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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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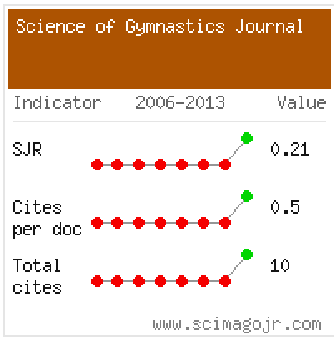


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Fundacija za šport

Slovenian Research Agency

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# International Scientific Conference
# Sport Health & Education
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**18-20th of June 2015**

**Organizers:**

# Gdansk University of Physical Education and Sport

**In cooperation with the:**

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**University of Debrecen , Hungary**
**Charles University in Prague, Czech Republic**
**University of Ljubljana, Slovenia**
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SCIENCE OF GYMNASTICS JOURNAL

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**EDITORIAL**

Dear friends,

We are entering into the 7th year of publishing our journal. Up until this issue, 91 original scientific articles and 6 review articles have been published. With this issue (17th) we cross the threshold of 100 published articles which is quite a significant number for a highly specialized journal. For this year it is our plan again to publish 20 articles. Our journal has been recently entered into the ErihPlus data base for humanities and social sciences. The process of evaluation took more than half a year but was successfully completed.

Just after we published last issue, sad news came from Brazil. Our friend, who dedicated his life to gymnastics and science, John H. Salmela passed away. In his memory his friends Natalie Durand-Bush, Jean Côté, Gordon Bloom wrote John H. Salmela, Ph.D, Celebration of life.

International Scientific Conference: Sport, Health & Education – Complementary Approach to Gymnastics, held 18 -20 June 2015 at Gdansk University of Physical Education and Sport in Poland, would like to welcome all our readers. For more information please check our next pages or visit their home page http://www.v4gymnastics.awfis.net/.

The first article in the current issue is by Pia M. Vinken (Germany). She explores short term effects of elastic taping on gymnast's performance. Please take note and transfer her results to practice: for healthy gymnasts, taping has no use.

The second article is also medical in content. It was written by Greek Italian authors Paschalis Kirialanis, George Dallas, Allessandra Di Cagno and Giovanni Fiorilli and deals with knee injuries at the landing and take-off phases. Most common causes of injury seem to be landings in floor exercises and take-offs in vaulting.

The third article is again from Germany. Damian Jeraj and Thomas Heinen conducted a research of coaches manual guidance techniques. They discovered that timing is much more important than the angle or the force the coach uses.

The forth article by Petr Hedbávný and Miriam Kalichová of the Czech Republic looks at how to optimize velocity on Yurchenko vault. As it is currently performed by both man and women it may be interesting to coaches of artistic gymnastics.

In this issue we have another article from Asia (two articles by authors from China have already been published): more specifically, from Iran, where Mahammad Mehrtash, Hadi Rohani, Esmail Farzaneh and Rasoul Nasiri monitored effects of six months of specific aerobic gymnastics training on motor abilities of 10-12-year-old boys.

The sixth article is about judging and is contributed by the author of these lines who conducted a research study on reliability and validity of spectators judging along with professional judges. The results are surprising and show that it may be possible to include spectators into the judging process.

The seventh article is a review of book 'Science of Gymnastics' written by German authors Damian Jeraj, Linda Hennig and David Schmidt-Maaß. In previous issues we presented lists of new books on the market; this issue features our first book review.

Finally, Anton Gajdoš prepared for Short Historical Notes II a memo about three excellent gymnasts: Larisa Latynina, Vera Časlavska and Viktor Čukarin.

Just to remind you, if you quote the Journal: its abbreviation on the Web of Knowledge is SCI GYMNASTICS J. I wish you pleasant reading and a lot of inspiration for new research projects and articles,

Ivan Čuk
Editor-in-Chief

# SHORT-TERM EFFECTS OF ELASTIC TAPING ON GYMNAST'S JUMPING PERFORMANCE

**Pia M. Vinken**

Institute of Sport Sciences, Georg-August-University Göttingen, Germany

*Original article*

***Abstract***

*It was explored whether three different applications of elastic tape on the lower limbs of active, healthy gymnasts influence their vertical jumping performance. 16 gymnasts randomly performed drop jumps, squat jumps, and counter movement jumps on a force platform in four experimental conditions: 1. no tape application, 2. rectus femoris tape application, 3. triceps surae tape application, and 4. sham tape application. Five task-relevant parameters were calculated in order to represent vertical jumping performance in the three vertical jumping tasks: 1) contact time during take-off phase, 2) peak vertical force during take-off phase, 3) flight duration, 4) peak vertical impact force during landing phase, and 5) time to peak vertical impact force during landing phase. A decrease in flight duration during drop jumping, and counter movement jumping appeared when elastic tape was applied. During drop jumping gymnasts' flight duration decreased when elastic tape was applied to the triceps surae muscle. During counter movement jumping gymnasts' flight duration decreased when elastic tape was applied on the rectus femoris muscles. It is concluded that there is no apparent beneficial need for active, healthy gymnasts to apply elastic tape in order to enhance vertical jumping performance.*

***Keywords:*** *Vertical Jumping, Force Platform, Athletic Performance.*

## INTRODUCTION

The implementation of elastic tape straps in the applied sport became quite apparent in the last few years. The primary aim in using these tape straps is to support muscle functioning, when athletes are suffering from an injury, or in case of restricted muscle functioning due to overuse and/or harm. However, elastic tape straps may also be used in terms of prevention, or even performance enhancement when muscle functioning is not restricted (Kumbrink, 2012). Therefore, the aim of this study was to explore whether the application of elastic tape on the lower limb may influence vertical jumping performance. To approach this, three different applications of elastic tape at the lower limb were examined to influence vertical jumping performance in three different jumping tasks.

There are several conceptualizations for the cotton elastic tape straps in sport science and related fields. These conceptualizations are *kinesio tape* (O'Sullivan & Bird, 2011; Williams, Whatman, Hume, & Sheerin, 2012), *kinaesthetic tape* (Bassett, Lingman,

& Ellis, 2010), and *elastic tape* (Huang, Hsieh, Lu, & Su, 2011). There are also specific brand names, such as Kinesio® Tape, K-Tape®, Kintex™, or alike. In this manuscript the term *elastic tape* is used, referring to tape straps that can be stretched longitudinally up to 120-140% of their original length, and shorten after they were attached to the skin (Halseth, McChesney, DeBelsio, Vaughn, & Lien, 2004).

Elastic taping is hypothesized in sport prevention and sport rehabilitation to improve body functioning when for instance dealing with pain, blood and lymph flow, sensory perception, as well as joint, muscle, and fascia functioning (Kase, Wallis, & Kase, 2003). However, a systematic review conducted on the use and treatment efficacy of elastic taping highlights, that the reviewed articles neither indicated a clinical significance of elastic taping on pain reduction (shoulder and neck), scapular kinematics, muscle strength, electromyographic activity, nor on cervical range of motion. It is argued that the discussed studies failed to report significant effects mainly due to insufficient methodological quality (Bassett et al., 2010). Nevertheless, a meta-analysis concerning the use of elastic taping in treatment and prevention of sport injuries indicated that elastic taping could have a small, yet beneficial effect on muscle strength but fails for instance to affect proprioception at the ankle (Williams et al., 2012).

Empirical results of elastic, lower leg taping on active, healthy subject's performance are also conflicting. Positive effects of elastic taping occurred for instance when measuring relative peak torque changes of the vastus medialis muscle via surface electromyography (Slupik, Dwornik, Bialoszewski, & Zych, 2007), vertical ground reaction force (Huang et al., 2011), and height of flight (Mostert-Wentzel et al., 2012) when performing a vertical jump. Furthermore, no or even contradictory effects of elastic tape occurred when measuring isokinetic muscle strength of the anterior and posterior thigh (Fu et al., 2008), isokinetic quadriceps femoris muscle strength, lower limb performance and subjective perception of strength (Vercelli et al., 2012), tensiomyographic response of vastus lateralis and medialis muscles, maximum power output, performance of counter movement jump and 10-m-sprint (De Hoyo, Álvarez-Mesa, Sañudo, Carrasco, & Domínguez, 2013) as well as during measurements of vertical and horizontal jumping performance and dynamic balance (Nunes, de Noronha, Cunha, Ruschel, & Borges 2013).

Inconclusive evidence concerning performance related effects of elastic taping might in part be explained by methodological differences between the studies just mentioned, like for instance differences in tape application procedures, participant characteristics, measurement procedures, or empirical tasks. Given that elastic taping is likely to influence vertical jumping performance (Huang et al., 2011; Mostert-Wentzel et al., 2012) this may be of special, practical interest when the experimental tasks implemented cover the requirements of the sporting event. Compared to other sport disciplines like team sports, combat sports, swimming and track and field, the jumping performance in artistic gymnastics training and competition is quite manifold and requires two-legged reactive take-offs, decelerated landings as well as generating momentum with and without a counter movement (Arkaev & Suchilin, 2004). The standardized experimental vertical jumping tasks implemented in this study cover the characteristics of gymnasts' vertical jumping during training and competition. For instance, reactive take-offs occur in floor and vaulting events and represent the drop jump. Generating momentum with and without a counter movement occurs in mounts to beam, pommel horse and parallel bars as well as in artistic floor and beam leaps, thus representing the squat jump, and the counter movement jump. Additionally, it is of special interest to explore possible performance related effects of elastic taping in gymnastics because the use of tapes, bandages and/or orthoses in gymnastic competitions is restricted unless they are skin-coloured (FIG, 2013).

Given that for instance elastic taping is likely to influence gymnasts' vertical jumping performance (Huang et al., 2011; Mostert-Wentzel, 2012) at least two questions arise: First, does the hypothesized effect of elastic taping depend on the kind of the vertical jumping task (e.g., drop jump vs. squat jump vs. counter movement jump)? Second, does the hypothesized effect of elastic taping depend on the tape application area and/or procedure (e.g., rectus femoris muscle and/or triceps surae muscle)? Exploring these questions may reveal if different elastic tape applications may influence different requirements of vertical jumping.

In order to address these questions, it was explored whether three different applications of elastic tape on the lower limbs of active and healthy gymnasts influence their corresponding jumping performance in three different vertical jumping tasks. It was hypothesized that elastic tape applications on gymnasts' rectus femoris and triceps surae muscles influences vertical jumping performance. Rectus femoris and triceps surae muscles primarily affect vertical jumping performance (Finni, Komi, & Lepola, 2000; Viitasalo, Salo, & Lahtinen, 1998). Therefore, if any effects occur, tape applications on these muscles most likely should influence gymnast's vertical jumping performance. Additionally it was hypothesized that this effect may or may not depend on the vertical jumping tasks, namely the drop jump, the squat jump, and the counter movement jump. A sham tape application was hypothesized to have no influence on vertical jumping performance but should function as a control condition (Williams et al., 2012).

## METHODS

**Experimental Tasks.** Gymnasts were instructed to perform drop jumps, squat jumps, and counter movement jumps on a force platform with a sampling rate of 1000 Hz (TrueImpulse™, Northern Digital Inc., Canada). It was decided to use the aforementioned standardized vertical jumping tasks, since they also occur in general artistic gymnastic situations.

During all jumps, the arms were held at the hip, whereas take-off and landing of each jump occurred on the force platform. When performing a drop jump, the gymnast dropped from a gymnastic block onto the force platform and performed a reactive maximum vertical jump. The height between the surface of the block and the surface of the force platform was 35 cm. Bobbert and colleagues (1986) suggest dropping heights between 20 and 40 cm regarding joint reaction forces, mechanical output and quality of jumping performance (Bobbert, Mackay, Schinkelshoek, Huijing & van Ingen Schenau, 1986). Additionally, the dropping height of the gymnastic block fits the requirements of gymnastics training and conditioning (Arkaev & Suchilin, 2004). When performing a squat jump, the gymnast got into a squatted resting position with an individually preferred knee-angle between 70 and 90° (Baechle & Earle, 2008; Bobbert, Gerritsen, Litjens, & Van Soest, 1996). From this resting position, the gymnast performs a maximum vertical jump. When performing a counter movement jump, the gymnast performed a maximum vertical jump starting from an upright standing position followed by a downward movement to an individually preferred knee-angle between 70-90° (Baechle & Earle, 2008; Bobbert et al., 1996; Bobbert et al., 1986). Knee-angles were controlled first, via visual observation. Second, each trial was videotaped with a digital high-speed video camera (Casio Exilim ZR-400) operating at 120 Hz and with a spatial resolution of 640 x 480 pixels. The camera was placed orthogonal to the performing gymnast's sagittal axis and 5 m away from the centre of the force platform. A movement analysis with the software utilius easyINSPECT (CCC-Software, 2008) revealed no deviations of knee-angles above 90° or below 70°. Prior to each jump, the gymnast was instructed to jump as high as possible. Additionally in all tape application conditions, the gymnast was instructed in such a way that all tape applications support vertical jumping performance. The instruction was: "This tape applications is positively influencing your general vertical jumping performance, and we want to explore in which jumping task which tape application may best support your vertical jumping performance."

**Task Analysis.** Vertical ground reaction force measurements and time-discrete task parameters of all vertical jumping performances were analysed using a force platform operating with a sampling rate of 1000 Hz. Following the argumentation of previous studies (Enoka, 2002; Marina, Jemni & Rodríguez, 2013; Mkauer, Jemni, Amara, Chaabèn & Tabka, 2012) and with the help of a professional sport biomechanist, five task parameters occurring in each jumping task were calculated in order to represent vertical jumping performance during take-off-, flight- and landing phase in the three vertical jumping tasks. The parameters were: 1) contact time during take-off phase ($t_0 – t_1$), 2) peak vertical force during take-off phase ($F_1$), 3) flight duration ($t_1 – t_2$), 4) peak vertical impact force during landing phase ($F_2$), and 5) time to peak vertical impact force during landing phase ($t_2 – t_3$). 1), 3) and 5) indicate the durations between starting and end point of each phase in Milliseconds. $t_0$ was defined as the first deviation of vertical ground reaction force from the resting position's vertical ground reaction force (zero in the drop jump and approx. body weight in the squat and countermovement jump). $t_1$ was defined as the last deviation from zero before the final take-off. $t_2$ was defined as the first deviation from zero following the initial landing contact. $t_3$ was defined depending on the time of the peak vertical impact force during the landing phase ($F_2$). $F_1$ and $F_2$ indicate the maximum vertical peak force of the take-off ($F_1$) and landing ($F_2$) phase in Newton.

The task parameters just mentioned on the one appear in each of the three vertical jumping tasks and thus make the tasks comparable. On the other hand these parameters can modulate force diagrams and rely to further parameters, which cannot be assessed directly like for instance internal load etc. Furthermore the five parameters calculated are sensitive to interventions of the vertical jumping tasks (Bobbert et al., 1986; Finni et al., 2000).

**Tape Application Procedures.** The elastic tape applied in this study was a black, 5 cm wide, elastic tape (K-Tape®, biviax GmbH, Germany). It was decided to use black tape throughout the whole study to avoid colour preferences. Nevertheless, one may argue in line with the philosophy of elastic taping that black elastic tape should enhance and empower muscle functioning (Kase et al., 2003; Kumbrink, 2012). In one tape application condition (RFTA), the left and right rectus femoris muscle was taped from origin to insertion (proximal to distal) using a Y-shaped elastic tape strap (Vercelli et al., 2012). In another tape application condition (TSTA), the left and right triceps surae muscle was taped from origin to insertion (proximal to distal) using a Y-shaped elastic tape strap (Nunes et al., 2013). It was decided to apply the elastic tape from origin to insertion and with 50-75% of stretch, because this direction and amount of stretch is thought to facilitate and activate the taped muscle (Kase et al., 2003; Kumbrink, 2012). In an additional tape application condition, a sham tape (Vercelli et al., 2012) was applied on the left and right muscle belly of both, rectus femoris and triceps surae muscles perpendicular to their muscle fibre orientation. Here, two I-shaped elastic tape straps were applied without additional stretch (SHTA, c.f. Fig. 1). A professional taping expert was asked to apply all elastic tapings.

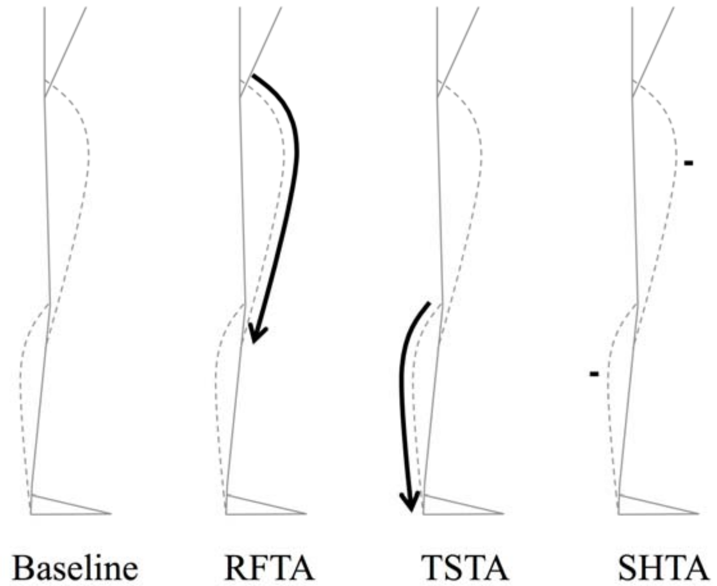


*Figure 1.* Schematic representation of the elastic tape applications implemented in this study. In the baseline condition no tape was applied neither on gymnast's rectus femoris nor triceps surae muscles (dotted grey lines). In the RFTA and TSTA conditions elastic tape was applied from origin to insertion on either gymnast's rectus femoris or triceps surae muscles. In the SHTA condition elastic tape was applied on the muscle belly and perpendicular to muscle fibre orientation of gymnast's rectus femoris and triceps surae muscles.

The study consisted of four phases. During the first phase the gymnast arrived at the laboratory, was instructed about the general purpose of the study, and completed an informed consent form. Gymnast's height and weight was measured and the gymnast was given an individual, self-directed ten-minute warm-up phase consisting of mobilisation drills, like heel rises, squats and lunges as well as basic gymnastic jumps and landings, like reactive jumps, tucked jumps and basic one- and two-legged jumps and landings. Afterwards a practice period of at least four practice trials of each vertical jumping task was conducted to familiarize the gymnast with each task. The second phase comprised a baseline condition without any elastic tape application in which the gymnast performed blocks of four valid drop jumps, squat jumps, and counter movement jumps for a total of twelve jumps. Jumping tasks were presented in a blockwise randomized order for each participating gymnast. When gymnasts accidently performed the wrong jumping task, did not reach the defined knee-angle, did not dropped-off and/or land on the force platform or reported/showed any movement discrepancies, like for instance an unstable landing, the trial was repeated.

The third phase consisted of a total of 36 jumps. Each gymnast was asked to perform blocks of four valid drop jumps, squat jumps, and counter movement jumps in the three tape application conditions, whereas block order (drop jump, squat jump, and counter movement jump) was randomly presented to each gymnasts in each tape application condition. Rectus femoris tape applications and triceps surae tape applications were also randomly presented to each gymnast in such a way, that one of the two tape applications was presented first and the other one afterwards. The sham tape application condition was always presented last. During each tape application condition, both legs were taped and after a ten-minute time slot to ensure full adhesive strength of the elastic tape the gymnast performed the jumping tasks (Vercelli et al., 2012). In the fourth phase the gymnast was debriefed and received a thank-you gift. During the debriefing process a manipulation check was conducted indicating that none of the participating gymnasts indicated to perceived an experimental manipulation concerning the tape application procedures, neither the experimenter's instructions nor the experimental tasks. There was no time pressure during the study and the gymnast was allowed to rest as needed.

**Data Analysis**. In order to get an estimation of the average performance in each individual case and in order to reduce within participant variation, means and standard errors of each gymnast's four trials in each jumping task and each tape application condition were calculated. A significant level of $\alpha = .05$ was defined for all results reported in this study. According to differences in task characteristics of the three vertical jumping tasks, separate univariate analyses of variance were calculated, taking the five task parameters 1) contact time during take-off phase, 2) peak vertical force during take-off phase, 3) flight duration, 4) peak vertical impact force during landing phase, and 5) time to peak vertical impact force during landing phase as dependent variables. Tape application condition (Baseline vs. RFTA vs. TSTA vs. SHTA) was treated as a within-subjects factor. Cohen's $f$ was calculated for all significant results reported. Post-hoc tests (Tukey HSD) were calculated for all significant results reported. In order to get an estimation of gymnasts' jumping performance, means and standard errors were calculated for each of the five parameters.

## RESULTS

It was hypothesized that the elastic tape application on gymnasts' rectus femoris and triceps surae muscles influences vertical jumping performance. Additionally it was hypothesized that this influence may or may not depend on the vertical jumping tasks, namely the drop jump, the squat jump, and the counter movement jump. A sham tape application was hypothesized to have no influence on vertical jumping performance.

Table 1 shows the aggregated data of the analysis. There was a significant main effect of tape application condition (Baseline vs. RFTA vs. TSTA vs. SHTA) for flight duration in the drop jump, $F(3, 45) = 3.229$, $p = .031$, Cohen's $f = 0.46$, and for flight duration in the counter movement jump, $F(3, 45) = 4.105$, $p = .012$, Cohen's $f = 0.52$. Figure 2 illustrates the average flight durations in the three vertical jumping tasks and the four tape application conditions. Gymnasts' average flight duration of the drop jump decreased compared to the baseline condition about 16.24 ms in the triceps surae tape application condition. During the counter movement jump the most apparent decrease of gymnasts' average flight duration compared to the baseline condition appears in the rectus femoris tape application condition. Here, the mean flight duration decreases about 12.52 ms. According to Tukey HSD post-hoc analysis, first a significant difference between the baseline tape application condition and the triceps surae tape application condition was found for the drop jump. Second, a significant difference appeared for the counter movement jump between the baseline tape application condition and the rectus femoris tape application condition. Nevertheless, none of the remaining calculated effects became significant, indicating no differences in the particular parameters between the tape application conditions.

## DISCUSION

The aim of this study was to explore whether three different applications of elastic tape on the lower limbs of active and healthy gymnasts influences their vertical jumping performance in three different vertical jumping tasks. It was hypothesized that the elastic tape application on gymnasts' rectus femoris and triceps surae muscles influences vertical jumping performance. Additionally it was hypothesized that this influence may or may not depend on three different jumping tasks.

