items:

- Influence of different training modes on the exercise fulfillment's quality and pulse frequency;
- Optimal rate of results' increment (optimal step of result's increment is a size equal to X+s. Where X – normal, s – standard deviation);
- Time correlation of different kinds of training in gymnastic all-round (forming motive skills, repetition of exercises, development of endurance);
- Working mode, ensuring optimal increment of results (rotation of physical exercises with rest interval).

Collection of information: to obtain the data about progress in training and pulse frequency we conducted full factorial experiment of 2^2 type. The plan of the experiment is given in the table 1.

Table 1.
Matrix of plan of 2^2 for sub-group (5-6 persons) of junior gymnasts

Description of exercise	Variant	X_1 Scope in elements, quantity	X_2 Time of rest, sec.
Rings, horizontal bar, parallel bars	1	30	60
	2	50	60
	3	30	110
	4	50	110
Gymnastic horse	1	70	50
	2	100	50
	3	70	80
	4	100	80
Spring jump	1	10	40
	2	20	40
	3	10	60
	4	20	60
Acrobatics	1	60	60
	2	90	60
	3	60	90
	4	90	90

Table 2
Results of training process's dependence on dynamic of puls in a session

№	X, HBR	Y, points for fulfillment of exercise	Values of function	
			Logistic	Parabol of the second order
1	128.234	0.862	1.111	0.834
2	130.102	0.985	1.101	0.926
3	131.969	0.971	1.092	1.004
4	133.,837	1.033	1.082	1.068
5	135.705	1.058	1.071	1.118
6	137.573	1.099	1.060	1.155
7	139.440	1.139	1.049	1.177
8	141.308	1.212	1.037	1.186
9	143.176	1.254	1.025	1.181
10	145.044	1.220	1.013	1.162
11	146.911	1.168	1.000	1.129
12	148.779	1.100	0.987	1.082
13	150.647	1.007	0.974	1.022
14	152.515	0.930	0.960	0.947

Table 3
Mathematical analysis of functions

Parameters	Logistic function	Parabol of the second order
Bending point	-161.148	
Min Y	0.655	
Max Y	1.149	1.186
Min X	200.241	
Max X	119.239	141.551
Error of regression	0.126	0.030
Coefficient R	0.499	0.989
F-criterion	0.460	0.001

In every session we registered change of training results and pulse frequency from one attempt to the other.

Storage of information

Data base (gymnastics.DBF) was created for storage and processing of results. The results are stored in a file. With the help of a base EXE file (DBGMN.EXE) we enlarged the data base and created text files for analysis of results. Information was stored on a flash drive in a catalogue under the name of a gymnast (for example C:\STEPANOV).

Ideology of processing of information

The conducted research permitted to determine effectiveness and reliability of pans of factorial experiment of 2^2 type in assessment of different working modes' results and their influence on the functional state and junior gymnasts' ability to master movement.

Analysis of the change of training results and pulse frequency in every plan of training showed that both processes can be described with models of increment

$$Y = [A/1+10(^{am+bx})] + C \quad (1)$$

where Y (heart rate / level of mastering) – result of function depending on quantity of attempts (x).

Coefficients of regression equations of logistic function substantially change depending on modes of exercises' fulfillment and rest.

This dependence can be described by equations 2-5:

$$A = b_0 + b_1x_1 + b_2x_2 + b_3x_1x_2 \quad (2)$$
$$C = b_0 + b_1x_1 + b_2x_2 + b_3x_1x_2 \quad (3)$$
$$am = b_0 + b_1x_1 + b_2x_2 + b_3x_1x_2 \quad (4)$$
$$b = b_0 + b_1x_1 + b_2x_2 + b_3x_1x_2 \quad (5)$$

where A, C, *am, b* coefficient of logistic function, x_1 - scope of movements in training, x_2 - interval of rest.

It was found that there exists a non-linear dependence between the change in training process and pulse frequency of type:

$$Y = a + b_1x + b_2x^2 \quad (6)$$

where Y - result of training, x - pulse frequency.

At the point $x = -b_1/2b_2$ we observed a maximal level of result and pulse frequency approach to border between work oriented on mastering and development of endurance.

Processing of information

Algorithm of analysis of research results:

1. Calculation of logistic function's parameters
2. Calculation of MINMAX characteristics of logistic functions (Khudolii, 2005).
3. For determination of experimental and theoretical points' similarity we carried out dispersion analysis. Errors calculated as well as coefficient of in-class correlation and Fisher's criterion.
4. For determination of coefficients of logistic function depending of working mode we used algorithm of analysis of full factorial experiment.
5. Calculation experiment (1). A mass of training results and pulse frequencies from attempt to attempt is formed. Elements of masses are calculated on the basis of logistic function's analysis.

Parameters of equation: A, a, b, C are calculated on the base of solution of equations 2-5.

Regression coefficients were received as a result of analysis of data of full factorial experiment (FFE) of 2^2 type.

Results of calculation experiment are presented in the form of logistic function and parabola of the second order.

6. Calculation experiment (2). Distribution of training results Yres = Yk - Yp is analyzed with parameters of work on apparatuses as well as with pulse frequencies, correlation of mastering work, development of endurance and repetitions. Where Yk – is the final result, Yp – initial result.

Interpretation of results

1. Calculation of logistic function's coefficients for dynamics of heart beat rate (HBR) in every experience of a plan (see table 1).
2. Results of the analysis show that

logistic function describes results of HBR dynamic (r_1=0.843; r_2=0.756; r_3=0,623; r_4=0.921; p<0.05) rather exactly. Verification of logistic function's coefficients witnesses that between experimental and theoretical values there is no statistically significant difference (p<0.001).

3. Calculation of regression coefficients for specifying of logistic function's parameters depending on the offered working mode for HBR dynamic.

4. Calculation of coefficients of logistic function for dynamics in exercise's fulfillment in every item of the research plan (see table 1).

5. Results of analysis witness that logistic function describes exercise's assessment dynamic quite exactly (r_1=0.974; r_2=0.746; r_3=0.786; r_4=0.935; p<0.05). Verification of logistic function's coefficients witnesses that between experimental and theoretical values there is no statistically significant difference (p<0.001).

6. Calculation of regression coefficients for specifying of logistic function's parameters depending on the offered working mode for dynamics of exercise fulfillment.

6. Analysis of the data distribution witnesses that training results can be considered, to certain extent, to be normally distributed. Optimal increment step is value, equal to X+s. Where, X – is mean arithmetic, s – standard deviation (see fig.1).

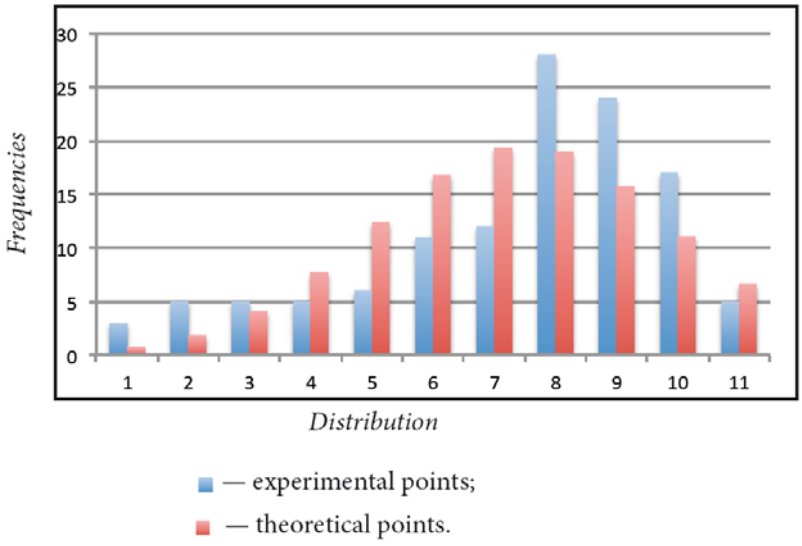

Figure 1. Distribution of points' for junior gymnasts' fulfillment of exercises increments as per results of calculation experiment .

7. Mathematical analysis of logistic function and parabola of the second order shows that equations of parabola of the second order describe results of calculation experiment better. In this case regression error is lower and reliability is higher (see tables 2, 3).

$$Y = 0.716 / 1 + 10^{(-2,936+0,018\,x)} + 0.538 \quad (7)$$

$$Y = -38.593 + 0.562\,x - 0.002\,x^2 \quad (8)$$

HBR of 141 bpm can be regarded as a border between work, oriented on endurance and

training.

8. The conducted regression analysis showed that increment of points for exercise's fulfillment statistically significantly depends on the following groups of indicators:

- *Level of fitness:* maximal mark is (x_1), efficiency (x_2), maximal HBR (x_3); quantity of attempts for reaching of optimal HBR is (x_4) (multiple coefficient of determination DM=0.978; $p<0.001$):

$$Y=3.968+0.216x_1+0.649x_2-0.034x_3+0.027x_4 \quad (9)$$

- *Organization of loads:* volume in elements is (x_1), time of rest (x_2), quantity of attempts (x_3), quantity of elements in attempt (x_4) (multiple coefficient of determination DM=0.972; $p<0.001$):

$$Y=-3.217+0.066x_1+0.035x_2+0.053x_3-1.523x_4 \quad (10)$$

- *Orientation of training:* time assigned for mastering % (x_1), time assigned for development of endurance, % (x_2), time for repetitions, % (x_3), volume in elements (x_4) (multiple coefficient of determination DM=0.924; $p<0.001$):

$$Y=-5.103+0.076x_1+0.072x_2+0.081x_3-0.026x_4 \quad (11)$$

Thus, the offered algorithm of computer simulation of training process permits to receive new information about influence of fitness level, load, organization and trainings' orientation on effectiveness of formation of child and adolescent motor skills.

DISCUSSION

In this work we used methodological approach to create applied program in the field of physical education and sport (Hong, 2013), worked out the software for taking decisions in planning of trainings (Wu, 2013), simulation in the field of bio-mechanics (Merala & Piziali, 1996; Kirk, 1999; Takei, Blucker, Nohara, & Yamashita, 2000; Boloban, Litvinenko, & Otsupok, 2012; Jensen, Scott, Krustrup, & Mohr, 2013; Bhatia, Davis, & Shamas-Brandt, 2015), assessment of pupils' functional state (Wright, 1999; Lucenko, 2003; Rink, Jones, Kirby, Mitchell, & Doutis, 2007).

The results, received by us, supplement the data of other researchers and agree with them. Griggs & McGregor (2011) recommends to use creative approach to training of gymnastic exercises. Hiley, Wangler, & Predescu (2009) recommends to apply computer imitation models to increase the quality of front arms' fulfillment, which permits to optimize methodological approach to training. Irwin, Hanton, & Kerwin. (2005) stresses the demand to understand main mechanisms of motor skill formation. The offered approaches concerning simulation of training process of junior gymnasts also agree with results of other researchers. Adams, Cintas, & Llabrés (2005), Correa, Grima, & Tort-Martorell (2009, 2012) say that in factorial experiment expected effect can not be achieved always with neutralization of unknown factors' influence. That is why the authors offer to combine proper level of protection from unknown factors with minimal quantity of factors and their levels. Lundkvist & Vanhatalo (2014) in their research of dynamic processes attract attention to inadmissibility of errors in observations, the data of which are used for building of factorial experiments' plans.

The received data are confirmed by researches of Ivashchenko (1988), who showed that fulfillment of exercises on apparatuses by junior girl-gymnasts in HBR zone within 140-160 bpm results in tiredness. In its turn, it results in worsening of exercise's fulfillment quality by 0.3-0.6 points. Fulfillment of exercises in HBR zone within 120-135 bpm does not worsen the quality of exercise's fulfillment. Fulfillment of exercises in HBR zone within 100-119 bpm facilitates increasing of quality by 0.3-0.4 points. Also, the purpose of calculation and usage of control system of complex assessment of gymnast fitness (Zaporozhanov, Kochanowicz, & Kochanowicz, 2014; Zaporozhanov, Borachinski, & Nosko, 2015) have been proved.

Our results expand and supplement the data of Khudolii and Karpunec' (2001), Khudolii and Ivashchenko (2004), and Khudolii (2005) about effectiveness of application of factorial experiments' plans in studying of training process's effectiveness and in development of children's and adolescents' motor skills. In opinion of Wang, Karns and Meredith (2003) and García-Moya, Moreno, and Jiménez-Iglesias (2012) application of factorial experiment plan in research involving children and adolescents, facilitates increase of their indicators. Validity of application of 2^k full factorial experiment is also proved by data of Correa, Grima, & Tort-Martorell (2009).

Results of our research witness that in the offered matrices of factorial experiment plans, the chosen step of factors' varying is sufficient for studying of influence of different modes of physical exercises' fulfillment on progressing of strength and effectiveness of children's and adolescents' training (see table 1).

Novel is the algorithm of informational provisioning of children's and adolescents' training to motor skills, which differs from commonly known approaches (see fig.2).

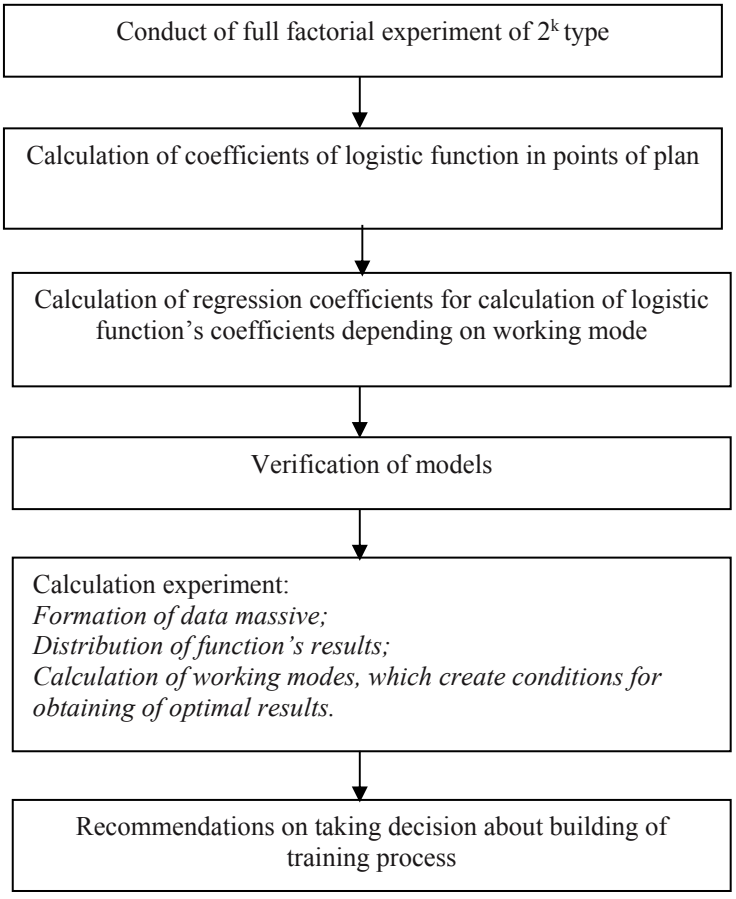

Figure 2. Schema of algorithm of informational provisioning for training process of children's

and adolescents' motor actions.

In distinction from applied programs of complex monitoring of 1-11 forms' pupils' physical condition, considering physical condition, functional and physical fitness, depending on peculiarities of schoolchildren mass-height indicators (Shandrigos', 2000, 2002; Vovk, 2002; Borysova & Vlasyuk, 2013) the algorithm offered by us is based on computer simulation of children's and adolescents' training process.

CONCLUSIONS

The worked out algorithm of computer simulation of modes of gymnastic exercise fulfillment permitted to determine that increments in points of exercise fulfillment statistically confidently depends on the following groups of indicators:

- *Level of fitness:* maximal mark is (x_1), efficiency (x_2), maximal HBR (x_3); quantity of attempts for reaching of optimal HBR is (x_4) (multiple coefficient of determination DM=0.978; p<0.001);
- *Organization of loads:* volume in elements is (x_1), time of rest (x_2), quantity of attempts (x_3), quantity of elements in attempt (x_4) (multiple coefficient of determination DM=0.972; p<0.001);
- *Orientation of training:* time assigned for mastering % (x_1), time assigned for development of endurance, % (x_2), time for repetitions, % (x_3), volume in elements (x_4) (multiple coefficient of determination DM=0.924; p<0.001).

On the base of this algorithm we created a pilot complex of programs of informational provisioning of children's and adolescents' training in motor actions as well as in development of their motor skills.

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EVALUATING ROUTINES IN TRAMPOLINE GYMNASTICS

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Original article

Abstract

In trampoline gymnastics, judges' task is to evaluate a particular routine based on the evaluation of overall degree of difficulty, overall skill execution, and the measurement of time of flight duration. The aim of this study was to investigate differences in the three judgment variables between gymnast's age, gymnast's gender, year of competition, and in relation to the final competition standings in trampoline gymnastics. N = 279 datasets from the World Championships and World Age Group Competitions of the years 2011, 2013, 2014, and 2015 served as a database for this study. Results revealed that the judgment variables varied as a function of gymnasts' age, gymnasts' gender, and year of competition. For example, male gymnasts exhibited higher difficulty scores, slightly higher execution scores, higher time of flight scores, and higher total scores as compared to their female counterparts. A similar pattern of results was found when comparing senior gymnasts to gymnasts from younger age groups. Furthermore, all three judgment variables contributed to final competition standings. Difficulty score showed in average a larger contribution while execution score showed in average a tendency to a slightly smaller contribution for male gymnasts, as compared to female gymnasts. From the viewpoint of an individual gymnast, it is concluded that execution score of a routine should be maximized, while time-of-flight score should be optimized given the difficulty that a gymnast is able to present in a particular routine, thereby guaranteeing a safe and deduction-free skill performance.

Keywords: *constraints, degree of difficulty, execution score, time of flight measurement.*

INTRODUCTION

In individual trampoline competitions, athletes perform routines with ten elements, incorporating somersault and twisting movements. In the competition finals, judges' task is to evaluate a particular routine, and to generate a total score for this routine based on the evaluation of overall *degree of difficulty*, overall *skill execution*, and the (recently installed) measurement of *time of flight duration* (as an indicator for gymnasts' overall 'time in the air' during a routine) (FIG, 2013). Although it is stated that judge's end score is an accurate indicator of gymnast's performance (Johns & Brouner, 2012), a validity and reliability evaluation in another acrobatic sports discipline (woman's artistic gymnastics) revealed systematically biased ratings, leading to the conclusion that a deeper analysis concerning scoring in gymnastics should be conducted (Čuk, 2015; Pajek, Kovač, Pajek, & Leskošek, 2014).

Given the current theoretical and empirical evidence, the question arises, which role each of the three aforementioned judgment variables (difficulty, execution, time of flight) plays in the evaluation of routines in trampoline gymnastics? The aim

of this study was therefore to investigate the three judgment variables in relation to gymnast's age and gender, and in relation to the final competition standings in trampoline gymnastics. A particular focus was given to the time-of-flight variable, because it is the latest evaluation criterion in trampoline gymnastics, and there is some initial evidence for a competition-dependent influence on final standings (Luo, & Wang, 2012; Wang, 2013).

The Code of Points comprises the regulations and rules applied to trampoline gymnastics (FIG, 2013). Gymnasts are allowed to perform several initial straight leaps prior to the first scored element of the routine. Depending on the competition type, a particular amount of routines (with and without special requirements) have to be demonstrated in a preliminary contest, while one voluntary routine has to be demonstrated in the finals. In the finals, judges' task is to evaluate these routines (FIG, 2013; Johns & Brouner, 2012). The total score is generated from the following three variables: 1.) *routines' overall degree of difficulty* ('D' score), 2.) *evaluation of routines' execution* ('E' score), and 3.) *measured time of flight* ('T' score). The total score is calculated by summing up each 'D', 'E', and 'T' score. In a last step, penalties, such as wrong clothing or alike, are subtracted from the total score (FIG, 2013).

The degree of difficulty ('D' score) is calculated by summing up the difficulty scores for each presented element in the routine. The difficulty score for each element arises from the amount of somersaults and twist rotations. For example, the value of a complete single somersault is 0.5 points. The value of a complete quadruple somersault is 2.2 points (0.5 points for each of the four somersaults plus 0.1 points for completing each of the two 720 degree rotations). The value of a twist of 180 degrees is 0.1 points. In performances combining twists and somersaults, the corresponding values are summed up. Thus, the higher the difficulty of each of the ten performed elements, the higher the total difficulty score of the routine will be.

The execution score ('E' score) of the routine is calculated by subtracting deductions from the maximum execution score of 10.0 points. The deductions are mainly related to quality aspects of the performed elements, but they also consider additional aspects such as landing outside the landing zone. For example, a poor execution may be seen in the position of the arms, the legs or the body during twisting and somersaulting, or during the opening and landing phase (i.e., a large displacement on trampoline bed). According to the code of points, five judges evaluate the execution score. The highest and lowest scores are neglected and the scores of the remaining three judges are summed up to form the execution score.

The time of flight score ('T' score) is measured electronically. It represents the total time a gymnast was in the air during the presented routine. Time of flight measurements were installed in senior level competitions in 2010 as an additional measurement dimension. The general idea is that gymnasts, who are able to maintain longer flight duration in each element, should be rewarded in final scoring. There are several commercial systems available that measure gymnasts time of flight, such as the AirTime Trampoline System© (http://www.trampolinetimingsystems.com/) or the TMD1©-system and TMD2©-system (http://www.acontests.com/). If the electronic system stops functioning, the time of flight is determined by official video recordings of the routine. The total time of flight constitutes the time of flight score in seconds. The longer the gymnast is in the air during his or her routine, the higher the time of flight score will be.

