Science of Gymnastics Journal

vol. 6, num. 2, year 2014

Published by Department of Gymnastics, Faculty of Sport, University of Ljubljana ISSN 1855-7171

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.

Science of Gymnastics Journal is indexed in
EBSCOhost SPORTDiscus, SCOPUS, COBISS (IZUM), SIRC (Canada), OPEN. J-GATE, GET CITED, ELECTRONIC JOURNALS INDEX, SCIRUS, NEW JOUR, GOOGLE SCHOLAR, PRO QUEST and INDEX COPERNICUS.
ScGYM® (ISSN 1855-7171) is an international online journal published three times a year (February, June, October).

Front page design: Sandi Radovan, Slovenia.

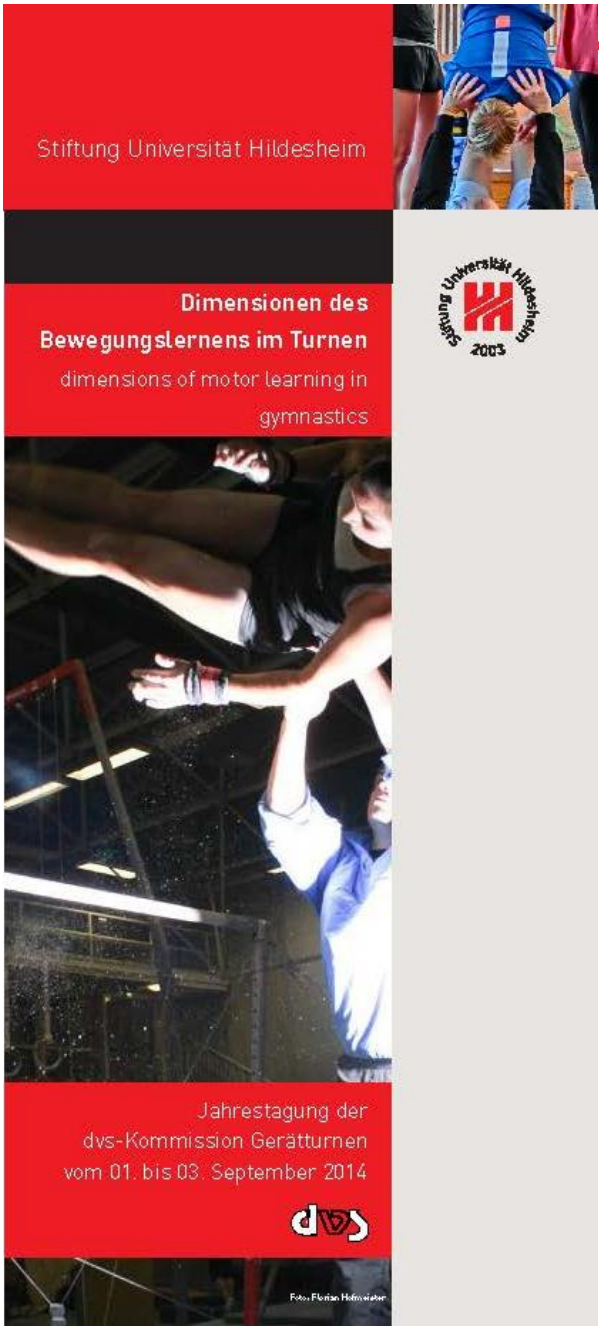
Editorial Office Address
Science of Gymnastics Journal
Faculty of Sport, Department of Gymnastics
Gortanova 22, SI-1000 Ljubljana, Slovenia
Telephone: +386 (0)1 520 7765
Fax: +386 (0)1 520 7750
E-mail: scgym@fsp.uni-lj.si
Home page: http://www.scienceofgymnastics.com

Science of Gymnastics Journal is supported by Foundation for financing sport organisations in Slovenia, Slovenian Research Agency and International Gymnastics Federation.

Fundacija za šport

Slovenian Research Agency

CONTENTS



Information

The concept of »dimension« is one inherent component of motor learning in gymnastics. Exploring the third dimension in space can be seen as a fundamental characteristic of performing simple and complex skills in gymnastics. Specific options for acting in the environment are generated, which enable the performer to gain particular experiences that can hardly be gained outside the area of gymnastics.

This argumentation highlights specific demands in the area of organized sports (clubs, schools) when putting motor learning theory into practice. In addition, this argumentation raises specific questions concerning the exploration of »dimensions« when discussing motor learning in areas, such as Parkour or Freerunning.

One aim of the conference is to analyze and discuss »dimensions of motor learning in gymnastics« from a multifaceted scientific perspective. Different settings of motor learning in gymnastics should be analyzed. Last but not least, it will be discussed how theory and application in motor learning in gymnastics can be related by means of practical examples.

The conference takes place at the University of Hildesheim from September 1st to September 3rd 2014. Further information can be found on the conference homepage: www.uni-hildesheim.de/fb1/institute/institut-fuer-sportwissenschaft/veranstaltungen-und-tagungen/dvs-tagung-geraetturnen-2014/

Tagungsprogramm

Montag, 1. September 2014

bis 13.45 Uhr	Anreise und Registrierung
14.00-14.45 Uhr	Eröffnung und Begrüßung
15.00-18.45 Uhr	Vorträge und Praxisworkshops
ab 19.00 Uhr	Abendveranstaltung

Dienstag, 2. September 2014

9.00-12.30 Uhr	Vorträge und Praxisworkshops
14.00-17.15 Uhr	Vorträge und Praxisworkshops
17.30-18.30 Uhr	Laborbesuch
ab 19.00 Uhr	Abendveranstaltung

Mittwoch, 3. September 2014

9.00-10.30 Uhr	Vorträge und Praxisworkshops
11.00-12.30 Uhr	Mitgliederversammlung
12.30 Uhr	Ende der Tagung

EDITORIAL

Dear friends,

In front of you is the 15th issue of our journal. To date, we published 91 articles, most of them original, and 4 review articles. This makes quite a good database of knowledge for our sport.

First some housekeeping issues: In the beginning of the year we were informed by our friends from the United States that our website www.scienceofgymnastics.com was not working. We solved the problem and our website is now working properly.

There is still time to apply to Stiftung Universität Hildesheim, Institut für Sportwissenschaft to participate at their conference titled Dimensions of Motor Learning in Gymnastics for 1 September 2014. We will try to provide more information about it in our October issue.

For the second issue in 2014, our fellow researchers prepared seven articles from the fields of history, biomechanics, motor development, judging and the relation between acrobatic knowledge and skiing knowledge. The first article is about 110 years of history of the World Championships (WC) in artistic gymnastics. Its author Abie Grossfeld who attended almost all world championships since 1958 (as a gymnast, coach, judge, journalist, expert, video analyst and perhaps even in some other capacity), including the last one in Antwerp, outlines the history from the beginning in 1903 up to 2013. At this point, let me invite you all to find and submit photos from world championships 1903-1913. The Journal would like to publish them as we believe that it is of great importance that we preserve our gymnastics heritage.

The second article deals with the Code of Points and competition systems from 1896 up to 1912 It comes from Greek authors Georgios Papadopoulos, Vasilios Kaimakamis, Dimitrios Kaimakamis and Miltiadis Proios.

The third article was prepared by William A Sands, Brent Alumbaugh, Jeni R McNeal, Steven Ross Murray and Michael H Stone from USA. They compared two types of springs in floor and their findings are very interesting. The fourth article is from the Czech team of Roman Farana, Jaroslav Uchytil, David Zahradník, Daniel Jandacka and Frantisek Vaverka. They compared kinematic data for handspring and Tsukahara vaults with the same difficulty value. Their paper shows that handspring vaults require higher amplitude which in other words means they are actually more difficult to perform.

The fifth article from Greek authors Olyvia Donti, Anastasia Donti, Kalliopi Theodorakou presents an overview of choreography preparation in respect of the Code of Points. The article may be of interest not only to those involved in women rhythmic gymnastics but also to those in other gymnastics disciplines.

The sixth and the seventh article are dealing with gymnastics knowledge. The sixth article's authors from Croatia: Zoran Čuljak, Sunčica Delaš Kalinski, Ana Kezić and Đurđica Miletić explored the influence of fundamental movement skills on basic gymnastics skills acquisition and found important relationships between them; the authors of the last article from Bosnia and Herzegovina Edin Mujanović, Almir Atiković, Amra Nožinović Mujanović researched how knowledge of acrobatic elements affected skiing knowledge. The article clearly shows that acrobatic is the base sport: basic skills in acrobatics improve skills and knowledge in other sports.

Just to remind you, if you quote the Journal: its abbreviation in 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

CHANGES DURING THE 110 YEARS OF THE WORLD ARTISTIC GYMNASTICS CHAMPIONSHIPS

Abie Grossfeld

Southern Connecticut State University, New Haven, CT, USA

Original article

Abstract

This article presents changes, along with historical perspectives, in the World Gymnastics Championships during the last 110 years - 1903 to 2013. Changes include: the events contested, team and individual achievements and dominance, debut of skills, difficulty expansion, judges, scoring, competition format, Finals qualification system, expansion of FIG affiliation, frequency cycle of the WC, number of teams and gymnasts per competition, age requirement of gymnasts, team size, venues, apparatus, devices for learning, education and certification courses, disseminating information, and expanded media coverage.

Keywords*: History, Gymnasts, Rules, Judges.*

INTRODUCTION

2013 marked the 110th anniversary of the World Artistic Gymnastics Championships.

This article cites many changes and differences in the WC that took place through the years. Timelines are presented for various aspects of gymnastics.

Abbreviations and terms for this paper: WC for World Artistic Gymnastics Championships; OG for Olympic Games; FIG for International Gymnastics Federation; CP for Code of Points; events are apparatus; skills are elements; tumbling is acro; titles are championships, AA for all-around; FX for floor exercise; PH for pommel horse; R for rings; PB for parallel bars; HB for horizontal bar; UB for uneven bars; BB for balance beam; T&F for track and field.

CHANGE IN THE CHAMPIONSHIPS NAME

From 1903 to 1913, the official title of the ‘world - international’ competition was organized by the European Federation of Gymnastics (founded in 1881), which was latter renamed to the FIG (1921). The title was changed in 1931 (or 1934 onward) to the World Gymnastics Championships (by same document it is not known when it really starts (FIG, 1981). For this paper, the championships from 1903 onward will be referred to as the WC. However, it was not until 1930 that the FIG Congress determined that those would be the first with an official WC title. **Note:** Up until 1950, the WC format often differed from the OG format because the WC were governed by the FIG, and the OG (including gymnastics) were governed by the International Olympic Committee (IOC).

COUNTRIES AND DATES OF THEIR FIG AFFILIATION

Original FIG members in 1881 were two Belgium federations (fiamic and valoric), France, and Netherlands. Dates of other that became members of the FIG by the first Championship in 1903 were Great Britain in 1896, Czechoslovakia in 1897, Canada in 1899 (the first non-European and Western Hemisphere nation), Italy, Spain Luxemburg and Hungary and Luxemburg in 1902. Dates of FIG membership of some other countries: Romania, Slovenia and Croatia in 1907; Egypt in 1910 (the first African nation); USA in 1921; Switzerland in 1923; South Africa and Iran in 1947; Argentina, Columbia and Cuba in 1948; USSR in 1949; Japan, Germany and Brazil in 1951; India in 1952; Australia in 1954; Syria in 1956; Morocco in 1960; Mongolia and New Zealand in 1962; and China rejoined in 1978 (*China competed at the 1958 and 1962 WC but then withdrew, largely because of the Taiwan recognition).*

Total number of FIG affiliated nations through the years were: four countries in 1881; eight countries by 1903; 12 countries in 1921; 20 countries in 1938; 28 countries in 1950; 37 countries in 1954; 69 countries in 1978; and 127 countries by 2013.

Figure 1. *Main square in Antwerp.*

THE YEAR AND NUMBER OF GYMNASTS/TEAMS WHO TOOK PART IN EACH WC

1903 36/4; **1905** 24/4; **1907** 36/6; **1909** 36/6; **1911** 48/8; **1913** 36-48/6; **1922** 30-40/5; 1926 36-48/6; **1930** 36-48/6; **1934** men 78-104/13; **1938** men 48-64/8; **1950** men 60/6, women 53/7; **1954** men 132/16, women 126/15; **1958** men 128/15, women 88/13; women; **1962** men 132/20, women 116/17; **1966** men 143/20, women 156/22; **1970** men 154/22, women 137/21; **1974** men 126/18, women 148/22; **1978** men 147/22, women 145/22; **1979** men 151/23, women 164/26; **1981** men 171/27, women 135/19; **1983** men 175/26, women 176/28; **1985** men 147/21, women 158/23; **1987** men 176/27, women 201/31; **1989** men 190/29, women 187/28; **1991** men 213/30, women 190/29; **1992** (no team) men 141, women 104; **1993** (no team) 57 countries and at least 50 gymnasts taking part in the AA; **1994** (individual) men 85, women**;** **1994** (team) men 141/21, women 112/16; **1995** men 209/24, women 197/26; **1996** (no team) men approx. 25 in each event, women approx. 50 in each event; **1997** men 236, women 149; **1999** men 293, women 260; **2001** men 268, women 172; **2002** men averaged 57 in each event, women averaged 43 in each event; **2003** men 323/52, women 224/35; **2005** men 177, women 95; **2006** men 279/43, women 223/33; **2007** men 253/24, women 214/24; **2009** men 243, women 146; **2010** men 343/45, women 272/34 (representing 46 countries; **2011** men 262/24, women 216/24 (478 competitors representing 81 countries); **2013** men 264 (71 countries), women 134 (57 countries) - the men had over 135 and the women over 100 competitors in every single event.

For the first nine WC, 1903 to 1930, there were no more than 48 gymnasts. The first WC where there were well over 100 competitors was in 1954. The men topped 200 competitors in 1997 and the women in 1999.

Summary of the number of teams (countries) that took part in the WC

The first two WC, 1903 and 1905, had four teams; 1922 had five teams; 1911 and 1938 had eight teams; 1934 had 13 teams; except for those WC just mentioned the other six WC between 1907 and 1950 had six teams.

For the 1954 and 1958 WC there were 15 and 16 teams respectively. The number of teams escalated after 1958, reaching a total of 52 men's teams and 35 women's teams in 2003.

Only European nations took part in all WC up until 1950 when Egypt participated with a full team of eight gymnasts (which were the first gymnasts from the African continent). The USSR and Japan made its WC debut in 1954 (with their men's teams placing first and second respectively). Iran made its WC debut with one male gymnast in 1954. And, the USA also first took part in the 1954 WC with two male gymnasts (which were the first gymnasts from the Americas). USA first entered with a full men's team in 1958, which was the year that China, with a full men's team, made its debut.

The first WC where women took part was in 1934 where medals were awarded for only team. In 1938 the women's program consisted of team, AA, V, BB, FX and PB. In 1934 and 1938, three teams took part in each of these WC. In 1950, seven women's teams took part, all from Europe, and the uneven bars replaced the parallel bars as one of their events. In 1954, the USSR women's team made their debut (and placed first). One female Canadian gymnast, its first, took part in 1958. The USA women made their WC debut with a team in 1962.

THE HOSTS, FREQUENCY CYCLE AND YEARS OF THE WC

In the 110 years of the WC, 1903 to 2013, 20 countries and 33 different cities have been hosts. France and Germany were hosts four times. Belgium, Czech, Hungary and USA were hosts three times. Nine other countries were hosts twice. The first WC outside of Europe and in the Western Hemisphere was in 1979, in Fort Worth, Texas. The first WC in Australia (Brisbane) was in 1994, and in Asia (Sabae, Japan) in 1995.

Host countries and cities of the WC

1. France – Bordeaux, Lyon, Strasbourg, Paris - 4
2. Germany – Dortmund, Stuttgart, Dortmund, Stuttgart - 4
3. Belgium – Antwerp, Ghent, Antwerp - 3
4. Czech – Prague, Prague, Prague - 3
5. Hungary – Budapest, Budapest, Debrecen - 3
6. USA – Fort Worth, Indianapolis, Anaheim - 3
7. Italy – Turin, Rome - 2
8. Luxembourg – Luxembourg, Luxembourg - 2
9. Yugoslavia (Slovenia) – Ljubljana, Ljubljana - 2
10. Switzerland – Basel, Lausanne - 2
11. USSR (Russia) – Moscow, Moscow - 2
12. Netherlands – Rotterdam, Rotterdam - 2
13. Great Britain – Birmingham, London - 2
14. Australia – Brisbane, Melbourne - 2
15. Japan – Sabae, Tokyo - 2
16. China – Tianjin, *(in Nanning 2014) - 1 *(2)
17. Bulgaria – Varna
18. Canada – Montreal
19. Denmark – Aarhus,
20. Puerto Rico – San Juan

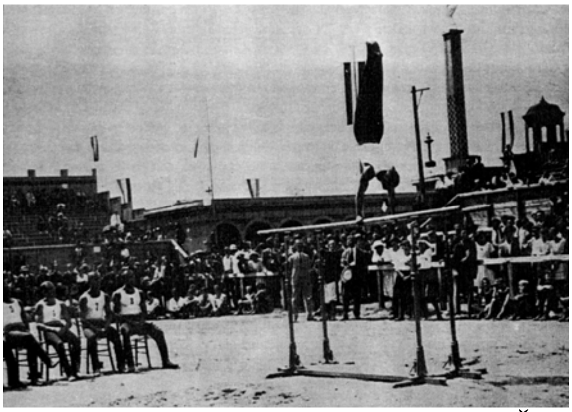


Figure 2. *WC 1922 Ljubljana, Peter Šumi (AA champion 1922 and 1926) on parallel bars.*

The WC were held every two years from 1903 to 1913. (The WC were not held from 1916 to 1919, due to World War I). The WC resumed in 1922 and until 1938 were held every four years. (Once more, the WC were not held in 1942 or 1946 due to World War II.) From 1950 to 1978, the WC continued to be held every four years. From 1979 until 1991, the WC cycle changed from four years to two years. From 1992 to 1997, the WC were held every year. However, two WC were held in 1994 - the first contested only all-around and individual events (no team)**;** the second, held five months later, was a team only competition (no AA or individual events). Also, an individual events WC (no team or AA) was held a few months before the 1996 OG. The next two WC were in 1999 and 2001. Then, starting in 2001 the WC were held every year except for the Olympic year. The format for the WC the year before the OG is a full program (team, AA, individual events) since it is used as a qualifying competition for the succeeding year's OG.

THE GYMNASTICS EVENTS (APPARATUS) CONTESTED IN THE WC

The current men's events of PH, R (debuted in 1909), PB and HB were part of the WC competition program from 1903 to the 1930. In 1930 FIG Technical Committee was organized. For the first time in 1930, exercises as a group (which were of minor difficulty) were not a contested event. FX made its WC debut in 1930 and vaulting in 1934.

In addition to the gymnastics apparatus, track and field (T&F) and swimming events, weight lifting and/or rope climbing were contested as part of the combined all-around (and were given points which were added to the apparatus scores) through the 1950 WC. The T&F events usually were: a run from 60 to 150 meters, the long or high jump, the shot put or discus and the pole vault.

THE MAXIMUM NUMBER OF GYMNASTS PER TEAM

For the WC through the years was as follows:
1903 - Nine per team.
1905 to 1922 - Six per team.
1926 to 1954 - Eight per team (with the six best scores counting toward the team score).
1958 to 1991, 1994, 1997 and 1999 - Six per team.
1995 - Seven per team (7-5-4 format, explained later under 'Summary of WC format and participation.').
1997 - Six per team (6-5-4 format, explained later under 'Summary of WC format and participation.').
2006 - Six per team (2007, 2010).
2011 - 6-5-3 format.

CHANGES IN WC COMPETITION DOMINANCE

Men's TEAM dominance in WC:

France won team medals in each of the first six WC from 1903 through 1913, with Belgium winning medals in five, and Italy and the Czech-Bohemia in three, Luxembourg won medals in two, and Netherlands and Slovenia in one WC.

In the first two WC in 1903 to 1905, the overall most successful team was from France (whose gymnasts took the top five places in AA in the 1905 WC). From the 1907 to 1930 and 1938 WC, Czech-Bohemia was the most dominant, aside from France's dominance in 1909 and 1913 WC. At the 1922 WC, all the medals were won by just three countries – Yugoslavia (13), Czechoslovakia (9) and France (1). Yugoslavia was second to Czechoslovakia in 1922 and 1926 WC. Switzerland, second to Czechoslovakia in 1938, was the most dominant team in the 1934 and 1950 WC.

