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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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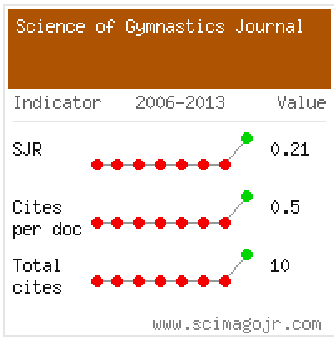

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SIGARC
IV INTERNATIONAL SEMINAR
on COMPETITIVE
ARTISTIC and RHYTHMIC
GYMNASTICS
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2nd - 3rd/Oct/2015
Abstract submissions
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(limited availability)
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EDITORIAL

Dear friends,

Four months have passed and seven new articles are in front of you. In addition to presenting Anton Gajdoš's Historical Notes, we are also inviting you to attend two international scientific conferences about gymnastics and to read one new book. International Scientific Conference: Sport, Health & Education – Complementary Approach to Gymnastics will be held 18 -20 June 2015 at Gdansk University of Physical Education and Sport in Poland. For more information please visit their home page http://www.v4gymnastics.awfis.net/. A brief report will appear in our October issue. The second conference, SIGARC, will be held in Sao Paolo, Brazil in October this year. The IV International Seminar on Competitive Artistic and Rhythmic Gymnastics had very good speakers and very high scientific contribution in the past. Please visit their web site for more details https://ivsigarcen.wordpress.com/.

The first article in the current issue is by Roman Farana, Petra Janezckova, Jaroslav Uchytil from the Czech Republic and Gareth Irwin from United Kingdom. They researched effects of the hand position on elbow loading during the round off. As the round off is a widely performed element in different gymnastic disciplines and is in a sense of health workout, it is important to minimize the loads.

The second article also refers to biomechanics. It is written by authors Joshie Motoshima and Akira Maeda from Japan and is related to the first article. They compared the Tsukahara and the Kasametsu vault in kinematic variables (both vaults use the round off). No main differences were found which underlines the need to take another look at the Code of Points.

The third article comes from Iran. Vahid Saleh explores the relationship between floor exercise landing errors, anthropometric characteristics, and balance abilities in young gymnasts. With simple motor tests it is also possible to predict more successful landings.

The forth article by Mercedes Vernetta Santana, Águeda Gutiérrez-Sánchez, Jesús López-Bodoya from Spain provides those among us who run university gymnastics courses with interesting information on how to upgrade our work. Coaches can also benefit from this article as it provides a deeper understanding of the gymnast's experience.

Andrea Ferreira João and José Fernandes Filho of Brazil contribute an article about the somato type and the body composition of elite Brazilian gymnasts. Personally, I hope we will eventually have more articles of this type and be able to collect data from all over the world in our joint database.

Portuguese - Brazilian team of Amanda Batista Santos, Maria Elisa Lemos, Eunice Lebre, and Lurdes Ávila Carvalho researched active and passive lower limb flexibility. Their most important finding is that gymnasts are asymmetrical in the left and the right leg flexibility. Coaches should pay more attention to a symmetrical load and to gymnast's motor abilities to preserve their health.

The last article is from alpine skiers Blaž Lešnik, Vanja Glinšek and Milan Žvan of Slovenia. They explore the relationship between the knowledge of gymnastics and success in alpine skiing among young Slovene skiers. It seems that gymnastics is an important sport for skiers and can improve their skiing results.

Finally, Anton Gajdoš wrote for Short Historical Notes III a bio of three excellent gymnasts: Takashi Ono, Jack Günthard and Eva Věchtova-Bosáková.

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


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EFFECT OF DIFFERENT HAND POSITIONS ON ELBOW LOADING DURING THE ROUND OFF IN MALE GYMNASTICS: A CASE STUDY

Roman Farana[1], Petra Janezckova[1], Jaroslav Uchytil[1], Gareth Irwin[1,2]

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Original article

Abstract

Elbow lesions are a potential reason for ending a gymnastics career, and presents a real concern for coaches, scientist and clinicians. Previous research has focused on female gymnastics and as such the aim of the current study was to investigate key elbow joint injury risk factors including impact forces, elbow joint kinetics, and kinematics during different round-off techniques in male artistic gymnastics. An international level active male gymnast performed 15 successful trials of a round-off from a hurdle step to back handspring with three different hand positions (parallel (5), T-shape (5) and reverse (5)). Synchronized kinematic (3D-automated motion analysis system; 240 Hz) and kinetic (force plate; 1200 Hz) data were collected for each trial. Effect-size statistics determined differences between each hand position. The key conclusions were, the T-shape technique reduces vertical, anterior-posterior and resultant ground reaction forces. Differences in elbow joint internal adduction moment and elbow joint compression force indicated that the T-shape technique may prevent elbow joint complex overload and reduces potential of elbow injuries.

Keywords: *biomechanics, gymnastics, round-off, upper limbs, injury prevention.*

INTRODUCTION

Artistic gymnastics is a unique sports due to the fact that the upper limbs are used for weight-bearing activities (Webb & Rettig, 2008). Artistic gymnastics training was previously associated with on average more than 100 impacts per one training session on the upper limbs with peak ground reaction force (GRF) magnitudes more than 3 times body weight (BW) (Daly, Rich, Klein, & Bass, 1999). The consequence of upper limbs being weight - bearing causes high impact loads to be distributed through the wrist and elbow (Webb & Rettig, 2008). There are both negative and positive effects of this weight-bearing impact (Bradshaw, 2010). Positive effects include increased bone mass and reduced risk of osteoporosis later in life (Zanker, Osborne, Cooke, Oldroyd, & Truscott, 2004). As for negative effects, elbow pain and injury in young athletes include both acute traumatic and chronic overuse injuries

(Kramer, 2010). Elbow injuries from tumbling and vaulting in gymnastics present a serious problem for performers, where elbow lesions are a potential reason for ending a gymnastics career (Chan, Aldridge, Maffulli, & Davies, 1991). Previous research by Koh, Grabiner and Weiker, (1992) highlighted that, during the back handspring, the hands experience large compression forces, and sizable moments at the elbow that may contribute to upper limb injuries. In a study that examined reaction forces transmitted to the upper extremities, Panzer, Bates and McGinnis, (1987) found that during the Tsukahara vault, elbow joint reaction forces ranged from 1.7 to 2.2 BW. Evidence from review studies has showed that chronic elbow injuries typically stem from abduction load (Hume, Reid, & Edwards, 2006) and probably contributes to some of the overuse injury patterns such as valgus extension overload (Magra, Caine, & Majfulli, 2007).

In gymnastics the round-off (RO) is one of the most fundamental skills. The importance of this skill is that it is simple and effective way for the gymnast to change from forward-rotating to backward-rotating movements while moving in one direction along a straight line (Hay, 1993). Previous research investigated GRF of the second contact hand during the RO phase of the Yurchenko vault and RO on the floor exercise (Seeley & Bressel, 2005). They found significantly greater peaks of vertical GRF (VGRF) and anterior-posterior GRF (APGRF) in the RO phase of the Yurchenko vault than on the floor exercise. Research groups from Ostrava and Cardiff have examined injury risk and technique selection associated with the choice of hand placement in RO skills in female gymnastics. These authors showed increased in elbow joint loading (Farana, Jandacka, Uchytil, Zahradnik, & Irwin, 2014) and lower levels of biological variability (Farana, Irwin, Jandacka, Uchytil, & Mullineaux, 2015) in parallel technique. More specifically, Farana et al. (2014) found that the T-shape hand position reduces VGRF, APGRF, resultant GRF (RGRF) and has decreased loading rates indicating a safer technique for the RO. Significant differences observed in joint elbow moments highlighted that the T-shape position may prevent overloading of the joint complex and consequently reduce the potential for elbow injury. The main findings from study by Farana et al. (2015) was a higher level of biological variability in the elbow joint abduction angle and adduction moment of force in the T-shaped hand position, which may lead to a reduced repetitive abduction stress and thus protect the elbow joint from overload. The focus of previous research has been with female gymnastics and there is a paucity of research examining the mechanisms of injury risk of the elbow joint during round-off with different hand position in male gymnastics. Moreover, our observations within gymnastics trainings and competitions shows that male gymnasts use three different hand positions during RO skills.

The aim of the current study was to investigate key elbow joint injury risk factors including impact forces, elbow joint kinetics, and kinematics during different round-off techniques in male artistic gymnastics. It was hypothesized that (a) hand position would change the biomechanical characteristics of impact forces and (b) hand position would change elbow joint kinematics and kinetics. Building on previous research by Farana, Jandacka, and Irwin (2013) and Farana et al. (2014) the overall purpose of this research is to increase the understanding of upper limbs injury potential in male gymnastics, which would be useful for coaches, clinicians, and scientists.

METHODS

Participant and protocol

An international level active male gymnast from Czech Republic participated in the current study. Gymnast age, height and mass were 18 years, 1.68 m and 68 kg. The gymnast is a member of the national team of the Czech Republic with more than

10 years' experience with systematic training and competitive gymnastics. The gymnast had no previous history of upper extremities injury and at the time of testing was injury-free. Informed consent was obtained in accordance with the guidelines of the Institute's Ethics and Research Committee. The research was conducted in the Biomechanical Laboratory of Human Motion Diagnostic Centre. The gymnast completed his self-selected warm up and completed a number of practice RO trials with different hand positions. A thin gymnastic floor mat (dimension 20 mm, Baenfer, Germany) was used that was taped down onto force plate to replicate the feel of a typical gymnastics' floor. Landing mats were used to provide safety for the gymnasts' landings (Figure 1).

Figure 1. Force plate with a thin floor mat, and mat for back handspring and landing.

After warm up and practice the gymnast performed 5 trials of a round-off from a hurdle step to back handspring with "parallel" hand position, 5 trials of round-off from a hurdle step to back handspring with "T-shape" hand position and 5 trials of round-off from a hurdle step to back handspring with "reverse" shape hand position (Figure 2). All trials were performed with a maximal effort, in random order (from all 15 trials) and separated by a one minute rest period.

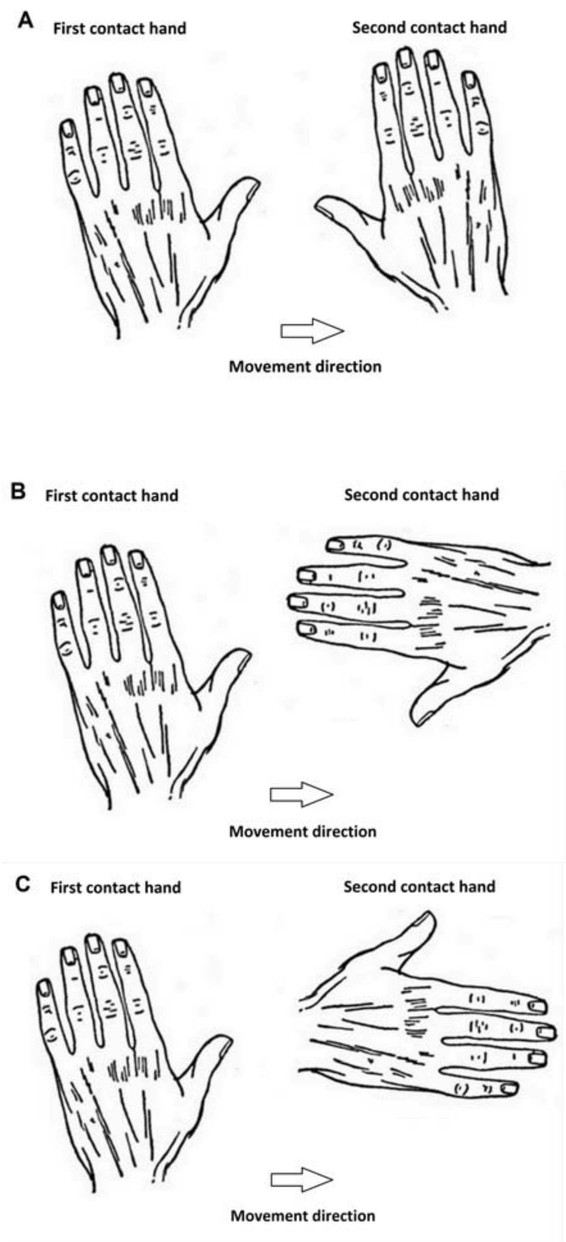

Figure 2. Round-off hand positions (A) Parallel, (B) T-shape and (C) Reverse.

Experimental set-up

One force plate (Kistler, 9286 AA, Switzerland) embedded into the floor were used to determine ground reaction force data at a sampling rate of 1200 Hz. A motion-capture system (Qualisys Oqus, Sweden) consisting of eight infrared cameras were employed to collect the kinematic data at a sampling rate of 240 Hz and synchronized with force plate. A right handed global coordinate system were employed and defined using an L-frame with four markers of the known location. A two-marker wand of known length was used to calibrate the global coordinate system and it was set up so that the z-axis was vertical, the y-axis was anterior–posterior, and the x-axis was medio-lateral. Data from the force plates and the cameras were collected simultaneously. Based on C-motion Company (C-motion, Rockville, MD, USA) recommendation, retroreflective markers (diameter of 19 mm) were attached to the gymnasts' upper limbs and trunk (Figure 3). Markers were bilaterally placed on each participant at the following anatomical locations: the acromio-clavicular joint, shoulder, lateral epicondyle of the humerus, medial epicondyle of the humerus, radial-styloid, ulnar-styloid, head of the second metacarpal, head of the fifth metacarpal, iliac crest tubercle, and inferior–medial angle of the scapula, and markers were placed on the seventh cervical and tenth thoracic vertebrae. Two clusters containing three markers each were also placed bilaterally on the upper arm and forearm. Two photocells were used to controlled hurdle step velocity. Based on previous studies by Farana et al. (2013, 2014 and 2015) the hurdle step velocity was standardized at the range of 3.3 – 3.7 m/s.

Data analysis

Raw data were processed using the Visual 3D software (C-motion, Rockville, MD, USA). The local coordinate systems were defined using a standing calibration trial in handstand position (Farana et al., 2014). All analysis focused on the contact phase of the second hand during the round off. Key injury risk variables included peak VGRF, APGRF and RGRF; loading rates of these forces; elbow joint vertical reaction force, frontal plane (+ adduction; - abduction) elbow internal moment of force and corresponding frontal plane (+ adduction; - abduction) elbow angle. The net three dimensional elbow joint moments and elbow joint reaction forces were quantified using the Newton–Euler inverse dynamics technique (Selbie, Hamill, & Kepple, 2014) and are expressed in the local coordinate system of the upper arm. The coordinate and force plate data were low-pass filtered using the fourth-order Butterworth filter with a 12 Hz and 50 Hz cut off frequency, respectively. The GRF data, moment of force data and joint reaction force data were normalized to body mass. Continuous profiles of the GRF, elbow joint reaction forces and elbow joint moments were time-normalized to 101 points, which represents an interval from 0 to 100% of the second hand contact time.

Figure 3. Marker placement on gymnast body.

Statistical analysis

Means and standard deviations (M ± SD) were calculated for all measured variables. Due to research design of this case study, an effect size (ES) statistics were used to establish differences in means. ESs were calculated and interpreted as <0.2 trivial, 0.21 - 0.6 small, 0.61 - 1.2 moderate, 1.21 - 2.0 large, 2.01 - 4.0 very large and >4.0 nearly perfect (Hopkins, 2002). The effect of >1.2 was considered to be practically significant (Manning, Irwin, Gittoes, & Kerwin, 2011).

RESULTS

Peak VGRF displayed large ESs between parallel and T-shape technique (ES = 1.3, large), and between T-shape and reverse technique (ES = 1.5, large). Additionally, for peak APGRF very large to nearly perfect ESs were found between parallel and T-shape technique (ES = 3.7, very large), between parallel and reverse technique (ES = 2.1, very large), between parallel and T-shape technique (ES = 4.4, nearly perfect). RGRF displayed large ESs between parallel and T-shape technique (ES = 1.5, large), and between T-shape and reverse technique (ES = 1.6, large). The highest magnitude of VGRF, APGRF and RGRF were observed in the reverse technique (Table 1). Figure 4 shows magnitudes for RGRF in three RO techniques.

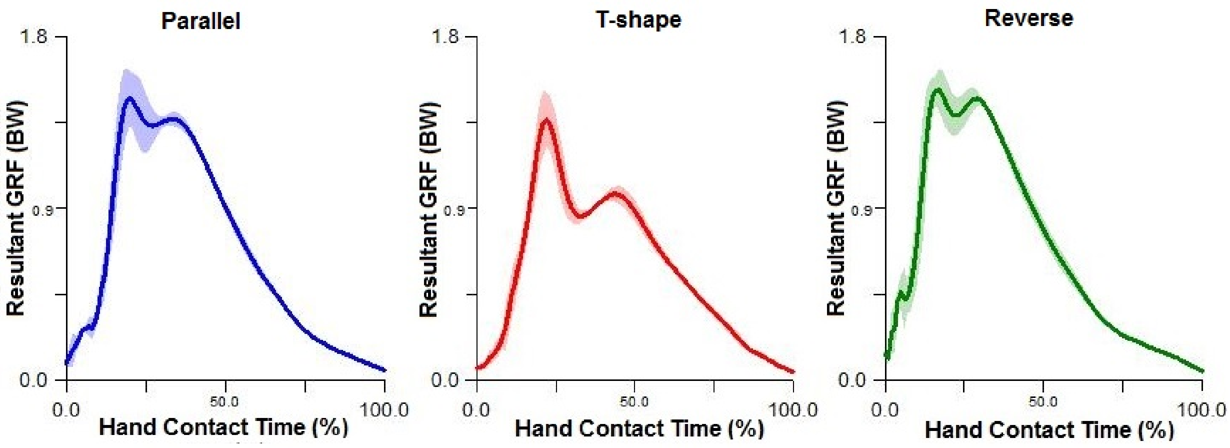

Figure 4. Resultant ground reaction force (RGRF) profiles of the second contact hand in parallel (blue), T-shape (red) and reverse (green) techniques.

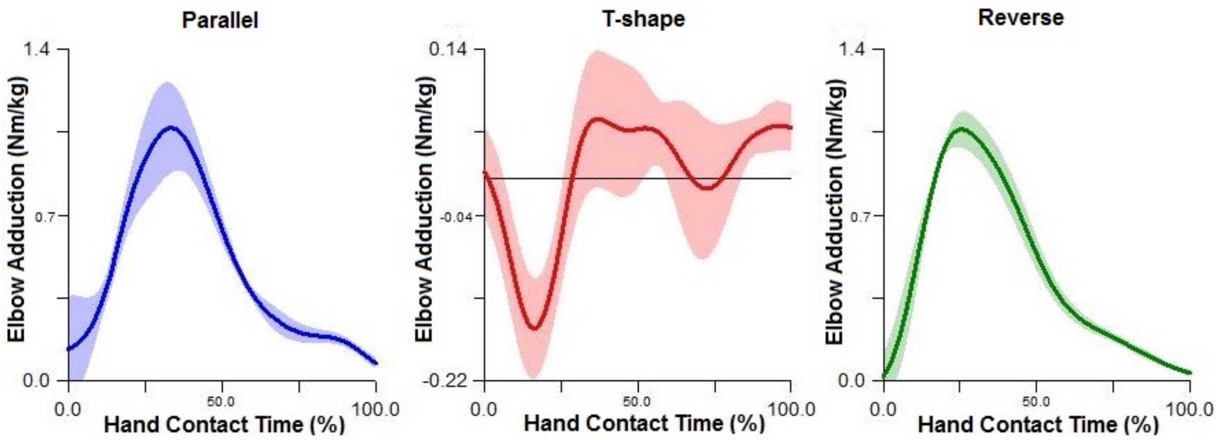

Figure 5. Elbow joint internal adduction moment of force profiles of the second contact hand in parallel (blue), T-shape (red) and reverse (green) techniques.

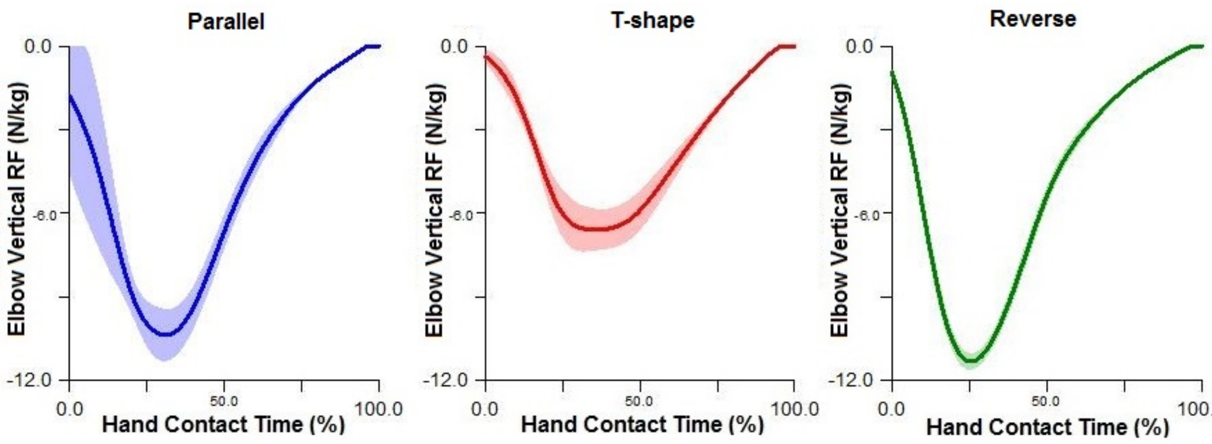

Figure 6. Elbow joint vertical reaction force profiles of the second contact hand in parallel (blue), T-shape (red) and reverse (green) techniques.

Table 1
Ground reaction forces, loading rates of ground reaction forces, elbow joint kinematics and kinetics of second contact hand during round off with three different hand positions.

Variable	Parallel technique	T-shape technique	Reverse technique	ES (PxT)	ES (PxR)	ES (TxR)
Peak VGRF (BW)	1.48 ± 0.07	1.36 ± 0.11	1.49 ± 0.05	**1.3**	0.2	**1.5**
Peak APGRF (BW)	-0.42 ± 0.03	-0.31 ± 0.03	-0.52 ± 0.06	**3.7**	**2.1**	**4.4**
Peak RGRF (BW)	1.54 ± 0.07	1.39 ± 0.12	1.55 ± 0.07	**1.5**	0.1	**1.6**
Loading rate VGRF (BW/s)	37.06 ± 2.19	33.38 ± 4.59	46.77 ± 2.68	1.0	**3.6**	**4.0**
Loading rate APGRF (BW/s)	-8.45 ± 2.20	-5.63 ± 0.42	-17.78 ± 2.15	**1.8**	**4.3**	**7.8**
Loading rate RGRF (BW/s)	36.07 ± 2.51	32.71 ± 3.10	48.74 ± 3.51	1.2	**4.8**	**4.2**
Elbow ab/adduction angle (°)	-2.84 ± 1.53	3.55 ± 0.51	-5.77 ± 1.56	**5.6**	**1.9**	**8.0**
Elbow adduction moment (Nm/kg)	1.11 ± 0.12	0.10 ± 0.03	1.06 ± 0.05	**11.5**	0.5	**23.3**
Elbow vertical reaction force (N/kg)	-10.39 ± 0.73	-6.63 ± 0.60	-11.33 ± 0.21	**5.6**	**1.8**	**10.5**

Notes: VGRF, vertical ground reaction force; APGRF, anterior-posterior ground reaction force; RGRF, resultant ground reaction force; BW, body weight; BW/s, body weight per second; °, degrees; Nm/kg, Newton meter per kilogram; N/kg, Newton per kilogram; ES, effect size; P, parallel technique; T, T-shape technique; R, reverse technique.

Very large ESs were observed for VGRF loading rates between parallel and T-shape technique (ES = 3.6, very large), and between T-shape and reverse technique (ES = 4.0, very large). In addition large to nearly perfect ESs were found for APGRF loading rates between parallel and T-shape technique (ES = 1.8, large), between parallel and reverse technique (ES = 4.3, nearly perfect), and between T-shape and reverse technique (ES = 7.8, nearly perfect). RGRF loading rates displayed nearly perfect ESs between parallel and reverse technique (ES = 4.8, nearly perfect), and between T-shape and reverse technique (ES = 4.2, nearly perfect).

As for elbow joint kinematics large to nearly perfect ESs were found for abduction angle between parallel and T-shape technique (ES = 5.6, nearly perfect), between parallel and reverse (ES = 1.9, large), and between T-shape and reverse technique (ES = 8.0, nearly perfect). In addition, nearly perfect ESs were observed for internal adduction moment between parallel and T-shape technique (ES = 11.5, nearly perfect), and between T-shape and reverse technique (ES = 23.3, nearly perfect). The highest magnitude of elbow internal adduction moment was observed in the parallel technique (Figure 5 and Table 1).

Elbow joint vertical reaction force displayed large to nearly perfect ESs between parallel and T-shape technique (ES = 5.6, nearly perfect), between parallel and reverse technique (ES = 1.8, large), and between T-shape and reverse technique (ES = 10.5, nearly perfect). The highest magnitude of elbow joint reaction force was observed in the reverse technique (Figure 6 and Table 1).

DISCUSSION

Building on previous research by Farana et al. (2013, 2014) which focused on female gymnastics, this study aimed to investigate key injury risk factors including impact forces, elbow joint kinetics, and kinematics during round-off skills with three different hand positions in male artistic gymnastics.