One could hypothesize that at least the difficulty score and the time of flight score differ with regard to gymnast's age and gender. One usually finds gender differences in muscular strength and muscle architecture in healthy humans (Miller, MacDougall, Tarnopolsky, & Sale, 1993). The same gender difference can often be

found in terms of sport-specific strength for matured athletes from acrobatic sports such as artistic gymnastics (Arkaev & Suchilin, 2004; Bale & Goodway, 1990). In addition, sport-specific strength is likely to vary as a function of gymnasts' age (Calmels, Van Den Borne, Nellen et al., 1995; Lindle, Metter, Lynch, Fleg, Fozard et al., 1997).

We therefore speculated that male trampoline gymnasts exhibit higher difficulty as well as higher time of flight scores than female trampoline gymnasts, and that senior gymnasts exhibit higher difficulty as well as higher time of flight scores than gymnasts from younger age groups, because due to their higher sport-specific strength they are likely able to perform skills of higher difficulty and/or longer flight duration (Brüggemann, 1994; Yeadon & Mikulcik, 2000). The execution score, however, could be unrelated to gymnast's age or gender, assuming, that gymnasts first and foremost perform skills in competition, which they have learned with a high degree of stability and precision.

Differences in the three judgment variables with regard to aspects such as gymnast's age or gender, however, do not necessarily reflect relationships to final competition standings. The additional question would therefore be: Which role plays each of the three variables with regard to final competition standings? Answering this question should help in clarifying the particular contribution of each variable to final competition standings in trampoline gymnastics. To the best of our knowledge, there is for example no conclusive evidence on the role of time of flight measurements as a criterion to discriminate between the performance of different gymnast's (Luo, & Wang, 2012; Wang, 2013). Nevertheless, we hypothesized that all three judgment scores contribute to final competition standings in trampoline gymnastics. There were no specific predictions on the magnitude of these contributions, but we sought to explore the magnitude of these contributions as a function of gymnast's age, and gender.

METHODS

Time-of-flight measurements were installed in (senior level) competitions in 2010. Therefore, individual finals in World Championships and World Age Group Competitions that took place in 2011, 2013, 2014, and 2015 were selected to serve as a database for this study. Individual trampoline results were thus collected for men and women from different age groups. The individual results were gathered from different official internet sources, such as several competition websites, the homepage and document servers of the FIG, or the database servers of several companies providing competition results in trampoline gymnastics. In particular, the total score for each finalist and his or her final rank, as well as the scores for difficulty, execution, and time of flight were noted for later data analysis. Gymnast's age group was categorized either as *senior* (> 18 years; World Championships), as *11-12 years*, *13-14 years*, *15-16 years*, or *17-18 years* (World Age Group Competitions). From the initial N = 320 datasets, 41 datasets had to be removed from the database, because they were denoted as outliers (i.e., very low score due to aborted routine). Thus, a total of N = 279 datasets could be used for later data analysis.

In order to analyze the individual contribution of each judgment variable to final competition standings, the amount of correctly predicted ranks of final competition standings were calculated from the judgment variables. Because the calculation of the final score follows an additive logic (FIG, 2013), the following calculations were performed: In the first step, the percentage of correctly predicted ranks in the final standings was calculated on the basis of the difficulty score only. Therefore, the ranks from gymnasts' difficulty score were compared to final competition standings, and the percentage of correctly predicted ranks was counted. This percentage was defined as difficulty scores'

contribution to prediction accuracy of final competition standings.

In the second step, the percentage of correctly predicted ranks in the final standings was calculated on the basis of the summed difficulty and execution score. Therefore, gymnasts' difficulty and execution score were summed up. The ranks from this summed score were compared to final competition standings, and the percentage of correctly predicted ranks was counted. The difference between this percentage value and the percentage of correctly predicted ranks based on the difficulty score only was defined as the executions scores' contribution to prediction accuracy of final competition standings.

In the third step, the difference between the sum of both contribution values and 100% was defined as the time of flight scores' contribution to prediction accuracy of final competition standings.

A significance criterion of $\alpha = 5\%$ was defined a priori for all reported results. In order to assess differences in difficulty score, execution score, time of flight score, and overall score between male and female gymnasts, between different age groups and between different years of competition, a multivariate analysis of variance (MANOVA) was conducted, including difficulty score, execution score, time-of-flight score, and overall score as dependent variables. In order to estimate the overall contribution of the three judgment variables to final competition standings, an analysis of variance (ANOVA) with repeated measures was conducted, taking the calculated contribution values of the three judgment scores as dependent variables. In order to assess differences in contributions of the judgment variables to final competition standings between male and female gymnasts, between different age groups, and between different years of competition, separate multivariate analyses of variance (MANOVA) were conducted, including the three contribution values as dependent variables.

Gender (male, female), *year of competition* (2011, 2013, 2014, 2015), and *age group* (11-12 years, 13-14 years, 15-16 years, 17-18 years, senior) were treated as between-subject factors for the analyses of variance. In case the MANOVAs showed an overall effect ($p < .10$), separate univariate ANOVAs for each of the dependent variables were calculated. In case an univariate ANOVA showed a significant effect. Fisher LSD post-hoc tests were calculated to explore the structure of the particular effects (Graziano & Raulin, 2012).

RESULTS

Judgment Scores, Gymnast's Age and Gymnast's Gender

The MANOVA showed significant overall main effects of *age group*, Wilks' $\lambda = 0.151$, $F(12, 627.34) = 54.650$, $p < .05$, *year of competition*, Wilks' $\lambda = 0.802$, $F(9, 576.95) = 6.080$, $p < .05$, and *gender*, Wilks' $\lambda = 0.415$, $F(3, 237.00) = 111.45$, $p < .05$. There was an additional significant interaction effect of *age group* x *gender*, Wilks' $\lambda = 0.781$, $F(12, 627.34) = 5.120$, $p < .05$. An overview of the aggregated data can be found in Table 1. When inspecting the separate univariate ANOVAs, the effect of *age group* occurred for difficulty score, $F(4, 239) = 210.130$, $p < .05$, execution score, $F(4, 239) = 12.430$, $p < .05$, time of flight score, $F(4, 239) = 63.100$, $p < .05$, as well as for overall score, $F(4, 239) = 94.500$, $p < .05$. All three judgment variables varied as a function of gymnast's age. In particular, senior gymnasts exhibited in average higher difficulty scores, higher execution scores, and higher time of flight scores, as compared to gymnasts from younger age groups. There were neither differences in difficulty scores, nor in time of flight scores between gymnasts from the age group 15-16 and gymnasts from the age group 17-18. In addition, gymnasts from the age group 11-12 exhibited in average similar execution scores than gymnasts from the age groups 13-14 and 15-16. Gymnasts from the age group 13-14 did not differ in execution score from gymnasts of the age group 15-16. Senior gymnasts exhibited the

Table 1

Gymnast's aggregated difficulty scores, execution scores, time of flight scores, and total scores, differentiated by age group, year of competition and gender (mean ± standard errors)

		Difficulty				Execution				TimeofFlight				TotalScore			
		Female		Male		Female		Male		Female		Male		Female		Male	
AgeGroup	Year	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Age11-12	2011	9.600	0.392	10.175	0.392	23.050	0.566	22.375	0.566	14.093	0.289	13.971	0.289	46.743	0.938	46.521	0.938
	2013	9.125	0.392	10.183	0.453	22.763	0.566	24.100	0.654	14.686	0.289	14.575	0.334	46.573	0.938	48.858	1.084
	2014	9.163	0.392	10.363	0.392	22.913	0.566	22.838	0.566	14.134	0.289	14.771	0.289	46.209	0.938	47.971	0.938
	2015	9.629	0.419	11.071	0.419	24.686	0.605	24.086	0.605	14.882	0.309	15.096	0.309	49.196	1.003	50.254	1.003
Age13-14	2011	11.238	0.392	13.175	0.392	21.600	0.566	23.850	0.566	14.298	0.289	15.508	0.289	47.136	0.938	52.533	0.938
	2013	11.213	0.392	12.275	0.392	24.300	0.566	23.175	0.566	15.557	0.289	15.546	0.289	51.069	0.938	50.996	0.938
	2014	9.586	0.419	12.057	0.419	22.543	0.605	22.414	0.605	14.561	0.309	15.365	0.309	46.690	1.003	49.836	1.003
	2015	10.325	0.392	12.971	0.419	23.363	0.566	23.614	0.605	14.936	0.289	16.288	0.309	48.623	0.938	52.874	1.003
Age15-16	2011	11.650	0.392	14.600	0.453	23.000	0.566	22.900	0.654	14.961	0.289	16.489	0.334	49.611	0.938	53.989	1.084
	2013	12.183	0.453	13.417	0.453	22.400	0.654	23.150	0.654	15.653	0.334	16.675	0.334	50.236	1.084	53.242	1.084
	2014	12.340	0.496	13.500	0.392	22.980	0.716	23.513	0.566	15.411	0.366	16.219	0.289	50.731	1.187	53.232	0.938
	2015	11.986	0.419	13.680	0.496	23.700	0.605	23.040	0.716	15.900	0.309	16.299	0.366	51.586	1.003	53.019	1.187
Age 17-18	2011	10.133	0.453	14.180	0.496	21.700	0.654	22.060	0.716	13.953	0.334	15.847	0.366	45.787	1.084	52.087	1.187
	2013	12.057	0.419	15.540	0.496	22.071	0.605	21.780	0.716	15.421	0.309	16.946	0.366	49.549	1.003	54.266	1.187
	2014	11.263	0.392	14.650	0.453	21.450	0.566	22.700	0.654	15.068	0.289	16.584	0.334	47.781	0.938	53.934	1.084
	2015	11.933	0.453	14.638	0.392	23.100	0.654	23.850	0.566	15.361	0.334	17.134	0.289	50.394	1.084	55.622	0.938
Senior	2011	14.600	0.419	17.000	0.453	24.129	0.605	25.697	0.654	15.825	0.309	17.415	0.334	54.554	1.003	60.111	1.084
	2013	14.143	0.419	16.871	0.419	23.914	0.605	24.129	0.605	15.939	0.309	17.745	0.309	53.996	1.003	58.745	1.003
	2014	14.488	0.392	17.071	0.419	23.175	0.566	24.986	0.605	16.055	0.289	17.450	0.309	53.718	0.938	59.507	1.003
	2015	14.113	0.392	17.267	0.453	24.113	0.566	25.700	0.654	16.101	0.289	18.215	0.334	54.326	0.938	61.182	1.084

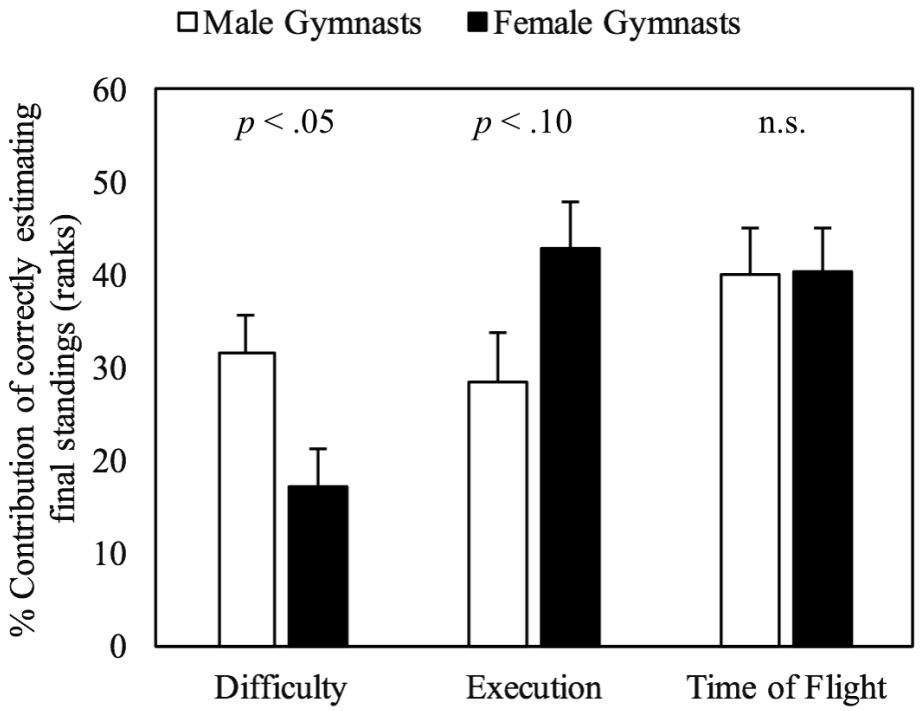

Figure 1. Individual contributions of the three judment variables to correctly estimate final competitions standings (means ± standard errors). Difficulty score showed a larger contribution in male gymnasts as compared to female gymnasts ($p < .05$). Execution score showed a tendency for a smaller contribution in male gymnasts as compared to female gymnasts ($p < .10$).

highest overall scores, followed by gymnasts from the age group 15-16, gymnasts from the age group 17-18, gymnasts from the age group 13-14, and gymnasts from the age group 11-12, while there were no significant differences in overall score between gymnasts from the age group 15-16 and gymnasts from the age group 17-18.An effect of *year of competition* occurred for execution score, $F(3, 239) = 5.260$, $p < .05$, time of flight score, $F(3, 239) = 12.400$, $p < .05$, as well as for overall score, $F(3, 239) = 6.900$, $p < .05$. In average, there were slightly higher execution scores in 2015 as compared to 2014, 2013, and 2011, and there was higher time of flight scores in 2015 as compared to 2014 and 2011. Furthermore, time of flight scores were higher in 2014 and 2013 as compared to 2011. Time of flight scores were lower in 2014, as compared to 2013.

As a consequence of this, total score varied as a function of year of competition. In particular, there were the highest overall scores in 2015, followed by 2013, 2014, and 2011, while there were neither significant differences in overall scores between 2011 and 2014, nor between 2013 and 2014.

An effect of *gender* occurred for difficulty score, $F(1, 239) = 267.040$, $p < .05$, execution score, $F(1, 239) = 5.390$, $p < .05$, time of flight score, $F(1, 239) = 116.100$, $p < .05$, and (as a consequence of this) for overall score, $F(1, 239) = 133.30$, $p < .05$. The interaction effect of *age group* x *gender* occurred for difficulty score, $F(4, 239) = 8.820$, $p < .05$, time of flight score, $F(4, 239) = 9.000$, $p < .05$, as well as overall score, $F(4, 239) = 7.300$, $p < .05$. In average, male gymnasts exhibited higher difficulty scores, slightly higher execution scores, higher time of flight scores, and (as a consequence of this) higher overall scores as compared to female gymnasts. In particular, male gymnasts of all age groups exhibited higher difficulty scores when compared to their female counterparts. Time of flight scores, however, did not differ between

male gymnasts and female gymnasts from the age group 11-12.

Judgment Score's Contributions to Final Standings

Results revealed significant differences between the individual contributions of the three judgment variables, $F(2, 78) = 3.681$, $p < .030$. Difficulty score had an average contribution of 24.30 ± 3.13 % to final competition standings. Execution score contributed in average for 35.57 ± 3.86 %, and time of flight had an average contribution of 40.13 ± 3.36 % to final competition standings. Post-hoc analysis revealed that the contribution of difficulty score was significant smaller than the contribution of time of flight score, while the contribution of difficulty score tended to be significant smaller than the contribution of execution score ($p = .06$). There was no statistically significant difference between the contribution of time of flight score and the contribution of execution score.

Results furthermore revealed neither an overall effect of *age group*, Wilks' $\lambda = 0.768$, $F(8, 68) = 1.201$, $p = .31$, nor of *year of competition*, Wilks' $\lambda = 0.962$, $F(6, 70) = 0.226$, $p = .967$. There was a tendency for an overall effect of *gender*, Wilks' $\lambda = 0.854$, $F(2, 37) = 3.162$, $p = .054$. Inspecting the separate univariate ANOVAs revealed that the effect of gender occurred for difficulty score, $F(1, 38) = 5.870$, $p = .020$, and there was a tendency for execution score, $F(1, 38) = 3.602$, $p = .065$ (see Figure 1). For male gymnasts, the difficulty score showed in average a larger contribution to final competition standings than for female gymnasts, while the execution score showed in average a tendency to a slightly smaller contribution to final competition standings for male gymnasts as compared to female gymnasts. The contribution of time of flight score to final competition standings did not differentiate between male and female gymnasts.

DISCUSSION

Taking the results together, it becomes apparent that male gymnasts exhibited in average higher difficulty scores, slightly higher execution scores, higher time of flight scores, and (as a consequence of this) higher total scores as compared to female gymnasts. Additionally, the three judgment variables varied as a function of gymnasts' age. One could speculate that this might at least in part be explained by age and/or gender differences in muscular strength, and muscle architecture (Bale & Goodway, 1990; Baxter-Jones, 2013; Calmels, Van Den Borne, Nellen et al., 1995; Miller et al., 1993). Senior male trampoline gymnasts for example likely outperform senior female trampoline gymnasts in sport-specific strength, and may thus exhibit longer flight durations (Chen, Zhuo, He, & Zeng, 2006). In turn, longer flight durations might enable the gymnasts to perform skills with higher difficulty (Arkaev & Suchilin, 2004; Yeadon, 2000).

The same skills performed with a longer time in the air may look more spectacular to the judges (Ste-Marie, 2003), likely resulting in a higher execution score. Additionally, athletes have less time constraints to perform a particular skill with adequate precision (i.e., correct opening phase in a somersault and precise landing on the trampoline bed) when having a longer flight phase. This may, however, also depend on the heterogeneity of the field of competitors. Senior gymnasts likely perform more difficult skills than their younger counterparts, so that gymnasts of younger age groups perform more similar in terms of execution or time of flight (Baxter-Jones, 2013; Hume et al., 2013).

Nevertheless, given that in tournaments such as World Championships or World Age Group Competitions the best athletes of the world in their respective age group compete each other, it could likely be that they perform quite similar with regard to their individual routines' difficulty. Subsequent studies could therefore realize a more detailed analysis of competitor's

intraindividual performance variation with regard to the field of competitors in particular competitions.

It should be acknowledged that execution score, time of flight score, and (as a consequence of this) total score varied as a function of year of competition. Competition performance is always the result of a complex interaction of a variety of factors whereas some factors have rather short-term consequences, while others lead to rather long-term consequences (Bradshaw, Hume, & Alsbett, 2012; Kerr & Obel, 2015). For instance, a particular training program could lead to short-term consequences such as muscle soreness the next day, this cause-effect relationship may not be that trivial when it comes to rule changes, such as the installation of time-of-flight recordings in individual trampoline competitions (Cormery, Marcil, & Bouvard, 2008; Rhea, 2004).

The differences in judgment variables between the years could be a result of a delayed effect in gymnasts training schedules, given that rule changes in sport are likely to last up to several years (Liu, 2006). This argument, however, is speculative and needs further empirical investigation. Subsequent studies could utilize a rather qualitative approach by using retrospective interviews with the former gymnasts on topics such as the role of time-of-flight measurements in their training.

Results furthermore revealed that in average the contribution of difficulty score to final competition standings was smaller than the contribution of time of flight score to final competition standings, and it tended to be significant smaller than the contribution of execution score to final competition standings. For male gymnasts, the difficulty score showed in average a larger contribution than for female gymnasts, while the execution score showed in average a tendency to a slightly smaller contribution for male gymnasts as compared to female gymnasts. The contribution of time of flight score did not differentiate between male and female gymnasts. This result follows an additive logic. Difficulty score predicted approximately 31% of final competition standings for male gymnasts, while it accounted for 17% of final competition standings in female gymnasts. When adding execution score for male and female gymnasts, approximately 60% of final standings could be correctly predicted. Adding time of flight scores led to an exhaustive prediction of final competition standings.

It can be concluded that all three judgment scores significantly contribute to the final competition standings, thereby first and foremost differentiating between male and female gymnasts. One could therefore argue that all three judgment variables represent rather distinct evaluation dimensions in trampoline gymnastics. While execution score is mainly based on judges' observation, time-of-flight score is based on a mechanistic measurement. Difficulty score is also based on observation but it comprises a different decision process as compared to the observation of routines' execution. Final competition standings are in average most influenced by time of flight score, and less influenced by difficulty score. This may again reflect that in tournaments such as World Championships or World Age Group Competitions the competitors of their respective competition are more homogeneous in terms of difficulty as compared to execution and time of flight.

While difficulty of a routine can in principle be defined independently of the actual performance of the routine there are several other factors that may for instance influence performance of a routine but not necessarily difficulty of a routine (Davids, Button, & Bennett, 2008; Raab, de Oliveira, & Heinen, 2009). Subsequent studies could for instance try to address questions concerning the performance, and judgment of routines with the same difficulty but different time of flight scores and different execution scores. This approach could help in clarifying the contribution of a particular judgment variables as a function of the other two judgment variables.

Concerning practical implications of this study, it is stated, that difficulty score,

execution score and time-of-flight score are of importance in the evaluation of trampoline routines. From the viewpoint of an individual gymnast, it is argued that execution score of a routine should be maximized by performing to perfection, thereby avoiding deductions. It could furthermore be advantageous if routine difficulty matches (or even excels) the average difficulty level of the other competitors in a particular competition. Time-of-flight score should be optimized for an individual gymnast given the difficulty that he/she is able to present in a particular routine and in order to perform the intended skills under the given constraints, thereby guaranteeing a deduction-free skill execution.

A maximization of time of flight may be not advisable (even thought it has quite a huge weight in predicting final competition standings) due to a lack or inconclusive evidence concerning this parameter (i.e., potential confounding of gymnast's height with time of flight, or potentially higher risk of injury when trying to maximize time of flight without proper technique; Hume, Bradshaw, & Brueggemann, 2015). Although trampoline gymnastics is an Olympic discipline there are still many questions to be answered, and researchers should feel encouraged to approach this highly attractive and evolving sport.