In the 1954 WC, the USSR completely dominated the competition with their men winning the team by 16.65 points over second place Japan. The USSR placed an unprecedented first through seventh in the AA, and won five of the six individual apparatus, with a clean sweep of the top six places in rings. Also, except for Japan's Masao Takemoto tying for first in FX and Japan's team silver medal (which was a prelude to their men's future world dominance), European gymnasts won all the other men's medals. The USSR maintained its dominance in 1958 with Japan, again, placing second. Then for the next five WC - 1962, 1966, 1970, 1974 and 1978 – dominance switched, with Japan's team winning and the Soviet team placing second. The Soviets regained the top spot in the next two WC - 1979 and 1981 – with Japan being second. In 1983, China was the top team with the USSR second. The USSR was most dominant in the 1985, 1987, 1989 and 1991 WC. China was second in 1985, 1987 and 1991. East Germany was second in 1989. China regained dominance in the 1994 team WC, with Russia being second. China remained the most dominant for the next three WC - 1995, 1997 and 1999. Japan was second in 1995, with Belarus second in 1997 and Russia being second in 1999. At the 2001 WC, Belarus was the most dominant, with USA second. In 2001 and 2003, China was the most dominant for the next five WC - 2003, 2006, 2007, 2010 and 2011. The second most dominant teams were as follows: Russia in 2006, Japan in 2007, 2010 and 2011**.**

Summary of the top men's TEAM titles by nations in WC

France 1903, 1905, 1909; Czech-Bohemia 1907, 1911, 1913, 1922, 1926, 1930, 1938; Swiss 1934 and 1950; USSR 1954, 1958, 1979, 1981, 1985, 1987, 1989, 1991(was not under name of USSR but United team); Russia 1994; China 1983, 1995, 1997, 1999, 2003, 2006, 2007, 2010, 2011. Germany (neither as DDR or FDR or GER) never won the team WC, but had one second and ten third place teams. In 1954 the USSR and Japan and later China teams took over dominance from the traditional gymnastics powers – Switzerland, Germany, Czechs and some others.

The most men's team titles/and 2nd place by nations in WC

China 9/3; USSR 8/6; Japan 5/8; Czechoslovakia 7/1.

A rank order of men's TEAM dominance in WC

China, USSR, Japan, Czechoslovakia, Germany.

Men's ALL-AROUND dominance by individuals in WC (with OG in brackets)

Marco Torres of France 1st in 1909 and 1913 (2nd 1920 OG).

Peter Sumi of Slovenia 1st in 1922 and 1926.

Viktor Chukarin 1st in 1954, (1st in both the 1952 and 1956 OG).

Eizo Kenmotsu 1st in 1970, 2nd 1978, 3rd 1974, (2nd in 1972, 4th in 1968 OG).

Nicolai Andrianov of USSR 1st in 1978 (1st 1976, 2nd 1980 OG).

Yuri Korolev 1st in 1981 and 1985.

Dimitri Bilozerchev 1st in 1983 and 1987, (3rd in 1988 OG).

Vitaly Scherbo 1st in 1993, 2nd in 1991 and 1995, 3rd 1994, (1st in 1992 and 3rd in 1996 OG).

Ivan Ivankov 1st in 1994 and 1997, 2nd 2001.

Yang Wei 1st in 2006 and 2007, 3rd in 2003 (1st in 2008, 2nd in 2000 OG); Kohei Uchimura 2009, 2010, 2011 and 2013 (1st in 2012, 2nd in 2008 OG).

A rank order of men's AA dominance by individuals in WC

Uchimura, Scherbo, Ivankov, Yang Wei, Kenmotsu, Bilozerchev. Korolev, Torres and Sumi.

AA dominance by a nation's men gymnasts in a single WC

In 1938, the Czechoslovakia placed 1st, 2nd and 3rd in AA.

In 1954, the USSR placed 1st, 2nd, 3rd, 4th, 5th, 6th and 7th in AA.

In 1958, the USSR placed 2nd, 4th, 6th and 7th in AA.

In 1970, the Japanese placed 1st, 3rd, 4th, 5th and 7th in AA.

In 1974, the Japanese placed 1st, 2nd, 4th, 5th, and 7th in AA.

In 1978, the USSR placed 1st, 2nd, and 3rd, in AA.

Rank order of the most dominant nations in men's AA in a WC

USSR in 1954; Japan in 1974; Japan in 1970; USSR in 1978 tied with Czechoslovakia in 1938; USSR in 1958.

Men's APPARATUS dominance in WC

FLOOR EXERCISE (men):

Georges Miez of Switzerland 1st in 1934, (1st in 1936, 2nd in 1932 OG).

Eugen Mack of Switzerland 2nd in 1934 and 1938.

Valentin Muratov of USSR 1st in 1954 (1956 in OG).

Masao Takemoto of Japan in 1st 1954 and 1958.

William Thoresson of Sweden 3rd in 1954 (1st in 1952 OG, 2nd in 1956 OG).

Nobuyuki Aihara of Japan 1st in 1962 (1st in 1960, 2nd in 1956 OG).

Franco Menichelli of Italy 3rd in 1962 and 1966, (1st in 1964, 3rd in 1960 OG).

Yukio Endo of Japan 1st in 1962, 2nd in 1966 (2nd in 1964 OG).

Akinori Nakayama of Japan 1st in 1966, and 1970, (2nd in 1968 and 1972 OG).

Shigeru Kasamatsu of Japan 1st in 1974, 2nd in 1978, (3rd in 1972 OG).

Kurt Thomas of USA 1st in 1978 (1st in Western Hemisphere and American world champion) and

1979.

Roland Bruckner of E. Germany 1st in 1979 (1st in 1980 OG).

Li Yuejiu of China 1st in 1981.

Tong Fei of China 1st in 1983 and 1985.

Yuri Korolev of USSR 1st in 1981, 2nd in 1985.

Igor Korobchinsky of USSR-Unified Team in 1st 1989, 1991 and 1992.

Vitaly Scherbo of BLR 1st in 1994, 1995, 1996, 2nd in 1991, 1992 and 1993 (1992 OG).

Grigory Misutin of UKR 1st in 1993, 3rd in 1995, 1996, (2nd in 1992 OG).

Ioannis Melissanidis of Greece 2nd in 1994, (1st in 1996 OG).

Alexei Nemov of Russia 1st in 1997, 1999, (2nd in 2000, 3rd in 1996 OG).

Gervasio Deferr of Spain 2nd in 1999, 2007, (2nd in 2008 OG).

Marian Dragulescu of Romania 1st in 2001, 2002, 2006, 2009, (2nd in 2004 OG).

Paul Hamm of USA 1st in 2003, 3rd in 2002.

Jordan Yovtchev of Bulgaria 1st in 2001 and 2003, 2nd in 2002, 3rd in 2000 and 2004 OG).

Diego Hypolito of Brazil 1st in 2005, 2007, 2nd in 2006, 3rd in 2011.

Kyle Shewfelt of Canada 3rd in 2003, 2006, (1st in 2004 OG).

Zou Kai of China 2nd in 2009, 2011, (1st in 2008 and 2012 OG).

Alexander Shatilov of Israel 3rd in 2009, 4th in 2011.

Eleftherios Kosmidis of Greece 1st in 2010.

Kohei Uchimura of Japan 1st in 2011, 2nd in 2010, 3rd in 2013, (2nd in 2012 OG).

A rank order of men's FX dominance by individuals in WC

Scherbo, Dragulescu, Zou Kai, Korobchinsky, Hypolito, Yovtchev, Nakayama, Menichelli.

Figure 3.*Takashi Ono (2nd in AA at the 1958 WC), Vera Caslavska (AA Champion at the 1966 WC), Abie Grossfeld (USA) and Yuri Titov (AA champion at the 1962 WC) taken in 2011.*

POMMEL HORSE:

Osvaldo Palazzi of Italy 1st in 1911 (scored the seemingly maximum 24.00 points).

Grant Shaginyan of USSR 1st in 1954, (2nd in 1952 OG).

Boris Shakhlin of USSR 1st in 1958, 2nd in 1962, 4th in 1954 (1st in 1956 and 1960 OG).

Miroslav Cerar of Yugoslavia (Slovenia) 1st in 1962, 1966 and 1970, 3rd in 1958, (1st in 1964 and 1968 OG).

Zoltan Magyar of Hungary 1st in 1974, 1978 and 1979, (1st in 1976 and 1980 OG).

Dimitri Bilozerchev of USSR 1st in 1983 and 1987, (1st in 1988 OG).

Gyorgy Guczoghy of Hungary 2nd in 1983, 3rd in 1981, and 5th in 1985.

Valentin Mogilny of USSR 1st in 1989.

Valeri Belenky of USSR 1st in 1991 and 1997, (9th in 1992 OG).

Li Jing of China 1st 1992, 3rd in 1991.

Erik Poujade of France 2nd in 1994 and 1997, (2nd in 2000 OG).

Li Donhua of Switzerland 1st in 1995, 2nd in 1996, 3rd in 1994 (1st in 1996 OG).

Alexei Nemov of USSR 1st in 1999, 3rd in 1996, (3rd in 1996 and 2000 OG).

Pae Gil Su of no. Korea 1st in 1992, 1993, and 1996, 3rd in 1997, (1st in 1992 OG).

Marius Urzica of Romania 1st in 1994, 2001, 2002, 2nd in 1999, 5th in 2003, (1st in 2000, 3rd in 1996 and 2004 OG).

Xiao Qin of China in 2005, 2006 and 2007, 2nd in 2001 and 2002, 7th in 2003, (1st in 2008 OG).

Takehiro Kashima of Japan 1st in 2003, 3rd in 2002 and 2005, (3rd in 2004 OG)

Nikolai Kryukov of USSR 3rd in 1999 and 2003.

Kristian Berki of Hungary 1st in 2010 and 2011, 2nd in 2007 and 2009, 4th in 2005 (1st in 2012 OG).

Prashanth Sellathurai of Australia 2nd in 2006, 3rd in 2009.

Louis Smith of GB 2nd in 2010, 3rd in 2007, 2010 and 2011.

Zhang Hongtao of China 1st in 2009, 4th in 2013.

A rank order of PH dominance by individuals in WC

Cerar, Magyar, Xiao Qin, Urzica, Pae Gil Su, Berki.

RINGS:

Joseph Martinez of France 1st in 1903 (scored the seemingly maximum 20.00 points).

Ferdinand Steiner of Czechoslovakia 1st in 1911 (scored the seemingly maximum 24.00 points).

Leon Stukelj of Yugoslavia (Slovenia) 1st in 1922 and 1926 (1st in 1928, 3rd in 1936 OG).

Emanuel Loffler of Czechoslovakia 1st in 1930 (scored the seemingly maximum 32.00 points).

Alois Hudec of Czechoslovakia 1st in 1934 and 1938 (1st in 1936 OG).

Albert Azaryan of USSR 1st in 1954 and 1958 (1st in 1956 and 1960 OG).

Yuri Titov of USSR 1st in 1962, 3rd in 1958.

Mikhail Voronin of USSR 1st in 1966, third in 1970, (2nd in 1968 and 1972 OG).

Akinori Nakayama of Japan 1st in 1970, 2nd in 1966, (1st in 1968 and 1972 OG).

Nikolai Andrianov of USSR 1st in 1974 and 1978, (1st in 1976 OG).

Alexander Ditiatin of USSR 1st in 1979 and 1981 (1st in 1980, 2nd in 1976 OG).

Dan Grecu of Romania 1st in 1974, 2nd in 1979, 3rd in 1978, (3rd in 1976 OG).

Dimitri Bilozerchev of USSR 1st in 1983, 2nd in 1987, (1st in 1988 OG).

Li Ning of China 1st in 1985, 2nd in 1987, 3rd in 1983 (1st1984 OG).

Yuri Korolev of USSR 1st in 1985 and 1987.

Andreas Aguilar of Germany 1st in 1989, 5th in 1985 and 1987.

Andreas Wecker of Germany 2nd in 1989, 1991 and 1993.

Grigori Misutin of USSR 1st in 1991, 3rd in 1992.

Yuri Chechi of Italy 1st in 1992, 1993, 1994, 1995, 1996, 1997, 3rd in 1989 and 1991, 5th in 1987,

(1st in 1996 OG).

Silvester Czollany of Hungary 1st in 2002, 2nd in 1992, 1997, 1996, 1999, 2001, (1st in 2000, 3rd in 1996 OG).

Paul O'Neill of USA 2nd in 1994, 4th in 1992.

Dan Burinck of Romania 2nd in 1995, 3rd in 1994.

Jordan Yovtchev of Bulgaria 1st in 2001 and 2003, 2nd in 1996, 2002, 2006, 2009, 3rd in 1995, 2007, (2nd in 2004, 3rd in 2000 OG).

Dong Zhen of China 1st in 1999.

Demosthenes Tampakos of Greece 1st in 2003, 3rd in 1999 (1st in 2004, 2nd in 2000 OG).

Matteo Morandi of Italy 3rd in 2002, 2003, 2005, 2010, 4th in 2011, 6th in 2009 (3rd in 2012 OG).

Yuri van Gelder of Netherlands 1st in 2005, 2nd in 2007, 3rd in 2006.

Chen Yibing of China in 2006, 2007, 2010 and 2011, (1st in 2008 OG).

Yan Mingyong of China in 2009, 2nd in 2010.

Arthur Zanetti of Brazil in 2011 and 2013, 2nd in 2011, 4th in 2009, (1st in 2012 OG).

A rank order of RINGS dominance by individuals in WC

Chechi, Azaryan, Yovtchev, Zanetti, Stukelj, Ditiatin, Nakayama, Andrianov.

VAULT (men):

Eugen Mack of Switzerland 1st in 1934 and 1938 (scored the seemingly maximum 20.00 points) (1st in 1928, 2nd in 1936 OG).

Helmut Bantz of Germany 2nd in 1954. (1st in 1956 OG).

Takashi Ono of Japan 3rd in 1958, 4th in 1954, 5th in 1962, (1st in 1960, 2nd in 1952 OG).

Premysl Krbec of Czechoslovakia 1st in 1962.

Haruhiro Yamashita-Matsuda of Japan 1st in 1966 (1st in 1964 OG).

Mitsuo Tsukahara of Japan 1st in 1970 (2nd in OG).

Shigeru Kasamatsu of Japan 1st in 1974.

Nikolai Andrianov of USSR 2nd in 1974, 1976 and 1979. (1st in 1976 and 1980, (3rd in 1972 OG)

Junichi Shimizu of Japan 1st in 1978.

Arthur Akopian of USSR 1st in 1983, 2nd in 1981.

Lou Yun of China 2nd in 1985, 4th in 1983, (1st in 1984 and 1988 OG).

Sylvio Kroll of E. Germany 1st in 1987, 2nd in 1989, 4th in 1983, 1991, 7th in 1987, (2nd in 1988 OG).

You Ok Youl of Korea 1st in 1991 and 1992, 3rd in 1993, (3rd in 1992 OG).

Vitaly Scherbo of USSR 1st in 1993, 1994, 2nd in 1991, 3rd in 1995 (1st in 1992, 3rd in OG).

Yeo Hong-Chul of Korea 2nd in 1995, 3rd in 1994, (2nd in 1996 OG).

Alexei Nemov of Russia 1st in 1995, 1996, (1st in 1996 OG).

Grigory Misutin of Ukraine 1st in 1995, (2nd in 1992 OG).

Marion Dragulescu of Romania 1st in 2001, 2005, 2006, 2009, 2nd in 2003 (3rd in 2004 OG).

Li Xiaopeng of China 1st in 2002, 2003.

Lescek Blanik of Poland 1st in 2007, 2nd in 2002, 2005, (1st in 2008 OG).

Dimitri Kaspiarovich of BLR 2nd in 2006, 3rd in 2010.

Anton Golotsutskov of Russia 2nd in 2010 and 2011, 3rd in 2009, 4th in 2005, (3rd in 2008 OG).

Thomas Bouhail of France 1st in 2010, (2nd in 2008 OG).

Yang Hak-Seon of Korea 1st in 2011, 2013, 4th in 2010, (1st 2012 OG).

A rank order of men's VAULT dominance by individuals in WC

Dragulescu, Scherbo, Mack, Yang Hak-Seon, Nemov, You Ok Youl.

PARALLEL BARS:

Joseph Martinez of France 1st in 1903, 1905 and 1909 (scored the seemingly maximum of 24.00 points in 1909).

Francois Hentges of Luxemburg 1st in 1903.

Georgio Zampori of Italy 1st in 1911 and 1913 (scored the seemingly maximum of 24.00 points in 1911, and 20.00 points in 1913).

Guido Boni of Italy 1st in 1911 (scored the seemingly maximum of 20.00 points), (3rd in 1924 OG).

Leon Stukelj of Yugoslavia (Slovenia) 1st in 1922 (scored the maximum of 20.00 points), 3rd in 1928.

Ladislav Vacha of Czechoslovakia 1st in 1928, 3rd in 1930, (1st in 1928 OG).

Josip Primozic of Yugoslavia 1st in 1930, third in in 1938, (2nd in 1928 OG).

Eugen Mack of Switzerland 1st in 1934, fourth in 1938.

Michael Reusch of Switzerland in 1938, (1st 1948, 2nd in 1936 OG).

Hans Eugster of Switzerland in 1950 (scored the maximum of 10 points in the compulsory PB exercise), third in 1954, (1st 1952 OG).

Viktor Chukarin of USSR in 1954 (1st in 1956, 2nd in 1952 OG).

Boris Shakhlin of USSR in 1958, 2nd in 1962, (1st in 1960 OG).

Miroslav Cerar of Yugoslavia (Slovenia) 1st in 1962, 3rd in 1966.

Sergei Diomidov of USSR 1st in 1966.

Akinori Nakayama 1st in 1970, (1st in 1968 OG).

Eizo Kenmotsu of Japan 1st 1974, 1978, 2nd in 1970, (3rd in 1972 OG).

Bart Conner of USA 1st in 1979, 5th in 1978, 6th in 1983, (1st in 1984 OG).

Vladimir Artemov of Russia 1st in 1987 and 1989, (1st in 1988 OG).

Li Jing of China 1st in 1991 and 1992, (2nd in 1992 OG).

Vitaly Scherbo of BLR 1st in 1993, 1995, 2nd in 1996, (1st in 1992, 3rd in 1996 OG).

Huang Liping of China 1st in 1994, 2nd in 1995.

Rustam Shripov of Ukraine 1st in 1996, 2nd in 1994 (1st in 1996 OG).

Alexei Nemov of Russia 2nd in 1996, 2003, 3rd in 1994, (3rd in 2000 OG).

Zhang Jinjing of China 1st in 1997.

Li Xiaopeng of China 1st in 2002, 2003, 2nd in 1997, 2005, (1st in 2008, 3rd in 2004 OG).

Sean Townsend of USA 1st in 2001.

Mitja Petkovsek of Slovenia 1st in 2005, 2007, 2nd in 2002.

Vasilerios Tsolakidis of Greece 2nd in 2011, 4th in 2009, 6th in 2005, (3rd in 2012 OG).

Yang Wei of China 1st in 2006.

Feng Zhe of China 1st in 2010, 2nd in 2009.

Danell Leyva of USA 1st in 2011.

A rank order of PB dominance by individuals in WC

Li Xianpeng, Scherbo, Kenmotsu, Artemov, Petkovsek, Li Jing, Tsolakidis.

HORIZONTAL BAR:

Joseph Martinez of France 1st in 1903 and 1909, 2nd in 1905 (scored seemingly maximum of 24.00 points).

Josef Cada of Czechoslovakia 1st in 1909 and 1922 (scored seemingly the maximum of 24.00 points in 1911 and 20.00 points in 1913), 2nd in 1909.

Marcos Torres of France 1st in 1913 (scored the seemingly maximum of 20.00 points).

Leon Stukelj of Yugoslavia (Slovenia) 1st in 1922 and 1926, 3rd in 1930, (1st in 1924 OG).

Josip Primozic of Yugoslavia 2nd in 1926, 5th in 1938.

Josef Stalder of Switzerland 3rd in 1950 and 4th in 1954 (1st in 1948, 2nd in 1952 OG).

Valentin Muratov of USSR 1st in 1954 (13th in 1956 OG).

Boris Shakhlin of USSR 1st in 1958, 2nd in 1954 (1st in 1964, 3rd in 1960 OG).