Table 1
*Aggregated data of vertical jumping task performance*

| **Jumping Task** Parameter | Baseline No tape Mean ± SE | Tape Application Conditions RFTA Mean ± SE | TSTA Mean ± SE | SHTA Mean ± SE | *F*(3, 45) | *p* | Cohen's *f* |
|---|---|---|---|---|---|---|---|
| **Drop Jump** | | | | | | | |
| Contact time during take-off phase [ms] | 207.33 ± 10.02 | 212.48 ± 15.39 | 209.00 ± 12.60 | 207.70 ± 14.05 | 0.237 | .870 | - |
| Peak force during take-off phase [N] | 2296.51 ± 29.48 | 2290.14 ± 32.23 | 2300.61 ± 26.82 | 2282.25 ± 28.46 | 0.171 | .915 | - |
| Flight duration [ms] | 487.44 ± 10.02 | 476.92 ± 9.83 | 471.20 ± 9.33 | 476.25 ± 10.37 | 3.229 | .031 | 0.46 |
| Peak impact force during landing phase [N] | 2006.43 ± 56.70 | 2054.08 ± 51.93 | 1987.45 ± 53.14 | 2076.06 ± 55.51 | 1.438 | .244 | - |
| Time to peak impact force during landing phase [ms] | 80.50 ± 2.42 | 83.21 ± 2.06 | 82.30 ± 1.84 | 82.53 ± 2.18 | 0.739 | .534 | - |
| **Squat Jump** | | | | | | | |
| Contact time during take-off phase [ms] | 359.17 ± 20.50 | 366.07 ± 17.12 | 350.08 ± 12.16 | 368.63 ± 16.93 | 0.690 | .563 | - |
| Peak force during take-off phase [N] | 1578.34 ± 89.41 | 1606.22 ± 99.30 | 1601.22 ± 90.66 | 1591.41 ± 94.37 | 0.783 | .510 | - |
| Flight duration [ms] | 479.59 ± 11.15 | 475.44 ± 11.69 | 471.84 ± 11.31 | 471.45 ± 10.78 | 1.732 | .174 | - |
| Peak impact force during landing phase [N] | 2037.38 ± 63.46 | 2065.24 ± 50.86 | 2033.04 ± 51.16 | 2074.78 ± 57.20 | 0.588 | .626 | - |
| Time to peak impact force during landing phase [ms] | 82.65 ± 2.81 | 87.57 ± 2.81 | 86.30 ± 2.85 | 87.25 ± 3.16 | 2.142 | .108 | - |
| **Counter Movement Jump** | | | | | | | |
| Contact time during take-off phase [ms] | 756.53 ± 31.23 | 769.80 ± 29.85 | 776.94 ± 30.03 | 772.45 ± 33.59 | 0.860 | .469 | - |
| Peak force during take-off phase [N] | 1619.69 ± 96.38 | 1621.75 ± 85.04 | 1607.18 ± 85.26 | 1645.18 ± 68.93 | 0.243 | .866 | - |
| Flight duration [ms] | 492.85 ± 11.79 | 480.33 ± 13.53 | 490.28 ± 12.88 | 488.81 ± 13.14 | 4.105 | .012 | 0.52 |
| Peak impact force during landing phase [N] | 2022.91 ± 65.20 | 1987.12 ± 60.63 | 1980.40 ± 63.04 | 1997.80 ± 101.97 | 0.217 | .884 | - |
| Time to peak impact force during landing phase [ms] | 83.32 ± 2.35 | 86.02 ± 3.04 | 86.73 ± 2.86 | 86.41 ± 3.70 | 0.950 | .424 | - |

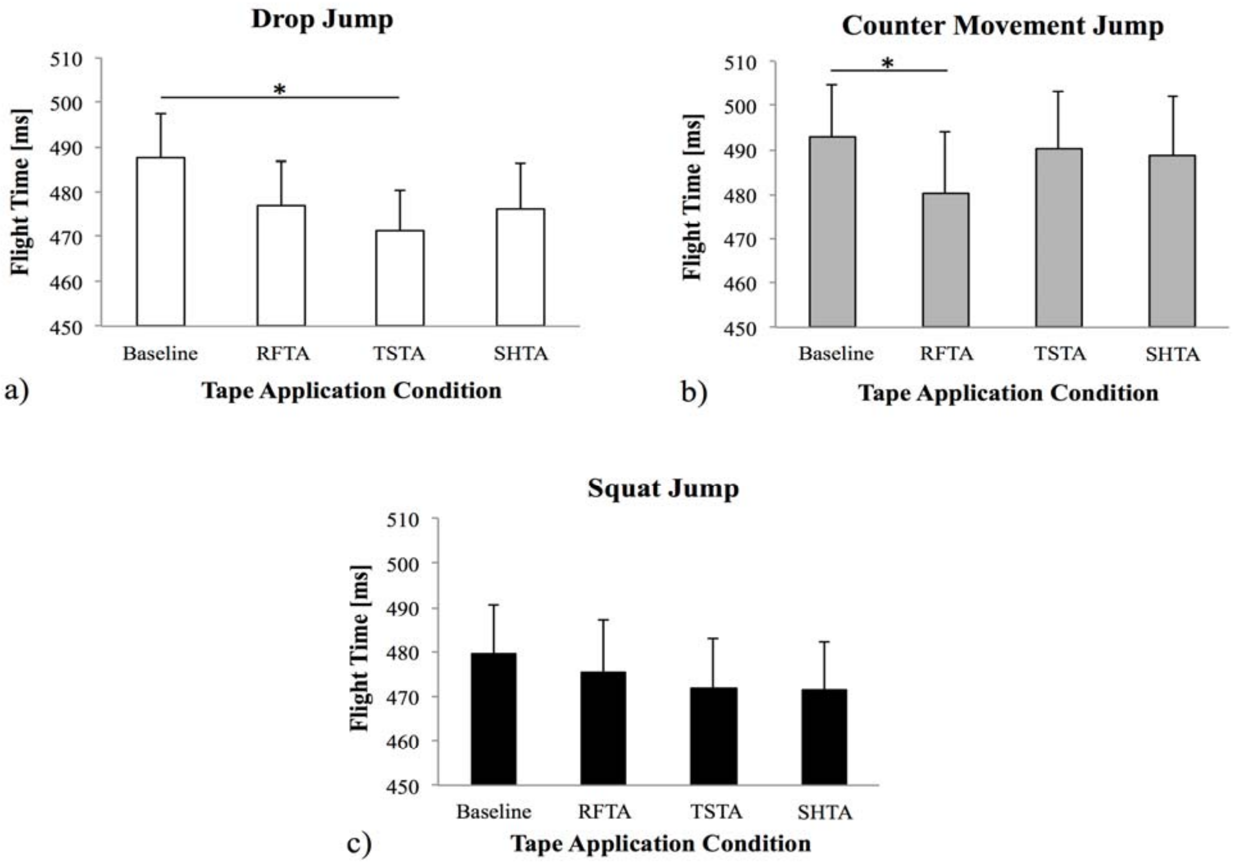


*Figure 2.* Means and standard errors of gymnast's flight duration in the three vertical jumping tasks a) the drop jump, b) the counter movement jump and c) the squat jump in the four study conditions (* = significant difference at $p < .05$ according to Tukey HSD post-hoc analysis).

A sham tape application was hypothesized to have no influence on vertical jumping performance but should function as a control condition. In all tape application conditions gymnasts were instructed in such a way that each tape application is due to support vertical jumping and is thought to function as a performance-enhancing tool. However, it should be explored in which parameters, which tasks and which amount these effects occur.

Most surprisingly, and in contrast to most of the results of the former studies on performance related effects of elastic tape (c.f. Huang et al., 2011; Mostert-Wentzel et al., 2012), the results of this study revealed a decrease in flight duration during drop jumping and counter movement jumping when elastic tape was applied. In the rectus femoris tape application condition gymnasts flight duration during the counter movement jump significantly decreased. This may be due to the fact that the facilitative tape application (from origin to insertion) on gymnasts' rectus femoris muscles inhibits the stretching part during the stretch-shortening cycle of the counter movement during this specific jumping task (Finni et al., 2000). The same may be true for the drop jumping task in which gymnasts' flight duration decreased in the triceps surae tape application condition compared to the baseline condition without an elastic tape application. The result that there is no significant effect on flight duration during the squat jumping task underlines the argumentation, that facilitative elastic tape application (from origin to insertion) has a performance hampering effect on vertical jumping performance in jumping tasks containing a stretch-shortening cycle, whereas no such effect could be shown for a vertical jumping task performed from a resting position without any stretch-shortening movement (squat jump).

The sham tape application was hypothesized to have no influence on jumping performance but should function as a control condition (Williams et al., 2012). In line with the results of former studies implementing an elastic tape application as a control condition (Chang, Chou, Lin, Lin, & Wang, 2010; Fratocchi et al., 2013; Mostert-Wentzel et al., 2012; Vercelli et al., 2012) the results of this study revealed no performance influencing effect of the sham tape application condition when it is applied on the muscle belly of the rectus femoris and triceps surae and perpendicular to their muscle fibre orientation. In the sham tape application it was decided to apply the elastic tape perpendicular to the muscle fibre orientation of rectus femoris and triceps surae to avoid mechanical co-interactions of neighbouring muscles (c.f. vastus intermedius, vastus lateralis, vastus medialis, tibialis anterior) which may have occurred when the sham tape application would have been applied longitudinal and next to the intended muscles. However, gymnasts in this study reported to indicate no manipulation of the tape application conditions, the sham tape application should be quite similar to the other tape application conditions. Containing for instance the same amount of elastic tape, and/or focusing on one body segment area in each tape application condition should be appropriate for future studies.

Quite confidently, the decreasing, yet performance hampering effect of the elastic tape application on the triceps surae during the drop jump and on the rectus femoris during the counter movement jump, seems to be caused mostly by mechanical properties instead of superstitious effects, like for instance increased attention, hampering tactile perception or a negative attitude. Nevertheless the elastic tape application may have a facilitating effect on factors such as inter- and intramuscular coordination or even muscular co-contraction as well as sensory input. But these effects are yet speculative and open to further investigations.

However, the flight duration in vertical jumping is highly depending on the way the gymnast performs the landing phase (e.g. bend or straight ankle, knee and hip joints; Horita, Komi, Nicol, & Kyröläinen, 2002) and 36 jumps may result in fatigue, these aspects do not seem explain the decrease in gymnasts' flight time. First, gymnasts' general execution of the vertical jumping tasks was well trained and did not vary significantly during the study progress. Additionally in a general floor, vault or beam warm-up and/or preparatory drill gymnasts are exposed to about 80 reactive take-offs and 60-80 take-offs with and without a counter-movement (e.g. basic drills, gymnastic leaps, somersaults) and the appropriate number of landings (Arkaev & Suchilin, 2004). Second, in spite of that, means and standard errors of the four jumps of each vertical jumping task in each tape application condition were calculated and utilized for further statistics.

There are several limitations of this study, and three specific aspects should be highlighted. First, it was decided to assess vertical jumping performance by means of a force platform since former studies indicated a positive effect of elastic taping on vertical jumping performance (Huang et al. 2011; Mostert-Wentzel et al., 2012). However, the same vertical jumping performance may result from different activation patterns of the leg muscles (Enoka, 2002) thus masking the isolated effect of elastic taping on one particular area. Future studies could integrate more complex measurements in their designs such as electromyographic measurements or alike. Second, it was decided to apply the elastic taping from origin to insertion, which should have a facilitating and activating effect on the taped muscle (Kase et al., 2003; Kumbrink, 2012). Surprisingly our results revealed a contrary result. Therefore, on the one hand it seems advisable for future studies to implement both tape application directions into their design

(Vercelli et al., 2012). On the other hand possible effects of tape applications implemented on (soft) tissues other than muscle, like for instance tendon, ligament, capsule, and other joint structures should be investigated (O'Sullivan & Bird, 2011). Third, one could argue that elastic taping may have different performance related effects in more coordinative task in which participants need to respond and adjust their movements according to natural or manipulated changes in the task execution, like for instance in tasks affording dynamic balance and/or dealing with perturbation. Therefore it might be beneficial to explore the effects of elastic taping on tasks with different demands in particular, or in light of the requirements of the sporting event in which athletes apply elastic taping in general.

However, two practical implications of this study can be summarized. First, there is no need for healthy, active gymnasts to apply elastic tape on rectus femoris and/or triceps surae in order to enhance vertical jumping performance. But second, depending on the vertical jumping task elastic tape applications which do not hamper performance (e.g. RFTA and SHTA in the drop jumping task, TSTA and SHTA in the counter movement jumping task, and all elastic tape applications in the squat jumping task) may function as superstitious, supporting and/or prophylactic tools when athletes believe in their postulated effects and thus may support performance although this is not measurable by the five task parameters applied in this study.

## CONCLUSION

When applying elastic tape for performance enhancing purposes it should be taken into account that empirical evidence is still inconclusive. Whereas former studies failed to report conclusive performance-enhancing effects, the results of the present study revealed performance-decreasing effects of elastic taping on gymnasts' vertical jumping performance. It is concluded that there is no need for healthy, active gymnasts to apply elastic tape in order to enhance vertical jumping performance. Conflicting scientific results may thus indicate that generalized effects are controversial and positive influences in one specific characteristic can induce a decrease in another performance influencing characteristic. Although, athletes may use elastic tape for individual reasons such as comfort or even the belief in its clinical significance, it still seems to be of high interest to study potential effects of elastic taping in a standardized methodological approach and in light of the requirements of the sporting event.

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# KNEE INJURIES AT LANDING AND TAKE-OFF PHASE IN GYMNASTICS

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*Original article*

***Abstract***

*The purpose of the present study was to record the incidence of knee injuries in Greek artistic gymnasts in relation to the event and exercise phase. Two hundred artistic gymnasts aged 12.2 ± 2.8 years from different clubs of North and South Greece volunteered to participate in this study for the 2010-2012 seasons. Authors twice a week registered any injury occurred during practice or event which made the gymnast miss the next practice or event session. Results showed that gymnasts sustained 49.5% of knee injuries in landing mainly in the floor routines causing ligament sprains with these injuries to be occurring at the pre-competition season, usually during training time. Furthermore, knee injuries at take off phase (11.9%) occurred mainly in the vaulting horse on forward rotation exercises on the first competition level. Conclusively, coaches mainly must use supplementary soft mats during training to restrict pressure on knee joints on landing phase and control the amount of jumping in an effort to reduce the possibilities to increase knee injuries, especially in this particular age group gymnasts.*

***Keywords:*** *Gymnastics, Risk Factors, Injury Prevention.*

## INTRODUCTION

Sports injuries are phenomenons with variable interaction of risk factors. Every incident that had as a result to deprive the athlete of his/her competence in Artistic Gymnastics (AG) to follow a part of his/her training or contest, was defined as an injury (Caine et al., 1989). Injuries such as those that occur in AG generally result from the culmination of a pre-existing condition and/or a particular set of circumstances (Meeuwise, 1994). The answer to what causes sports injuries has rarely been studied (Lysens et al., 1984). 55-65% of injuries in AG that occur on the lower extremities are related with high repetition frequencies, with 50-70 % of lower limb injuries occurring on the tibiotalar and knee joints (Arampatzis et al., 2003; McNitt et al., 1993). Numerous studies support that the most injured body parts in AG are the lower extremities (Andrish, 1985; Bak et al., 1994; Hunter & Torgan, 1983; Hutchison & Ireland, 1995; Kolt & Kirkby, 1999; Pfister et al., 1985), especially in ankle and knee joints (Bale & Goodway, 1990; Garrick & Requa, 1980; Kerr & Minden, 1988; Pettrone & Ricciardelli, 1983; Tenvergert et al., 1992).

Most injuries are related with landing (Kirialanis et al., 2002; Lindner & Caine, 1990; McNitt-Gray et al., 1994; Meeusen & Borms, 1992; Panzer, 1987; Verhagen et al., 2000). This phase not only affects the final rank of gymnasts during competition (Leskosek et al., 2010), but also entails a high risk of injury, mainly due to the high impact magnitudes of 14 to 18 Body Weight applied to one leg (Panzer, 1987), and to the mat's instability (Arampatzis et al., 2002, 2003). Landing imposes forces on the body that must be absorbed primarily by the musculoskeletal components of the lower extremities. If the loads become too great for the body to accommodate, a potential injury situation arises (Dufek & Bates, 1990). Drawing programs with exercises for good landing in gymnastics, separated from the all routine, would help to decrease impact forces during landing (Gervais, 1997). Takeoff and land are important phases in gymnastics routines. Previous studies showed that the magnitude of impact forces tends to increase with the skill complexity and with the increase of falling height (Karacsony & Cuk, 2005; Marinsek, 2010; McNitt-Gray et al., 1994; Panzer, 1987), ranged from 3.9 to 14.4 times the gymnast's body weight (BW) (McNitt-Gray et al., 1993; Panzer, 1987).Take off also is a phase used primarily in the vault, floor exercise and balance beam (BB) exercises. The take off imposes forces on the body, primarily in the musculoskeletal components of the lower extremities. Takei (1989) reported that the average horizontal and vertical forces during periods were 2970 N, which translated into 4.9 times the BW of the subjects. In addition, forces at takeoff at different somersaults can be up to 13.9 times the participant's BW (Karacsony & Čuk, 2005). Thus, the large changes in knee and hip joints in the range of motion (ROM) suggest that these joints play a greater role than the ankle in adjusting to landings (McNitt-Gray, 1991). However, there is luck of studies about the risk factors causing injuries during these two phases. The purpose of this study was to investigate the risk factors for the knee injuries especially during landing and takeoff phase in AG.

## METHODS

**Subjects.** Two hundred artistic gymnasts (100 males and 100 females) (aged: 12.2±2.8, years, mass 35.6±11.2 kg, height 141.5±15.8 cm,) from different clubs of North and South Greece volunteered to participate in this study. Authors twice a week registered any injury that occurred during practice or event which made the gymnast miss the next practice or event session.

**Statistical Analysis.** An analysis of correspondence was used after an analysis of frequencies to estimate the relation between the criterion variables and the predictor variables for gymnasts.

## RESULTS

From the analysis of frequencies, gymnasts sustained 49.5% of knee injuries in landing and 11.9% in take off. Analysis of correspondence revealed that three factors explain the total variance of the depended variables included in the analysis. The eigenvalues and the percent of variation explained by each factor are presented.

The first factor was created by the depended variables related to the take off (blocking) (Table 2) and the depended variables related to the training characteristics (strength training – flexibility training-warm-up etc).

The second factor was created by the depended variables related to the take off and variables related to the landing (Table 3).

The third factor was created by the depended variables related to the take off and variables related to the fall. (Table 1).

It is evident that knee injuries from landings mainly occur during backward saltos particularly in the floor exercise causing ligament sprains. Moreover, the time of rehabilitation lasts more than 2 months, in most not "selected" gymnasts sustained one injury in the knee over the season (for the competition gymnastics). In the side of the first and third factor axes, where are located the take off (blocking) are loaded the variables of table 3.

As it turns out from table 3, knee injuries at take off phase occurred mainly in the vaulting horse on forward rotation exercises (forward saltos), and they are presented to the first competition level (beginners: ages 7-10 for boys and 7-9 for girls), in not "selected" gymnasts and they did not need medical care, due the fact that the duration of rehabilitation was less than one month.

From the analysis of correspondence for the relation between the phases at which occurred the knee injuries and the predictor variables as risk factors resulted two factor axes which interpret the 80.5% of total variation.

By table 2, it is realized that knee injuries at the landing occur at the pre-competition season, usually during training time, when the training duration is more than four hours a day and the repetition of elements on the vault is more than twenty. Knee injured gymnasts present re-injury and first aids are usually given by a physiotherapist. Also, variables that are related to the knee injuries at the landing are the lack of safety and spotting equipment e.g. springboard tumbling, foam pits which reduce up to 50% peak vertical ground reaction forces (VGRF) (Daly et al, 2001; Wilson et al, 1989). Landing at the competition season under normal conditions without using thick and soft landing mats and not practicing special landing elements can be a risk factor for knee injuries.

In the side of the first factor axis where are located knee injuries at the take off, the variables that are loaded usually occur during training time, when the training duration is more than 2-4 hours daily, and the repetition of taking off is more than 30 times in a training day (table 3).

Table 1

*Eigenvalue % of variance and % Cumulative variation*

| Factors | Eigenvalue | % of variance explaned | Cumulative variation |
|---|---|---|---|
| 1st factor (take-off - other) | 0.077 | 38.21 | 38.21 |
| 2nd factor (landing-take-off) | 0.072 | 35.79 | 74.00 |
| 3th factor | 0.0527 | 26.00 | 100.00 |

Table 2
*Variables that are included in the side of factor axes where are located knee injuries due take-off*

| Variables | Coordinates | Absolute attendance | Relative attendance |
|---|---|---|---|
| Age of beginning training 3,4, 5 years | 0.30 | 7.1 | 0.95 |
| Vault | 0.44 | 5.7 | 0.26 |
| Exercises with front rotation (front saltos) | 0.35 | 6.4 | 0.74 |
| Re-establishment in less than 1 month | 0.14 | 1.2 | 0.62 |
| 1st competition level (young - boys 7-10 and girls 7-9 years old) | - 0.49 | 11.8 | 0.99 |
| Non selected | - 0.13 | 2.1 | 0.25 |
| No medical treatment | - 0.36 | 5.5 | 0.49 |
| Training 2 until 4 hours | 0.67 | 5.7 | 0.63 |
| Injuries at training time | 0.04 | 0.1 | 0.18 |
| Above 30 vault elements | 0.19 | 1.3 | 0.23 |
| They afterwards continued training after injury | 0.08 | 0.4 | 0.62 |
| Does not exist re-injury | 0.17 | 0.7 | 0.26 |

Table 3
*Variables that are loaded in the side of factor axes where are located knee injuries due landing*

| Variables | Coordinates | Absolute contribution | Relative contribution |
|---|---|---|---|
| Not selected gymnasts | 0.22 | 4.2 | 0.70 |
| One time injured | 0.15 | 2.4 | 0.72 |
| Floor | 0.22 | 4.5 | 0.63 |
| Sprain of ligaments | 0.30 | 4.5 | 0.90 |
| Time of rehabilitation > 2 months | 0.51 | 11.0 | 0.43 |
| Backward rotation (backward salto) | 0.35 | 8.6 | 0.82 |
| First aids from physiotherapist | 0.30 | 3.1 | 0.72 |
| Training above 4 hours | - 0.23 | 2.8 | 0.32 |
| Lack of foam pits | - 0.48 | 1.4 | 0.42 |
| Lack of spring floor | - 0.15 | 1.4 | 0.15 |
| Injuries at the training time | - 0.05 | 0.3 | 0.31 |
| Injuries at preparatory period | - 0.10 | 0.7 | 0.76 |
| Landings out of foam pits at the competition period | - 0.24 | 1.4 | 0.31 |
| Not used lading mat | - 0.27 | 2.2 | 0.56 |
| Not using special landing exersises | - 0.23 | 4.2 | 0.84 |
| 20-29 vault elements daily | - 0.50 | 9.0 | 0.70 |
| Re-injury | - 0.11 | 0.5 | 0.94 |

## DISCUSSION

**Knee injuries concerning the phase of injuries.** Our results that came from take-off (49.5%) and landing (11.9%) are in agreement with previous studies (Bak et al., 1994; Garrock & Requa, 1980; Gervais, 1997; Hudash & Albright, 1993; Hunter & Torgan, 1983; Kirialanis et al., 2003; Pettrone & Ricciardelli, 1987; Readhead, 1987; Tauton et al., 1988) which support that the repeated jumps and landings at dismounts can cause problems in young gymnasts.

**Knee injuries at landing.** The analysis of equivalences revealed that the greater number of knee injuries at landing occurs during floor exercise. This finding reinforces data of Linder and Caine (1990) which report that 40% of the injuries happened in floor exercise, in erroneous movement and from a lack of the body control at the phase of landing. Also, it was shown by the results that when gymnasts are landing at the competition period outside of foam pits without using thick landing mat, it influences the appearance of knee injuries.

Ligament sprains at the knee during landing are the most common injuries that occur usually after exercises with back rotation and particularly during landing after back somersaults, result that verify previous data (Caine et al., 1989; Vergouwen, 1986). Also, Andrish (1985) supports that ligament sprains have the second place as for the frequency but are the most serious and they need surgical attention.

It is realized that knee injuries at landing are more serious than ankle injuries as a result of the longer time for rehabilitation (2 vs 1 month for knee and ankle injury, respectively) and despite that a lot of knee injured gymnasts tried to continue training after the injury; they presented re-injury. Perhaps, this it is owed to the complexity of the knee articulation and to the Special Forces where it accepts the knee at the landing. With this ascertainment agree findings of Bos and Sol (1982), which report that landing during exercise on the vault and after dismounts, can cause big forces in the ankle joint and particularly in the ligaments. Another factor which contributes to an increasing in the frequency of a knee injuries at the landing includes the number of hours spent training daily (> 2-4 hours daily for the knee injuries and > 4 hours daily for the ankle injuries). No reports exist particularly for the knee injuries at the landing in relation to the duration of training. However, the duration of training has been incriminated by the researchers weekly (Pettrone & Ricciardelli, 1983) generally for knee injuries in gymnastics (Bak et al., 1994; Caine et al., 1994). Also, another external factor that seems to affect the appearance of knee injuries at landing is the lack of certain spotting apparatus like tumbling floor, foam pits.

Our results are partly equivalent with reports of Goodway et al (1990), which support that in gymnastics teams that had fewer safety equipment, more injuries occurred, whereas Lowry and Le Veau (1982) support that the presence of safety equipment does not ensure that they will be used. Meeusen and Borms (1992) report that various spotting equipment are used for the protection from various injuries, emphasizing however that it constitutes question for investigation how much it really happens. On the contrary, other studies (Pettrone & Ricciardelli, 1983; Weiker & Ganim, 1982), did not find a significant relationship between injuries and safety equipment. However, Wilson et al (1989) found that peak VGRF reduced by 50% with the use of a mat and sprung floor, compared with a mat placed directly on a concrete floor. Daly et al (2001), in their review report that no formal controlled studies have evaluated the effectiveness of matting, sprung floors, padded vaults, or other protective devices suggest that safety devices and protective equipment are designed to reduce the magnitude of impact forces imposed on the musculoskeletal system and thereby the potential for injury.

Gymnasts who are not using special exercises for landing during the "training season" and involve a great number of repetition of jumps (>20 jumps daily in vaulting horse) increase the probabilities of knee injuries, a finding that was confirmed by the value and relative attendance at the analysis of correspondence.