Previously, Seeley and Bressel (2005) highlighted that, during the round-off phase of the Yurchenko vault, the hands produce high peak reaction forces which may be responsible for upper-extremity injuries. In the current study, peak VGRF, peak APGRF, and peak RGRF of the second hand were higher in the parallel and reverse techniques compared with the T-shape technique. As shows Figure 4 and Table 1, highest magnitude of RGRF was observed in the reverse technique. A typical "braking" (i.e., high negative peak) occurs in the first part of the round-off in the anterior-posterior direction (Table 1). Table 1 shows that highest magnitude of these "braking" forces were observed in the parallel and reverse techniques compared with the T-shape technique. From an injury prospective these observations concur with the comments of Whiting and Zernicke (2008) who stated that peak forces are among the most fundamental injury risk factors. Moreover, these observations suggest that the T-shape technique may provide a technique of the round-off that reduces the risk of bio-physical overload and consequently reduces the risk of injury (Farana et al., 2014). Interestingly, the reverse technique also shows the highest second peak of RGRF which may be useful from performance perspective, when the second peak shows take-off force from the ground. Therefore, the reverse technique is more often use by male gymnasts especially for vault performance, when explosive take-off from the vaulting table is required to increase post-flight time (e.g., Takei, Dunn, & Blucker, 2003; Lim, 2004). From the vault performance perspective, an increase in post-flight time provides gymnasts the capacity to complete more complex skills, increase the vault difficulty and potential for achieving a higher score (Bradshaw et al., 2010). However, from an injury perspective this position should be used with caution.

Previous studies highlighted an important role of a forearm rotation on the elbow joint loading during the RO in female gymnast (Farana et al., 2014; Farana et al., 2015). In the current study a significantly greater peak internal adduction moment was found in the round-off with parallel and reverse hand position compared with the T-shape hand position (Figure 5). These findings are in accordance with Farana et al. (2013) and Farana et al. (2014) research who found significantly lower magnitudes of internal adduction moment in the T-shape technique compared with parallel hand position. Moreover, evidence from previous research has identified that repetitive abduction stress placed on the elbow joint can lead to chronic elbow injuries (Hume, Reid, & Edwards, 2006). Furthermore, higher magnitudes of elbow joint vertical reaction force were observed in the parallel and reverse technique compared with the T-shape technique (Figure 6). These compression forces and sizeable adduction moments placed on the elbow joint may be responsible for chronic injuries a finding which concurs with the previous study by Koh et al. (1992). In the current study elbow abduction angle were found in the parallel and reverse technique compared with the T-shape technique (Table 1). However, magnitudes of these abduction angles were lower compared with female gymnasts (Farana et al., 2014). This could be explained from the elbow joint anatomical perspective, when larger elbow carrying angle were observed in females that in males (van Roy, Baeyens, Fauvart, Lanssiers, & Clarijs, 2005).

Conclusions from this study must be considered with the sample size in mind. This limitation reduces the wider application of these results. However, the current study has benefited from the use of elite level gymnast and shows similar trends in results as previous research by Farana et at. (2013, 2014). These initial findings provide a foundation to investigate this area further, with a larger sample, different performance levels and stages of learning to examine other factors that may influence the occurrence of injury.

CONCLUSIONS

The results of the current case study provide initial findings about three different hand positions during RO skills in male gymnastics. This study found that the T-shape hand position reduces VGRFs, APGRFs, RGFRs, loading rates of these forces and indicate a safer technique of RO skills. Specifically, differences in elbow joint reaction forces and internal adduction moments highlighted that from an injury perspective the parallel and reverse techniques may be responsible for elbow joint overloading and consequently increase potential for elbow injury. These initial results may have implications for injury and performance. When potential risk factors are identified, the process of technique selection may be more objective and safe.

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KASAMATSU VERSUS TSUKAHARA VAULT

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Original article

Abstract

In the gymnastics vault, many male gymnasts presently perform vaulting of the Kasamatsu type in competitions. The purpose of this study was to clarify the characteristics of the vaulting motion of the Kasamatsu vault in comparison with the Tsukahara vault. Six male college gymnasts performed the Kasamatsu and Tsukahara vaults. Their vaulting motion was captured by the 3-dimensional optical motion capture system MAC3D. For both the Kasamatsu and Tsukahara vaults, horizontal velocity of the center of mass decreased, vertical velocity increased, and angular momentum was produced in the board contact phase. In addition, horizontal and vertical velocity decreased in the vault contact phase. However, no significant difference was observed between both vaults. The contribution of the upper limbs to angular momentum about the center of mass was significantly higher for the Kasamatsu vault than that for the Tsukahara vault at vault takeoff. These results suggest that the turn during the Kasamatsu vault was performed with rotation of the lower limbs being suppressed and angular momentum being maintained using the upper limbs.

Keywords: *biomechanics, gymnastics, kinamtics, upper limbs, lower limbs.*

INTRODUCTION

The vaulting motion is composed of the run-up, board contact, pre-flight, vault contact, post-flight, and landing phases. Among them, it is possible to alter the mechanical parameters in the board and vault contact phases, but the force that can be adjusted in the vault contact phase is slight, and it is difficult to make up for an error by the vault contact phase if it occurs during the board takeoff motion (Prassas, 1999). The force in the board contact phase is important to the success of vaulting performance (Takei, Dunn, & Blucker, 2003).

There are 3 types of vaults: front handspring, sideways handspring, and Yurchenko. With respect to the front handspring type, it has been reported that there is a positive correlation between distance of the post-flight phase and horizontal velocity of the center of mass at board takeoff (Cheetham, 1983), velocity and angular velocity in the pre-flight and vault contact phases are important determinants for the success of the ‘handspring and somersault forward tucked’ (King, Yeadon, & Kerwin, 1999; Takei, 1988), the force in the vault contact phase affects the height of the center of mass and the number of rotations of the somersault (Takei, 1991a, 1991b), and the force in the board contact phase is an important factor

(Takei, Dunn, & Blucker, 2003). With respect to the Yurchenko type, it has been reported that touching down on the springboard by raising the upper body and increasing the vertical velocity of the center of mass by block motion in the vault contact phase affect the height and distance of the post-flight phase (Uzunov, 2010). As noted, there have been many studies showing the importance of the board contact and vault contact phases in vaults of the front handspring and Yurchenko types. However, with respect to the Kasamatsu type, which is a sideways handspring type of vault that many male gymnasts have been performing in competitions in recent years, although it has been reported for hand placement (Kerwin et al., 1993) and kinematic parameters of Kasamatsu vault with 1 turn (Akopian) (Farana, Uchytil, Jandacka, Zahradnik, & Vaverka, 2014), biomechanical study of vault of the Kasamatsu type is less than the front handspring type.

The Kasamatsu vault was first pioneered by Shigeru Kasamatsu at the 1974 World Cup. This vault is performed by a handspring with 1/4 turn in pre-flight and a backward somersault with 3/4 turn in post-flight. In the vaults of the Kasamatsu type, the D-score is incremented by 0.4 for each additional 1/2 turn in the post-flight phase. Kasamatsu vault with 2 turns (Lopez, D-score 6.0) is described in the code of points of men's artistic gymnastics as the vault of the highest difficulty among the Kasamatsu-type vaults (FIG, 2013). The motions of board contact and vault contact are also important factors for the success of Kasamatsu-type vaults, and it is important to clearly teach the motions and techniques in order to effectively improve performance. Therefore, the present study aimed to clarify the characteristics of the vaulting motion of the Kasamatsu vault by comparison with the Tsukahara vault, which is a sideways type that does not have a turn in the post-flight phase.

METHODS

Subjects

Six male college gymnasts (age: 20.0±1.5 years, height: 1.64±0.04 m, body mass: 59.6±3.7 kg, competition history: 11.5±2.3 years) volunteered to participate in this study. After explaining the purpose, measurement content, risks, and data management of the study, informed consent was obtained from each subject. This study was conducted in accordance with the Declaration of Helsinki and approved by the ethics committee of the National Institute of Fitness and Sports in Kanoya.

Measurement methods and data processing

After sufficient warm-up, subjects performed the Kasamatsu vault (D-score 4.4, Figure 1) and Tsukahara vault (D-score 3.6, Figure 2) each twice randomly. All trials were recorded using the 3-dimensional optical motion capture system MAC3D (Motion Analysis Corp., USA, 400Hz), and the performance was scored by a certified judge of the Japan Gymnastics Association. A higher trial of E-score, indicating the quality of the performance, was selected for analysis for each vault. A reflective marker with a diameter of 18mm, which was attached to the body portion of the subject, was captured by synchronized Raptor 12 cameras, and 3-dimensional coordinates were recorded by Cortex 3.1.1 (Motion Analysis Corp., USA) key software. The reflective makers were attached to the parietal, front head, rear head, acromion (left and right), lateral epicondyle of the humerus (left and right), ulnar styloid process (left and right), third metacarpal bone (left and right), lower end of the scapula (right), sacrum, lower rib (left and right), anterior superior iliac spine (left and right), greater trochanter (left and right), lateral epicondyle of the femur (left and right), heel bone (left and right), external condyle fibula (left and right), and third metatarsal bone (left and right). The coordinate system was set to a static coordinate system consisting of X-axis vector in the horizontal direction with respect to the advancing direction, Y-axis vector in the advancing direction, and Z-axis vector in the vertical direction. The plus X-axis represented the direction in which each subject turned. The 3-dimensional coordinate values obtained by MAC3D were smoothed using a fourth-order lowpass Butterworth filter with 10.3-19.5Hz cut-off frequency calculated by residual analysis (Winter, 2009) .

Evaluation items

Based on the smoothed 3-dimensional coordinates, the body was regarded as a rigid body composed of 15 segments, and velocity of the center of mass, angular velocity of trunk and lower limbs, and angular momentum about the center of mass (Hay et al., 1977) were calculated using the inertia coefficient of the body segments in Japanese athletes (Ae et al., 1992). In addition, angular momentums of the head, trunk, right upper limbs, left upper limbs, right lower limbs, and left lower limbs were calculated, and their contribution was calculated by dividing by the angular momentum of the whole body. The performance of the vault was divided into four phases: board contact phase (to board takeoff from board touchdown), pre-flight phase (to vault touchdown from board takeoff), vault contact phase (to vault takeoff from vault touchdown), and post-flight phase (to landing from vault takeoff). The time of each phase was calculated.

Statistical analysis

Descriptive data are presented as mean and standard deviation. After the tests of normality and equal variance, two-way ANOVA with repeated measures (vaults vs. phases) was used to test changes in the velocity and angular momentum of the two vaults. If significant main effects were found, Bonferroni post-hoc test was used to identify the differences. The paired t-test was used to compare the two vaults. This statistical analysis was performed using the IBM SPSS Statistics 22 (IBM Corp., USA) and the significance level was set at $p<0.05$.

RESULTS

Motion time of each phase

Table 1 shows the results of the time of each phase. There was no significant difference in the times of board support, pre-flight, vault support, and post-flight phases between the two vaults.

Velocity of the center of mass

Horizontal velocity of the center of mass was not an observed interaction between vaults and phases. A main effect was not observed for the vaults, but was observed for phases ($F=268.846$, $p<0.001$). The post-hoc tests showed horizontal velocity of the center of mass significantly decreased in board takeoff from board touchdown ($p<0.001$) and in vault takeoff from vault touchdown ($p<0.01$, Table 2). Vertical velocity of the center of mass was not an observed interaction between vaults and phases. A main effect was not observed for the vaults, but was observed for phases ($F=1798.924$, $p<0.001$).

The post-hoc tests showed vertical velocity of the center of mass significantly increased in board takeoff from board touchdown ($p<0.001$) and decreased in vault touchdown from board takeoff, vault takeoff from vault touchdown, and landing from vault takeoff ($p<0.001$, Table 2).

Angular momentum about the center of mass

Angular momentum about the center of mass was not an observed interaction between vaults and phases. A main effect was not observed for the vaults, but was observed for phases ($F=452.77$, $p<0.001$). The post-hoc tests showed the absolute value of angular momentum significantly increased in board takeoff from board touchdown and decreased in vault takeoff from landing ($p<0.001$, Table 2).

Regarding the contribution of each body segment in angular momentum, there was no significant difference between the vaults at board touchdown, board takeoff, or vault touchdown (Table 3). On the other hand, the contribution of the upper limbs in the Kasamatsu vault was significantly higher than that in the Tsukahara vault ($p<0.05$), and the contribution of the right lower limbs in the Kasamatsu vault was significantly lower than that in the Tsukahara vault at vault takeoff ($p<0.05$, Table3). The contribution of the left upper limbs in the Kasamatsu vault was significantly lower than that in the Tsukahara vault ($p<0.05$, Table 3).

Angular velocity of trunk and lower limbs

Angular velocity of the trunk was not an observed interaction between vaults and phases. A main effect was not observed for the vaults, but was observed for phases ($F=66.865$, $p<0.001$). The post-hoc tests showed the absolute value of angular velocity of the trunk significantly increased in board takeoff from board touchdown ($p<0.01$, Table 4). On the other hand, angular velocity of the lower limbs was an observed interaction between vaults and phases ($F=8.133$, $p<0.001$). A simple main effect was observed for the vaults at vault takeoff ($F=16.635$, $p<0.01$). In addition, a simple main effect was observed for phases ($F=876.824$, $p<0.05$), changing significantly in board takeoff from board touchdown ($p<0.05$), vault touchdown from board takeoff ($p<0.05$), and landing from vault takeoff ($p<0.001$, Table 4).

Table 1
Motion time of each phase

	Kasamatsu vault	Tsukahara vault	t-test
Board contact phase (s)	0.124 ± 0.008	0.128 ± 0.007	n.s.
Pre-flight phase (s)	0.067 ± 0.023	0.069 ± 0.022	n.s.
Vault contact phase (s)	0.283 ± 0.036	0.296 ± 0.029	n.s.
Post-flight phase (s)	0.865 ± 0.026	0.842 ± 0.030	n.s.

Table 2
Velocity of the center of mass and angular momentum about the center of mass.

Variables	Kasamatsu vault	Tsukahara vault	Vaults vs. Phases	Vaults	Phases
Horizontal velocity (m/s)					F=268.846 ***
Board touchdown	7.24 ± 0.23	7.21 ± 0.17	F=0.993 n.s.	F=0.585 n.s.	] ***
Board takeoff	4.89 ± 0.23	4.91 ± 0.21			] n.s.
Vault touchdown	4.68 ± 0.31	4.77 ± 0.31			] **
Vault takeoff	3.10 ± 0.24	3.00 ± 0.40			] n.s.
Landing	3.01 ± 0.47	2.96 ± 0.41			
Vertical velocity (m/s)					F=1798.924 ***
Board touchdown	-1.46 ± 0.14	-1.51 ± 0.15	F=0.884 n.s.	F=5.043 n.s.	] ***
Board takeoff	4.23 ± 0.18	4.17 ± 0.14			] ***
Vault touchdown	3.43 ± 0.18	3.28 ± 0.17			] ***
Vault takeoff	2.47 ± 0.09	2.14 ± 0.27			] ***
Landing	-3.75 ± 0.56	-3.63 ± 0.71			
Angular momentum (kgm^2/s)					F=452.779 ***
Board touchdown	-5.9 ± 1.5	-5.3 ± 2.3	F=0.643 n.s.	F=0.002 n.s.	] ***
Board takeoff	-79.6 ± 4.1	-78.3 ± 6.2			] n.s.
Vault touchdown	-79.0 ± 5.1	-78.0 ± 6.5			] n.s.
Vault takeoff	-82.7 ± 8.1	-81.6 ± 6.0			] ***
Landing	-44.0 ± 6.6	-48.8 ± 10.3			

** : $p<0.01$, ***: $p<0.001$

Table 3

Contribution of each body segment to angular momentum.

Variables	Kasamatsu vault	Tsukahara vault	t-test
Board touchdown (%)			
Head	-16.4 ± 13.5	-22.9 ± 20.8	n.s.
Trunk	-3.3 ± 4.3	-9.4 ± 14.3	n.s.
Upper limbs (Right)	-15.5 ± 32.7	-13.2 ± 44.5	n.s.
Upper limbs (Left)	-35.6 ± 31.3	-36.8 ± 49.9	n.s.
Lower limbs (Right)	75.3 ± 31.7	95.1 ± 46.9	n.s.
Lower limbs (Left)	95.5 ± 41.4	87.1 ± 69.1	n.s.
Board takeoff (%)			
Head	12.7 ± 0.8	12.6 ± 0.7	n.s.
Trunk	11.2 ± 0.8	11.5 ± 0.8	n.s.
Upper limbs (Right)	9.3 ± 1.6	9.3 ± 1.7	n.s.
Upper limbs (Left)	8.9 ± 1.5	8.2 ± 2.3	n.s.
Lower limbs (Right)	25.2 ± 8.9	23.7 ± 7.1	n.s.
Lower limbs (Left)	32.7 ± 9.8	34.7 ± 8.5	n.s.
Vault touchdown (%)			
Head	11.4 ± 1.4	11.8 ± 1.3	n.s.
Trunk	10.4 ± 1.2	10.5 ± 0.6	n.s.
Upper limbs (Right)	8.2 ± 0.8	8.2 ± 1.3	n.s.
Upper limbs (Left)	7.2 ± 1.5	7.0 ± 1.6	n.s.
Lower limbs (Right)	26.3 ± 12.9	25.4 ± 9.6	n.s.
Lower limbs (Left)	36.6 ± 14.0	37.1 ± 10.8	n.s.
Vault takeoff (%)			
Head	13.3 ± 1.5	11.8 ± 2.1	n.s.
Trunk	10.7 ± 1.4	11.5 ± 0.5	n.s.
Upper limbs (Right)	7.1 ± 3.2	3.6 ± 1.8	*
Upper limbs (Left)	7.8 ± 1.3	5.8 ± 1.5	**
Lower limbs (Right)	30.8 ± 2.4	34.9 ± 2.5	*
Lower limbs (Left)	30.4 ± 3.7	32.3 ± 3.1	n.s.
Landing (%)			
Head	25.5 ± 5.4	24.5 ± 6.3	n.s.
Trunk	20.7 ± 3.3	19.1 ± 4.7	n.s.
Upper limbs (Right)	5.9 ± 3.2	6.5 ± 3.0	n.s.
Upper limbs (Left)	2.9 ± 2.9	6.7 ± 3.3	*
Lower limbs (Right)	21.0 ± 3.6	20.3 ± 1.6	n.s.
Lower limbs (Left)	24.0 ± 3.7	22.9 ± 2.9	n.s.

* : $p<0.05$, **: $p<0.01$

Table 4
Angular velocity of trunk and lower limbs.

Variables	Tsukahara vault	Kasamatsu vault	Vaults vs. Phases	Vaults	Phases	
Trunk angular velocity (deg/s)					F=66.865 ***	
Board touchdown	193.8 ± 30.2	185.0 ± 26.4			] ***	
Board takeoff	-397.7 ± 42.5	-403.6 ± 40.7	F=1.451 n.s.	F=1.212 n.s.	] n.s.	
Vault touchdown	-352.8 ± 49.8	-365.8 ± 39.6			] n.s.	
Vault takeoff	-471.0 ± 35.5	-302.4 ± 55.8			] n.s.	
Landing	-443.3 ± 161.6	-458.3 ± 235.3				
Lower limb angular velocity (deg/s)					Kasamatsu	Tsukahara F=76.824 ***
Board touchdown	-365.0 ± 40.0	-334.1 ± 70.9		F=1.757, n.s.		] ***
Board takeoff	-534.0 ± 29.4	-532.6 ± 66.7		F=0.002, n.s.		] n.s.
Vault touchdown	-605.3 ± 101.7	-578.3 ± 66.9	F=8.133 ***	F=1.387, n.s.	F=16.891 n.s.	] **
Vault takeoff	-500.5 ± 65.7	-722.8 ± 54.9		F=16.635, **		] ***
Landing	-78.2 ± 117.6	-83.7 ± 83.5		F=0.035, n.s.		

** : p<0.01, ***: p<0.001

DISCUSSION

The motion time of post-flight affects the acquisition of sufficient height and distance in the air, and it is important to perform somersaults and turns. In studies comparing high-score and low-score gymnasts among gymnasts performing a ‘handspring and somersault forward tucked’, it has been reported that the motion time of post-flight of high-score gymnasts is longer (Takei, 1991a, 1991b). However, in a study carrying out a similar comparison in a ‘handspring and two somersaults forward tucked (Roche)’, no significant difference was found between the two groups (Takei, Dunn, & Blucker, 2003). The difference in the difficulty of the vaults affected the results of these studies.

Roche is a vault that has an additional somersault compared to the ‘handspring with somersault forward tucked’, and it has a D-score of 6.0 under the current rules (FIG, 2013). In addition, the motion time of post-flight in these studies was 0.95 seconds when performing the ‘handspring with somersault forward tucked’ and 1.02 seconds when performing the Roche. Therefore, vaults of high difficulty require a longer motion time in the post-flight phase. In other words, it is estimated that the motion time of the Kasamatsu vault is longer because the Kasamatsu vault is a technique that has an additional turn compared to the Tsukahara vault. However, no significant difference was observed in the motion time of the post-flight phase (Table 1). In the present study, the gymnasts performed both the Tsukahara and Kasamatsu vaults, and their performance levels were higher when performing the former, which is less difficult.

In the board contact phase, horizontal velocity of the center of mass decreased, vertical velocity of the center of mass increased, and angular momentum about the center of mass was produced (Table 2). This result is consistent with many previous studies (Dillman, Cheetham, & Smith, 1985; Takei, 1988; Takei & Komi, 1990; Takei, Dunn, & Blucker, 2003; Uzunov, 2010). The block motion executed during the board contact phase, with the lower limbs tilting backwards, may have enabled the gymnasts to add a large anterior force to the springboard during the initial jump-off phase and effectively use it, in order to convert the horizontal velocity of the center of mass into the vertical velocity. At this time, the direction of the force applied to the body deviates from the direction of the center of mass. The lower limbs can easily swing up and the rotation required for the somersault of the post-flight phase is produced. It was shown that angular velocity of the lower limbs has a higher absolute value than that of the angular velocity of the trunk at board takeoff (Table 4). This suggests too that quickly swinging up the lower limbs can also be performed.

In the vault contact phase, vertical velocity of the center of mass significantly decreased (Table 2). It has been reported that vaults of the front handspring type are shorter contact time than vaults of the sideways handspring type (Farana et al., 2014), and vertical velocity of the center of mass increases in vault touchdown of vaults of the front handspring type (Dillman, Cheetham, & Smith, 1985; Takei, 1988; Takei & Kim, 1990; Takei, 1991a, 1991b; Takei, Dunn, & Blucker, 2003). Because both hands touch down at the same time in vaults of the front handspring type, the vault contact time is short and vault contact motion can be performed effectively by using block motion of the shoulder. On the other hand, vaults of the sideways handspring type have a long vault contact time and force is absorbed in the first vault touchdown because the hands touch down one at a time. Therefore, in the sideways handspring type, vault contact motion is not performed effectively. In vaults of the sideways handspring type, accelerating the velocity before and preventing it from decreasing during the vault contact phase may be key to successful performance. A new vault was introduced in 2001, in which the width between the hands in vault touchdown is narrower than that of vaults of the sideways handspring type. When the motion of the Lopez performed by Yang Huk-Seon, who won a gold medal in the Olympics, is observed with video, it involves a narrow width between the hands, a short time touching the vault with only one hand, and contact motion with the vault similar to that of the front handspring type. The vault contact motion makes it possible to convey force effectively and enables acquiring sufficient height in post-flight.

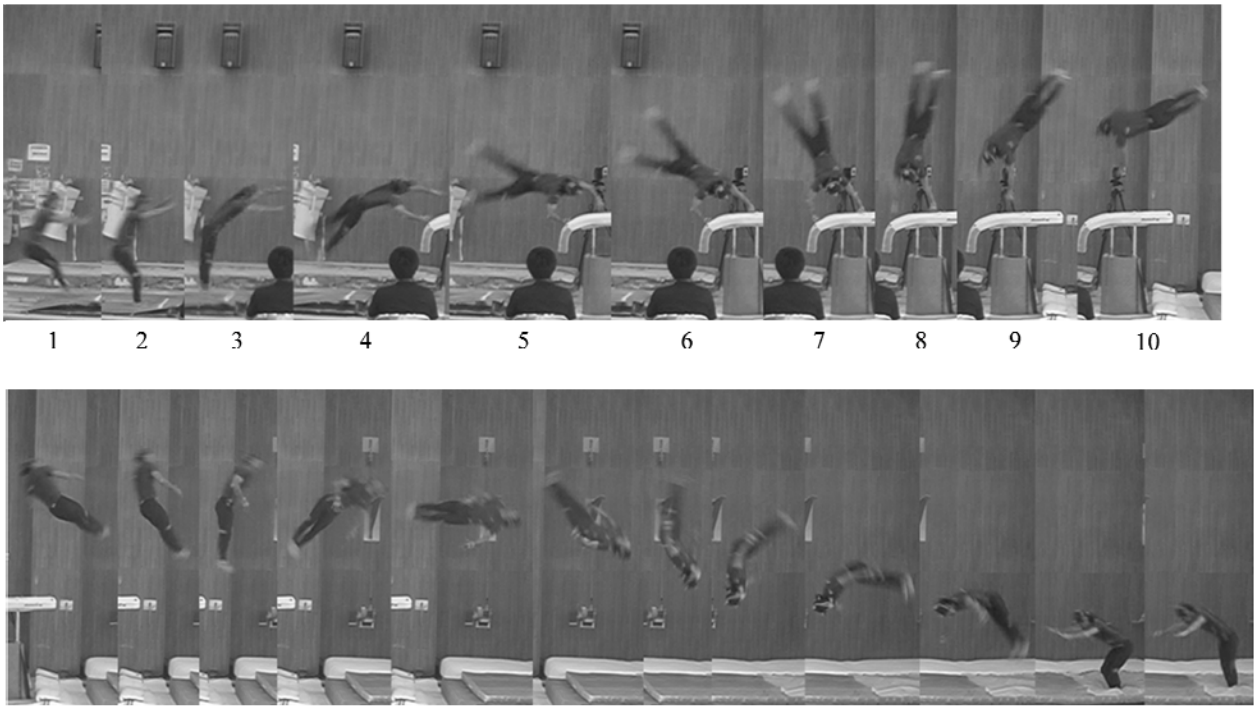

Figure 1. The sequence of the Kasamatsu vault.