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ERROR PERCEPTION IN GYMNASTICS: TWO CONSECUTIVE INTERVENTIONS

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Original article

Abstract

The coach's perception of movement errors is crucial for the feedback. Two consecutive studies investigated exploratory the influence of transfer of knowledge (study 1; S1) and the influence of motor experience (study 2; S2) on error perception rate of the gymnastics element handstand with a roll. Participants of S1 (n = 18) and S2 (n = 21) are distributed to either a control or an intervention condition. The error perception rate of a video test was used as the dependent variable. Interventions consisted of 180 minutes transfer of knowledge sessions (S1) and 90 executions of handstand with a roll (S2). The mental structure (S1) and an execution protocol with subjective performance are used for monitoring. The error perception rate increased significantly for all conditions. An influence of transfer of knowledge and motor experience was not found. A systematic change in the mental structure on the descriptive level and a subjective improvement of the handstand performance was found. The overall increase of the error perception rate is seen as a learning effect. It remains unclear whether there are long term effects on error perception and to what extent changes of mental structure and subjective performance can be used for the feedback.

Keywords: *augmented feedback, movement errors, perception, coaching.*

INTRODUCTION

It is well known that augmented feedback, such as in form of a video feedback or a coach's feedback has an impact on the learning process of movements (Guadagnoli, Holcomb, & Davis, 2002; Magill & Anderson, 2012). Thus, the way in which the feedback is communicated as well as the content of the feedback is correlated with or determining the movement performance (Hodges & Franks, 2002; Veit, Jeraj, & Lobinger, accepted). This is transferable to simple movements, such as one dimensional arm movements (Armstrong, 1970) as well as to more complex movements, such as sport techniques (Kernodlea & Carlton, 1992). Especially in technical compositional sports as in gymnastics, this performance is associated with its degree of perfectionism during demonstration (Robin, 2014). The ultimate goal is an error free demonstration of the athlete's performance (Arkaev & Suchilin, 2009). Taking into account the goal of a perfect demonstration and the usual way to reach this goal by the coach's feedback, the importance of an optimal feedback based on the error perception of the coach is obvious (Jeraj, Hennig, &

Heinen, 2015; Marković, Krističević, & Aleksić-Veljković, 2015). The aims of the two consecutive studies were to exploratory investigate the influences of two factors on error perception of the coach as a function of the error correction process.

The error perception is one of the fundamental steps of an error correction process because it builds the crucial cue on which the decision for the feedback is based on (Jeraj, Hennig, & Heinen, 2015). During the observation of the movement, the coach needs to detect and perceive *relevant* information in order to be able to give appropriate feedback to their athlete. It is still unclear whether and when those observations is a more top-down or bottom-up influenced process (Brewer & Loschky, 2005). Nevertheless there is general agreement for differences found in gaze behavior comparing experts and laypeople (Gegenfurtner, Lethinen, & Säljö, 2011). According to a meta-analysis of Mann, Williams, Ward, and Janelle (2007), experts are better in the perception of visual tasks because of different gaze behavior. On the other hand, it is either possible that the same gaze behavior of experts and laypeople leads to different results, as one study showed in the accuracy measurement of foul-/no-foul decisions during the observation of videotaped material (Hancock & Ste-Marie, 2013). This makes clear that there is not yet enough evidence to state how such relevant information is perceived in detail. The error perception rate in both consecutive conducted studies at hand is used as a measurement of the coach's ability to have perceived the relevant information which would be needed for an appropriate feedback.

Taking into account several recently published work (Heinen, Vinken, & Velentzas, 2012; Pizzera, 2012, 2015), there is support that a specific motor experience helps the observer to identify and use relevant information to form judgments. Thus the motor experience is chosen to be a crucial factor that is used in the consecutive study design here as an independent variable. In addition, one can assume that the knowledge of the coach is also a crucial factor (Jeraj, Veit, Heinen, & Raab, 2015). This becomes plausible arguing with the steps of the error correction process where (a) the perception of relevant information happens before the judgment of the observed movement and (b) assuming that different knowledge leads to a different perception. One study (Iserbyt, Ward, & Martens, 2015) who used the term content knowledge showed the relation between the latter and the performance of the learners. This study focused on the learner and not on a coach or teacher, but the finding is transferable to the two consecutive studies here as it gives a hint that there is a link between knowledge and error perception. This assumption is strengthened when referring to the general view on feedback and its quality (Hattie, 2008; Hattie & Timperley, 2007). Therefor the knowledge is used in the consecutive study design here as an independent variable.

According to the Cognitive Action Architecture-Approach (Schack & Ritter, 2009), learned motor actions are represented stable in the long-term memory system and are built by several so called basic action concepts (BAC) through their execution and practice (Schack, 2012). A recently conducted study shows that the mental structure of a learnt motor action is most elaborate when using a combination of mental and physical training (Frank, Land, & Schack, 2016). This effect was shown after already three practice sessions of 10 executions and 10 imaginations each in comparison to one physical practice only group and one control group. First, one can argue that the execution and imagination of movements lead to a different mental structure whereas the change in error perception rate is questionable. Second, the mentioned studies give also a hint that knowledge from a more global perspective could lead to a change in mental structures because more knowledge about a movement should be go along with a clearer imagination of the movement. Consecutively, one would assume that either a different knowledge level or a different

motor experience level lead to a different error perception rate or at least to a different mental structure.

The main aims of the two studies were to show the influence of knowledge and motor experience on the error perception rate whereas the methodical approach of study 2 was driven by the results of study 1. It is hypothesized in study 1 that a higher knowledge level leads to a more structured mental representation, and that in turn a higher knowledge level leads to a higher error perception rate. The hypothesis of study 2 was that a higher motor experience level leads to a higher error perception rate.

One additional aspect which has to be considered in error perception tasks, is the fact that the perception of angles between body segments during judgment tasks is influenced by the visual perspective of the observer (Dallas, Mavidis, & Chairopoulou, 2011; Plessner & Schallies, 2005). This effect was shown for pictures of gymnastics elements taken from different perspectives. Thus one can assume that the perception of errors of a gymnastics movement in a video clip is also influenced by the perspective the video was captured. The additional assumption of the first study was that one of the two perspectives leads to a higher perception rate.

The two following studies were conducted separately whereas the first study (for a timeline see Figure 1) led to the second study (for a timeline see Figure 2). Before the start of the studies, the local university's ethic committee approved both study designs, following the requirements of the Declaration of Helsinki.

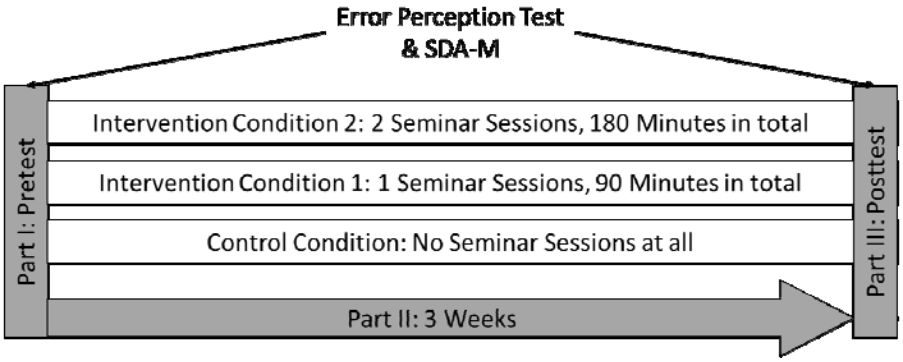

Figure 1. Illustration of the first conducted study with its two time of measurements (pretest and posttest) whereas the error perception test as well as the SDA-M were conducted. Participants were assigned to one of the three different conditions for the three weeks of part II.

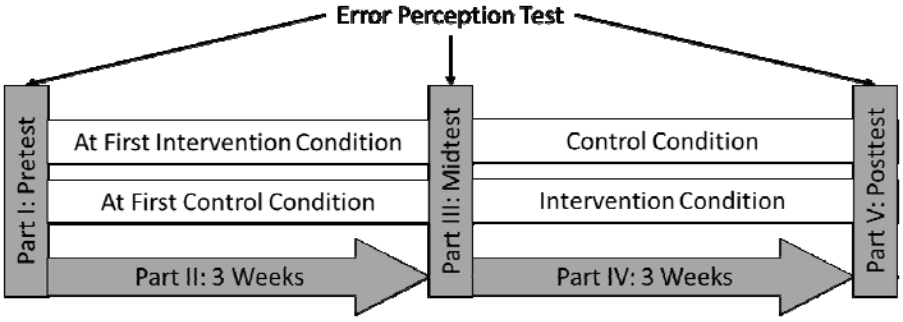

Figure 2. Illustration of the second conducted study with its three time of measurements (pretest, midtest and posttest) whereas the error perception test was conducted each time. Participants started either in the practicing or control condition after conducting at the pretest and changed their condition after conducting at the midtest.

METHODS OF STUDY 1

In total, n = 18 students of physical education participated in this study (M_{age} = 24.5 ± 1.34 years; 13 female and 5 male students). Self-reported none of the participants worked as a gymnastics coach and none of the participants were former or active gymnasts. All participants had completed a gymnastics course at the university and signed an informed consent before participating. Taking into account a participant dropout, the distribution was not equal anymore and the random condition assignment was as follows: Control (n_0 = 7); Intervention 1 (n_1 = 6); Intervention 2 (n_2 = 5).

The *handstand with a roll forward* was the gymnastics element chosen to be explored for the following reasons: First, this element is part of the university's gymnastics education course and it can, therefore, be assumed that all participants have at least a slight or similar knowledge and motor experience with regard to this element. Second, this element can be divided into three phases (Bartlett, 2007) which allows a clear assignment to (a) different error images (1 image per movement phase, resulting in 3 error images); (b) different methodical images (1 image per movement phase, resulting in 3 methodical images); (c) different movement images (2 images per movement phase, resulting in 6 movement images); and (d) different error type videos (2 per movement phase, resulting in 6 error type videos). In addition, this element is easy to teach in a school and training settings and thus, it is interesting for future PE teachers as well as for gymnastics coaches. That is, gymnastics and the chosen element allows for operationalizing error perception because the goal of gymnastics is an error free execution.

Video material was created by asking five gymnasts to demonstrate, one at a time, one specific error type out of the six most frequent error types for the handstand with a roll forward (Bessi, 2005; Gerling, 2009). They were also asked to demonstrate a handstand with a roll forward without any errors. During the execution they were filmed by two cameras, one placed at a distance of 5 meters and at a height of 1.5 meters, orthogonal to the movement plane. The second was placed at a distance of 5 meters and at a height of 1.5 meters, diagonal to the movement plane. The recorded videos were positively evaluated by four independent experts (all had a second highest coaching level license and all were part of the national education team) to ensure that the demonstrated error type and non-error demonstration is perceivable. In total, the video clip pool consisted of 70 different videos (i.e. 7 different executions, from 5 gymnasts, from 2 perspectives).

For the pretest, videos from 3 randomly chosen gymnasts were taken and were shown to the participants (Cloes, Hilbert, & Piéron, 1995; Cloes, Premuzak, & Piéron, 1995). This resulted in 42 videos which was an appropriate amount balancing test practicability and requirements. For the posttest, also videos from 3 gymnasts were selected, but only one gymnast and thus the video clips as well were the same as during pretest (see Table 1). This approach was chosen to avoid learning or memorization effects.

Each participant had to decide if they perceived an error or not. Using a paper sheet, the participant had to mark the preferred option from a 7-point option list. On these 7-point option list, the option "no error perceived" was given in each case and six additional options representing 6 different error types were selectable. Only one option was defined as the correct answer based on the aforementioned expert evaluation. All options except of the "no error perceived" option were presented randomly to reduce the chance to mark the correct option unintentionally.

The Structure Dimensional Analysis-Motoric (SDA-M; Schack, 2004) was used to monitor changes in mental structure between pretest and posttest, according to the point of view that laypeople have a less structured mental representation of a movement than experts (i.e., Schack &

Hackfort, 2007). Besides the most popular form of using terms, it is also possible to use movement videos or images (Stöckel, Hughes, & Schack, 2012). The used paper-pencil version of SDA-M consisted of 12 different images representing 6 movement images, 3 error images and 3 methodical images. The 6 movement images were generated from a videotaped error free demonstration of the handstand with a roll forward where respectively 2 images were taken from the 3 different movement phases as mentioned in the element description. The 3 error images represented 3 different error types, and the 3 methodical images represented 3 different methodical steps where 1 image respectively was taken from the 3 different movement phases. These 12 items were chosen to have a full picture of movement, possible errors and their possible solution which should be considered during error-correction processes. With the paper-pencil version, the participants had to decide for each of the possible 12 x 11 compares resulting in 132 decisions, if the two images belong together or not (for one example see Figure 3), without any further restrictions or hints (Schack, 2012).

Table 1

Illustration of the video clips used for the error perception test from the five different gymnasts for the two times of measurements (pretest and posttest) in study 1, resulted in 42 video clips each.

Used in Pretest		Used in Pretest & Posttest	Used in Posttest	
Gymnast 1	**Gymnast 2**	**Gymnast 3**	**Gymnast 4**	**Gymnast 5**
6 Error Types Demonstrations & 1 Correct Demonstration filmed from 2 perspectives resulting in 42 videos per test				

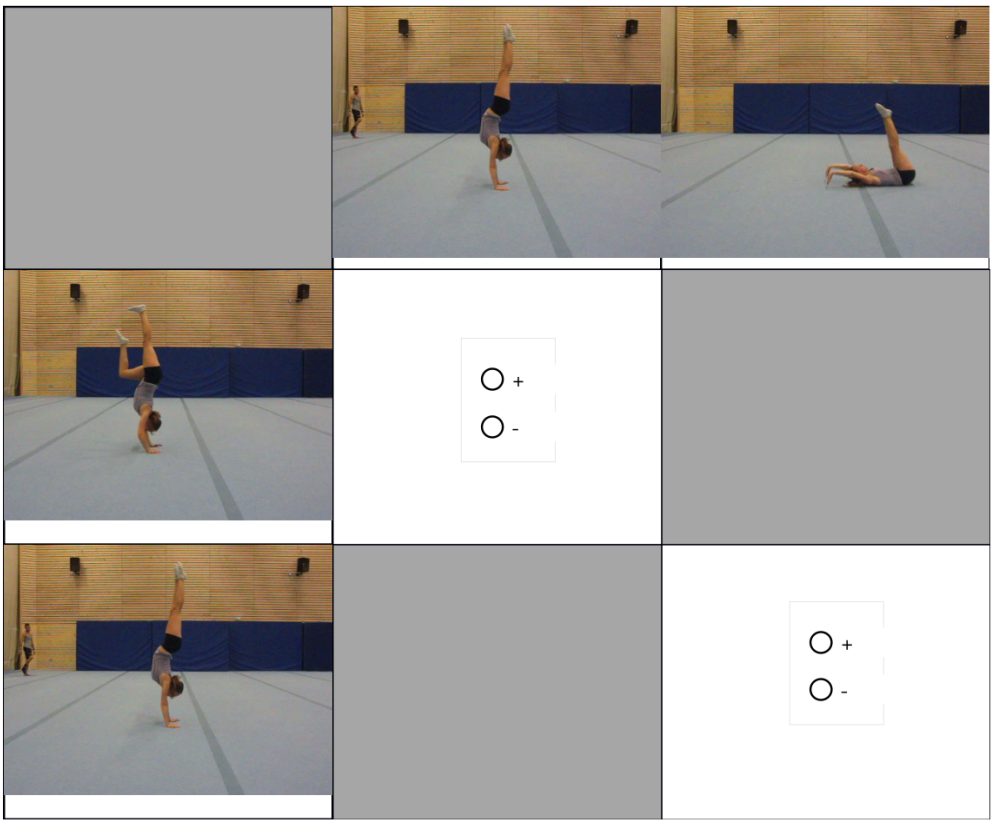

Figure 3. One example of the paper pencil version whereas the participant had to decide whether the two presented pictures belong together (+) or not (-). Afterwards, the decisions of the participant were analyzed according to the SDA-M procedure (for details see Schack, 2012).

In addition, four independent experts filled out this paper-pencil version. The mean mental structure of those experts acted as a reference structure for the further analyses because one assumes that expert's mental structure is well established (Schack & Hackfort, 2007; Velentzas, Heinen, Tenenbaum, & Schack, 2010).

The intervention consisted of two seminar sessions of 90 minutes each where content of biomechanical and methodical knowledge in gymnastics was taught to the students (Bessi, 2005; Deutscher Turner Bund, 2011). Intervention group 1 received one session (90 minutes in total), intervention group 2 received two sessions (180 minutes in total). The amount and the material was taken from the education program for gymnastics coaches and the sessions were conducted by a full educated and licensed gymnastics expert of the national teaching team. Within these seminar sessions, there was explicitly neither a link nor examples of handstand and rolls to avoid that the participants are able to remember aspects in regard to error perception of the videos.

Study 1 consisted of three parts (see Figure 1): In part I, the participants were welcomed in the seminar room where they received information about the study and that the voluntary participation could be canceled at any time without consequences, followed by their informed consent. All collected data used a coding system to ensure anonymity over the whole investigated time. The participants filled out a demographic data sheet, followed by the developed paper-pencil version of the SDA-M. The instructions were written on the sheet to ensure that all participants receive the same information and the same instructions. Before taking part at the error perception test, the selectable options were explained to ensure that all participants know what is meant by the several options. In addition, one video was shown that showed a handstand with a roll forward in an error free demonstration to act as a reference for the participants. This video was not part of the investigated videos later. Then the first video was presented. After the participants' decision, the next video was presented until all videos were shown once, using a random order. After completion of both instruments, the participants were randomly assigned to one of the two intervention groups or to the control group. In total, the whole first part (pretest) lasts 45 minutes.

In part II, Intervention group 1 received one seminar session of 90 minutes, in which knowledge about methodical and biomechanical aspects in gymnastics was taught. Intervention group 2 received two seminar sessions of each 90 minutes with the same content as Intervention group 1. The control group did not receive any information or tasks during the second phase.

In part III, both instruments used in part I were conducted again. The only difference to the pretest was in the selection of videos (see above). Afterwards, the participants were debriefed and given candy too, part III (posttest) was finished after 40 minutes.

A significance criterion of $\alpha = 5\%$ was defined a priori for all results reported. In addition, effect sizes were calculated for all following ANOVA analyses, resulting in partial eta-squared η_p^2.

In order to analyze the SDA-M and their individual changes, several steps were necessary starting with a split procedure for each case which resulted in the calculation of a Z-matrix (for details, see Schack, 2012). *All following distance calculations of the SDA-M used the mean mental structure of four experts as a reference structure (Figure 4)*: (1) The Adjusted Rand Index (ARI) as a measure of similarity (Rand, 1971; Santos & Embrechts, 2009) which resulted in an index between -1 (not similar) and 1 (same). (2) The λ-value as a measure of invariance whereas the critical value resulted in $d_{crit} = 3.444$ (Lander, 2002; Schack, 2012). Here, the calculated range of the λ-value was between 0 and 1 whereas two compares were seen as invariant for $\lambda \geq .683$ and variant for $\lambda < .683$ (Lander &

Huth, 1999). (3) Based on the former calculated Z-matrices, the Pearson correlation coefficient *r was calculated for each case* (Field, 2013). *Here, data is independent from specific aspects of the aforementioned two analyses (such as handling of single items or defining the critical value). Then, these correlation values were Fisher z-transformed to an arithmetic mean for each of the conditions and time of measurements* (Silver & Dunlap, 1987). *Finally, a descriptive analysis was chosen for this correlation values to report mental structure of the groups.*

For the error perception, all correct answers were summarized and resulted in a relative error perception rate as an independent variable. Afterwards, an analysis of variance (ANOVA) with repeated measures (pretest vs. posttest) was calculated with group assignment (intervention 1, intervention 2 and control condition) as a between-subject factor to detect changes in the three SDA-M values and in error perception as the dependent variables. Finally, paired t-tests were used to calculate differences in mean between the two visual perspectives used (once for pretest and once for posttest) as well as the corresponding effect sizes using Cohen's *d*.

RESULTS OF STUDY 1

No correlation between ARI and λ-values was found, all calculations (pretest and posttest) resulted in $p > .05$. Thus, Pearson correlation coefficient *r* was calculated for each case and the Fisher z-transformed arithmetic means of Pearson correlation coefficient *r* for the three groups (intervention 1, intervention 2, control group) and the two times of measurement whereas the analysis revealed the following values (see Table 2):

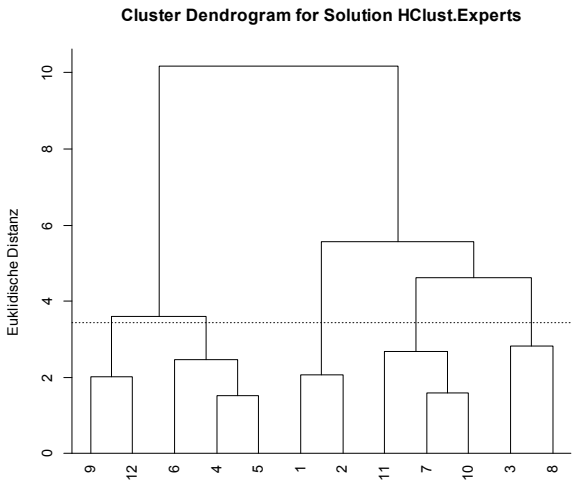

Figure 4. The expert's dendrogram acting as the reference structure. The experts structure the methodical step (9) and the error image (12) of the last phase together, as well as the imageof the mid phase (3) and the methodical step of the mid phase (8). One can also see that experts use a chronological structure for some of the movement images (1, 2; and 4, 5, 6). The images of a methodical step (7) is seen together with two error images of two phases (10, 11). *Note: The dotted line represents the critical* d *value of 3.444 defined by the SDA-M calculation*

Table 2

The Arithmetic Means of Fisher Z-values (Silver & Dunlap, 1987) based on the Pearson's Correlation Coefficients r for the Two Time of Measurements and the Three Different Conditions. None of the Calculations between Pretest and Posttest Value Revealed a Significant Result.