The lack of relative reports limits the documentation of ascertainment in the present research on the particular relation. It was realized that non selected gymnasts present more possibilities to be injured in knee joint at landing, compared to selected gymnasts. This ascertainment may be explained by the fact that gymnasts that are selected have certain special characteristics such as special somato-type, small height and body mass (Caine et al., 1989; Claessens et al., 1991), and specific physiologic characteristics such as strength and flexibility (1990). Nevertheless some researchers have characterized certain characteristics as risk factors that affect the appearance of injuries such as higher height and weight (Steele & White, 1986).

Knee injuries in landing phase correlated with the young gymnasts (boys 7-10 years and girls 7-9 years). In this critical age, the knee joint should not be burdened with such a great number of repetitions combined with the length of training spent daily. The results strengthen the opinion that knee injuries at landing or take off phases in gymnastics occurred to the children who are starting gymnastics from an earlier age (3-5 years old) and they usually affect young gymnasts in the competition level (boys 7-10 and girls 7-9 years old). It is common for a gymnast to start training at the age of five or six years (Dixon & Fricker, 1993). Daly et al. (2001) suggest the majority of participants in gymnastics are children and this is probably because of the widely held belief that to achieve success at the highest level, training and competition should begin before puberty.

**Knee injuries at take off.** Our results support that takeoff influences mainly the appearance of ankle injuries. Some of the gymnastics apparatus like the vault for the knee injuries at takeoff seems to have a greater risk of injury than the other apparatus. No previous studies have examined the relation between the incidents of knee injuries at the take off and in the gymnastics apparatus they appear.

According to McAuley et al. (1987) the few injuries that are observed in vaulting could be, be cows of the small time spent on this apparatus, a finding that opposed those of Vergouwen (1986), which report that most injuries occur on vault. From the results of analysis of equivalences did not result particular type of knee injuries at the take off. There is not exists particular report in the probability of knee and ankle injuries at take off, that would argue this suggestion. This can be explained by the fact that in floor exercise and vault apparatus executed, the most important role is played by the ankle joint. The particularity of the step in the spring board, or the ankle at take off, causes the calf muscles to act more than any other muscle. Because these jumps are repeated many times, tendinitis is created, particularly in the Achilles tendon, which needs a long time and particular care for the right rehabilitation. Taunton et al (1988) agree that the repeated jumps can create injuries in new athletes of gymnastics but the most frequent type in these cases are apofysitis and the illness of Osgood. Contrary to the appearance of injuries at the landing, where more serious problems are created in the knee, the phase of take off isn't as serious for the knee injuries. The time of training (2-4 hours) and the big number of takes off (> 30) in a daily unit training affect the appearance of knee injuries at this phase.

Our result, are in congruence with other studies which shows that the great number of takes offs leads to the appearance of injuries (Hudash & Albright, 1993; Tauton et al., 1988). Finally, it is realized that the "selection" is not only factor that determines the athletic career but it also plays an important role in the likely appearance of injuries, which can be interpreted from the fact that "selected" gymnasts will have the suitable mobility, characteristics and fitness, which for some number of researchers constitute risk factors that affect the appearance of injuries (Ekstand & Gilliquist, 1983; Meeusen & Borms, 1992; Micheli, 1985; Steele & White, 1986).

## CONCLUSIONS

Coaches must mainly use supplementary soft mats during training to restrict pressure on knee joints during the landing phase. Further, a strict control and recording of the amount of exercises that is performed during daily training must be done in order to regulate the progressive volume of training, especially in this particular age group of gymnasts.

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# THE SIMULATION OF COACHES' MANUAL GUIDANCE TECHNIQUES DURING THE PERFORMANCE OF A GYMNASTIC SKILL

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*Original article*

***Abstract***

*The aim of this study was to explore the effect of different manual guidance techniques on performance-related variables of a backward salto. We simulated a backward salto by means of a computer model. Changes in performance-related variables were calculated as a result of isolated and combined hand applications. We created seven conditions that varied in angle and amount of added forces, the location of the added forces, and the activation time of the added forces, resulting in 231 simulation runs. We found that the most effective guidance technique was situation specific, because reducing or increasing the gymnast's rotation speed and adding movement height are interdependent. To accompany a movement, it is possible to use an isolated hand application at the iliac crest during the flight phase of the salto, but for stronger support it is necessary to apply a guidance technique immediately at takeoff. When using a guidance technique that involves both hands, it seems that the timing of the hand application is more critical than the angle or amount of added force a coach uses.*
.

***Keywords:*** *Sport, Computer Model, Hand Application, Performance Effects.*

## INTRODUCTION

In the current study, we wanted to analyze the effects of a specific manual guidance technique on the performance of a backward salto. In the research field of sports simulation a variety of models have been developed and the literature reveals a number of different aims (for a review see Chow & Knudson, 2011). Much of the research has to do with identifying optimal sports techniques or optimal sports movements (Mkaouer, Jemni, Amara, Chaabèn, & Tabka, 2012; Sheets & Hubbard, 2009), often focusing on the outcome (Hiley & Yeadon, 2008). Other studies have been aimed at optimizing the equipment used (Cagran, Huber, & Müller, 2010; Gu & Li, 2007), evaluating models against real performance (Sheets & Hubbard, 2008), or predicting new techniques (Čuk, Atiković, & Tabaković, 2009; Heinen, Jeraj, Vinken, Knieps, Velentzas, & Richter, 2011). The aim of the current study was to evaluate the effects of various techniques for manually applying additional force on movement performance in gymnastics (manual guidance), in particular during the backward salto.

Manual guidance is functional when the gymnast has already learned a movement and is potentially able to perform it but needs support in a slight way to optimize the movement or to lower the risk of injury when performing the movement (Sands, 1996). Manual guidance results in a better movement performance (Armstrong, 1970). In gymnastics, this approach is commonly used in most of the methodical steps of a complex gymnastic technique to prevent injuries and to offer the athlete a secure feeling (Arkaev & Suchilin, 2007). In the backward salto, guidance techniques that usually involve an isolated hand application at the thigh or iliac crest or one that combines hand applications at the two locations (Heinen, Vinken, & Ölsberg, 2010).

Studies revealed that manual guidance influences psychological aspects of movement performance, such as fear of injury and self-efficacy (Heinen, Pizzera, & Cottyn, 2009). The authors of this study examined the effects on performance of the fear of injury and level of self-efficacy in different methodical steps of two gymnastic techniques on the balance beam, with and without manual guidance of the coach. Guidance, in this study, led to enhanced self-efficacy and changes in the level of fear of injury, but the strength of the effect depended on the complexity and the biomechanical demands of the movement. In another study, a coach used different guidance techniques for the same gymnastic movement (Heinen, Vinken, & Ölsberg, 2010) while kinematic analyses were conducted. It was shown that there were kinematic effects on performance when a coach guided a complex gymnastic technique with different guidance techniques. The effects were significant in several kinematic parameters; for example, the angular momentum decreased and the flight time increased when a coach supported the performance of a round-off with a backward salto with hand application at the iliac crest and thigh.

The current literature leads us to believe that there is a link between manual guidance and performance (Heinen, Vinken, & Ölsberg, 2010), but the details of this relationship are still unclear. Movement input and movement output can be observed and estimated, but the interaction between these entities has not been clarified. Additionally and from a more pragmatic point of view, it has often been reported in continuing education programs and in daily training situations that manual guidance is a skill that has to be continually practiced (Sands, 1996) and it has influence on the risk of injury (Sands, McNeal, Jemni, & Penitente, 2011). Thus, even though coaches are trained in guiding a gymnastic element, the manual guidance may not be optimal in every case, and the output (the performance) may not be enhanced.

In sum, a simulation of the backward salto and different specific guidance techniques should help clarify the relation between input (hand applications) and the resulting movement (kinematic parameters). From the existing simulation models and with the help of a biomechanist, we determined that the following factors are the most important when guiding the backward salto (Yeadon, 1990; Yeadon & Morlock, 1989): timing, duration, magnitude, and direction. Timing refers to when in the movement manual guidance is applied. Duration refers to the length of application, magnitude to the amount of force applied, and direction to whether the angle of force is positive (cranial) or negative (caudal). We expected that the different force inputs for an optimal hand application to support the gymnast's body are very small in terms of timing, direction, duration, and magnitude for the resulting movement. Furthermore, we expected that a suboptimal use of one input factor should be compensated for by a second input factor, but also that a suboptimal use of one input factor could lead to a worse movement performance.

## METHODS

**Data collection.** Data was collected in collaboration with a regional-level female German gymnast (23 years old, 1.59 m, 50 kg) during training, while she performed single backward saltos from stand to stand (10 trials). The gymnast was videotaped after she gave informed consent. The data collection was carried out according to the ethical guidelines of the local university. The performances were videotaped using a digital video camera (Casio EX-FH100) operating at 120 frames/s (spatial resolution: 640 × 480 pixels). The camera was placed approximately 5 m from the gymnast and orthogonal to the movement plane and was calibrated with a 2 × 2 m calibration square.

A national-level gymnastics coach was asked to select the best performance of the gymnast from the videotaped sequences of the 10 salto trials. The gymnast's best performance was digitized using the software Simi Motion (Simi Reality Motion Systems, 2012). The two-dimensional (2D) coordinates of the body landmarks were reconstructed from the digitized data using the direct linear transformation algorithm (Shapiro, 1978). A digital filter was applied for data smoothing. A mean temporal error of ± 0.0033 s and a mean spatial error of ± 0.008 m were calculated from the data. The corresponding joint angle histories were calculated from the 2D coordinates of the segment endpoints.

To estimate the additional forces a coach can create when guiding the salto manually, we measured the maximum isometric force with a force-measuring device in body and ankle positions such as if the coach would guide the movement. Based on the measured maximal isometric force with both hands of 150 N, we defined three different force amplitudes for the simulations: 50 N, 100 N, and 150 N.

**Simulation model**. We used a computer simulation model based on 16 body segments, developed to simulate skills in gymnastics was used (Heinen et al., 2011). The 16 segments represented two feet, two shanks, two thighs, the hip and lower trunk, the middle trunk, the upper trunk, two upper arms, two forearms, two hands, and the gymnasts' head. Fifteen joints connected the segments. Since the input data was generated from 2D body landmark data, the computer simulation model was used in its 2D version. Therefore, the motions of both feet, both shanks, both thighs, both upper arms, both forearms, and both hands, respectively, were linked, so that the two segments (one from each body side) were treated as one segment.

The model was furthermore customized to the real gymnast through the determination of subject-specific inertial parameters (Yeadon, 1990, Yeadon & Morlock, 1989). These input parameters comprised segmental inertial parameters and the gymnast's performance in terms of calculated and smoothed angle–time histories. Initial conditions consisted of the gymnast's vertical and horizontal release velocities of the center of mass and the angular velocity about the transverse axis at release. The Kutta–Merson algorithm was used with a frame rate of 300 Hz and a variable integration step size of 0.00167 s to solve the model's motion. Output from the model comprised the resulting motion of the gymnast as well as the angular momentum and the height of flight (Gervais & Dunn, 2003). A three-dimensional computer graphics model of the human body was used to illustrate the model output after the motion was solved (see Figure 1).

**Procedure.** The present study consisted of two phases. In the first phase, the backward salto of the regional gymnast was simulated. All relevant parameters were integrated in the model, namely, the gymnast's angle–time histories, the gymnast's vertical and horizontal velocity at release, and the angular velocity about the transverse axis at the release.

In the second phase, the simulated performance was estimated from the resulting motion as well as from the height of flight and the angular momentum of the model for each simulated variant of the different hand applications. The simulation variants were (1) isolated hand application simulations in four conditions ($n$ = 84 simulation runs) and (2) combined hand application simulations in three conditions (*n* = 147 simulation runs). The conditions were defined as follows:

(1a) Isolated hand application at the *thigh* with different angles ranging from -45° (caudal direction) to +45° (cranial direction) in 15° steps with three different force amplitudes (50N, 100N, 150N), resulting in 7 × 3 = 21 simulation runs. The forces were applied from 0 to 0.23 s during each simulation run (see Figure 2a).

(1b) Isolated hand application at the *iliac crest* with different angles ranging from -45° to +45° in 15° steps with three different force amplitudes (50N, 100N, 150N), resulting in 7 × 3 = 21 simulation runs. The forces were applied from 0 to 0.23 s during each simulation run (see Figure 2b).

(1c) Isolated hand application at the iliac crest as in condition 1b, but with *longer* force activation, resulting in 7 × 3 = 21 simulation runs. The forces were applied from 0 to 0.33 seconds during each simulation run (longer activation with same magnitude; see Figure 2b).

(1d) Isolated hand application at the iliac crest as in conditions 1b and 1c, but with *later* activation, resulting in 7 × 3 = 21 simulation runs. The forces were applied from 0.10 to 0.33 s during each simulation run (see Figure 2b).

The conditions comprising combined hand applications were simulated with constant force amplitude of 100 N and a constant activation of the hand application at the thigh. The conditions were defined as follows:

(2a) *Simultaneous* activation of the iliac crest and thigh hand application with different angles ranging from -45° to +45° in 15° steps for both hands, resulting in 7 × 7 = 49 simulation runs.

(2b) *Longer activation* of the iliac crest and normal activation of the thigh hand application with different angles ranging from -45° to +45° in 15° steps for both hands, resulting in 7 × 7 = 49 simulation cycles.

(2c) *Later activation* of the iliac crest and normal activation of the thigh hand application with different angles ranging from -45° to +45° in 15° steps for both hands, resulting in 7 × 7 = 49 simulation runs.

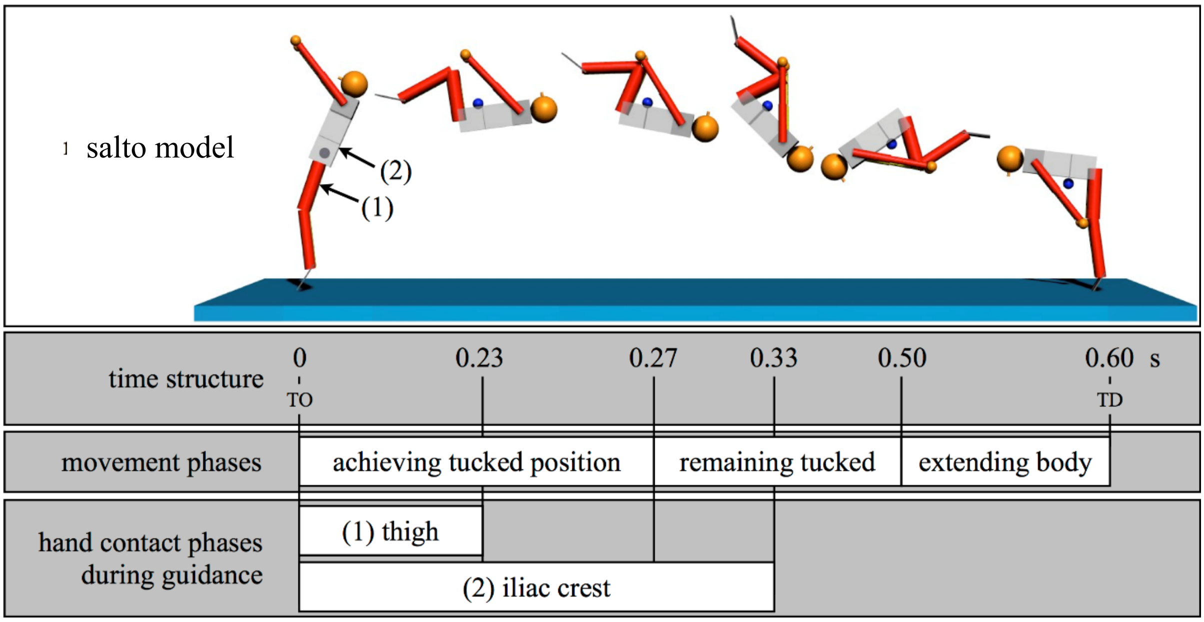


*Figure 1.* Illustration of a simulated backward salto from takeoff (TO) to touchdown (TD), together with its corresponding movement phases and hand contact phases on (1) thigh and (2) iliac crest, during which guiding forces were applied. *Note: For illustration purposes, the time course is not true to scale.*

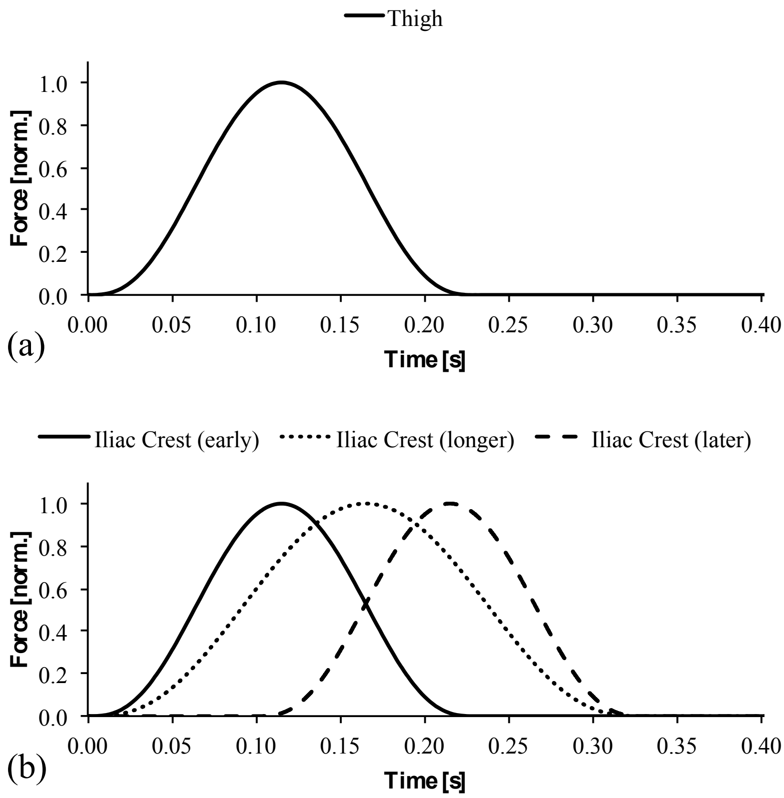


*Figure 2*. Normalized force–time histories when applying different guiding forces to the backward salto model: (a) hand contact on thigh, (b) hand contact on iliac crest (solid line: early activation, dotted line: longer activation with same magnitude, dashed line: later activation).

## RESULTS

### *Original performance of the backward salto*

Integrating the angle–time histories, the vertical and horizontal velocity at takeoff, as well as the angular velocity about the transverse axis at takeoff into the present model led to a successful simulation of the backward salto (see Figure 1). The salto angle was calculated from the original performance of the gymnast's salto as well as from the salto performance of the simulation model. Additionally, the time of flight was calculated. We evaluated the model by comparing the time courses of the two angles. The simulated salto rotation angle matched the gymnast's salto rotation angle within 1.8° root mean square difference (cf., Hiley & Yeadon, 2007). The flight time matched the original performance within 0.0033 s.

### *Effects of isolated hand applications*

For a detailed illustration of the estimated angular momentum and height of flight output, see Figure 3. Taken together, the results of the simulation conditions (1a–d) are as follows: Condition 1a: The strongest effect on angular momentum was estimated for the simulation of an isolated hand application at the thigh with an optimum angle of about -30°. The strongest effect on height of flight was estimated with an optimum angle of about +15°. Condition 1b: The strongest effect on height of flight was estimated for the simulation of an isolated hand application at the iliac crest with an optimum angle of about +30°. Simultaneously, this +30° application led to a reduction of the angular momentum. Condition 1c: The differentiation between the contact times of the simulated hand applications showed only marginal differences between early and short hand contact and longer hand contact. However, longer isolated hand contact on the iliac crest had a slightly stronger effect on reduction of angular momentum. Condition 1d: The simulation showed only a weak effect on angular momentum and on height of flight for the isolated hand application at the iliac crest with a later activation.

***Effects of combined hand applications***

For a detailed illustration of the estimated output angular momentum and height of flight, see Figure 4. Taken together, the results of the simulation conditions (2a–c) are as follows: Condition 2a: The simulation showed a small effect on angular momentum. Condition 2b: Simulating a longer contact time on the iliac crest showed no differences on height of flight. However, there was a small effect on angular momentum, slightly higher than in condition 2a. Condition 2c: Simulating a later activation of force applied on the iliac crest showed almost the same effect on angular momentum and a small effect on height of flight as compared to the previous conditions.

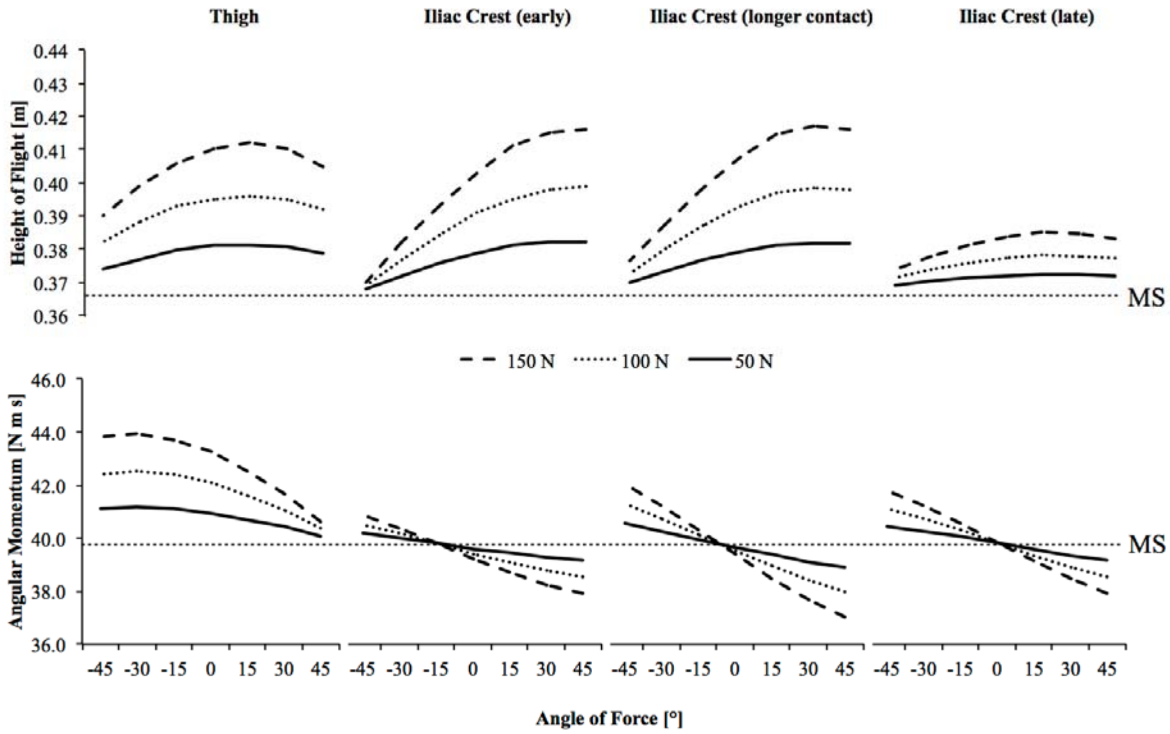


*Figure 3*. Isolated effects (conditions 1a–d) of applying guiding hand contact forces in different directions and with different magnitudes on angular momentum and height of flight of the backward salto. *Note: A negative angle of force value indicates that the force was applied in a caudal direction, and a positive angle of force value indicates that the force was applied in a cranial direction. MS represents the values for the simulated salto without any guiding hand contact force.*

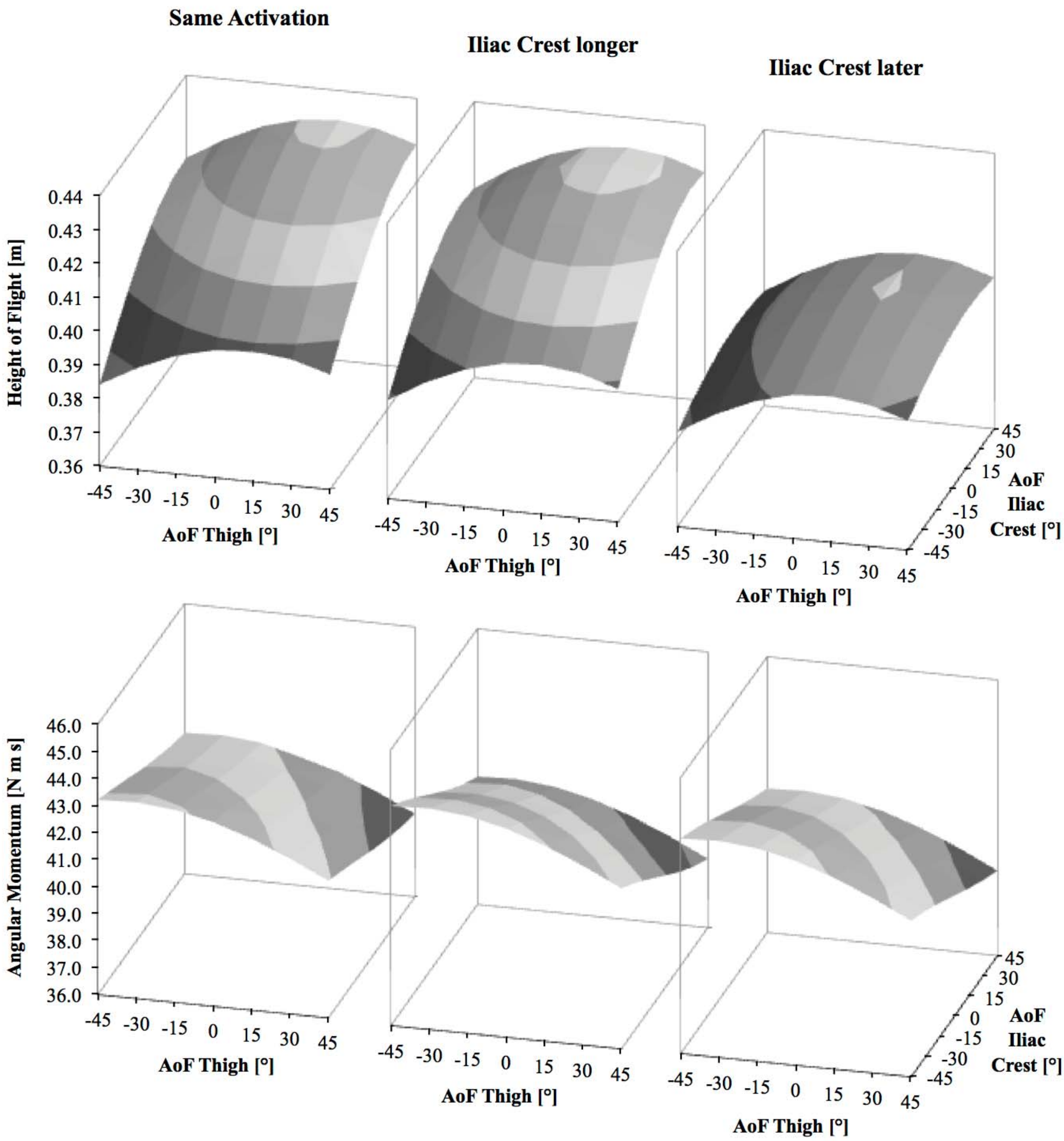


*Figure 4*. Combined effects (conditions 2a–c) when applying guiding hand contact forces on the thigh and iliac crest in different directions and with different timings (simultaneous on thigh and iliac crest, longer on iliac crest, later on iliac crest) on angular momentum and height of flight of the backward salto. *Note: A negative angle of force value (AoF) indicates that the force was applied in a caudal direction, and a positive angle of force value indicates that the force was applied in a cranial direction.*

## DISCUSSION

The aim of the simulation was to explore the effects of manual guidance (input) on movement kinematics (output). Initially, a good match between the simulated movement and a videotaped performance is required. The low root mean square value of 1.8° and the time difference of only 0.0033 s between simulated movement and videotaped performance meant that we had achieved a good match for angle rotation and flight time (Hiley & Yeadon, 2007). Thus, the results of the simulation results can be considered applicable to real life.