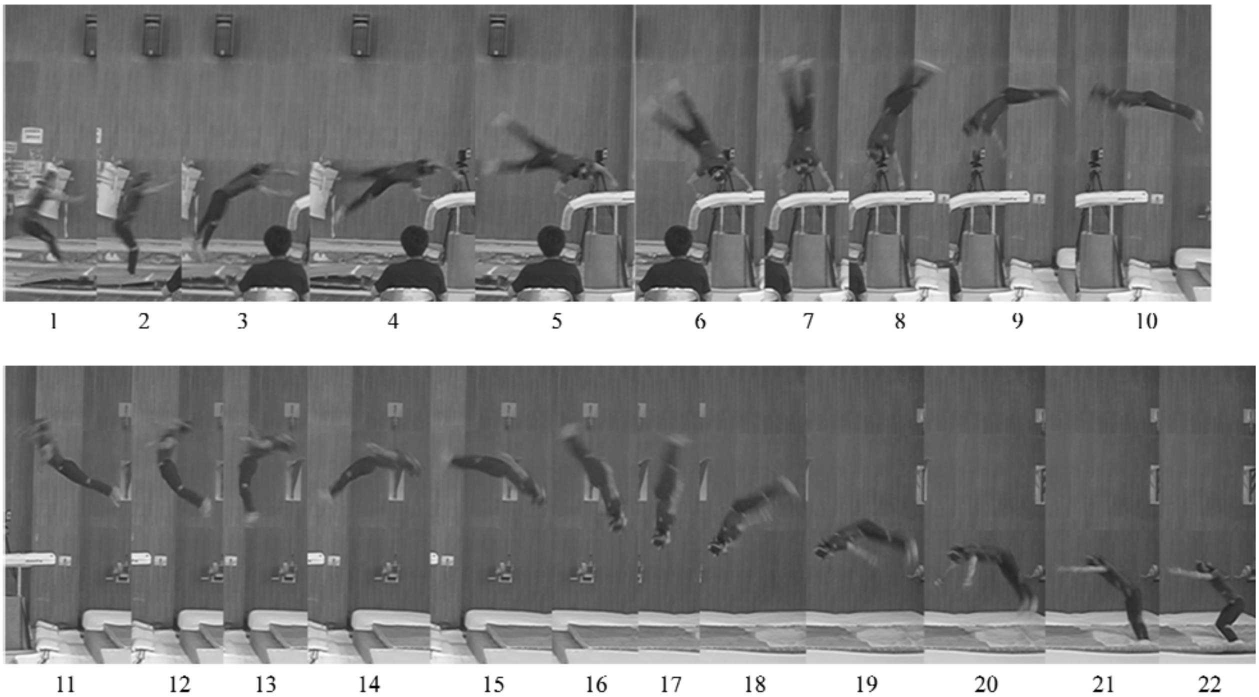

Figure 2. The sequence of the Tsukahara vault.

There was no significant difference in angular momentum about the center of mass between vaults (Table 2). No difference in the results of the present study was observed from the lateral axis of the body because the number of rotations of the somersault is the same in the Tsukahara and Kasamatsu vaults. On the other hand, the previous study comparing the ‘handspring and somersault forward straight with 3/2 turns (Lou Yun)’ and the Akopian has shown that the Akopian is more 1/2 turn in the post-flight and higher angularvelocity about the longitudinal axis than the Lou Yun (Farana et al. 2014). From this, here may be differences in the angular momentum based on the longitudinal body axis between two vaults. In vault takeoff, the contribution of the upper limbs in the Kasamatsu vault was significantly higher than that of the Tsukahara vault, and the contribution of the lower limbs in the Kasamatsu vault tended to be lower than that of the Tsukahara vault (Table 3). Looking at frames 8-11 in Figures 1 and 2, after vault takeoff, the arms were kept close to the side of the trunk when performing the Tsukahara vault, while they were lifted when performing the Kasamatsu vault. In addition, in the Kasamatsu vault there seems to be suppression of rotation of the lower limbs (Figure 2, frame 10). That is, no difference was observed between vaults in angular momentum of the whole body, but the factors maintaining angular momentum during the vault may be different. The Kasamatsu vault creates an additional turn by suppressing the rotation of the lower limbs and making use of the upper limbs. The contribution of the left upper limbs to angular momentum in the Kasamatsu vault was significantly lower at landing (Table 3). This may be explained by the influence of the twist-releasing motion to prepare for landing as seen in frames 16-20 of Figure 2.

CONCLUSIONS

The purpose of this study was to clarify the characteristics of the vaulting motion of the Kasamatsu vault in comparison with the Tsukahara vault. According to the results, the characteristics of the Kasamatsu vault are as follows:

1) In the board contact phase, horizontal velocity of the center of mass was converted to vertical velocity, and angular momentum was produced.

2) In the vault contact phase, vertical velocity of the center of mass decreased.

3) Angular momentum about the lateral axis of the Kasamatsu vault was comparable to the Tsukahara vault.

4) Suppressing the rotation of the lower limbs and performing a turn with the upper limbs swinging up was effective in order to maintain angular momentum about the lateral axis and obtain angular momentum about the longitudinal axis at vault takeoff.

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THE RELATIONSHIP BETWEEN FLOOR EXERCISE LANDING DEDUCTION, ANTHROPOMETRIC CHARACTERISTICS AND BALANCE IN 6 TO 8 YEAR OLD GYMNASTS

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Original article

Abstract

Without doubt balance is one of a major effective aspect of appropriate sport skill performance (especially in Gymnastic). The purpose of this study was to investigate the relationship between floor exercise landing deduction, anthropometric characteristics and balance in twenty 6 to 8 year old gymnasts. For measuring balance: Stork test for static balance and Time to get up and go test for dynamic balance were used. To analyze the landing deduction in floor exercises, the floor routine were performed and recorded by video, and each landing deduction following each gymnastic element was evaluated. A total of 8 anthropometric variables were measured of each gymnast. A highly significant positive correlation was found between the landing deduction and dynamic balance ($r=0.807$; $p<0.01$) and highly significant negative correlation was found between landing deduction and static balance ($r=-0.862$; $p<0.01$). Significant negative correlation was found between dynamic balance and static balance ($r=-0.736$; $p<0.01$). Balance (static and dynamic) have important relation towards landing quality. Height, body weight, waist circumference, sole length and leg length are important characteristic in this age group. Also technical mastery is another factors that influence quality of landing.

Keywords: *gymnastics, male gymnasts, judging, succes.*

INTRODUCTION

Gymnastics is sport requires a high level of physical fitness factors such as strength, flexibility, agility, co-ordination, balance, and grace. It is a well-known exercise and sport in the world. An elite gymnast is supposed to be equipped with a combination of these motor features (Marinsek, 2009; Vandorpe, 2011). A gymnast for success and achieve to international level in gymnastic minimum needs ten years preparation and hard exercise (Marinsek, 2010; Markovic & Omrcen, 2010). This period of extensive preparation entails a long process of training covering special teaching methods to practice the moves with proper technique (Markovic & Omrcen, 2010). Today male gymnasts compete on Floor, Pommel Horse, Rings, Vault, Parallel Bars and High Bar apparatuses (FIG, 2009). Without doubt balance is one of a major effective aspect of appropriate sport skill performance (especially in Gymnastic) (Ashton-Miller, Wojtys, Huston, & Fry-Welch, 2001). Good gymnasts must maintain balances in order to successfully perform the dynamic and static acrobatic moves at different levels. Thus, during the special training period, posture control exercises should be particularly emphasized (Vuillerme & Nougier, 2004). For performing acrobatic gymnastic elements, gymnasts have to immediately transfer their body's weight from one position to another (Asseman, Caron, & Cremieux, 2004). Therefore, gymnasts practice special training methods by using their own body weights. These exercises consist of the move itself or similar but modified moves (Halilaj & Vehapi, 2009). In the process of learning a move, repetitions over a long period of time also serve as special strength exercises, which help to increase the gymnast's strength and stamina (Jemni, Sands, Friemel, Stone, & Cooke, 2006). Practicing various training techniques improves the gymnast's ability to control his body position in the air during somersault moves and ability to stand in landing. As the number of somersaults increases, the angular momentum in the transversal axis will also increase and make it harder for the gymnast to keep his balance in landing (Suchilin & Arkaev, 2004). The gymnast`s total effort lasts for 12-15 minutes including warm-ups. The gymnast has to perform his skills in such a short time by applying maximum strength, agility and ability (Halilaj & Vehapi, 2009; Jemni, Sands, Friemel, Stone, & Cooke, 2006). In the evaluation of the performances by the judges during the competition, the gymnast is expected to achieve a goal special requirements for each apparatus. In this complex structure, the male gymnasts are expected to perform a series of moves in all 6 apparatuses. These series of moves consist of simple and complex skills following one another consecutively (Bruggemann, 1994; FIG, 2012). Code of point (COP) is regulation of international Gymnastics federation for gymnasts, coaches and judges. According the code of point, a floor exercise has to be completed in 70 seconds (Bruggemann, 1994). Thus, the energy system for a floor exercise is anaerobic energy system, because floor routine consist of acrobatic moves of short duration and high intensity. Judges evaluate each gymnast elements with base on regulation in code of point to mastery in technical skills (Bruggemann, 1994), comparison of different techniques (Franks, 1993, Yoshiaki, Dunn; & Blucker, 2003) and defects in execution (FIG, 2012). Except rolling elements, each acrobatic element in floor exercises must end in a perfect standing position (FIG, 2012). Any deviation from the correct position is considered as mistakes and the judges made deduction according code of point (COP). In landing from the twisting and somersault elements consisting of acrobatic skills, the primary purpose is to be able to stop the linear and angular movement effectively at the moment of contacting the floor. Professional gymnasts shows the control and well landing, because they have good technic and sufficient height, but mistakes in technical execution and insufficient height can affect the balance in landing negatively (McNitt-Gray, Requejo, Costa, & Mathiyakom, 2001).

General balance ability is vital for both obtain and controlling the motor skills. Even if this skill may be a genetic characteristic of the person, it is said that it can be improved by training (Polishchuc & Mosakowska, 2007). The speed and the level of learning the technical skills in sports are closely associated with balance ability. According to study and researches athletes specially gymnasts have better static and dynamic balance ability than people who are not involved in sports and are untrained people, and the balance ability improve in tandem with the number of years spent in sports (Paillard et al., 2006). Extra to this, posture control is thought to be related to the kind of activity undertaken (Asseman, Caron, & Cremieux, 2004). Studies indicates that gymnastic exercises enhance the balance ability (Kruczkowski, 2007, Vuillerme, Teasdale, & Nougier, 2001). For example the men have an event that requires extraordinary balance abilities- pommel horse. Of course, handstands are probably the single most recognized balance skills. The still rings in men's gymnastics is an underrated balance event which requires the gymnast to continuously keep the movable rings under himself. Gymnasts learn to balance on their feet and their hands. Interestingly, gymnasts tend to develop a higher tolerance for imbalance or disturbances to their balance. Gymnasts do not react with as large a "startle response" to sudden imbalances as non-gymnasts. This probably means that gymnasts can tolerate larger disturbances to their posture because they have become more familiar with these positions and do not consider them to be such a threat (Bosco, 1973; Debu, Woollacott, 1988; Kioumourtzoglou, Derri, Mertzanidou, & Tzetzis, 1997). However, there are some studies comparing landing in floor exercise with balancing skills (Marinsek, 2009; Markovic & Omrcen, 2010; Marinsek & Čuk 2013; Čuk & Marinšek 2013).

Starting from this fact, the purpose of this study is the relationship between floor exercise landing deduction, anthropometric characteristics and balance in 6 to 8 year old gymnasts.

METHODS

Twenty gymnasts in age group 6 to 8 competition in Ardebil choose to participate in this study. Participants were excluded if they had an abnormalities, general health problems, vestibular problems, visual problems, or a concussion before the study. Before testing began, the aim and procedures of the study were explained to the participants and informed consent was obtained. A total of 8 anthropometric variables (heights, body weights, length: total hand, total leg, sole, Circumference: calf, waist, hips) were recorded of each subject on right sides of body on the day before the competition. The study was performed during competitive season. Subjects were restrained from fatiguing exercise before test days. The limb dominance was determined by asking the participant which leg he preferred for doing handstand. During the competition, starting and resulting scores, and deductions made by the jury for the floor exercise performances of the gymnasts were recorded. Floor exercise routines were also recorded by a camera in order to analyze the landing deduction. The performances of the recorded gymnasts were watched and evaluated once again by six International Iranian Judges only for landing deductions no other deductions like technical deductions.

The following anthropometric instruments were used:

Seca 220R telescopic stadiometer (measuring range: 85-200cm; precision: 1mm). Seca 710R weighing scale, calibrated beforehand (capacity: 200kg; precision: 50g). Anthropometric tape (precision: 1mm). Sliding Caliper (precision: 1mm). Additional equipment (a wax pencil for marking the individual, a spirit level to ensure the correct alignment of the anthropometry).

Balance performance of the participants was assessed with the aid of the SEBT (Stork balance stand test) (Johnson & Nelson 2009). (This test measures the ability of the participant to balance on the ball of the foot with hands placed on the hips while positioning the non-supporting foot against the inside knee of the supporting leg. Afterwards, the gymnasts were given one trial. Using a stopwatch, the amount of time in seconds that the participant is able to stand on the ball of the foot of one leg is indicative of his balance performance. The timing is stopped if:

(i) The supporting foot swivels or moves (hops) in any direction. (ii) The non-supporting foot loses contact with the knee. (iii) The heel of the supporting foot touches the floor. Since, time is increasing in this test, participant obtain higher score in the higher duration. For each participant, the overall score was the best of three attempts. The same procedure was carried out for both lower limbs.

For Evaluating of the dynamic balance we used the Timed Up & Go Test (TUG). The TUG test was developed as a brief screen for mobility and falls risk. It has good test-retest reliability and sensitivity and specificity for falls. The TUG test measures, in seconds, the time it takes for an individual to stand up from a standard arm chair, walk a distance of 3 meters (9.84 feet), turn, walk back to the chair, and sit down again. The participant wears his gymnastics footwear. No physical assistance is given. Participants start with their back against the chair, their arms resting on the armrests, and their walking aid at hand if needed. When I say "go" I'd like you to stand up and walk as quickly as safely as possible to that line on the floor, turn, return to the chair, and sit down again. Have the participant practice one trial to be sure they understand the procedure. Start timing when you say go and stop when the participant sits down.

Use a stop-watch to time the performance and observe balance closely, especially at the turn. If the participant does not perform the test correctly the first time (stops at the turn, does not sit down right away, or does not walk all of the way to the 3 meter mark) repeat the test. Since, time is decreasing in this test, participant obtain higher score in the lower duration.

Process of evaluating floor exercise was simple and according regularly of code of point (COP). Floor exercise program for athletes were Optional. In artistic gymnastics competition two separates scores, “D” and “E”, will be calculated on all apparatus. The D-jury establishes the “D” score, the content of an exercise, and the E-jury the “E” score, the exercise presentation related to compositional requirements, technique and body position. According the code of point “E” jury for any small LD (landing deduction) and Poor posture or body position or postural corrections in end positions considered (0.10), medium (0.30), and major (0.50) errors. In line with the purpose of the study, a jury of six International Iranian Judges was formed to detect the LD in floor routines. Keeping in mind the deductions made by the “E” jury and score given by the head judge “D” jury during the competition, these judges watched the recorded routines once again. In this study in conformity with the international code of points, errors in balance was penalized as small (0.10), medium (0.30), and major (0.50) faults. Mistakes in landing due to insufficient height or poor technique in the execution of a skill were not taken into account.

In ferential and descriptive statistics and relationship between, static and dynamic balance, LD and age, height, body weight, lengths of total hand, leg and sole, circumferences of calf and waist were investigate by using multiple correlations. The level of statistical significance was set to $p \leq 0.05$. The statistical analyses were done by using statistical software (SPSS version 19.0).

RESULTS

According Kolmogorov Smirnov test distribution of variables were normal. More detailed information (means and standard deviations) about gymnasts are reported in table 1.

All collected data were analyzed using Pearson Correlation Coefficient shown in table 2 and 3.

Result showed that there was a negative correlation between LD and sole length ($r=-0.542$; $p<0.05$) and A highly significant positive correlation was found between leg length ($r=0.866$; $p<0.05$) and positive correlation between height ($r=0.670$; $p<0.05$). In dynamic balance (DB) there was a negative correlation between body weight ($r=-0.529$; $p<0.05$) and sole length ($r=-0.551$; $p<0.05$). Also we found positive correlation between height ($r=0.784$; $p<0.05$) and leg length ($r=0.684$; $p<0.05$). In SB we observed highly negative correlation between height ($r=-0.807$; $p<0.05$) and leg length ($r=-0.710$; $p<0.05$) and positive correlation between body weight ($r=0.784$; $p<0.05$), waist circumference ($r=0.606$; $p<0.05$), total hand length ($r=0.575$; $p<0.05$). There was not found any statistically significant correlation between LD and age, training history, body weight, Calf circumference, waist circumference and total hand length ($p>0.05$). No correlation was found between DB and age, training history, Calf circumference ($p>0.05$). Also not found any correlation between SB and age, training history ($p>0.05$). Correlation between floor exercise evaluations and balance tests was assessed with Pearson Correlation coefficient, shown as correlation matrix in table 4.

A highly significant positive correlation was found between the LD and DB ($r=0.807$; $p<0.01$) and highly significant negative correlation was found between LD and SB ($r=-0.862$; $p<0.01$). Significant negative correlation was found between DB and SB ($r=-0.736$; $p<0.01$).

Table 1

Means and Standard Deviation of the gymnasts.

Variables	Mean	SD
Age (Year)	6.85	.745
Training history (years)	2.75	.638
Height (cm)	118.80	5.836
Weight (kg)	22.35	2.967
Calf circumference	23.30	3.514
Waist circumference	54.32	3.514
total hand length	54.35	2.763
sole length	18.62	.930
Leg length (cm)	66.27	3.871
Static Balance(SB)	3.79	1.496
Dynamic Balance(DB)	5.68	.478
Landing Deduction (LD)	.72	.168

Table 2

Pearson correlation between balance and landing deduction and some anthropometric variables.

Variables	Landing deduction (LD)	Dynamic Balance (DB)	Static Balance (SB)
Age (Year)	-.388	-.048	.353
Training history (year)	-.135	.176	.034
Height (cm)	.670*	.784*	-.807*
Body weight (kg)	-.254	-.529*	.784*
Calf circumference (cm)	-.471	-.370	.464
Waist circumference (cm)	-.540	-.534*	.606*
Total hand length(cm)	-.569	-.493	.575*
Sole length (cm)	-.542*	-.551*	.468
Leg length (cm)	.866*	.684*	-.710*

*Correlation is significant at the 0.05 level.

Table 3.

Pearson correlation matrix for Landing deduction and Dynamic Balance and Static Balance.

Variables	Landing deduction (LD)	Dynamic Balance (DB)	Static Balance (SB)
Landing deduction (LD)	1	.807**	-.862**
Dynamic Balance (DB)		1	-.736**
Static Balance (SB)			1

**. Correlation is significant at the 0.01 level.

DISCUSSION

The purpose of this study is the relationship between floor exercise landing deduction, anthropometric characteristics and balance in 6 to 8 year old gymnasts. In LD we found a negative correlation between SB, Sole length and positive correlation between heights, leg lengths. According to the result we can say a gymnast that have good SB, long sole length, short leg length and height will have low deduction in landing and better control in landing. In DB we observed a negative correlation between SB, waist circumference, sole length, body weight and positive correlation between heights, leg length. According to the result we can say a gymnast that have good SB, more waist circumference, long sole length and low height, leg length will have low deduction in landing and better control in landing. In SB we observed negative correlation between height, leg length and positive correlation between body weight, waist circumference, and total hand length. According to the result we can say when gymnast have short height, leg length and approximately high body weight, more waist circumference and long total hand length will have better control in landing and low LD. Measuring DB in high level athletes (Davlin, 2004) found negative correlation between DB performance and height and weight. Our study found correlation between the length of some body parts and LD during floor routines of the 6 to 8 years old age group of Iranian federation gymnastic program. Among the population of the competing gymnasts, physical performance special to gymnastics, general motor coordination and high level skills are the most important values in determining the profile of the talented gymnast (Suchilin & Arkaev, 2004). When the gymnasts want to land, some anthropometric characteristics played important role in maintaining balance and reducing deduction. Short height is considered an advantage in gymnastic because a shorter person's center of gravity is closer to the gravity than that of taller gymnasts and he can overcome the resistance applied by his feet to the floor and reaction resistance of the floor more easily by muscle strength and coordination (Lohman, Roche, & Martorell, 1998). Study indicated that only 1 gymnast out of 20 did not make any mistake in dismount moves in parallel bar and horizontal bar routines in1996 Olympics (McNitt-Gray, Requejo, Costa, & Mathiyakom, 2001). In performing acrobatic elements, a gymnast can make mistakes at any phase of the move. These phases are interrelated, and it is stated that a mistake in the first stage of the move can affect the final stage and thus the balance in landing (Markovic & Omrcen, 2010; Suchilin & Arkaev, 2004). There are dismounts in all of the gymnastics apparatuses. Controlling balance and landing without deduction plays important role for getting high score. In artistic gymnastics, on the other hand, the force applied to the floor is very high during the moment of take off and landing. It is pointed out that force applied to the floor during landing is 3.9 to 14.4 times greater than the gymnast's body weight (Marinsek, 2010; McNitt-Gray, Requejo, Costa, & Mathiyakom, 2001). The goal in landing is to absorb on the floor the energy produced by the body during the flight period in the air. The gymnast has to figure out during the flight period how to orient the direction and the amount of energy in his landing. The direction of the kinetic energy can be diverted as the gymnast contacts the floor in landing or the kinetic energy can be reduced by slowing down the move during the flight in the air (Marinsek, 2009). There are many factors and variables that cause the gymnast's success in control of his standing against the reaction force of the floor during the landing, like the gymnast's muscle coordination, and some anthropometry characteristics like body weight, height and ability to conquer the impact at the moment of contacting the floor (Marinsek, 2010; McNitt-Gray, Requejo, Costa, &

Mathiyakom, 2001). According code of point (COP) and gymnastics rules there are various deduction in gymnastics. One of them is related to LD. When the gymnast cannot control his balance in landing, judges consider deduct for the gymnast. Therefore, maintaining one's balance are an important factor in taking the high score. Sufficient height of the somersault and elements is vital for a successful landing. If a gymnast have sufficient height in somersault, he will be more time to do his element and will have enough landing phase to prepare himself for the landing, and the probability of making mistakes in landing will decrease (Marinsek, 2009). In this study we did not consider the deduction in balance due to problems related to insufficient height and poor technique.

CONCLUSION

The result of study point out correlation between SB, DB parameters LD and some anthropometric characteristics. Balance (static and dynamic) have important relation towards landing quality. Both tests are directly related with better balance we will have better landing. In anthropometric characteristics height, body weight, Waist circumference, Sole length and leg length are important in this age group. Also technical mastery is another factors that influence on better landing. We suggest to researches to do this study in other age group and do with girls gymnastic and use development of test batteries that are more sensitive to the technical characteristics specific to gymnastics. At the end we suggest to couches for decrease their gymnastics deductions and taking high score, notice to athletes' balance performance and some anthropometry characteristics and train their athletes with balance exercise to have good landing.

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RECIPROCAL TEACHING OF GYMNASTIC LINKS IN HIGHER EDUCATION

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Original article

Abstract

The aim of this study was to compare the effect of two teaching styles on theoretical knowledge and technical learning of gymnastic links within Higher Education. Similarly, we checked their effects on the number of successful and unsuccessful repetitions of a specific gymnastic link and on the students' degree of satisfaction, participation and opinion about their learning were checked only on the group B (reciprocal teaching style). An experimental design was created with two groups, each of 22 subjects of both sexes, assessed with pre and post measures, using two different methodological teaching models, namely, task assignment and reciprocal teaching. The results showed significant improvements in both groups between pretest and posttest. However, reciprocal teaching proved more effective with statistically significant differences (p <0.05) in the technical learning of the link as well as theoretical knowledge of it, with more correct repetitions of the action. With regard to perception, participation and satisfaction about their learning, group B showed a very positive assessment in all items of the questionnaire.

***Keywords**: Higher Education, Gymnastic skills, Teaching styles, Reciprocal teaching, Task assignment.*

INTRODUCTION

Identifying which styles of teaching and learning may be the most effective is an interesting subject for most teachers. The existing teaching styles cover different approaches and possible applications and occupy an important place in contemporary literature in the last two decades: (Ashworth, 1992; Biddle & Goudas, 1993; Boyce, 1992; Brunner & Hill, 1992; Derri & Pachta 2007; Goldberger & Howarth, 1993; Mosston & Ashworth, 2008; Sicilia-Camacho & Brown, 2008).

With the incorporation of Spanish universities into the Bologna process, the focus is on more formative and participatory teaching styles that promote the college student's autonomous learning and is adapted to the European Higher Education Area (EHEA). Hence Álvarez (2005) points out the importance of actively involving students in their learning process, so that it is more meaningful for them.The European Framework establishes among its core competences learning autonomy, critical and self-critical capacities, problem solving and decision making, which can be achieved through more participatory teaching styles (Learreta, Montil, González, & Asensio, 2009).

The literature on the subject includes various studies and documents arguing for active student participation in their learning through less managerial and more participatory and autonomous teaching styles (Fraile, 2004; Lara, 2001; Lorente & Joven, 2009; Prieto & Nistal, 2009; Qin, Johnson & Johnson , 1995; Solana, 2005; Velázquez, 2004). In the specific area of artistic gymnastics, Vernetta, Gutiérrez-Sánchez, López-Bedoya, & Ariza (2013) suggest participatory teaching styles, among them reciprocal teaching and working in small groups, to encourage greater autonomy and communication among students who, moreover, become more involved in the teaching-learning process.