Takashi Ono of Japan 1st in 1962, 6th in 1958. (1st in 1956 and 1960, 6th in 1964 OG).

Yukio Endo of Japan 2nd in 1962 and 1966, (5th in 1964 OG).

Akinori Nakayama of Japan 1st in 1966, 2nd in 1970. (1st in 1968, 5th in 1972 OG).

Eizo Kenmotsu of Japan 1st in 1970, 3rd in 1974, 8th in 1978. (3rd 1968, 4th in 1972, 2nd in 1976 OG).

Eberhard Gienger of Germany 1st in 1974, 2nd in 1978 and 1981, (3rd I 1976 OG).

Alexander Tkachev of USSR 1st in 1981, 2nd in 1979, 5th in 1978.

Alexander Pogorelov of USSR 2nd in 1983.

Dimitri Bilozerchev of USSR 1st in 1983 and 1987.

Sylvio Kroll Of E. Germany 2nd in 1985, 6th in 1991.

Casimiro Suarez of Cuba 5th in 1987, (6th in 1980 OG).

Li Chunyang of China 1st in 1989 and 1991, (8th in 1992 OG).

Zoltan Supola of Hungary 2nd in 1994, 3rd in 1993, 5th in 1991.

Grigory Misutin of Ukraine 1st in 1992, 7th in 1991 (2nd in 1992 OG).

Sergei Kharkov of Russia 1st in 1993.

Vitali Scherbo of Belarus 1st in 1993, 3rd in 1996, (3rd in 1996 OG).

Ivan Ivankov of Belarus 3rd in 1994, 2nd in 2002, 7th in 2003.

Andreas Wecker of Germany 1st in 1995 (1st in 1996, 3rd in 1992, 8th in 1988 OG).

Kasimir Dounev of Bulgaria 2nd in 1996, 3rd in 1995, (2nd in 1996 OG).

Jesus Carballo of Spain 1st in 1995, 1996 and 1999, 2nd in 1997.

Jani Tanskanen of Finland 1st in 1997.

Alexander Beresch of Ukraine 3rd in 1997, 2nd in 2001.

Vlasios Maras of Greece 1st in 2001 and 2002, 3rd in 2006, 5th in 2005.

Philippe Rizzo of Australia 1st in 2006, 2nd in 2001, 4th in 2003.

Aljaz Pegan of Slovenia 1st in 2005, 2nd in 2002, 2006 and 2007.

Takehiro Kashima of Japan 1st in 2003.

Igor Cassina of Italy 2nd in 2003, 3rd in 2009 (1st 2004 OG).

Alexei Nemov of USSR 3rd in 2003, (1st in 2000, 3rd in 1996 OG).

Fabian Hambuchen of Germany 1st in 2007, 2nd in 2013, 3rd in 2010, 4th in 2005, (3rd in 2008 OG).

Zou Kai of China 1st in 2009, 2011 (1st in 2008 OG).

Epke Zonderland of Netherlands 1st in 2013, 2nd in 2009, 2010 (1st in 2012 OG).

Zhang Chenglong of China 1st in 2010, 2nd in 2011.

Kohei Uchimura of Japan 3rd in 2010 and 2013.

A rank order of HB dominance by individuals in WC

Carballo, Hambuchen, Zou Kai, Zonderland, Pegan, Maras.

Women's TEAM dominance in WC

In the first two women's WC, 1934 and 1938 Czechoslovakia was the most successful. Sweden was the dominant at the 1950 WC. The USSR was the most dominant in 1954, 1958 and 1962, with Hungary being second in 1954 (6.03 points behind the USSR). The USSR women's team, in 1954, placed first and won three of the events. (All the women's medals were won by Europeans except for the BB, which was won by Japan's Keiko Tanaka-Ikeda). In 1958 and 1962, Czechoslovakia finished second. In 1966, Czechoslovakia was the most dominant team, with the USSR being second. Then the USSR was the most dominant for the next three WC in 1970, 1974 and 1978, with East Germany being second in 1970 and 1974, and Romania being second in 1978. Romania was the most dominant in 1979, with the USSR second. The USSR was the most dominant for the next three WC, 1981, 1983 and 1985, with China being second in 1981, and Romania second in 1983 and 1985. Romanians regained dominance in 1987, with the USSR second in 1987. The USSR was the most dominant in 1989 and 1991 (as United team), with the Romanian second in 1989 and USA second in 1991 (their first WC team medal). The Romanians were the most dominant in 1994, 1995, 1997, 1999, and 2001. The following teams were second - USA in 1994, China in 1995, Russia in 1997, 1999, and 2001, USA was the most dominant for the first time in 2003, with Romania being second. Australia placing third in 2003 medaled for the first time. China was the most dominant in 2006, with USA being second. USA was most dominant in 2007 with China being second. Russia was the most dominant in 2010 and second in 2011. USA was the most dominant in 2011**.**

The most women's TEAM titles by nations in WC

Since women started competing in the WC in 1934, the USSR has been by far the most dominant team over the years with 11 titles; Romania is next with seven titles; the Czechs have three titles and the U.S. has two titles. Since the break-up of the USSR after the 1991 WC and until 2013, the Russians have won one team title.

Rank order of women's TEAM dominance in WC

USSR, Romania, Czech, USA, China.

Women's ALL-AROUND dominance by individuals in WC (with OG in brackets)

Vlasta Dekanova of Czechoslovakia 1st in 1934 and 1938.

Helena Rakoczy of Poland 1st in 1950 and third in 1954; Galina Rudko of USSR in 1954.

Larisa Latynina of USSR 1st in 1958 and 1962 (1st in 1956 and 1960 OG).

Vera Caslavska of Czechoslovakia 1st in 1966 and 2nd in 1962 (1st in 1964 and 1968 OG).

Ludmilla Turischeva of USSR 1st in 1970 and 1974. (1st in 1972 OG).

Elena Mukhina of USSR 1st in 1978.

Nellie Kim of USSR 1st in 1979 and 2nd in 1978 (2nd in 1976 OG).

Yelena Shushunova of USSR 1st in 1985 and 2nd in 1987 (1st in 1988 OG).

Svetlana Boginskaya of USSR, Belarus 1st in 1989 and 2nd in 1991 (3rd in 1988 OG).

Shannon Miller of USA 1st in 1993 and 1994 (2nd in 1992 OG).

Lillia Podkopayeva of USSR, Ukraine 1st in 1995 (1st in 1996 OG).

Svetlana Khorkina of Russia 1st in 1997, 2001, 2003, 2nd in 1995 (2nd in 2004 OG).

Vanessa Ferrari of Italy 1st in 2006, 3rd in 2007.

Aliya Mustafina of Russia 1st in 2010, 3rd in 2013 (3rd 2012 OG).

A rank order of women's AA dominance by individuals in WC

Khorkina, Latynina, Turischeva, Caslavska, Miller, Shushunova, Kim, Boginskaya, Dekanova.

Summary of the number of women's AA titles by nations in WC

From 1934 through 1989, the USSR women have won 11 AA titles (12 titles if consideration is given to two Soviets tying for first place in 1985). From 1991 through 2013, the U.S. women won eight titles; the Russians won four titles; the Romanians and the Czechs won two titles each.

Rank order of women's AA dominance by nations in WC

USSR, USA, Russia, Romania, and Czech.

Women's APPARATUS dominance in WC

<u>VAULT (women)</u>:

Larisa Latynina of USSR 3rd in 1958, 2nd in 1962, (1st in 1956, 3rd in 1960, 2nd in 1964 OG).

Vera Caslavska of Czechoslovakia 1st in 1962 and 1966, (1st in 1964 and 1968 OG).

Yelena Shushunova of USSR 1st in 1985, 1987 and 3rd in 1991.

Lavinia Milosovici of Romania 1st in 1991, 2nd in 1993, 3rd in 1994, 1995, (1st in 1992 Olympics).

Oksana Chusovitina of Uzbekistan 1st in 2003, 2nd in 2001, 2005 and 2011, 3rd in 1992, 1993, 2002 and 2006, (2nd in 2008 OG).

Simona Amanar of Romania 1st in 1995 and 1997, 2nd in 1996 and 1999, (1st in 1996 OG).

Gina Gogean of Romania in 1st 1994 and 1996, 3rd in 1995 and 1997, 4th in 1993, (3rd in 1996 OG).

Elena Zamolodckikova of Russia 1st in 1999, 2002, 2nd in 2003, (1st in 2000 OG).

Cheng Fei of China 1st in 2005, 2006 and 2007, (3rd in 2008 OG).

Alicia Sacramone of USA 1st in 2010, 2nd in 2006, 3rd in 2005 and 2007.

Kayla Williams of USA 1st in 2009 (won over 2nd by .562).

McKayla Maroney of USA 1st in 2011 (won over 2nd by .567) and 2013, (2nd 2012 Olympics).

A rank order of women's VAULT dominance by individuals in WC

Amanar, Cheng Fei, Maroney, Milosovici, Gogean, Zamolodchikova, Sacramone.

UNEVEN BARS:

Larisa Latynina of USSR 1st in 1958, 3rd in 1962, (1st in 1956, 2nd in 1960, 3rd in 1964 OG).

Marcia Frederick of USA 1st in 1978 (1st American world champion), 6th in 1979.

Maxi Gnauck of E. Germany 1st in 1979, 1981 and 1983, (1st in 1980 OG).

Ma Yanhong of China 1st in 1979 and 2nd in 1981 (1st in 1984 OG).

Daniela Silivas of Romania 1st in 1987 and 1989, (1st in 1988 OG).

Svetlana Khorkina of Russia 1st in 1995, 1996, 1997, 2001, 2nd in 1994, (1st in 1996 and 2000 OG).

Chellsie Memmel of USA 1st in 2003, 2nd in 2005.

Elizabeth Tweddle of GB 1st in 2006 and 2010, 3rd in 2003, 2005, 4th in 2007, (3rd in 2012 OG).

Anastasia Liukin of USA 1st in 2005, 2nd in 2006, 2007 (2nd 2008 OG).

He Kexin of China 1st in 2009, (1st in 2008 OG).

Aliya Mustafina of Russia 2nd in 2010, 3rd in 2013 (1st 2012 OG).

A rank order of UB dominance by individuals in WC

Khorkina, Gnauck, Tweddle, Liukin, Silivas.

BALANCE BEAM:

Tanaka (Ikeda) of Japan 1st in 1954, 3rd in 1958 and 1962 (first Japanese and Asian women's world champion).

Eva Bosakova of Czechoslovakia 1st in 1962, 2nd in 1954 (2nd in 1956 and 1960 OG).

Larisa Latynina of USSR 1st in 1958, 2nd in 1962, (2nd in 1960, 3rd in 1964, 4th in 1956 OG).

Natalia Kutchinskaya of USSR 1st in 1966, (1st in 1968 OG).

Nadia Comaneci of Romania 1st in 1978, (1st in 1976 and 1980 OG).

Daniela Silivas of Romania 1st in 1985 and 1989, (1st in 1988 OG).

Svetlana Boginskaya of USSR 1st in 1991, 3rd in 1987.

Shannon Miller of USA 1st in 1994, 4th in 1995, (1st in 1996, 2nd in 1992 OG).

Lavinia Milsovici of Romania 1st in 1993.

Gina Gogean of Romania 1st in 1997, 3rd in 1993, (3rd in 1996 OG).

Lilla Podkopayeva of Ukraine 2nd in 1994, 1995, (2nd in 1996 OG).

Andreena Raducan of Romania 1st in 2001, 2nd in 1999.

Catalina Ponor of Romania 2nd in 2003, 3rd in 2005, 4th in 2007, (1st in 2004 OG).

Anastasia Liukin of USA 1st in 2005, 2007, (2nd in 2008 OG).

A rank order of BB dominance by individuals in WC

Silivas, Liukin, Tanaka-Ikeda, Ponor, Miller.

FLOOR EXERCISE (women):

Eva Bosakova of Czechoslovakia 1st in 1958, 2nd in 1954.

Larisa Latynina of USSR 1st in 1962, (1st in 1956, 1960 and 1964 OG).

Vera Caslavska of Czechoslovakia 2nd in 1966, 3rd in 1962 (1st in 1968 OG).

Natalia Kuchinskaya of USSR 1st in 1966, (3rd in 1968 OG).

Ludmilla Turischeva of USSR 1st in 1970 and 1974, (2nd in 1972 and 1976 OG).

Nellie Kim of USSR 1st in 1978, 2nd in 1979 (1st in 1976 and 1980 OG).

Yelena Shushunova of USSR 1st in 1987, 2nd in 1985 (7th in 1988 OG).

Daniela Silivas of Romania 1st in 1987 and 1989, 4th in 1985 (1st in 1988 OG).

Shannon Miller of USA 1st in 1993, (3rd in 1992 OG).

Gina Gogean of Romania 1st in 1995, 1996, 1997 2nd in 1993.

Andreena Raducan of Romania 2nd in 1999, 2001.

Svetlana Khorkina of USSR 2nd in 1997, 3rd in 1999, 2001, (2nd in 2000 OG).

Catalina Ponor of Romania 2nd in 2003, (1st in 2004, 3rd in 2012 OG).

Alicia Sacramone of USA 1st in 2005, 2nd in 2007.

Cheng Fei of China 1st in 2006.

Vanessa Ferrari of Italy 3rd in 2006, 2nd in 2013.

Shawn Johnson of USA 1st in 2007 (2nd in 2008 OG).

Lauren Mitchell of Australia 1st in 2010, 2nd in 2009.

Aly Raisman of USA 3rd in 2011, 4th in 2010 (1st in 2012 OG).

Simone Biles of USA 1st in 2013.

A rank order of women's FX dominance by individuals in WC

Gogean, Turischeva, Silivas, Latynina, Kim, Sacramone.

Note**:** As a nation, the USSR competed in the 1991 WC for the last time (under name of United team) and was subsequently broken up into 15 separate countries.

Extra Special individual achievements in WC

Men: Dimitri Bilozerchev's winning four individual titles in 1983 at age 16 and winning the AA in 1987 after shattering his shinbones in an auto accident in 1985. Kohei Uchimura winning four WC AA titles - 2009, 2010, 2011, and 2013 (and the 2012 OG AA). Viktor Chukarin, considering the hardships he endured during WWII as a prisoner in a concentration camp for over three years and winning the AA at age 33 in 1954, his only opportunity to take part in the WC.

Women: Svetlana Khorkina's three AA WC and one second, is the all-time leader in medals won at 20, of which 9 were gold. Larisa Latynina won four major AA titles, that includes two WC and two OG (and placing second in AA in her third OG), and competed in four WC (as Dirij in 1954) when they were four years apart. She ranks third in WC medals won at 14, of which 9 were gold. (Note: Latynina competed in three OG and won 14 out of 15 possible individual medals – a supreme achievement.)

CHANGES INVOLVING NUMBER OF JUDGES AND ARRIVING AT A SCORE

From 1903 to 1922 WC two judges were used to arrive at an average score. Evaluations were by quarter points in a 10-point system, with one point each 'set aside' for the approach and the retreat from the apparatus.

In the 1926 and 1930 WC there was an average score from three judges, where the deductions were by tenths of a point, and that was multiplied by 1.5, and with one point for approach and retreat presentation, the maximum score obtainable, for both of these Championships, was 16 points. (The maximum score was not always 10 points.) The number of judges per event varied through the years, but from the 1938 through 1989 WC there were four judges per event, and the average of the two middle scores determined the final score. From 1993 to 2003 WC, the average of the four middle scores of six judges determined the final score.

In the 2006 WC, 'open' scoring (beyond the limit of 10 points) was introduced which significantly improved differentiating the difficulty values of performances. Eight judges served on each event panel. Two judges evaluated the content (difficulty, connection points and element groups) and six judges evaluated the execution, with the average of the four middle scores, determining the final score. As of the 2011 WC, two judges evaluated the content, five judges evaluated the execution, and two ‘reference’ judges served on the panel. The final score is the content score and the average of the three middle execution scores.

Judging Guide: Evolution of the Code of Points lead to more objective, accurate and, thus, fairer evaluation through quantifying difficulty and spelling out specific standards for execution. The Code of Points was introduced in 1949 and until 1962, only general guidelines were offered for evaluating difficulty, which relied solely upon the judge’s opinion. Directives for judging at the time were: perfect performance, good, excellent or superior, inferior to average or satisfactory, fair, and insufficient or very defective (8). Although there were some guidelines for judging execution (which was, in the past, also referred to as presentation), it was not until 1989 that specific angles for execution were introduced.

A timeline of difficulty expansion: Elements were quantified by the FIG in 1962, with three difficulty categories (A, B, C) and first appeared in the 1964 Code of Points. Those categories were applied for the 1964 OG and the following WC (in 1966). The three categories lasted through the 1970s and were far from sufficient to properly award the many levels of difficulty, but it was a start. One reason given for just three categories was to keep the application of the rules practical and not too complicated for the judges. In 1979 risk was added for extra ‘C’ elements, but this proved inadequate. Women used 2 difficulty categories and medium and superior until 1979 and then went to A, B, C.

There are far more than three levels of difficulty, which are shown, for example, by the numerous ratings of difficulty in the vaulting table. Consequently, the ‘D’ category was added in the 1985. In time, more difficulty categories were added rewarding truer credits for gymnastics performance, which was necessary for fairer evaluations. In 1993 an ‘E’ category was added, then expanded to ‘super E’ category in 1997, along with the awarding of bonus points for connecting elements. In 2005 ‘super E’ was changed to an ‘F’ category. The ‘G’ category first appeared in 2009, and the 2013 women’s Code further added an ‘H’ and then an ‘I’ category in its addendum. Through the years, it has been shown that judges could handle a complex set of rules.

Judges’ Education: Rather than rely on just experience, the FIG first step toward instituting judges’ education was at the 1954 WC. The first full intercontinental judges’ course and examination was in 1964 in Zurich, and the FIG brevet certification was introduced.

Instant video replay was installed near each apparatus for the 1978 WC, enabling judges to verify, when needed, what the gymnast actually performed. This, especially, helped in deciding judging inquiry disputes.

CHANGES IN FORMAT AND THE QUALIFICATION SYSTEM FOR FINALS

Score accumulation versus scores from ‘a clean slate’ or ‘new life’ for each round of competition: Until the 1987 WC, scores were carried over from the qualifying rounds to the succeeding rounds of competition or finals. Starting with the 1989 WC, scores were no longer carried over to the team, AA and individual events finals.

It should be noted that when all the gymnasts competed in the AA (before ‘new life’), a minimum AA average score of 8.0 points or a version of this minimum average score from the qualifying round was required to advance to the individual event finals. The AA average qualifying score requirement was eliminated once non-AA competitors and event specialists were permitted to take part in the WC (and Olympics).

A significant gymnastics change occurred in eliminating the compulsory exercises, which was implemented in the 1997 WC. Reasons given for eliminating the compulsory exercises: they were not interesting for television or the general public viewing; the scoring, especially with 'new life,' simplified following the competition results, making it more attractive to the public. Also, the competition was shortened which was less taxing for the gymnasts.

The element groups (originally as combination, then special requirements) for each event, more or less, 'filled the gap' made by eliminating compulsory exercises, requiring gymnasts to display event 'all-around' ability.

CHANGES IN AGE REQUIREMENT OF GYMNASTS

The top-level international women gymnasts before 1966 were usually not younger than 20 years of age. Starting in the 1966 WC, 17-year-old women were on the gold medal team. Then, in the 1976 OG the women's AA gold medalist was just 14 years old. With a concern for young girls' welfare, the minimum age limit was changed from 14 to 15 before the 1980 OG. This did not eliminate the problem of pushing adolescences into major international elite (senior) competition, which occurred in the 1992 OG. In 1997, the minimum age requirement for international elite competition was raised to 16 years.

Men have not had the same problem as women concerning young teenagers for elite level competition. In 1981, the youngest male to date won the world AA championships at age 19. Then, in the 1983 WC a 16 years old won the AA and three other events plus a second on a fourth event, achievement was same in 2001 AA was also won by a 16 year old boy. However, with the current non-AA format, other 16 year olds may soon find themselves on the winner's podium, which is also the minimum age for men (new minimum age is 18 for senior men).

THE NUMBER OF GYMNASTS QUALIFYING FOR THE AA FINALS AND APPARATUS FINALS

Apparatus (individual event) finals were introduced in the 1958 WC with the top six qualifiers advancing to finals, with no limit in number from any one country. Starting in 1972 and followed up in the 1974 WC, only the top 36 AA gymnasts from the qualifying round advanced to the AA finals, with no limit in number from any one country.