We found that late hand application on the iliac crest had only a weak effect on height of flight but a similar effect on angular momentum to early or longer hand application on iliac crest. Thus, a coach might use this technique to rescue spot if a gymnast needs a bit more angular momentum and height to land on the feet (Sands, 1996). The advantage would be that in comparison to early hand application on the iliac crest, the output in angular momentum is similar, but the reaction time for the coach is greater and thus this technique should be easier to use based on motor anticipation and control (Schmidt & Lee, 2011). In other words, it is not necessary to support the gymnast with one hand on the iliac crest immediately at the takeoff point if the performance of the backward salto is made automatic; the coach could "wait" 0.10 s and still be able to produce the same output in angular momentum. But only in regard to rescuing this planned movement because spotting is rarely effective to react on unplanned failures (Sands et al., 2011).

Additionally, according to our results, the coach can adjust the amount of height of flight by defining the timing of the isolated hand support at the iliac crest. Given that the applied force direction is approximately orthogonal to the gymnast's longitudinal axis (about -15° – 0°, see Figure 3), the earlier or longer the force is activated the stronger the gymnast can be supported in the height of flight without changing the angular momentum. For that, the coach needs to guide the gymnast in an appropriate way. Meaning, it is necessary to rotate the pressure at the iliac crest with the gymnast's salto rotation and it is not sufficient just pushing the hand of the coach upwards. This could become important when the gymnast is at the end of the learning process and wants to fine-tune the performance (Magill & Anderson, 2014).

But if the gymnast needs more support and it is necessary for the coach to apply help immediately at takeoff, a combined effect on height of flight and angular momentum is possible with an isolated hand application on the thigh. Thus, the coach has to anticipate the hand application and it will always enhance both the height of flight and the angular momentum because the hand application results in an eccentric force (McGinnis, 2013).

For the combined hand applications, our results show a small effect on height of flight when application of the hand to the iliac crest was later than that to the thigh (condition 2c) compared to a simultaneous activation (condition 2a), but the two conditions produced almost the same effect on angular momentum. Later activation on the iliac crest led to lower increase in height of flight than simultaneous activation. Thus, the timing of application may determine how height and angular momentum change depending on the level of the gymnast. It seems that the timing is a better control parameter than angle or amount of force, since it is a more ballistic movement for the coach where he or she has to anticipate the forces and their directions (Schmidt & Lee, 2011).

There are some limitations of this study and one aspect should be highlighted: Possible and unpredictable interactions between coach and gymnast in the real world—such as reflexive movements or changes of the direction and amount of added force during the whole movement—were not part of the simulation model. However, it might be interesting to explore how differences in the gymnast's position and differences in the coach's hand application during the flight phase are related to differences in salto performance. This would necessitate developments of the simulation model.

## CONCLUSION

The results of our simulation lead us to conclude that coaches have to decide in advance what hand application they want to use for the planned support—a securing technique with one hand at the iliac crest which still allows the gymnast to fine-tune the performance or support during the movement with one or two hands immediately at the takeoff phase.

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# OPTIMIZATION OF VELOCITY CHARACTERISTICS OF THE YURCHENKO VAULT

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*Original article*

***Abstract***

*Various versions of the Yurchenko vault are contemporarily the most widely used vaults in women's gymnastics. Using a 3D kinematic analysis of the velocity characteristics, our aim was to investigate basic variants of the Yurchenko vault, their mutual relations in chosen phases and various influences on the technique of execution. 14 vaults performed by elite artistic gymnasts both from the Czech Republic and abroad were assessed, among which it was possible to observe an individual approach to handling the locomotor task displaying varying degrees of fluctuation in both the overall velocity of the COG - $v_{abs}$, and its horizontal component $v_x$ as well as vertical component $v_z$. Despite the variety, the obtained results were used to determine the optimal course of these velocity parameters, which serves as a precondition of the correct technical execution of the Yurchenko vault. Although our study deals only with the selected characteristics of the whole series of variables affecting the quality of the execution of the Yurchenko streched, we believe our new research findings may be used by coaches and their athletes in their training practice.*

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***Keywords:*** *Biomechanics, Gymnastics, Vault, Optimization of Techniques.*

## INTRODUCTION

The appeal of the Yurchenko vault topic lies in its rapid development over the last decade, unparalleled by any other gymnastic event and leading to the steep improvement of performance on this type of apparatus. To be able to perform the diagnostics of the technique execution and to improve athlete's motion performance, the motion analysis has to be performed.

We have chosen for the analysis the basic execution of the Yurchenko vault which is performed as early as the school-age category (at the age of 13-14 years) but whose mastery is critical for further development of the vault. Gymnasts should start learning this vault no later than at the age of 10 years. Although the vault only takes seconds to perform, it takes years to achieve its mastery. Wrong motion routines can stop the work even in the beginnings of practice, therefore, for trainers, it is important to have a good understanding of its mechanical principles influencing techniques. As with any other skill, the development of the Yurchenko vault may be divided into three stages, which may be trained simultaneously. These are a special physical preparation, special technical training and performance simulation. At the beginning, a gymnast should focus solely on the physical and technical training using specific exercises and their repetition. Only after sufficient technical preparation has been completed leading to a well-mastered practice of the Yurchenko vault, can the gymnast begin to perform the whole jump safely and effectively.

The Yurchenko vault can be devided in following seven phases (Čuk & Karacsony, 2004; Atikovič & Smajlovič, 2011): run, jump on springboard, springboard support phase, first flight phase, support on the table, second flight phase and landing.

The technical basis for each Yurchenko vault phase is as follows.

Each vault begins with a run phase, the aim of which is to obtain the maximum amount of kinetic energy, which is then converted to the corresponding vertical, horizontal and rotational velocity for the further course of the jump. The length of the run phase depends primarily on the individual personality of a gymnast and mastery of technique.

The main task of two next phases - jump on the springboard and springboard support phase is to maintain the horizontal velocity required for the next phase of the vault. With the Yurchenko vault the gymnast performs a round-off (a sideways somersault with landing on both feet) with landing on the springboard with their back to the vaulting table.

The first flight phase includes the execution of a back handspring with landing on hands on the vaulting table. The first flight phase will be mainly characterized by its duration. Its main task is to prepare the best possible conditions for both the touch and take-off from the vaulting table.

The touch and take-off phase from the vaulting table directs and extends a further movement of the centre of gravity (COG) upward and forward. Following the touch on the vaulting table the gymnast's body should make as a rapid movement as possible around the axis passing through the shoulder joints, with a simultaneous partial-movement around the axis passing through the touch spot, while the body's centre of gravity (BCG) rises. The prerequisite for the vaulting table contact phase is a correct and timely execution of the take-off prior to the gymnast performing a handstand.

The second flight phase is the longest and thus the most interesting phase of the vault. It includes another important action of the gymnast, namely one and a half somersault with landing on a landing mat. A gymnast pushes up from her hands off the vaulting table into a back layout. Following the push-up from the hands the COG is supposed to reach its highest point. Once the gymnast leaves the table, the potential of the technical execution of the back layout is given and cannot be changed.

Landing, through which the kinetic energy of the second flight phase is reduced, is the final part of each vault. Its quality depends mainly on the activities performed by the gymnast in the previous phases of the vault. The work of the arms is particularly important in this phase as the gymnast's arms, which are initially down, are raised in front of him or her thereby stopping the body rotation.

As is obvious, the technical basis of the motion is very complex. It is therefore kinematically possible to observe a number of relations between time, space and velocity characteristics. In this study, we focus on the velocity parameters of the Yurchenko vault.

In a number of studies, the authors state that the correct technical performance of the run phase is crucial for the successful execution of the entire vault. Arkaev and Suchilin (2004) reported that the last 5 m of the run phase prior to the landing on the springboard should not contain any significant increase or decrease in the velocity. This fact is, however, contradicted to some extent by Bradshaw (2004), who mentions a noticeable decrease in the horizontal velocity prior to the landing on the springboard. This is due to the required visual inspection and the preparation for the jump on the springboard. The ability to minimize the velocity loss while landing on the springboard may lead to a more successfully executed jump. Petković (2011) focused on the difference between the run start strategy of the best gymnasts, who slow down half way through the run start for a moment, and the average gymnasts who keep raising their velocity throughout the run phase. In their work, Bradshaw, Hume, Calton, & Aisbett (2009) also studied the acceleration rate in the run phase. They compared the velocity of different vaults performed by outstanding Australian gymnasts during their practice. Studies have shown that the slowest run phase velocity was measured with the very Yurchenko vault carried out by women. This is also stated by Farana & Vaverka (2011) in their article, where "the results of the study revealed that with the vaults of the Yurchenko type, the run phase velocity is lower than with the front handspring vault group and the round-off vault group. The lowest run speed velocity was achieved by the Yurchenko vault group, 7.35 $ms^{-1}$ for men and 6.98 $ms^{-1}$ for women". It must be, however, emphasized that it was the introduction of the new vaulting table which led to the increased need to maximize the velocity components in the run phase. Especially with the Yurchenko vault the landing onto the springboard phase is essential and very often critical for the execution of the vault. At this stage, the gymnast performing a round-off with landing on the spring board changes the direction of her body's momentum. Hence, a great emphasis is placed on proper training of the technique to succesfully handle and execute this phase of the vault. For the fast execution of the round-off, it is therefore crucial to create sufficient momentum for the entire vault.

In their kinematic analysis Penitente, Merni, Fantozzi, & Perretta (2007) deal with the landing and the springboard take-off phase. The results show that the gymnasts are able to effectively use the springboard without decreasing the horizontal velocity while increasing the vertical velocity. The horizontal velocity while landing on the springboard reached the average value of 5.27 $ms^{-1}$. Similar values can also be seen in publications by other authors: 5.32 $ms^{-1}$ (Nelson, Gross, & Street, 1985), 5.08 $ms^{-1}$ (Ragheb & Fortney, 1988), 5.14 $ms^{-1}$ (Kwon, Fortney, & Shin, 1990). The springboard take-off is a dynamic phase lasting for a very short time. In their work, Čuk & Karacsony (2004) deal with the take-off force and the springboard contact time for individual types of vaults. With the Yurchenko vault, the springboard contact time stood at 0.15 for women and 0.14 for men. It is important to note that the key variable for the moment of take-off from the springboard is the size of the horizontal speed.

The ideal conditions of the following first flight phase are characterized by the fastest possible performance of the back handspring onto the vaulting table. What is important is the correct body position throughout the first flight phase and especially prior to the landing on the vaulting table, thus ensuring a minimum speed loss.

The contact of the gymnast with the vaulting table is an important and most examined phase of the Yurchenko vault. The touch and take-off phase has been affected primarily by the change of the vaulting tools in 2001. Uzunov (2011) focused in his article on possible changes in the technique Yurchenko stretched execution, which can emerge resulting from the replacement for a new type of tool, and how these changes are reflected in biomechanical variables. Uzunov (2011) states in his other article that the vertical velocity of the COG upon completion of the take-off from the table is considered the most important variable. The optimal horizontal velocity of a gymnast upon leaving the table is 2.34 $ms^{-1}$ and the vertical velocity is 2.27 $ms^{-1}$.

The quality of the second flight phase which largely contributes to the assessment of the actual vault is considered the most important. Following the take-off from the vaulting table the movement of the body during this phase shows an upward trend, which is dependent on the conditions created in the previous phases of the vault. Already Takei (1989) focused on the comparison of vaults performed at major international competitions, that received either high or low marks. The results showed that gymnasts that achieved higher horizontal and vertical velocity values upon touching the apparatus, achieved higher marks. "This resulted in a shorter duration of contact with the apparatus. Higher vertical and horizontal velocity affects the duration of the second flight phase and also the maximum height and distance when landing." Koh, Jennings, Elliott, & Lloid (2003) in their extensive research sought to identify changes in the technology needed to execute the optimal Yurchenko vault. The results showed that the best recorded attempt was not sufficient in comparison with the optimal execution of the Yurchenko vault. The vault failed to acquire sufficient length and height in the second flight phase due to the small vertical velocity when taking off from the table. Consequently, the gymnast in the second flight phase was slightly bent at the hips and due to this she would not receive too high a score.

Landing is one of the basic motion activities practised with all tools in artistic gymnastics and it also is the final phase of our analyzed vault. The correctly performed landing is important for the successful execution of the vault. This final stage requires great stabilization and the work of eccentric forces of great magnitude decreasing the body velocity in order to avoid injury to the lower extremities due to their large external load. Marinšek (2010) states that the forces measured during landing may be in the 3.9 to 14.4 BW (body weight) range.

As is shown by previous research, the best achieved velocity of the BCG at the end of the run phase is one of the key factors limiting the quality of the Yurchenko vault execution. The aim of this work is to extend the existing knowledge, especially in terms of velocity characteristics. The authors usually indicate maximum velocity achieved by gymnasts. We, however, aim not only to determine the maximum velocity values, but to focus on the velocity development in the course of the vault execution. We are interested in finding out what stages are characterized by the possible increase or decrease in the velocity of the BCG. We believe that a comprehensive overview of velocity changes during various stages can point to the facts important for the optimization of the techniques of the observed element.

## METHODS

The research sample consisted of 14 artistic gymnasts of both Czech and foreign nationality. They are all contemporary national representatives in artistic gymnastics who participate in international and other high-profile competitions. The selected gymnasts fall within the age range of 18-25 years. The girls have been engaged in artistic gymnastics approximately since their 4 years of age, they have daily two-phase practices. In selection of the tested sample the emphasis was put on the high performance level and the absolute technical execution of the basic form of the Yurchenko vault. Following the consultation with coaches of the selected gymnasts, a 3D kinematic analysis of this vault was performed. The measurement sessions took place in the competition season during which we were able to record already stabilized level of the vault execution, i.e. a high performance level of the selected gymnasts. The data was collected during the two measurement sessions. One was held at the International Grand Prix competition in Brno, the other one during practice, nevertheless in the identical gym of the Sokol Brno I, which is the best gymnastics gym in the Czech Republic equipped with high-quality apparatuses. All of our tested persons (TP) were in a good shape and good health.

To carry out research, it was necessary to employ a quantitative method of motion analysis through which numerical values are generated, which refer to the magnitude of physical quantities. We therefore chose a 3D kinematic method to record the motion where two synchronized SIMI Motion high-frequency digital cameras with the frame rate of 100 Hz were used. Individual attempts were recorded from the moment of the hands touching the mat in a round-off after reaching the maximum height in the second flight phase of the performed vault. All these phases took place in the pre-calibrated space. The tested persons were provided with retroreflective markers which allowed easier evaluation of the video recording. The head as well as all the major joints - wrists, elbows, shoulders, hips, knees and ankles were marked. With each gymnast three attempts were filmed where the best one was chosen for the subsequent analysis based on the assessment of an international referee of artistic gymnastics. In the next step the data was processed using the SIMI Motion software produced by the German company SIMI Reality Motion Systeme GmbH. Due to suboptimal ligting conditions during field measurements in the gym, we decided to track data mainly manually.

From the recorded data, we assessed the selected temporal, spatial and velocity characteristics. For each of these variables basic statistical data was calculated. Given the non-normal data distribution (vertical velicities $v_z$ of the BCG at the moment of landing on the springboard and take-off from the vaulting table) the Spearman correlation at the significance level of $p<0.05$ was used for a closer statistical analysis of the relations between velocity parametres.

## RESULTS

We have observed three phases of the Yurchenko vault: take-off on the springboard, the first flight phase and take-off on the vaulting table. For each phase, we evaluated the speed of the COG - $v_{abs}$, the horizontal velocity component $v_x$ and also vertical velocity component $v_z$ at the time of commencement and completion of each phase, as well as the size of their changes during the phases. Fig. 1 neatly shows the course of the overall velocity and its components for one of the attempts, which is closest to the average performance of the entire test set. The curves show the velocity changes from the moment of landing on the springboard to leaving the table; the first vertical line indicating the moment of leaving the springboard while the second one indicating the moment of landing on the vaulting table.

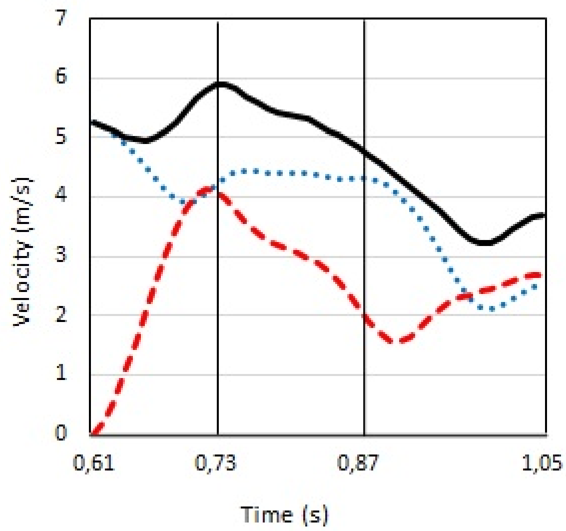


*Figure 1.* Graph shows the overall velocity curve $v_{abs}$ - solid black curve, horizontal velocity components $v_x$ - blue dotted curve and the vertical velocity components $v_z$ - red dashed curve.

*The take-off phase on the springboard:*

At the moment of landing on the springboard gymnasts had the average velocity $v_{abs}$ of 5.362 ± 0.204 $ms^{-1}$. At the end of this stage, during which a significant acceleration occurs, gymnasts reach their maximum velocity within the vault, i.e. 5.912 ± 0.299 $ms^{-1}$ on average. The average velocity $v_{abs}$ increase was 0.550 ± 0.238 $ms^{-1}$ on average while the other phases displayed velocity losses of limited amounts only. It was detected that at the moment of landing on the springboard the average $v_x$ value stood at 5.344 ± 0.203 $ms^{-1}$ which is almost identical to the $v_{abs}$ value. At the completion of the take-off phase the average $v_x$ value is of 4.485 ± 0.424 $ms^{-1}$ meaning there occurs a loss of $v_x$ at the expense of $v_z$ at this stage, as the gymnast is required to obtain a certain vertical velocity to be able to move her COG from the current height over to the vaulting table. This means that the horizontal velocity $v_x$ fell on the springboard by 0.859 ± 0.364 $ms^{-1}$. The vertical component of the velocity $v_z$ shows a negative value of - 0.133 ± 0.238 $ms^{-1}$ at the moment of commencement of take-off on the springboard, which can be explained by the movement of the body in the second round-off phase, which smoothly converts to the landing on a flexible springboard plate. During the take-off there occurs a significant $v_z$ increase of 3.935 ± 0.438 $ms^{-1}$ on average. So gymnasts leave the springboard with a vertical speed of the COG of 3.803 ± 0.296 $ms^{-1}$.

*The first flight phase:*

During the first flight phase, i.e. from the moment of take-off completion from the springboard till the commencement of take-off on the vaulting table, all competitors were losing the overall $v_{abs}$ velocity, by 1.116 ± 0.298 $ms^{-1}$ on average. The velocity loss occurred even in the $v_x$ component (- 0.231 ± 0.243 $ms^{-1}$) and the vertical velocity component $v_z$ (- 1.621 ± 0.435 $ms^{-1}$).

*The take-off phases on the vaulting table:*

The competitors opened this phase with an average $v_{abs}$ velocity of 4.796 ± 0.285 $ms^{-1}$ and completed it with the lowest velocity recorded during the observed phases; with the average $v_{abs}$ value of 3.721 ± 0.367 $ms^{-1}$. The decrease in the $v_{abs}$ velocity in the gymnasts chosen for our observation therefore was of 1.074 ± 0.337 $ms^{-1}$. The horizontal velocity component $v_x$ was also reduced from 4.255 ± 0.368 $ms^{-1}$ at the moment of touching the vaulting table to 2.760 ± 0.320 $ms^{-1}$ at the time of leaving it, i.e. by 1.495 ± 0.333 $ms^{-1}$. The vertical velocity component $v_z$, which contributes to the maximum height of the COG in the second flight phase, rose in accordance with our estimates, from the 2.182 ± 0.352 $ms^{-1}$ value at the commencement of the take-off to the 2.449 ± 0.307 $ms^{-1}$ value upon its completion. The increase amount was therefore of 0.267 ± 0.404 $ms^{-1}$ on average.

*The overall velocity characteristics:*

We were interested in the amount of total loss for the individual velocity components. Regarding the overall velocity of the COG - $v_{abs}$, the average loss was that of 1.641 ± 0.253 $ms^{-1}$ during the three observed phases, where the difference between the maximum and minimum velocity during the observed phases is equal to the average of 2.304 ± 0.439 $ms^{-1}$. With the $v_x$ velocity, the total losses averaged 2.585 ± 0.246 $ms^{-1}$. In contrast, the $v_z$ component increased by 2.581 ± 0.463 $ms^{-1}$ on average.

## DISCUSSION

Even at first glance, both the velocity of the COG and its components show differences among gymnasts. We were therefore interested to find out about the development of these velocity values during each of the monitored microphases, and their mutual influence during the selected stages of the Yurchenko vault. Table 1 shows the correlation coefficients of $v_{abs}$, $v_x$ and $v_z$ relations for all observed phases of the movement. The bold red numbers are commented in the text below.