These teaching styles have been applied to learning different gymnastic skills in some sessions within a teaching unit, organizing the students in pairs or small groups using observation / evaluation record sheets (Hein & Kivimets, 2000; Thomas, Fiard, Soulard, & Chautemps, 1997, Vernetta, Gutiérrez & López Bedoya, 2009; Vernetta, López Bedoya & Panadero, 2000; Vernetta, López Bedoya & Delgado, 2009). These authors consider that the use of observation sheets as a basic tool in cooperative learning teaching styles has many advantages as it leads students to more meaningful learning, promotes their responsibility to be more autonomous and independent in their learning, stimulates their active participation in the learning process and encourages more positive interpersonal relationships. The studies of Bayraktar (2011), as in the previous studies of Barrett, (2005), Ward and Lee (2005) and Tuncel (2006) indicate the link between cooperative learning and students' academic success, as well as a better attitude toward learning and practicing skills.

Hence, bearing in mind all the benefits described above and seeking more participatory and collaborative processes in the university, we have applied the reciprocal teaching style in a teaching unit of the subject Teaching Artistic Gymnastics. Furthermore, one of the key components of learning these gymnastic skills, executed separately or linked together, is the number of repetitions performed during the process (Bourgeois, 1999; Carrasco, 1989; Rodrigues, Castello, Jardim, & Aguiar 2012). The high coordination requirements also demand execution with the minimum possible error, enabling the student to assimilate a more accurate ideal model and to learn more effectively (Vernetta et al., 2009, Vernetta, López Bedoya, & Delgado, 2009).

Therefore, the objectives of this study are as follows:

- To check the effectiveness of reciprocal teaching in acquiring gymnastic links for university students.
- To assess the level of theoretical knowledge of the technique of the gymnastic link practiced.
- To analyze the effects of both styles on the number of correct and incorrect repetitions executed during the teaching-learning process.
- To discover the degree of student satisfaction and their perception of the level of learning in those classes in the group B *(reciprocal teaching style).*

METHODS

Participants

The sample used in this study is part of a university population, students of the Faculty of Sport Sciences in a university in Spain. A total of 44 students (29 men and 15 women) with an age range of 20-21 years (M = 20.39, SD = 0.57) participated voluntarily. Each signed a consent form after being fully informed of the experiment and its purpose. Consent was also given by the relevant Ethics Committee. None of the participants had previously received classes on the gymnastic link to be studied.

Experimental Design

Two experimental groups of twenty-two students each were formed and pre and post measures were carried out by both.

The dependent variable (DV) to be considered was skill in learning the gymnastic link selected taking into account two aspects:

- The execution of the gymnastic link known as *round off* and *straddle jump*. This skill links an acrobatic gymnastic skill with a jumping skill and is called a *mixed link*. The first skill, (round off), is a forward jump with a handstand in the forward / backward axis with support from alternate hands when passing through the inverted position (the handstand) and a 180° turn in the longitudinal axis, either to the right or left side depending on the driving leg. The second skill, (the straddle jump), is a jump using both feet to push off and land, which in the flight phase consists of raising the extended legs, open to the front, to the horizontal or slightly higher, while the trunk leans forward, making a slight flexion (folding the trunk to the legs). The two skills should be linked without pauses or intermediate steps between them (Figure 1).

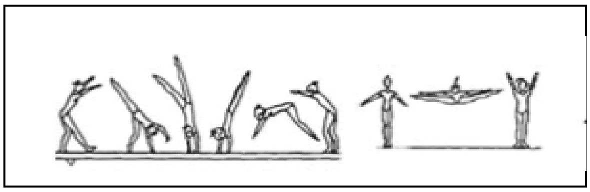

Figure 1. Round off linked to straddle jump (taken from the Code of Points 2009-2012 of Women's Artistic Gymnastics).

- Theoretical knowledge of the learned linking technique. Specific knowledge is required of the technical aspects of the actions to be performed, the methodological approach and mistakes to be avoided.

Furthermore, throughout the process variables were analyzed, such as the number of repetitions and the number of correct and incorrect executions in all sessions. To determine if the link was made correctly or not, it had to meet the following criteria:

- Two criteria in the round off: to bring the legs to the vertical with the correct support of the hands (the1st in the perpendicular position, the 2nd in internal rotation pointing toward the first) and to make the flight phase after pushing with the hands the legs being in the pike position until landing with both feet simultaneously while continuing into the straddle jump.
- Two criteria in the straddle jump: to raise the extended legs at least to the horizontal, with a slight forward flexion of trunk and to land with both legs stable with feet together.
- Furthermore, the pause between one skills and the next must not exceed one second, and there can be no intermediate steps for the link to be considered correct.

The Independent Variables (IV) were the teaching styles applied to both groups to learn the gymnastic link:

IV 1: Teaching Style "Task Assignment" (TA), using a mini-circuit organization.

IV 2: Participatory teaching style: "Reciprocal Teaching" (RT) through a mini-circuit organization using observation sheets recording details of execution.

Materials

Teaching materials. In teaching the selected gymnastic link, plinths, mini-tramps, trampolines and safety mats were used as auxiliary material to facilitate learning.

Recording Material. Two tripods with two video cameras, one arranged laterally and the other frontally were used to record pre- and post-tests. In addition, several observation sheets were designed:

- A record sheet to evaluate the execution of the gymnastic link (round off plus straddle jump) was used for the pretest and posttest of both groups. A number of technical criteria were specifically described, breaking down the two skills into three phases (initial, main and final), according to the definitions and explanations of relevant technical aspects mentioned by several authors specializing in the field of gymnastic activity (Smoleuskiy

& Gaverdouskiy, 1996) along with a current review of the criteria listed in the latest edition of the Code of Points in Women's Artistic Gymnastics (Edition 2009-2012).

- Questionnaire for the assessment of theoretical knowledge of the skill of the link under consideration. It consists of 16 questions related to the two skills.

- Observation sheets of the technical aspects to be observed during the process for the reciprocal teaching group.

- Questionnaire on the satisfaction, participation and opinion of the students about the improvement in their learning. The questionnaire used is based on that proposed by Calderón, Palao and Ortega (2005), subsequently validated by Ortega, Calderón, Palao and Puigcerver (2009), used for PE classes in high schools, obtaining reliable values by internal consistency (alpha = 0.825). Items were selected from both questionnaires and modified as objectives according to the aims of this study. This instrument sets out 10 questions with a rating scale of four answers: Not at all, A little, Quite a lot and Very much, which takes into account the following dimensions: Motivation (items 1 and 6), achievements or learning objectives (items 2, 7 and 8), feedback (items 4, 5, 9 and 10) and initial information (item 3).

Procedure

The research began with the initial assessment of 53 students enrolled in the undergraduate course "Teaching sports: Artistic Gymnastics" (38 men and 15 women), using a pretest of DV (mixed link: round off and straddle jump) consisting of the execution of three trials of the link after receiving previous instructions on how to do it identical for all participants. Subsequently, the selected sample of 44 participants were assigned to two different training groups by blocking techniques based on data obtained in the pretest for DV (mixed link: round off and straddle jump). The identifying characteristics of the selected sample, plus age range and sex as indicated above, were distinguished by the following characteristics:

- All subjects had taken the previous course "Fundamentals of gymnastic skills" in which they had learned the round off in isolation, as a basic requirement to enable them successfully to learn how to link this skill with the skill of gymnastic straddle jump.

- None of the participants in the experiment had practical experience of this mixed link and all started at a low level in the pretest, excluding those who obtained more than 26% of the maximum score in the total sum of correct items in the proposed link. The data of inter-observer reliability achieved in the pretest was 93%.

- All participants in both groups participated in the same session to learn the link but with different teaching styles, group A- task assignment (TA) and group B- reciprocal teaching (RT). Both groups received a total of 6 sessions of 1 hour 15 minutes per session. The structure of the session was as shown in table 1.

Table 1.
Structure of the session

Phases	Duration
1. Giving out material and information about the session and the tasks	5 minutes
2. Warm-up	15 minutes
3. Main part (execution of the link)	45 minutes
4. Cool down with stretching and collecting material	10 minutes

The characteristics of the methodological approaches for each group is set out in table 2.

Table 2
Methodological approaches characteristic of each experimental group

	Teaching style	Characteristics	Organization and students' role
Group A	Traditional teaching through teaching style: *Task Assignment*	**-** Teaching centered on teacher. - Teacher takes all decisions on students' learning. - Student merely receives and executes learning tasks. - Teacher administers *feedback* stimulating and interacting with the student, while moving among them.	**-** Mass Organization of the group distributed in the space. - Decisions about their situation in the space and the rythmn of exection fall on the student.
Group B	Participative teaching style: *Reciprocal teaching*	**-**Students' active participation in their own learning. -Students' greater autonomy and responsability.	**-** Pairs with observation sheets on criteria of the link**.** -Pairs interchange roles: executing/observing**.** - Pairs initiate and conclude the task according to the notes on the observation sheet. **-** Both students provide *feedback* after observation and noting the results.

The main part (execution) of all sessions of both groups was recorded to keep track of the number of correct and incorrect repetitions of the overall link.

After the learning phase, the participants were evaluated by performing three repetitions of the mixed link of round off and straddle jump, under the same conditions as the pretest. The reliability of the inter-observer data was 94% in the posttest. Therefore, to evaluate the effectiveness of the two teaching styles, we used a group design with pretest and posttest measures.

Statistical Data Analysis

The preliminary test of normality (Shapiro-Wilk test) and equal variance (Levene test) determined normality ($p > 0.05$) and homogeneity of variance ($p > 0.05$) in both the pretest and posttest for each of the experimental groups in the DV: execution of the gymnastic link of round off and straddle jump, so we proceeded to use parametric techniques for inferential analysis.

RESULTS

Table 3 shows the results of descriptive statistics for the two groups in the pretest and posttest. The mean values of the pretest (out of a maximum of 48 points) were very similar for both groups. The results obtained in the posttest for both groups showed improvements, the average being higher in Group B.

In the intra-group analysis (Table 4), using the paired t test, significant differences were found ($p < 0.001$) between the averages for the pretest and posttest in both experimental groups, demonstrating that both groups had improved in learning the mixed link of round off and straddle jump.

Furthermore, when comparing the results in the pretest and posttest measures between the two groups (Figure 2), the results of the pretest confirmed the absence of statistically significant differences, so it appears that the starting levels of both groups were homogeneous before beginning the gymnastic link. However, the post-test results confirmed the existence of statistically significant differences ($p < 0.05$) between the two groups, Group B (reciprocal learning) having the higher score and therefore a higher level of learning.

In relation to theoretical knowledge of the technique of the link under consideration, after applying the two teaching styles to each of the groups it was observed when comparing the percentages of grades obtained, that group B, reciprocal learning, gained a significant increase in the percentages of very good (7/8 out of 10) and outstanding compared to group A, task assignment (Table 5).

Regarding the number of repetitions, Table 4 shows the score obtained from both groups in the total number of sessions, and the total number of correct and incorrect repetitions with the respective percentages in each.

Table 3
Descriptive Statistics of Group A and B in Pre and Posttests.

Groups	N	Mean	S.D.	Minimum	Maximum
G A. Pretest	22	13.50	1.71	9	20
G.A. Posttest		28.15	3.13	24	30
G B. Pretest	22	13.71	1,64	9	21
G.B. Posttest		43.15	2.46	33	42

Table 4
Scores for Mixed Link (round off and straddle jump).

Treatment Groups	Round off and straddle jump	
	Pre	**Post**
Group A (n=22)	13.41±1.71	32.11*±3.13
Group B (n= 22)	13.00±1.64	41.03*±2.46

Points ± SD. * P<0.001

Table 5
Percentage of total scores with respect to total number of students in each group.

GROUPS	Failed		Passed		Very good		Outstanding	
	Nº	%	Nº	%	Nº	%	Nº	%
Group A. (TA)	3	13.6%	16	72.7%	3	13.6%	0	
Group B (RT)	0		5	22.7%	11	50%	6	27.7%

Table 6
Number of correct and incorrect repetitions in both groups.

	Mixed Acrobatic link: Round off + Straddle jump									
	GROUP A					**GROUP B**				
	Total	**Correct**	**%**	**Incorrect**	**%**	**Total**	**Correct**	**%**	**Incorrect**	**%**
Session 1	10	4	40	6	60	10	6	60	4	40
Session 2	15	9	60	6	40	15	11	72	4	28
Session 3	20	11	55	9	45	20	15	75	5	25
Session 4	20	13	65	7	35	20	16	80	4	20
Session 5	25	12	48	13	52	25	20	80	5	20
Session 6	25	14	56	11	44	25	20	80	5	20
TOTAL	115	63		52		115	88		27	
Average		10.5	52.33	8.6	46		14.6	74.5	4.5	25.5

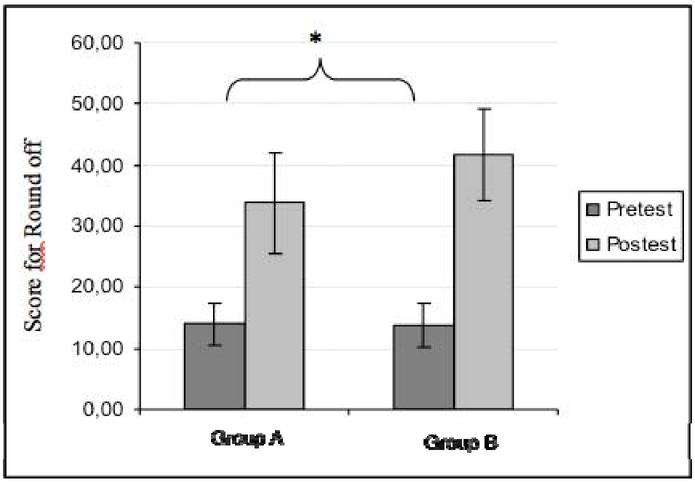

Figure 2. Graph showing pretest and posttest data of groups A and B (* P<0.05).

Table 7.
Questionnaire of Satisfaction and students' perception of the use of reciprocal teaching style in terms of their learning achievements and information and feedback received.

	Not at all	A little	Quite a lot	Very Much
1.- Did you enjoy the practice in this Teaching Unit?			5%	95%
2.- To what extent do you think you are skilled (reaching the planned objectives) after finishing the Teaching Unit?			4%	96%
3.- Do you think that the information the teacher gave you AT THE BEGINNING of each session helped you improve?			3%	97%
4.- Do you think that the information yor parner gave you DURING each session helped you improve your level of gyimnastic skill?			3%	97%
5.- To what extent are you satisfied with the information you gave youe partner DURING the execution of the exercises proposed by the observation sheets used?			8%	92%
6.- Did you enjoy the exercises planned by your teacher throughout this Teaching Unit?			2%	98%
7.- Do you think that the the exercises proposed have helped you to assimilate and learn the Content of thie Teaching Unit?			3%	97%
8.- Do you think that the the exercises proposed have helped you improve your overall gymnastic level?				100%
9.- Do you think that the feedback you have given to your partner through the use of the observation sheets has helped you in your own learning?			2%	98%
10.- Do you think the responsability of giving feedback to your partner is important for you in the future as a teacher?				100%

It can be seen, firstly, that the total number of repetitions was the same in all sessions for both groups, since they were scheduled as follows: (1st session: 3 blocks of 5 repetitions, 2nd session: 3 blocks of 5 repetitions 3rd and 4th sessions: 4 blocks of 5 repetitions, 5th and 6th sessions: 5 blocks of 5 repetitions). However, Group B made more correct repetitions of the link, and thus fewer incorrect links, being only 25.5% compared to 46% of Group A, task assignment.

With regard to satisfaction, participation and their opinion about their learning, group B (reciprocal teaching style), showed a very positive assessment in all items of the questionnaire (Table 7). The valuations were highest in some items related to the influence on their learning, and the importance of feedback. Regarding their learning achievements, this perception reached 100% in the valuation of the proposed tasks on their gymnastic level (item 8). Equally, 96% considered that the exercises helped them to assimilate and learn the content of the teaching unit, so achieving the aim of the class (item 7), with 96% feeling that they had become competent (item 2).

Motivation (items 1 and 6) was also rated very positively, 95% stating that they had enjoyed themselves and the exercises in this teaching unit very much.

In relation to items 3, 4 and 5 on the information received during the whole teaching and learning process, the students' assessment was also very positive, especially in items referring to the information given by the teacher at the beginning of each session (item 3) and the information given by the classmate/partner during each session (item 4). In both items, 97% considered that the information given had helped them improve Very much). Regarding the importance of the responsibility of giving *feedback* to their partner as future teachers, all students gave this responsibility the full value of 100% (item 10). Similarly, the assessment of the impact on their own learning of giving feedback to their partner was rated as highly positive (item 9).

DISCUSSION AND CONCLUSIONS

This work is part of the introduction of reciprocal teaching in the subject of "Teaching Artistic Gymnastics" within the degree of Bachelor of Science in Sport and Physical Activity. The main aim of this study was to compare whether reciprocal teaching influences students' learning. The results found, firstly, judging by the significant improvement of the students in both groups, that both teaching styles produce significant rates of learning. These results agree with those obtained in other studies that have shown the efficacy of different methodological approaches in learning different gymnastic skills (Cox, 2002; Vernetta et al., 2009; Vernetta, López Bedoya & Delgado, 2009; Vernetta et al., 2013).

Our results confirm the findings of other studies which show that more participatory teaching styles that involve the students enable them to achieve greater success in practice or motor execution (Dyson, 2001; Dyson, Griffin & Hastie, 2004; Glover & Midura, 1992; Vernetta, López Bedoya & Robles, 2009).

Similarly, with regard to the results of technical theoretical knowledge on linking, it was noted that no Group B student failed the course. This may be explained by the students' greater involvement in the dynamics of the course, participating with the responsibility of giving knowledge of results to their peers, so guaranteeing better learning. In short, one can say "good evaluation that instructs", that is, evaluation becomes a learning and knowledge-enhancing activity (Alvarez, 2000).

The fact that students in Group B observe, assess and correct their fellow-students' execution encourages a more rigorous and detailed observation than if only the teacher does so; this enables students to understand the learning process better, and as a result, gives them more meaningful learning, both theoretical and practical (Vernetta, López Bedoya & Delgado, 2009). However, Cox (2002), comparing three styles of teaching and learning: command style, task assignment and reciprocal learning in gymnastic skills, found no difference in the learning achieved by the three models, although he found that the number of feedback imparted by the reciprocal teaching style group was the highest.

Furthermore, the study of Vernetta, López Bedoya and Delgado (2009) and Vernetta, López Bedoya and Robles (2009) found students learned gymnastic skills better when they used observation sheets, as they had more control of the information about the skill they had to learn. The fact that students in Group B (RT) had that selective attention on the information to be given to their partner immediately after completion of the mixed link enabled them not only to give details of execution to their partner, but also to pay more attention to these key points in their own execution. This efficiently improved their own learning since they had greater control and understanding of that information. Hence, technical knowledge was greater in the questionnaire on theoretical content in this group.

The student's role as observer should be highlighted as it is an important ingredient of their learning and complements their know-how, making them more autonomous learners. Regarding this autonomy, many authors consider that to form responsible people within a democratic education, students have to be given responsibility and student involvement in the teaching-learning process should be encouraged (Fraile, 2004; Martinez, Santos & Sicilia, 2006).

Moreover, the existence of a greater number of correct repetitions during the process by Group B is consistent with the results of other studies that have shown the importance of correct repetitions with minimum possible error in the specific field of teaching- learning different gymnastic skills (Vernetta et al., 2009; Vernetta, López Bedoya & Delgado, 2009; Vernetta, López Bedoya & Robles, 2009). It is important to appreciate that specific guidance on the mistakes to avoid can become an indispensable resource in learning these unusual skills that make high demands on spatial orientation because of the body's inverted position.

Finally, the degree of satisfaction and enjoyment, participation and feeling of improvement in learning are consistent with the findings of Vernetta et al. (2009) and Vernetta, López Bedoya and Delgado (2009), who pointed out that university students who accept the challenge to become more involved in the teaching-learning process are more responsible for their learning. As verified in this study, students who participated in it with the RT method, using observation techniques on their execution, not only recognized its importance to the successful learning of this link, but also their own greater responsibility.

According to the results of this study, it can be emphasized that the use of RT as a participative style was more effective in the students' theoretical and technical learning, corroborating the studies of Barrett (2005), Bayraktar (2011), Tuncel (2006) and Ward and Lee (2005). Furthermore, as Viciana and Delgado (1999) stated, its most valuable application lies in the training of students who will be future teachers, instructors or coaches, thus presenting them with a consistent model in accordance with the demands of skills in undergraduate training. Students' self-perception of their skills directly and indirectly influences their acquisition, reinforcing their persistence (Bandura, 1997). We would point out that, in the context of the objectives of the EHEA, if this methodology is incorporated into the learning environment, it will facilitate the transition from the role of student to the professional role that students must perform after graduation (Eva & Lingard, 2008; Schmidt, Vermeulen & Van der Molen, 2006).

A limitation in the generalization of the results of this particular study is the small number of the sample. Accordingly, further work is required to increase the number of students and to try different links of different motor skill structures and gymnastic complexity. Also, the degree of development of other social variables could be chosen to better link this type of cooperative learning with learning other skills.

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SOMATOTYPE AND BODY COMPOSITION OF ELITE BRAZILIAN GYMNASTS

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Original article

Abstract

The main objective of this study was to analyze the somatotype and body composition of elite athletes in Brazilian artistic gymnastics, belonging to the junior and senior categories. Forty-six athletes were assessed, whereby 21 were from Male Artistic Gymnastics and 25 from Female Artistic Gymnastics. To determine the somatotype, the Heath & Carter's anthropometric method was used (1990). The body composition was assessed by electrical bioimpedance on the InBody R20 scale, and variables of skeletal muscle mass (MM), fat mass (MG), fat-free mass (MLG) and fat percentage (%G) were measured. Descriptive statistics was used. Results show that the dominant somatotype within the group of male gymnasts was the Balanced mesomorph while among the females, the prevalent classification was Ectomorphic mesomorph. The body composition of the male gymnasts presented the average values of 33.08 ± 3.53 kg for lean muscle mass, 7.44 ± 1.57 kg for fat mass, 57.74 ± 5.78 kg for fat-free mass and a fat percentage of 11.39 ± 2.08, while the female gymnasts showed values of 21.7 ± 3.38 kg for lean body mass, 7.55 ± 2.73 kg for fat mass, 38.12 ± 5.77 kg for fat-free mass and a fat percentage of 15.84 ± 3.79. These results corroborate with the existing profiles for the modality of artistic gymnastics found in literature.

Keywords: *Artistic gymnastics, Anthropometry, Somatotype, Elite Gymnasts, Body composition.*

INTRODUCTION

There are many factors that determine success in elite sport. Among them, having anthropometric characteristics specific to one's chosen sport brings various advantages to the athlete. The process by which the physical demands of a sport determine the most adequate morphology and body composition for said sport is known as "morphological optimization" (Norton & Olds, 2000).

The somatotype and body composition has great influence on the performance of various sports in high level. In artistic gymnastics these variables also play an important role. In general, the morphological characteristics of elite gymnasts are basic in competitions, due to the new demands of gymnastics code of points, and the creation of new exercises that are increasingly difficult, as those who need more rotation about the axis vertical and horizontal. There are few studies that address the influence of somatotype and body composition in the performance of gymnasts (Poblano-Alcalá & Braum-Zawosnik, 2014).

The somatotype is a method used to assess the morphological characteristics of an individual. It is defined as the quantification of the current form and composition of the human body. It is expressed in a classification of three numbers which represent the endomorph, mesomorph and ectomorph components respectively, and always appear in this same order. Endomorph refers to the state of relative fatness, mesomorph represents relative musculoskeletal robustness, and ectomorph is the relative linearity or leanness of a body. Results within each of the aforementioned categories of ½ to 2½ are considered low, from 3 to 5 are moderate, 5 ½ to 7 are high, and 7 ½ or more are very high. This classification is phenotypic, i.e. it is subject to change with growth, exercise, nutrition and ageing, and is applicable to both genders from childhood to old age. (Carter & Heath, 1990).

Heath and Carter's anthropometric somatotype system has been the most commonly used to identify the somatotype profile of athletes from various sports, including Men's (MAG) and Women's (WAG) Artistic Gymnastics respectively (Claessens, Beunen, Stjnen, Maes, & Veer, 1991; João & Fernandes Filho, 2002; Čuk, et al., 2007; Arkaev & Suchilin, 2009; Kvetoslava, Vadasová, & Sousková, 2013; Massidda, Toselli, Brasili, & Calò, 2013; Hedbávný, Cacek, & Svobodová, 2014; Mosqueira, et al., 2014; Rodrígues, Castillo, Tejo, & Rozowski, 2014). A review of the somatotype of female gymnasts shows the predominance of mesomorphism, while the rate of ectomorphism is higher than endomorphism. This classification is known as "Ectomorphic mesomorph" and differentiates the gymnasts from non-athletic women, who tend to be more endomorphic and less mesomorphic (Sands, Caine, & Borms, 2003).

Furthermore, artistic gymnastics is an example of a sport in which the body is pushed against gravity, and because of this, the gymnast should be light. For gymnasts, the advantages of being lighter and shorter can be proven by biomechanics and also by the ratio of absolute force to relative force and the relation between height and weight.

Body composition plays an important role when leading programs that control body weight and in the prescription of exercises. It is normally used to describe the percentage of fat, bones and muscles in the human body. It encompasses predetermined genetic factors, but ones that can be enhanced and are approximate to the reference values of the chosen sport (Fernandes Filho, 2010).

A case study in China reports the difficulty faced by a gymnast from the male national team to reduce his body weight just before the 2012 Olympic Games.