Due to the few countries' gymnasts that qualified and dominated the finalists, starting with the 1976 OG and the subsequent WC, no more than three AA and two individual event (apparatus) qualifiers per country could advance to the finals. This certainly helped spread encouragement and the rewards in the gymnastics world. Starting with the 1978 WC, the apparatus finalists changed from six to the top eight qualifiers.

The 1979 WC served as a qualifying competition for the subsequent year's OG. The top 12 teams plus a limited number of individuals from the next several placing teams, qualified for the 1980 OG. However, this qualifying process turned out to be a 'wash,' since the Olympics were boycotted by a number of the leading countries.

Summary of WC format and participation

1989 - 'New life' was introduced, where the scores from qualification rounds were not carried over.

1992 - Only individual events (apparatus) were contested. First WC where team and AA were not contested. Up to six men and four women gymnasts per country could be entered with no more than two gymnasts per event.

1993 - AA and individual events (no team) were contested. First WC where top 24 qualified for AA finals, with two gymnasts per country (reduced from three).

1994 – The first of two WC was only for AA and individual events (no team). The first gymnasts from Nigeria took part in a WC.

1994 – The second WC (six months later) was a team only competition.

1995 - The teams consisted of seven gymnasts with six competing during the qualifying round. For the Team Finals five gymnasts per team competed with the best four scores counting toward the final team score, thus a 7-5-4 format. The first WC hosted in Asia.

1997 - The first WC without compulsory exercises. Six gymnasts per team competed with the best five scores counting toward qualifying for a team finals. Then, the top six teams of five gymnasts per team competed with the best four scores counting toward the final team score, thus a 6-5-4 format.

1999 – The WC started being held every year.

2001 – The top eight teams (rather than six) advanced to team finals, consisting of just three gymnasts per event per country (chosen from among each team's six gymnasts) with all three scores counting toward the final team score. The top 30 gymnasts from the qualifying rounds competed in the AA finals.

2002 - Only individual events (apparatus) were contested.

2003 - The number of gymnasts for AA finals, for the second time, was reduced from 36 to 24 (the 1993 WC had 24 AA finalists) with no more than two gymnasts per country – same for the individual event finals. This became the format for future WC.

These changes and the three gymnasts per country format for team finals have fostered the use of event specialists, which has resulted in de-emphasizing the AA, by substantially reducing the number of gymnasts per team taking part in the AA. A prime example, in the 2012 OG, the men's team from China won the team gold without any of their gymnasts competing in the AA.

2005 – The WC contested AA and individual events, but no team competition. Each country was permitted to have six men and 4 women gymnasts, with no more than two entries per country per event.

2006 - The first 24 teams plus the top placing individuals qualified for the 2007 WC. This was the start of the 2008 OG qualification process. 'Open' scoring (going beyond the 10 point limit) was instituted.

2007 - 24 teams entered, with eight of those teams qualifying for team finals. The top 24 gymnasts advanced to the AA Finals, and eight gymnasts to the individual event finals. Also, the top 12 teams and up to three gymnasts per country from those teams ranked lower than 12, (3 for teams 12-15) - qualified for the 2008 OG.

2010 - The top 24 teams plus the top individuals qualified for the 2011 WC, which was the start of the qualifying process for the 2012 OG.

2011 - The top eight teams plus the top three places in the AA and individual events qualified for the 2012 OG. Then, there was a second OG qualifier in January 2012 which qualified four more teams plus individuals. The 2012 OG consisted of a maximum of five gymnasts per team (reduced from the previous six team members), which will be the team size for subsequent WC.

2013 – The WC had no team competition, just the AA and individual events. The maximum entries per country were five men and four women gymnasts, with no more than two per event per country.

CHANGE IN COMPETITIVE VENUE

All WC competitions up through 1954 were held outdoors. Then, from 1958 onward, the WC were held indoors and the gymnasts competed on a raised podium, which has become the norm for major international competitions. Judges were seated well below the top of the podium, which did not obstruct the view of spectators and better highlighted the gymnasts' performances.

CHANGES IN APPARATUS AND PERFORMANCE REQUIREMENTS, LANDING MATS, HANDGUARDS AND SAFETY MEASURES; EVOLUTION AND YEARLY TIMELINE FOR SKILLS INITIALLY PERFORMED IN THE WC

(Note: Some skills were previously performed in other competitions - the OG, European or National championships).

Some of the following skills changed the structure of an event's performance. Through the years, apparatus and landing mats specifications have evolved. There was a time that certain pieces of the same apparatus were not uniform but in time apparatus specification details have been refined and with FIG certification, significant differences in equipment have been eliminated.

FLOOR EXERCISE: *The mat, spring floor, and size of area*: For the 1952 OG, the FX area was expanded from the previous size of approximately 20 x 20 feet (6 x 6 meters) to 39.4 x 39.4 feet (12 x 12 meters) – instituted for the WC in 1954. Up to 1954, the WC were outdoors and FX was conducted on grass. Then, when the WC went indoors in 1958, the FX area consisted of 1/8-inch (3 millimeters) thick felt covered with a carpet. In the 1978 WC the FX mat was a carpet covered one-inch (2.5 cm) thick foam with a slight elasticity approximately one-inch thick (2.5 centimeters). In 1979 the first floor with springs was introduced. It contained about two inch (5 cm) high springs or elastic foam pads attached to approximately ½ inch (1.25 cm) plywood for the entire the FX area, which was covered by a one-inch (2.5 cm) foam mat. This type of floor facilitated tumbling (acro) which became the dominant elements in FX rather than the non-tumbling previous agility skills, leg and arm balances, leaps and 'break dancing' type skills. As the springs and/or foam increased in size, bounding saltos (directly connected saltos) and far more difficult tumbling elements became the standard. From the beginning tumbling skills of plain single saltos, twists were soon added, followed by double saltos (first attempted in the 1962 WC but was not successfully completed until the 1964 OG), then doubles with twists (full-twisting double saltos were successfully performed in 1974 WC; the double twisting double saltos followed in the 1980s).

Time limit for FX: Up to 1954 the time limit for FX was from 90 to 120 seconds. In 1958, the time limit changed from 60 to 90 seconds. Then, for 1979 it was changed to 50 to 70 seconds for men and 70 to 90 seconds for women. In 2008 the minimum time limit was eliminated and the maximum of 70 seconds for men and 90 seconds for women was retained.

Music accompaniment for women's FX was first required in the 1956 OG and then in the 1958 WC. but only for the compulsory exercise. In 1962 music was required for both the FX compulsory and optional exercise. The compulsory and most of the optional exercises were accompanied by piano music, however some gymnasts used full orchestra music for their optional exercise. At the time, some of the FIG Technical Committee Members felt that there was an advantage of a full orchestra over piano music. So after 1962, the rules mandated that accompaniment for the optional exercise could only be by a single instrument. In 1988, the rules concerning optional exercise music accompaniment could, once again, be by a full orchestra.

The debut of various FX tumbling (acro) skills (men and women) in WC(other competitions in brackets)

Back salto 1/1 twist in the 1958 WC.
Back salto 2/1 or women in 1974 (performed earlier in 1972 OG).
Back salto 3/1 twist for men in 1970,
Double back salto tuck (with a major error) in 1962 (first performed successfully in the 1964 OG),
Double back salto tuck 1/1 twist in 1974.
Double back salto straight in 1978.
Double back salto 1/1 twist straight in 1983.
Back salto 4/1 twists in 2013.
Front salto with 3/1 twists in 2013.

Triple back salto in 1989 (introduced in 1987 European Championships and the 1988 OG).
Double back salto by a woman in 1978 (introduced in 1975 Milk Meet in Canada).
Double back salto 1/1 twist by a woman at OG 1976.

POMMEL HORSE: In 1980, the pommels were increased in width size, which facilitated simultaneous multi-hand placements on one pommel. In 2008 the body of the horse was increased in width size along with a further increase in the pommels size.

The debut of various PH skills in WC

360 Russian on pommels, introduced in 1952 OG, then in 1954.
Shaginyan introduced in 1952 OG and then in 1954.
Bailie in the 1962 WC.
Longitudinal circular travel end to end (Magyar) in 1972.
360 spindle (counter turns) in 1975.
Flair in 1978 (previously shown in the 1976 OG).
Handstand dismount in 1978 as compulsory dismount.
Li Ning (scissor handstand) in 1983.
Full horse turning with travels on leather in 1989.
360 Russian on single pommel 1990s.
Sohn (360 kehre) in 1992.
Driggs (cross hop end to end) in 1995.

RINGS: Construction evolved from wood to fiberglass with a wood veneer or a very dense laminated hardwood used at the 1991 WC. The advent of dowelled handguards in the early 1970s facilitated a secure grip for the large swing elements, which necessitated that the wooden rings be made of a much stronger material to withstand the great stress put on them and afforded greater safety to the gymnasts.

Straight-arm shoot to handstand was introduced in the 1966 WC, shortly followed by the back rise handstand with straight arms. Soon the big swing skills with straight arms became the standard.

Routines could get top scores with predominately swing elements through the 1980s. Starting in the 1990s, greater strength skills were needed (required) to attain a top score.

The inverted cross had been shown close to horizontal by a number of gymnasts in past WC. Currently, gymnasts are executing skills that, just a short time ago, would not have seemed possible.

The debut of various Rings skills in WC

Back salto 1/1 twist dismount in 1958.
Back salto 2/1 twists in 1970.
Double back salto 1962.
Double back salto 1/1 twist tuck in 1974.
Double salto straight in 1978.
Double back salto 2/1 twists tuck in 1979.
Yamawaki in 1983.
Triple back salto introduced in 1974 WC (Andrianov)
Goczoghy in 1985.
O'Neill (Guczoghy straight) in 1994.
Inverted cross in 1924 OG.
Maltese press to planch in 1994 (first performed in the 1962 U.S. National Championships by Carl 'Bill' Wolf).
Hang, pull with straight arms to cross 1996 (performed in 1961 USSR National Championships by Yuri Aivazyan).
Cross press straight body to inverted cross in 2001.
Back lever pull to maltese in 2001.

VAULT: The vaulting boards in the early WC were a slightly inclined wooden board with the front end being about three inches (7 centimeters) high with no or very little elasticity (spring). The subsequent boards being developed had a slight spring. Through the years, the size of the springs and/or foam pads and the elasticity of the boards increased so that in the 21st Century the height of the boards are about eight inches (20 cm).

While vaulting was contested in the early OG, it was conducted with the horse broadways or sideways. When vaulting was first contested in the WC 1934, the horse was turned long ways (for men), thus the term 'long horse vault.' From the 1930s into the mid-1960s, the long horse body had four thin lines painted on the top of the horse - two lines were 16 inches (40 cm) from each end, and two other lines 8 inches (20 cm) inward from the lines nearer to the ends. If the hand(s) touched the line closest to the end, the performed received a one full point (1.0) deduction in score, if the hand(s) touched the inner line, the deduction was two points (2.0). In the late 1960s, the inner lines were eliminated, and the deduction for touching the line was reduced to a half point. In 1979, the lines near to the ends were eliminated and one thin line was painted across the middle of the horse. By 1989, the line was eliminated. In the 1979, the running approach had been lengthened from a previous 20 meters to 25 meters.

In to the 1950s**,** the best vault of two attempts determined a vault score. Then, there was a change - if the second vault was attempted, the first vault score was discarded and the second vault score counted. The rules eventually changed to just one vault in the qualifying round, however two different vaults were required to qualify for vault finals, of which a limited number of gymnasts take advantage. For example, in the 2011 WC, an Olympic qualifying competition, the men had 227 gymnasts in the vault qualifying competition, with just 37 who competed for vaulting medals, and the women had 192 gymnasts in the vault qualifying competition with only 31 who competed for vaulting medals, also with the hope of qualifying for the following OG.

Through the 1950s, non-turnover (handsprings and salto) vaults were almost exclusively performed. The handspring vault won in the 1960 OG, however non-turnover vaults won in 1962 and 1966 WC (and the 1964 OG) – the winning vaults were the hecht, and the Yamashita respectively. The Tsukahara vault was introduced in the 1970 WC. Then the boards became springier and the handspring front salto followed in the 1970s. Next came the Kasamatsu vault in 1974.

Then, with the increase in saltos and twists, safety measures had to be implemented, and the mats became thicker and softer to absorb the increased impact from the multi-rotated vaults. Soon after the Yurchenko vault was introduced for women in the 1982 World Cup and then in the 1983 WC, and not permitted until 1989 for men, the collar mat around the vault board was instituted in the United States. A request was made to the FIG Women Technical Committee to use the collar mat around the board for the Yurchenko vault, but its use was refused. Unfortunately, changes are often met with resistance, and not until after a catastrophic accident occurred in competition in Japan in 1995, was the collar mat accepted. And, it use has become standard for the Yurchenko type vaults in competition.

The current vault table, which replaced the horse, was first used in the 2001 WC, making it considerably safer, especially, for Yurchenko and Tsukahara type vaults.

An interesting change is that the category of direct vaults (non-handsprings or saltos) has been eliminated from the 2013 men's CP, since international level gymnasts for many years have not performed these vaults in competition.

The debut of various Vaults in WC

Tsukahara in 1970.
Handspring front salto tuck in 1970.
Kasamatsu in 1974.
Kasamatsu 1/1 twist in 1979.
Yurchenko introduced in 1982 World Cup, then in 1983.
Handspring double front salto in 1979. For Women in 1981.
Handspring front salto 5/2 twists (Yeo Hong-Chui) in 1994.
Tsukahara and Yurchenko double back salto in 1999.

PARALLEL BARS: One primary change in the parallel bars was the rails, which were formerly made of wood and than with a medal bar down the length. The rails were not always identical in their elasticity. Today the rail composition is fiberglass with a wood veneer cover, introduced in 1977 and FIG approved in 1979, which eliminated the manufacturers' problem of equalizing the elasticity of the rails. With the introduction of the giant swing in 1978and an increase in under bar skills being performed, gymnasts apply honey, sugar and water or other sticky substance to the bars to prevent grip slippage in these types of skills. This has facilitated the wide use of straight-arm basket, giant, and Belle type skills - also all with turns. Other skills that have evolved are: hand support double forward and backward saltos to upper arms, Diomidov, Healy; advanced upper arm skills (front rise back salto and stutz handstand, front rise Diomidov, Dimetrienko, back rise front salto); and double salto dismounts.

The debut of various PB skills in WC

Back salto handstand in 1954.
Stutz to handstand in 1962.
Double back salto dismount in 1966.
Diomidov in 1964.
Healy in 1974.
Giant in 1978.
Front 1¼ straddle to support in 1979.
Front rise stutz handstand in 1981.
Makuts in 1979.
Morisue in 1983.
Front rise Diomidov in 1983 (Richards).
Belle in 1987.
Dimitrienko in 1999.

HORIZONTAL BAR: Most bars were no more than seven feet (210 cm) wide before the 1950s. In the late 1950s the width of the bar was increased and standardized to approximately eight feet (240 cm), which also increased the elasticity of the bar. The first of the larger flight skills started becoming prevalent in the mid-1960s. Spectacular flight skills that evolved were: flying giant skills over the bar, Jagers, Giengers, Tkachevs, Kovacs, Gaylords (also all with twists) - where the bar is released and regrasped, displaying great flight amplitude. Dismounts with double and triple saltos with straight body and twists are regularly performed. The dowelled handguards have markedly facilitated the gymnasts' regrasp on flight skills.

The debut of various HB skills in WC

Stalder shoot in 1950 WC (first performed in the 1948 OG).
Endo in the WC in 1962.
Front 1/1 pirouette in 1962.
Voronin in 1966.
Double salto tuck 1/1 twist dismount in 1970.
Jaeger in 1974.
Kovacs in 1979.
Kolman in 1990 (performed in the 1990 European Championships).
Markelov In 1978 (performed in the 1977 European Championships) – first performed piked rather than straddled in the 1964 OG).
Tkachev in 1978 (first performed in the 1977 European Championships).
Deltchev in 1978 (first performed in the 1977 European Championships).
Gienger in 1978.
Winkler in 1981.
Deff in 1983.
Gaylord 1 in 1983.
Gaylord 2 in 1984 (OG).
Pegan 1993.
Back double salto 1/1 twist tuck in 1974 (first performed in the 1972 OG).
Back triple salto dismount in 1979.
Back double salto 2/1 twists tuck dismount in 1983.
Back double salto 3/1 twist tuck dismount in 1997.

UNEVEN BARS: (formerly known as the uneven parallel bars or asymmetrical bars): Uneven bars were introduced at the 1936 Olympic Games and first contested in the 1938 WC. The uneven bars were originally transformed from men's parallel bars where one bar was lowered and the other bar raised high with a maximum separation of approximately 1.5 feet (46 cm). With the advent of large circular swings and flight skills, the spread of the bars increasingly widened to a maximum of approximately six feet (180 cm) apart.

The wood rails were replaced with fiberglass covered with a wood veneer in 1975 and approved by the FIG in 1979. Then, the thicker rails (originally egg-shaped, then oval shaped) were replaced with thinner round rails, approved by the FIG after the 1988 OG. The thinner rails better suited the size of women's hands and along with the dowelled handguards, their grip on the bars was significantly enhanced.

The debut of various UB skills in WC

Facing out on low bar, front salto to high bar (Rodochla) in 1962
Comaneci introduced in the 1976 OG, then in 1978 WC
Shaposhnikova in 1978.
Back giant swings in 1978.
Elgrip giants in 1980s.
Gaylord 1 in 2013 (performed in the 1995 pre-OG).
Pak salto 1/1 twist in 2001.
Triple back dismount in 1995.

Figure 4. *Bart Conner, Natalia, Shaposhnikova, Nadia Comaneci, Svetlana Boguinskaya (Antwerp 2013.)*

BALANCE BEAM: Originally beams were plain wood with straight sides. In the late 1950s the sides were convex curved. Then in the 1960s, a leather cover was added. Eventually, the top pad had a slight cushioning effect. In 1980 a spring reflex mechanism was in the beam's aluminum core, which had minimal give and helped reduce the impact from the acrobatic and leap skills.

<u>The debut of various BB skills in WC</u>:

Back salto in 1972.
Front salto introduced in the 1976 OG, then in 1978 WC.
Back double salto dismount in 1979.
Back double salto 1/1 twist dismount in 1985.
Onodi in 1989.
Back salto straight on beam in 1974.
Back salto 1/1 twist on the beam in 1985.
Front double salto dismount in 1997.
Triple lunge turn in 2004.

LEARNING AIDS AND DEVICES

(that facilitated acquisition of especially difficult skills)

In the 1960s, gymnastics apparatus companies developed thick foam mats (cushions), which made for softer landings. Also, along with the spread of deep foam pits, learning of multi-salto and twisting skills in tumbling, vaulting, flight skills and dismounts from R, PB, HB, UB, BB were facilitated. Other aids employed are: trampoline (1940s); ski and rod floor; tumble track (long trampoline; developed in the early 1980s); overhead spotting belt system; twisting belt (early 1950s); mushroom (1970s); bar straps; dowelled handguards (already mentioned); video analyzing equipment and other devices. All these aids and devices have enabled gymnasts to learn and acquire especially higher-level skills faster and in a safer manner.

Through the efforts of the FIG and the apparatus companies, the equipment became standardized which enhanced the equipment's quality and consistency.

EDUCATION: MEANS AND SIMPLICITY OF DISSEMINATING INFORMATION

Increased knowledge and that gained from the FIG Academies and 'scientific' training have enhanced learning and fitness levels. Expansion of disseminating information through the media, videotaping, literature, making information accessible especially at no cost through the internet has helped spread and raise the level of gymnastics across the world. Publications such as the 'Science of Gymnastics Journal', 'International Gymnast' magazine, Gerald George's 'Championship Gymnastics' are just a few of the examples of educational material available.

Computer scoring helped streamline gymnastics: The advent of computer scoring programs within, perhaps, the last 30 years have provided accurate and 'instant' results of competitions for the media and public. This has contributed to making gymnastics more attractive and enjoyable for the public.