Table 1
*Spearman correlation coefficients of $v_{abs}$, $v_x$ and $v_z$ relations*

| Vault phases | | Landing springboard | | | Take-off springboard | | | Landing table | | | Take-off table | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | var | $v_{abs}$ | $v_x$ | $v_z$ | $v_{abs}$ | $v_x$ | $v_z$ | $v_{abs}$ | $v_x$ | $v_z$ | $v_{abs}$ | $v_x$ | $v_z$ |
| Landing springboard | $v_{abs}$ | 1.00 | **0.969** | -0.112 | 0.53 | 0.415 | 0.033 | 0.086 | 0.253 | -0.04 | **0.78** | **0.648** | **0.365** |
| | $v_x$ | | 1.000 | -0.077 | 0.442 | 0.455 | -0.134 | 0.17 | 0.31 | 0.015 | 0.736 | 0.613 | 0.349 |
| | $v_z$ | | | 1.000 | -0.068 | -0.015 | -0.398 | -0.319 | -0.226 | -0.052 | -0.437 | -0.266 | -0.361 |
| Take-off springboard | $v_{abs}$ | | | | 1.000 | **0.758** | 0.231 | 0.248 | 0.547 | -0.675 | 0.31 | 0.284 | -0.108 |
| | $v_x$ | | | | | 1.000 | -0.336 | 0.477 | 0.754 | -0.724 | 0.2 | 0.262 | -0.262 |
| | $v_z$ | | | | | | 1.000 | -0.152 | -0.165 | -0.614 | 0.24 | 0.077 | 0.389 |
| Landing table | $v_{abs}$ | | | | | | | 1.000 | **0.807** | -0.169 | 0.279 | 0.125 | 0.02 |
| | $v_x$ | | | | | | | | 1.000 | -0.614 | 0.327 | 0.292 | -0.046 |
| | $v_z$ | | | | | | | | | 1.000 | 0.07 | -0.092 | 0.383 |
| Take-off table | $v_{abs}$ | | | | | | | | | | 1.000 | **0.824** | 0.51 |
| | $v_x$ | | | | | | | | | | | 1.000 | 0.026 |
| | $v_z$ | | | | | | | | | | | | 1.000 |

First, we are going to take a closer look at the velocity values at the moment of landing on the springboard and at the moment of take-off from the vaulting table in order to detect the relationship between the velocity characteristics of this crucial moment which determines the character of the second flight phase and the velocity obtained from a run phase. Due to the correlation coefficient r = 0.780, we were able to find out a strong connection between the $v_{abs}$ velocity, at which the gymnast lands on the springboard, and the $v_{abs}$ velocity which is in operation upon leaving the vaulting table. Given the fact that $v_{abs}$ upon landing on the springboard is nearly equal to $v_x$, we may say that the horizontal velocity of the COG - $v_x$ obtained during the run phase and the subsequent round-off is one of the decisive factors affecting the velocity of the COG at the moment of leaving the table. From the spatial-temporal structure of the observed vault it is clear that after leaving the table the gymnast must be able to fly far enough beyond the vaulting table but most importantly to be first able to rise to the height needed to obtain the time necessary for the execution of the given rotations of the body. From the kinematic characteristics of projectile motion it is clear that it is a $v_z$ value which determines the second flight phase time as well as the height reached by the COG. We are therefore interested in the impact of the initial $v_{abs}$ on the $v_x$ and $v_z$ values at the moment of leaving the table. The correlation coefficient r = 0.648 shows a closer relationship between the $v_{abs}$ value when landing on the springboard and the $v_x$ value upon taking off from the table, where the correlation coefficient is as low as r = 0.365. We therefore conclude that the initial velocity $v_{abs}$ remains substantially unchanged in the horizontal axis. The height which the COG is able to reach in the second flight phase, is therefore not proportionally related to the velocity which the gymnast was able to obtain prior to landing on the springboard.

If we look at the velocity values at the moment of leaving the table, we are able to observe that on average the $v_x$ exceeds $v_z$ by of 0.31 $ms^{-1}$. Here, however, we need to admit that a greater conversion of $v_x$ to $v_z$, i.e. a greater size of $v_z$ in comparison with $v_x$ was expected. However, when compared with the results of Uzunov (2011) the $v_x$ (2.760 $ms^{-1}$) and $v_z$ velocity values (2.449 $ms^{-1}$) achieved by our competitors at the end of the second take-off phase are above-average. According to Uzunov it is sufficient, if the horizontal velocity of the gymnast's COG is of 2.34 $ms^{-1}$ and the vertical velocity reaches the value of 2.27 $ms^{-1}$ upon leaving the table. Despite these optimal velocities according Uzunov (2011) where $v_x$ exceeds $v_z$, in the separate assessment of these overall velocity components which was carried out for individual analyzed attempts we found out that upon leaving the table the $v_z$ value was slightly higher than the $v_x$ value in those gymnasts within the observed group who demonstrate above-average performance as assessed by international refererees. These vaults include the TP 2, TP 4, TP 8 or TP 12 attempts, where the $v_z$ values range between 2.568 $ms^{-1}$ and 2798 $ms^{-1}$. The reverse ratio of these two components in the average values of the test group is due to those poorer attempts where larger $v_x$ than $v_z$ was recorded. The examples include TP 13 and TP 14, where the $v_z$ values reached were only of 1.854 $ms^{-1}$ and 1.846 $ms^{-1}$ respectively. On the basis of these results we would therefore argue that the correlation coefficient between the $v_{abs}$ when landing on the springboard and the $v_z$ upon taking-off from the table should, with the correct performance, be higher than the above-mentioned r = 0.365, namely due to the larger and proportional conversion of $v_{abs}$ to $v_z$.

Let's look at how the individual velocity components of the COG change between the beginning and the end of the section of the Yurchenko vault chosen for observation, i.e. during its various phases. Table 2 shows the correlation coefficients of relations among $v_{abs}$, $v_x$ and $v_z$ changes for all observed phases of the movement. The bold red numbers are commented in the text below.

Table 2
*Spearman correlation coefficiens - $v_{abs}$, $v_x$ and $v_z$ changes*

| Vault phases | | Springboard | | | Flight 1 | | | Vaulting table | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | variable | $\Delta v_{abs}$ | $\Delta v_x$ | $\Delta v_z$ | $\Delta v_{abs}$ | $\Delta v_x$ | $\Delta v_z$ | $\Delta v_{abs}$ | $\Delta v_x$ | $\Delta v_z$ |
| Springboard | $\Delta v_{abs}$ | 1.000 | 0.746 | 0.148 | -0.544 | -0.386 | -0.653 | -0.425 | -0.531 | 0.365 |
| | $\Delta v_x$ | | 1.000 | **-0.507** | -0.214 | -0.531 | -0.223 | -0.585 | **-0.597** | 0.249 |
| | $\Delta v_z$ | | | 1.000 | -0.34 | -0.408 | -0.054 | -0.638 | -0.548 | -0.229 |
| Flight 1 | $\Delta v_{abs}$ | | | | 1.000 | **0.659** | **0.785** | -0.248 | -0.02 | -0.514 |
| | $\Delta v_x$ | | | | | 1.000 | 0.177 | -0.005 | -0.02 | -0.187 |
| | $\Delta v_z$ | | | | | | 1.000 | -0.195 | 0.145 | -0.692 |
| Vaulting table | $\Delta v_{abs}$ | | | | | | | 1.000 | **0.806** | 0.368 |
| | $\Delta v_x$ | | | | | | | | 1.000 | **-0.204** |
| | $\Delta v_z$ | | | | | | | | | 1.000 |

The results of our analysis point to the fact that for the successful execution of the Yurchenko vault both horizontal and vertical velocity components are essential. The horizontal velocity component $v_x$ correlates in many phases with the total $V_{abs}$ velocity of the COG. Similarity and some synchronization of changes in these two types of velocity is evident in the observed time interval of the vault, i.e. from the moment of landing on the springboard to the moment of leaving the vaulting table. This is evidenced also by the correlation coefficients between the $v_{abs}$ and $v_x$ values at the time of landing on the springboard (r = 0.969), upon the take-off from the springboard (r = 0.758), upon landing on the vaulting table (r = 0.807) and upon the take-off from the table (r = 0.824).

At the moment of landing on the springboard the horizontal velocity $v_x$ of our test set averaged at 5.344 ± 0.203 $ms^{-1}$. The comparison of these results with those reported by other authors (Penitente, Merni, Fantozzi & Perretta, 2007, $v_x$ = 5.27 $ms^{-1}$, Nelson, Gross & Street, 1985, $v_x$ = 5.32 $ms^{-1}$, Ragheb & Fortny, 1988, $v_x$ = 5.08 $ms^{-1}$, Kwon, Fortney & Shin, 1990, $v_x$ = 5.14 $ms^{-1}$) shows that our gymnasts gave a superior performance in this respect. As stated by Petkovic (2011), achievement of the maximum velocity does not always set a perfect stage for the execution of further stages of the vault following the round-off. Sometimes lower velocity proves to be more efficient for the execution of a technically perfect vault. We lean towards this view too as we believe that the maximum velocity obtainable before having counterproductive effects depends on the technical expertise and functional capabilities of the given gymnast. This hypothesis is confirmed by the TP 13 vault, where the velocity was not handled well. On the springboard this gymnast's overall velocity $v_{abs}$ increased by the above average 0.889 $ms^{-1}$, however, in the other phases, we observe in our test set the worst declines in both horizontal and vertical velocity values. For example, on the table the $v_{abs}$ fell by 1.949 $ms^{-1}$, $v_x$ decreased by 2.2 $ms^{-1}$ and contrary to the expected growth the $v_z$ dropped by 0.063 $ms^{-1}$. It is therefore necessary to speak about the optimal velocity rather than the maximum velocity, where the ideal condition is defined as that of the optimal velocity being equal to the maximum velocity.

The horizontal velocity during each phase is partially retained and partially transformed to the vertical velocity component of the BCG. The conversion of $v_x$ to $v_z$ may occur in the support stages, which in our case correspond to the first and second take-off phases. The values of the individual correlation coefficients reveal more precisely the relationships between these parameters during major or minor velocity changes. If we focus on the $v_x$ variable, we can see that the higher the degree of $v_x$ loss occurring on the springboard, the smaller the degree of $v_x$ decrease occurring on the table, and vice versa (r = - 0.597). It is, however, not possible to claim the same regarding the vertical velocity component $v_z$ (r = 0.212), which means that if there is an above-average $v_z$ increase on the springboard, a proportionately smaller $v_z$ increase on the table is not likely to follow. Let us, therefore, consider the relationship of these two variables separately on the springboard and on the table.

It is clear that in the first take-off phase the gymnast must obtain sufficient vertical velocity to be able to lift the COG from its current height over the vaulting table. This corresponds to the magnitude of the $v_z$ change, which is at its largest during this phase of the entire vault. Let's now consider the relationship between changes in $v_x$ and $v_z$ on the springboard. The correlation coefficient r = - 0.507 expressing the relationship between the $v_x$ change and $v_z$ change on the springboard points to the fact that the decrease in the horizontal velocity is accompanied by the increase in the vertical velocity component. These two variables, however, are not as closely related as might be expected. We believe this is due to the fact that the issue in question is not a mere mechanical conversion of the $v_x$ obtained in the run phase. An irreplaceable role is also played by the explosive power of the lower extremities, which to various degrees shows in the acceleration of the movement of the COG in the vertical axis. By comparing the magnitude of the $v_x$ and $v_z$ changes with the technical capability of individual gymnasts, we have come to a conclusion that the observed phenomenon is that of a very individual handling of the situation. As for the vertical velocity component, gymnasts demonstrating advanced techniques created within the test set an above-average $v_z$ change, while other gymnasts created a below-average $v_z$ change. However, concerning the horizontal velocity, unlike their weaker counterparts better gymnasts were able to maintain a higher $v_x$. This result corresponds with the findings of Penitente, Merni, Fantozzi and Perretta (2007), who stated that gymnasts should be able to effectively use the springboard without decreasing the horizontal velocity while increasing the vertical velocity. In the springboad phase it is therefore necessary to pay utmost attention to maintaining the horizontal velocity $v_x$ accompanied by the optimal, not the maximum increase in the vertical velocity $v_z$.

In the first flight phase the COG rises for the gymnast to be able to reach the vaulting table with her hands. The decrease in the overall $v_{abs}$ velocity in flight correlates primarily with the $v_z$ (r = 0.785) decrease, to a lesser extent with the $v_x$ (r = 0.659), mainly because the issue in question is that of a significant change in the height of the COG which is related to the conversion of the kinetic energy to the potential energy.

We believe that the following second take-off phase should be characteristized by the conversion of the horizontal velocity to the vertical velocity. We are able to observe here a considerable decrease in the overall velocity, correlating (r = 0.806) with the loss of horizontal velocity accompanied by an increase in the average vertical velocity of 0.267 $ms^{-1}$. The correlation coefficient (r = 0.204) between the change in the horizontal velocity $v_x$ and the vertical velocity $v_z$ during the second take-off phase on the table is even much lower than previously on the springboard. This indicates a highly individual execution, as regards the velocity transfer from the x-axis to the z-axis. As is evident from the magnitude of change in the $v_z$, its largest increase occurs in the springboard phase. In contrast, the increase in the $v_z$ on the table is minimum, although the vaults of those gymnasts within the test set, who were able to perform an above-average conversion of $v_x$ to $v_z$ on the table, may be considered more technically advanced. This corresponds with their results at international events compared to the remaining gymnasts of the test set.

To better understand the velocity changes in the phase on the table, it is necessary to take into account not only the values at the beginning and end of the table phase, but also to consider the development of velocity curves during this phase. The TP 2, TP 5 and TP 8 (Fig. 2) graphs show the initial growth of the overall velocity $v_{abs}$ on the table and its subsequent decline starting approximately half way through the contact time with the table. This $v_{abs}$ development is based on the ability of the gymnasts to maintain the $v_x$ constant as long as possible and to increase the $v_z$ immediately after the contact with the table. If we compare these characteristics in less successful attempts, namely the TP 1, TP 3 and TP 13 vaults (Fig. 3), we are able to observe clear differences. These gymnasts are unable to preserve the magnitude of $v_x$ even during the first moments of contact with the table. This velocity component tends to drop sharply very early on. Regarding $v_z$, gymnasts are unable to start accelerating from the moment of touching the table, their vertical velocity first significantly decreases and only then it begins to rise, however, not to such a degree as with gymnasts demonstrating advanced techniques.This development of $v_x$ and $v_z$ is manifested in the continuous decrease in the overall speed $v_{abs}$ almost from the beginning of the second take-off phase.

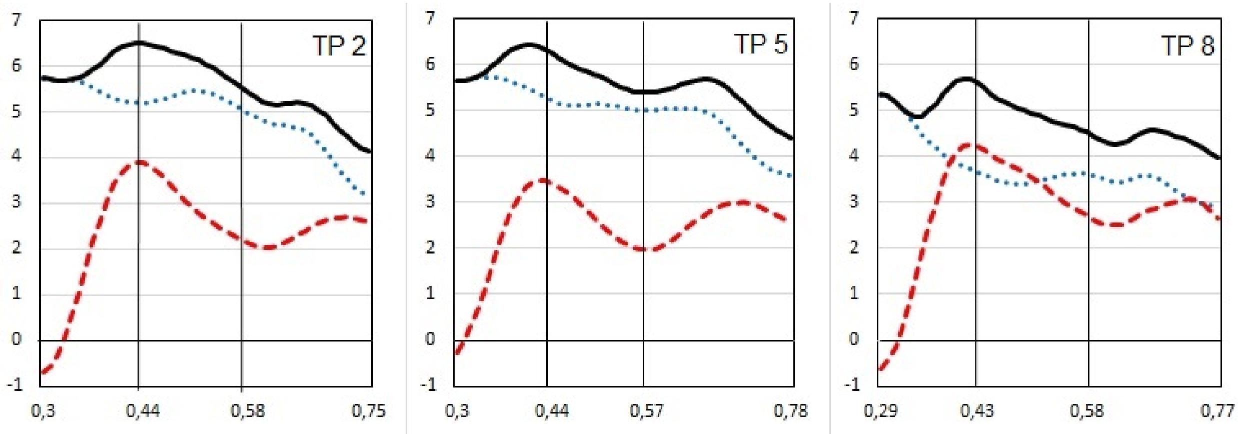


*Figure 2.* Curves showing velocity development in TP 2, TP 5 and TP 8, overall velocity $v_{abs}$ - solid black curve, horizontal velocity component $v_x$ - blue dotted curve and the vertical velocity component, $v_z$ - red dashed curve.

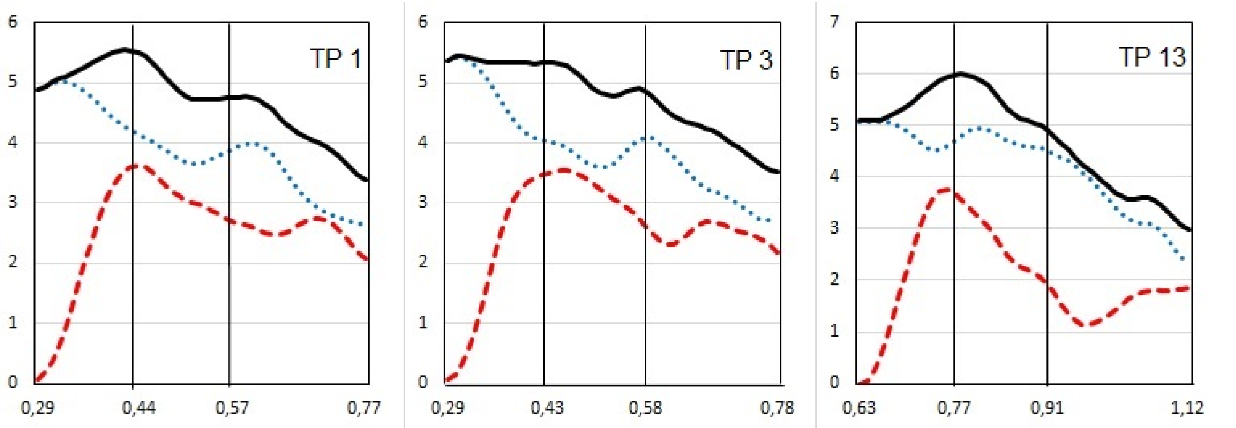


*Figure 3.* Curves showing velocity development in TP 1, TP 3, TP 13, overal velocity $v_{abs}$ - solid black curve, horizontal velocity component $v_x$ - blue dotted curve and the vertical velocity component $v_z$ - red dashed curve.

The purpose of the take-off phases should be the minimization of the velocity loss. The graphs show gymnasts take a very individual approach to the work with the centre of body's velocity both on the springboard and on the table, as a result of which we are able to observe significant differences in the timing of acceleration and deceleration moments. The aim of the gymnast should therefore be landing on the springboard with the optimal speed in order to achieve a convenient starting position and subsequently to attempt to minimize velocity losses or even to increase velocity during a microphase on the springboard and the table. When comparing the velocity change in gymnasts that occurred between landing on the springboard and leaving the table, we note the smallest decline in TP 5 (1.251 $ms^{-1}$) and almost the same drop in TP 8 (1.267 $ms^{-1}$). The velocity curves showed in graphs for both of these gymnasts are characterized by rather discontinuous changes, something which we believe shows the dynamics of the execution associated with high explosive capabilities of the force. This is particularly obvious in the take-off phases both on the springboard and on the table, where both gymnasts display a tendency to acceleration at a certain moment. Frequent changes of the accelerated and decelarated movements are taking place here with a greater frequency, however, to a lesser extent than is the case with most of the test subjects. The reverse trend is observed, for example, with TP 3 and TP 13, where the continuity of velocity changes is apparent, but where a greater drop in velocity occurred between the beginning of landing on the springboard and the take-off from the table and where larger differences may be observed between the maximum and minimum recorded value of velocity.

## CONCLUSION

In individual phases of the Yurchenko vault an individual approach to handling the locomotor task displaying varying degrees of velocity variations may be observed. First phase chosen for observation was the body work on the springboard. The velocity development for the individual gymnasts tested varied widely, although almost all of them demonstrated an acceleration in the phase of leaving the springboard, which signals the fulfilling of the take-off task and proper preparation for the first flight phase. In the first flight phase all tested persons were found to have lost velocity, although an overall duration of the flight played an important part in this microphase. Next is the support phase on the vaulting table, which we consider crucial to the performance and most significantly contributing to the entire vault assessment. Individual competitors show different levels of functional aptitudes. Through the analysis of these phases and as a result of comparing 14 different vaults performed by elite gymnasts, we were able to establish the basic criteria necessary for the successful execution of the Yurchenko vault such as obtaining optimal, if possible maximum, velocity in the first take-off phase, which the gymnast is able to use to her best advantage in order to execute a technically perfect vault. The other basic criteria include a minimum loss of horizontal velocity in the first flight phase and obtaining the optimal vertical velocity component in the take-off phase on the vaulting table. Our results were compared with those presented by other authors and a high degree of agreement between the two was detected, which shows a technical maturity of the research sample chosen for observation as well as provides us with the platfom to formulate valid conclusions for practice. Although it is vault, in our opinion, it is necessary to focus on work of upper extremities used in Yurchenko vault in two phases - round-off and the phase on the table, in comparison with most other types of vaults. Concerning work of upper extremities in the round-off, their dynamic take-off creates necessary conditions for optimal movement execution on the springboard. This phase should be, according to results, characterized by a minimal loss of horizontal velocity and the increase of vertical velocity which, in our opinion, is impossible without perfectly mastered round-off. Moreover, a fact worth mentioning is that the greatest velocity loss was found on the vaulting table. For this reason, we would recommend putting emphasis on the technical aspects of this phase execution and not neglecting fitness training focusing on the dynamic work of upper extremities again. Specifically, in round-off it is necessary to focus on powerful arms take-off and then to keep rebound to prevent lower limbs from falling down during jumping on the springboard. To strengthen the upper extremities dynamic work we recommend, for example, repeated take-offs in the handstand in different variations, also using trampolines. We want to use our research results as a basis for other measurements. Within the Yurchenko vault it would be appropriate to focus further studies on a more detailed analysis of the vertical and horizontal velocity components in each phase and their relation with angle characteristics. Futhermore, we are interested in kinematical changes in observed phases within the more complex forms of the Yurchenko vault. These measurements would provide relevant information for coaches on how to train this jump in beginners, as well as in jump improvement phase in advanced gymnasts.

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# THE EFFECTS OF 6 MONTHS SPECIFIC AEROBIC GYMNASTIC TRAINING ON MOTOR ABILITIES IN 10 - 12 YEARS OLD BOYS

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*Original article*

***Abstract***

*The purpose of this study was to investigate the effect of six months specific aerobic gymnastic training on motor abilities in 10-12 years old boys. Eighteen boys (aged 10-12 years old) volunteered to participate in the 6 months aerobic gymnastic training. Some motor ability parameters were measured weekly in addition to pre training. Data were analyzed using one-way ANOVA with repeated measures. The mean values of Chin-Up in 30 Seconds, Legs Lift in 30 sec, Horizontal Jump and Press Handstand test records were significantly changed after 6 months training ($p<0.05$).The Rope Climbing Using Legs/Feet records were significantly decreased (promoted) after 6 months specific training in aerobic gymnasts. Similarly, Tuck up Trunk and Leg Flexion records were significantly increased in the first, 3$^{rd}$ and last month evaluations ($p<0.05$).The records of Single Leg Squats test were significantly increased in both legs approximately similar to a higher value in pre training for right leg ($p<0.05$). Based on the results of this study it can be concluded that specific training in aerobic gymnastic, (independent of growth and maturation) causes positive changes in motor abilities in 10-12 years old boys.*

***Keywords:*** *Aerobic Gymnastic, Motor Abilities, Explosive Strength, Static Strength.*

## INTRODUCTION

Gymnastics' subgroups are composed of a series of moves that included several movements in the form of simple, complex, static and dynamic techniques that are marked with a precise definition. The use of physical activity during the period of growth improves anaerobic strength and aerobic capacity in adolescent (Bouchard, Thibault, & Jobin, 1981, Payne & Morrow, 1993).

Aerobic gymnastic (AG) is a relatively new discipline in gymnastic family, with no more than thirty years of history. As its inclusion in the International Gymnastics Federation (FIG) and until now, it is a topic of ongoing regulamentary reviews with the aim to attain better functional, harmony and coherence structure among its judges (Gutiérrez & Vernetta, 2006). This sport has unparalleled structure and it's composed of movements that are categorized according to difficulty. Set of intricate movement forms as regular stepwise by combining music and steps.