The authors reported that one aspect of the gymnast's successful weight-loss program was the use of the "*true" body weight indicator to record the gymnast's emotions and encourage the athlete.* The gymnast's body composition was assessed so that he could clearly understand the difference between body weight and body fat. As well as motivating the gymnast to follow the program, this made it possible to control his weight effectively, yielding excellent results in the competition. (Haitao Chen, 2013). This assessment of the athletes' body composition allowed for the measurement of the ideal body weight for a competition and the monitoring of changes in the lean and fat components of the body, used as a way of monitoring athletes preparing for competitions (Rodrigues C. et al., 2013).

Various studies found in literature note the use of electrical bioimpedance to assess the body composition of gymnasts (Perecinská, Vadasová, & Sousková, 2013; Hedbávný, Cacek, & Svobodová, 2014). The method of bioimpedance involves passing a low- intensity electrical current through two electrodes and into the hands and feet of the individual under assessment.

Cellular fluids act as conductors and the cellular membranes as condensers. The difference of current caused by the impedance is detected by two receptors. Knowing a person's height and impedance makes it possible to calculate the volume of water in the body (Fernandes Filho, 2010).

There are many studies on the somatotype and body composition of gymnasts but none directed towards both male and female Brazilian artistic gymnasts, thus leaving a gap in literature on the topic.

The main objective of this study was to analyze the somatotype and the body composition of elite Brazilian artistic gymnasts belonging to the junior and senior categories.

METHODS

This study analyzed the somatotype and body composition of 46 elite Brazilian Artistic Gymnasts belonging to the junior and senior categories, where 21 gymnasts were from Male Artistic Gymnastics and *aged* 20.3 ± 3.41 years and 25 were from Female Artistic Gymnastics and aged 17 ± 4.66 years. The criterion of inclusion was to have been selected at least once to represent the Brazilian Team in an International Championship since 2012. The study was presented to the Brazilian Gymnastics Federation and the coaches responsible for the gymnasts, who were informed about the research and its objectives. Then the coaches and gymnasts voluntarily signed the Consent Form to participate in the study.

All the anthropometric measurements follow the protocol of the norms and techniques of measurement recommended by the "International Society for the Advancement of Kinanthropometry" (ISAK). To calculate the somatotype, the Heath & Carter's anthropometric method was used (1990).

Ten anthropometric variables were analyzed: Subescapular Cutaneous Fold, Triceps Cutaneous Fold, Supraspinal Cutaneous Fold, Cutaneous Fold of the Calf, Humerus Bi- epicondylar Diameter, Femur Bi-epicondylar Diameter, Perimeter of the Contracted Arm, Perimeter of the Calf, Height and Weight.

In order to determine body composition, the method of electrical bioimpedance was used in conjunction with the Inbody R20 scale. The muscle mass (MM), fat mass (MG), fat percentage (%G) and fat-free mass (MLG) were assessed. All the gymnasts were informed of the standard necessary conditions before measurement of body composition using the Inbody R20 took place: 1. To conduct the test with an empty stomach and bladder; 2. To not conduct exercise before the test nor have a shower, dry or steam sauna, as the heat provokes a temporary change in conductivity inside the body;

3. That their arms needed to be by their sides and away from the body.

The cutaneous folds were measured using the Prime Digita compass (Terra Azul); the diameters using the Cescorf pachymeter and perimeters with the Sanny measuring tape (precision 1.0 mm). For body composition, the Inbody R20 model scale of Biospace was used, based on the principle of electrical bioimpedance (BIA).

The current study was developed within a model of descriptive and transversal research. The statistical analysis was conducted by describing the data obtained for the somatotype and body composition, using the measurements of central trend (average) and standard deviation, as well as the minimum and maximum values.

RESULTS

The objective of this study was to analyze the somatotype and body composition of elite Brazilian Artistic Gymnasts, belonging to the junior and senior categories.

The average age, weight and height of the groups of male and female gymnasts are presented in tables 1 and 2, respectively. The minimum age for a gymnast to compete in the junior category in Brazil is 14 for boys and 12 for girls with birthdays in the same year as the competition. For this reason, the authors observed younger female gymnasts. On the other hand, men tend to remain in the sport longer, so the average age of men is higher than that of women.

Assessment of the male gymnasts shows that the predominant somatotype is the Balanced mesomorph, as demonstrated in Table 3. According to Heath & Carter (1990), this classification corresponds to dominant mesomorphism, while endomorphism and ectomorphism are the same (or do not differ by more than 0.5).

Graph 1 shows the percentage distribution of the somatotype in which 3 classifications were observed. The first was found in 48% of the gymnasts assessed with Balanced mesomorph, the second in 33% of the Endomorphic mesomorph and the third, Ectomorphic mesomorph in 19%. It is worth noting that in 33% of gymnasts classified as Endomorphic mesomorph, mesomorphism was dominant, however endomorphism was greater than ectomorphism.

Table 1
Average values and their derivatives for Age, Weight and Height of the athletes in Male Artistic Gymnastics.

Variables	*Age/year*	*Weight/kg*	*Height/cm*
Average	20.14	65.06	165.38
Standard Deviation	2.94	6.37	5.91
Minimum	15	53.90	156
Maximum	27	77.3	177

Table 2
Average values and their derivatives for Age, Weight and Height of the athletes in Female Artistic Gymnastics.

Variables	*Age/year*	*Weight/kg*	*Height/cm*
Average	14.3	43.7	148.7
Standard Deviation	2.30	8.68	8.61
Minimum	12	29.50	131
Maximum	22	57.30	160

Table 3
Components of the Male Artistic Gymnasts' somatotype.

Variables	Endo	Meso	Ecto
Average	1.82	7.06	1.60
Standard deviation	0.53	1.15	0.58
Minimum	1.05	4.33	0.54
Maximum	2.87	9.38	3.04

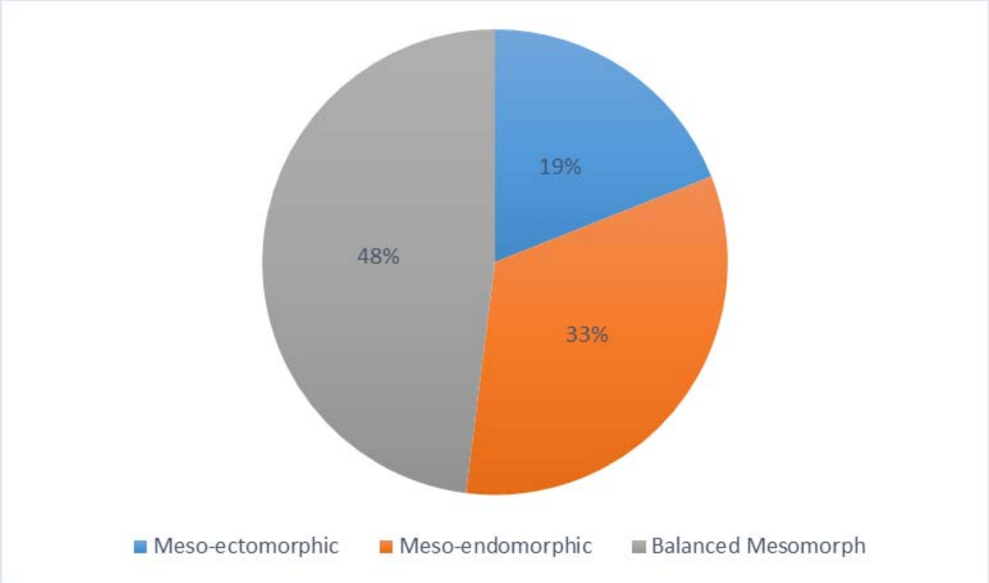

Figure 1. Percentage distribution of the Male Artistic Gymnasts' somatotypes.

Table 4
Components of the somatotype of Female Artistic Gymnasts.

Variables	Endo	Meso	Ecto
Average	1.84	5.20	2.52
Standard Deviation	0.67	0.63	1.04
Minimum	0.96	3.92	0.86
Maximum	3.09	6.12	4.44

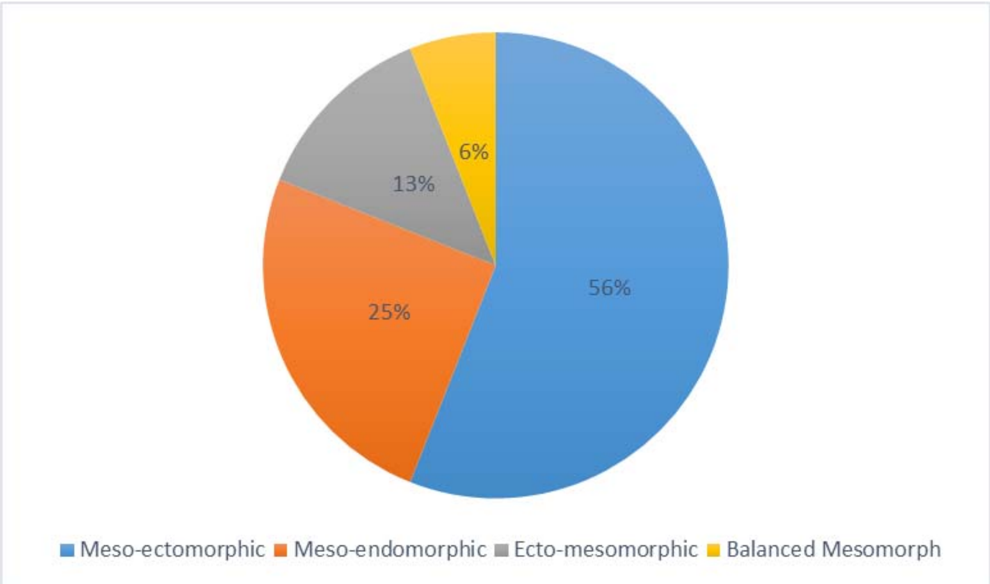

Figure 2. Percentage distribution of the somatotypes present in Female Artistic Gymnasts.

Table 5
Body composition of Male Artistic Gymnasts.

	Muscle Mass (kg)	Fat mass (kg)	Fat-free mass (kg)	Fat (%)
Average	33.08	7.44	57.74	11.39
Standard Deviation	3.53	1.57	5.78	2.08

Table 6
Body composition of Female Artistic Gymnasts.

	Muscle Mass (kg)	Fat mass (kg)	Fat-free mass (kg)	Fat (%)
Average	21,07	7.55	38.12	15.84
Standard Deviation	3.38	2.73	5.77	3.79

As shown in table 4, assessment of the female gymnasts showed that the predominant somatotype is the Ectomorphic mesomorph, whereby mesomorphism is dominant and ectomorphism is greater than endomorphism (Heath & Carter, 1990).

This study showed that 56% of the gymnasts assessed were classified as Ectomorphic mesomorph, 25% Endomorphic mesomorph, 13% Mesomorph-ectomorph and 6% Ectomorphic mesomorph. This distribution can be seen in Graph 2.

The body composition of the male gymnasts showed the average values of 33.08 ± 3.53 kg for lean muscle mass, 7.44 ± 1.57 kg of fat mass, 57.74 ± 5.78 kg for fat-free mass and a fat percentage of 11.39 ± 2.08. Meanwhile, the female gymnasts exhibited values of 21.7 ± 3.38 kg for lean body mass, 7.55 ± 2.73 kg of fat mass, 38.12 ± 5.77 kg for fat-free mass and a fat percentage of 15.84 ± 3.79, as shown in Table 6.

DISCUSSION

Analysis of the somatotype's basic parameters and the body composition of both male and female artistic gymnasts will allow coaches to create training programs that are adequate for the needs of the gymnasts, as well as assist in sports selection and guidance, examining and monitoring young people that best fit the required elite profile (João, Fernandes Filho, & Dantas, 1999; João & Fernandes Filho, 2002).

Arkaev & Suchilin (2009), presented the height and weight of the Russian gymnasts as 160-170 cm and 56 to 70 kg respectively for men and 150-160 cm and 38-50 kg for women. The results of this study verified that male Brazilian gymnasts showed similar values to the male Russian group, while the female group's were slightly inferior. This reinforces the idea that gymnasts are getting smaller and lighter. However, these same authors highlight that it is possible to find real "Gullivers" at an elite level, such as Alexander Dityatin (178 cm in height, weighing 72 kg), Eberhard Ginger (176 cm, 70 kg), Alexei Nemov (174 cm and 74 kg), Elvira Saade (166 cm and 52.5 kg), and Svetlana Khorkina (165 cm and 47 kg).

A study conducted in Chile assessed the somatotype of various sports, in which the male elite gymnasts presented a predominantly mesomorphic profile, as well as age values of 27 ± 2.38, a weight of 74.1 ± 4.5 kg and height of 173.8 ± 7.3 cm. This classification presents an average level of fat and the predominance of muscle mass, which is favorable for the performance of these athletes (Rodrígues, Castillo, Tejo, & Rozowski, 2014). The Chilean gymnasts' results are similar to those of the Brazilian gymnasts and of other nationalities found in literature.

In this study, the somatotypic profile of the Female Artistic Gymnasts was characterized as Ectomorphic mesomorph, whereby mesomorphism is dominant and ectomorphism is greater than endomorphism. This result differs from the somatotype found in the study conducted in 2002, conducted with 25 highly-qualified Brazilian gymnasts (João & Fernandes Filho, 2002). These athletes were classified as Mesomorph-ectomorph, whereby ectomorphism is dominant and mesomorphism is greater than endomorphism. This demonstrates that the mesomorph component, where the low relative adiposity and low subcutaneous fat, with muscular visible contours were maintained, while the characteristic of increased relative linearity was substituted by the high development and volume of skeletal musculature, bone diameters and large articulations. This can be explained by the influence of the phenotype, a change in the methods of training and new requirements of the code of points.

Sands, Slater, McNeal, Murray, & Stone (2012) conducted a study that assessed the changes in size and age of 106 gymnasts from 14 Olympic teams between 1956 and 2008 at two levels: height, weight, age, and body-mass index (BMI). They concluded that since 1956, the height, weight, age, and body-mass index (BMI) of the athletes have been reducing. They attributed this to the changes in the rule of minimum age during this period. Low values can also be observed in the data for female Brazilian gymnasts, presented in this study. However, they verified that in the last four Olympic Games, the gymnasts of the United States team, on the other hand, have been getting bigger. The changes observed within the American team are important, as the United States' team was runner up in the 2008 Olympics and champions in 2012.

The National Health Institute of the United States of America recommends that the body of a healthy male adult should be between 6% - 24% fat and between 14%-31% for females. This study found values below the reference values in both the male and female groups of Brazilian gymnasts. This corroborates with the study of Poblano- Alcalá & Braum-Zawosnik (2014), which says that athletes such as gymnasts, slimmer individuals, and more muscular individuals present a body fat percentage lower than these levels. In general, most athletes manage to perform with a body fat percentage of between 7% - 19% for men, and 10% - 25% for women depending on their sport. (Poblano-Alcalá & Braum-Zawosnik, 2014)

The average amount of subcutaneous fat (13.33% ± 2.81), assessed by electrical bioimpedance using the Inbody 720, was found in a study of eight female gymnasts from the Czech Republic that took part in the World Championship of 2010 (Hedbávný, Cacek, & Svobodová, 2014). This result is lower than the 15.84% ± 3.79 found in Brazilian gymnasts. However, the gymnasts from Brazil have a result similar to the 16.4% ± 4.99 found in 113 participants of European and World Championships in the last 15 years (Georgopoulos et al. cited by Hedbávný, Cacek, & Svobodová, 2014).

Another study of somatotype and body composition (assessed by electrical bioimpedance using the Inbody 720) was conducted on 13 female gymnasts from Slovakia between the ages of 7 and 13 and at different levels of performance (Perecinská, Vadasová, & Sousková, 2013). The results from the group of elite gymnasts of a higher average age (13.3) show that the fat percentage of 14.1%, and muscle mass of 23.4 kg are in line with the values obtained in this study, but with a difference in the variables of weight (50.5 kg) and height (161.2 cm), whereby the Brazilian gymnasts showed lower values.

CONCLUSION

The somatotype is phenotypic, and is therefore susceptible to change with growth, training, nutrition and ageing. This is a transversal study, so a long term follow-up of young gymnasts ranging up to the adult category is advisable.

These results can be seen as trends, considering that with the constant changes of the code of points, technology, equipment and the evolution of the sport, they can undergo changes. Therefore, the authors strongly recommend the study of the dynamics of the morphological indexes and body composition of the gymnasts, seeing as these are bodily properties that change under the effect of training, growth and development.

It is important to highlight that the results reflect the current time and should be constantly updated in order to guarantee their reliability and, whenever possible, seek to increase the size of the sample.

Finally, it is important to highlight that Brazilian gymnastics has seen improved results in international events. Conducting a follow-up study of the athletes' somatotype and body composition is of major importance and may assist in the maintenance or improvement of these results.

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ACTIVE AND PASSIVE LOWER LIMB FLEXIBILITY IN HIGH LEVEL RHYTHMIC GYMNASTICS

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Original article

Abstract

Flexibility is one of the main physical abilities required in Rhythmic Gymnastics practice. It's expected that high level gymnasts as National Teams members show high levels of this motor ability. The aim of this study was to evaluate the level of active and passive flexibility of the lower limbs (preferred and non-preferred) of 5 high level junior gymnasts (13.60 ± 0.25 years old) during a sport season. The limb which effectively performs the task is considered the preferred and the one which functions as support is considered the non-preferred. For the flexibility assessment gymnasts were evaluated performing 7 specific Rhythmic Gymnastics movements in three different moments of the sports season. These movements were filmed and the videos were analyzed. A five point scale (from 0 to 4) was used to classify the performance of the gymnasts in each movement. For statistical analysis nonparametric tests (Mann-Whitney, Friedman and Wilcoxon test) were used. The results revealed that the gymnasts showed a high level of active and passive flexibility for the preferred lower limb (average of 3,98 points in the 7 tests) but lower levels with non-preferred lower limb (average of 3,10 points in the 7 tests). However, the gymnasts registered a significant improvement of the flexibility levels on the non-preferred lower limb at the different measurements moments over the season.

Keywords: *Preferred Lower Limb, Non-preferred Lower Limb, Flexibility, Rhythmic Gymnastics, High Level gymnasts.*

INTRODUCTION

Rhythmic gymnastics (RG) is a sport that combines elements of gymnastics, dance, and apparatus manipulation: rope, ball, hoop, clubs and ribbon (Despina et al., 2014) that involves beauty, elegance and excellence in body movement. A high level of development in motor skills, flexibility, strength, endurance, coordination, agility, rhythm and balance (Laffranchi, 2005) is required. However, flexibility and strength play a key role in RG. This sport requires gymnasts with high flexibility and a good compromise between strength and flexibility is advisable for high quality performance (Donti, Tsolakis, & Bogdanis, 2014; Douda, Tokmakidis, & Tsigilis, 2002). The work of these motor skills is closely linked and considered indispensable for achieving a high level with top performances. For Laffranchi (2005), these performances are reached through a detailed planning and organization of training, in addition to the application of multilateral work for the harmonious development of the gymnast´s body, as well as necessary adjustments according to the sport requirements.

Lebre (1993) pointed out the importance of coaches devoting great attention to the training of motor skills. During training, knowing each gymnast individually is crucial to drawing up and planning a training program focused on their needs and physical and technical shortcomings, whilst also respecting their limits.

Gurak (2002) mentions that is essential to carry out assessments of gymnasts to promote RG development by enabling the progress monitoring, as well as the acquisition in the process of sports orientation and selection.

According to Monteiro (2000), the high importance of periodic evaluation of the training process is supported by various authors (Bobo & Sierra, 1998; Lisitskaya, 1995; Llobet, 2000). The evaluation of training process development allows monitoring the work objectives and the success levels during all process.

The aim of this study is to evaluate the level of passive and active lower limb (LL) flexibility and compare the level of flexibility of both lower limbs (lower limb preferred and non-preferred) in high level junior gymnasts at three distinct moments during the season 2010-2011. This longitudinal evaluation was important because the gymnasts were selected in begin to be part of the national team competing in international competitions and we would like to evaluate their evolution since the moment that the gymnasts were selected until the main competition in this sport season (European Championship).

The hypothesis of the study is that the elite gymnasts have high level of passive and active flexibility for the preferred and non-preferred lower limb (maximum levels, according to the battery of tests applied).

METHODS

Sample

This study concerns the analysis of 5 high level RG junior gymnasts with an average age of 13.6 ± 0.25 and with 7.2 years of gymnastics practice, i.e. since 6 or 7 years of age. They trained 7 times per week with an average of 3.75 hours per session.

In Table 1 we present the somatic measurements and some training characteristics of our sample.

Table 1
Descriptive statistics of somatic measurements and training characteristics.

Somatic Measurements(x ± sd)	
Age (years)	13.60 ± 0.245
Height (cm)	1.58 ± 0.007
Weight (kg)	41.60 ± 0.828
Years of practice (years)	7.20 ± 0.490
No. of training sessions / week	7 ± 0,000
No. of hours of training / day	3.57 ± 0.000

The first evaluation was carried out after a selection trial in November 2010, when the gymnasts were chosen to represent their country in European Championships. The second evaluation took place in March, 2011 and the third in June, 2011, following the European Championships.

The gymnasts were free of injury and testing was performed during the season 2010-2011. The parents of the gymnasts gave their written consent for the study before data collection. The study was approved by the University of Porto and all procedures were in accordance with the Helsinki declaration. Portugal Gymnastics Federation has also been informed and authorized the study.

Flexibility measurement

The battery of LL flexibility tests of Federation International Gymnastics (FIG, 2010) carried out in this study consists of the evaluation of 7 specific RG movements, executed with both LL: preferred lower limb (PLL) and non-preferred (NPLL). The limb which effectively performs the task is considered the PLL and the one which functions as support is considered the NPLL.

It should be pointed out that the gymnasts should have warmed up prior to the testing. The gymnasts performed the usual training warm up with ballet bar exercises, floor exercises and flexibility exercises – splits on one or two benches (about 1,5 hour). The tests were carried out in competition ambient in 1st evaluation (in the afternoon), and training ambient in 2nd and 3rd evaluation (in the afternoon). Each evaluation was carried in 30-45 minutes.

The tests evaluate maximum passive and active flexibility through the dimensionless method which compares the gymnast's joint range of motion against an assessment chart. There are 5 classification values attributed to each movement, referring to the maximum possible range of motion and on an ascending scale from 0 to 4 points, in which 0 = very poor, 1 = poor, 2 = average, 3 = good and 4 = excellent. Only whole numbers are attributed to results. For movements with a range of movement between two points of the assessment chart, the next lower value is registered. To register the images to a posterior analysis a Nikon Photographic Camera and a Samsung Video Camera were used. The flexibility tests were analyzed by an international judge with 10 years of experience. After 10 days, the judge repeated the evaluation two times. The data was processed using the SPSS statistics. Cronbach's reliability coefficient alpha and calculation of concordance between respective evaluator's grades and the common test object were used for evaluation of reliability. The reliability of assessment was high, which indicates an appropriate selection of test criteria and descriptions.

The tests and their 5 classification points are presented below in figures 1 to 7. To evaluate passive flexibility, supported hold exercises were performed of LL to the front (test 1), LL to the side (test 2), LL to the rear (test 5) and the splits on two benches (test 7). To evaluate flexibility, unsupported hold exercises were performed of LL to the front (test 3), LL to the side (test 4) and LL to the rear in Penché position (test 6).

The gymnasts were familiar with the stretching protocols, since they performed these exercises in every day training and competition.

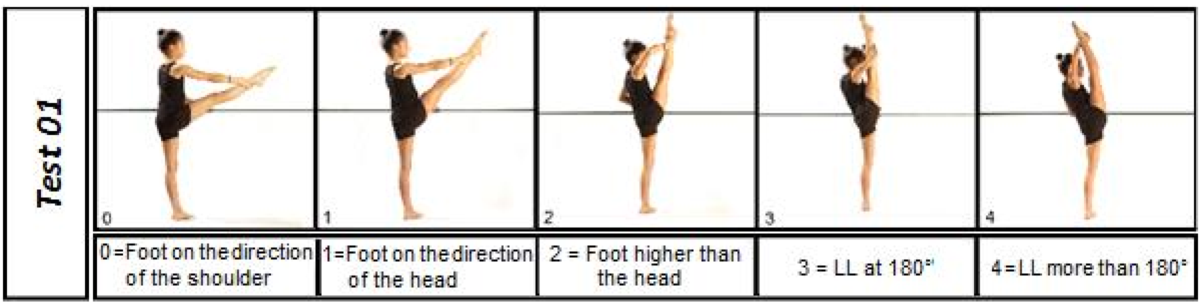

Figure 1. Reference points (0 – 4) of test 1: "supported LL hold to the front".

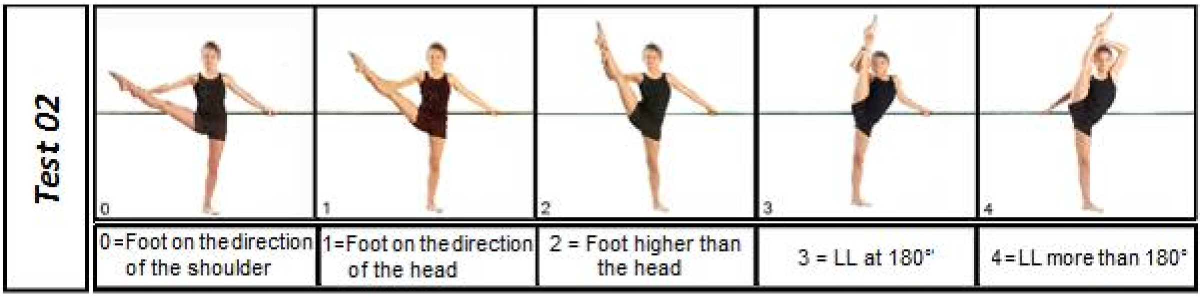

Figure 2. Reference points (0 – 4) of test 2: “supported LL hold to the side”.