	Arithmetic Means of Fisher's z-transformation		
	Control condition	Intervention 1	Intervention 2
Pretest	0.559	0.872	0.719
Posttest	0.559	0.946	0.820

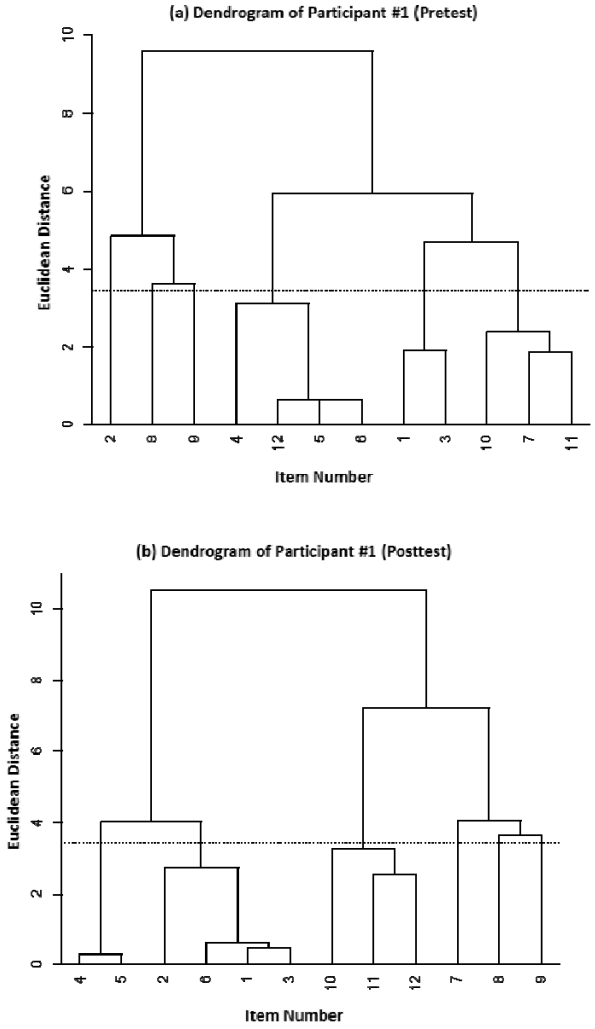

Figure 5. One laypeople's dendrogram of the (a) pretest and (b) posttest measurement who was part of the intervention group. (a) With the pretest measurement, the participant grouped the second part of the movement images (4 - 6) together with the last error image (12). In addition to that there is no systematic way recognizable how the rest of the images are grouped together or not. (b) After the intervention, the participant structures all movement images together (1 – 6). All methodical images (7 – 9) were seen as one group and all error images (10 – 12) were seen as single items. *Note: The dotted line represents the critical* d *value of 3.444 defined by the SDA-M calculation.*

But although the Fisher z-transformed arithmetic means seem to differ in a systematic way, no statistical significance was found according to the calculated analyses, neither for ARI: $F(2, 13) = 0.323$, $p = .730$, $\eta_p^2 = .047$; nor for λ-values: $F(2, 13) = 2.614$, $p = .111$, $\eta_p^2 = .287$; and for Fisher z-transformed arithmetic means: $F(2, 13) = 0.487$, $p = .625$, $\eta_p^2 = .070$. But although, as one exemplary single result, two dendrograms of the SDA-Ms are displayed (see Figure 5). This participant was part of the intervention group and the dendrograms derived from the pretest and posttest measurement. In the first dendrogram (Figure 5a, pretest), one can recognize that the participant has a relative unstructured representation of the movement and their relations to errors and methodical steps, the most items seem to be grouped unsystematically (please see Figure 4 for the experts' reference structure). After the participant's intervention phase, it is remarkable that he or she now structures all movement images together (1 – 6), all methodical images (7 – 9) were seen as one group and all error images (10 – 12) were seen as single items.

It was expected that those participants who were part of the intervention groups show a higher error perception rate than the control group, but there was an increase of 15 % in error perception rate for all groups, $F(2, 15) = 38.781$, $p < .001$, $\eta_p^2 = .721$, and no influence of the intervention on error perception rate was found, $F(2, 15) = 0.036$, $p = .965$, $\eta_p^2 = .005$.

There was no influence of the visual perspective on error perception, neither for the pretest data, $t(17) = 0.768$, $p = .453$, $d = -0.208$, nor for the posttest data, $t(17) = 0.195$, $p = .848$, $d = -0.045$. As a note, the same null results were found for additional calculated analyses in order to check for possible influences, using repeated measures ANOVA, ANCOVA and MANOVA.

The goal of this first study was to show the influence of knowledge on the error perception rate. It was expected at first that a higher knowledge level leads to a more structured mental representation, and at second that a higher knowledge level leads to a higher error perception rate. Additionally, it was expected that one of the two visual perspectives leads to a higher error perception rate.

The results revealed that there is no verifiable influence of knowledge on the mental structure on a statistical level although the structure on the descriptive level follows a systematic way resulting in an improvement of the mental structure for the two intervention groups. This is on the one hand a nice support that the knowledge level is indeed changed caused by the transfer of knowledge. On the other hand it is surprising that the change is not statistically significant because compared to the study of Frank, Land, and Schack (2016), while an intervention amount of already 30 executions and 30 imaginations of a movement lead to a different mental structure. One explanation besides the relative small sample size could be the complexity of the investigated motor tasks used in the study of Frank, Land, and Schack (2016) and in the study here. The movement of an arm swing resulting in hitting a golf ball is less complex comparing this to the whole body movement with different actions during the execution of the handstand with a roll forward. Thus, the assumption is that an imagination of the golfing task is easier transferable and lead to a faster change in the mental structure.

Regarding the result of the increased overall error perception rate independent of the condition was not expected and can be explained by the increase of visual experience caused by the observation of the videos. This result is in line with a previous published study where the task to judge a gymnastics element addressed a slightly different judgement just because of their visual experience in comparison to a group with motor experience instead of the visual experience (Heinen, Vinken, & Velentzas, 2012). The effect here is seen therefor as a learning effect whereas the whole error perception process is not influenced by the interventions. This is interesting because

taking into account the aforementioned structural mental change on the descriptive level does not seem to be enough to change as well the error perception as a performance output measure. Thus, it stays unclear if the underlying process is a more top-down or bottom-up influenced process (Brewer & Loschky, 2005).

The additional result of the indifferent error perception rate for the two visual perspectives gives a hint that providing two perspectives for the whole gymnastics element is not enough. Although it was shown that there is an optimal perspective to perceive a specific angle of static elements (Dallas, Mavidis, & Chairopoulou, 2011; Plessner & Schallies, 2005), this optimal perspective is not as easy transferable to complex movements as in this case the handstand with a roll forward. During the observation of the movement execution, it is possible that the optimal perspective changes all the time because the specific and relevant angles or body positions which has to be considered for an error correction changes as well.

As a consequence of the mentioned results, the following study did not use an instrument to monitor changes in mental structure and did not differentiate between two visual perspectives. The influence of the second explorative factor motor experience was used while the hypothesis of study 2 was that a higher motor experience level leads to a higher error perception rate.

METHODS OF STUDY 2

In total, n = 21 students of physical education participated in this study (M_{age} = 21.4 ± 2.1 years; 10 female and 11 male students). One person gave the information that he or she worked as a gymnastics coach and he or she was as well as three participants former or active gymnasts. All participants just started a gymnastics course at the university and signed an informed consent before participating.

The investigated gymnastics element was the *handstand with a roll forward* as before.

The error perception test was similar as before with one difference: All available videos from the orthogonal visual perspective were shown, resulting in 35 videos (each of the five gymnasts demonstrated 6 error types and 1 error free execution) because there were not found differences of the error perception rate based on the perspectives.

The documentation sheet consisted of an instruction part and a predefined table where the participants had to fill out the amount of executions of handstand with a roll forward for the duration of the intervention phase. During the time of measurements, the participants answered one question about the subjective rating of their own performance of the handstand with a roll forward on a 10 point scale between “no execution possible” and “perfect execution possible”.

The intervention consisted of 90 executions of handstand with a roll forward which has to be performed autonomously by the participants using the documentation sheet as a monitoring tool. The handstands had to be performed three times a week, ten times per date resulting in 90 executions within three weeks. The amount of 90 executions were based on a study of Maleki, Nia, Zarghami, and Neisi (2010), in which the completion of 90 motor executions significantly enhanced the handstand performance of gymnastics beginners.

Study 2 consisted of five parts (see Figure 2) and used a cross-over study design: In part I, the participants were welcomed at the seminar room where they received information about the aims of the study and that the voluntary participation could be canceled at any time without consequences, followed by their informed consent. All collected data used a coding system to ensure anonymity over the whole intervention time. The participants filled out a demographic data sheet. Before taking part at the error perception test, the selectable options were explained to ensure that all participants know what is meant by the several options. In addition, one video was shown that showed a handstand with a

roll forward in an error free demonstration to act as a reference for the participants. This video was not part of the investigated videos later. Then, the first video was presented. After the participants' decision, the next video was presented until all videos were shown once, using a random order. After completion of the test, the participants were randomly assigned to one of the two groups (either *at first practicing condition* or *at first control condition*). In total, part I (pretest) lasts 30 minutes.

In part II, within the following three weeks, participants of the *at first practicing condition* were asked to perform three times per week ten handstands with a roll forward by themselves, using the documentation sheet as a monitoring device. Participants of the *at first control condition* were instructed *not* to perform handstands with a roll forward for the next three weeks.

In part III, the data collection was conducted exactly three weeks later where the procedure from part I was used again, thus the error perception test was performed again. The documentation sheets were collected from the *at first practicing condition's* participants. In total, part III (midtest) lasted 25 minutes.

In part IV, afterwards the participants changed their condition, meaning that those who were part of the *at first control condition* now received the task to perform the 90 handstands with a roll forward within the next three weeks using the documentation sheet. And vice versa, those who were part of the *at first practicing condition* now were instructed *not* to perform handstands with a roll forward within the next three weeks.

In part V, the data collection was conducted exactly three weeks later whereas the procedure from part I and III was used again. Thus, the error perception test was performed again. The documentation sheets were collected from the practical condition's participants. In addition, participants were debriefed and given candy too. Part V (posttest) was finished after 25 minutes.

A significance criterion of $\alpha = 5\%$ was defined a priori for all results reported. For the monitoring tool, the subjective rating of the handstand with a roll forward was analyzed by using a Wilcoxon Signed Rank test. For the error perception test, all correct answers were summarized and resulted in a relative error perception rate. Afterwards, an analyses of variance (ANOVA) with repeated measures (pretest vs. midtest vs. posttest) was calculated with group assignment (at first practicing condition and at first control condition) as a between-subject factor to detect changes in error perception as the dependent variable. In addition, effect size was calculated, resulting in partial eta-squared in ANOVA η_p^2.

RESULTS OF STUDY 2

The participants have executed in mean 89.8 handstands with a roll forward whereas the subjective rating increased from pretest to posttest measure, $Z = -3.397$, $p = 0.001$.

It was expected that those participants who were part of the intervention groups show a higher error perception rate than the control group for the appropriate time of measurement, but there was an increase of round about 7 % in error perception rate for both groups. $F(2, 38) = 8.065$, $p < .001$; $\eta p^2 = .301$; and no influence of the condition on error perception rate was found, $F(2, 38) = 0.290$, $p = .750$, $\eta_p^2 = .015$.

The goal of this second study was to show the influence of motor experience on the error perception rate. It was expected that a higher motor experience level leads to a higher error perception rate.

Although an overall increase in the error perception rate for all groups of round about 7 % is found, there is neither an influence of the condition on the error perception rate nor a systematic pattern of the error perception rate. The increase of the motor experience of 90 executions did not lead to an increase of the error perception rate. According to the subjective rating there is an improvement in the handstand with a roll forward performance. This subjective

improvement is comparable to the objective improvement of the performance shown by a study for all investigated conditions where the students had to execute a handstand 90 times (Maleki, Nia, Zarghami, & Neisi, 2010). The finding is supported here by the subjective rating of the own handstand with a roll forward which increased significant from pretest to posttest measure. Thus, it seems that the change in motor experience is not enough to change the error perception but show slightly changes in the monitoring measurement.

Taken together, there was found a general pattern in both consecutive studies. It seems that a change of one feedback factor of the heuristic concept (Jeraj, Hennig, & Heinen, 2015), goes along with a change in the monitoring parameter (mental structure & subjective handstand performance) but did not change the outcome parameter (error perception rate). The explanations of such a pattern are manifold. One meaningful argumentation is related to the underlying process. It is possible that either the error perception rate as an outcome parameter was not appropriate enough or that the process is less top-down orientated as assumed. One can speculate that for a better error perception, and thus the processing of the relevant information, it is needed to change in addition to the top-down oriented process as well the bottom-up oriented process as it is shown by previous published work whereas single visual training did not lead to improvements on outcome performances (Abernethy & Wood, 2001). A further probable explanation is related to the used interventions. The content and the amount of the knowledge intervention was oriented on national coach education regularities (Deutscher Turner Bund, 2011) but it could be that the duration of the intervention was too short resulting in changes of the error perception rate. Considering that such new content was learned probably but the knowledge of this content was never applied before the posttest measurement would explain changes in the mental structure and the absence of the increase of the transferred performance. Regarding the motor execution manipulation, a similar argumentation leads to the point that a simple increase of the motor experience in the investigated study design does not increase the transfer performance. That could be the case because when persons become experts they can use their own motor experience (Pizzera, 2012) but for the here used times of measurements, persons were not yet familiar to use their increased experiences in the applied field, such as detecting errors by other performers. It would be interesting to investigate possible retention test effects of the two studies here to answer this line of thoughts.

Considering the limitations of the two studies, one aspect should be highlighted here. Although a positive aspect of the material is the used error perception test material that was videotaped from a near real training session. Nevertheless the complexity of the material could be too high for a performance measure of the participant's perception because compared to previous studies only static positions were used to investigate the judgment of the material (Dallas, Mavidis, & Chairopoulou, 2011; Plessner & Schallies, 2005).

CONCLUSIONS

Based on the results, one should focus on differentiating whether and when motor experience or transfer of knowledge leads to a higher error perception because this part of the feedback process on the learning of a gymnastics skill is crucial (Jeraj, Hennig, & Heinen, 2015; Marković, Krističević, & Aleksić-Veljković, 2015). It is necessary to detect the mechanism that lead to the usage of increased knowledge or increased motor experience to develop training and education programs. This could be done for example by investigating coach's gaze behavior during movement observation or by a training of a combination of knowledge and observational tasks to find out when the application is at most effective. Additionally, a gaze behavior analysis combined with a think aloud analysis or

comparable approaches might have a decisive contribution to understand and control the highly rapid error correction process.

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NUTRITIONAL STATUS AND DIETARY ASSESSMENT OF ELITE FEMALE ARTISTIC AND RHYTHMIC GYMNASTS – A CASE STUDY

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Case study

Abstract

Pre-adolescence and adolescence athletes of aesthetic sports such as artistic and rhythmic gymnastics are at high risk of deficiency in basic nutrients. The increasing demands of puberty combined with the intense daily training without adequate nutrition, exposes the young athletes to growth disorders, severe nutritional deficiencies, problems of emotional nature, dissatisfaction with body image (i.e., obsession with physical appearance), hormonal disorders (amenorrhea), chronic fatigue, osteopenia and especially an increased risk of injuries. The purpose of this study was to assess the dietary intake and identify nutritional deficiencies and/or possible excess intake (unhealthy nutrition), thus potential dietary risks and abnormal eating habits. Self-esteem and perception of body image were also assessed. Two young female athletes, one artistic (AG) and one rhythmic gymnast (RG), members of the Greek national team were surveyed. The dietary history and the 7-day weighed food record protocol revealed an average daily energy intake of 1712 ± 165 Kcal and 1976 ± 219 kcal, respectively (or ~ 42,5 kcal/kg lean mass) and inadequate consumption of carbohydrates. The calcium intake had the highest deviation from the recommended daily requirements. Both athletes reported daily individual weighings. A high number of serious injuries and menstrual dysfunction were also reported with one of the athletes presenting a strong predisposition to nutritional risk factors and pathological eating behaviour, and negative emotions both with the external appearance and the body weight. The use of dietary supplements was not mentioned by any athlete. Therefore, targeted nutritional guidelines and psychological support for young elite athletes are required.

Keywords: *gymnastics, females, nutritional status, dietary intake.*

INTRODUCTION

The competitive profile of aesthetic sports such as Artistic (AG) and Rythmic Gymnastics (RG), and diving and synchronised swimming, predisposes mainly female athletes to a constant preoccupation with their shape, size and/or body weight, which are considered participation criteria. Furthermore, they often work under pressure to meet extremely high performance standards.

Previous research has shown that throughout their sporting careers, the vast majority of these athletes try to acquire and preserve the "perfect" body with specific body proportions and unrealistically low body weight and fat mass (Avila-Carvalho, Klentrou, da luz Palomero & Lebre, 2012; D'Alessandro, Morelli, Evangelisti, Galetta & Franzoni, 2007; Klentrou & Plyley, 2003). Under conditions of continuous self-control, low self-esteem, rigorous self-criticism and perfectionism they feel the need to constantly show the most disciplined side of themselves: their body becomes their greatest "achievement". In fact, this preoccupation with body appearance has become part of the behavioural culture of these sports, which is a gradual evolution towards subclinical forms of disordered eating behaviour, especially in elite athletes. It is estimated that 40-45% of elite athletes of these sports show symptoms of eating disorders (Beals, 2004; Bonci et al., 2008; De Bruin, Oudejans, & Bakker 2007; De Souza et al., 2014; Ferrand, Champely & Filaire, 2009; Francisco, Alarcao & Narciso, 2012; Kerr, Berman & de Souza, 2006; Klentrou, 2006; Nordin, Harris & Cumming, 2003; Sundgot-Borgen & Garthe, 2011; Torstveit, Rosenvinque & Sundgot-Borgen, 2008; Wilde, 2013).

In particular, the pre-adolescent and adolescent athletes are at high risk of deficiency in basic nutrients. The most common nutritional deficiencies identified relate to: calcium, iron, folate, zinc (Benardot, 2014; Cupisti et al, 2000; D' Alessandro et al, 2007; Michopoulou et al, 2011; Silva & Paiva, 2015). The main reason for this is the long-standing malnutrition (chronic low energy intake) in combination with the increased needs of accelerated adolescence development.

A combination of various parameters such as the increased needs of nutrient intake due to the accelerated pubertal development, the need to maintain low body weight (and indirectly low fat mass), the potential long-term poor in nutrients and possibly limited energy intake (chronic malnutrition), the intense training required especially in aesthetic and endurance sports, expose the young athletes to growth disorders (Caine, Russell & Lim, 2013), severe nutritional deficiencies (Benardot, 2014; Desrow, 2014; Meyer & Manore, 2011; Weimann et al, 2000; Wilde, 2013), problems of emotional nature, hormonal disorders (amenorrhea), chronic fatigue, eating disorders, osteopenia and increased risk of stress fractures and other injuries (Caine, Russell & Lim, 2013; De Bruin, Oudejans, & Bakker, 2007; Maïmoun et al, 2013; 2014; Mallinson & Souza, 2014; Meyer & Manore, 2011; Nordin, Harris, & Cumming, 2003; Rottstein, 2013; Smith, 2000). All these disorders are central to the pathogenesis of the "*female athlete triad*", whose main components are: reduced energy availability (with or without eating disorders), menstrual dysfunction and decreased bone mineral density (osteopenia). These components are interrelated in causality, pathogenesis and effects (Ackerman & Madhusmita, 2011; Bahner, 2009; De Souza et al., 2014; Ducher et al., 2011; Sundgot-Borgen et al., 2013; Zach, 2011; Wilde, 2013). For athletes at the highest competitive level of AG and RG, the high volume, intensity, frequency and duration of training (6 days/wk, 4-6 h/day) often reach exhausting levels. Dual training sessions are the norm with a total length of training approaching or surpassing 30 h/wk. The age of first engagement usually lies between 5 to 7 years of age, and at the age of 10 the training level and volume are intensified (Benardot, 2014; Caine, Russell & Lim, 2013). During growth, energy availability should be in positive balance, beyond the typical daily energy intake needs and the total energy expenditure, due to the higher requirements of the accelerated pubertal development and the needs of composing new tissue (Desbrow et al., 2014; Klentrou, 2006). However, this surplus of available energy cannot be accurately calculated because of the multivariate pubertal development needs.

Discrepancies between the total daily energy expenditure and the actual energy intake (~ 20-35%) have been observed in published surveys of nutritional assessment of athletes (Thompson, 1998). These discrepancies have been attributed to the under-reporting of energy intake by the athletes and not to the overestimation of the energy expenditure when using indirect calculations (Crenshaw, 2009). It is reported that especially athletes of aesthetic sports intentionally record either lesser amounts, or completely fail to declare selected intake such as various snacks. Likewise, they may either declare larger quantities of "desirable" foods, or temporarily positively alter their nutritional behaviour. The most common recording errors are observed in athletes who are dissatisfied with their body image. One of the reasons of underestimating the energy intake is the fear of disclosing improper dietary practices and the need to positively impress the researchers (Beals, 2004; Black, 2001; De Bruin, Oudejans & Bakker, 2007; Meyer & Manore, 2011). In survey studies, where the record of dietary intake (with weighed food) was performed under the guidance of a qualified dietitian, the reporting of lower values was significantly reduced as verified by the double labeled water method (Martin et al., 1996).