Movement patterns of legs, which include seven original steps in march, jogging, skipping, knee lifting, kicking, jumping jacking and lunging, are putting on a show. Also, it is a way in which all actions must be performed continuously without any cut-off between them is therefore a part of aerobic disciplines. The average of total time of routine in competition is 1.5 minutes (FIG, 2008).

Motor ability can be imaged as a person's ability to carry out different acts, including coordination of both thin and large motor skills (Haga, et al., 2008; Gallahue, Ozmun, & Goodway, 2006). Some of the existing motor abilities tests concentrate on balance, flexibility, agility, speed, muscular strength and endurance (Fjørtoft, Pedersen, Sigmundsson, & Vereijken, 2011; Gallahue, Ozmun, & Goodway, 2006).

Strength, balance, coordination, speed, agility and flexibility are often described as a performance related fitness, reflecting the positive changes are expected, especially in the area of motor abilities Motor competence has important implications for different aspects of development in children (Haga et al., 2008; Malina & Bouchard, 1991; Piek, Baynam, & Barrett, 2006).

Most exercises in aerobic gymnastic include explosive power movements. The body's ability for movement in the air and muscle activity are based on the needs of movement, increase the range of motion that maintaining high levels can lead to the desired level of accuracy in the condition of organs that move is running. Thus to achieve the optimal quality and safety program performance, at first step should focus on physical condition and then training program (Marković, Čavar, & Sporiš, 2012).

In aerobic gymnastics athlete should have an extraordinary and high level of suitability of preparation and this importance obtains in exercise not in tournaments. The high level of the basic requirements of fitness is necessary for the success in learning of skills. Gymnasts in motor abilities that reflect onthe quality of performance, accuracy of techniques and movements are different. This achieved with adequate and appropriate training. These athletes have a very good relationship in neuromuscular characteristics, such as very high levels of power, strength, flexibility, muscular endurance, speed and coordination (Jemni, Sands, Friemel, Stone, & Cooke, 2006).

The success of any gymnast is directly dependent on the level of motor abilities, particularly on the special strength of the gymnast. Has strength in all three forms of; explosive, static and dynamic are very important for success gymnast. Gymnastics requires a great variety of movements example; the transition from dynamic to static elements and contrariwise, frequent changes in body position and various positions in the space (Bučar Pajek et al., 2010).

Investigations that have been done on champions gymnastics indicated that they have little muscle mass despite a high power (Sands, Caine, & Borms, 2003). As a member of the gymnastics' family, aerobic gymnastics is comparable in some aspects with other subtypes (Alexander et al., 1991; Behm & Kibele, 2007; Gionet, Babineau, & Bryant, 1986).

When we look at the child gymnasts, based on the definition of power we can only discuss about of power, especially explosive power, and there will be no discussion about strength (Marković, Čavar, & Sporiš, 2012). In our search, we find a study that analysis the motor skill of 100 female aerobic gymnasts in 19-21 years old. This study show the model of the motor skills necessary for the performance of aerobics gymnastics difficulty elements are: legs and hips flexibility, the strength of hip joint flexors, coordination, general strength and power. Based our search We didn't find any more research in background of this study.

One of the crucial period in the beginning stages of training on aerobic gymnastics training is at the age of 10 to 12 years. Because official aerobic gymnastic competition start at 12 years old (AG1) and previous age is 10 to 12 years old (national development) that is starter of age (FIG, 2008). So it is very important that we have given extraordinary attention to the training requirements. In any educational program as well as its various stages, to achieve the main purpose we should have a specific program, which it can introduction to performing gymnastic exercises in the right way. Based on the principles outlined above as well as the relationship between gymnastics phases we assumed that our training program increased motor abilities to extents that are important for aerobic gymnastics.

On the other hand, there is a lack of studies which investigate the effect of a long period training course of aerobic gymnastic on motor abilities in 10-12 years-old aerobic gymnastic boys. Therefore, the aim of this study was to assess the influence of programmed training on certain motor abilities of aerobic gymnasts aged 10 to 12 years, after 6 months participation in this training.

## METHODS

The sample of subjects consisted of 18 boys (Age 11.7±0.5 years; Height, 142.2±1.7 cm; mass, 35.6±4.8 kg) that volunteered to participate in this study. All subjects had a minimum of two years' experience in gymnastic training and decided to start specific aerobic gymnastic training. They had a appropriate style and talent for aerobic gymnastic that selected by Iranian aerobic gymnastic national coach. Before conducting the study, subjects completed consent forms and questionnaires. Regarding medical information and physical exercise, none of them had any motor problems. Individuals who have a bone or joint problems in the year, before the study were barred from participating in this study.

The total period of training in current study six months (5 sessions per week for three hours per session because they have professional aerobic gymnastic training) lasted (Katić, Maleš, & Miletić, 2002). Training program generally were include: learning routine and difficulty element, artistic (specific of aerobic gymnastic and different of Artistic filde), chorography, full routine and general physical preparation. Also Warm up and cool down was constant in each session. Training period and measurements were performed under the national coach and training conditions for all subjects were the same. During the study period, subjects had not another additional non organized physical activity. All gymnasts were in the same school and have the same physical education class that we neglected it.

Measurements on seven sessions during the six-month training period held to calculate 9 functional standard tests of gymnasts. Tests were chosen so that the cover filed strength ability of hands and shoulders, and legs and trunk as well as hip flexibility. These tests include 2 tests to measure hands and shoulders, 3 tests to measure power of the trunk; 3 tests for lower body and one test for the total body (Table 1) (Marković, Čavar, & Sporiš, 2012). Before accomplishing the tests, each gymnast performed 5 minutes running and 10 minutes of dynamic stretching warm up to him.

Table 1
*Motor tests, measurement unit and motor ability*

| Name of motor test | Unit | Motor ability |
|---|---|---|
| Legs Lift From Piked Position | number | Power (Low Abs And Gauds) |
| Chin-Up In 30 Seconds | number | Power (Arms And Shoulder Belt) |
| Legs Lift In L-site position | sec | Power (Low Abs And Quads) |
| Rope Climbing Using Legs/Feet | sec | Explosive Power (Arms And Shoulder Belt) |
| Tuck Up Trunk And Leg Flexion | sec | Power |
| Single Leg Squats (Right) | number | Power (Lower Limbs) |
| Single Leg Squats(Left) | number | Power(Lower Limbs) |
| Horizontal Jump | cm | Explosive Power |
| Press Handstand | number | Power Of The Entire Body |

Data were analyzed using SPSS statistical software Version 16. Descriptive statistics (means and standard deviation) were calculated for all variables. The Kolmogorov-Smirnov test was applied to test for a normal distribution. Data were analyzed using one-way ANOVA with repeated measures. Significance levels for all statistical analyzes were considered as $p \leq 0.05$.

**RESULTS**

The mean values of Legs Lift from Picked Position test have no significant change during training period. But, the mean values of Chin-Up in 30 Seconds test records were significantly changed after 6 months training and this variable increased by 16.2% in compare to pre training values. Also, the records of Legs Lift in 30 sec test were significantly increased by 65.2% after 6 months specific training in compare to pre training values ($p<0.05$) (Figure 1).

The Rope Climbing Using Legs/Feet records were significantly decreased (promoted) by 15.9% after 6 months specific training in aerobic gymnasts. Interestingly, this variable was significantly changed in the first month as same as all later months. Similarly, Tuck Up Trunk and Leg Flexion records were significantly increased in the first, 3rd and last month evaluations. Mean changes of this variable were 23.9% after 6 months specific training ($p<0.05$) (Figure 2).

The mean values of Single Leg Squats test with left and right legs are presented in Fig 3. The records of this variable were significantly increased in both legs approximately similar to a higher value in pre training for right leg ($p<0.05$). Accordingly, this variable was increased after 6 months specific training by 190.5% in left leg and 106.8% in right leg in compare to pre training values (Figure 3).

**DISCUSSION**

The aim of physical education is to ensure comprehensive and harmonious development of children by developing their motor abilities and helping them to increase the skills and experience useful in different sports (Granacher, Muehlbauer, Doerflinger, Strohmeier, & Gollhofer, 2011; Piek, Baynam, & Barrett, 2006; Alpkaya, 2013). Any motor ability plays an important role in the process of physical education (Haga et al., 2008; Lucertini, Spazzafumo, De Lillo, Centonze, Valentini, & Federici, 2013). Physical activity in the great rang influence the growth and development of children

(Malina & Bouchard, 1991; Lopes, Rodrigues, Maia, & Malina, 2011). The motor development and sports skills of children have been considered important in the physical education program (Haga et al., 2008). The importance of different forms of sports has been verified for good lifelong physical activity and for the versatile development of fitness and motor abilities (Fujinaga, et al., 2008; Gallahue, Ozmun, & Goodway, 2006; Pehkonen et al., 2011). Some of the motor tests typically concentrate on balance, flexibility, agility, speed, muscular strength and endurance (Baláš & Bulc, 2007; Fjørtoft, Pedersen, Sigmundsson, & Vereijken, 2011; Haga et al., 2008). Some exercise like gymnastics are highly influenced on the development of these characteristics (Bučar Pajek, Čuk, Kovač, & Jakše 2010; Werner, Williams, & Hall, 2011). Horizontal Jump and Press Handstand records were significantly increased by 3.7% and 146.3%, respectively, after specific training period (p<0.05) (Figure 4).

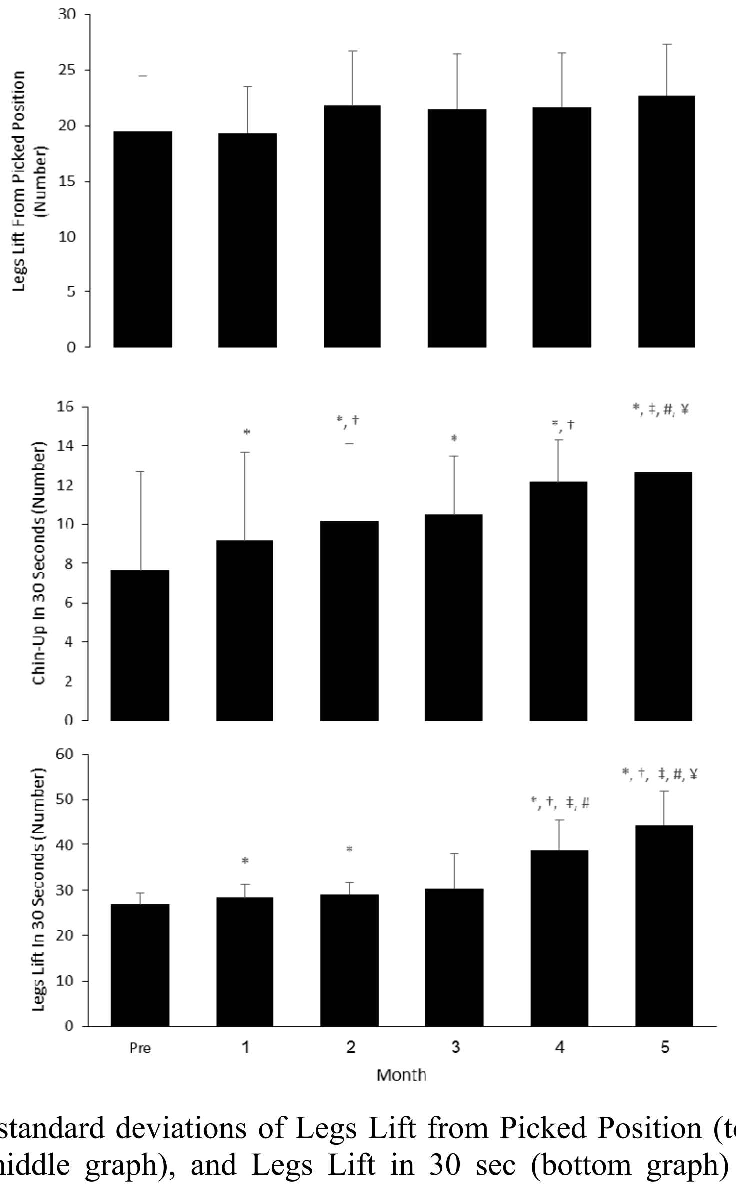


*Figure 1*. Means and standard deviations of Legs Lift from Picked Position (top graph), Chin-Up in 30 Seconds (middle graph), and Legs Lift in 30 sec (bottom graph) tests of aerobic gymnasts during 6 months specific training. *, Significant differences from pre-training values; †, Significant differences from 1 month ago values ‡, Significant differences from 2 months ago

values; #, Significant differences from 3 months ago values; ¥, Significant differences from 4 months ago values (p<0.05).

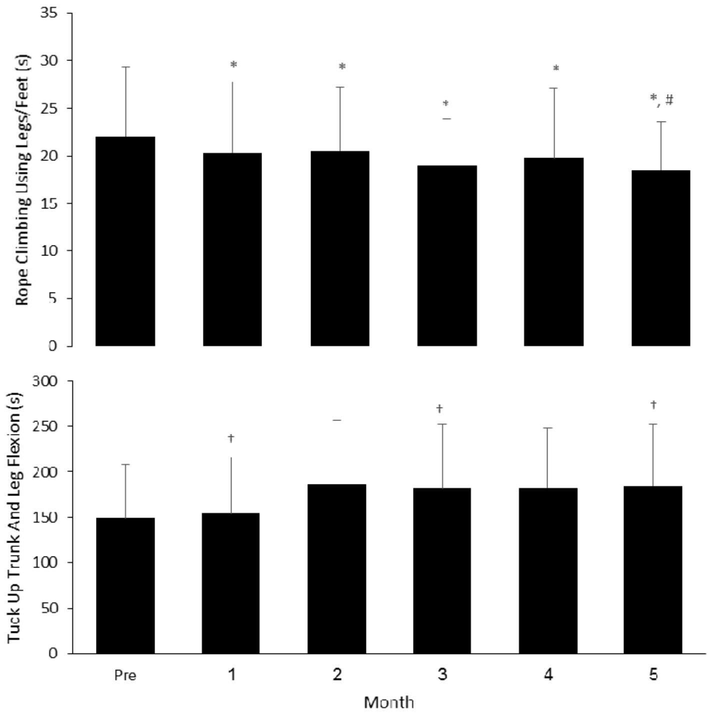


*Figure 2.* Means and standard deviations of Rope Climbing Using Legs/Feet (top graph), and Tuck up Trunk and Leg Flexion (bottom graph) tests of aerobic gymnasts during 6 months specific training. *, Significant differences from pre-training values; †, Significant differences from 1 month ago values ‡, Significant differences from 2 months ago values; #, Significant differences from 3 months ago values; ¥, Significant differences from 4 months ago values (p<0.05).

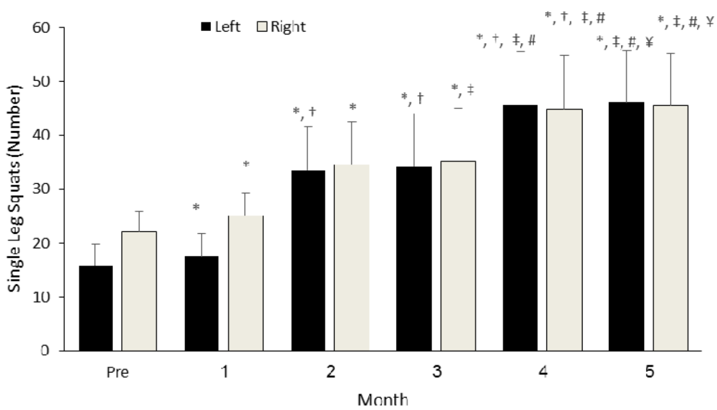


*Figure 3.* Means and standard deviations of Single Leg Squats (left and right) tests of aerobic gymnasts during 6 months specific training. *, Significant differences from pre-training values; †, Significant differences from 1 month ago values ‡, Significant differences from 2 months ago values; #, Significant differences from 3 months ago values; ¥, Significant differences from 4 months ago values (p<0.05).

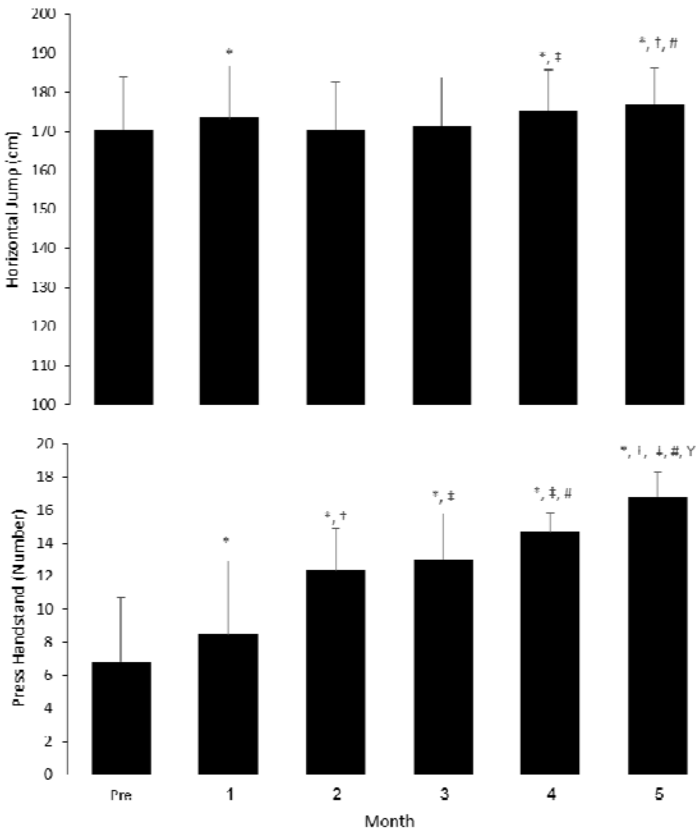


*Figure 4.* Means and standard deviations of Horizontal Jump (top graph), and Press Handstand (bottom graph) tests of aerobic gymnasts during 6 months specific training. *, Significant differences from pre-training values; †, Significant differences from 1 month ago values ‡, Significant differences from 2 months ago values; #, Significant differences from 3 months ago values; ¥, Significant differences from 4 months ago values ($p<0.05$).

Gymnastics is one of the key sports as any physical exercise on the floor or apparatus that offers a great deal of locomotive, stability and body control movements that are highly critical for the development of the children (Bučar Pajek Čuk, Kovač, & Jakše, 2010). Gymnastics needs a great variety of movement; transitions from dynamic to static elements and conversely, many changes of the body situation in space (Bressel, Yonker, Kras, & Heath, 2007; Čuljak, Ćavar, Crnjac, Marić, & Ćorluka, 2011). Gymnastic has different branches include artistic for men, artistic for women, acrobatic, trampoline, gymnastic for all, rhythmic and aerobic gymnastic. Because of lake research in this context, we try to descriptive the results of this study and highlight the effect of each motor ability roll in success of gymnast. Also we explain roll of specific aerobic gymnastic training in develop of motor ability in young children.

Aerobic gymnastics is a sport with great technical demand and needs specific characteristics in some ability: anaerobic endurance, relative strength, explosive power or strength and flexibility (López et al., 2002; Abalo Núñez, Gutiérrez-Sánchez, & Vernetta Santana, 2013). In addition, because of the current high level sports cause continues difficulties to the gymnast (Torrents et al., 2005).

Follows these results we can conclude that the specific aerobic gymnastic training had a positive influence on explosive strength, dynamic and static muscular endurance, flexibility and frequency of movements in 10 to 12 years-old boys. Changes happened in aerobic gymnastic training are partially anticipated because gymnastics is physically complicated and has a key role in the development of motor abilities (Côté, Salmela, & Russell, 1995). According to the statically analysis, the boys' motor abilities in the final measuring, compared with the initial measuring, had, in general, improved significantly.

The progress achieved in boys was in the test of explosive power, dynamic and static muscular strength. The results show that applied aerobic gymnastic training improved all motor abilities. Interesting fact is that there was exceptional improvement of explosive strength that it has a more percentage of genetic. The reason may be partly prescribed and observed during the final measurement, where the children evidently improved technique of performing the tests, which finally was more effective (Čuljak, Ćavar, Crnjac, Marić, & Ćorluka, 2011).

Poest et al (1990) reported that providing young children with the intently planned movement experiences will increase fundamental movement skills. Their results show that the applied dance program for preschool children differently affects boys (Poest et al., 1990). Thus, use of music in aerobic gymnastic can be useful in improvingthe motor ability of the gymnasts. Katić, Maleš, & Miletić (2002) have proposed that the same kinesiologictraining can differently affect 7-year-old boys, and he identified the morphological – motor variables to be addressed by general and differentiated programs of kinesiologicprogram in order for them to be achieved during the development of the child's body. Obviously, the morphological – motor development should be observed through the interaction of morphological and motor systems, thereby employing target kinesiologic treatments to bring the structures of these systems into optimal interrelationships (Katić, Maleš, & Miletić, 2002).

In Iran, PE classes (just second grade) do not contain gymnastics skills performed on the apparatus and gymnastic branches but only some simple floor exercises. Generally, the PE curriculum focuses on ball games (such as volleyball, football, tennis, etc.), track and field activities,however, the most experts would agree that gymnastics and their branches is important activities for the healthy growth and development of children. Specially, gymnastics may promote the development of coordination, strength, muscular endurance, flexibility and balance (Bencke, Damsgaard, Sækmose, Jørgensen, Jørgensen, & Klausen, 2002; Bressel, Yonker, Kras, & Heath, 2007; Werner, Williams, & Hall, 2011). Jeleska (2007) and Males et al. (2006) found that children who are in the PE classes and are regularly active in the sport branches have superior improvement in all motor abilities, compared with a group of children who participated only PE classes.

Based on the results of this study it can be concluded that specific training in aerobic gymnastic, (independent of growth and maturation) causes positive changes in motor abilities in 10 to 12-year-old boys.

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# CAN AUDIENCE REPLACE EXECUTION JUDGES IN MALE GYMNASTICS?

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*Original article*

***Abstract***

*The aim of research was to test the quality of spectator's execution evaluation of gymnast's performance compared to official judges. For the purpose 91 participants (spectators) evaluated 26 exercises on parallel bars on a scale from 0-10.0 points like it is used in diving (0-Completely failed, 0.5-2.0 – unsatisfactory, 2.5-4.5 – deficient, 5.0-6.5 – satisfactory, 7.0-8.0 – good, 8.5-9.5 - very good, and 10 – excellent). Following analysis were performed: Kolmogorov Smirnov test, Cronbach's Alpha, Spearmans Rank correlation, cluster analyze (square distance method), and Kruskal Wallis analyze of variance. Spectator's reliability of judging is same as for official judges; ranking is similar to the official judges and even better. Cluster analysis extracted three groups of spectators – strict ones, medium ones and permissive ones. As an average, they function well. The biggest challenge for spectators is bias towards their local (national) heroes and champions. However, in the spectators is also a group of those who are honest and strict without having biased opinion and they formed quite a big group (one quarter).*

***Keywords:*** *Judging, Code of Points, Spectators, Reliability, Validity.*

## INTRODUCTION

Since the first world championship in gymnastics in 1903 judging have changed severely (Bučar 1998, Grossfeld 2014). In the beginning two judges were evaluating gymnasts, later number of judges raised to three, four, six, nine, while in 2014 there are 5 judges for execution, two for difficulty and 2 as a reference judges (Štukelj, 1989, FIG, 2014). In the past there were some extreme events, where judging was not in line with spectators. Such most referred event was during World Championship in Praque in 1962, when Boris Schahklin (Soviet Union, later Ukraine) was on parallel bars awarded with the highest score, while in public spectator's opinion Miroslav Cerar (Yugoslavia, later Slovenia) should win (Satler, Šlamberger, 1966). Whistling and clapping was so noise and long term, judges have changed their score and gymnasts tied for gold. Similar situation happened at Olympic Games in Athens 2004 when spectators did not accept Alexei Nemov (Russia) score on high bar. Judges changed the score but in such way, it did not change the ranking of the gymnasts.

At the major competitions, usually spectators know the sport they attend and they award the value (exercise as a whole) of the gymnasts exercise with appropriate clapping; of course their heart beats with their best local (national) gymnasts and they are slightly biased what can be noticed by lauder cheering and clapping at the end of the exercise.