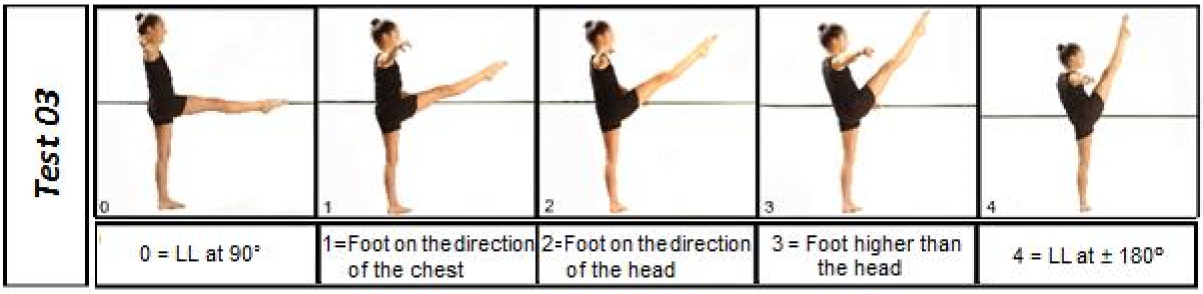

Figure 3. Reference points (0 – 4) of test 3: “unsupported LL hold to the front

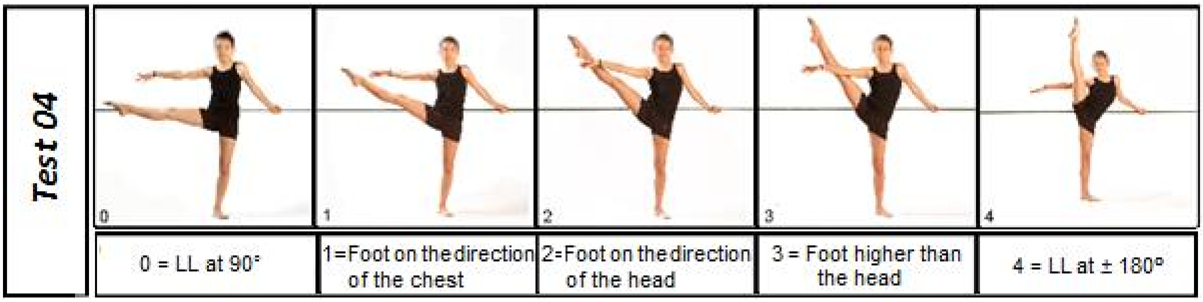

Figure 4. Reference points (0 – 4) of test 4: “unsupported LL hold to the side”.

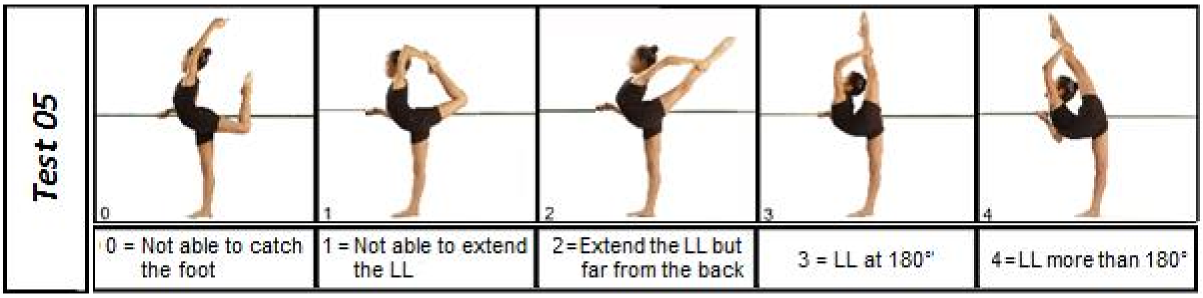

Figure 5. Reference points (0 – 4) of test 5: “supported LL hold to the rear”

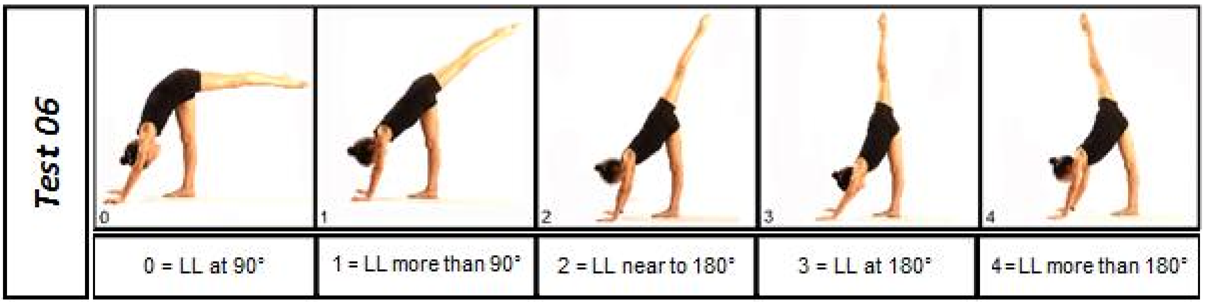

Figure 6. Reference points (0 – 4) of test 6: “unsupported LL hold to the rear – *Penché*”.

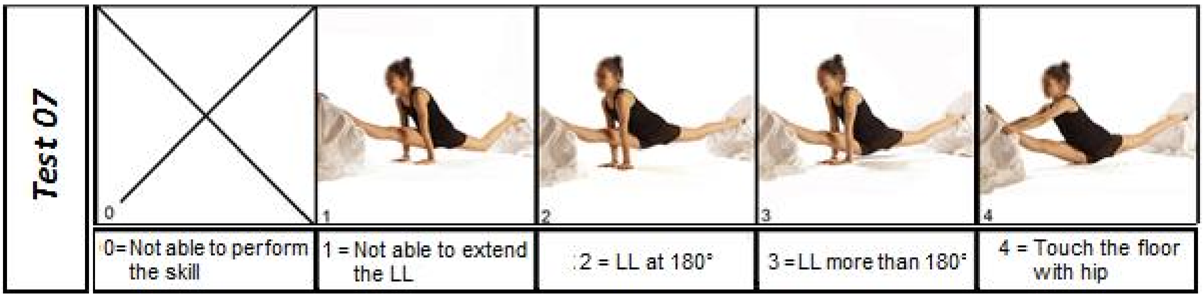

Figure 7. Reference points (0 – 4) of test 7: “Splits on two benches”.

Statistical Procedures

The program *Statistical Package for the Social Sciences* – Version 18.0 (SPSS *Statistics* 18.0) was used for statistical treatment of the data, The significance level for the rejection of the null hypothesis was set at α=0.05 (confidence interval of 95%).

Initially perform the Shapiro-Wilk normality test (Table 2) and although some variables had normal distribution, as the flexibility tests are represented by ordinal variables, using of a scale of 0 to 4 points and our sample was reduced, the statistical treatment of these variables was carried out using non-parametric tests –Mann-Whitney test, Friedman test and Wilcoxon test, because they are free scale tests. The descriptive statistics were carried out using the median as measure of central tendency and the minimum and maximum values as measures of relative position.

Table 2
The Sapiro-Wilk normality test to Flexibility tests.

	Shapiro-Wilk normality test	
	PLL	*NPLL*
Test 01	– **	0.046
Test 02	– **	0.161*
Test 03	– **	0.161*
Test 04	– **	0.001
Test 05	– **	0.200*
Test 06	– **	0.200*
Test 07	– **	0.026

RESULTS

Individual improvement on the tests with PLL and NPLL

The improvement was focused in the NPLL. It can be seen crossing the different evaluations, even when the differences were not highlighted in statistical terms. It is therefore necessary to point out the improvements made at the three evaluations for each test.

As can be observed in Figure 8 of Test 1 with NPLL, the gymnasts showed an improvement from the 1st to the 3rd evaluations in the level reached. Gymnast C made significant progress, from 0 on the 1st evaluation to 3 on the 3rd. Gymnast D maintained the same results at the three points, showing any improvement.

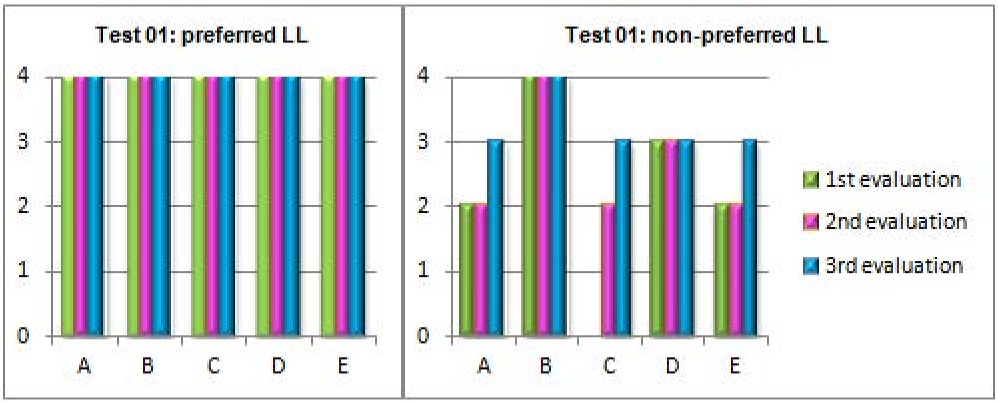

Figure 8. Level reached by each gymnast at three evaluations for Test 1 – "LL hold to the front".

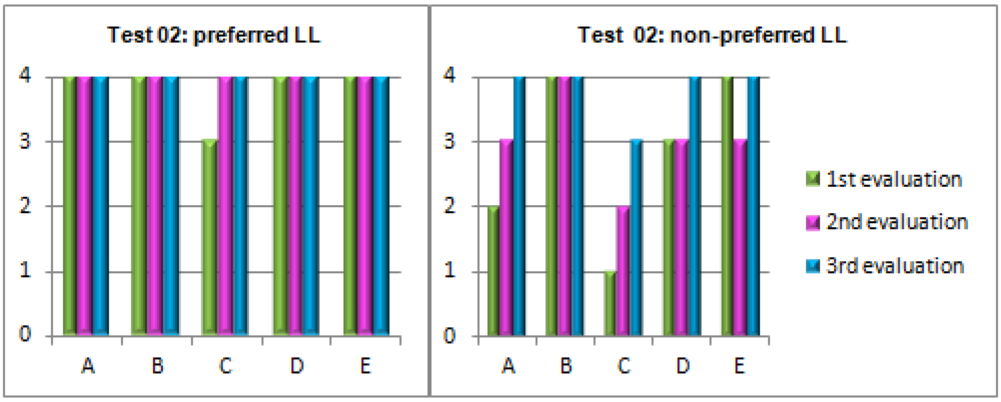

Figure 9. Level reached by each gymnast at three evaluations for Test 2 – "supported LL hold to the side".

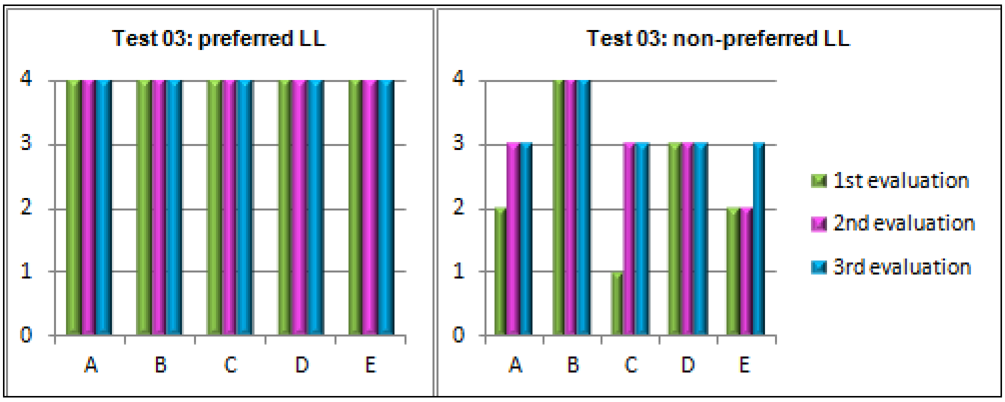

Figure 10. Level reached by each gymnast at three evaluations of Test 3 – "unsupported LL hold to the front".

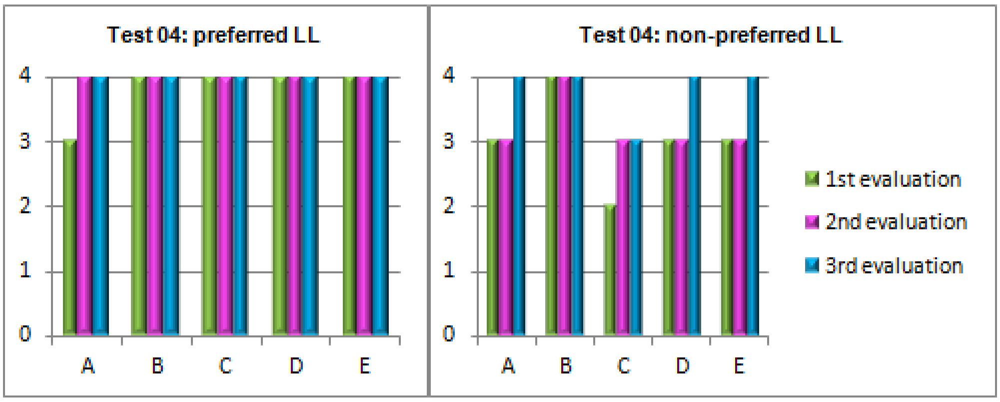

Figure 11. Level reached by each gymnast at three evaluations of Test 04 – "unsupported LL hold to the side".

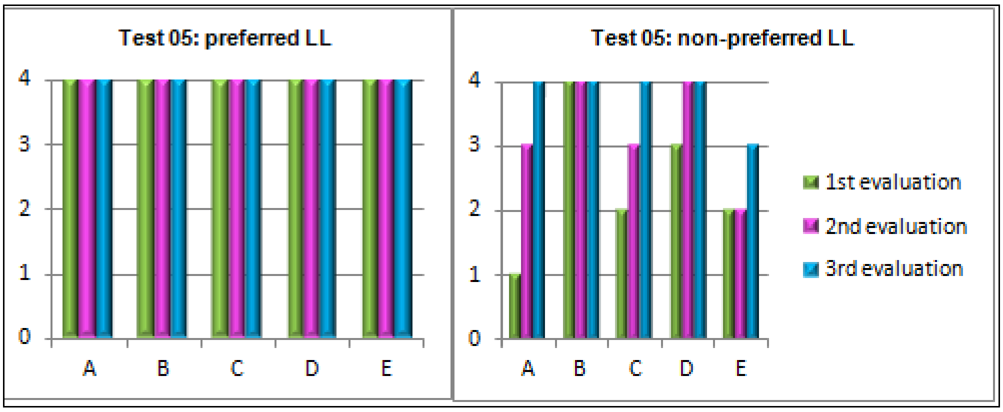

Figure 12. Level reached by each gymnast at three evaluations of Test 5 – "supported LL hold to the rear".

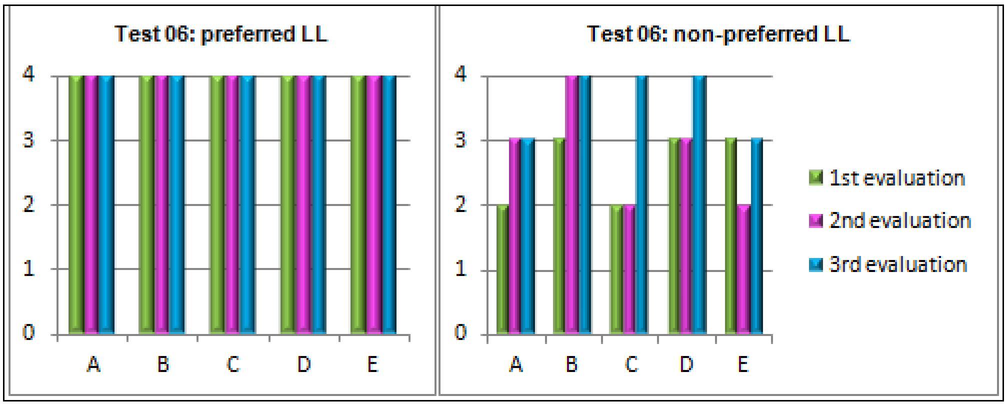

Figure 13. Level reached by each gymnast at three evaluations of Test 6 – unsupported LL hold to the rear – *Penché.*

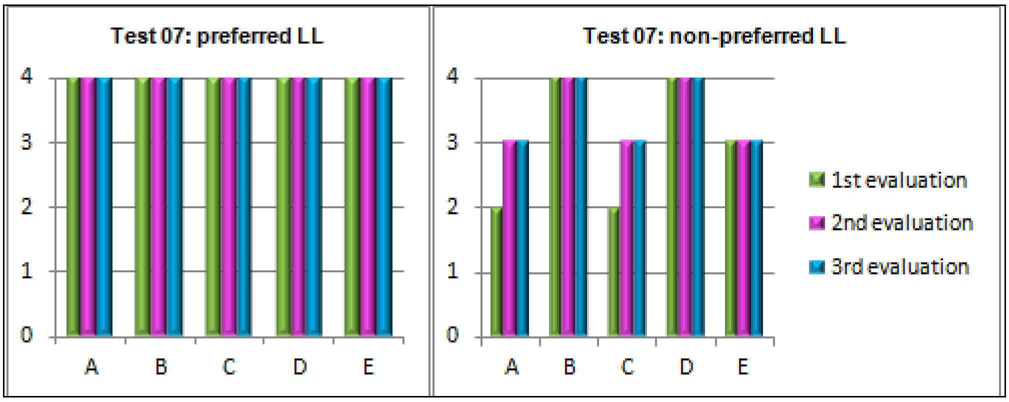

Figure 14. Level reached by each gymnast at three evaluations of Test 6 – "Splits on two benches".

Observing the results for Test 2 (figure 9), it can be found that the gymnasts showed an improvement in the level reached with NPLL from the 1st to the 3rd point, with the exception of gymnast E. All the gymnasts reached level 4 at the 3rd point, with the exception of gymnast C, who reached level 3. This gymnast showed great progress during the evaluation process, as in Test 1, from level 1 to level 3.

In the values for the Test 3 carried out with NPLL (figure 10) the gymnasts showed an improvement from the 1st to the 3rd evaluations, with the exception of gymnast D, who maintained the same results at the three points without any improvement, and gymnast B, who attained level 4 from the 1st evaluation. At the 3rd evaluation all the gymnasts attained level 3 with NPLL as their maximum at all points, except gymnast B who attained level 4. Once again, attention must be drawn to gymnast C who progressed from level 1 to level 3 during the three evaluations.

In test 4 (figure 11) all the gymnasts attained level 4 at the 3rd evaluation with NPLL, with the exception of gymnast C.

In Figure 12, it can be seen that in Test 5 with NPLL all the gymnasts reached level 4 at the final evaluation, with the exception of gymnast E. The results of gymnast A must be highlighted, she achieved level 1 at the 1st evaluation, level 3 at the 2nd evaluation and finally level 4 at the 3rd evaluation.

Observing the results for the Test 6, we can point out that the gymnasts improved on their level with NPLL from the 1st evaluation to the 3rd, with the exception of gymnast E, who registered a drop from the 1st to the 2nd evaluation and then returned to the same level attained at the 1st evaluation. At the 3rd evaluation, gymnasts B, C and D reached level 4 and gymnasts A and E reached level 3. Gymnast C registered the more visible evaluation (level 2 at the 1st and 2nd evaluation and level 4 at the 3rd evaluation).

As shown in Figure 14 of Test 7, it was registered a slight progress in level attained from the 1st to the 3rd evaluations with NPLL.

PLL evaluation at three moments:

According to Table 3, in all the flexibility tests carried out with PLL there were no significant differences between the results obtained at the three moments for the majority of the tests. The gymnasts had the highest level (level 4) at all evaluation moments on the tests 1, 3, 5, 6, and 7. For the tests 2 and 4, one gymnast obtained level 3 only in 1st evaluation.

At table 4 is visible the evolution on the data for NPLL. In Test 1, at least one gymnast exhibited level 0, defined as "very weak", at the 1st evaluation moment. Furthermore, in all the tests the highest level (level 4) was reached by at least one gymnast at each of the three evaluation moment.

Table 3
Median, minimum and maximum values and significance levels of Friedman tests in results obtained on PLL evaluation at three moments.

	PREFERRED LOWER LIMB (PLL)									
	1ST EVALUATION			2ND Evaluation			3RD Evaluation			*p*
	Min.	Max.	Median	Min.	Max.	Median	Min.	Max.	Median	
Test 01	4	4	4.0	4	4	4.0	4	4	4.0	– **
Test 02	3	4	4.0	4	4	4.0	4	4	4.0	*0.368*
Test 03	4	4	4.0	4	4	4.0	4	4	4.0	– **
Test 04	3	4	4.0	4	4	4.0	4	4	4.0	*0.368*
Test 05	4	4	4.0	4	4	4.0	4	4	4.0	– **
Test 06	4	4	4.0	4	4	4.0	4	4	4.0	– **
Test 07	4	4	4.0	4	4	4.0	4	4	4.0	– **

*p<0.05: there are significant differences
** there is no change in the results at the three moments

NPLL evaluation at three moments:

Table 4:
Median, minimum and maximum values and significance levels of Friedman tests referring to results obtained in the comparison of NPLL evaluation at three moments.

	NON-PREFERRED LOWER LIMB (NPLL)									
	1ST evaluation			2ND evaluation			3RD evaluation			*p*
	Min.	Max.	Median	Min.	Max.	Median	Min.	Max.	Median	
Test 01	0	4	2,0	2	4	2,0	3	4	3,0	*0.061*
Test 02	1	4	3,0	2	4	3,0	3	4	4,0	*0.071*
Test 03	1	4	2,0	2	4	3,0	3	4	3,0	*0.097*
Test 04	2	4	3,0	3	4	3,0	3	4	4,0	*0.039**
Test 05	1	4	2,0	2	4	3,0	3	4	4,0	*0.030**
Test 06	2	3	3,0	2	4	3,0	3	4	4,0	*0.074*
Test 07	2	4	3,0	3	4	3,0	3	4	3,0	*0.135*

*p<0.05: there are significant differences

From the data in Table 4 we can observe that were significant differences between at least two evaluation moments only in the Tests 4 and 5.

In order to determine between which points these differences exist in statistical terms in Tests 4 and 5, the analysis *Post-hoc* was used, performed with the Wilcoxon Signed-Rank Test, according to the following tables.

In Test 4 (unsupported LL hold to the side – NPLL), according to the significance level shown in the comparisons of each evaluations, it can be seen in Table 5 that significant differences were only found in the results attained from the 1st to the 3rd evaluations.

Table 5
Comparison of three evaluations of Test 4 to determine statistical differences between evaluations.

Test 04	1st evaluation	2nd evaluation
1st evaluation		
2nd evaluation	*0.317*	
3rd evaluation	*0.046**	*0.083*

*p<0.05: there are significant differences

In Test 5 (LL hold to the rear – NPLL) (Table 6), there were significant differences from the 1st to the 2nd evaluations and from the 1st to the 3rd evaluations

Table 6
Comparison of three evaluation of Test 5 to determine statistical differences between evaluations.

Test 05	1st evaluation	2nd evaluation
1st evaluation		
2nd evaluation	*0.047**	
3rd evaluation	*0.036**	*0.063*

*p<0.05: there are significant differences

From the results of data in Test 5, it is possible to see that there was improvement from the 2nd to the 3rd evaluations, however, significant differences were not found.

DISCUSSION

According to Jastrjembskaia and Titov (1999) and Laffranchi (2005), the flexibility is the main motor skill of RG. Gymnasts of this sport are mainly characterized by their flexible joints and compliant muscles (Donti et al., 2014). Róbeva and Rankélova (1991), Petry (2008) and Stadnik, Ulbricht, Perin, and Ripka (2010) consider that gymnasts should exhibit flexible joints, in particular the joints of the hips. (coxo-femoral), the shoulders (scapula-humerus) and the vertebral column. These tests aim to assess flexibility levels of the coxo-femoral joint through exercises regularly used by the gymnasts in training. The ballet bar exercises aim to develop motor skills, as does the conscious assimiliation of the basic positions of RG for correct posture, facilitating, other than the bar, the execution of movements. These exercises are performed in many, if not all, training sessions (Laffranchi, 2001). Therefore, this statement appears to explain the good results in the fact that the gymnasts mainly obtained levels 3 and 4 in the PLL flexibility tests. However, the results obtained with NPLL at the 1st evaluation must be stressed; the gymnasts, despite their high technical level did not attain very significant levels.

Initially (in 1st evaluation), the results don’t meet the hypothesis made in this study, because the gymnasts didn’t submitted high levels of passive and active flexibility with NPLL.

However, it was possible to observe the gymnast's evolution during the concerned season, through the improvement registered in the flexibility level in lower limbs from the 1st to 3rd evaluation. The fact that these gymnasts were chosen to represent their country in the European Championships played a considerable motivation role in their daily training objectives.

The group level was crucial in the planning and definition of the aim of each training session, given that for Laffranchi (2005), the homogeneity of the team is essential for the gymnasts’ growth and progress. For this reason, based on the results obtained at the last evaluation point, excellent advances were seen in NPLL flexibility. We don't know the type of training led to improvements in flexibility, but through the results, it is possible recognize that the focus on symmetrical work caused the considerable fall in asymmetry ratings of the gymnasts.

Sometimes, the flexibility asymmetries appear as a result of the training type. Emphasis is given to the preferred limb through executing a higher number of repetitions with it or because of the greater intensity and desire of the gymnast to perform the exercise with the limb which is easiest. According to Cobalchini and Silva (2008), the NPLL can achieve a similar performance to the PLL when properly stimulated.