Nutritional assessment is the first of the four stages of the nutritional care process. The other stages include diagnosis, intervention and dietary control/monitoring. A qualified dietitian detects signs of malnutrition and/or excess dietary intake, and assesses the maintenance of normal body development and good state of health while recognising the predisposition to nutritional risk factors. In addition, low self-esteem is associated with an increased risk of eating disorders and negative perception of body image (Desbrow et al., 2014; Steinmuller et al., 2014). The purpose of this study was: i) to assess the dietary intake of two elite female gymnasts during a typical training period, ii) to identify nutritional deficiencies and/or excess intake, and iii) to evaluate the self-esteem and perception of body image of these young athletes. This information would then be used to evaluate possible health risks and abnormal eating attitudes in young female athletes involved in high performance aesthetic sports.

METHODS

After having informed the respective Greek national coaches, two female athletes, members of the respective Greek national Artistic Gymnastic (AG) (age 18.5 years) and Rhythmic Gymnastic (RG) (age 16.1 years) teams, were randomly selected (through a draw) among 20 eligible members of these teams. These two athletes consented to participate in the study which was conducted during the preparation period, when both female athletes had prescribed times of eating and training. The study was approved by the Ethics Board of the University of Athens.

Dietary Intake, Physical Activity and Training Records

Dietary intake was assessed using three different methods: α) an Arbitration history (emphasis on basic and customary intake) via personal interviews; b) a 7-day record of weighed food and drink consumption; and c) a Food Frequency Questionnaire (FFQ) with emphasis on foods rich in calcium and vitamin D. The dietary analysis was conducted using the NUTRITICS (Nutrition Analysis Software) v 3.74 *Professional Edition.*

Selected Food Frequency Consumption Questionnaire (rich in calcium and vit. D)

Dairy group
Milk
Milk type……
Yoghurt …
Soft cheese.
Hard chesse
Fish / Seafood (salmon, sardines, anchovies, mackerel)
Eggs (yolks)
Liver
Enriched Cereal

Enriched Margarine

Special nutritional supplements of vit. D, in *cps* or *syrup* (cod liver oil, fish oil)

Both gymnasts received a sealed envelope with instructions on how to keep the 7-day dietary record, as well as other self-report questionnaires which they were requested to answer. In the 7-day diet record, a detailed manual with pictures and detailed examples of how to correctly complete the diary were attached. Particular attention was paid to reducing error in the self-reporting of food and liquid consumed. In parallel, the participants were given instructions and technical recommendations on how to record both their daily habitual and their training activities. For additional clarifications and questions they could communicate by telephone with the researchers. To ensure confidentiality, it was highlighted to the female athletes that all information would be treated as private and confidential by the researchers, and that the code of conduct would be observed. During their diet history interview, the gymnasts also provided results from recent blood test. There was no clinical observation worthy of our attention.

Dietary history interview

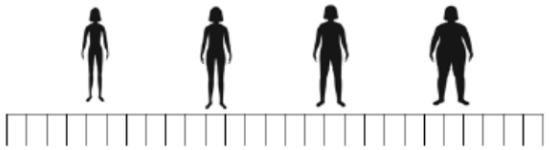
Please answer as precisely as possible:

(1) How frequently do you go on a diet? What diet do you follow and for how long?
(2) Do you feel fat (overweight) and/or frustrated by your weight, appearance and body size?

► Are you pleased with your current weight?

► If not, what is your ideal weight?

► Place an X in the box of the body shape that you believe represents your current physical appearance:



(3) Do you weigh yourself daily?
(4) Is food a great concern of yours and do you constantly think about food? Do you worry and have persistent thoughts that you will gain weight?
(5) Are you strict in the choice of food you consume? If yes, which kinds of food do you avoid eating?
(6) Are there times when you eat nothing all day?
(7) Do you secretly eat "forbidden" foods?
(8) How many meals do you consume daily?
(9) Have you ever purged (induced vomiting) after eating to avoid gaining weight?
(10) After a big meal do you eat less (than usual) during the following days?
(11) Have you ever attempted to "control" your weight with medicines (anorectics, laxatives, diuretics)?
(12) Are you concerned when others watch you eat?

Special attention should be paid to the following warning signs :
- Heavy bleeding during the menstruation
- Longer menstrual period
- Fluctuations / variations in the rhythm of the menstrual cycle (in particular in the absence of 3 consecutive cycles)
- Repeated dieting and avoiding meal intake
- Early, unexplained fatigue
- Systematic, persistent refusal for food and liquids.

(1) At what age did you have your first period? [What was your mother's equivalent age?]
(2) How many times did you have your menstrual period during the last 12 months?
(3) In the last 12 months have you missed 2 or more consecutive periods?
(4) When was your last period and how long did it last?
(5) Have you lost weight during the last three years?

► If yes, how much and for how many months in a row?

► When you lost weight did your period continue normally?

(6) To date have you ever endured severe injuries or fractures?

Anthropometric Measurements

Height was measured using a measuring rod (Stadiometer 222, SECA) and body mass was measured with a precision scale ± 0,1 kg (type 711, SECA - Hamburg, Germany). Body composition was estimated from skinfold thickness (Jackson and Pollock, 1980) using a Lange-type skinfold caliper. The skinfolds measurements were performed on the right side of the body at four sites (triceps, superilliac, abdominal and thigh). The circumference of the left arm was also measured. The resting metabolic rate (RMR) was calculated according to the equations for gymnasts proposed by Pavlou (1992).

Questionnaires

To identify potential eating disorders and to evaluate the dietary behaviour of female athletes, the following questionnaires were used:

The Eating Attitude Test EAT-26 (Garner, Olmsted, Bohr and Garfinkel, 1982) is a dietary attitudes test that has been validated for use in Greek populations. It is a leading diagnostic evaluation marker for the early identification of subclinical cases of disordered eating behaviour. In addition to the single factor "eating attitudes" (26 questions in a 4-point Likert-type scale), the questionnaire includes 3 separate sub-scales dealing with: slimming diets (dieting), "bulimia and pre-occupation with food" and "oral control". Overall performance of ≥ 20 at EAT-26 indicates abnormal eating behaviour and appearance of symptoms of disordered food intake.

The specialised diagnostic gymnast test FAST (Female Athlete Screening Tool) includes 33 questions tailored to the needs of the gymnasts (Beals, 2004; Bonci et al., 2008; Knapp, Aerni and Anderson, 2014; McNulty, Adams, Anderson and Affenito, 2001). It is designed to assist in the early identification of a gymnast who exercises intensively to achieve weight loss, is a perfectionist, worries excessively about body size and external appearance, and/or is already exhibiting disordered eating behaviour. This diagnostic tool scores on a 4-point Likert-type scale, where 4 increases the probability of disordered eating behaviour. The overall performance and severity of symptoms are classified as a) subclinical symptoms that range between 77 and 94, b) clinical symptoms with values> 94.

The Body-esteem scale for adolescents and adults (Mendelson, 2001) has already been used in various studies of Greek female gymnasts (Kosmidou, 2014). It is composed of 22 questions, which form three subscales using a 5-point Likert-type scale (0 = never, 4 = always). The questionnaire is used in two ways, either as a single agent or using all three sub-scales that assess the individual's evaluation of their external appearance, their weight and the way they perceive that others view their appearance. The higher scores indicate higher physical self-esteem.

RESULTS

The anthropometric characteristics and body composition of both athletes are presented in Tables 1 and 2, respectively.

Table 1
Gymnast's general physical characteristics

	AG	RG
Age (years)	18.5	16.1
Body Height (cm)	154,3	167,5
Body mass (kg)	45,8	55.2
BMI (kg/m2)	19.3	19.6
Upper limbs width (cm)	163	170
Standing height (cm)	81.5	91.3
Upper limbs width / Body height	1.058	1.016
Standing height / Body height x 100	52.9	54.6
Arm circumference (mm)	215	228
Mid-arm muscle area (cm^2)	37.3	42.2
Start of systematic Training (age)	6.5	6.2
Number of days of training per week	6	6
Hours of training per week	30	46
First menstruation (age in years)	15.2	12
Situation of menstruation cycle	Normal	Secondary amenorchea / oligomenorchea
Injuries (absence > 7 ημ.)	4	2
Stress injuries	2	1
Changes of weight during a competitive year	≤ 1 kg	≤ 1 kg
EAT - 26 (score)	14	23
FAST (score)	68	89
Adolescents' scale of self-respect of body	54	39

Table 2
Body composition and gymnast's anthropometric characteristics

	3/10/15 - 11/10/15	3/10/15 - 11/10/15
Body weight (kg)	45,8 - 45,9	55,0 - 55,3
Sum of skinfolds (mm)	37,5 - 37	47,5 - 48
Body Fat (%)	11,84 - 11,63	15,11 - 15,38
Nonfat body mass (kg)	40,37 - 40,65	46,7 - 46,8
Somatometric circumferenes (cm)		
Chest	84 - 84	82 - 82
Arm	24 - 24	25 - 25
Waist	65 - 65	67 - 67,5
Belly	68 - 68	71 - 72
Hip circumference	85 - 85	92 - 92
Thigh circumference	46 - 47	50 - 50

Table 3
Average daily nutritional intake of female gymnasts

	AG		RG	
Average daily Energy Intake (kcal)	1712		1976	
Resting Metabolic Rate (RMR) (kcal)	1050		1243	
Energy intake: RMR	1.63		1.59	
Energy / kg (kcal)	37.3		35.8	
Energy / kg Nonfat body mass (kcal)	42.4		42.3	
Carbohydrates (%)	51.6		56.7	
Fat (%)	33.5		28.1	
Proteins (%)	14.8		15.1	
Carbohydrates (gr/kg)	4.8		5.1	
Fat, gr/kg	1.4		1.1	
Proteins, gr/kg	1.37		1.35	
Water, total (L)	2,9		2.6	
Water, during training (L)	1.6		1.1	
Fiber (gr)	14.7		20.4	
		Dietary Recommended Intakes (DRI's) (%)		Dietary Recommended Intakes (DRI's) (%)
Ca (mg)	878	67.5	1143	88
P (mg)	994	79.5	1326	106
Fe (mg)	11.6	77.3	16.2	108
Zinc (mg)	9.4	104.4	11.2	124.4
Mg (mg)	287	79.7	385	106.9
Vit. B 6 (mg)	2.2	185	2.5	208.3
Vit. B 12 (μg)	1.9	79.1	2.9	120.8
Vit. C (mg)	152	233,8	185	284.6
Vit. E (mg)	12.8	85	15.8	105.3

Table 4
A typical example of the daily food consumption of a gymnast of AG (double workout, totaling 6.5 hours)

Breakfast	500 mL Tea with lemon and 1 tablespoon sugar	5 Crackers whole grain
Morning workout	Nothing	
Noon	300 gr Pasta with 50gr parmesan cheese	Broiled cabbage salad (260gr) with 30gr olive oil
Afternoon (training)	only four glasses of water	
Evening	1 cup milk (300 ml) 1,5% fat	1 medium banana

Compared to national development standards (i.e. non-athlete peers), the height of the AG athlete was found to be in the 10th percentile for the corresponding age and gender, and the RG athlete was found to be in the 75th percentile. The weight of the female gymnasts ranged between ± 1 kg annually. Both the muscle mass of the perimeter of the arm and muscular arm area (mid-arm muscle area) of our athletes were

found to be at very satisfactory levels. The gymnast of AG was in the 75th and the gymnast of RG was in the 90th percentile position for their corresponding age and gender. The average daily total energy intake ranged at 1712 ± 165 and 1976 ± 219 kcal, for the gymnasts of AG and the RG respectively (or ~ 42,5 kcal/kg lean mass). With respect to intake of vitamins and minerals, only vitamin C, zinc (Zn) and vitamin B6 exceeded the daily recommended amounts for the AG athlete. The calcium intake was insufficient and had the highest deviation from the recommended daily amounts (Table 3). It was not possible to carry out full nutritional analysis of all foods consumed because they were not included in the nutrient database (eg some various Greek dishes such as giouvarlakia/rice meat-balls in egg lemon sauce, lahano-dolmades/stuffed cabbage leaves, etc.). This was the reason that individual and complete analysis of saturated / unsaturated fat, omega-3 fatty acids, and vit. D was not carried out.

There were no exclusions (or limitations) of specific foods or food groups. Of particular interest was the zero egg consumption by both gymnasts according to their 7-day intake records. Use of dietary supplements was not mentioned by any athlete. During training it was found that the gymnasts had only water intake and no other snack. Both female athletes on repo days, systematically had decompensatory behavior with high energy intake (~ 3000 kcal). For their daily intake of dietary fibers it was noted that both athletes systematically consumed whole grain cereals.

Daily weighting was reported by both athletes. The most common weight control behaviour involves the drastic reduction of energy intake the day following a day of pre-determined (deliberate) increased intake. This compensatory behaviour was applied periodically (3-4 times / month). No other pathological eating behaviours were reported (induced vomiting, use of laxatives or diuretics, fasting). Both athletes reported feeling that they were on a permanent (chronic) dieting regimen. The RG athlete showed a strong predisposition to abnormal eating behaviour and a negative self-assesment of emotions concerning both her external appearance and her body weight.

For the gymnasts of RG the individual level of self-esteem / self-perception of her image and body size, was classified as low whereas the corresponding level for the gymnast of AG was assessed as moderate. Concerning the medical history of the female athletes, normal values of haematological indices were observed. The athletes did not report using oral contraceptive pills. Particularly impressive is the high number of serious injuries reported by both athletes during their sporting careers. The AG athlete reported 4 injuries including 2 stress fractures of the ankle and spine. The RG athlete reported 2 injuries including one stress fracture of the ankle.

DISCUSSION

This research is one of the few published studies with a 7-day record of weighed food consumption in the sport of gymnastics. Compared with similar surveys, there were no significant differences in dietary intakes between the two female athletes. However, in our study dietary intake was higher (~42,5 kcal/kg lean mass) than previously reported for female gymnasts. Specifically, in Thompson's (1998) review of 5 surveys with 56 female gymnasts, aged 15-18, the average daily energy intake was 1789 kcal or 35,6 kcal/kg. The reported daily energy intake of ~42,5 kcal/kg lean mass also approaches the

recommended minimum energy intake of 45 kcal/kg lean mass/day required during periods of intense training and pubertal development (Meyer & Manore, 2011). In addition, according to several experimental protocols (via the double labeled water method), the proposed recommendation for overall energy consumption in adolescent girls is about 40 kcal/kg or 1.75 times x RMR (Thompson, 1998). However, the calcium intake for both gymnasts was below the daily recommendations (DRA's), which is in agreement with previous studies (Cupisti, D'Alessandro, Gastrogiovanni, Barale, & Morelli, 2000; D'Alessandro, Morelli, Evangelisti, Galetta & Franzoni, 2007; Jonnalagadda, Benardot & Dill, 2000; Michopoulou et al., 2011; Silva & Paiva, 2015; Soric, Misiqoi-Durakovic & Pedisis, 2008). The AG athlete had significantly low daily intakes of other essential micronutrients. The RG athlete offset the recommended amounts of micronutrients through daily consumption of fortified wholegrain cereal (there were days where consumption exceeded 200 gr). The water intake exceeded the recommended values in both female athletes (2,3 L / date).

There seems to be an overestimate of predicted energy consumption in both the equations of RMR and consumed energy expenditure in aesthetic sports. Crenshaw (2009) found an overestimation of >200 kcal when using equations both for the forecasted RMR and the projected total energy balance. The review of Thompson (1998) also reports a systematic overestimation of the recommended total daily energy intake in adolescents. In our estimation, the equation to calculate the RMR, which has arisen solely from measurements of female Greek gymnastic athletes (Pavlou, 1992), seems to be appropriate in this investigation, since our athletes maintained a stable body weight [balance energy balance, SD (7-day): RMR = ≥ 1,6]. Indeed the projected RMR proposed by Pavlou (1992) coincides with the boundary values proposed by McMurray (2011), i.e. 0.9 kcal/kg/h for females in the general population and 1,15 kcal/kg lean mass/h for athletes. Something similar was noted in recent research by Silva and Paiva (2015).The discrepancies between the actual energy balance and the actual energy needs of female gymnasts, are a cause for reflection. The athletes of aesthetic sports appear to have a negative energy balance (between 250 and 1200 kcal) with a greatly reduced energy intake (Deutz, Benardot, Martin and Cody, 2000). In these studies, the reason seems to be the self-declared energy intake of athletes. However, there are studies that have questioned the validity and reliability of the calculation equations of both the RMR and the total daily energy consumption of the gymnasts (Crenshaw, 2009). We believe that more specific surveys are needed, with specialised techniques in order to calculate more accurately the energy expenditure for every athlete who endures the long hours of daily training of both AG and RG (Black, 2000; 2001). Furthermore, we observed a large energy deficit during the training of the athletes, since the average 6-hour daily training is not adequately supported nutritionally with the corresponding energy coverage (qualitative and quantitative). This applies even more to rhythmic gymnasts, where the long daily training sessions (~ 8 h) permanently expose them to negative energy balance, especially following the afternoon training. This was confirmed in the research of Deutz, Benardot, Martin, and Cody (2000). They found that the large energy deficit per hour (> 300 kcal) is associated with a higher body fat percentage in elite female athletes, especially in RG. The most likely reasons to explain this phenomenon involve various homeostatic mechanisms including reduction in mean metabolic rate (MMR) and the adjusted thermogenesis (energy storage), increased muscle catabolism, decreased levels of anabolic hormones such as oestrogen, T3 and IGF-1, increased levels of stress hormones such as cortisol, and general endocrine "resistance" and impaired hormonal homeostasis of fatty tissue (Benardot, 2014; De Souza & Williams, 2004; De Souza et al., 2014; Deutz,

Benardot, Martin & Cody, 2000; Filaire,Colombier, Beque & Lac, 2003; Gibbs et al., 2013; Lebenstedt, Platte & Pirke, 1999; Malina et al., 2013; Rottstein, 2013; Smith, 2000; Weimann, 2002; Weimann, Witzel, Schwiderqall & Bohles, 2000). Obviously, this situation seems to confirm the overestimation the daily energy consumption in research methodology of dietary assessment of gymnasts in AG and even more in RG (Figure 1).

Based on the research of Deutz et al. (2000) (Figure 1), female gymnasts are permanently exposed to a 24 hours negative energy balance, as concluded in this survey. Figure 1 begins when the athlete wakes up and ends after 24 h. Energy surplus and deficit are depicted above and below the point 0 which corresponds to the total energy balance. When the energy balance is negative then the athlete spends larger amounts of energy than the intake. Large daily energy deficits per hour (> 400 kcal), associated with a higher percentage of body fat in elite female athletes are probably due to increased muscle catabolism and a corresponding reduction in metabolic rate and thermogenesis (and other hormonal and homeostatic adjustments). The danger area of energy deficit seems to worsen during training hours (Deutz, Benardot, Martin & Cody, 2000). At the end of the day, a high density energy meal restores the athlete's energy equilibrium but most of the energy intake is stored as fat. Finally, these findings should discourage athletes from drastically reducing energy intake, since far from achieving their "ideal" body composition and their target weight, they actually increase body fat. In fact, greater energy deficit (per h) leads to higher body fat (Deutz, Benardot, Martin & Cody, 2000). They should also be discouraged from remaining without food for long hours while training. The reduced daily energy intake (qualitatively and quantitatively) crucially contributes to severe hormonal disorders, especially prolactin. Increased prolactin, reduces the secretion of the hypothalamic releasing hormone of gonadotropin (GnRH), which in turn leads to amenorrhea. This phenomenon is exacerbated by the intense physical strain of training (volume, intensity, frequency) done without the required nutritional rehabilitation. Therefore, although menstrual disorders have a multifactorial etiology, the main one is reduced energy intake (Benson, Engelbert-Fenton and Eisenman, 1996; Caine, Russell & Lim, 2013; Dueck, Manore & Matt, 1996; Gibbs et al., 2013; Maimoun et al., 2013; Maimoun, Georgopoulos & Sultan, 2014; Malina et al., 2013; Mallinson & De Souza, 2014; Roupas and Georgopoulos, 2011; Warren & Perlroth, 2001; Williams, Helmreich, Parfitt, Caston-Balderrama & Cameron, 2001).

Following hours of intense and monotonous training and increasing strain the risk of severe acute trauma, chronic overuse syndromes, and stress fractures dramatically increases (Benardot, 2014; Caine, Russell & Lim, 2013; Malina et al, 2013; Rottstein, 2013; Smith, 2000). Researchers estimate that an elite gymnast, male or female, may miss up to 21% of annual training due to injuries (injury frequency > 4/1000 h training), i.e. approximately two months (Caine, Russell and Lim, 2013). This agrees with our findings, where the artistic gymnast reported a 2-month absence from training within the last year. The corresponding frequency of injuries for rhythmic gymnastics is ≤ 2 injuries/1000 h of training (Caine, Russell and Lim, 2013). Particularly during the critical developmental period of adolescence, many female champions having exceeded their high expectations/demands of themselves and having an impaired perception of their body image, i.e. the illusion of being overweight, become keen to lose extra weight and at the same time, very anxious to maintain the "ideal" weight at all costs. In general, they tend to evaluate themselves negatively. Under continuous pressure, the gymnasts aim to drastically improve their physical appearance (thinner is better) and to increase their opportunity of distinction in their sport. The pinnacle of the problem, especially in athletes of RG, is their

negative self-perception of their image and their body size (Beals, 2004; Bratland-Sanda and Sundgot-Borgen, 2013; Caine, Russell & Lim, 2013; De Bruin, Oudejans and Bakker, 2007; De Souza et al., 2014; Ferrand, Champely & Filaire, 2009; Francisco, Alarcao & Narciso, 2012; Martinsen et al., 2014; Nordin, Harris & Cumming, 2003; Zach, 2011).