TELEVISION AND MEDIA COVERAGE, ITS IMPACT AND EXPANDED POPULARITY OF GYMNASTICS

The first OG gymnastics competition was televised in 1960 from Rome. Ever since then, Olympic coverage escalated and gymnastics is among the few sports receiving the most television coverage. In 1972 OG, gymnastics was given a huge boost with the television coverage of Olga Korbut's spectacular performances and her outbreak of emotion during the competition - which did much to popularizing gymnastics worldwide. Gymnastics has become a favorite among Olympic sports and is among the first sports sold out at the OG, which has carried over to the WC.

Figure 5. 2013 WC women's AA ceremony: 1st Simone Biles (USA), 2nd Kyla Ross (USA), 3rd Aliya Mustafina (RUS).

CONCLUSION

Gymnastics will continue to evolve in its skills, rules, and equipment. The changes presented have all impacted the development of gymnastics. The knowledge gained through the years, along with the educational and certification programs, and the advances in equipment, has led to an incredible increase in gymnastics skill difficulty, along with the necessary safety measures. The expanded television coverage, as limited as it is other than that of the OG, has accounted for the public's familiarity and knowledge of gymnastics, with an offshoot being a tremendous increase in participation, and its athletes becoming superstars throughout the world. In May 2013, the International Olympic Committee declared that gymnastics is in the top tier of the three most popular and revenue ranking Olympic sports, which ensures that gymnastics will remain in the Olympics as one of the five original sports.

REFERENCES

Amateur Athletic Union Official Gymnastics Yearbook (1951).

Amateur Athletic Union Official Gymnastics Yearbook (1952).

Amateur Athletic Union Official Gymnastics Yearbook (1953).

Amateur Athletic Union Official Gymnastics Yearbook (1958).

Cuk, I., Fink, H., Leskosek, B. (2012) Modeling the Final Score in Artistic Gymnastics by Different Weights of Difficulty and Execution. *Science of Gymnastics Journal*, 1*(4)*: 73-82.

FIG. (1983) *Liste des Resultats, Championnats du Monde 1950-1983*.

FIG. (1981a). *100 Years of the International Gymnastics Federation 1881 – 1981*.

FIG. (1964). *Code of Points for Men Artistic Gymnastics Competition*.

FIG. (1975). *Code of Points for Men Artistic Gymnastics Competition*.

FIG. (1979a). *Code of Points for Men Artistic Gymnastics Competition.*

FIG. (1981b). *Code of Points for Men Artistic Gymnastics Competition.*

FIG. (1989a). *Code of Points for Men Artistic Gymnastics Competition*.

FIG. (2009a). *Code of Points for Men Artistic Gymnastics Competition.*

FIG. (2013b). *Code of Points for Men Artistic Gymnastics Competition*.

FIG (1979b). *Code of Points for Women, Artistic Gymnastics Competition*. Editions 1979, 2009, 2013.

FIG (2009b). *Code of Points for Women, Artistic Gymnastics Competition*.

FIG (2013b). *Code of Points for Women, Artistic Gymnastics Competition.*

FIG (2013c). WTC *Newsletter No. 34*, December 2013.

FIG. (2011). *Apparatus Norms, 2011*.

Anson W. (2014). *Historical information from apparatus expert Whitey Anson*.

FIG. (1989b). *Technical Regulations*.

FIG. (2013d). *Technical Regulations*.

Fink, H., (2006). 51 Years of Canadian Gymnastics Results of the Major FIG Competitions.

Gajdoš, A., Provaznikova, M., Banjak, S.J. (2012a). 150 years of the sokol gymnastics in Czechoslovakia, Czech and Slovak Republic. *Science of gymnastics journal*, *2*(4), 5-26.

Gotze, A., and Herholz, E. (1992). Das Turnjahrhundert der Deutschen. Berlin: Tribune Druck GmbH.

Gajdoš, A., Provaznikova, M., Banjak, S.J. (2012b). Sokol slets - the essence of gymnastics in Czechoslovakia, Czech and Slovak Republic (celebrating 150 years of gymnastics). *Science of gymnastics journal*, *3*(4),73-82.

Grossfeld, A. (2010). A history of United States artistics gymnastics. *Science of gymnastics journal*, 2*(2)*:5-28.

Pavlin, T. (2013). "The duty of Sokol is to yet again step into the national front line" : Sokol movement in Slovenia - 150th anniversary of Južni Sokol. *Science of gymnastics journal*, *3*(5),5-18.

Stukelj, L. (1989). *My Seven World Competitions*, Novo mesto: Dolenjska zalozba.

ACKNOWLEDGE

The author is grateful to some places and references which helped in preparation of this article, but author was not in position to cite them completely. Such information was obtained from:

Wikipedia and World Gymnastics Championships information via the internet.

Reuters - IOC Olympic sports ranking (Internet).

Top End Sports – Most Popular Olympic Sports (Internet).

Competition Results of World Artistic Championships, 1903 to 2013, via the internet and personal possession.

Personal accounts and films.

Figures 1, 3, 4, 5 are from authors archive, Figure 2 is from ŠD Narodni dom archive

*Note: for further information about the references please contact author directly.

Corresponding author:

Abie Grossfeld
Southern Connecticut State University,
New Haven, CT, USA
E-mail: grossfelda1@southernct.edu

MAIN CHARACTERISTICS OF RULES AND COMPETITION SYSTEMS IN GYMNASTICS FROM 1896 TO 1912

Georgios Papadopoulos, Vasilios Kaimakamis, Dimitrios Kaimakamis. Miltiadis Proios

Department of Physical Education and Sport Science
Aristotle University of Thessaloniki, Greece

Original article

Abstract

The efforts for a subjective and fair judgment for Gymnastics began since the first decades of the 19th century i.e. since the sport began to take a primitive competition form. In the years that followed, various competitive systems and rules were formed without being commonly accepted for all countries and federations. Nevertheless, the two international sport agencies, the IOC and the FEG organized international tournaments (Olympic Games, International Tournament), where participating countries accepted, more or less, the rules and competitive systems applied each time. The lack of permanent and commonly accepted rules and specifications of gymnastic apparatus created many problems at the six Olympic Games mentioned in the present study. This fact created suspiciousness within gymnastics and especially within the two international agencies with a direct impact on the progress and development of the sport.

Keywords: *Gymnastics, Olympic Games, Judgment, Competitive systems, Rules*

INTRODUCTION

From the end of the 19th century to the beginnings of the second decade of the 20th century (1896-1913) it was the most important period in the total history of gymnastics. During these two decades the sport was highly promoted, formed, specialized and internationalized. Competitions began to be organized by the two important international sports institutions, the Olympic Games of the IOC and the international tournament of the FEG (Federatious Europeennes de Gymnastque later named FIG). During this time we see important efforts for the finding of reliable and commonly accepted scoring systems, without positive results since disagreements and problems were aroused during this period. This fact was a rather suspending factor for the progress and international acceptance of the sport as well as an important reason for consideration for all agencies involved (Kaimakamis, 2001). FEG established for its tournaments unified rules and assessment system without success since different federations were characterized by introversion and did not have the will to give up their own systems. Problems also occurred at the Olympic Games, since each organizing country imposed its own scoring and competition system and its own events based on its own specified preferences. Even more when participating countries followed a different system, problems were rather great since each side competed according to its own scoring and competition system (Kaimakamis, 2001).

The fact that many countries participated at both the Olympic Games and the International Tournament which followed with the same rules and regulations was a big success especially for an era when many Gymnastics' Federations presented introversion and arrogance following their own path.

It should also be noted that in both these decades cooperation did not exist among the IOC and the FEG, despite the fact that these two important international agencies could be bonded based on their special love for Gymnastics. FEG for more than 20 years since its founding in 1881 up to 1903 when it organized the first international Gymnastics Tournament (then renamed to World Championship of Gymnastics), showed no activity worth of mentioning.

The path to development was long since the FIG rules were first composed and commonly accepted in 1949 (with a total of 12 pages), and have been continuously improved up to present (Zschocke, 1997).

During this time and for the following decades Gymnastics, then called by the general name of *"Gymnastic Sports"*, was not a separate and specialized sport but a mixed and integrated sport within a more general gymnastic system, which apart from the traditional competitive gymnastics events also included track and field games and even swimming. These extra events were included in Gymnastics' competitions up to 1950.

Today the Scoring System covers all details relating to competition and assessment. Subjectivity was not eliminated, often creating disagreement, confusion and problems. This is the reason why the FIG, as well as some federations in many countries never stopped working to find a more reliable and simpler ways of assessment (Dörrer, 1999; Uhr, 1999a, b). The leaders of world gymnastics should be directed to such a path since it is proven that the objectivity and reliability of rules is directly linked to the sport's progress. It should be mentioned that 2001 the last change (improvement) of rules and regulations took place, which surely will not be the last since Gymnastics development will continue to be ongoing (Strickrodt, 1999). It is certain that in such an effort for the finding of ideal rules and regulations, their history could provide the necessary guidance. The present study offers assistance not only towards this direction but also to the knowledge derived from the general history of this sport.

METHODS

The present study makes an effort to investigate record and showcase the problems found within rules and competition systems of the first five (5) Olympic Games (1896-1912), and the Mid Olympic Games of Athens in 1906. This specific era was selected since the infrastructure of these games was formed not only for competitive systems and assessment method for athletes, but because it was a landmark for the development of Gymnastics.

The method used in the collection of data was made based on historic research of archives and focused on the rules and competitive systems used at the greatest sport event, the Olympic Games.

The collection of data for the present study was mainly based on written and sources of Guts Muthts (1793), Jahn (1816), Brustmann (1906), Savvidis (1906), Diem (1912) and Chrysafis (1930). Data were also derived from modern writers such as Göhler (1980), Lennartz /Teutenberg (1995), Gajdos (1997), e.t.c. Useful data came from the two studies by Kaimakamis (2002, 2003), where Gymnastics in the Olympic Games of 1896 and the Mid Olympics of 1906 were analyzed.

COMPETITION AND ASSESSMENT IN GYMNASTICS BY GUTS MUTHS AND JAHN

It is widely known that the birth, formation and the first development of Gymnastics took place during the first decades of the 19th century where the bases were set for this sport. A short mention of Gymnastics during this era will be helpful for the present study.

Since the first years the students of Jahn felt the need to be compared, to compete and to show excellence in many gymnastics events. In the sport's "primitive" era there were no technical specifications for the various gymnastic exercises. What was assessed was the number of repetitions of the various exercises and the endurance of the total performance time. In this way the best were easily found since the only thing needed was to measure repetitions or time. Jahn in his book «*Die Deutsche Turnkunst*», proudly narrates the story of his young student named August Thaer, who performed on the high bar 60 rotations (Aufschwünge), later increased to 132 (Göhler, 1987; Jahn, 1816; Spieth, 1989). Guts Muts, who is considered as the immediate precursor of Jahn in Gymnastics, in his writing *«Gymnastik für die Jugend»*, suggests that he assessed gymnastics by the number of repetitions and endurance (time). For exercise, competition and winners in his primitive high bar, many athletes were found simultaneously at the same apparatus, Guts Muts (1793, p. 225-226) mentions that: *"On the signal they jump and keep their weight on the bar. It is something one may do during climbing. It is very good if the gymnast competes and the winner is the one that will hold the most time"*.

At the beginning, the role of the judge was undertaken by the fellow athletes or the coaches who based their judgment on empirical observation and simple comparison of those competing. Later these primitive forms of assessment determined the winners and were developed, reformed and used by the creators of gymnastics, since this was necessary for the development of the sport itself. The development and specialization led the people involved with Gymnastics to search and apply more reliable assessment systems relevant to the level and needs of the sport.

Borrmann (1987, p. 36-37), informs us that the first official forms of gymnastics took place in 1832 at the gymnastics' festival of the city of Aarau, Germany while in 1844 the German city of Feldberg also held other activities and gymnastic events without archives regarding the assessment of athletes.

From the middle of the 19th century onward, the organization of athletic games always included gymnastics. No archives for the assessments were found.

Gajdos (1997, p. 198), informs us that in 1862 the Czech Federation of Gymnastics organized the first public events where the athletes' performance and the type of exercises were determined by a type of "lottery" as follows: *"Little pieces of paper with the various exercises were placed in a hat. Each athlete put his hand in the hat and after mixing the papers he took one. He then executed the exercise mentioned on the piece of paper while three judges graded with a score scaled from one to five"*.

In 1880 Frankfurt held a mixed event (exathlon) including three track and field and gymnastic apparatus events. For the assessment of these events, a scale from one to five was used (Borrmann, 1987).

JUDGMENT AND SCORING SYSTEMS IN THE FIRST OLYMPIC GAMES IN ATHENS (1896)

Just before the end of the 19th century many Gymnastics' Federations had been created in Europe, which used a score system with the highest score being the 10 or 20, with many specificities and deviations. During the same time though, a general mixed system began a form of specialization with qualitative execution. Assessment and classification of athletes became a complex and difficult situation. For this reason people involved with Gymnastics tried to find even more reliable and simpler ways of assessment.

In the German Gymnastics system we find a similar philosophy regarding the direction of assessment not only from country to country, but even from teams of different areas of the same country. Occasionally disputes arose causing many problems.

At the first modern Olympics in Athens (1896), the rules under which the so called *"gymnastics"* took place were not formed by the IOC or any international organization. The organizing country through a special committee had undertaken the obligation to form the regulations, taking under consideration only some directions given by the IOC and Coubertin (Kaimakamis, et al, 2002).

The committee members, that were all Greeks, supervised by gymnast Ioannis Fokianos, did not take under consideration foreign regulations used for many years prior to the games by many central European countries with a great tradition in gymnastics. (Chrysafis, 238).

Being aware of the fact that these regulations would not favor Greece, Fokianos adapted them to fit the abilities of local athletes, aiming to increase participation and possibly the chance for distinction. Both goals were reached since from a total of 71 athletes, 52 were Greek and the Olympic winner in still rings was the Greek Ioannis Mitropoulos. It should be noted that the success of the Greek athlete was not due to his excellent performance but mainly on the adapted in the Greek standards regulations. Lennartz (1995, p. 105) mentions for the winning of Mitropoulos: *«Despite the fact that German athletes were obviously superior in the still rings, the judges committee with Prince George presiding, announce the Greek Ioannis Mitropoulos as the winner».*

At the Olympic Games of Athens (1896), where the first games of Gymnastics took place, the score system with a scale of 20 points (Kaimakamis et al, 2002). For the assessment of athletes an international committee of seven judges presided by the Greek Prince George was used. The President's opinion was not doubted in case of disagreement among judge (Chrysafis, 1930; Teutenberg, 1995).

For synchronized team execution (high bars, parallel bars) the assessment was done as follows: Each judge assessed three factors simultaneously, i.e. synchronization (general team performance), rhythm and technique. For the above three factors each judge produced three scores from zero to 20 (Kaimakamis et al, 2003). The secretary added all the scores and then divided the sum of the seven judges. This means that if a team was awarded perfect scores from all judges then the final score would be 20+20+ 20X7:7 = 60. The assessment of the individual execution of the above two events, was done as follows: Each judge gave the athlete's routine two marks, one for power exercises and one for agility exercises. The secretariat then added all marks and produced a mean score which was divided by the number of judges (Kaimakamis, et al, 2002). As can be seen by some photographs of the Athens Olympic Games, judges would stand far from one another wearing black round hats and long black coats (Kluge, 1996; Tselika, 1995).

JUDGMENT AND SCORING SYSTEMS IN THE SECOND OLYMPIC GAMES IN PARIS (1900)

The second Olympics were set to take place in 1900 in Paris, despite the Greek reactions and the strong wish of some athletes, mainly Americans, for the Olympics to take place permanently in Greece (Mouratidis, 2009). Coubertin was very active in order to ensure success for the Games and for this reason he took advantage of the international trade fair in Paris, within which he included the sports of the Games. Things though, did not go as the French organizers wished since this fair not only did not give any merit and perspective to the revival of the Olympic Games but on the contrary it downgraded them (Yalouris, 1996). No mention neither the Olympics nor the International Athletic Games was found in any advertising material of the organizers (Concours Internationaux d' exercicis phissiques sports) or even of a world championship (Wohlrath, 1900). A main characteristic of the pretty bad organization and the chaos relating to the Games was the fact that these lasted for more than five months (from May 14 to October 28), without any opening and closing ceremonies. Many historians support that it was rather difficult for anyone to separate sports included in the Olympic program from simple demonstrations or other separate games that took place during the same period (Kamper, 1972; Lennartz & Teutenberg, 1995; Umminger, 1969).

At the Paris Olympic Games (1900) gymnastics took place according to the German system but with events and rules that favored the organizers (Chrysafis, 1930). Athletes competed only in one individual medley, including a total of 16 events from which some were track and field events. No individual medley was included in the competitive program because of a disagreement among the various sides regarding rules and judgments (Kaimakamis, 2001). For better organization athletes were separated in to 16 groups and moved from each event with the three judges grading with a scoring scale from zero to 20 with no decimals. In other words if an athlete scored perfect scores in all events his final score would be 16X20 = 320 points. At every event the score was a result of the mean of the scores given by the three judges (Wohlrath, 1900). The French Gustave Sandras was the winner, gathering 302 out of the 320 points. It should be noted that the organizers awarded Sandras the title of Champion du Monde without any mention of an Olympic Winner, a sign of a bad organization and downgrading of the Paris Olympics (Lennartz & Teutenberg, 1995).

During these games as well as at those that followed a big problem was created regarding objectivity of the judges and with the scoring system itself. The unprecedented triumph of the French athletes taking the top 27 places was not just a product of their numerical superiority (109 French out of a total of 136 athletes) or of their obvious competitive level by the competitive system formed according to their measures, along with the competition taking place in their country and the judges' favorable attitude (Wohlrath, 1900). Apart from this all events were well known to the French since for a long time these were included in the examinations' material for the military academy where almost all athletes were members.

The formation of the competitive system in favour of the organizing country as well as favourable judging was a fact for almost all games. Fokianos, four years earlier, during the Athens Games (1896) formed the competitive system based on his own views. On this issue Chrysafis (1930, p. 382) mentions that: *"For Fokianos it was a unique opportunity to adjust the rules of Gymnastics based on his own views and ideas".*

Regarding the lack of subjectivity of judges during the Paris Olympics, many eye witnesses-writers offered the following information. Chrysafis (1930, p. 382), who watched the games, writes: *"The outcome of the game is a great surprise while doubt is created regarding the correctness and impartiality of the judges' decisions".* The President of the Competition Committee Dr. Lauchaud (French) following the end of the games submitted a special report where among others admits that *"something went wrong with the judges"* (Chrysafis, 1930). Nevertheless, the fact that only capable German athletes many of which had triumphed at the Athens Games of 1896 were classified at lower positions (the first German was found at the 29^{th} position) definitely raises some questions. Pahncke (1983, p. 65) supports that *"it was a bitter* *disappointment resulting from the hostility shown by the German Federation against the Olympic Movement".* Lennartz & Teutenberg (1995, p. 34) wrote on same subject: *"German athletes expressed many complaints on the condition of the organs, the biased subjectivity of the judges and mainly on the facts that they were not allowed to exercise prior the main event".*

Information on the judgment issue, according to the above mentioned writers, is also given to us by the coach of the German team Fritz Hofmann (at a written report to the President of the German Olympic Committee, Dr. Gebhardt), the German athlete Theodor Wohlrath (1900, p. 36), the correspondence following the Games between Goubertin and Gebhardt, as well as by the written report submitted to the German Federation after the games by President of the German Olympic Committee (Gebhardt 1900). In other words, athletes, coaches, leaders and observers complained not only about the competitive system, which they knew in advance, but also for biased objectivity on behalf of the judges.

JUDGMENT AND COMPETITIVE SYSTEMS AT THE THIRD OLYMPIC GAMES IN ST LOUIS (1904)

The third international Olympic Games were organized at St. Louis, USA and lasted from July 1st to November 23. They were too included in a large international fair trade (Louisiana Purchase Exposition), despite the fact that the Americans had protested four years earlier against the French for such a form of the Games (Diem, 1912).

Gymnastics was quite a tradition throughout the USA and especially at the city hosting the Games, since a few decades ago many students and associates of Ludwig Jahn had moved there. This was actually the reason why there were so many gymnastics teams (Turnvereine) of German immigrants who promoted the German gymnastics system (Binz, 1985; Temme, 2000)

It should be mentioned that the participation of foreign athletes at the overseas

Olympics was very limited since only 10 foreign athletes (nine Germans and one Swiss) participated at the gymnastics events, while the 111 Americans participating were mostly of German origin (Gajdos, 1977; Göhler, 1980; Umminger, 1969). It was therefore a case of the organizing country with the German-American athletes and the few German ones. This was the reason why the proclamation of all gymnastics events as well as the program was written only in the German language (Kaimakamis, 2001).