From the results of this study, gymnast B must be singled out for maintaining the highest level (level 4) in all the tests at all three evaluations, with the exception of test 06 (unsupported LL hold to the rear – *Penché*) in which only level 3 was obtained at the 1st point. This gymnast could be considered “excellent” according to our battery of flexibility tests. Gymnast C must also be singled out for obtaining an improvement of 130.1% with the NPLL from the 1st to the 3rd evaluation.

This type of study, accompanying the progress of the gymnasts over a season, is considered extremely valid to report performance, to orientate results, strengthen goals, as well as motivate and install the confidence in the work being done (Llobet, 2000). The work developed with the gymnasts observed on this study had a lot of positive points, proved by the results set out in this study.

Lisitskaya (1995) advises that in some training sessions, a larger proportion of movements with the NPLL should be used, given that according to (Giolo, 2008), both preferred and non-preferred sides are essential in the practice of RG. Thereby it is the responsibility of coaches to create the appropriate balance to avoid overloading one limb, as well as to direct the work in the training sessions in accordance with the needs and weaknesses of each gymnast.

CONCLUSIONS

These elite RG gymnasts from the 1st to 3rd evaluations showed excellent improvements in NPLL flexibility, and based on the results obtained at the last evaluation point, it can be concluded that, the focus on symmetrical work caused the considerable fall in asymmetry ratings of the gymnasts. They showed high level of flexibility in their preferred lower limb since 1st evaluation.

According the hypothesis of the study, it was expected that the elite gymnasts had high level of passive and active flexibility for the preferred and non-preferred lower limb, however, in 1st evaluation, the results don’t meet the hypothesis, because the gymnasts showed high level of passive and active flexibility with PLL only. In 3rd evaluation, despite the improvement in the passive and active flexibility level with NPLL, this lower limb didn't showed the level maximum.

Thereby, the best suggestion for the flexibility training in RG is the implementation of symmetrical work, independent the selection of exercises, for to promote the correct and balanced development the gymnasts. The coaches are the key for success in this sport.

This study had limitations as the reduced sample, because the Portuguese junior gymnasts were the unique elite gymnasts in the country in the data collection moment. Furthermore, the tests applied had as limitation the type of evaluation with comparison of images and an assessment chart, but they are the FIG suggested tests, and they are close to Rhythmic Gymnastics reality.

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CORRELATION BETWEEN GYMNASTICS ELEMENTS KNOWLEDGE AND PERFORMANCE SUCCESS IN YOUNGER CATEGORIES OF ALPINE SKIING

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Original article

Abstract

On a sample of 24 female competitors and 30 male competitors (ages 12 to 13 years) we wished to determine the correlation between knowledge of gymnastic elements and acrobatics, and performance success in Mercator Cup children's competitions in alpine skiing. The sample of variables at the measurements consisted of evaluations of eight (8) gymnastic and acrobatic skills (evaluated on scale 0-5), while performance success criterion was represented by competitors ranking in the official children's competitions in ski season 2013/14.
By means of calculating the Spearman coefficient of correlation (r_s), we found that by female competitors two individual gymnastics variables, as well as average evaluations of all gymnastics variables are statistically significantly associated with the performance success criterion. Based on the processing of data by the method of using the "Mann Whitney U test," we both in girls (GIM; Sig. =0.012) as well as in boys (GIM; Sig.=0.033*) confirmed a statistically significant correlation between the average values of gymnastics variables (GIM) and the performance success in competitions in the Mercator Cup. This means that both in boys as well as in girls higher rankings in competitions were achieved by those with better knowledge of acrobatics and gymnastics elements.*

Keywords: alpine skiing, children, gymnastic and acrobatic elements, successfulness, training

INTRODUCTION

Acrobatics is nowadays in terms of basic physical preparation a very important complementary part of the training process in alpine skiing (Mujanović, Atiković, & Nožinović Mujanović, 2014). With practicing acrobatics we enrich both the energetic as well as informatic part of motor efficiency of an athlete in situations where the result can be decisively influenced on by the determination and ability of orienting in space. The diversity and complexity of motor tasks, which primarily involve controlling one's own body (Lešnik, 1996), according to the theory of motor learning is an important factor in the adequate formation of motor schemes (Bolkovič & Kristan, 2002; Schmidt & Lee, 2005; Willingham, 1998). Mastery of gymnastic elements is a good base for faster and easier conquering of new motor programs from other kinds of sports, including alpine skiing. Acrobatics with its complexity has also in training of young alpine skiers a positive impact on the development of overall movement coordination, ability to move in space and body control in a non-supportive fase (Krističević, Živčić, Cigrovski, Simović, & Rački, 2010). In accordance with some scientific studies, acrobatics presents a helping hand also in the development of all forms of power (Bompa, 1999; Cigrovski & Matković, 2007; Žvan & Lešnik, 2000).

Alpine skiing ranks among the complex sports (Hébert-Losier, Supej, & Holmberg, 2014; Lešnik, 1999), so it is difficult to determine all the factors which influence on achieving good results. The training process is a case of developing motor abilities through a variety of methods and training contents (Bompa, 1999; Bosco, 1997; Kostelić, 2005; Ušaj, 1996). Therefore, the integration of training of gymnastics and acrobatics into special preparation of alpine skiers is very important (Glinšek, 2013; Petrović, Šmitek, & Žvan, 1984). The latter in alpine skiing is particularly important due to possible unpredictable situations, which the competitor must solve with the objective to race through the ski piste as fast as possible and without mistakes (Figure 1). Situations like slip on the icy surface, loss of balance and falls can be very frequent in alpine skiing, so it is important that competitors have good control over their body movement (Lešnik, Podovšovnik Axelsson, & Supej, 2013). Efficiency of movement in skiing requires coordinated action of the whole body of the skier, being almost equally important the work of legs, torso and arms (Mujanović, Atiković, & Nožinović Mujanović, 2014). The structures of movement in alpine skiing are becoming more and more sophisticated and complex due to increasing speed and more difficult settings of ski pistes (Jentschura and Fahrbach, 2004; Lešnik, 1999; Vaverka, Vodičkova, & Elfmark, 2012). Therefore, it is important that trainings in alpine skiing enable competitors comprehensive development and simultaneous progression in all dimensions, which have a significant impact on performance success in competitions (Lešnik, 1996; Neumayr et al., 2014).

Figure 1. Skier during giant slalom.

Figure 2. Skier attempting handstand.

Krističević, Živčić, Cigrovski, Simović and Rački (2010) determined in their study the correlation of control of acrobatic elements with success in slalom and giant slalom in younger alpine skiers. The sample of measured participants consisted of 46 young alpine skiers (24 boys and 22 girls), aged 8-10 years. They found that the control of acrobatic elements is statistically significantly associated with the success of competitors in alpine skiing.

One of the most important roles of gymnastics program is to develop basic motor abilities such as strength, movement coordination, flexibility, balance and speed and the main objectives of gymnastic education is the development of conscious control of the position and movement of the body (Bučar Pajek, Čuk, Kovač, & Turšič, 2010; Novak, Kovač, & Čuk, 2008; Živčić, 2007). Therefore, it is important that the contents of gymnastics and acrobatics are intertwined with the physical preparation programs in all age categories of alpine skiers through all the periods of training (Kostelić, 2005; Živčić & Krističević, 2008).

The main objective of the research is to determine the relation between control of gymnastic elements and performance success in competitions of young girls and boys in alpine skiing. Given the fact that the presented sample of measured participants is in a sensitive period of psycho-physical development (12-13 years), it is also interesting to compare the influence of covered variables according to the gender. Since, in practice, the contents of acrobatics are an important part of the training process in different categories of skiers (Krstičević, Živčić, Cigrovski, Simović & Rački, 2010), we were interested in how mastering of gymnastic elements affects the performance success in the category of younger girls and boys in alpine skiing.

METHODS

The study included 24 younger girls and 28 younger boys, aged 12 to 13 years. In the measurements performed on November 10th, 2012 (Faculty of Sport, University of Ljubljana), they had to fulfil the following requirements: that they were born between 1999 and 2000, were registered as competitors in Slovenian skiing clubs and had actively taken part in the regular training process in the previous year, and had no physical injuries or other problems.

The evaluation of body control has been done by assessing gymnastic skills (gymnastics variables). The sample of variables consists of:

- 8 gymnastics variables: straddle vault (STR), forward roll (RFOR), backward roll (RBAC), handstand to forward roll (HS-RFOR), cartwheel (FLIS), roundoff (FLIS90°), felge on lower bar on uneven bars (TRN), squat vault (SQU) and
- the average score of all gymnastics elements (GYM).

These gymnastics variables were used because they are in terms of the complexity of body movement and solving motoric problems related to movement in alpine skiing. By movement in alpine skiing it is considered both ski sliding, jumping over the turning points as well as any falls and loss of balance. The selected elements of gymnastics, the examinees performed after preliminary preparation (heating) and demonstration of each element. Exercises were performed in the same order, and all executions were recorded with the camera. Based on the recorded material each examinee received for the execution of each exercise (variable) an assessment from 1 to 5. The final assessment of each implemented element was represented by an average assessment of two independent and experienced gymnastics judges (Čuk, Fink, & Leskošek, 2012). The final assessment of the GYM variable was represented by an average value of assessments of all the other variables.

The criterion of success (PTS) is represented by performance success or the number of points scored by an individual in Mercator Cup in ski season 2012/13. In the season 2012/13 in Mercator Cup there were realized 10 competitions in total (5 x slalom and 5 x giant slalom competitions). Super giant slalom result could not be taken into account because it had not been performed due to bad weather conditions. Based on the calculation of points scored was calculated the performance success rankings of younger boys and girls in the Mercator Cup. The Ski Association of Slovenia determines the performance success of participants in competitions after the agreed criteria, where a competitor is given 150 points for the 1st place, 135 points for the 2nd place, 120 points for the 3rd place, 108 points for the 4th place, 96 points for the 5th place… (Competition System in Alpine skiing, 2013).

Data processing was carried out using the program SPSS - statistical package for social sciences. For the results obtained, we first calculated the basic statistical parameters (M-mean, and SD-standard deviation). To determine the relation between body control variables (STR, RFOR, RBAC, HS-RFOR, FLIS, FLIS90°, TRN and SQU) and the average score of all gymnastics elements (GYM) with performance success (PTS), the Spearman correlation rho coefficient (rs) and statistical significance of Spearman correlation rho coefficient (Sig.rs) were used. The coefficient of statistical significance was calculated due to the reliability of the data of the correlation between individual variables and criterion variable. The risk level of statistical significance was between 1% and 5%.

We also calculated the U-test (Mann-Whitney U-test) and statistical significance (Sig.) of correlation between used variables and criterion, separately for younger girls and younger boys. The categories of measured participants were divided into two ranks. With younger girls the first rank consisted of those who in the final standings reached places from 1-12 and the second of those who reached places from 13-24. With younger boys the first group consisted of those who reached places from 1-15, and the other for places from 16-30. Using this method, we would like to identify in which gymnastics variables are more successful the competitors from the first rank, and in which the competitors from the second rank.

RESULTS

Based on the calculation of basic statistical parameters and the use of methods of calculating the correlation (Spearman correlation coefficients and the Mann-Whitney U-test) between gymnastics variables and criterion variable, we have in the category of young girls and boys in alpine skiing come to the following conclusions.

The Table 1 shows that the average score range of gymnastic elements in a sample of younger girls is 3 to 4.12 (FLIS 90°; M=3.0, RFOR; M=4.12). The scores of other gymnastic elements are within the mentioned interval, with contestants achieving higher scores in elements carthwheel, squat vault, straddle vault (FLIS; M=3.96, SQU; M=3.96, STR; M=3.75), while the scores of other gymnastic elements were slightly lower (HS-RFOR; M=3.29, TRN; M=3.21, RBAC; M=3.12). The highest correlation with the points is noticable by the roundoff (FLIS90°/PTS; rs=0.58**), high correlation with the Cup points is present also by the forward roll variable (RFOR/PTS; rs = 0.42*).

Table 1
Results of the arithmetic mean (M) and Spearman's rho correlaton (rs) of individual gymnastics variables and total score of gymnastic elements (GYM) with points (PTS) scored in Mercator Cup in younger girls (N=24).

	VARIABLES									
	STR	RFOR	RBAC	HS-RFOR	FLIS	FLIS90°	TRN	SQU	PTS	GYM
M (SD)	3.75 (1.11)	4.12 (0.74)	3.12 (1.29)	3.29 (0.80)	3.96 (0.99)	3.00 (1.47)	3.21 (1.28)	3,96 (0.85)	312.00 (223.58)	3.55
PTS (rs)	0.29	**0.42***	0.36	0.33	0.35	**0.58****	0.26	0,26	1.00	**0.51***

Legend: N – number of competitors; STR – straddle vault; RFOR – forward roll; RBAC – backward roll; HS-RFOR – handstand to forward roll; FLIS – carthwheel; FLIS90° - roundoff; TRN – felge; SQU – squat vault; PTS – points scored in Mercator Cup; rs - Spearman's rho correlaton, GYM – total score of gymnastic elements; M – arithmetic mean, SD –standard deviation, * Statistically significant correlation on a 5 % risk level, ** Statistically significant correlation on a 1 % risk level.

Table 2
Results of Mann-Whitney U test of points scored in Mercator Cup, gymnastic element variables and total score of gymnastic elements in younger girls (N=24).

Rank 1= 1- 12 Rank 2= 13-24 N= 24	M-W U-TEST	SIG. (1-TAIL)	RANK	M-RANK	SUM OF RANKS
PTS	0	**0**	1	18.50	**222**
			2	6.50	**78**
STR	44	0.55	1	14.83	178
			2	10.17	122
RFOR	43.50	0.52	1	14.88	178.5
			2	10.12	121.5
RBAC	58	0.19	1	13.67	164
			2	11.33	136
HS-RFOR	64	0.32	1	13.17	158
			2	11.83	142
FLIS	55	0.18	1	13.92	167
			2	11.08	133
FLIS 90°	37	**0.02***	1	15.42	**185**
			2	9.58	**115**
TRN	44.50	0.06	1	14.79	177.5
			2	10.21	122.5
SQU	52.50	0.15	1	14.12	169.5
			2	10.88	130.5
GYM	**33.50**	**0.01***	1	15.71	**188.5**
			2	9.29	**111.5**

Legend: N – number of competitors; Rank 1 – first rank of competitors; Rank 2 – second rank of competitors; M-W U-test – Mann-Withney U test; Sig. – significance of correlation; M-rank – Mean of rank; SUM OF RANKS – sum of ranks; PTS – points scored in the Cup; STR – straddle vault; RFOR – forward roll; RBAC – backward roll; HS-RFOR – handstand to forward roll; FLIS – carthwheel; FLIS90° - roundoff; TRN – felge; SQU – squat vault; GYM – total score of gymnastic elements; * Statistically significant correlation on a 5 % risk level

Table 3
Results of the arithmetic mean (M) and Spearman's rho correlaton (rs) of individual gymnastics variables and total score of gymnastic elements (GYM) with points scored in Mercator Cup in younger boys (N=30).

	VARIABLES									
N=30	STR	RFOR	RBAC	HS-RFOR	FLIS	FLIS 90°	TRN	SQU	PTS	GYM
M (SD)	3.93 (0.98)	4.03 (0.61)	3.23 (1.27)	2.70 (1.23)	2.83 (1.31)	2.17 (1.26)	2.43 (1.41)	4.03 (1.37)	248.77 (219.54)	3.17
PTS	0.19	-0.06	0.06	0.30	0.05	-0.01	0.14	0.32	1	0.25

Legend: N – number of competitors; STR – straddle vault; RFOR – forward roll; RBAC – backward roll; HS-RFOR – handstand to forward roll; ; HS-RFOR – handstand to forward roll; FLIS – carthwheel; FLIS90° - roundoff; TRN – felge; SQU – squat vault; PTS – points scored in Mercator Cup; rs - Spearman's rho correlaton, GYM – total score of gymnastic elements; M – arithmetic mean, SD – standard deviation* Statistically significant correlation on a 5 % risk level, ** Statistically significant correlation on a 1 % risk level

Table 4
Results of Mann-Whitney U test of points scored in Mercator Cup, gymnastic element variables and total score of gymnastic elements in younger boys (N=30)

Rank 1= 1- 15 Rank 2= 16- 30 N= 30	M-W U TEST	SIG. (1-TAIL)	RANK	M-RANK	SUM OF RANKS
PTS	0	**0**	1	23	**345**
			2	8	**120**
STR	83	0.11	1	17.47	262
			2	13.53	203
RFOR	106	0.36	1	15.93	239
			2	15.07	226
RBAC	109	0.45	1	15.73	236
			2	15.27	229
HS-RFOR	71	**0.04***	1	18.27	**274**
			2	12.73	**191**
FLIS	111	0.467	1	15.60	234
			2	15.40	231
FLIS 90°	98.50	0.277	1	16.43	246.50
			2	14.57	218.50
TRN	73	**0.05***	1	18.13	**272**
			2	12.87	**193**
SQU	68.50	**0.03***	1	18.43	**276.50**
			2	12.57	**188.50**
GYM	68	**0.03***	1	18.47	**277**
			2	12.53	**188**

Legend: N – nubmer of competitors; Rank 1 – first rank of competitors; Rank 2 – second rank of competitors; M-W U-test – Mann-Withney U test; Sig. – significance of correlation; M-rank – Mean of rank; SUM OF RANKS – sum of ranks; PTS – points scored in the Cup; STR – straddle vault; RFOR – forward roll; RBAC – backward roll; HS-RFOR – handstand to forward roll; ; HS-RFOR – handstand to forward roll; FLIS – carthwheel; FLIS90° - roundoff; TRN – felge; SQU – squat vault; GYM – total score of gymnastic elements; * Statistically significant correlation on a 5 % risk level.

From the Table 1 we can see that in younger girls the correlation between the overall gymnastics score and points scored in the Cup is statistically significant (GYM/PTS; rs=0.51*). The calculated coefficient of statistical significance of the relation between the average score of all gymnastic elements (GYM) and points won in the Mercator Cup (PTS) in the measured sample is on a 5% risk level (GYM/PTS; Sig.rs=0.01*). Important statistically significant impact on the performance of the measured sample in the Mecator Cup (PTS) was calculated also with the roll forward variable (RFOR/PTS; rs=0.42*). The level of correlation is statistically significant on a 5 % risk level (RFOR/PTS; Sig.rs=0.05*). It is also evident from the table that of the individual variables the variable roundoff has the strongest influence on the results achieved (FLIS90°/PTS; rs=0.58**). Statistical correlation of the mentioned element with the performance success of measured sample is on a 1 % risk level (FLIS90°/PTS; Sig.rs=0.003**).

The Table 2 shows that in younger girls the influence of gymnastic elements scores on (GYM) performance success at competitions (PTS) is statistically significant on a 5% risk level (GYM; Sig.=0.01*). The obtained calculation was largely contributed to by the results of the contestants in the first rank (Rank 1=1-12). Among individual variables (gymnastic elements) the greatest influence on achieving results in competitions was contributed by the variable roundoff (FLIS90°; Sig.=0.02*). The calculated correlation is statistically significant on a 5% risk level, and close to a statistically significant influence on the success of the measured sample was also the calculation of the felge variable correlation (TRN; Sig.=0.06). The calculated results confirm that in girls, with the criterion variable there are largely related the gymnastics variables, which are among the more difficult to perform (FLIS90° and TRN). The highest level of correlation with the criterion variable is noticed in the variable of average score of all individual elements of gymnastics (GYM). Since the latter is including the average score of all gymnastics variables, we can speak of a real relationship between mastery of gymnastic elements and performance success in competitions in alpine skiing.

The Table 3 shows that the average score range of gymnastic elements in a sample of younger boys is 2.17 to 4.03 (FLIS90°; M=2.17, RFOR and SQU; M=4.03). The scores of other gymnastic elements are within the mentioned interval, with contestants achieving higher scores in elements straddle vault, backward roll and carthwheel (STR; M=3.93, RBAC; M=3.23, FLIS; M=2.83), while the scores of other gymnastic elements were slightly lower (HS-RFOR; M=2.7, TRN; M=2.43). The highest correlation with the points scored is noticable by handstand to forward roll (HS-RFOR/PTS; rs=0.30) and squat vault (SQU/PTS; rs=0.32). With younger boys there is a correlation between performance success and body control, but not so strong that we could say that it is statistically significant. In a sample of younger boys also other gymnastic elements are not statistically significantly correlated with performance success. The same is true for the overall score of gymnastics and points scored (GYM/PTS; rs=0.25).

The Table 4 shows that in younger boys the influence of gymnastic elements scores (GYM) on performance success at competitions (PTS) is statistically significant on a 5% risk level (GIM; Sig.=0.03*). The obtained calculation was mainly contributed to by the results of the contestants in the first rank (Rank 1=1-15). Among individual variables (gymnastic elements) the greatest influence on achieving results in competitions was contributed by the elements handstand to forward roll (HS-RFOR; Sig.=0.04*), felge (TRN; Sig.=0.05*) and squat vault (SQU; Sig.=0.03*). The calculated correlations are statistically significant on a 5% risk level. The calculated results confirm that also in boys (like in girls) the gymnastics variables, which are among more difficult to perform (HS-RFOR, SQU and TRN), are correlated with the criterion variable the most. Also in boys the variable of average score of all individual gymnastics elements (GYM) is highly and statistically significantly correlated to the criterion. As the latter (GYM) includes the average score of all gymnastics variables, we can also in the case of boys speak of a real relationship between mastery of gymnastic elements and performance success in competitions in alpine skiing.

DISCUSSION

The aim of this study was to determine the level of correlation between controlling gymnastic elements and performance success of younger girls and boys in competitions in alpine skiing. The examined sample of participants was conducted in a sensitive period of their psycho-physical development (12-13 years), so we were interested also in possible differences in the influence of the variables sample according to gender (Pišot & Šimunič, 2006).

The obtained results confirm our predictions and observations from practice and give us the answer in relation to the dilemma of whether the knowledge of acrobatics is important to achieve better results in competitions in alpine skiing. In younger girls (Table 1) the correlation between the overall gymnastics score and points scored in the Cup is statistically significant (GYM/PTS; rs=0.51*), while in younger boys (Table 3) a statistically significant influence on a 5 % risk level could not be confirmed (GYM/PTS; rs=0.25). The reasons for the results obtained may also arise from the fact that in the pre-pubertal fase there is no significant difference in body structure and weight between boys and girls (Škof & Kalan, 2007). Later, sometime after 10 years of age, girls begin to overtake boys in development and growth. During the period of puberty, which begins in girls at around 10 years old and in boys a year or two later (Horvat & Magajna, 1989). It is going about a sensitive period with the major growth spurt and hormonal changes with the development of the sexual organs and secondary sexual characters (Škof & Kalan, 2007). In accordance with the stated fact, boys enter into the puberty period slightly late, therefore, the accelerated growth comes with a delay of approximately two years. The consequences of accelerated growth are reflected in the altered relationship between muscle, bone and adipose tissue, which results in poorer movement coordination and consequently in poorer performing of more complex motor tasks (Pišot & Planinšec, 2005; Simons-Morton et al., 1988; Thomas & French, 1985). This may be the reason that a statistically significant correlation between controlling the elements of acrobatics and performance success in competitions in the Mercator Cup could not be proved with boys (GYM/PTS; rs=0.25). Despite the fact that the calculation of the Spearman correlation coefficients (rs) at the 5% risk level did not confirm statistically significant correlations between gymnastics variables and criterion, this does not mean that 12 and 13 year-old competitors in alpine skiing do not require acrobatics training. Acrobatics training is highly recommended and should, in particular to reduce the risk of injury, be an important part of training of alpine skiers.

In recent years in practice, particularly in measurements of children, we observe significant differences in body constitution (Lešnik, 2009). The reasons for this lie in genetic design of younger generations, as well as modern lifestyle (Maffetone, 2012). In the period after 12 years of age, children are subjected to accelerated development, which for some starts sooner, and for others later (Horvat & Magajna, 1989). With physical growth also the body weight is relatively increasing, which for competitors aged 11-14 years (categories of younger and older boys) may represent an inhibiting factor in the controlling of one's own body in space, but can greatly contribute to faster skiing between the gates (Müller & Schwameder, 2003). Technical knowledge of competitive ski turns in young competitors is not yet so sophisticated that the outcome could be affected by the small details, as is the case in top-level athletes (Federolf et al., 2008; Maffiuleti et al., 2009; Supej, Kipp, & Holmberg, 2011). Therefore, the more body weight can be very helpful for a child in getting speed after braking (slipping from the ideal line) with changes in the direction of skiing down the slope (Bandalo & Lešnik, 2011; Lešnik & Žvan, 2013). According to the results of one other study the set of body measures variables is statistically significantly related to success in competitions (Lešnik & Žvan, 2014). Greater weight could therefore hypothetically represent an advantage in children's competitions. This, according to our results, does not apply for controlling gymnastic elements in boys.

Alpine skiers are on the piste constantly confronted with situations that need to be resolved quickly and efficiently. Like in gymnastics, also in skiing it is about the complex movement in accordance with the formed movement programs (Schmidt & Lee, 2005; Winter, 2009). In every moment they should be aware of orientation in space and body position (Glinšek, 2013; Luethi & Denoth, 1987; Supej & Cernigoj, 2006). Especially in girls the performance success in competitions is correlated strongly with gymnastic elements (Table 1), in which rotation in the forward or sideways direction is present (RFOR, FLIS90°). Mastering these elements allows the skier better preservation of the equilibrium position and effective rescue in the event of falls at higher speeds. Based on the findings of this study it can be said that in the Mercator Cup competitions higher ranks were achieved by female competitors with better knowledge of acrobatics and gymnastic elements. Girls who scored more points and were ranked higher in the final standings, received the highest scores especially by roundoff (FLIS90°). Similar results were obtained also by using the Mann Whitney U test, with which we confirmed that acrobatics and gymnastic elements are an important part of the training already at the lowest level competitive groups in alpine skiing (Table 2). The latter was confirmed with the calculation of statiscally significant correlations of variables FLIS90° (Sig.=0.019*) and GYM (Sig.=0.012*).