Judging is difficulty task (Plessner, 1999). It divides into two areas of work at the competition. The first task is to define content value (difficulty, special requirements and connections) and the second task is to define execution value (FIG, 2013). To evaluate content value it is necessary to memorize a lot of information e.g. - how element is defined (starting position, movement, final position), how difficult it is; in which group it belongs; what is the symbol of element (writing is compulsory) and at the end judge have to decide which elements will be count for content value. Content value is as an objective measure (Fink, 1986; Fink, Fetzer 1992) and can be controlled via video recording system IRCOS) in case of doubt (FIG, 2011b). On other side, judging execution is much simpler, in sense of amount of information needed to evaluate exercise. There are only four main deductions to apply – small one 0.1 point, medium one 0.3 point, large 0.5 point and fall 1.0 point (FIG, 2013)

By FIG Men's Code of Points (2013)(which includes more than 800 elements with different difficulties, special requirements, connection bonus, what is hard to memorize even for judges) it is evident spectators do not have proper information (in sense of content) what gymnasts are performing. Spectators can hardly define difficulty value; even experts without writing down whole exercise cannot always tell the exact score. Execution is easier to define by spectators. At least they can say the gymnasts succeeded or not. During our school days, we are and we evaluate on at least five level scale – unsatisfactory, satisfactory, good, very good, and excellent. So also, spectators (with some school experience) can give remarks according to their own criteria, what is e.g. excellent.

In the past many judges analysis were performed about their validity, reliability, bias, some of the ideas FIG accepted, some are still waiting to be applied (as Real time Judging System, Bučar Pajek et.al. (2011). Bias is in gymnastics quite common, Plessner (1999) found that placing of gymnast within the team competition have impact on its score. Similar found Ste-Marie (2003) that memory biases are evident according to previous knowledge of gymnasts. Another Ste- Marie (2000) analyses showed that novice judges, as compared to expert judges, spent less time looking at the gymnast perform, spent more time looking at the scoring paper, and were less able to engage in the dual-task demands required in gymnastic judging. Yet Another Ste-Marie analysis showed expert judges were significantly better at perceptually anticipating upcoming gymnastic elements from advance information; also, gymnastic elements that were correctly anticipated were judged more accurately than those that had been anticipated incorrectly; experts also exhibited significantly greater depth and breadth in their declarative knowledge base. In general we can conclude, judging in gymnastics is in general good (uniform judging education, FIG level of judges) according to reliability and validity of judges (Dallas, Kirialanis, 2010; Bučar Pajek et.al. 2012). Of course some problems persist, especially in area of execution where decisions have to distinguish between small and medium error and between medium and large error.

Reliability is defined how measurement results can be repeated with same results (IBM, 2013). It is also calculated how different results of same subject (from different evaluators, judges, spectators) are related. Cronbach's Alpha coefficient is a measure, which tells if there are reliably results. In general, Cronbach's Alpha higher of 0.9 is a reliably measurement. Reliability can be raised with higher number of measurements of subject (what FIG already done from two to 9 judges), but it would be of special interest how few tens of spectators are reliably. Up to now nobody tested spectators how they evaluate gymnastics exercises.

Some sports with similar approach as gymnastics (difficulty and execution) have, also simplified execution evaluation (Čuk, Fink, Leskošek, 2012). The simplest is in diving where execution is evaluated on the scale from 0 to 10 (FINA, 2011). Adults understand and could use 0-10 level scale of diving in most of life situations.

Diving execution values:

0 - completely failed
0.5 - 2.0 - unsatisfactory
2.5 - 4.5 - deficient
5.0 - 6.5 - satisfactory
7.0 - 8.0 - good
8.5 - 9.5 - very good
10 – excellent.

Before OG in Beijing there were serious attempts to include audience to evaluate sport events and judge athletes performance, even some technological solutions were prepared, however the idea did not live and we have no data on how audience is evaluating athletes performance (Biggar et al., 2005).

The aim of research is to find out how spectators can evaluate gymnasts performance comparing to judges in ranking gymnasts and in compare judges reliability and spectators reliability.

## METHODS

For experiment, we choose 91 participants (62 males and 29 females) - students of the first year at university, before they took any sport course. Average age was 19.5 years. They were not involved with gymnastics otherwise as in primary or secondary school during P.E: classes or as TV spectators.

Each participant received a paper with written guidelines what scores from 0-10 mean, and the table with three columns. In the first column there was number of gymnast presented on video (numbers from 1- 26), the second column was for participants remarks and the third column was for the participant score, they were not instructed to work as judge but to watch exercise from the beginning to the end, make short notes and give result.

Gymnast's exercises were from parallel bars only. We choose whole competition video recording and results from World Cup competition (FIG, 2011a). Participants had to evaluate 26 exercises. After the first gymnasts dismount, participants had 45 second to give their score (at competitions - 30 seconds for judges plus 15 seconds, as is time of results show results on panel), than next gymnasts, exercise was showed. Order of the gymnasts was same as at competition judges evaluated (if exist to have same order bias with spectators).

Participants seated apart and conversation forbidden.

Sample of variables consisted of: official judge's results (six judges scores (variables J1 to J6, final E score - EFINAL), average score from all spectators - VIEWER, scores from each spectator.

For data analysis, we used SPSS 22.0. Following analysis were performed: Kolmogorov Smirnov test, Cronbach's Alpha, Spearmans Rank correlation, hierarchical cluster analyze (between groups linkage and interval of squared Euclidean distance method), and Kruskal Wallis analyze of variance. Results were significant at $p<0.05$.

## RESULTS AND DISCUSION

Kolmogorov Smirnov test showed only 24 spectators succeeded to make normal scores distribution. However, also only two judges have normal distribution of scores as well. Despite the fact most of data have not normal distribution, we calculated Cronbach's Alpha as a measure of reliability. Judges and spectators have similar reliability (0.994 versus 0.997), and comparative to results in past (Bučar Pajek et al., 2012; Leskošek, et al., 2010).

Table 1
*Spearman Rank Correlation matrix*

| | VIEWER | EFINAL | J1 | J2 | J3 | J4 | J5 | J6 |
|---|---|---|---|---|---|---|---|---|
| VIEWER | 1.000 | .927** | .759** | .885** | .933** | .901** | .892** | .878** |
| EFINAL | | 1.000 | .747** | .946** | .951** | .979** | .964** | .942** |
| J1 | | | 1.000 | .811** | .704** | .732** | .673** | .699** |
| J2 | | | | 1.000 | .913** | .921** | .846** | .893** |
| J3 | | | | | 1.000 | .927** | .891** | .902** |
| J4 | | | | | | 1.000 | .959** | .908** |
| J5 | | | | | | | 1.000 | .914** |
| J6 | | | | | | | | 1.000 |

Rank correlations in Table 1 are all significant and very high. Average spectators score shares same ranking as other judges comparing towards final execution score. Even more spectators were much better in ranking than judge number 1. In addition, rank correlations between judges and average spectator are of the same level, while some are again much better than between judge one and other judges.

From the statistics point of view, spectators can even replace international judge, spectators reliability is adequate (number of measurements (judges) is very high and reliability increases). Even ranking is adequate, as average rank correlation between judges and final execution score is 0.921.

Further, we were interested if spectators are homogenous group. For a purpose we did cluster, analyze with groups from two to 10. The Figure

1 shows dendrogram of hierarchical cluster results. The best solution was with five groups where the first group had 59 spectators, the second 7 the third 22, the fourth 1 and the fifth 2. In next iteration with four groups the first group was composed of 81 spectator (59 from previous the first group and 22 from previous the third group).. For further analysis, the solution with five groups have been used, as the fourth group had only one spectator, statistics is not available, and the fifth group of two spectators was omitted in further statistics as number was too low. In Table 2 are averages from each, group, their standard deviations and standard errors for each evaluated gymnast. Unintentional perhaps it was good first gymnast scored by spectators opinion satisfactory value, what put spectators in position to adjust their scores later on with upgrading or downgrading their scores. As a rule, the first group have medium scores, the second group the highest scores and the third group have the lowest scores. Some particular results are interesting; the second group gave in average 10 points to Petkovšek and Fahrig, while in official results the highest score was for Wang. Petkovšek as a local hero (recognized by spectators) have higher ranking than Wang for the first and second group, while the third group placed Petkovšek and Wang as judges placed them. Kruskal Walis test showed for all gymnasts that spectators groups have different opinion, while only for Wang it showed there are all three groups of same opinion.

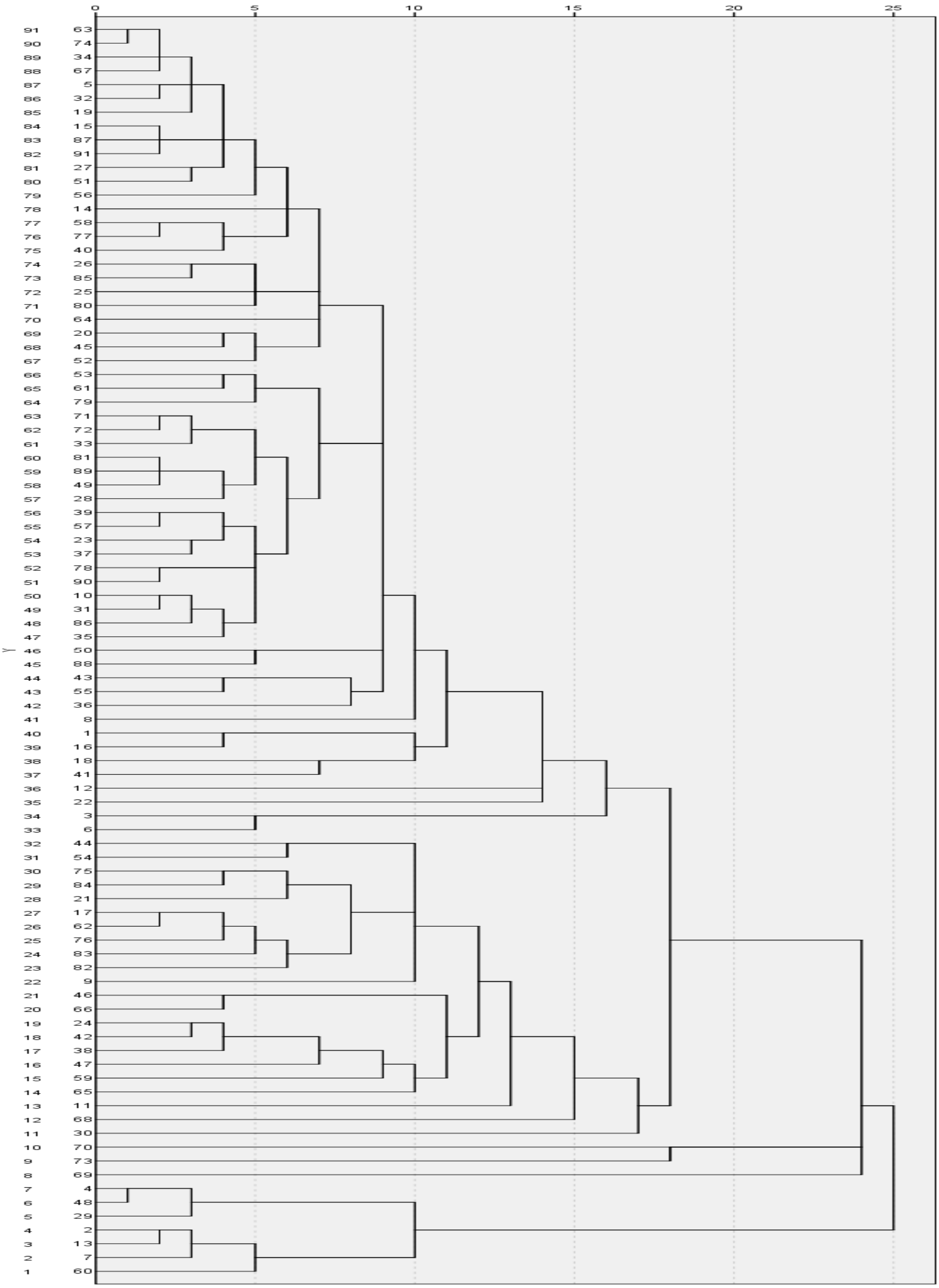


*Figure 1*. Dendrogram using average linkage between groups.

Table 2
*Average Scores from different participants group groups (participants used 0-10 scale without introducing into gymnastics judging principles)*

| | N=59 | | N=7 | | N=22 | | N=88 | |
|---|---|---|---|---|---|---|---|---|
| Gymnast | XA1 | SE1 | XA2 | SE2 | XA3 | SE3 | XAtot | SEtot |
| Leimlehner_AUT | 7.33 | .133 | 7.85 | .508 | 5.18 | .306 | 6.84 | .160 |
| Krasias_CYP | 2.47 | .195 | 4.57 | .868 | 1.22 | .262 | 2.32 | .183 |
| Batinkov_BUL | 7.49 | .193 | 8.71 | .285 | 5.90 | .353 | 7.19 | .179 |
| Babos_HUN | 8.64 | .122 | 9.42 | .202 | 7.90 | .227 | 8.52 | .109 |
| Alsadi_QAT | 5.81 | .164 | 7.71 | .521 | 4.45 | .320 | 5.62 | .167 |
| Bretschneider_GER | 8.94 | .103 | 9.57 | .202 | 8.31 | .190 | 8.84 | .092 |
| Masri_LUX | 7.20 | .146 | 9.00 | .218 | 5.40 | .204 | 6.89 | .153 |
| Palgen_LUX | 8.27 | .158 | 9.57 | .297 | 5.95 | .363 | 7.79 | .184 |
| Ishikawa_JAP | 8.64 | .089 | 9.28 | .184 | 8.18 | .214 | 8.57 | .086 |
| Behan_IRL | 7.74 | .140 | 8.85 | .404 | 6.50 | .252 | 7.52 | .136 |
| Neuteleers_BEL | 8.54 | .119 | 9.71 | .184 | 7.09 | .321 | 8.27 | .138 |
| Piasecky_SVK | 4.15 | .174 | 7.14 | .142 | 3.09 | .185 | 4.12 | .164 |
| Vovk_BUL | 8.71 | .128 | 9.71 | .184 | 7.90 | .185 | 8.59 | .110 |
| Kulesza_POL | 7.69 | .137 | 8.71 | .420 | 7.00 | .294 | 7.60 | .129 |
| Aoyama_JAP | 9.42 | .080 | 9.71 | .184 | 8.77 | .196 | 9.28 | .080 |
| Abdulrada_KUW | 7.35 | .159 | 8.57 | .368 | 6.00 | .294 | 7.11 | .152 |
| Britovsek_SLO | 3.54 | .201 | 6.14 | .260 | 2.50 | .225 | 3.48 | .175 |
| Kallai_HUN | 7.86 | .121 | 8.85 | .260 | 7.09 | .293 | 7.75 | .121 |
| Petkovsek_SLO | 9.83 | .049 | 10.0 | .000 | 9.54 | .143 | 9.77 | .050 |
| Neczli_SVK | 7.16 | .123 | 8.85 | .142 | 4.77 | .293 | 6.70 | .169 |
| Kierzkowski_POL | 7.03 | .132 | 8.28 | .184 | 5.59 | .370 | 6.77 | .151 |
| Wang_CHN | 9.50 | .097 | 9.85 | .142 | 9.68 | .121 | 9.57 | .073 |
| Alsaffar_KUW | 5.30 | .221 | 7.71 | .420 | 3.00 | .254 | 4.92 | .213 |
| Fahrig_GER | 8.25 | .161 | 10.0 | .000 | 7.81 | .260 | 8.28 | .138 |
| Decker_AUT | 8.06 | .107 | 9.71 | .184 | 6.63 | .233 | 7.84 | .128 |
| Bahlawan_SYR | 1.08 | .135 | 4.42 | .972 | 0.50 | .215 | 1.20 | .164 |

Legend: N-numerus, XA – average, SE-standard error, 1,2,3-groups, tot-total

It is important to note, each spectator made his own criteria what goes with his scores. The scores were then going up or down in accordance with gymnasts presentation. As spectators were not educated gymnasts or coaches or judges, we can say they were consistent via their own scores. High number of spectators represented as items increased reliability and validity. Despite Ste-Marie (2003) results between novice and expert judges, we can not compare them in same sense; judges did have instructions and they have to evaluate according to the Code of Points with small, medium, large and fall errors, what is very different to evaluation of whole exercise within simple 0-10 points. The content of score is different.

## CONCLUSIONS

Experiment with spectators to serve as a judge showed interesting results. Reliability of exercise presentation judging is same as for official judges; ranking is similar to the official judges and even better. Cluster analysis extracted three groups of spectators – strict ones, medium ones and permissive ones. As an average, they function well. The biggest challenge for spectators is bias towards their local (national) heroes and champions, but in the spectators is also a group of those who are honest and strict without having biased opinion. They form quite a big group (one quarter).

With modern technology, e.g. smart mobile phones FIG could perform some experimental judging among spectators. With further data collection and data analysis, perhaps some new horizon open as there is not much sports events by now, where spectators could have active role in competition.

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# BOOK REVIEW: THE SCIENCE OF GYMNASTICS

**Damian Jeraj[1,2], Linda Hennig[1] and David Schmidt-Maaß[1]**

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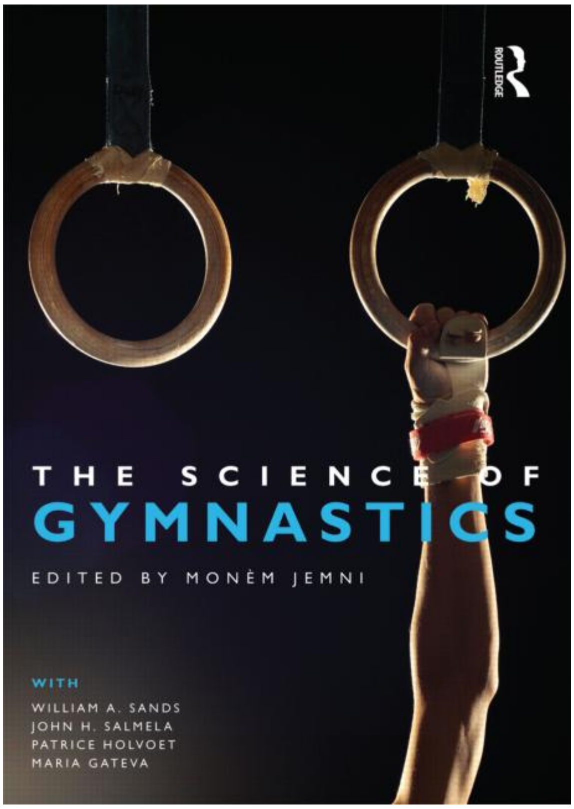
*Book review*

The book entitled "The Science of Gymnastics" written by Monèm Jemni, William Sands, John Salmela, Patrice Holvoet and Maria Gateva, provides a compilation of three fundamental principles and their interaction and relation for gymnastics, namely the physiological, the biomechanical and the psychological principle. Compared to existing textbooks, it is the first time that the reader finds the compilation and integration of these three different research areas which is necessary to know for successful coaching and developing gymnastics.

Divided into four parts, the content of the book is structured clearly. Each of the first three chapters explains in detail one of the mentioned principles above closing with summarizing questions. The authors combine these principles in the fourth part and show the interaction of the physiological, the biomechanical and the psychological view in order to enhance gymnastics performance. Based on their scientific view, the authors draw conclusions for future work in the research field of gymnastics. Additionally, based on both point of views, from the scientific and from the practitioners view, they show implications for practitioners and coaches for the different gymnastics apparatuses.




The physiological part (Part I) of the book addresses aerobic and anaerobic metabolism and their relation to the different gymnastics exercises. Afterwards, a fitness model for gymnastics is explained and training principles are shown in order to complete the physiological view of gymnastics. In addition to that, the authors show how physical and physiological assessments of gymnasts can be monitored and tested besides nationally developed test batteries. The authors close with explanations of diet, nutrition and supplementation and their effects on the gymnast's body. In the last chapter of Part I, the reader gets an impression of how physical aspects are considered in rhythmic gymnastics.

The biomechanical part (Part II) of the book firstly deals with linear and angular kinematics and secondly with linear and angular kinetics in a detailed description and explanation. Physical units and their calculation are introduced as well as their application to gymnastics. The authors show many examples (vaults, dismounts, floor exercises, etc.) which help to understand mechanical principles (calculation of forces, movement analyses, Newton's laws, etc.) and their implications for a specific gymnast or a specific movement.

The psychological part (Part III) of the book explains the development from a novice to an expert gymnast and addresses implications of coaching and of parenting for learning and performing in gymnastics. Afterwards, the Ottawa Mental Skills Assessment Tool with its 12 scales is described. Especially, the comprehensible implications for learning and performing gymnastics should be highlighted. Just as one example, it is shown how fear control or relaxation can influence the performance, which is important for all gymnasts during training and competition.

The fourth part (Part IV) of the book shows the three mentioned scientific views on gymnastics, how they interact and how the three views can explain for example the performance of a gymnast. This should be highlighted because it helps coaches, gymnasts and scientists to generate a complete base for developing gymnastics. Although it is probable not the main aim of the authors, it is absolutely conceivable that the collected and illuminative material is transferable to other kind of sports such as speed skating, figure skating or other related sport. Furthermore, the chapters of each section and especially of the integrative fourth part provides a knowledge foundation which is worth to think about own training methods or to pursue own research.

Overall, the book written by leading international sport scientists is a *must-have* for coaches, gymnasts as well as for scientists because it provides not only useful and fundamental links between theory and the applied field, but also a transfer to enhance performance. All persons engaged in the field of (artistic or rhythmic) gymnastics should recognize this up-to-date work.

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# SHORT HISTORICAL NOTES II

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.

## LARISA LATYNINA

Born on 27th December 1934 (Kherson, Soviet Union, today Ukraina), she just turned 80. We wish to most decorated gymnast all the best in future and lot of healthy days. Her first appearance at international competition started with gold medal as member of winning team at World Championship in 1954. Afterwards she collected medals at Olympic Games, World Championship and European Championship; she won 25 gold, 15 silvers and 6 bronze medals in a sum 46 medals. Her career is impressive as she started to compete as 19 years old (World Championship in Rome) and finished at World Championship in Dortmund in 1966 at age of 32; still decorated with silver medal as team member. Today she is still the only women who won 9 gold medals at OG and it seems her record will still be valid in near future.

| | | |
|---|---|---|
| Olympic Games | 1956 | 1.team, AA, FX, VT, 2.UB, 3.rhytmic apparatus |
| | 1960 | 1.team, AA, FX, 2.UB, BB, 3.VT |
| | 1964 | 1.team, FX, 2.AA, VT, 3.UB, BB |
| World Championship | 1954 | 1.team |
| | 1958 | 1.team, AA, VT, UB, BB, FX |
| | 1962 | 1.team, AA, FX, 2. VT, BB, 3.UB |
| | 1966 | 2.team |

| | | |
|---|---|---|
| European Championship | 1957 | 1.AA, VT, UB, BB, FX |
| | 1961 | 1.AA, FX, 2.UB, BB |
| | 1965 | 2. AA, UB, BB, FX, 3. VT |

It is worth to mention she won all possible disciplines at 1958 Moscow World Championship and at 1957 Bucharest European Championship.