As expected the Olympic Games of St. Louis (1904) were organized according to the German system but the Americans adjusted the competitive systems and the rules based on their own preference as was done by the organizers in 1896 and 1900.

(Kaimakamis, 2001). The above scoring system included four individual medleys (triathlon, hexathlon, heptathlon, enneathlon), and a team event which was unique for the history of the Games. The organizers included the last event (individual medley) to favor themselves, since only domestic teams and not nations were allowed to participate (Chrysafis, 1930; Kamper, 1972; Kluge, 1981). In total, seven gymnastics apparatus were included (some of which had obligatory programs) while from athletics triathlon, shot put, running and long jump were included, as well as swimming (Göhler, 1980; Ummiger, 1969).

At the Olympic Games of 1904 a total of eleven gymnastics events took place from which the IOC recognized only two sets of events as Olympic. The events were conducted in two different competition dates four months apart. At the first competition date, July 1-2, the International Turner's Championships took place including the all-around, the triathlon and team events. On October 29, the second competition date, the individual events took place in seven individual apparatus and the combined event. The latter were actually a

USA- AAU (Amateur Athletic Union) Gymnastics Championship, but because few foreign athletes also competed the games were recognized as Olympic Gymnastics Championships.(Göhler,1980; Merert, 1983).

At the St. Louis Olympics USA won almost all medals (29 out of 33 and 12 gold), since they took advantage of their numerical superiority, the selected by them events and the athletic abilities of the American athletes (Kaimakamis, 2001).

JUDGMENT AND COMPETITIVE SYSTEMS AT THE MID-OLYMPIC GAMES IN ATHENS (1904)

At the Mid-Olympics of Athens (1906), not organized by the IOC, two competitive systems with three events were included. In other words there was a team round according to the Swedish system and two individual rounds (pentathlon and hexathlon) according to the German system. At the first one, the team had 25 minutes to present the best exercises in various events, while the judges graded two factors, team synchronization and technique. In order to impress the judges all teams tried to put the aspect of difficulty in their exercises (Lennartz & Teutenberg, 1991; Savvidis, 1906). Scoring ranged from zero to 20 points resulting from the means scores of all the judges. The final team score came from the mean of all scores given for all events while decimals were also calculated. Teams scoring from 18 to 20 were classified at the first category while those scoring from 16 to 17, 90 were classified at the second category (Kaimakamis et al, 2001).

At the two individual rounds each athlete was given three minutes on each event to perform the best exercises of *power* and *skill.* Score for every event resulted from the mean of the scores given by each judge. The highest score an athlete could get was 20 points, while the final of the individual round resulted from the addition of the five scores given for the five organs. In other words, if an athlete scored in every apparatus 20 points, then his final score would be 20+20+20+20+20=100. In both team and individual rounds we had decimals and two categories (Kaimakamis et al, 2001).

Regarding judging and the organization of judges, the Greek organizers (up to the point that they could) did not leave space for negative comments and protests. It should be mentioned that at the Paris Olympics (1900) there was, as already mentioned, big problems due to the attitude of the organizers (Chrysafis, 1930). For this reason the Hellenic Olympic Committee sent on October 1905, Ioannis Chrysafis to various European cities (Stockholm, Copenhagen, Paris, Berlin) to be updated on the rules and regulations of the most important sports, in order for the rules applied at the Athens Olympics to be more or less commonly accepted. It should be noted that the Germans had submitted since 1901 to the IOC a proposal for the formation of unified and commonly accepted rules, which did not get accepted by the IOC. The Germans talked about a set of commonly accepted written rules as these were applied by their federation (Lennartz, 1999; Lennartz & Teutenberg, 1991). The German Olympic Committee noted that what happened during these games, made the following positive comments regarding judgment and organization shown by the Greeks: *“At the same time one should congratulate the judges. They were generally objective and only a few actions led to protest. It should also be mentioned that the work of a judge is very difficult when it comes to international games. We wish for the formation of international rules at future Olympic Games”* (Lennartz & Teutenberg, 1991).

As a protest one can consider the view of M. Brustmann for excessive time (3 minutes), given to athletes in individual rounds for each event. Here is what a track and field athlete wrote, who seemed to know in depth issues related to Gymnastics in that era: *“It seems to me that rules for gymnastics pentathlon and hexathlon have been formed by people who did not know* *much about competition, since in my opinion it is bad for an athlete's health to execute exercises on an apparatus for such a long time"* (Brustmann, 1906).

Also, the German coach Fritz Hofmann (also coach at the Olympics of 1896 and 1904), in order to justify the not so flattering position of the German team, expressed the view that the Greek leaders favored more the Danish and Norwegians since the coaches of both these teams were their army colleagues. Such a view though seems to have no basis. The fact though that Greece had started to use the Swedish system leaving the German one aside, may have led the Greeks to emotionally affect them towards the Swedish. The heart of these Games was Chrysafis who since 1900 and onward had endorsed the Swedish system showing at the same time a blind hatred towards the German one (Paleologos, 1960).

Finally, Savvidis (1906, p. 38) (an eye witness and sports commentator) who among others promotes the excellent organization and subjectivity of Greeks expresses some reservations regarding judging at pentathlon: *"The judges' committee is divided. Others watch (assess) parallel bars, others the high bar, others the still rings and others pommel horse, meaning that no judgment will be fair considering that the same judges should judge all events".*

During the same year and during the Mid-Olympics of Athens, a technical committee was formed for the first time under the auspices of FEG in order to discuss and offer solutions to many problems regarding the primitive existing rules (Huguenin, 1981). This committee consisting mostly of active athletes made some progress towards this direction but it was not possible yet to solve all problems and form a commonly accepted scoring system. It should be noted that this committee with its first president, Pierre Hentges, was initially activated during the fourth International Tournament (Prague, 1907), while the initial proposal for its formation was prepared and submitted by the well organized Czechoslovakian Gymnastics Federation. In this sense technical and rules related issues that up to then were dealt by FEG's President, N. J. Cuperus and his Belgian advisors were now under the jurisdiction of an international committee (Huguenin, 1981). Regarding the above mentioned competition the Czechoslovakian professor Miroslav Klinger writes among others that: *"Scoring was secret and made known only at the end of the competition, while athletes were obliged to wear shoes when performing* (Huguenin, 1981). The same Czechoslovakian Federation from 1907 to 1936 applied the following rules: "*Execution errors, change or replacement of elements in the obligatory program that was graded from zero to 10, was penalized with the score of zero. Free program was graded with the highest score 20, i.e. up to 10 points for the assessment of difficulty and up to 10 for execution. Already since then, athletes in their free program should have included elements of power, position and swinging without clarifying the specific analogies".*(Gajdos, 1994).

It is important to state that during this era there was no cooperation at all between FIG and the IOC.

JUDGING AND COMPETITIVE SYSTEMS DURING THE FOURTH OLYMPIC GAMES IN LONDON (1908)

The Olympics of 1908, officially the Games of IV Olympiad, took place parallel to the Franco – British Exhibition, from April 27 to October 31, 1908. Contrary to the Paris and St. Louis Olympics, which due to chaotic conditions in sports the Games were downgraded, the London Games were quite successful. Success was mainly a result of the fact that more than a 2/3 of all sports took place within the two weeks of

July at the White City Stadium. (Kluge, 1997; Lennartz, 1998).

Gymnastics games also took place at the White City Stadium at specially formed premises from July 13 to July 18. At the

London Olympics, and in order for the IOC to maintain some balance among the German and the Swedish systems, it organized the Games with two competitive systems: One team event according to the Swedish system and an individual event according to the German system (Göhler, 1980). At the first competition a team consisting from 16 to 40 athletes had 30 minutes to execute exercises on various apparatus. The competitions were judged by three judges who assessed general impression, difficulty, versatility, entrance and exit of its team. Each judge could give a maximum of 160 points for each execution. In other words a judge could give 40 points (the maximum) for entrance and exit, 60 for versatility and accuracy and 60 for level of difficulty. At the end of the competition the scores of all three judges were added and the summary was the actual score of the team (160+160+160=480 maximum score) (Lennartz, 1999).

At the individual round (heptathlon) according to the German system each athlete had two minutes time on every apparatus.(Gajdos, 1997; Kaimakamis, 2001; Kluge, 1977). For this competition there were also three judges, who graded on a scale from zero to 24 points. For every apparatus the grade resulted from the mean of the scores of all judges, while the final (individual all- around event) score was the sum of the scores of all apparatus. These Games were the first to assess separately the difficulty of the exercise and technique (Gajdos, 1997). Many protests were made though for unreliable judgments and the competitive systems (especially by the Italians and German athletes and team leaders).

It should be noted that by Coubertin's proposal the judges were all English who supported, as did the viewers, the Swedish system (Gajdos, 1997; Pahncke, 1983). The fact that the English athlete Tysal was placed second and had no other athletic achievements and, thus, no athletic future was an indication for the lack of biased subjectivity of the judges. Göhler (1980, p. 160) conveying the view of the Germans, Gunsch and Wiedemann on the same issue writes: *"German athletes did not lose because of lack of ability but because arbitrariness and lack of objectivity of the international and more specifically of the English judges"*.

The German Federation believed that the competitive system and the judging were not proper or objective, and ignored the institution of the Olympic Games. As already mentioned the German Olympic Committee had suggested that the IOC suggested the formation of special international judges' committee for judging and assessing all sports. This was not accepted due to other existing predicaments (Lennartz, 1995). It should be mentioned that during these Games FEG participated for the first time without having any special jurisdiction.

JUDGING AND COMPETITIVE SYSTEMS DURING THE FIFTH OLYMPIC GAMES IN STOCKHOLM (1912)

Stockholm Olympics with their good organization and great success created hopes for their global promotion and acceptance (Mouratidis, 2009). After 1896, these were the first Olympic Games that were not included or were a secondary event within some international trade.

At the Stockholm Olympic Games (1912) the IOC and the FEG cooperated for the first time in organizing the competition, before problems resulted by competition and diversity of the two main systems (Swedish and German) (Kaimakamis, 2001). In order to keep some balance and keep all sides happy they organized the Games according to the following four systems:

-A team round according to the Swedish system.

-A team round with free selection of events, apparatus and exercises.

-A team round according to the German system.

-An individual round according to the German system (Kluge, 1977).

Despite these efforts protests were made for both competitive systems and judging. At the second competition which was a peculiar team round, there was a free selection of apparatus, events and exercises with a time limit of one hour and the team consisted of 16 to 40 athletes. There were five judges who graded not only qualitative execution and synchronization but also the number of athletes per team for a specific apparatus. The final score, each time, resulted from the addition of the scores given by all judges divided by the number of athletes and apparatus (Gajdos, 1997). If one studies the scores given by each judge and compares them with the rest of the judges (for a specific country), the degree of the judgment problem becomes obvious and was nothing but a *"Babel"*. Some scores were so far apart that one score was almost double the other. Carl Diem, chief of German delegation in O.G. 1912, presented a table with judges and scores given for each country, where the large difference among scores was clearly visible. At the third competition, a team round according to the German system also had five judges. Each team could have up to 24 athletes who competed on four events in one hour. Just as happened in the previous Games, there were great differences in the judges' scores (Diem, 1990).

Despite all the above, the games of Stockholm remained in history for the intense juxtaposition among the two main gymnastics system and mostly for the well organized effort of the Swedish to promote their own system (Huguenin, 1981). It should be noted that a first serious effort to promote the Swedish gymnastics system at a world level, was done in 1906 during the Mid-Olympics of Athens.

CONCLUSIONS

At the Olympic Games organized by the IOC (1896-1912) there were no commonly accepted rules. Each participating country composed its own rules in order to have balance on the one hand but favor itself on the other. This was the reason why in each Olympiad we had different competitive systems. It should be noted that we had only one competition (individual medley) in 1900 in Paris.

At almost all Olympic Games there was protesting not only for competitive systems but for the judgment as well. It should be noted that protesting during the Games of 1896 and 1906 was very limited.

At the competitive program of the first three Olympic Games (1896-1904) competitive systems and rules were added only according to the German Gymnastic system, while at the other three games (1906-1912) we also had the Swedish system. This was the reason why the problem with rules grew over the last three Games.

FEG and the representatives of various federations early on recognized various imperfections in rules and therefore agreed to change them. The fact though that each federation led its own path did not leave any room for mutual understanding, and so the significant changes did not occur immediately but much later.

During time cooperation did not exist between the IOC and FIG, regarding the organization of tournaments or even any exchanging of views. The two agencies first met at the Olympic Games of 1908. It was during the Games of 1912 where they first cooperated with each other. During the last years there was a sense of cooperation between the two agencies.

At that time Gymnastics was not a separate and specialized sport since it included more events than it does today. Apart from the traditional gymnastics events, various competitive systems included other sports as well (mainly track & field).

Various scoring scales were used (mainly 10 & 20 points). The factors assessed were synchronization (in team performance), technique, rhythm and difficulty. Within the same events there was different assessment for power and swinging.

The lack of written set of rules and commonly accepted operational specifications for gymnastics competitions, created great problems in the development of gymnastics. It should be mentioned that at competitions organized by FEG the various teams had the right to use their own events creating even bigger problems.

The German and Swiss were the most important Federations during this era (especially the first had the most power and the most athletes), did not like the two international agencies (FIG, FEG), neither the competitions organized by them. The two federations never participated at competitions organized by the FEG.

REFERENCES

Binz, R. (1985). Deutsche Turner in Amerika, *Turnen und Sport, 2*, 6-8.

Borrmann, G. (1978). *Gerätturnen* (3 th ed.). Berlin, Sportverlag.

Brustmann, M. (1906). Von Sport und Körper Kultur. Olympische Reiseneindrücke. *Kraft und Schönheit, 6,* 161-167.

Chrysafis, I. (1930). *Οι σύγχρονοι διεθνείς Ολυμπιακοί αγώνες (The moderne indernational Olympic Games),* Athens.

Diem, C. (1912/1990*). Die Olympischen Spiele 1912.* Kassel.

Dörrer, H. J. (1999). Neues für die Kampfrichter. *Olympisches Turnen Aktuell, 3,* 15.

Gajdos, A. (1994). Entwicklung und Prognose am Barren. *Olympisches Turnen Aktuell, 4,* 34.

Gajdos, A. (1997). *Artistic Gymnastics, A history of development and Olympic Competition.* Louborough: British Amateur Gymnastics Association. Limited, Louborough University.

Gebhardt, W. (1904). Korrespondenz zwischen Gedhardt und Coubertin, zwischen 1901 und 1902. In K. Lennartz, & W.Teutenberg, (1995) (Eds). *Olympische Spiele 1900 in Paris.* Kassel, Agon Sportverlag.

Göhler, W. (1980). Die Turnkunst bei den Olympischen Spielen. *Stadion, 6,* 158-164.

Göhler, W. (1987). Die Geburtsstunde des Recks vor 75 Jahren. *Turnen und Sport, 2*, 42.

Guts-Muths, J.C.F. (1793).*Gymnastik für die Jugend*, Schnepfenthal.

Jahn, L., & Eiselen, E. (1816). *Die Deutsche Turnkunst.* Berlin.

Huguenin, A. (1981). 100 years of the International Gymnastic Federation, 1881 – 1981. FIG: Moutier.

Kaimakamis, V. (2001). *Κύρια χαρακτηριστικά της εξέλιξης της Ενόργανης Γυμναστικής στο πρώτο μισό του 20ου αιώνα.* (*Major Features of Apparatus Gymnastics during the first Half of the 20th Century*). Unpublished doctoral dissertation, Aristotle University, Thessaloniki, Greece.

Kaimakamis, V., Koronas, K., Stefanidis, P. & Papadopoulos, P. (2001). The Gymnastic Competition at the Mesolympic Games of Athens (1906). *Studies in physical culture & Tourism, 8,* 17-23.

Kaimakamis, V. Balasas, G., Bara A. & Mouradidis, I. (2002). Gymnastics During the first Olympic Games of modern times (Athens 1896). *Studies in physical culture & Tourism, 9,* 40-48.

Kaimakamis, V. Stefanidis P., Laskari, T. & Mouratidis, I. (2003).The rules for gymnastics in the first international Olympic Games in Athens (1896). *Annual of CESH, 1,* 67-76.

Kampere, E. (1972*). Enzyklopädie der Olympischen Spielen*. Sttutgart, Römmerverlag.

Gluge, V. (1996). 1896 Athen, Athens, Athenes, Atenas. Die Bilder der Spiele der I. Olympiade von Albert Meyer und anderen Fotografen. Berlin, Brandenburgisches Verlagshaus.

Kluge, V. (1997). *Die Olympische Spiele von 1896 - 1986*. Berlin: Sportverlag.

Lennartz, K., & Teutenberg, W. (1991). *Die Deutsche Beteiligung an den Olympischen Spielen 1906 in Athen.* Köln: Agon Sportverlag.

Lennartz, K. & Teutenberg, W. (1995). *Olympische Spiele 1900 in Paris.* Kassel: Agon Sportverlag.

Lennartz, K. (1998). *Olympische Spiele 1908 in London.* Kassel: Agon Sportverlag.

Merert, F. (1983). *Olympische Spiele der Neuzeit von Athen bis L. Angeles*. Niederhausen: Verlag Schors.

Mouratidis, I. (2009). *History of Physical Education and Sports.* Thessaloniki: Copy City.

Panhcke, W. (1983). *Gerätturnen Einst und Jetzt.* Berlin: Sportverlag.

Paleologos, K. (1960).Τα γυμναστικά συστήματα και η εξέλιξης της γυμναστικής (The Gymnastik Systems and the Evolution of Gymnastik), *Δεκαετερίς Εθνικής Ακαδημίας Σωματικής Αγωγής*, Athens, *2*, 51-76.

Savvidis, P. (1906). *Λεύκωμα των εν Αθήναις Β' Ολυμπιακών Αγώνων του 1906 (Album of the 2nd Olympic Games of Athens 1906).* Athens.

Spieth, R. (1989). *Geschichte der Turngeräte.* Eicklingen.

Strickrodta, A. (1999). Neues Wertungssystem erstmals erprobt. *Olympisches Turnen Aktuell, 3,* 25.

Temme, M. (2000). *Die deutsche Turnbewegung in Chile 1852-1945.* Würzburg: Ergon Verlag.

Teutenberg, W. (1995). *Die Olympischen Spiele 1896 in Athen*, Kassel.

Tselika, B. (1995).*Ολυμπιακοί αγώνες 1896 (Olympic Games 1896).* Athens.

Uhr, J. (1999). Neues aus dem Turnen Kunst der Männer. *Olympisches Turnen Aktuell*, *1*, 7.

Uhr, J. (1999). Hardy Fink - Das Niveau ist weiter gestiegen. *Olympisches Turnen Aktuell*, *6*, 11.

Ummiger, W. (1969). *Die Olympischen Spiele der Neuzeit*. Dortmund.

Wohlrath, T. (1900). Das Internationale Wetturnen in Paris. *Deutsches Turn-Zeitung*, *45*, 36-39.

Yalouris, N. (1996). *The Olympic Games.* Athens: Ekdotiki Athinon.

Zschoke, K. H. (1997). *Κώδικας FIG, Ενόργανης Αγωνιστικής Γυμναστικής, Ολυμπιακός Κύκλος 1997-2000,(Code of Points, Artistic Gymnastics, 1997- 2000).*

Corresponding author:

George Papadopoulos
Themistokli 3, 54634
Thessaloniki, Greece
E-mail: papage55@yahoo.gr

COMPARISON OF FLOOR EXERCISE APPARATUS SPRING-TYPES ON A GYMNASTICS REARWARD TUMBLING TAKE-OFF

William A Sands[1], Brent Alumbaugh[2], Jeni R McNeal[3], Steven Ross Murray[2], Michael H Stone[1]

[1]East Tennessee State University, USA

[2]Colorado Mesa University, USA

[3]Eastern Washington University, USA

Original article

Abstract

Gymnastics tumbling has occurred on large spring floor apparatuses for several decades. The spring floors have used a variety of elastic materials and designs to provide an increased take-off velocity and a forgiving landing surface. The purpose of this study was to assess the efficacy of a standard cylindrical spring (10.7 cm x 5 cm diameter, 9 coils) and a modified spring (10.7 cm, 5 cm widening to 6.7 cm diameter, 9 coils) in tumbling take-offs. Specifically, take-off foot contact durations and center of mass (COM) velocities from female gymnasts (14.8±2.8 y, 159.0±7.2 cm, 49.3±7.1 kg) were measured. Gymnasts performed two trials each of a round off, flic flac, to a layout rearward somersault on each spring-type attached to a tumbling strip (12.19m x 2.41m). Data were acquired via a Vicon^{TM} kinematic system using 43 markers and 10 cameras at 200 Hz. Data were found to be reliable across trials. Analysis consisted of two, 2x3 repeated measures ANOVAs. The results showed no statistical differences between spring-types in terms of contact durations or COM component velocities. Spring-type design differences may lead to disparate spring constant and frequency effects, however, these effects of may be overwhelmed by the influences of gymnast skill, matting, carpet, and the wood and fiberglass laminate panels.