CONCLUSION AND RECOMMENDATIONS

When assessing nutrition, it is preferable that sport nutritionists use combined techniques for the estimation of the total energy intake and expenditure of the athletes (individually), instead of being based only on indirect calculation of the corresponding equations/predictions (Burke, 2015). In any case, dietary recommendations are specified by the necessary consideration of all parameters: age, sex, type of sport, phases of annual competitive preparation, duration and weekly frequency of training, environmental conditions, nutritional assessment, medical history etc. During this investigation, we were puzzled by the low daily energy availability that was recorded. In particular, carbohydrate intake should be increased to ≥ 6 gr/kg BW per day in order to ensure optimal glycogen stores and next day training should take place in safe energy limits. Gymnasts show a permanent "deficit" of glycogen due to the long daily and weekly duration of their trainings. It is possible to gradually and individually increase 20-30% their energy intake (more snacks). It is preferable that a gymnast regularly, timely and in sufficient quantity increases the energy intake than permanently being in energy deficit during the entire day or, even worse, retrospectively trying to cover such deficit, no matter how. The qualitative adequacy of intake of B12, vit. D and omega-3 fatty acids (EPA, DHA) is a matter of specialized nutritional assessment and in athletes it is usually covered by administering dietary supplements, antioxidants etc. We also believe that the most critical parameter for the promotion and acceleration of the rehabilitation-recovery process [faster healing of minor injuries, regeneration of injured cells / tissues, immune protection] of muscle stress / fatigue due to training is the favorable energy support strategy, recovery and replacement of fluids during training and post training, through specially designed snacks (high glycemic index). Specifically, because the usual duration of training is > 3 h, energy coverage / reinforcement with carbo-hydrates and electrolytes is required during long training sessions. These should be supplied at the right time and in sufficient quantity, according to the rule ≥ 30 gr of carbohydrates per hour (or 0.5 gr carbohydrate + 0,2 gr of protein / kg body weight / h).

It is estimated that 1 in 2 young athletes engaged in sports where special emphasis is placed on the impossible body, have significantly more nutrition related behavioural problems compared to both the general population and the athletes whose body weight is not a significant performance factor in their sport. Also, 1 in 5 gymnasts of aesthetic sports has at least two components of the female athlete syndrome (reduced energy intake and menstrual dysfunction) and is exposed to multiple risks of injuries and other health problems. It is suggested that the athlete exhibiting symptoms of the female athlete syndrome, be considered "injured", with direct intervention (combination of curative measures) and a clear restriction/abstention from training and competitions (Sundgot-Borgen et al., 2013).

The nutritional education of the athletes (individually and collectively) and coaches are enforced supported by a scientific support team (sports dietician, sports medicine physician, sports psychologist, gynecologist). We consider that in every gymnastic team is essential the basic cooperation between sports dietitian, coach and parents. In sensitive developmental ages of aesthetic sports, the role of the coach is crucial in terms of informing the athletes of

immediate and long-term negative consequences of reduced energy availability (malnutrition), of disorders of menstrual function and of loss of valuable bone density. Undoubtedly, cooperation is required between coaches and parents on all subjects (information, supervision, monitoring, guidance, compliance). Especially for chronic forms of reduced energy intake it should be emphasised that it is detrimental to athletic performance, with serious effects on future health due to weakening of the immune system, nutritional deficiencies of critical nutrients, dehydration, chronic fatigue, abnormal menstrual and hormone function, decreased bone density, increased injury susceptibility and an increased risk of eating disorders.

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PERSONAL FACTORS ASSOCIATED WITH PRE-COMPETITIVE ANXIETY IN ELITE GYMNASTS

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Case study

Abstract

The aim of this study was to analyze how goal orientations and two facets of perfectionism – striving for perfection and negative reactions to imperfection- be related to precompetitive anxiety in elite gymnasts. Thirty seven artistic gymnasts answered a series of questionnaires to measure the study variables. The results showed that cognitive anxiety was related to negative reactions to imperfection, while the self-confidence was predicted by the task orientation. In conclusion, aspects of personality, such as task orientation and negative reactions to imperfection, anticipate the cognitive self-confidence and anxiety, respectively, at the time previous to a senior gymnastics competition.

Keywords: *personality, effort, perfection, goal orientations, emotion.*

INTRODUCTION

The artistic gymnastic can generate anxiety and/or concern for fail during the competition because many of the technical elements defy gravity. Taylor (1981) proposed that two psychological variables that show a considerable influence on competitive performance are anxiety and self-confidence. Moreover, Martens, Vealey and Burton (1990) pointed out that those individual sport athletes that are judged in a subjective manner during competition show a high degree of cognitive anxiety and a lower self-confidence. On the other hand, some authors emphasize the importance of cognitive and emotional processes in the occurrence of injuries (Hackfort & Kleinert, 2007), where it has been shown that anxiety plays an important role (Olmedilla, Ortega, & Gomez, 2014).

The state of competitive anxiety is an immediate emotional state that includes feelings of being apprehensive, tension, and activation during competitive situations (Martens et al., 1990).

The anxiety that appears before a competition is known as pre-competitive anxiety (Cox, 2009).

Three dimensions have been identified in the competitive experience (Martens et al., 1990):

Cognitive anxiety, which refers to the mental component caused by a fear to social evaluation, failure, and loss of self-confidence (Cox, 2009); somatic anxiety which includes those physiological responses such as muscle tension, and self-confidence that refers to the perception of personal abilities and the belief to show an

adequate performance. Although this last dimension is not a direct measurement of anxiety, the pre-competition self-confidence is usually associated to low competitive anxiety (Craft, Magyar, Becker & Fletz, 2003).

Roberts (1986) established that personal meanings play a key role during the appearance of anxiety, and suggests that personal meanings related to achievement contexts, like in the case of sports, can function as disposition variables related to motivation.

Within this context, goal orientations would anticipate pre-competitive anxiety. Goal orientations are defined as the individual differences in the form of judging the competition or ability (Ames, 1992; Nicholls, 1989). Nicholls (1989) identified two types within his classic conception. The first one being an orientation to the task, in which the competition judgment is self-referenced. In other words, it is based on the level of mastery of the task that is being carried out. The second one is an orientation to the ego, in which the competition is judged based on normative criteria according to social comparison to others.

Roberts (1986) stated that athletes who are highly task oriented and with a low ego orientation, see the achievement in self-referred terms, and because of that they are less prone to experience an excessive state of anxiety. Some studies have supported this idea in a pre-competitive situation, like that conducted by Newton and Duda (1995) which showed that ego orientation predicted self-confidence in a negative manner. Hall, Kerr and Matthews (1998) stated that a day before the event ego and task orientations showed a significant correlation with self-confidence and that, 30 minutes before the competition task orientation held a negative correlation to somatic anxiety and self-confidence was predicted positively. Moreover, ego orientation had a positive correlation with cognitive anxiety. Pineda-Espejel and López-Walle (2012) were able to prove that ego orientation predicts somatic and cognitive anxiety, and that task orientation predicts self-confidence positively as well as both anxieties in a negative manner. Ruiz-Juan and Zarauz (2013) supported for their entire sample, that ego orientation predicted cognitive anxiety positively.

Furthermore, different personality traits such as perfectionism, also anticipate the state of competitive anxiety (Cox, 2009). Recent approximations have defined perfectionism as a personality trait characterized by an effort of being impeccable and of establishing high standards of performance, also accompanied by a tendency to offer excessively critical assessments of one´s conduct or performance (Flett & Hewitt, 2002).

Subsequent studies have suggested that there are two different dimensions of perfectionism (Frost, Heimberg, Holt, Mattia, & Neubauer, 1993; Stoeber & Otto, 2006). The first dimension is called perfectionistic striving, which captures aspects or facets related to striving for perfection or establishing high standards of performance and excellence. The second dimension is known as perfectionistic concern which captures aspects associated to a concern for errors, doubts on the execution of tasks, and negative reactions towards imperfection.

There are not so many studies measuring both dimensions of perfectionism (perfectionistic strivings and perfectionistic concerns) with regards to the study of pre-competitive anxiety and perfectionism. For example, Frost and Henderson (1991) showed with university athletes that total perfectionism had a positive relation with pre-competitive anxiety and a negative relation with self-confidence. Hall and cols. in 1998 showed by studying student athletes that only the concern for errors (a facet of perfectionistic concerns) had a positive relation with anxiety and a negative one with self-confidence; whereas personal standards (a facet of perfectionistic strivings) had a positive relation with self-confidence. It is important to highlight that both studies focused on general

perfectionism and not perfectionism in sports.

In addition to this, Stoeber, Otto, Pescheck, Becker and Stoll (2007) in a study that included university and school athletes, as well as low performance football players; showed that total perfectionism was associated with high cognitive and somatic anxiety. Negative reactions to imperfection (a facet of perfectionistic concern) were particularly associated to high anxiety (cognitive and somatic) and held a negative relation with self-confidence in every group. However, the relationship between the strive for perfection (a facet of perfectionistic striving) and anxiety and self-confidence remained unclear. Besides, these results cannot be generalized in high performance cases.

Finally, Hamidi and Besharat (2010) conducted a study with different professional athletes, and found that a strive for perfection predicted cognitive and somatic anxiety in a negative manner and was positively related with self-confidence. In contrast, negative reactions to imperfection positively predicted somatic anxiety and had a correlation with cognitive anxiety and a negative correlation with self-confidence.

Even though previous research has focused on both dimensions of perfectionism (perfectionistic striving and perfectionistic concern), only two measured both variables in the sports context and in competitive situations; therefore this study focuses on the perfectionism in competition and makes the differentiation between both facets in perfectionism. These two facets are the striving for perfection and the negative reactions towards imperfection. This since there is proof that the striving for perfection represents the central element in the positive dimension of perfectionism (Stoeber & Otto, 2006). Furthermore, negative reactions to imperfection have been closely related to a concern for errors and a maladaptive perfectionism (Frost & Henderson, 1991; Rice & Preusser, 2002).

Based on these facts and since perfectionism is a common trait in high-performance athletes (Gould, Dieffenbach & Moffett, 2002), the purpose of this study is to analyze how goal orientation and both facets of perfectionism (striving for perfection and negative reactions to imperfection) are associated with pre-competitive anxiety in elite gymnasts. Additionally, compare the variables through sex, and between best and worst teams positioned in the team final event.

METHODS

The sample consisted of 37 male and female artistic gymnasts participated in the study (15 male and 18 female, 4 did not report their gender). These athletes represented 57% of the population that competed in the 2014 Veracruz Central America and the Caribbean Games. The average age was 21.07 years (*SD* = 4.45), and reported having trained for 12.56 years (*SD* = 5.73), with a training range of 5 to 7 hours per day. These athletes represented different Spanish-speaking countries: Colombia, Costa Rica, Cuba, El Salvador, Honduras, Panama, the Dominican Republic and Venezuela). The male gymnasts obtained notes in the all around event between 88.150 and 70.100, while in the female branch the notes ranged were between 55.633 and 40.798.

We used the Task and Ego Orientation in Sport Questionnaire (TEOSQ; Duda, 1989) to measure goal orientations in its adapted version for the Mexican context (López-Walle, Balaguer, Meliá, Castillo and Tristán, 2011). The questionnaire is composed of 13 items responding to the initial phrase "I feel the most successful in my sport when…" and it is divided in two scales measuring the orientation to the task (i.e. "I learn a new exercise and it makes me want to practice more") and the orientation to the ego (i.e. "I am the only one who can do such exercises or techniques"). Answers are on a five-point Likert scale which oscillate from *completely disagree* (1) to *totally agree* (5).

The striving for perfection facets and negative reactions towards imperfection in

competition were measured with a short version of the *Multidimensional Inventory of Perfectionism in Sport* (MIPS; Stoeber et al., 2007) adapted to Spanish (Pineda-Espejel, Alarcón, López-Walle and Tomás-Marco, in press). It is composed of ten items answering the initial phrase: "During the competition…" five of them capture the striving for perfection (i.e. "I have the desire to do everything perfectly"), and the other five capture the negative reactions to imperfection (i.e. "I feel completely furious if I make mistakes"). There was a Likert answer scale used which goes from *never* (1) to *always* (6). The global index of perfectionism during competition was calculated by combining the scores from the striving for perfection items and those of negative reactions to imperfection.

We used the Revised Competitive State Anxiety Inventory-2 (CSAI-2R; Cox, Martens & Rusell, 2003) in its version adapted to the Mexican context (Pineda-Espejel, López-Walle & Tomás, 2014) to analyze the intensity of pre-competitive anxiety symptoms. It is composed of 17 items responding to the initial question "How do you feel right now before the competition?" They are then grouped in three factors: somatic anxiety (i.e. "I am pretty restless"), cognitive anxiety (i.e. "I am worried about losing") and self-confidence (i.e. "I am confident enough to do well"). Answers were grouped on a four-point Likert scale oscillating from *nothing* (1) to *a lot* (4).

This present research was conducted according to the ethical directives proposed by the American Psychological Association (APA). Before proceeding to data collection, we requested via telematics for authorization from the General Office and the Technical Sports Deputy Office of the XXII Central America and the Caribbean Games 2014, as well as from the Mexican Gymnastics Federation to conduct the study. We had the support from the Deputy Office of Medical Services and Drug Control in order to have access to the competition facilities.

The first personal contact was with the trainers in order to inform them about the study and to request the participation of their gymnasts. In the case of under-age gymnasts, we requested participation consent from the trainer or team delegate. The application of the questionnaires was realize about 40 minutes before starting the warming up of the competition qualification session 1, in the presence of a pollster who is the main researcher, to answer any question regarding the comprehension of any item. Likewise, they were informed that by answering the questionnaires they were accepting their willful participation in the research. They were also informed about the fact that the data collected was to remain anonymous and confidentiality.

RESULTS

Descriptive Statistics and Reliability

The media, typical deviations, and data normality results for the study sample showed that, in average, these gymnasts report high levels of task orientation, perfectionism effort, overall perfectionism and self-confidence as well as moderate levels of ego orientation, negative reactions to imperfection and somatic anxiety (Table 1). The instrument reliability statistics (Table 1) reflected an adequate internal consistency by situating themselves above .70 criteria determined by the scales of the psychological domain (Nunnally, 1978).

Correlation and Linear Regression

Due to the normal distribution of data ($p > .05$), Pearson's bivariate correlations analysis showed that ego orientation is related to negative reactions to imperfection and with the global index of perfectionism. Cognitive anxiety was affected by the negative reactions to imperfection, whereas self-confidence was favorably influenced by task orientation (Table 1).

Table 1
Descriptive and variable normality statistics, reliability of scales (Cronbach Alpha), and Pearson's Correlations Matrix

	Rang	*M*	*SD*	*W*	1	2	3	4	5	6	7
1 Task Orientation	1-5	4.66	.43	.91	(.82)						
2 Ego Orientation	1-5	3.37	.85	.93	.18	(.81)					
3 Cognitive Anxiety	1-4	2.00	.60	.95	-.01	.01	(.81)				
4 Somatic Anxiety	1-4	2.15	.69	.95	-.01	-.17	.71**	(.85)			
5 Self-confidence	1-4	3.19	.58	.94	.42*	.24	-.18	-.36*	(.89)		
6 Striving for perfection	1-6	5.00	1.03	.97	.29	.30	-.06	-.06	.26	(.90)	
7 Negative reaction to imperfection	1-6	3.76	1.02	.92	-.13	.35*	.36*	.19	-.08	.02	(.81)
8 Global index to perfectionism	1-6	4.37	.73	.98	.11	.43*	.18	.08	.13	.71**	.71**

Note: * $p < .05$; ** $p < .01$. Reliability values are shown in parentheses (Cronbach alpha); *M (mean)*; *SD (Standard deviation)*; *W* (Shapiro-Wilk normality test).

Table 2
Differential analysis of the study variables between the best team and the lower team rank in the team final of WAG

	Countries rank	N	*M*	*SD*	*F*(d.f.)
Task orientation	2nd	4	4.85	0.14	4.00(6)
	4th	4	4.71	0.00	
Ego orientation	2nd	4	4.55	0.76	0.50(6)
	4th	4	4.00	0.60	
Cognitive anxiety	2nd	4	2.47	1.04	4.78(6)
	4th	4	2.04	0.41	
Somatic anxiety	2nd	4	2.40	1.21	10.28(6)*
	4th	4	2.60	0.20	
Self-confidence	2nd	4	4.14	0.84	0.41(6)
	4th	4	2.46	0.64	
Striving for perfection	2nd	4	5.40	0.40	7.84(6)*
	4th	4	5.00	1.56	
Negative reactions to imperfection	2nd	4	4.60	0.60	1.17(6)
	4th	4	4.26	1.20	
Total perfectionism	2nd	4	5.00	0.26	7.42(6)*
	4th	4	4.10	1.42	

Note: * $p < .05$

Based on correlation results, an analysis of linear regression was done disclosing that only task orientation predicts self-confidence (= .52, $p < .05$) explaining a 17% variance. Somatic and cognitive anxieties were predicted neither by goal orientation nor by any of the facets of perfectionism.

Differential analysis

The averages of the study variables were compared through sex. Student's t-test showed that women are more oriented on the task ($M = 4.81$; $SD = 0.25$) compared to men ($M = 4.38$; $SD = 0.54$) [$F = 7.87$ (31), $p < .01$]. While for the remaining variables there were no statistically significant differences.

In addition, were compared the averages of two teams of the sample, the best against the lower ranked at the team final, both WAG and MAG. The Student's *t*-test revealed, for WAG, significant differences in levels of somatic anxiety, striving for perfection, and global index of perfectionism, being the best team that showed fewer somatic anxiety, and more positive perfectionism (Table 2). While the two teams MAG were not significant differences.

DISCUSSION

This work was done in order to analyze how goal orientation and two facets of perfectionism (striving for perfection and negative reactions to imperfection) are associated with precompetitive anxiety in high performance gymnasts.

It has been found that these elite gymnasts demonstrate high perception of self-confidence, and moderate levels of intensity in the symptoms of anxiety, opposing the theoretical assumptions of Martens and cols. (1990) for practitioners of these sports. This result can be attributed to the high level of performance of this sample, suggesting that have past experiences of competition, and are familiar with the situation (Drévillon, 1999). In contrast, is related with exposed by Allen, Greenlees, & Jones (2011), respect to athletes competing in international competitions have been found to have lower levels of neuroticism (incorporating anxiety).

For these levels of self-confidence and anxiety prior to competition, on one hand, the results support that anxiety is a function of personality (Rivolier, 1999). Particularly, if a gymnast is defined competent mostly through effort, learning and mastery execution of technical elements, this predicts expressions of high level of confidence in their ability before the competition and makes them believe that they are able to perform the gymnastic techniques just as they trained for; agreeing with previous studies using samples of different athletes, and another level of performance (e.g. Hall et al., 1998; Pineda-Espejel & López-Walle, 2012).

This result maybe because these gymnasts maintained a high task orientation and a moderate ego orientation, they perceived the achievement in more personal terms, such as Roberts (1986) pointed out they are less likely to experience excessive worry and / or tension before the competition. The results support the idea of Craft et al (2013) that self-confidence before the competition is usually associated with low competitive anxiety; the reason is that self-confidence favors focusing on their strengths rather than their errors, and intensifying their efforts in order to achieve their objectives (Tognetti & Reda, 2004), such as showing sports mastery.

On the other hand, the results shown that if a gymnast feels competent only if shows to be superior to other gymnasts, then it is possible that when it fails in a motor gesture technique during competition, then bothers or frustrates himself/herself, and this leads to that prior to the competition, the gymnast has higher negative images and thoughts about their performance, which may arise feelings of worry, fear or insecurity of their performance capabilities, or failure to comply with their established achievement standards, leading to attention difficulties (Burton, 1988). This result agrees with the study of Hamidi and Besharat (2010) with high performance athletes, as well as the study of Stoeber et al (2007) with lower performance athletes.

The main effect of this condition is impotence and inability to properly perform their gymnastic skills and techniques. This supports the idea that the facet of negative reactions to imperfection resulting in a maladaptive perfectionism, furthermore, when the gymnast makes a mistake and reacts negatively to such imperfection of execution, it usually turns into distraction and uncertainty for the rest of the routine.

Although there is some evidence that striving for perfection may be related to precompetitive self-confidence (e.g. Hamidi & Besharat, 2010), and that negative

reactions to imperfections relate to somatic anxiety and inversely with self-confidence (e.g. Hamidi and Besharat, 2010; Stoeber et al., 2007), such relations were not significant in this study, probably due to the small size of the sampling; however, these associations keep the theoretical sense, since the negative reactions to imperfection have a negative tendency on self-confidence; while striving for perfection has a positive tendency on self-confidence and inversely with anxiety.

In this sense, the relationship between striving for perfection and precompetitive anxiety and self-confidence is unclear, as in the study of Stoeber and cols. (2007). However, it helps to reinforce that when effort perfectionist and doubt perfectionist are differentiated through its facets (e.g. striving for perfection and negative reactions to imperfection) only negative reactions to imperfection are related positively to precompetitive cognitive anxiety.

Moreover, because there is evidence that women can manifest more anxiety than men (e.g. Martens et al., 1990), the means of the study variables were compared between men and female gymnasts, showing that do not differ in levels of anxiety or self-confidence, consistent with other studies (e.g. Guillen & Alvarez-Malé, 2010; Montero, Moreno-Murcia, Gonzalez Pulido & Cervello, 2012). However, women consider a greater extent than men, which the main cause of success in sport comes from the effort.

In addition, since there are approaches that compare personality scores between athletes of low and high level, in this study make differential analysis of the means of the variables between two teams. It is noted that in the women, the best ranked team strives more to make perfect routines, and have lower levels of physiological arousal and the symptoms that this entails (e.g. sweating in the hands, muscle tension) compared with the equipment ranked in lower position. It is clear that both variables put in advantage the best ranked team, as the striving for perfection tends to favor them feel successful when they show sports mastery, and this increases the self-confidence under pressure, and thus the perception of ability (Besharat & Pourbohlool, 2011). However, in the male branch no significant difference between the two teams, which does not make clear the role of the variables on performance.