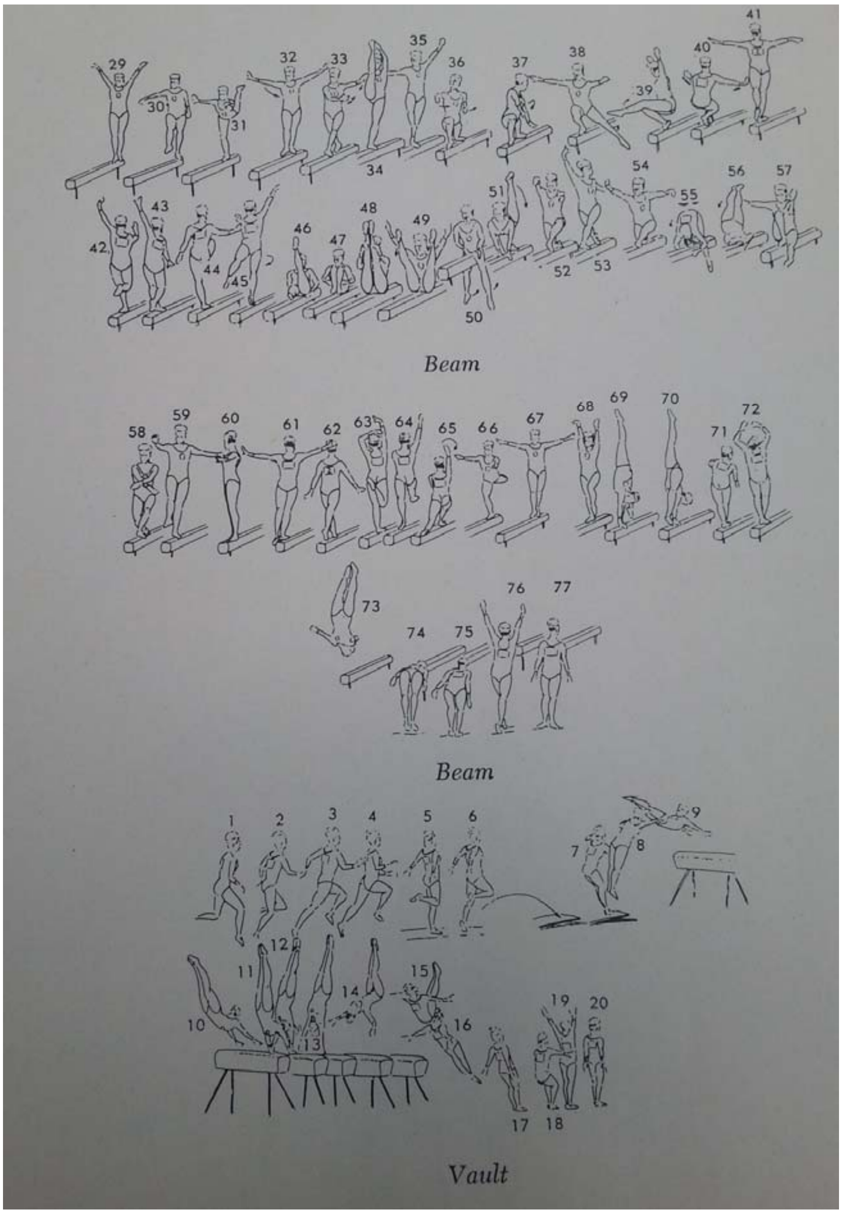
Larisa in action with her sign.

Part of Soviet Union (bold) team from 1958, best advertisement for long living of gymnasts. From left **Lydia Ivanova (born Kalinina), Larisa Latynina, Tamara Manina**, Tamara Ljuchina, Tamara Žalejeva present at Larisa's 80th birthday (L. Latynina archive)

**VERA ČASLAVSKA**

Born on 3rd May 1942 in Prague (Czechoslovakia, today Czech). She started her international competitions at age of 16, when she earned her first medal at World Championship in Moscow, and finished 10 years later after OG in New Mexico, due to political and family matters. It is important to notice she scored two 10.0 in event finals at the 1967 European Championship. We have to emphasize her seven gold medals at OG, which were all from individual rankings and her perfect domination among European championships in 1965 and 1967 where she won all disciplines (in that time European championship was equally qualitative as world championship as quality women gymnastics was not spread on other continents).

| | | |
|---|---|---|
| Olympic Games | 1960 | 2.team |
| | 1964 | 1.AA, BB, VT, 2.team, |
| | 1968 | 1.AA, FX, UB, VT, 2.team, BB |
| World Championship | 1958 | 2.team |
| | 1962 | 1.VT, 2.team, AA, 3. FX |
| | 1966 | 1.team, AA, VT, 2.BB, FX |
| European Championship | 1959 | 1. BB, 2.VT |
| | 1961 | 3.AA, FX |
| | 1965 | 1.AA, VT, UB, BB, FX |
| | 1967 | 1.AA, VT, UB, BB, FX |

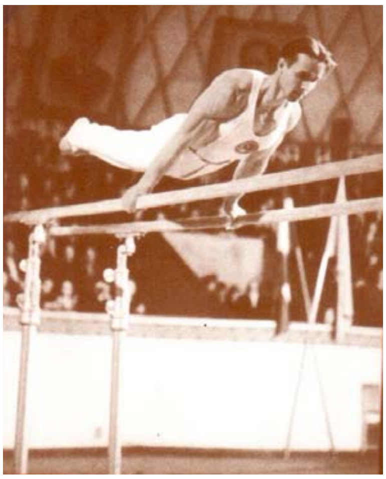


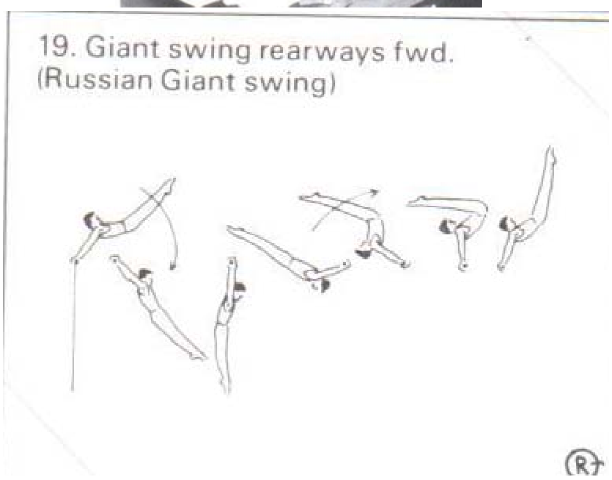

Example of Časlavska exercises at OG 1964 in Tokyo draw by A. Bruce Frederick

**VIKTOR ČUKARIN**

Born on 9th November 1921 in Mariupol (Soviet Union, today Ukraina), died in Lviv (Ukraina) on 25th August 1984. With him Soviet Union gymnastics started to dominate on international stage. Her career started at late ages according to WWII and he made his greatest achievements in age of 31 and 35 years.  Despite his international gymnasts career was short, he made open road to the next generations of excellent soviet gymnasts. Despite his name is not among original officially for Russian giants, he was one of the first men who performed it.

| | | |
|---|---|---|
| Olympic Games | 1952 | 1.team, AA, PH, VT, 2. RI |
| | 1956 | 1.team, AA, 2. PB, FX, 3.PH |
| World Championship | 1954 | 1.team, AA, PB, 3 PH |



**JOHN H. SALMELA, Ph.D.**
**A CELEBRATION OF LIFE**
**08.06.1945-29.10.2014**

***The athlete and student***

John H. Salmela, a native of Verdun, Québec, came from humble beginnings and had a successful career as a national level gymnast and a member of university gymnastics teams that won national titles. He also co-captained the Point St-Charles football team to the Canadian juvenile title in 1964. As a student, he attended the University of British Columbia, where he won the R. Tait McKenzie Award for the highest cumulative grade point average. After obtaining his Master's degree at the University of Western Ontario, he studied at the University of Alberta where he completed his Ph.D. in human performance (sport psychology).

***The scholar***

John subsequently pursued a 34-year teaching and research career that included positions at Université Laval, Université de Montréal, and the University of Ottawa, where he taught motor development and sport psychology courses in both English and French. Over the years, John's research interests spanned topics such as career development, mental skills assessment, talent identification, the development of expert performance of coaches and athletes, and the role of families in this process. After a world sabbatical tour in 1981, he wrote *The World Sport Psychology Sourcebook*, which defined the field at that time and has been updated with two subsequent editions. He has authored/edited 20 books and written 250 articles, both in academic journals and for professional audiences.

After taking early retirement in Canada in 1999, he relocated to Belo Horizonte, Brazil where he taught in Portolish (a combination of Portuguese and English) as an invited professor at the Federal University of Minas Gerais. Always looking for opportunities to write and help other colleagues, he also implemented a copy editing service in English for Brazilian scholars. John was still active and collaborating with scholars, coaches and athletes from all corners of the globe up until his passing.

Professionally, John served on various international editorial boards of scientific and professional journals, most prominently as Co-editor of the *International Journal of Sport Psychology* (1987-1995). From 1985-1995, he was the sport psychology consultant for the Canadian men's national gymnastics team where he participated in three World Championships and one Olympic Games. He trained Iranian sport psychology consultants and accompanied the Iranian delegation to the 2006 Asian Games in Doha, Quatar as the team's consultant. He also served for 16 years on the Managing Council of the International Society of Sport Psychology, including as Vice-President from 1989-1993. He wrote the three level sport psychology curriculum for the International Gymnastics Federation.

John received the International Society of Sport Psychology *Honor Award* (1993), The Sports Medicine Council of Canada Certificate of *Recognition of Dedicated Service* (1997), the Association for the Advancement of Applied Sport Psychology *Fellow Award* and the FIG International *Coaching Brevet* (2003).

***The supervisor***

John supervised 41 Master's and 12 Ph.D. students, crafting an invigorating and refreshing learning environment with his unique and efficient teaching and coaching style. He has left a legacy for being passionate about research, and his graduate students will always remember him for his ability to "listen, challenge, and support" and for his famous inspirational phrase, "Poor is the student who does not surpass his master." While John was known for being a straight shooter and for calling a spade a spade, he was also extremely caring, supportive, and generous with his time and effort to provide students with the conditions they required to succeed. His students agreed that his passion and provocative way to challenge the status quo fired them up and created the foundation they needed to push the boundaries, advance knowledge, and innovate. John had a brilliant mind and taught his students the fine art of critical thinking and global mindedness. He supervised several international students and mentored scholars from developing countries, making them feel right at home during their stay in Canada. John would say during the first day of class, "Look around, some of these people will be your friends for life" and he was right. That was the magic of Salmela, he didn't only teach students about science, he taught them about life. And that is why for many students, he was one of the best teachers they ever had.

***The father, husband, and friend***

Perhaps most will remember John as the person he was. John was a loving father, husband, brother, son, friend, and colleague. His son Max and wife Luci Fuscaldi Teixeria were the loves of his life. With pride, he beamed as he often shared Max and Luci's accomplishments with friends and colleagues. John and Luci were an admirable couple, radiating affection and respect for one another. They welcomed many people in their cherished home in Belo Horizonte, Brazil where they raised two Labrador retrievers, Forrest and Felix.

Indeed, many have memories of John as an extraordinary bon vivant. He loved to have a good laugh and life was never dull in his company. Everyone who has spent time with John has a great Salmela story to tell - from debating his idol Mag dog Vachon to swimming in Lac Gatineau at freezing point, to crawling out of windows, these stories are sure to make your belly ache from laughter, and your heart ache with nostalgia because in telling the story, you are inevitably reminded of how much you miss him. You miss him because the greatest gift John gave those who were fortunate enough to cross his path, was that of friendship. He had an enormous heart and he looked out for his people. John loved us and we loved him back. That is why he will be so greatly missed.

*- Written by Natalie Durand-Bush, Jean Côté, and Gordon Bloom -*
*Thank you to everyone who shared positive thoughts and memories of John*

# Slovenski izvlečki / Slovene Abstracts

Pia M Vinken

## KRATKOTRAJNI UČINKI ELASTIČNIH OBLIŽEV NA IZVEDBO SKOKOV PRI TELOVADCIH

Cilj raziskave je bil ugotoviti ali obliži prilepljeni na noge zdravih telovadcev vplivajo na njihovo sposobnost navpičnih skokov. 16 telovadcev je naključno izvajalo globinski skok, skok iz čepa, skok iz stoje na stegnjenih nogah na pritiskovni plošči v štirih načinih: brez obliža, obliž prilepljen na m. rectus femoris, obliž prilepljen na m. triceps surae in obliž prilepljen na sprednjo strn stegna in zadnjo stran meč prečno. Spremljano je bilo pet pomembnih spremenljivk skoka: trajanje odriva, največja sila odriva, trajanje leta, največja sila doskoka, trajanje od trenutka doskoka do najvišje sile. Kadar je bil uporabljen obliž je bilo trajanje leta krajše pri globinskem skoku, in skoku iz stoje na stegnjenih nogah. Pri globinskem skoku se je zmanjšalo trajanje leta kadar je bil obliž prilepljen na m. triceps surae. Pri skoki iz stoje na stegnjenih nogah se je trajanje leta zmanjšalo kadar je bil obliž prilepljen na m. rectus femoris. Kadar je telovadec zdrav, obliži niso potrebno, oz. so celo zavirajoči dejavnik uspešne izvedbe skoka.

Ključne besede: navpični skok, pritiskovna plošča, telovadčeve sposobnosti

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Paschalis Kirialanis, George Dallas, Allessandra Di Cagno, Giovanni Fiorilli

## POŠKODBE KOLENA PRI ODRIVU IN DOSKOKU PRI TELOVADBI

Namen raziskave je bil spremljati pogostost poškodb kolena pri grških orodnih telovadcih glede na čas nastanka poškodbe. 200 telovadcev v starosti 12,2 ± 2,8 let iz različnih društev severne in južne Grčije je prostovoljno sodelovalo pri raziskavi v sezonah 2010 do 2012. Dvakrat tedensko so bile beležene poškodbe in čas odsotnosti z vadbe. Telovadci so se največkrat poškodovali na parterju (49,5% vseh poškodb) pri doskoku, največ je bilo poškodb ligamentov v pripravljalnem obdobju, najbolj med vadbo. Pri odrivu je bilo 11,9% vseh poškodb, le-te so se najbolj pogosto zgodile na preskokupri vrtenjih naprej na tekmovanjih. Kot pomoč pri preprečevanju poškodb naj vaditelji bolj uporabljajo dodatne mehke blazine, da zmanjšajo sile pri doskoku.

Ključne besede: telovadba, dejavniki tveganja, preprečevanje poškodb

Damijan Jeraj, Thomas Heinen

## PREDVIDEVANJE VADITELJEVAGA VAROVANJA PRI IZVEDBI TELOVADNIH PRVIN

Namen raziskave je bil ugotoviti vpliv različnih načinov varovanja telovadcev pri saltu nazaj skrčeno. Narejen je bil računalniški model salta nazaj. Spremembe pri izvedbi salta nazaj so bile izračunane kot rezultat varovanja z eno roko ali obema. Pripravljeno je bilo sedem načinov, ki so spreminjali kot in dodano silo, oprijemališče sile, trajanje uporabe sile ter na ta način dobili 231 poskusov. Najbolj uspešno varovanje je bilo pogojeno s pravim trenutkom varovanja, ker je povečevanje, ali zmanjševanje hitrosti vrtenja in dodajanjem višine so med seboj odvisne spremenljivke. Za spremljanje vadečega v letu z eno roko je najuspešnejše varovanje za križ, za več pomoči pa mora biti le-ta zagotovljena že pri odrivu. Kadar varujemo dvoročno, je trenutek varovanja najpomembnejši dejavnik.

Ključne besede: šport, računalniški model, ročne spretnosti, uspešnost izvedbe

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Petr Hedbávný, Miriam Kalichová

## IZBOLJŠANJE HITROSTI PRI PRESKOKU JURČENKO

Danes telovadke izvajajo različne izvedbe preskoka jurčenko. S pomočjo 3D kinematične analize je bil namen raziskati osnovne izvedbe jurčenka stegnjeno , njihove medsebojne odnose v posameznih delih ter vpliv na uspešnost izvedbe. 14 vrhunskih mednarodnih telovadk je izvedlo jurčenka. Razčlenjena je bila hitrost težišča telesa tako v navpični kot vodoravni smeri. Kljub raznovrstnosti so bili dobljeni rezultati uporabljeni za napoved najboljše hitrosti, ki je pogoj za pravilno izvedbo jurčenka ter je v pomoč vaditeljem, in njihovim vadečim za čim hitrejši napredek.

Ključne besede: biomehanika, telovadba, preskok, izboljšanje tehnike

Mahammad Mehrtash, Hadi Rohani, Esmail Farzaneh, Rasoul Nasiri

## VPLIV ŠEST MESEČNE VADBE TELOVADNIH PLESOV NA GIBALNE SPOSOBNOSTI 10-12 LETNIH DEČKOV

Namen raziskave je bil ugotoviti vpliv šest mesečne vadbe telovadnih plesov na gibalne sposobnosti 10-12 letnih dečkov. Osemnajst dečkov je prostovoljno sodelovalo pri šest mesečni vadbi. Nekatere gibalne sposobnosti so bile merjene tedensko pred samo vadbo. Podatki so bili obdelani z metodo ANOVA. Povprečne vrednosti števila zgibov v 30 sekundah, dviganja nog v 30 sekundah, skok v daljino, plezanje po vrvi z nogami in rokami in povlek v stojo na rokah so se značilno izboljšale. Prav tako so se izboljšali rezultati v testu »dviganje trupa« v prvem, tretjem in zadnjem mesecu. Čepi in vzravnave v stoji na eni nogi so se izboljšali na obeh nogah. S telovadnimi plesi lahko uspešno razvijamo gibalne sposobnosti.

Ključne besede: telovadni plesi, gibalne sposobnosti, eksplozivna moč, statična moč

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Ivan Čuk

## ALI LAHKO GLEDALCI NADOMESTIJO SODNIKE PRI OCENJEAVNJU IZVEDBE PRI MOŠKI TEKMOVALNI ORODNI TELOVADBI

Namen raziskave je bil ugotoviti, kako gledalci ocenjujejo izvedbo telovadcev ter njihove ocene primerjati z ocenami sodnikov. 91 gledalcev je ocenjevalo 26 sestav na bradlji na lestvici od 0 do 10 točk podobno kot pri skokih v vodo (0-popolnoma neuspešna sestava, 0,5-2,0- zanič sestava, 2,5-4,5-neuspešna sestava, 5,0-6,5-pomanjkljiva sestava, 7,0-8,0-dobra sestava, 8,5-9,5-zelo dobra sestava, 10-odlična sestava). Po vrsti statističnih obdelavah lahko zaključimo, da so gledalci enako zanesljivi kot sodniki, ali tudi boljši. Gledalci so se razdelili v tri skupine: strogi, srednje strogi in blagi, vsi skupaj pa so tvorili dobrega sodnika. Največji izziv gledalcem je bila naklonjenost domačim telovadcem. Skupna strogih gledalcev (ki je predstavljala 25% vseh gledalcev) je tudi domače telovadce razvrstila pravilno.

Ključne besede: sojenje, Pravila za ocenjevanje, gledalci, zanesljivost, veljavnost

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**Elżbieta Piskorska,** (POL)
**Wojciech Przybylski** (POL)
**Tomasz Tomiak** (POL)
**Alina Woźniak** (POL)
**Mariusz Zasada** (POL)
**Artur Ziółkowski** (POL)
**Wiesław Ziółkowski** (POL)
**Walery Żukow** (POL)

## ORGANIZING COMMITTEE

**Andrzej Kochanowicz** – *chairman,*

**Jan Mieszkowski** – *vice-chairman,*

**Bartłomiej Niespodziński** – *secretary,*

**Monika Żmudzka-Brodnicka**

**Hanna Żukowska**

**Mirosława Szark-Eckardt**

**Aleksander Drobnik**

**Adam Szulc**

## INVITED SPEAKERS

**Elena Bendíková** (SVK) Department of Physical Education and Sports, Matei Bel University in Banská Bystrica.

**Finn Berggren** (DNK) Gerlev Physical Education and Sports Academy, Denmark.

**Maja Bučar Pajek** (SVN) Gymnastics and Kinesiology Department, University of Ljubljana.

**László Csernoch** (HUN) Department of Physiology, Department of Otorhinolaryngology and Head and Neck Surgery, Medical and Health Science Centre, University of Debrecen.

**Ivan Čuk** (SVN) Head of Gymnastics and Kinesiology Department, University of Ljubljana.

**Roman Farana** (CZE) Human Motion Diagnostics Centre, Department of Human Movement Studies, University of Ostrava.

**Thomas Heinen** (GER) Institute of Sports Science, University of Hildesheim.

**Eva Kohlíková CsC** (CZE) Department of Physiology and Biochemistry, Charles University.

**Juraj Kremnický** (SVK) Department of Physical Education and Sports, Matei Bel University in Banská Bystrica.

**Falk Naundorf** (GER) Institute for Applied Training Science, Department Strength-Technique, Leipzig.

**Michel Marina Evrard** (ESP) National Institute of Physical Education (INEFC), University of Barcelona**.**

**Pia M Vinken** (GER) Institute of Sport Sciences, Georg-August-Universität Göttingen.

***Dear Sirs,***

The aim of the conference is to present recent research results and views on the deteriorating health and physical fitness of children, adolescents and adults as well as to indicate the role of various sports activities, healthy lifestyle and education in efficacy to overcome this phenomenon. The conference will also provide an excellent opportunity to exchange views and knowledge from scientists, coaches, physical education teachers and medical representatives of many European countries on the topics of directions of the development and the importance of the complementary aspect of gymnastics in competitive sports, health and physical education. Thematic workshops of "best practices" directed at each profession will be provided. We hope that this conference will be a stimulus to establish a number of international partnership agreements yielding innovative scientific research projects and practical activities in the areas of sports, health and education.

We cordially invite you to participate in the conference.

The Chairman of the Scientific Committee

prof. Stanisław Sawczyn

The Chairman of the Organizing Committee

dr Andrzej Kochanowicz

**The conference is held within the International Visegrad Fund Standard Grants project:**

**"State, Role and Prospects of Gymnastics in V4 Countries"**

## THEMATIC AREA OF THE CONFFERENCE

1. New trends in gymnastic (sport, physical education, recreation)
2. Rehabilitation and corrective gymnastics
3. Biological Aspects of Sport and Sport Medicine
4. Children and Youth Sport
5. Sociological, Psychological and Pedagogical Aspects of Physical Education

## OFFICIAL LANGUAGES

English

## PLACE

Gdansk University of Physical Education and Sport
ul. Kazimierza Górskiego 1
80-336 Gdańsk, Poland

## DATE

18-20th of June 2015

## PRESENTATION FORM

invited lectures,
oral presentations,

## APPLICATION FOR PARTICIPATION

Till 30.03.2015 through electronic registration form for the conference - http://www.v4gymnastics.awfis.net/ and for the active participation in addition - sending an abstract by email (e-mail: **v4gymnastics@v4gymnastics.awfis.net**) in English, in the form of files saved in Word Editor (*.doc or *.docx). The abstract should include:

- Name and surname of the author/authors with their affiliation.
- Title in English and Polish (where applicable),
- Short (up to 250 words) description of presentation (font: Times New Roman 12 pkt., margins: 2,5 cm, spacing: 1,5) in English,

In addition, please write the necessary audiovisual media which are planned to use.

## KEY DATES

**DEADLINE FOR REGISTRATION : 30.03.2015**
**DEADLINE FOR ABSTRACTS : 30.04.2015**
**DEADLINE FOR CONFERENCE FEE : 14.05.2015**

**CONFERENCE: 18-20.06.2015**

## REGISTRATION FEES:

75 Euro = 300 PLN – full participation
50 Euro = 200 PLN – students' full participation
30 Euro = 120 PLN – Passive participation (with board and materials)
15 Euro = 50 PLN - Passive participations (only conference materials)

***The full participation fee includes:*** conference materials, lunches, coffee breaks, certificate of participation

## THE PAYMENT SHOULD BE SENT TO THE ACCOUNT:

### Transfers in PLN and EURO:

Akademia Wychowania Fizycznego i Sportu im. Jędrzeja Śniadeckiego w Gdańsku
ul. Kazimierza Górskiego 1; 80-336 Gdańsk, Poland

**BANK:** CITI HANDLOWY
Bank Handlowy w Warszawie S.A.
00-923 Warszawa
ul. Senatorska 16

SWIFT - CITIPLPX
Account number: **IBAN-63 1030 1117 0000 0000 8899 5457**

marked **„V4 Gymnastics"**

## PUBLISHING

Articles (in English) that will be presented by authors after the positive reviews will be published in Baltic Journal of Health and Physical Activity, (5.48 pkt IC i 6 pkt MNiSW) and in a scientific monograph. Editorial Board reserves the right to amendment language, graphics and text layout. For works published authors do not receive a fee. Articles published in monograph will be published as a chapter of the monograph. By chapter in a monograph is understand a scientific paper with minimum of 0,5 publishing sheet (20 000 characters including spaces). After acceptance of the paper, authors will be asked to pay 25 EURO/100 PLN of the publication fee.

***Publication Points of Polish Ministry of Science and Higher Education –*** 6 points.
Detailed information about the presentation will be given in the Communication No. 2.

## PUBLISHING REQUIREMENTS

Consistent with the guidelines of editorial board of: Baltic Journal of Health and Physical Activity:
http://www.degruyter.com/view/supplement/s20809999_Information_for_Authors.pdf

## RECOMMENDED ACCOMMODATION

Participants of the Conference can book their rooms in Sport and Leisure Centre, which is located at the conference facilities
http://opo.gda.pl/

**Organizers do not provide accommodation**

## ORGANIZER ADDRESS


Akademia Wychowania Fizycznego i Sportu im. Jędrzeja Śniadeckiego w Gdańsku
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