Keywords: *spring floor, somersault, jump, comparison.*

INTRODUCTION

The spring floor has been a mainstay of the floor exercise event for artistic men's and women's gymnastics for decades. The floor exercise apparatus is a 12m x12 m area that permits tumbling, balance, and other acrobatics in competition and training. The floor exercise apparatus in the United States has evolved in several stages: 1) a bare wooden gym floor, 2) a wooden gym floor with small mats strategically placed for skills, 3) a thin rubberized mat approximately one centimeter thick, 4) a wrestling-type mat, 5) a closed-cell foam mat with carpet, 6) a closed cell foam mat with vinyl covering, and 7) a spring floor using plywood laminate as the supporting surface with 5 or 10 cm (2 or 4 in) springs or foam blocks. The floor exercise supporting surface has transitioned from plywood to fiberglass-laminate panels and from 5 cm (2 in) to 10 cm (4 in) springs or foam blocks (Federation Internationale de Gymnastique, 2009). Internationally, the floor exercise apparatus has followed different design directions. For example, an early version included flexible wood panels separated in layers by staggered spacers that allowed the multilayer wood sections to rise and fall without interference (Figure 1).

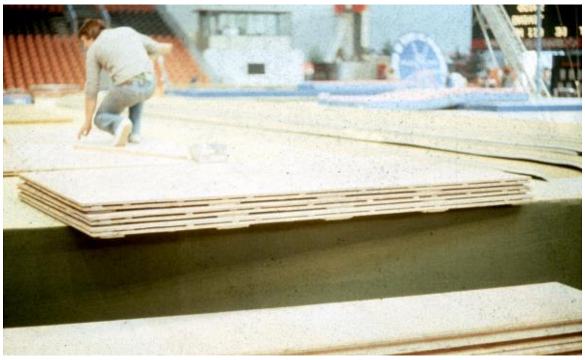


Figure 1. *Side view of an older spring floor design made completely of wood. Note the small spacers that are strategically placed such that no two spacers lie on top of each other thus giving the floor the ability to flex when loaded.*

The modern spring floor has been examined for various purposes in the past, particularly involving physical properties (Arampatzis & Bruggemann, 1999; Gormley, 1982; Paine, 1998; Peikenkamp, van Husen, & Nicol, 1999; Wilson, Neal, & Swannell, 1989). Less often, investigators have addressed the interactions between the gymnast and the spring floor (Arampatzis & Bruggemann, 1999; McNeal, Sands, & Shultz, 2007; Sands & George, 1988).

Characteristics investigated in the past have been the following:

- conical versus cylindrical springs (Gormley, 1982),
- foam block versus metal springs on somersault trajectory distances (Sands & George, 1988),
- dynamic loading response (Wilson et al., 1989),
- energy transfer from a somersault to a spring floor (Arampatzis & Bruggemann, 1999),
- optimal spring floor construction using 5cm springs and frequency response (Paine, 1998),
- leg stiffness control during jumping on an elastic surface (Arampatzis, Bruggemann, & Klapsing, 2000),
- a simulation of an area spring surface using a simple spring and mass damper model (Peikenkamp et al., 1999),
- kinematics of forward and backward twisting and non-twisting backward somersaults with electromyography (McNeal et al., 2007).

As the spring floor has evolved, elastic materials such as support panels and springs have been used to enhance the energy transfer of the legs to the spring floor and back to enhance flight phases and cushion landings. Elastic materials have increased the prominence of vibration and the influence of the frequency response of the floor to the athlete (Arampatzis et al., 2000). The concept of an ideal – tuning - of a floor area to achieve an optimal rebound response has been investigated and discussed for some time, primarily in running (Boyer & Nigg, 2006; McMahon, 1985; McMahon & Greene, 1978). Moreover, the ability of the participant to modify leg stiffness based on the running and jumping surface has also garnered attention (Arampatzis et al., 2000; Avela & Komi, 1998; Ferris & Farley, 1997; Grillner, 1972; Horita, Komi, Nicol, & Kyrolainen, 1996; Kuo, Wang, & Wang, 2002; Kyrolainen, Finni, Avela, & Komi, 2003; McHugh & Hogan, 2004).

One of the most important characteristics of the spring floor is the enhancement of the tumbling take-off in terms of trajectory height and rotation of the body about the feet and in the air. Trajectory height affords the gymnast ample time to complete his or her skills. The horizontal component velocity of the center of mass (COM) at take-off reflects the amount of a “trip-effect” that was obtained (Sands, 2011). The trip-effect leads to enhancing the somersault rotation of the gymnast. Paine and colleagues (Paine, 1998; Paine, Self, & Major, 1996; Self & Paine, 2001) studied the then current spring floor by cutting a rectangular section from a spring strip panel that fit over an in-ground force platform. As a part of his bioengineering doctoral dissertation, Paine experimented with spring floor modifications to “tune” the rebound characteristics of the spring floor by: adding springs (increasing stiffness), subtracting springs (decreasing stiffness), adding mass (changing the natural frequency), and using two different length springs (accommodating stiffness). Paine showed that a promising aspect of different length springs was the separation of elastic characteristics that could accommodate lighter loads, such as those from a small gymnast, and heavier loads, such as those from a larger more powerful gymnast. Previously and following Paine, the idea of an accommodating jumping surface has been studied by others (Gormley, 1982; Moritz & Farley, 2003; Wilson et al., 1989; Wilson, Swannell, Millhouse, & Neal, 1986). The basic premise is similar to that of adjusting the fulcrum on a diving board to match the approach and jump characteristics of the diver (Boda, 1993; Cheng & Hubbard, 2004; Jones & Miller, 1996).

The purpose of this study was to compare rearward somersault take-off characteristics as achieved from two types of coil springs attached to a spring tumbling strip. Specifically, this study sought to compare COM velocities (horizontal, mediolateral, vertical, and resultant), and foot contact phase durations (toe contact to heel contact, heel contact to heel departure, and heel departure to toe departure). It was hypothesized that there would be no statistical differences between the two spring floor-types. Our hope was that the modified spring would provide an obvious advantage to take-off parameters, but in keeping with a conservative approach, our hypothesis was - no difference.

METHODS

Subjects. Ten female gymnasts from the Grand Junction, Colorado area volunteered as subjects. All were experienced gymnasts with competitive abilities ranging from Level 7 to Level 10 within the USA Gymnastics Junior Olympic competitive hierarchy (USA_Gymnastics, 1994). Demographic information on the subjects is shown in Table 1. This study was approved by the Mesa State College and the East Tennessee State University Institutional Review Boards. All subjects and parents/guardians read and signed an informed consent/assent form in conjunction with data collection.

Table 1. *Subject Characteristics (N=10).*

Variable	Mean	SD	Minimum	Maximum	Range
Age (y)	14.8	2.8	11	19	8
Height (cm)	159.0	7.2	148.4	169.8	21.4
Mass (kg)	49.3	7.1	38.1	58.2	20.1

Equipment. The athletes performed a round off, flic flac (back handspring), back layout somersault on a tumbling strip (12.19 m x 2.41 m, 40 ft x 8 ft). The tumbling strip consisted of 2.41 m x 1.23 m x 0.013 m (8 ft x 4 ft x 0.5 in) panels of wood and fiberglass laminate. The tumbling strip was covered with continuous 12.8 m x 1.83 m x 0.05 m (42 ft x 6 ft x 2 in) foam matting (Figures 2 and 3). The matting was marked with red duct-tape near the take-off area 0.305 m (1 ft) from the edge. A start marking was used and represented the starting position of the athletes' tumbling sequences in their regular gym relative to their training gym floor exercise area and their regular foam pit landing area. A square of approximately 0.46 m was taped in red duct-tape as the take-off "target" for the feet of the gymnasts. This square was placed directly over the center of the take-off spring panel at the end of the tumbling strip and directly over the four central springs. Thirty-two springs were attached in 37 cm squares encompassing the bottom surface of each spring panel as per manufacturer instructions (Figure 4). The springs were provided by American Athletic Incorporated (ELITE™ Power Spring, Jefferson, IA, USA) and Weller Spring™ (King Bar Sports, Carefree AZ, USA, Patent No.: US 7,993,244 B2 Patent No.: US 8,337,368 B2), hereafter referred to as the cylindrical and modified springs, respectively.

Figure 2. *Spring strip as seen from the take-off end.*

The cylindrical spring was 10.7 cm in height and 5 cm in diameter with 9 coils. The modified spring was more complex in design, 10.7 cm in height, and 5 cm in diameter at the top and widening to a 6.7 cm diameter near the bottom. The modified spring used six coils on the upper spring section and three coils on the lower. Figure 5 shows the two types of springs and the fastening bracket.

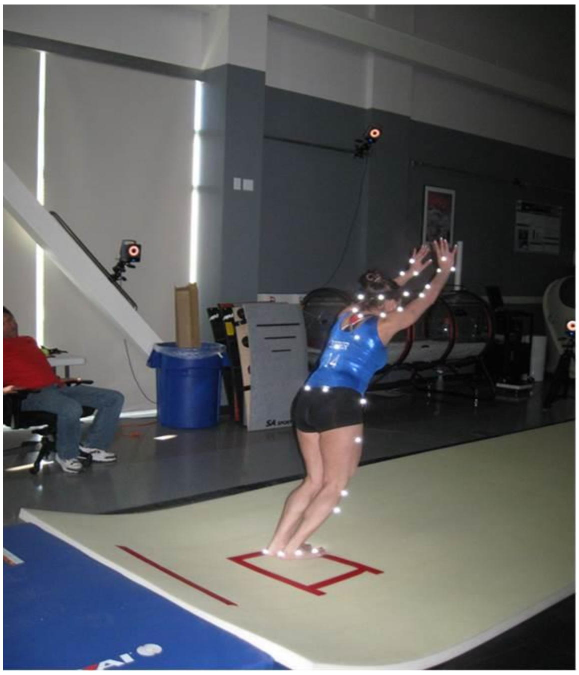


Figure 3. *Take-off area with taped markings.*

Figure 4. *Spring arrangement on the underside of the spring strip panel.*

Figure 5. *Modified spring on the left, spring end cap in the middle, and an cylindrical spring on the right.*

Instrumentation. Kinematic 3D data capture and analyses were performed automatically by detection of 43, 14.5mm reflective markers using 10, Vicon™ T-Series T040 infrared cameras. The cameras were placed around the tumbling take-off area with four cameras on tripods low to the ground and six cameras on metal pipes mounted on the walls above the athlete. The Vicon-Nexus™ system was set to capture athlete marker motion at 200 Hz.

Forty-three reflective markers (14 mm diameter) were used for calibration as per the manufacturer's instructions and the Vicon-Nexus™ KAD-alike PlugInGait FullBody segment model included with the Nexus™ collection and analysis software was used to create the body segment model. Calibration of the subject required the use of four reflective markers on the medial aspects of the knees and ankles that were later removed for the tumbling trials. The marker set included the following: left front head, right front head, left back head, right back head, seventh cervical vertebrae, tenth thoracic vertebrae, superior notch of the manubrium, center of the sternum, right inferior-medial angle of the scapula, left shoulder, left upper arm, left elbow, left forearm, left ulnar wrist, left radial wrist, and left index finger at the metacarpal-phalangeal joint, left anterior superior spine, right anterior superior spine, left posterior superior spine, right posterior superior spine, left lateral knee, left medial knee, left shank, left lateral malleolus, left medial malleolus, left heel, left foot at the metatarsal-phalangeal joint of the second toe, right shoulder, right upper arm, right elbow, right ulnar wrist, right radial wrist and right index finger at the metacarpal-phalangeal joint, right thigh, right lateral knee, right medial knee, right shank, right lateral malleolus, right medial malleolus, right foot at the metatarsal-phalangeal joint of the second toe, and right heel. Figure 6 shows the marker set on an athlete. The COM model is included automatically within the Vicon-Nexus™ KAD-alike_PlugInGait_FullBody body segment model. The markers were attached to the appropriate anatomical landmarks with toupee tape. System calibration, camera checks, and monitoring of infrared noise from the separate images of each camera were performed and corrected prior to each data collection session.

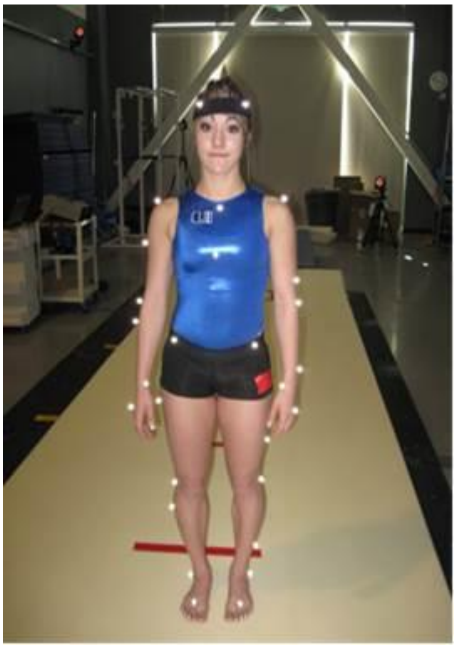


Figure 6. *Marker set for data capture. Note, the medial knee and ankle markers have been removed.*

Procedures. The subjects came to the laboratory dressed in a leotard and spandex-type shorts (Figure 6). All subjects performed the tumbling trials in bare feet. Upon arrival, the subjects were measured for heights, masses, and queried for ages and birth dates. The subjects were then weighed, and several anthropometric measurements were obtained from the subjects' right sides as per the Vicon-Nexus^{TM} KAD-alike_PlugInGait_FullBody segment model requirements. The anthropometric measurements were as follows: leg length from the anterior superior spine to the medial malleolus across the patella, knee breadth, ankle breadth, shoulder "offset" measured from the acromion to the presumed center of the glenoid fossa, elbow breadth, wrist breadth, and hand thickness. All measurements were recorded in millimeters for later computer program entry.

Following anthropometric measurements, the reflective markers were placed on the appropriate anatomical landmarks. The subjects then stood still with feet apart and arms sideward for a "T-Pose" that was recorded and used to later calculate and verify body segment parameters and the calculation of the location of the whole body center of mass. Once adorned with reflective markers the subject was allowed an unlimited self-selected warm up period to familiarize herself with the tumbling strip, landing area, and the tumbling pass. Following warm up, the gymnast performed two or more round off, flic flac (back handspring), back layout somersault tumbling passes. The athletes had unexpected difficulty hitting the target area with their feet during their tumbling take-offs. It was determined that a take-off within approximately 30cm of the target area was sufficient in order to prevent fatiguing the gymnast through excessive tumbling trials seeking an exact target hit.

The spring floor panels were set up with modified springs on four panels and cylindrical springs on five panels. This approach was used to ensure that the full tumbling pass, except for the start of the run, was always performed on the spring floor spring-type of interest. In this way, the investigators could rapidly exchange the two types of spring panels so that the subjects only had to come to the laboratory once instead of twice. By maintaining the first panel the same, the alignment of the spring strip was easier and the time required to make the panel transitions was reduced. Reducing time during the transition was important to maintain the athlete's warm up. Athletes performed two or more familiarization tumbling passes following the panel transitions to ensure adequate warm up and step and take-off spacing. Assignment of the spring-type order of use was randomized and counterbalanced. Thus, after completion of two recorded tumbling trials the athlete rested for several minutes while the spring strip panels were reversed and realigned for a second set of two tumbling trials. The entire procedure required approximately one hour.

Data Analysis. Variable values were extracted from collected data of each recorded tumbling trial. Each trial was filtered using a Woltring filter (Woltring, 1985, 1986) following cropping, processing, and to determine the center of mass location for each frame. All paired variables were subjected to reliability analyses using an intraclass correlation. The mean of the two legs and trials was used for further data analyses. Descriptive statistics, 95% confidence intervals, and two repeated measures ANOVAs (RMANOVA, both dimensions), paired t-tests, effect sizes, and statistical powers were calculated to determine if there were differences between the kinematic variables between the two spring floor spring-types and to characterize the foot contact behavior of the gymnast during take-off (Cohen, 1988). RMANOVAs were calculated including: 2x3 (spring floor spring-type by foot contact durations) and a 2x3 (spring floor spring-type by velocity components of the COM at take-off). Type I error was controlled via the Bonferroni method (Sokal & James Rohlf, 1969).

RESULTS

Descriptive statistics for foot contact times and durations are shown in Table 2. Table 3 provides the center of mass take-off velocity values obtained at departure of the toes from the spring floor. Reliability analyses were conducted on the paired variables such as left and right legs and on trials one and two. Reliability was calculated using spreadsheet algorithms provided by Hopkins (Hopkins, 2000). Intraclass correlations were calculated across trials first and then from variable-to-variable. Intraclass correlations were also calculated across spring-types first and then from variable-to-variable. The results showed that all intraclass correlation coefficients for all variables exceeded 0.79, indicating excellent reliability (Lexell & Downham, 2005). There were no statistical differences with any variable pair (all P > 0.05). Sample distribution normality was tested with the Shapiro-Wilk test (O'Donoghue, 2012).

Table 2. *Descriptive Statistics – Foot Contact Durations.*

Variable	Spring Type	Mean	SD	95% Confidence Interval Lower	Upper
Toe to Heel Duration (s)	Cylindrical	0.026	0.006	0.021	0.030
	Modified	0.024	0.004	0.021	0.027
Heel to Heel Departure (s)	Cylindrical	0.053	0.017	0.041	0.065
	Modified	0.058	0.012	0.050	0.065
Heel Departure to Toe-off (s)	Cylindrical	0.070	0.046	0.036	0.103
	Modified	0.051	0.019	0.037	0.064
Total Contact (s)	Cylindrical	0.148	0.046		
	Modified	0.133	0.017		

Table 3. *Descriptive Statistics – Take-off Velocities.*

Variable	Spring Type	Mean	SD	95% Confidence Interval Lower	Upper
Mediolateral (V_x m• s^{-1})	Cylindrical	0.04	0.18	-0.86	1.67
	Modified	0.07	0.19	-0.67	2.09
Horizontal (V_y m•s^{-1})	Cylindrical	3.04	0.48	2.69	3.39
	Modified	3.22	0.47	2.89	3.56
Vertical (V_z m•s^{-1})	Cylindrical	4.29	0.62	3.85	4.74
	Modified	4.24	0.49	3.89	4.59
Resultant (V_R m•s^{-1})	Cylindrical	5.29	0.57		
	Modified	5.35	0.48		

Three foot contact phases were identified, toe contact to heel contact, heel contact to heel departure, and heel departure to toe departure. All athletes touched their heels to the spring floor matting. A 2 (springs) x 3 (foot contact phases) RMANOVA was calculated. The analysis violated the sphericity assumption resulting in use of the Greenhouse-Geisser adjustment of degrees of freedom. The analysis showed no statistically significant within subjects main effects for spring-type ($F_{(1,9)} = 1.03$, $p = 0.34$, $\eta^2_{partial} = 0.10$, power = 0.15), or the spring by contact phase interaction ($F_{(1.3,11.7)} = 2.0$, $p = 0.19$, $\eta^2_{partial} = 0.18$, power = 0.28). There was a statistically significant main effect for foot contact phase times ($F_{(1.14,10.24)} = 10.72$, $p = 0.007$, $\eta^2_{partial} = 0.54$, power = 0.87). Contrast procedures showed that the first phase was statistically different from the third phase (F(19) = 20.7, p = 0.001, $\eta^2_{partial}$ = 0.70, power = 0.98). Ninety-five percent confidence intervals for the foot contact phase data are shown in Table 2.