In younger boys the strongest correlation with performance success in competitions is visible by handstand to forward roll (HS-RFOR) and squat vault (SQU). None of these correlations in boys did not reach a statistical significance of a 5% level (Table 3). Poorer body control correlation can be explained by accelerated growth in puberty, when development among competitors is subjected to large individual differences. These are reflected in the weaker coordination and poorer control of the body in space and time, which can represent a big problem for a young competitor. Also during this period, in addition to body height also the body weight increases, while muscles develope more in boys than in girls (Horvat & Magajna, 1989; Pišot & Šimunič, 2006). U test results (Table 4) also confirmed that boys with better competitive results have more knowledge and better scores with four variables (HS-RFOR; Sig.=0.037*, TRN; Sig.=0.048*, SQU; Sig.=0.027* and GYM; Sig.=0.033*). Among these there are two more complex elements of movement (HS-RFOR and TRN), which require a high level of motor potential from examinees in terms of the structure of the movement. Proven statistically significant influence of the average of all gymnastics variables (GYM) both in girls and in boys confirms the fact that an all-round training of acrobatics significantly impacts on achieving good results in alpine skiing.

This study is from the perspective of the applied research methods similar to the study conducted by Krističević, Živčić, Cigrovski, Simović and Rački (2010), but otherwise the mentioned studies are quite different. The main difference between the two studies is in the age of the chosen sample of participants. The age difference of the chosen samples is 2-5 years. In the age period from 8-13 years there can be significant differences in the development level of the children (Pišot & Planinšec, 2005). Given the fact that the sample of participants in our study is older (ages between 12 to 13 years) and physically and mentally more developed, we selected a sample of variables with slightly more complex gymnastic elements (for instance FLIS90° and TRN). Another difference is also the criterion variable, which in our case is defined as the total amount of points scored in the Mercator Cup (PTS) in accordance with the rules and the system of children's competitions of the Ski Association of Slovenia (Competition System in Alpine skiing, 2013). The results of those two studies have shown the importance of managing acrobatic elements to achieve success in competitions in alpine skiing. Consequently, it can be said that the acrobatics content in the alpine skiing training is important in different age categories of competitors.

Based on the obtained results it can be concluded that the correlation between control of gymnastic elements and performance success is statistically significant both in younger boys and girls. In the future it would therefore be necessary to include in the training process of young alpine skiers in all stages of training even more exercises with elements of acrobatics. Competitive alpine skiing will in the crowd of modern attractive ski disciplines (ski cross, new school, freeride ...) have to become even more dangerous and thus interesting and attractive for the people. The skiing speed that competitors are achieving in competitions is constantly growing (Lesnik & Žvan, 2010) and also presents more possibilities for falls and subsequent injuries (Cirgovski & Matković, 2007; Veselko & Polajnar, 2008). Besides other important factors that influence on the success in alpine skiing (Cirgovski, 2007; Dolenec & Žvan 2001), in the future the mastery of acrobatic elements will certainly become even more important. Such knowledge is in alpine skiing beneficial both in terms of better control of the skier's own body in solving complex motor tasks while skiing, as well as in the case of falls, when the movement of the skier can be controlled to a lesser extent (Kostelić, 2005; Živčić & Krističević, 2008). In the future, it would be necessary for the acrobatics training to move even closer to the contemporary trends of ski movement. The training of "ski acrobatics" should be implemented in ski equipment and the training conditions should resemble the ski sliding conditions. Situational acrobatics training could also be approached with e.g. jumping on a large inflatable cushion ("air bag"). A growing number of ski centers has that kind of equipment. Training with these kind of contents would on the one hand allow a higher quality practice of body control and solving movement tasks with skis in the air, on the other hand, this type of training could represent an important enrichment of daily training for all age categories of competitors in alpine skiing.

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SHORT HISTORICAL NOTES III

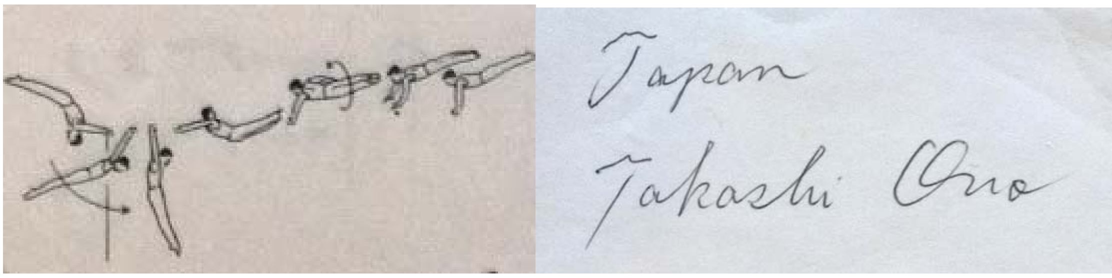
Anton Gajdoš, Bratislava, Slovakia

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. Happy 75th birthday. Chiers.

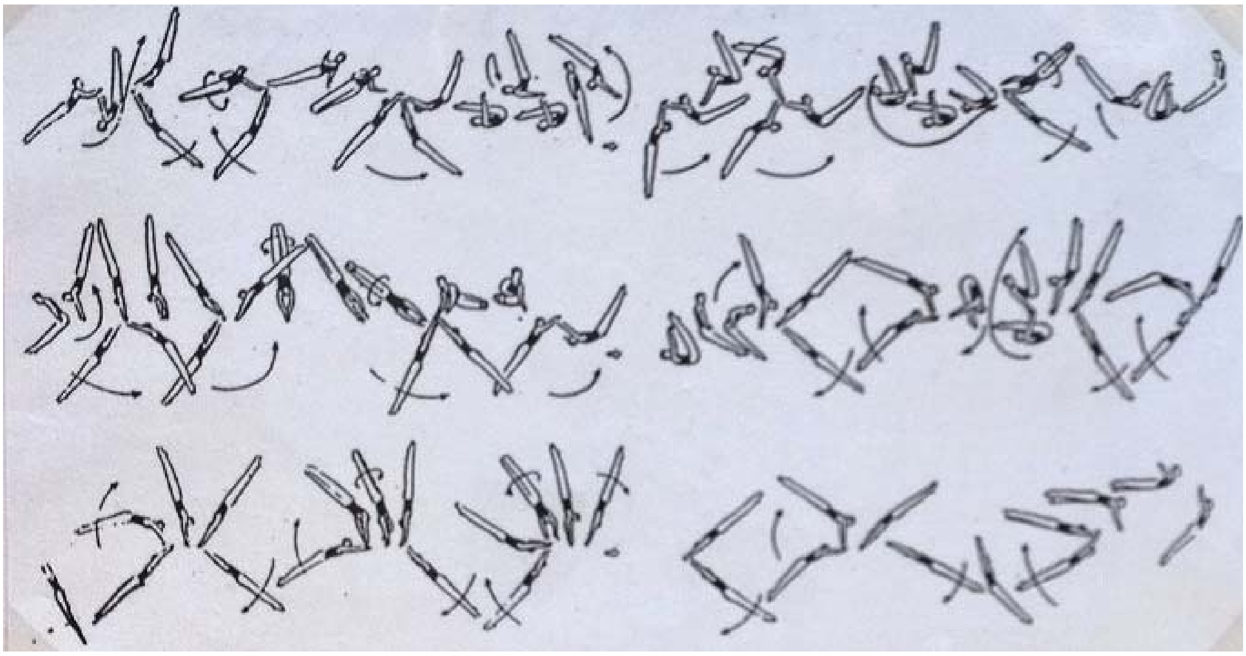
TAKASHI ONO

Born on 26th July 1931 in Noshiro, Akita, Japan. He was very universal gymnast and the first to chalange Soviet gymnasts. With his excellent exercises in all around he led Japan team also to the first victory in team competition at OG in Rome 1960 (in Rome he was also flag bearer for Japan). At 1964 OG in Tokio he was honored to give the Olympic Oath in the name of athletes. He is the most decorated Japanese gymnast with his original element in Code of Points.

Olympic Games	1952	3.VT, 4.FX, 5.team, 12. AA
	1956	1. HB, 2. Team, AA, PH, 5. RI
	1960	1. team, VT, HB, 2. AA, 3. RI, PB
	1964	1. team, 6. HB, 11. AA
World Championship	1954	2. team, 4. VT, 8. PH, 10. AA
	1958	2.team, AA, FX, PB 3. VT
	1962	1.team, HB, 4. AA, 5. VT, PB



Ono element in Code of Points (FIG, 2013)

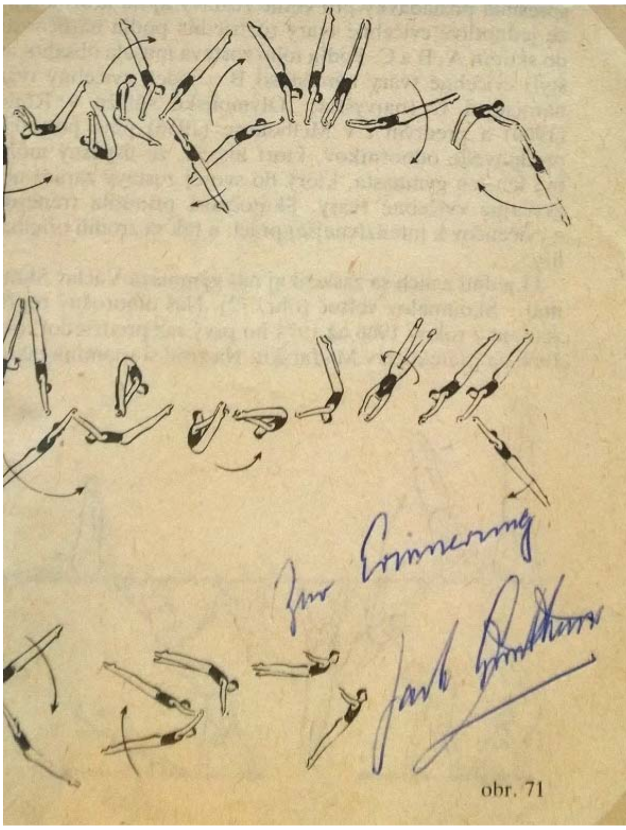


Takashi Ono exercise from 1956 OG (draw from Tadamiki Mori in Akitomo Kaneko (1970). Gymnastics Coaching Book II Horizontal Bar (Taisokyogi-Kyohon Tetsubo), FUMAIDO (Fumaido Shoten) p.268-269) as it is in Anton's book of autographs.

JACK GÜNTHARD

Born on 1st January 1920 (Hirzel, Switzerland). After the WWII he competed at OG 1952 in Helsinki and World Championship. He was excellent gymnast on high bar , and after his gymnasts career, he was coach of Switzerland and also Italian national team. He was also member of FIG MTC, UEG MTC (also president), and he was long time in charge of University Games Gymnastics. After coaching position he worked at Sportschule in Magglingen and tought many generations of Switzerland gymnasts and coaches.

Olympic Games	1952	1.high bar, 2.team, 17.AA
World Championship	1954	3.team, 6.PB, 12.AA.



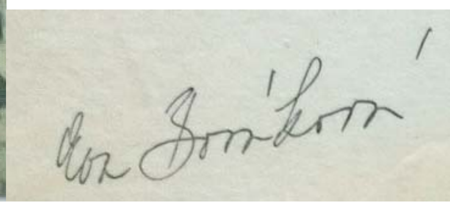
Part of Jack's exercise at OG (draw from Tadamiki Mori in Akitomo Kaneko (1970). Gymnastics Coaching Book II Horizontal Bar (Taisokyogi-Kyohon Tetsubo), FUMAIDO (Fumaido Shoten) p.262-263) as it is in Anton's book of autographs with his signature. Jack's Hecht dismount from high bar.

EVA VĚCHTOVA-BOSÁKOVÁ

Born on 18th December 1931 in Mlada Boleslav (Czechoslovakia, today Czech), died 10th November 1991 in Prague. Her best apparatus was balance beam, where she dominated at OG 1960 and WC 1962. She was the first gymnast who performed at competition carthwheel (1956). She worked also as a coach.

Olympic Games	1952	3.team
	1956	2.-3. BB, 4. UB, 4.-6. FX, 7.AA, 5.team
	1960	1. BB, 2.team, 4. FX, 10.AA

World Championship	1954	2. AA, FX, BB, 3.team, 4.-5. UB
	1958	1. FX, 2.team, AA, UB 5. BB
	1962	1. BB, 2.team, UB, 4. AA, 4.-5. FX
European Championship	1957	3. BB, FX
	1959	3. FX



Slovenski izvlečki / Slovene Abstracts

Roman Farana, Petra Janezckova, Jaroslav Uchytil, Gareth Irwin

VPLIV RAZLIČNIH POSTAVITEV DLANI NA OBREMENITEV KOMOLCA PRI PREMETU VSTRAN Z OBRATOM NAZAJ PRI TELOVADCIH: ŠTUDIJ PRIMERA

Lezije v komolcu so skriti razlog za prenehanje telovadčeve tekmovalne poti in predstavljajo resnično skrb za trenerje, znanstvenike in zdravnike. Predhodne raziskave so bile usmerjene v telovadke, tokrat pa je bil cilj ugotoviti vpliv impulza sile in kinematične značilnosti na tveganje poškodbe v komolcu glede na postavitev dlani pri premetu vstran z obratom nazaj pri telovadcih. Vrhunski telovadec je izvedel 15 premetov vstran z obratom nazaj, od tega pri petih je imel dlani vzporedno, pri petih pravokotno in pri petih obrnjeno pravokotno. Sočasni zajem podatkov iz 3D kinematičnega sistema (240 Hz) in pritiskovne plošče (1200 HZ) je bil narejen za vsak poskus. Ugotovljene so bile razlike med posameznimi položaji dlani na obremenitev v komolcu. Pravokotna postavitev zmanjšuje navpično, anteriorno-posteriorno (naprej-nazaj) in skupno silo reakcije podlage. Razlike v komolčnem sklepu pri primikanju in pritiskanju nakazujejo, da bi bila lahko pravokotna postavitev dlani najuspešnejša pri preprečevanju poškodb in zmanjševanju obremenitev v komolcu.

Ključne besede: biomehanika, telovadba, zgornje okončine, preprečevanje poškodb.

Joshie Motoshima, Akira Maeda

PRIMERJAVA PRESKOKA TIPA KASAMTCU IN CUKAHARA

Danes mnogo telovadcev na tekmovanju izvaja preskok tipa Kasamacu. Namen raziskave je bil ugotoviti podobnosti in razleke med dvema tipoma skokov in sicer Kasamcujem in Cukaharo. Šest telovadcev študentov je izvedlo tako Kasamcu kot tudi Cukahara skok. Njihova izvedba je bila analizirana z 3D MAC3D sklopom. Pri obeh skokih je bila hitrost težišča telesa v vodoravni smeri zmanjšana, navpična hitrost pa povečana in vrtilni moment je bil največji v trenutku naskoka na desko. Obe hitrosti sta se na deski zmanjšali, vendar med skokoma nismo zaznali značilnih razlik. Zgornje okončine so bistveno pomembnejše pri ustvarjanju vrtilnega momenta pri Kasamacuju pri odrivu. Rezultati nakazujejo da je obrat pri Kasamacuju posledica aktivnosti nog, , medtem ko roke le-tega le ohranjajo.

Ključne besede: biomehanika, telovadba, kinematika, zgornje okončine, spodnje okončine.

Vahid Saleh

POVEZANOST MED DOSKOKI NA PARTERJU IN TELESNIMI ZNAČILNOSTMI TER RAVNOTEŽJEM PRI 6-8 LETNIH TELOVADCIH

Ravnotežje je eno od najpomembnejših gibalnih sposobnosti za športne dosežke. (še posebej pri telovadbi). Namen raziskave je bil ugotoviti povezanost med doskoki na parterju in telesnimi značilnostmi ter ravnotežjem pri dvajsetih 6-8 letnih dečkih. Za oceno statičnega ravnotežja je bil uporabljen test »štorklje« in za oceno dinamičnega ravnotežja test »vstani in pojdi«. Za oceno doskoka na parterju je bila posneta izvedba parterne sestave, ter nato v skladu s pravili sojenja ocenjeni doskoki. Izmerjenih je bilo osem telesnih značilnosti. Značilna pozitivna povezanost je bila med doskoki in dinamičnim ravnotežjem, ter negativna s statičnim ravnotežjem (test »štorklje« pomeni višji rezultat boljši rezultat, test »vstani in pojdi« pomeni višji rezultat slabši rezultat). Prav tako sta v značilni negativni povezanosti tudi testa ravnotežja. Telesna višina, masa,, obseg pasu, dolžina stopala in dolžina noge so prav tako pomembni pri tej starosti, ne smemo pa pozabiti tudi tehničnega znanja.

Ključne besede: telovadba, sojenje, uspešnost.

Mercedes Vernetta Santana, Águeda Gutiérrez-Sánchez, Jesús López-Bedoya

VZAJEMNO POUČEVANJE TELOVADBE V VISOKOŠOLSTVU

Cilj raziskave je bil primerjati dva načina poučevanja telovadbe na teoretične in praktične vsebine v visokem šolstvu. Podobno smo tudi preverjali uspešnost glede na število uspešnih in neuspešnih poskusov izvedbe prvin, študentovo zadovoljstvo, prisotnost in mnenje o njihovem učenju. (pri skupini vzajemnega poučevanja). V poskusu je sodelovalo 44 študentov, ki so bili razdeljeni v dve skupini, obe mešani po spolu, katere smo merili pred in po poskusu, ena skupina je bila deležna vzajemnega poučevanja, druga pa poučevanja z reševanje določenih nalog. Rezultati kažejo, da je vzajemno poučevanje imelo večji učinek tako pri teoretičnih vsebinah kot tudi praktičnih, prav tako pa je bilo tudi več pravilnih izvedb prvin. Glede na zaznavo in zadovoljstvo poučevanja je skupina vzajemnega poučevanja bila zelo zadovoljna pri vseh vprašanjih vrednotenja poučevanja.

Ključne besede: visokošolstvo, teleovadne prvine, načini poučevanja, določanje nalog.

Andrea Ferreira João, José Fernandes Filho

SOMATOTP IN TELESNA SESTAVA VRHUNSKIH BRAZILSKIH TELOVADCEV IN TELOVADK

Cilj raziskave je bil ugotoviti somatotip in telesno sestavo vrhunskih brazilskih telovadcev in telovadk članske in mladinske kategorije. Merjenih je bilo 21 telovadcev in 25 telovadk. Za določitev somatotipa je bil uporabljen izračun po Heath in Carterju (1990). Sestava telesa je bila ocenjena z bioimpedanco, merjeno z napravo InBody R20, izmerjene so bile spremenljivke skeletne mišične mase (MM), maščobe mase (MG), masa brez maščobe (MLG) in izračunan odstotek maščobe (% G). Rezultati kažejo, da je prevladujoč somatotip v skupini telovadcev uravnoteženi mesomorf, medtem ko je pri telovadkah prevladujoči somatotip ektomorfni-mesomorfni. Pri telovadcih je mišične mase 33,08 ± 3,53 kg, maščobne mase 7,44 ± 1.57 kg, mase brez maščob 57,74 ± 5,78 kg, odstotek maščobne mase 11,39 ± 2,08, medtem ko je pri telovadkah mišične mase 21,7 ± 3,38 kg, maščobne mase 7,55 ± 2,73 kg, mase brez maščob 38,12 ± 5,77 kg, odstotek maščobe 15,84 ± 3,79. Ti rezultati se skladajo z obstoječimi podatki v literaturi.

Ključne besede: telovadba, telesne značilnosti, moški, ženske

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Amanda Batista Santos, Maria Elisa Lemos, Eunice Lebre, Lurdes Ávila Carvalho

DEJAVNA IN NEDEJAVNA GIBLJIVOST SPODNJIH OKONČIN PRI VRHUNSKIH RITMIČARKAH

Gibljivost je ena najpomembnejših gibalnih sposobnosti za uspeh v ritmiki. Pričakovati je, da imajo vrhunske ritmičarke , članice državne ekipevisoko stopnjo razvitosti te sposobnosti. Namen raziskave je bil ugotoviti dejavno in nedejavno gibljivost spodnjih okončin pri petih mladinkah (starih 13.60 ± 0.25 let) v času ene sezone. Okončina, ki z lahkoto izvaja naloge je bila določena kot vodilna in druga kot nevodilna. Merjenih je bilo 7 posebnih testov gibljivosti za ritmičarke (kjer so bile podane ocene na 5 stopenjski lestvici) v treh časovnih obdobjih. Neparametrična testa Mann-Whitney in Friedman and Wilcoxon test sta bila uporabljena za oceno sprememb. Rezultati kažejo visoko gibljivost vodilne okončine tako pri dejavni in nedejavni gibljivosti in bistvo slabše rezultate za nevodilno okončino. Med sezono se je tudi pri nevodilni okončini gibljivost deloma povečala v določenih časovnih obdobjih.

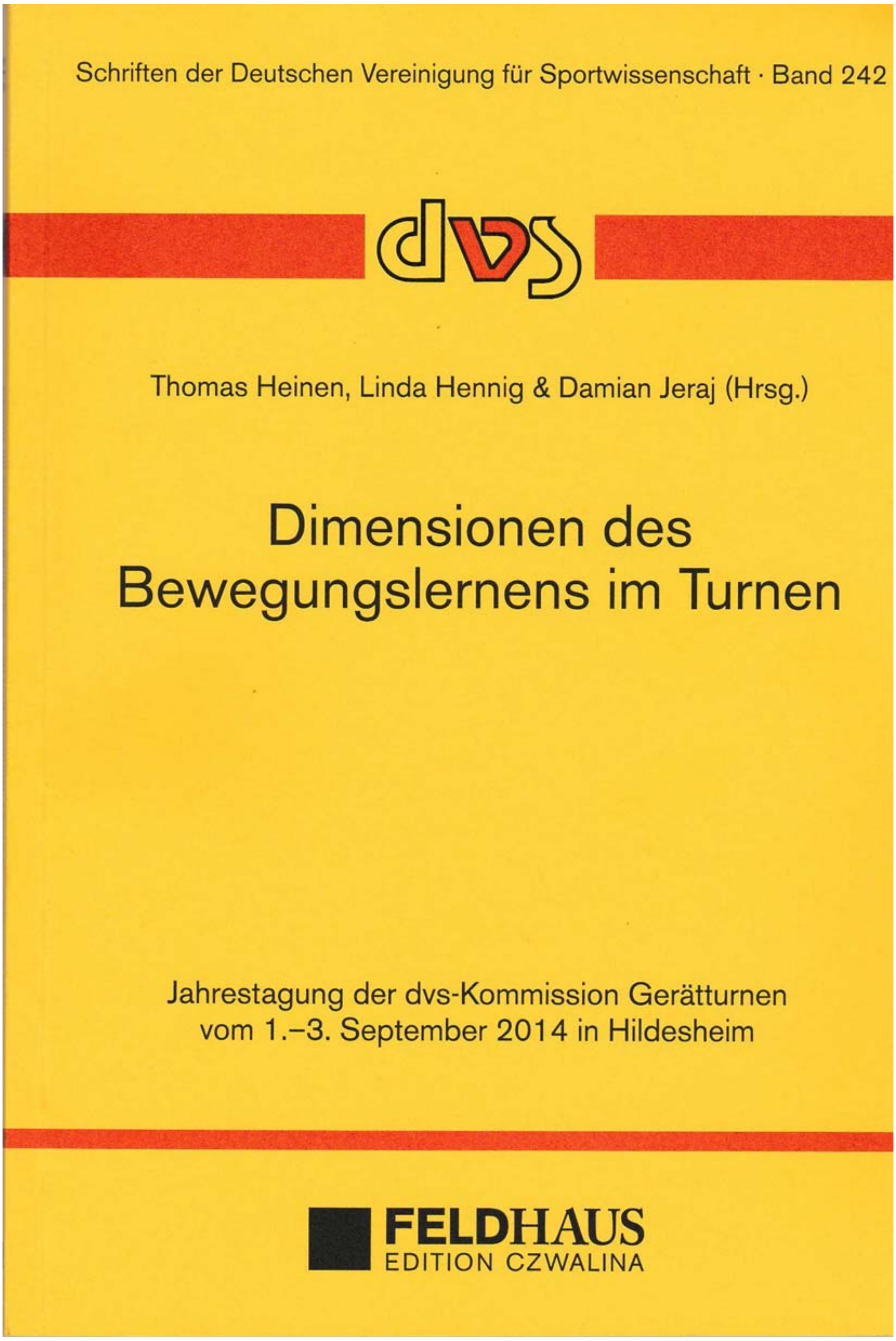
Ključne besede: vodilna spodnja okončina, nevodilna spodnja okončina, gibljivost, ritmika.

Blaž Lešnik, Vanja Glinšek, Milan Žvan

POVEZANOST MED ZNANJEM TELOVADNIH PRVIN IN USPEŠNOSTI V ALPSKEM SMUČANJU PRI MLAJŠI STAROSTNI KATEGORIJI

Na vzorcu 24 smučark in 30 smučarjev (starosti 12 in 13 let) smo želeli ugotoviti povezanost med znanjem telovadnih prvin in uspešnostjo v alpskem smučanju za Pokal Merkatorja. Preverjali smo znanje osmih telovadnih prvin, kot kriterij uspešnosti pa je bil odločujoč rang na pokalu v sezoni 2013/2014. Dve telovadni prvini in v vsota vseh ocen za telovadno znanje so pri dekletih bili značilno povezani, medtem ko pri dečkih ne. Man Whitneyev U test je pokzala, da tako pri dečkih kot deklicah so boljši v alpskem smučanju tisti, ki imajo boljše znanje telovadnih prvin.

Ključne besede: alpsko smučanje, otroci, telovadne prvine, uspešnost, vadba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