Among these findings, the high average of striving for perfection in comparison to the moderate average of negative reactions to imperfection, supports what was indicated by Gould and cols. (2002) regarding to adaptive perfectionism, which is being represented by the facet of striving for perfection, has been identified as a psychological feature of high performance athletes. We consider that the characteristics of high performance gymnastics influence gymnasts to strive for perform perfect routines, because this sport define ideals performances and forms of realization referenced; since the men take the initiative to improvement new motor skills, while women are more consistent and responsive to the technical details (Issurin, 2012). Coupled with that the apparatus are an artistic performance where participants have a very limited time to get their classification after that time it is no longer possible to make corrections, which entails the rendition of high difficulty elements with impeccable technique.

In the other hand, the fact that striving for perfection and negative reactions to imperfection are not relate in this sample means that gymnasts, who strive to perform routines with excellence during the competition, are not likely to react negatively when they fail to achieve perfect performances. This suggests that perfectionism in high performance artistic gymnastics can be adaptive in those who strive for perfection, but control their negative reactions when their performance is not perfect.

This work has important implications for understanding perfectionism in high performance artistic gymnastics as well as for reasoning some correlatives that anticipate precompetitive anxiety, as the

competition is preferably centered on the social contrast and subjective and objective assessment of individual skills, and is a situation where the gymnast must face facts that time, the results and, on many occasions, the consequences of their performance can determine their future as a gymnast (e.g. leave the headline team, to be part of a selection), generating uncertainty about the likely outcomes.

From the theoretical point of view, it provides information about the contribution of perfectionism and goal orientations on precompetitive anxiety. The results support that perfectionism is multidimensional, and that only facet of negative reactions to imperfection has negative effects. Consequently, only certain forms of perfectionism are associated with pre-competitive anxiety.

Secondly, this work used the CSAI-2R to measure pre-competitive anxiety, unlike most of the studies mentioned here that used CSAI-2, which showed low factorial validity (Cox et al., 2003), therefore helps to clarify the relationship between the dimensions of precompetitive anxiety and perfectionism in competition. It is also a research that provides information of personality on high performance to the existing literature.

From a practical point of view, supports that personality has a lot of predictive utility in sport, and provides that it is favorable that the gymnasts feel successful mostly when they master a technical element, and to strive to make the technical elements and gymnastic routines with impeccable execution technique (exacerbating punctuality, perseverance and obstinacy during training), because it helps to trust your skills before the competition, which opposes the excessive increase in physiological arousal. In contrast, gymnasts should control feelings of dissatisfied, angry or frustrated when you do not run the routines perfectly, since increasing these reactions lead to worry, fear and insecurity of their efficiency; and those doubts finally create anxiety (Weinberg & Gould, 2010). From a diachronic view, precompetitive anxiety can manifest in the physical plane with injuries such as sprains or tendinitis during training, and the mental plane with emotional block immediately before the competition (Rivolier, 1999), which undermines self-confidence.

And it provides information on how personality can affect gymnasts' responses to a competition. Then this information has important implications for sport psychologists design interventions whose goals are the constructs of this research, and the development of emotional control strategies, which further contribute to sporting conduct before the competition (e.g. attentional processes). In addition, understanding the personality can help coaches identify gymnasts require great support during competitions and major events in his career.

There are also some limitations in this study, such as having measured only two facets of perfectionism, striving for perfection and negative reactions to imperfection (Stoeber et al., 2007). It is therefore important that future studies employ different multidimensional measuring of perfectionism in sport and research other positive and negative aspects of perfectionism. Another limitation was the small sample size, making it impossible to generalize the results to the sport, or to the same level of performance. Therefore, further studies should be conducted with larger samples of high performance gymnasts.

Since anxiety and performance are closely linked, another limitation was not having assessed the athletic performance of each gymnast, so that was related to the variables under study. In addition, it would be important to include in future studies the direction dimension of anxiety, ie, how gymnasts perceive symptoms precompetitive anxiety, whether as beneficial or disturbing agents for their performance in competition (Jones, 1995), so that you can supplement information on whether a specific anxiety level will allow you to perform better or not; although there are unsupportive studies to evaluate the

directional perceptions of anxiety (e.g. Jerome and Williams, 2000).

Finally, this work has used a partnership approach between personality and precompetitive anxiety, however, the sport involves social interaction, so that behavior is influenced by the environment, such as organization and discipline; therefore it has been lacking assess the social context, considering that the high performance athletes, in his field evolution is more directly subjected to social pressure (Drévillon, 1999). So the assessment of the role of the environment (e.g. coach) as a predictor of anxiety in athletes (Rivolier, 1999) is another future line of research.

Based on the results of this study, we can conclude that aspects of personality, such as task orientation and negative reactions to imperfection can anticipate higher levels of self-confidence and cognitive anxiety, respectively, in the previous moments of a competition of high-level artistic gymnastic.

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USE OF THE DANCE PAD FOR THE DEVELOPMENT OF RHYTHMIC ABILITIES

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Case study

Abstract

In our research we assessed the effect of an intervention programme based on regular use of the dance pad on the level of rhythmic abilities as important factors influencing the performance in gymnastic sports, dancing, figure skating and so on. The sample consisted of 28 dancers aged between 8-13 years. The tested persons were divided into 2 groups according to age and length of dance practice. Each group was then divided into experimental and control group. Experimental groups were asked to dance on the dance pad 3 times a week for two and a half months. The level of rhythmic perception was measured by the test of rhythmic discrimination by Seashore. The level of rhythmic execution was measured by the test Software reaction meter and Hands and feet drumming. For data analysis of rhythmic abilities we chose descriptive statistics and T-test, calculation of Cohen's d coefficient and Spearman rank correlations. Although the research did not confirm positive influence of dance pad on the development of rhythmic abilities of the tested persons, more options to investigate were shown.

Keywords: *rhythmic perception, rhythmic execution, intervention programme, testing.*

INTRODUCTION

One of the issues associated with motor performance, which has not been dealt with extensively by previous research, is a perspective on movement in terms of rhythm. Rhythm is related not only to music or dance expression, but it also has broad applications. Rhythm is understood as a dynamic time-division motor act, which is an important part of correct execution of movement, and movement in connection with a technique improves performance, as confirmed by experts in the field of kinanthropology. For example Měkota and Novosad (2005) and Krištofič (2006) argue that rhythmic ability is not only important for technical and aesthetic sports, but it is also to some extent used for example in sports games.

The ability to perform rhythmic movement has a significant impact on the quality and economy of body movements. It can be easier to practice rhythm in cyclical movements, whereas the acyclic motion tasks (exercises on the trapeze, high jump, game activities, etc.) are very challenging as regards rhythm (Skotáková, 2014).

Rhythm during exercise movements must be aligned with the rhythm of

inhalation and exhalation, alternating tension and relaxation have to be arranged, and stress and relaxation. Joining movements in certain units - phrasing helps learning and remembering the sequence of movements (Novotná, Panská & Šimůnková, 2011).

Authors (Lehnert & Zítko, 2010; Měkota & Novosad, 2005) dealing with motor learning classify rhythmic ability as a coordination ability. There are two dominant components in the process of developing rhythmic abilities:

- Rhythmic **perception** – perception of acoustic (often musical), tactile and visual rhythmic stimuli from the external environment and their transformation into movement.
- Rhythmic **execution -** capturing the rhythm and translating this rhythm into one´s own physical activities. This way of rhythmic motor learning has got a great significance for acquisition of any movement.

Krištofič, Novotná, Panská, and Chrudimský (2009) in their book mention experiments in which it was shown that acoustic information given during movement streamlines the learning process. For example, the first group learned how to start and jump over the vaulting table with the sound recordings from a tape, the second group was taught by usual way, the result was clearly favourable for the first group.

The close connection between rhythmic abilities and sports performance was confirmed by Bago, Hedbavny and Kalichova (2013). In gymnastic sports, e.g. artistic gymnastics, team gym and sport aerobics, a high level of rhythmic abilities is needed in order to coordinate the movements with music accompaniment. A huge emphasis on rhythmic abilities is laid mainly in women artistic gymnastics where their routines include dance elements and in floor gymnastics they are accompanied by music.

In Code of Points (FIG, 2013) a correct rhythmic realization of movement is judged also within artistic performance, however, not only for the routines exercised with music accompaniment, but also for balance beam or uneven bars. In men gymnastics the rhythmic ability is of a significant importance as every movement, in order to perform correctly, has to be in the correct rhythm, as stated also in v Code of Points for Men's Artistic Gymnastics Competitions.

Also Loo Fung Chiat & Loo Fung Ying (2014) dealt with the topic of enhancement of the music accompaniment in a sports routine, particularly in terms of congruence between the two subjects in a rhythmic gymnastics. The experimental approach of using music in a sports routine was also one of the objectives in this research. It was found that the intended congruence between a music and routine was evidently perceived visually by respondents with a dancing background.

The importance of rhythm perception in children with deafness was verified by Fotiadou, Tsimaras, Giagazoglou, Sidiropoulou, Karamouzi and Angelopoulou (2006). Their findings show the effectiveness of the specific program in terms of improving rhythmic ability, thus indicating its use in educating children with deafness.

The above given results show the importance of developing rhythmic abilities not only in the aesthetic-coordination sports, but in physical activities in general.

In our study we chose dance pads, which work on the principle of interactive simulation dances and thus belong to the group of interactive computer games. We asked the question whether using of interactive computer technology can help develop rhythmic abilities. We included dance pads to a practice of a dance group practicing street dance, mainly because the level of rhythmic ability is one of the limiting factors in the performance of the dancer.

The dance pad has already been used in research, e.g. by Hoysniemi (2006), whose results confirmed that playing on the dance pad has a positive impact on social life and physical health of the players, developing endurance, muscle strength and sense of

rhythm and creativity. Different types of dance pads are also applied in the prevention of falls in the elderly (Lange, Flynn, Chang, Liang, Chien, Nanavati, & Rizzo, 2010) and also applied in working with people with visual disabilities (Gasperetti, Milford, Blanchard, Yang, Lieberman, & Foley, 2010).

The aim of the work was to determine whether the regular use of dance pad can lead to increased level of rhythmic ability.

METHODS

The sample consisted of 28 girls aged between 8-13 years. This period can be in the dance industry divided into two age categories, the children and the juniors. The test subjects were selected and divided according to age (8-10 years and 11-13 years) and length of dance practice.

In the children category we selected a dancer with a two-year practice and in the junior category a dancer with four-year dance practice. In this selection we wanted to avoid deviations that could result in the selection of different performance levels of the test subjects (e.g. speed familiarization and orientation on the dance pad etc.).

The number of tested persons in both categories was the same - 14 people in the children category and 14 people in the junior. Each category was divided (randomly) into experimental group (7 persons), using the dance pad and the control group (7 persons).

The intervention program was the basic idea of the research. The program was limited to girls belonging to the experimental group. It was about two and a half month period during which the dancers regularly trained on the dance pad. Training was led by trained educators. In this two and half month period they were asked to dance on the dance pad 3 times a week before the training session. We gradually increased the level (accelerating pace and increasing complexity of rhythmic patterns), individually according to performance of the tested persons. We oversaw the regularity and helped children with technology. The pad was connected to the screen, allowing better screening and better orientation. In this period, each of the girls had to complete at least 25 workouts on the pad.

Before and after the intervention program we carried out the following tests. Testing rhythmic abilities was divided, according to the focus, into three groups:

1) perception and recognition of rhythmic patterns

2) expression of rhythm by movement

3) the accuracy and speed of execution of the new movement

For our purposes we chose one test for each group.

1) Test of rhythmic discrimination

The test measures rhythmic perception and its author is Seashore (Seashore, 1919; Baldwin 2012) However, we use an innovative recording by Dohnalová. It is a recording of fifteen rhythmic patterns, five parts to individual beats -2/4, 3/4 and 4/4. Of all the thirty formulas sixteen patterns are identical and fourteen patterns different. The tested person (TP) listens to a recording and marks in the table whether the following beats are identical or not (Dohnalová, 2010; Seashore, 1919; Baldwin 2012). The smaller value, the better the result.

2) Software reaction meter

We measure rhythmic execution with a reaction meter. In evaluation, acoustic recording is compared with motion recording. TP sits at the table with the prepared the computer; finger is put on the mouse button and focuses on the acoustic signal emitted by the computer at regular intervals in the range of 2 seconds. The TP reacts to the acoustic signal. (Měkota & Novosad, 2005). The smaller value, the better the results.

3) Hands and feet drumming

The test is performed with the TP in a standing position facing the wall. First, the steps are explained. 1. the left foot hits twice the left side wall (at least 10 cm from the floor), 2. the right palm hits once the right side wall, 3. the left palm hits twice the left side wall, 4.the right foot hits once the right

part of the wall and takes the basic position. These four phases together form a cycle that TP repeat for 20 sec. The result is the number of cycles performed correctly during a specified time interval. We repeated the test three times and recorded all three results in the table. In the final evaluation test we used only the best result. (Měkota & Blahuš, 1983)

For statistical analysis we used the program Statistica 12 firmy Statsoft. For data analysis of rhythm abilities we chose descriptive statistics (average, standard deviation, minimum, maximum) and T-test. T-test is used to compare whether the results of the first measurement (pretest) are statistically different from the results of the second measurement (posttest). The calculations use the 5% level of significance. To be able to carry out t-test we had to verify the normality of the data.

As the calculations of statistical significance depend on the number of people tested, we use the processing results of the main concept of substantive significance. In our case we work with a small research sample, and therefore for processing and evaluation of results, statistical significance will not be the most important factor. The level of substantive significance was assessed by calculating the coefficient of Cohen's d. To verify the relationship between items in variables we used Spearman rank correlations.

Ensuring the quality of research

The validity and reliability of the tests used in the study was confirmed by the authors of the tests and studies. Respondents were informed about the whole research study and the precise procedure of measurement in subtests.

RESULTS

All the results are in the following tables.

Table 1
Test of rhythmic discrimination – descriptive statistics

	Group C-E n = 7 Mean±SD	Group C-C n = 7 Mean±SD	Group J-E n = 7 Mean±SD	Group J-C n = 7 Mean±SD	All Groups n = 28 Mean±SD
RhytmDisc (mistakes) pretest	3.14±4.1	3.57±3.51	3±3.7	3.86±3.53	3.39±3.51
RhytmDisc (mistakes) posttest	2.571±2.64	2.29±2.36	1±1.4	1.57±1.27	1.86±2

Legend: C-E – children experimental group, C-C – children control group, J-E – junior experimental group, J-C – junior control group

Table 2
Test of rhythmic discrimination – results of T-test and Cohen´s d

	Rhytmic discrimination			
	Group C-E	Group C-C	Group J-E	Group J-C
T	0.88	2.465	1.528	2.198
df	6	6	6	6
p	0.413	0.049	0.178	0.07
Cohen's d	0.15	0.4	0.66	0.8

Legend: T – value of student´s statistics, df – degree of freedom, p - statistical significance, Cohen's d - coefficient of effect size. C-E – children experimental group, C-C – children control group, J-E – junior experimental group, J-C – junior control group

Table 3
Test of software reaction - descriptive statistics

	Group C-E n = 7 Mean±SD	Group C-C n = 7 Mean±SD	Group J-E n = 7 Mean±SD	Group J-C n = 7 Mean±SD	All Groups n = 28 Mean±SD
SoftReact Time (ms) pretest	394.14±32.87	497.86±179.86	454.57±171.23	345.57±67.09	423.04±135.74
SoftReact Time (ms) posttest	366.14±29.17	437.29±148.8	316.57±81.15	277±60.36	349.25±105.34

Legend: C-E – children experimental group, C-C – children control group, J-E – junior experimental group, J-C – junior control group

Table 4
Test of software reaction - results of T-test and Cohen´s d

	Software reaction			
	Group C-E	Group C-C	Group J-E	Group J-C
T	2.353	0.883	2.228	2.704
df	6	6	6	6
P	0.057	0.411	0.067	0.035
Cohen's d	0.84	0.34	0.96	1

Legend: T – value of student´s statistics, df – degree of freedom, p - statistical significance, Cohen's d - coefficient of effect size, C-E – children experimental group, C-C – children control group, J-E – junior experimental group, J-C – junior control group Statistical significance and significant effect size is highlighted in red.

Table 5
Drumming test - descriptive statistics

	Group C-E n = 7 Mean±SD	Group C-C n = 7 Mean±SD	Group J-E n = 7 Mean±SD	Group J-C n = 7 Mean±SD	All Groups n = 28 Mean±SD
Drumming (cycles) pretest	6.71±0.76	6±2	9.86±0.9	8.14±1.22	7.68±1.95
Drumming (cycles) posttest	8.86±0.9	8.29±1.6	10±1.53	9.71±0.95	9.21±1.4

Legend: C-E – children experimental group, C-C – children control group, J-E – junior experimental group, J-C – junior control group

Table 6
Drumming test - results of T-test and Cohen´s d

	Drumming test			
	Group C-E	Group C-C	Group J-E	Group J-C
T	-6.301	-5.435	-0.311	-7.778
df	6	6	6	6
P	0.001	0.002	0.766	0.000
Cohen's d	-2.4	-1.17	0.11	-1.34

Legend: T – value of student´s statistics, df – degree of freedom, p - statistical significance, Cohen's d - coefficient of effect size, C-E – children experimental group, C-C – children control group, J-E – junior experimental group, J-C – junior control group

Table 7
Spearman rank correlations between items in variables

Variable	All Groups					
	rhythm 1	rhythm 2	drumm 1	drumm 2	reaction 1	reaction 2
rhythm 1	1.000	0.635*	-0.078	0.104	-0.333	0.142
rhythm 2	0.635*	1.000	-0.273	-0.017	-0.05	0.279
drumm 1	-0.078	-0.273	1.000	0.737*	0.059	-0.298
drumm 2	0.104	-0.017	0.737*	1.000	-0.027	-0.289
reaction 1	-0.333	-0.05	0.059	-0.027	1.000	0.621*
reaction 2	0.142	0.279	-0.298	-0.289	0.621*	1.000

Legend: rhythm 1 – pretest, rhythm 2 – posttest, beat 1 – pretest, beat 2 – posttest, reaction – pretest, reaction 2 – posttest, * - $p<0.05$.

Table 8
Spearman rank correlations between items in variables – group C-E

	C-E group					
	rhythm 1	rhythm 2	drumm 1	drumm 2	reaction 1	reaction 2
rhythm 1	1.000	0.861*	-0.02	-0.116	-0.546	0.073
rhythm 2	0.861*	1.000	-0.295	-0.144	-0.6	0.000
drumm 1	-0.02	-0.295	1.000	0.388	0.617	0.617
drumm 2	-0.116	-0.144	0.388	1.000	0.189	0.113
reaction 1	-0.546	-0.6	0.617	0.189	1.000	0.5
reaction 2	0.073	0.000	0.617	0.113	0.5	1.000

Legend: C-E – children experimental group. Rhythm 1 – pretest, rhythm 2 – posttest, beat 1 – pretest, beat 2 – posttest, reaction – pretest, reaction 2 – posttest, * - $p<0.05$.

Table 9
Spearman rank correlations between items in variables – group C-C

Variable	C-C group					
	rhythm 1	rhythm 2	drumm1	drumm 2	reaction 1	reaction 2
rhythm 1	1.000	0.972+	-0.426	-0.122	0.0	0.673
rhythm 2	0.972*	1.000	-0.333	-0.084	0.146	0.673
drumm 1	-0.426	-0.333	1.000	0.86*	0.273	-0.218
drumm 2	-0.122	-0.084	0.86*	1.000	0.110	-0.202
reaction 1	0.0	0.146	0.273	0.11	1.000	0.536
reaction 2	0.673	0.673	-0.218	-0.202	0.536	1.000

Legend: C-C – children control group. Rhythm 1 – pretest, rhythm 2 – posttest, beat 1 – pretest, beat 2 – posttest, reaction – pretest, reaction 2 – posttest, * - $p<0.05$

Table 10
Spearman rank correlations between items in variables – group J-E

Variable	J-E group					
	rhythm 1	rhythm 2	drumm 1	drumm 2	reaction 1	reaction 2
rhythm 1	1.000	0.132	0.221	0.505	-0.211	-0.146
rhythm 2	0.132	1.000	-0.042	0.686	0.342	0.199
drumm 1	0.221	-0.042	1.000	0.612	0.315	-0.51
drumm 2	0.505	0.686	0.612	1.000	0.195	-0.349
reaction 1	-0.211	0.342	0.315	0.195	1.000	0.541
reaction 2	-0.146	0.199	-0.51	-0.349	0.541	1.000

Legend: J-E – junior experimental group. Rhythm 1 – pretest, rhythm 2 – posttest, beat 1 – pretest, beat 2 – posttest, reaction – pretest, reaction 2 – posttest.

Table 11
Spearman rank correlations between items in variables – group J-C

Variable	J-C group					
	rhythm 1	rhythm 2	drumm 1	drumm 2	reaction 1	reaction 2
rhythm 1	1.000	0.704	0.03	0.358	-0.703	0.18
rhythm 2	0.704	1.000	0.051	0.132	-0.643	0.092
drumm 1	0.03	0.051	1.000	0.837	0.493	0.177
drumm 2	0.358	0.132	0.837	1.000	0.315	0.571
reaction 1	-0.703	-0.643	0.493	0.315	1.000	0.25
reaction 2	0.18	0.092	0.177	0.571	0.25	1.000

Legend: J-C – junior control group. Rhythm 1 – pretest, rhythm 2 – posttest, beat 1 – pretest, beat 2 – posttest, reaction – pretest, reaction 2 – posttest. Statistical significance is highlighted by red.

In the table 1 and table 2 are results of the test of rhythmic discrimination, they didn´t show any considerable progress in experimental groups. The rhythmic discrimination test determines the level of rhythmic perception. From the results we can conclude that regular use of dance pads used by our chosen dancers did not lead to increased levels of rhythmic perception.

To compare the results of pretest and posttest we chose median of response speed to acoustic signal as the starting value (table 3).

To compare the results of pretest and postest we chose the highest number of correctly completed cycles from the three measurements as the starting value (table 5).

We used the test of software reaction meter to investigate rhythmic level of implementation. In children groups (experimental and control) statistically significant changes weren´t shown (table 4). Improvements are seen only in terms of substantive significance - in children experimental group there is a great effect, in children control group a mid- effect. In both junior groups, we have not seen significant differences in favour of the experimental group.

Based on these claims, we conclude that the children category could use the dance pad to work on increasing of the level of rhythmic execution. In another research study it would be useful to investigate the role of age and initial level of ability. Furthermore, we acknowledge the fact that the test does not assess the rhythmic abilities separately, but is strongly influenced by the reaction rate of the tested persons.

Drumming test was included to determine the level of rhythmic execution. Unlike the previous test, drumming is unrelated to the reaction rate, but to differentiation capabilities and ability of grouping (division of coordination abilities according to Schnabel, 2003).

In both children groups the level of this ability was increased in both statistical and material significance. In the junior categories there were even better results in the control group (table 6).

The best relationship is between pretest and posttest of each test (table 7). Besides those relationships there are only small correlations. It means the absence of possibility to change all tests. All tests apparently describe different level of rhythmic perceptions.

This group (C – E) has the best predisposition for this test. Other tests are significantly more difficult to conduct in such sensitive period (table 8). Intervention on the dance pad has had a negative impact on the results of the “beat” and “reaction” tests in the group C – E, where the coefficient correlation value decreased sharply.

The dance pad has had a slightly different impact on the group C – C, the correlation between the tests "rhythm" and "beat" is very high (table 9). The correlation expressed by the correlation coefficient in the test "reaction" is lower and statistically insignificant.

We can conclude that in the group J – E there isn´t any closed relationship between the three tests expressed by this correlation (table 10). In addition, in the test "rhythm" the correlation value is extremely low (0, 13).

The use of the dance pad hasn´t brought significantly positive impact on juniors (table 11). The "rhythm" and "reaction" test correlation value coefficient is 0, 7, but in test "reaction" is very low (0,25).

DISCUSSION

It cannot be claimed that regular use of dance pads leads to an increased level of rhythmic ability of the tested persons. The question is whether there would be significant statistical changes of similar testing of the specific groups (seniors, people with sedentary job, etc.).

De Bruin , Schoene, Pichierri and Smith (2010) describe the potential of dance pad training protocols in the elderly and report on the theoretical rationale of combining physical game-like exercises with sensory and cognitive challenges in a virtual environment.

Also Brox, Luque, Evertsen and Hernandez (2011) confirmed that games with motion sensors that require the players to move, so-called exergames, have become very popular.

As implies from the above, there is already research focusing on the use of the dance pad in seniors to increase their physical activity and enhance cognitive functions. We could contribute by investigating the level of rhythm and balance abilities in this age group.

Another direction of research is to measure athletes for whom the level of rhythmic abilities represents one of the limiting factors for their sports performance (in artistic gymnastics, rhythm gymnastics, team gym, sport aerobics, figure skating, etc.).

Limitation

The number of tested persons was low, that is why the results cannot be generalised. Furthermore, the level of rhythmic abilities in dancers was high already before intervention that is why no significant difference was found. It would be advisable to select a group in which no other type of intervention was conducted (dance training in our case) focused on the same ability.

CONCLUSION

Our results show a certain improvement in rhythmic abilities in all the groups, which suggests that the cause of the improvement was not the use of dance pad, but regular dance training of all the groups. Our research was focused on the possibility of raising the level of regular rhythmic abilities using dance pad. Although the research did not confirm a positive influence of dance pad on the development of rhythmic abilities, more options to investigate were shown. We tested the girls in a sensitive period for the development of rhythmic abilities with two and four years dance experience. Extending the research sample, this study could be the basic building block for further research work. The results show that the very regular and properly led training dance training leads to the development of rhythmic ability.

In other measurements we would like to determine the effect of exercise on the dance pad on the selected motor abilities in the general population - people with no previous dance experience at different ages. Also we would like to test athletes who have rhythmic abilities as one of the limiting factors of their workout (rhythmic gymnastics, artistic gymnastic, team gym, sport aerobics, etc.)

Furthermore, we would focus our attention in research investigations on the fact that use of dance pad will help the

independent development and implementation of rhythmic perception, therefore each sub-rhythmic ability. Due to the fact that we have not found a test that measures the level of a rhythmic ability (the results obtained may be affected for example by levels of response speed, thus hybrid capability and with test of software reaction meter), in our future research we would include more tests that could be correlated to obtain more accurate results.

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SHORT HISTORICAL NOTES VII

Anton Gajdoš, Bratislava, Slovakia

Ph.D. Anton Gajdoš born on 1.6.1940 in Dubriniči (today Ukraine) lives most of his life in Bratislava (ex TCH, nowadays SVK). He comes from gymnastics family (his brother Pavel have world championship medals) and he devoted his life to gymnastics. His last achievement is establishment of Narodna encyklopedia športu Slovenska (www.sportency.sk). Among his passion is collecting photos and signatures of gymnasts. As we tend to forget old champions and important gymnasts, judges and coaches, we decided to publish part of his archive under title Short historical notes. All information on these pages is from Anton's archives and collected through years.

MIROSLAV KLINGER (20 January 1893 – 10 February 1979)

Miroslav Klinger was a gymnast (competing at OG 1920 and OG 1928), coach, judge, president of TC FIG and honorary member of FIG. As we have OG in Rio and electoral congress FIG, it is interesting Miroslav's view and memory on how FIG was dealing withit topics in 1948 in preparation towards OG 1948 in London. His views were published in Czech journal Cvičitel (1948, p. 35- 38).

The International Gymnastics Federation and the Olympic Games of 1948

I would like to write something about the Olympic Games. It would not be inappropriate, I think, if I were perhaps to proceed by first touching on what the conditions were really like for the international federation during the time when it resumed its activities. The first meeting to take place after the war was held in Geneva on the 23rd and 24th of March, 1946. This meeting saw the emergence of the

Scandinavians as a more active force, although whether this was a result of the Olympic Games, or of their efforts to establish contacts in the world of gymnastics, still cannot be determined. Their activities consisted not only of participating in meetings but also contributing to the reform of competitions. They wanted to have the pommel-horse discipline removed from gymnastics programs. The predominance of the English was not surprising. They are the organizers of the Olympic competitions. What was most surprising was the moderation shown by the Swiss towards their own member Huguenin. They wanted to replace him with Maurer, through the intercession of the technical commission. It didn't happen that way. We all supported Huguenin, and he won. He died three weeks later.

And shortly before that, one of the best known members of the technical committee for women, Mr. Demarbre, had died.

The question of who would be Huguenin's successor was solved by ballot. The election was conducted mainly on the basis of written ballots, and I was unanimously elected chairman of the committee. I didn't want to stay on, and so I didn't know what the results of the London election were, because until then the results of the elections had been only temporary. The makeup of the federation is now as follows: the Chairman is the Belgian, Goblet d'Alviella, the Vice-Chairman a Frenchman, Lecocq, while the position of Second Vice- Chairman is vacant (I don't want to be prophetic, but I have the impression that it is being reserved for an Italian). The Treasurer is our brother Muller, and the Secretary is Thoeni, a Swiss. The technical committee is arranged thus: I am the Chairman, the Vice-Chairman is the Frenchman Lapalu, the Secretary the Luxemburger Hentges and the invigilators are the Swiss Mauer, the Belgian Bodaert, and the Englishman,King, who for every negotiation is substituted by the Secretary of the British Amateur Gymnastics Association, Simmonds. The following nations were represented at the Geneva meeting: Belgium, France, England, Holland, Luxemburg, Switzerland, Sweden and Czechoslovakia, while Norway and Finland were absent. Italy, Hungary, Germany and Japan were expressly not invited. The invitation to Yugoslavia was returned with a message to the effect that ‚Sokol" didn't exist. In the absence of Norway, Sweden was invited and present.

The Executive Bureau (something like our office of the Chairman) restricted itself to questions of organization. It brought into being the first organs of the federation. We technicians are responsible mainly for applying the regulations and sanctions of the federation. And thus it was that the Americans proposed that competitions be judged by five referees. The American proposal was turned down because at the 1938 Basel Conference we had already definitively stated that 4 referees should be provided, that the highest and lowest scores should be dropped, and that the average of the remaining scores would be recorded in the standings. These arrangements had already been confirmed for the Olympic Games which were to have taken place in 1940. In addition to this declaration, it was accepted that among the marks from which the average scores were calculated, there shouldn't be a difference of greater than half a point. And futhermore, in contrast to the calculation of scores in Prague where whole marks were awarded from 0 to 10, partial marks would be given (to one decimal point), in order to organize scoring in such a way that from 0 to 8 points, quarter marks would be given, and from 8 to 10 points, tenths of a mark would be scored. And finally, it was agreed that among the 4 judges it would no longer be permitted to have a referee giving marks to a competitor from his native country during international competitions: this rule derived from experiences of bias during the competition in Budapest and was in effect for the Olympic Games in Berlin.

The Norwegian proposal, translated by the Swede Klaus Thorson, suggested that with regard to the participation of the northern countries, the pommel horse event should be scrapped: the change was firmly accepted, but its enactment was postponed until a later

time. Teams would compete in one of 2 or 3 (higher and lower) divisions. Both classes would have the same required exercises, but easier than until now. While the second group would have fewer elements (which would mean, in effect, the certain abandonment of the wide horse).

A change has been made to article 17 of the Rules of Competition, so that instead of this regulation (not excluding the springboard) the springboard can be said to be a required element. This is regarding the certain former FIG members. Admitted again were Italy and Hungary under condition that their organizations will be completely independent from their governments. Newly admitted were Austria, Iran, South Africa. The applications of Korea, Columbia, Cuba and Ireland were postponed to the next meeting. We again touched on the admission of Russia. The topic remained unresolved, even though we informed several times the Russian Embassy in Prague and Russian gymnasts during visits, that the applications needs to be submitted at least 1 year before the competition and there is danger that the Russians will not be allowed to attend the OG.

Very heated, but private, was the discussion between me and the Chairman about the admission of Spain. We discussed what the individual speakers said and very strongly protested against their presence. The Chairman retained his opinion that Spain never ceased to be a member of the federation and did not accept the reasons that they were close collaborators with the Axis (even if not directly at war and only was the supplier of the Axis). There is nothing we could have done. This could have caused public outrage. The situation was similar to a diplomatic one. The question remains if they will actually come to the competition. Then our situation would be very difficult. The FIG has 18 members. The proposal of S. Provaznikova that it should be put into protocol that Germany and Japan cannot be members of FIG because they misused the humanity, was not approved. We only stated that from FIG standpoint they do not exist.

The US proposal to have 5 judges was postponed to the next congress, because the actual rules are already finished. The same applied to the Mexican proposal for new types of competition.

The main part of the meeting was spent on comparing text of the exercises. That is proof to me that all delegates were in close connection to the athletes in the rehearsal. Their remarks and proposals were proving that. If it wasn't for such a connection, I would only have to limit myself to not allowing such changes that according to me could heart our athletes. I only allowed what I thought would be a benefit to them. The remarks and changes were related to all naradie, including prostne. Right after the return I informed about these changes to the exercises and rules, when I worked on the films for Mr. Penigra and Novotny, who lead the training. I also gave them the text of the exercises so that they correct their own, in order to allow our gymnasts to know where they stand and prepare in peace for the competition. There should be also the unofficial working issue with the changes at the COS. Mr. Simmondes was tasked with this from London and I don't know if it's already finished. If the COS don't have the text yet, he needs to be urged to do so. These are the names of the applicants so far: Belgium, France, Italy, Hungary, Finland, Netherlands, Czechoslovakia, USA, Luxemburg, England, Switzerland, Denmark, Mexico, Norway, and Egypt. In addition there are 11 women teams. Thus, there will be a big competition.

And the only question that remains is how will our athletes score in London in 1948. I was them 3 times within the last 2 years. First at a competition at home, second at the competition against Denmark and the last time during one training. I saw ones the English, 3 times the French and some Hungarians and also the Danes. I read the newspapers from Switzerland, Luxemburg, Denmark, France, and Italy. I analyzed and recalculated the results of the

competition between the US and us. I am not an optimist. If they were to succeed they have to do better.

Slovenski izvlečki / Slovene Abstracts

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RAČUNALNIŠKO MODELIRANJE VADBE MLADIH TELOVADCEV

Namen raziskave je bil razviti metodološki pristop k oblikovanju algoritma vadbe mladih telovadcev (otrok in mladostnikov). Raziskava je bila izvedena v skladu s faktorskim načrtom 2xs2 Dobljeni rezultati vadbe so bili uporabljeni za modeliranje. Pri vadbi začetnikov smo analizirali 530 vadbenih enot (92 telovadcev, starosti od 7-10 let starosti). Pri nadaljevalni vadbi smo analizirali 580 vadbenih enot (78 telovadcev, starosti 11-13 let). Za ugotavljanje vpliva različnih načinov vadbe o spremembi funkcionalnega stanja srca in ožilja in živčno-mišičnih sistemov smo izvedli petletno spremljanje (60 telovadcev). Pripravili smo algoritem za informacijsko spremljanje vadbe mladih telovadcev. Algoritem temelji na računalniški simulaciji procesa vadbe. Ugotovili smo, da je napredek odvisen od stopnje telesne pripravljenosti, organizacije vadbe in ciljnosti vadbe. Prikazani so rezultati rezultatov vadbe in frekvence bitja srca. Dokazali smo, da so bili rezultati faktorskega poskusa zanesljivi in učinkoviti pri določanju vpliva različnih načinov vadb dela na funkcionalno stanje. Algoritem izračuna normativno obremenitev za telovadce.

Ključne besede: telovadec, informacija, gibanje, obremenitev, otroci, mladostniki.

Thomas Heinen, Freya Krepela

OCENJEVANJE SESTAV NA VELIKI PROŽNI PONJAVI

Pri skokih na veliki prožni ponjavi se ocenjujejo težavnost, izvedba in trajanje leta. Cilj raziskave je bil ugotoviti razlike med ocenjevalnimi dejavniki glede na starost tekmovalcev, spol, leto tekmovanja in končnim uspehom. Analizirano je bilo 279 sestav, s svetovih prvenstev članov in mladincev v letih 2011, 2013, 2014 in 2015. Rezultati so pokazali, da se spremenljivke spreminjajo v odvisnosti od starosti, spola in leta konkurence. Na primer, moški dosegajo višjo težavnost, nekoliko višje rezultate izvedbe in višji čas letenja ter višjo vsoto točk, kot v primerjavi z ženskami. Podoben velja tudi za odnos med člani in mladinci. Rezultati kažejo, da k končni vsoti pri moških imajo večji vpliv ocene težavnosti in manjši vpliv ocene izvedbe, kar je pri ženskah ravno obratno. Za posameznika je pomembno, da kar najbolj poveča oceno za izvedbo, medtem, ko ocena za trajanje leta mora biti v skladu s težavnostjo, da lahko tekmovalec varno in brez odbitkov izvede sestavo.

Ključne besede: omejitve, stopnja težavnosti, ocene izvedbe, trajanje leta.

Damian Jeraj

ZAZNAVANJE NAPAK PRI TELOVADBI: DVA ZAPOREDNA POSKUA

Zaznavanje napak pri telovadcu je za vaditelja ključnega pomena za dajanje povratne informacije. Dve zaporedni študiji sta preiskali vpliv prenosa znanja (študija 1; S1) in vpliv gibalnih izkušenj (študija 2; S2) na napake in stopnje dojemanja stoje na rokah in sp. prevala naprej. Udeleženci S1 (n = 18) in S2 (n = 21) so bili razporejeni v poskusno ali kontrolno skupino. Stopnja dojemanje napak je bila ocenjena z uporabo video posnetka kot odvisne spremenljivke. Test prenosa znanja je trajal 180 minut (S1) in 90 ponovitev prvine (S2). Duševno struktura (S1) in protokol izvedbe subjektivne uspešnosti se je uporabilo za kriterij spremljanja. Stopnja zaznavanje napak se je znatno povečala pri obeh oblikah učenja. Vpliva prenosa znanja in gibalnih izkušenj ni bilo mogoče določiti. Skupno povečanje stopnje zaznavanja napak je videti kot učni učinek. Še vedno ni jasno, ali so za dolgoročne učinke na zaznavanju napak in v kolikšni meri odgovorne spremembe duševne strukture in subjektivne uspešnosti.

Ključne besede: ojačanje povratne informacije, napaka o gibanju, zaznavanje, vadenje.

George Dallas, Kostas Dallas, Jeremy Siatras

PREHRANSKI STATUSA IN OCENA PREHRANE VRHUNSKE TELOVADKE IN RITMIČARKE - ŠTUDIJ PRIMERA

Pri predpubertetnicah in pubertetnicah športnicah v estetskih športih, kot so orodna telovadba in ritmika obstoja visoko tveganje za pomanjkanje osnovnih hranil. Vse večje zahteve pubertete v kombinaciji z intenzivno dnevno vadbo brez ustrezne prehrane, izpostavlja mlade športnike motnjami rasti, hude prehranske pomanjkljivosti, težave čustvene narave, nezadovoljstvo s telesno podobo (tj obsedenost s telesnim videzom), hormonske motnje (amenoreja), kronična utrujenost, osteopenije in predvsem povečana nevarnost poškodb. Namen te raziskave je bil oceniti vnos s hrano in ugotoviti prehranske pomanjkljivosti in/ali morebitni odvečni vnos (nezdrave prehrane), torej potencialnih prehranskih tveganj in nenormalne prehranjevalnih navad. Ocenjeni so bili tudi samozavest in zaznavanje telesne podobe. Analizirani sta bili dve mladi športnici, telovadka in ritmičarka, obe članici grške reprezentance. Prehranska zgodovina in 7-dnevni zapis prehrane protokol je pokazala povprečen dnevni vnos energije 1712 ± 165 kcal in 1976 ± 219 kcal, oziroma (ali ~ 42,5 kcal / kg mišične mase) in nezadostno uživanje ogljikovih hidratov. Vnos kalcija sta imeli najvišje odstopanje od priporočenih dnevnih potreb. Obe športnici sta se dnevno tehtali. Visoko število resnih poškodb in menstrualne disfunkcije je poročala ena športnica, ki predstavljajo močno nagnjenost k prehranskimi dejavniki tveganja in patološkega vedenja prehranjevanja in negativna čustva, tako z zunanjim videzom in telesno težo. Nobena športnica ni uporabljala prehranskih dopolnila. Izkazuje se potreba za prehranske smernice in psihološko podporo za mlade vrhunske športnike.

Ključne besede: telovadba, ženske, prehranski status, prehrana.
H. Antonio Pineda-Espejel, Edgar Alarcón, Marina Trejo, Carlos Chávez, Raquel Arce

DEJAVNIKI OSEBNOSTI POVEZANI S PREDTEKMOVALNO NAPETOSTJO PRI VRHUNSKIH TELOVADCIH IN TELOVADKAH

Cilj raziskave je bil analizirati, kako so ciljna usmerjenost in dve plati perfekcionizma – težnja k popolnosti in negativne reakcije na napake - povezane s predtekmovalno napetostjo telovadcev in telovadk. Sedemintrideset njih je odgovoril na vrsto vprašalnikov. Rezultati so pokazali, da je kognitivna anksioznost povezana z negativno reakcijo na napake, medtem ko je samozavest povezana s ciljno usmerjenostjo k nalogi. Dejavniki osebnosti, kot so ciljna usmerjenost in negativna reakcija na napake, lahko napovedujejo kognitivno samozavest in tesnobo pred samim tekmovanjem.

Ključne besede: osebnost, navdušenje, ciljna usmerjenost, čustva..

Lenka Svobodová, Alena Skotáková, Petr Hedbávný, Pavlina Vaculíková, Martin Sebera

UPORABA PLESNE PLOŠČADI ZA RAZVOJ RITMIČNIH SPOSOBNOSTI

V naši raziskavi smo ocenili učinek programa vadbe na plesni ploščadi na razvoj ritmičnih sposobnosti, katere so pomembni dejavniki, ki vplivajo na uspešnost v orodni telovadbi, plesu, drsanju ipd. Vzorec je sestavljalo 28 plesalk, starih od 8-13 let. Testirane osebe so bile razdeljene v 2 skupini glede na starost in dolžino plesnega staža. Vsaka skupina je bila nato razdeljen na poskusno in kontrolno skupino. Poskusne skupine so bile pozvane, da plešejo na plesni ploščadi 3-krat na teden dva meseca in pol. Stopnjo ritmičnega zaznavanja smo izmerili s testom za ritmično diskriminacijo. Stopnja ritmične izvedbe je bila merjena s programsko opremo za testiranje reakcijskega časa pri testu bobnanja z rokami in nogami. Za analizo podatkov o spremembi ritmičnih sposobnosti smo izvedli opisno statistiko in t-test, izračunali Cohenof d koeficient in Spearman rang korelacijo. Čeprav raziskava ni potrdila pozitivnega vpliv plesne ploščadi na razvoj ritmičnih sposobnosti testiranih oseb, pa se lahko uporablja plesna ploščad za raznovrstno obliko vadbe.

Ključne besede: telesna vzgoja, orodna telovadba, merski postopki, znanje, smernice.