The velocity components (mediolateral (x), anterior-posterior (y), vertical (z)) of the COM at take-off were analyzed via a 2 (springs) x 3 (COM velocity components at take-off) RMANOVA. The analysis showed no statistically significant within subjects main effects for spring-type ($F_{(1,9)}$ = 1.65, p = 0.23, $\eta^2_{partial}$ = 0.15, power = 0.21), or the spring by velocity components interaction ($F_{(2,18)}$ = 2.2, p = 0.14, $\eta^2_{partial}$ = 0.19, power = 0.39). There was a statistically significant main effect for velocity components ($F_{(2,18)}$ = 259.0, p < 0.001, $\eta^2_{partial}$ = 0.97, power = 1.0). The main effect for velocity components was expected based on the directions of these vectors. Ninety-five percent confidence intervals for the velocity components data are shown in Table 3.

Paired variables for the total floor contact times and the COM resultant velocities between spring floor-types were examined using matched pairs t-tests. The mean values for each variable by spring floor-type are shown in Tables 2 and 3. The total foot contact times did not show a statistical difference between floor-types ($t_{(9)}$ = 1.02, p = 0.34, η^2 = 0.009, 95% CI: -0.019s to 0.050s). The resultant velocity of the COM at take-off did not show a statistical difference ($t_{(9)}$ = -0.8, p = 0.44, η^2 = 0.006, 95% CI: -226.3m•s^{-1} to 107.7ms^{-1}). Pearson correlation coefficients of the relationship between total foot contact times between the spring-types was r = 0.05, p = 0.88), and the resultant velocity of the COM between spring-types was r = 0.91, p < 0.001).

DISCUSSION

The goal of this study was to characterize the differences between spring floor-types characterized by different coil springs by assessing foot contact times and COM velocities at take-off. Although there were statistical differences between the durations of foot contact phases, and between the velocity components of the COM, there were no statistically significant differences between spring floor-types. In addition, the statistical correlation between COM resultant velocities across spring types showed that the velocities were highly similar. Moreover, effect sizes and confidence intervals supported the hypothesis test statistics. These analyses indicate that in spite of a clever spring design, the modified spring did not change or enhance performance relative to foot contact durations and take-off velocities. The cylindrical spring and the modified spring do not appear to differ in their influence on the gymnast's rearward somersault tumbling take-off.

Gymnastics performance analysis rarely considers the interaction of the gymnast and the apparatus. This simple study investigated whether two different types of springs resulted in differences in take-off performance. Tumbling take-offs have been shown to reveal differences in gymnast ability via anterior-posterior and vertical velocity components (Burgess & Noffal, 2001). Engineering approaches (Paine, 1998) and computer modeling (King & Yeadon, 2004a, 2004b) have been used to characterize the spring floor, perhaps because of the ease of maintaining experimental controls (Federation_Internationale_de_Gymnastique, 2009; Sands, 2000).

Although this study did not show enhanced take-off performance based on spring-type, the influence of the spring floor on performance and safety remains a possibility. Other performance factors may have a more dominant influence on take-off parameters. Gymnasts may alter their muscle stiffness properties as a result of practicing on different surfaces, much as runners alter their leg stiffness to cope with differing terrains (Arampatzis et al., 2000; Arampatzis, Bruggemann, & Klapsing, 2001; Günther & Blickhan, 2002; Kuitunen, Ogiso, & Komi, 2011; McNeal et al., 2007). Gymnasts' skill and strength may confound simple relationships by virtue of the ability of a gymnast to jump effectively during the take-off regardless of the spring floor by skillfully altering lower extremity muscle stiffness. Historically, gymnasts have performed rearward somersault take-offs on road pavement, sidewalks, and other surfaces that provide little or no rebound springiness. Of course, no one would advise regular use of harsher take-off and landing areas, but the floor exercise apparatus should be tuned properly such that the spring floor acts in synchrony with the gymnast. The present study indicates that spring characteristics may not be a powerful variable for controlling spring floor behaviors.

The future should bring increased emphasis on the identification of those factors that enhance tumbling skill performance while being sensitive to safety demands via injury prevention. Specifically, future investigations should address the mechanical behaviors of the various springs, matting, carpet, panels, and sub-flooring such as the competitive podium. Perhaps unfortunately, the specific performance context of spring floor in competition will be complicated by the interaction of many variables. Finally, the gymnast's ability to manage his/her lower extremity stiffness during the decisive moment of take-off should be explored and a reasonable range of stiffness management tactics should be identified for differing ages, sizes, and ability levels.

REFERENCES

Arampatzis, A. & Bruggemann, G.-P. (1999). Energy and performance - storage and return of elastic energy by gymnastic apparatus. In M. Leglise (Ed.), *Symposium Medico-Technique* (pp. 29-37). Lyss, Switzerland: International Gymnastics Federation.

Arampatzis, A., Bruggemann, G.-P. & Klapsing, G. M. (2000). Control of leg stiffness and its effect on mechanical energetic processes during jumping on a sprung surface. In Y. Hong & D. P. Johns (Eds.), *Proceedings of XVIII International Symposium on Biomechanics in Sports* (pp. 23-27). Hong Kong, China: The Chinese University of Hong Kong.

Arampatzis, A., Bruggemann, G. P. & Klapsing, G. M. (2001). Leg stiffness and mechanical energetic processes during jumping on a sprung surface. *Med Sci Sports Exerc, 33*(6), 923-931.

Avela, J. & Komi, P. V. (1998). Interaction between muscle stiffness and stretch reflex sensitivity after long-term cycle exercise. *Muscle Nerve, 21*, 1224-1227.

Boda, W. L. (1993). Predicting optimal fulcrum setting for backward takeoffs. In R. Malina & J. L. Gabriel (Eds.), *U.S. Diving Sport Science Seminar 1993 Proceedings* (pp. 60-66). Indianapolis, IN: U.S. Diving Publications.

Boyer, K. A. & Nigg, B. M. (2006). Muscle tuning during running: Implications of an un-tuned landing. *J Biomech Eng, 128*, 815-822.

Burgess, R. & Noffal, G. (2001). *Kinematic analysis of the back salto take-off in a tumbling series: Advanced vs. beginner techniques.* Paper presented at the 19 International Symposium on Biomechanics in Sports San Francisco.

Cheng, K. B. & Hubbard, M. (2004). Optimal jumping strategies from compliant surfaces: A simple model of springboard standing jumps. *Human Movement Science, 23*, 35-48.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Federation_Internationale_de_Gymnastique. (2009). *FIG Apparatus Norms*. Lausanne, Switzerland: International Gymnastics Federation.

Ferris, D. P. & Farley, C. T. (1997). Interaction of leg stiffness and surface stiffness during human hopping. *J Appl Physiol, 82*(1), 15-22.

Gormley, J. T. (1982). An investigation of two spring-floor type characteristics and the muscular response in gymnasts of different body mass and skill performance levels. Underdale: South Australia. South

Australia College of Advanced Education. Author. Underdale, South Australia: South Australia

Grillner, S. (1972). The role of muscle stiffness in meeting the changing postural and locomotor requirements for force development by the ankle extensors. *Acta Physiol Scand, 86,* 92-108.

Günther, M. & Blickhan, R. (2002). Joint stiffness of the ankle and knee in running. *J Biomech, 35*, 1459-1474.

Hopkins, W. G. (2000). Measures of reliability in sports medicine and science. *Sports Med, 30*(1), 1-15.

Horita, T., Komi, P. V., Nicol, C. & Kyrolainen, H. (1996). Stretch shortening cycle fatigue: interactions among joint stiness, [sic] reflex, and muscle mechanical performance in the drop jump. *Eur J Appl Physiol Occup Physiol, 73*, 393-403.

Jones, I. C. & Miller, D. I. (1996). Influence of fulcrum position on springboard response and takeoff performance in the running approach. *J Appl Biomech, 12*(3), 383-408.

King, M. A. & Yeadon, M. R. (2004a). Maximizing somersault rotation in tumbling. *J Biomech, 37,* 471-477.

King, M. A. & Yeadon, M. R. (2004b). Optimum performance in tumbling: optimisation criteria. In M. Hubbard, R. D. Metha & J. M. Pallis (Eds.), *The Engineering of Sport 5* (pp. 461-467). Sheffield, UK: International Sports Engineering Association.

Kuitunen, S., Ogiso, K., & Komi, P. V. (2011). Leg and joint stiffness in human hopping. *Scand J Med Sci Sports, 21*(6), e159-167. doi: 10.1111/j.1600-0838.2010.01202.x

Kuo, P.-h., Wang, L.-L. & Wang, S.-Y. (2002). Leg stiffness changes in drop jumps with different stretch amplitude. In K. E. Gianikellis (Ed.), *Scientific Proceedings of the XXth International Symposium on Biomechanics in Sports* (pp. 378-380). Caceres, Spain: Universidad de Extremadura, International Society of Biomechanics in Sports.

Kyrolainen, H., Finni, T., Avela, J. & Komi, P. V. (2003). Neuromuscular beahviour of the triceps surae muscle-tendon complex during running and jumping. *Int J Sports Med, 24*, 153-155.

Lexell, J. E. & Downham, D. Y. (2005). How to assess the reliability of measurements in rehabilitation. *Am J Phys Med Rehabil, 84*(9), 719-723.

McHugh, M. P. & Hogan, D. E. (2004). Effect of knee flexion angle on active joint stiffness. *Acta Physiol Scand, 180,* 249-254.

McMahon, T. A. (1985). The role of compliance in mammalian running gaits. *J Exper Biol, 115*, 263-285.

McMahon, T. A. & Greene, P. R. (1978). Fast running tracks. *Sci Amer, 239*, 148-163.

McNeal, J. R., Sands, W. A. & Shultz, B. B. (2007). Muscle activation characteristics of tumbling take-offs. *Sports Biomech, 6*(3), 375-390.

Moritz, C. & Farley, C. T. (2003). Human hopping on damped surfaces: strategies for adjusting leg mechanics. *Proceedings of Biological Science, 270*(1525), 1741-1746.

O'Donoghue, P. (2012). *Statistics*. New York, NY: Routledge.

Paine, D. D. (1998). *Spring floor resilience and compliance modeling.* (PhD), University of Utah, Salt Lake City, UT.

Paine, D. D., Self, B. P. & Major, J. A. (1996). Forces experienced by gymnasts during take-offs and landings. In J. A. Hoffer, A. Chapman, J. J. Eng, A. Hodgson, T. E. Milner & D. Sanderson (Eds.), *Proceedings of the Canadian Society for Biomechanics, IXth Biennial Conference* (pp. 130-131). Kingston, Ontario: Canadian Society for Biomechanics.

Peikenkamp, K., van Husen, M. & Nicol, K. (June 30-July 6, 1999). *An empirical and modeling analysis of the area-elastic surface in a gymnasium.* Paper presented at the ISBS '99 Scientific Proceedings of the XVII International Symposium on Biomechanics in Sports, Perth, Western Australia.

Sands, W. A. (2000). Injury prevention in women's gymnastics. *Sports Med, 30*(5), 359-373.

Sands, W. A. (2011). Angular kinetics applied to gymnastics. In M. Jemni (Ed.), *The Science of Gymnastics* (pp. 94-104). London, UK: Routledge.

Sands, W. A. & George, G. S. (1988). Somersault trajectory differences: Foam block versus coil spring floor. *Technique, 8*(1), 8-9.

Self, B. P. & Paine, D. (2001). Ankle biomechanics during four landing techniques. *Med Sci Sports Exer*, *33*(8), 1338-1344.

Sokal, R. R. & James Rohlf, F. (1969). *Biometry*. New York, NY: W.H. Freeman.

USA_Gymnastics. (1994). *1994-95 Women's Program Rules & Policies*. Indianapolis, IN: USA Gymnastics.

Wilson, B. D., Neal, R. J. & Swannell, P. D. (1989). The response of gymnastic sports floors to dynamic loading. *Austral J Sci Med Sport*, *21(1)*, 14-19.

Wilson, B. D., Swannell, P., Millhouse, D. & Neal, R. (1986). *A biomechanical investigation of gymnastic take off and landing surfaces. Technical Report to the Coordinator Applied Sports Research Program, Australian Sports Commission, Canberra, ACT, Australia*. Canberra, ACT, Australia: Australian Sports Commission.

Woltring, H. J. (1985). On optimal smoothing and derivative estimation from noisy displacement data in biomechanics. *Hum Mov Sci, 4*, 229-245.

Woltring, H. J. (1986). A FORTRAN package for a generalized, cross-validatory spline smoothing and differentiation. *Adv Engin Software, 8*(2), 104-113.

Corresponding author:

William A Sands, PhD, FACSM, NREMT, WEMT, CSCS
Professor, Department of Exercise and Sport Science
East Tennessee State University
Johnson City, TN 37601
719.313.8915
sandsw@etsu.edu
wmasands@hotmail.COM

DIFFERENCES IN THE KEY KINEMATIC PARAMETERS OF DIFFICULT HANDPSRING AND TSUKAHARA VAULTS PERFORMED BY ELITE MALE GYMNASTS

Roman Farana, Jaroslav Uchytil, David Zahradník, Daniel Jandacka, Frantisek Vaverka

University of Ostrava, Czech Republic

Original article

Abstract

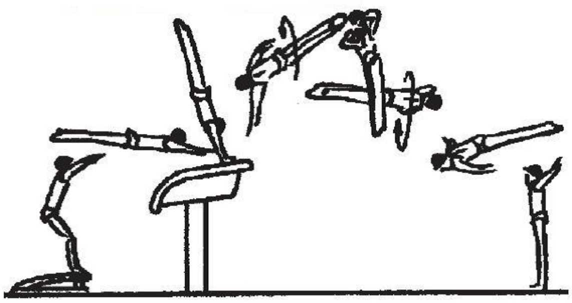
The aim of the study was to compare key kinematic parameters of two difficult groups of vaults performed by elite male gymnasts during a World Cup competition. The participants were twenty top-level male gymnasts who participated in the 2010 and 2011 World Cup competition in Czech Republic. The gymnasts performed Handspring and Tsukahara type vaults with a 5.2 level of difficulty. For the 3D movement analysis two digital camcorders with a frame rate of 50 Hz were used. The data was digitized by the SIMI MOTION software. To establish the differences between the means, the effect size (ES) was calculated. Results revealed significant technique differences. Although, both types of vaults are awarded the same initial points for difficulty, the Handspring group requires larger amplitude in the second flight phase and can be considered more difficult to perform.

Keywords*: kinematic analysis, gymnastics, technique, effect size.*

INTRODUCTION

One of the aims of gymnastics research is to assist in the understanding of already existing techniques and in performance optimization (Farana & Vaverka, 2012; Prassas, Kwon, & Sands, 2006). The technical requirements and the difficulties of the single skills and routines in artistic gymnastics increased dramatically in the last thirty years (Brüggemann, 2005). Sport biomechanics can improve the sport technique, training and minimize injuries (McGinnis, 2005). The vault is the only apparatus involving a single movement and, for this reason, it is the most researched and best understood apparatus (Prassas et al., 2006). A vaulting performance takes a short time and is affects by the quantity of mechanical variables. After the 2000 Olympic Games, the vaulting apparatus was changed. The traditional horse was replaced by a new vaulting table. The vaulting table was introduced by the FIG with the aim to improve safety without substantively changing the event (Irwin & Kerwin, 2009). However, this change has produced more difficult vaults (Rand, 2003). For example, the increase in the post-flight time provides gymnasts with the ability to complete more complex acrobatic movements in the air, increasing the degree of difficulty and the potential for a high score (Bradshaw, Hume, Calton & Aisbett, 2010).

There are five main types of vaults according to the entry and table contact characteristics (Federation Internationale de Gymnastique, 2013): Forward Handspring and Yamashita style vaults (Group I); Handspring with ¼ or ½ turn in in the 1st flight phase (Group II); Round-off entry vaults also ¼ turn with backward 2nd flight phase (Group III); Round-off entry vaults with ½ turn in the 1st flight phase and forward 2nd flight phase (Group IV); and Round-off entry vaults with ¾ or 1/1 turn in the 1st flight phase and forward 2nd flight phase (Group V). The Handspring, Tsukahara or Kasamatsu vaults (Group II) are the most common a popular vaults performed by elite male gymnasts in competitions and examined by researchers (e.g. Dillman, Cheetham & Smith, 1985; Takei & Kim, 1990; Kerwin, Harwood & Yeadon, 1993; Takei, Dunn & Blucker, 2003; Takei, 2007; Naundorf, Brehmer, Knoll, Bronst & Wagner, 2008). In the current study, we have focused on the execution of both specific vaults of the Handspring (HSP) group (Handspring forward and salto forward straight with 3/2 turns - Lou Yun, Figure 1A) and Tsukahara (TSK) group (Tsukahara straight with 2/1 turns – Akopian, Figure 1B) which have an identical initial point evaluation of 5.2 (FIG, 2013).



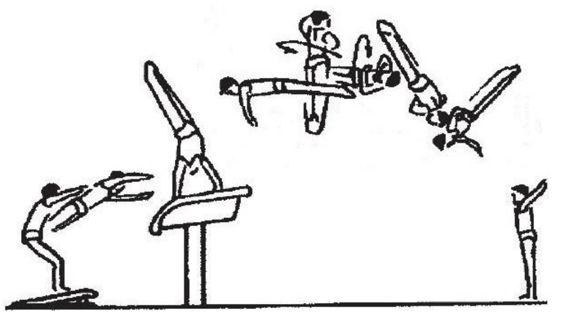


Figure 1. *(A) Handspring forward and salto forward straight with 3/2 turns - Lou Yun; (B) Tsukahara straight with 2/1 turns – Akopian (FIG, 2013).*

Cuk and Forbes (2010) concluded that the vault D-scores significantly differ from other apparatus and on the vault there was not enough discrimination among gymnast’s D-scores. Previous study by Atikovic and Smaljovic (2011) defined that degrees of turn around transversal axis, degrees of turns around longitudinal axis and body´s moment of inertia around transversal axis in the second flight phase were predictors of the vault difficulty value. The question is whether the execution of vaults corresponds, from the point of view of kinematics parameters, to the difficulty score (D-score), i.e. the specific value assigned to each vault in the Code of Points (FIG, 2013). Understanding mechanical and technical differences between two groups of vaults can help coaches develop a training strategy for effectively mastering the vaults. Moreover, the selection of a skill or technique may have a direct influence on the bio-physical demand placed on the performer (Farana, Jandacka & Irwin, 2013; Farana, Jandacka, Uchytil, Zahradnik & Irwin, in press). Especially on a vault with a high risk of injury, there is a need for effective and efficient skill development pathways to be identified that will not only optimize performance but also reduce the risk of injury (Irwin, Hanton & Kerwin, 2005).

The aim of this study was to compare key kinematic parameters of the difficult Handspring and Tsukahara vault groups performed by elite male gymnasts during a World Cup competition. The current study hypothesis was that the Tsukahara group vaults would need larger amplitude of the 2nd flight phase to complete more twists compared with the Handspring group vaults.

METHODS

All procedures used in this study complied with the guidelines of the University of Ostrava Ethics Committee.

Twenty top-level male gymnasts, who participated in the 2010 and 2011 World Cup competitions in the Czech Republic, were involved in this study. All gymnasts were members of the national teams of the participant countries. Both competitions took place in the competition period approximately two weeks before the World Championships in Rotterdam 2010 and Tokyo 2011, respectively. The age, height and weight of gymnasts were 22.69 ± 3.31 years, 166.92 ± 4.34 cm and 64.54 ± 3.67 kg. Gymnasts from this group performed ten HSP (vault no. 34; FIG, 2013; p. 99) and TSK (vault no. 29; FIG, 2013; p. 101) type vaults with 5.2 level of difficulty (FIG, 2013). From this group, we chose ten HSP and ten TSK vaults that received the highest score from the judges. The E-scores were 8.55 ± 0.35 points for HSP vaults and 8.90 ± 0.30 points for TSK vaults.

For the 3D movement analysis, two digital camcorders (Panasonic NV-MX500EG, Japan) with a frame rate of 50 Hz were used. The shutter speed was set to 1/500 s. The angle between the optical axes of the cameras was near to 90° (Bartlett, 2007). The cameras were fixed on tripods located on the right side of the apparatus, 35 meters from the centre of the vault. Time synchronization of each pair of digitized data sets was achieved using the fields from each view which correspond to an event (i.g. feet contact with the springboard). The calibration pole was defined with a calibration bar and was defined by a virtual cube of 7x4x3 m (Figure 2).

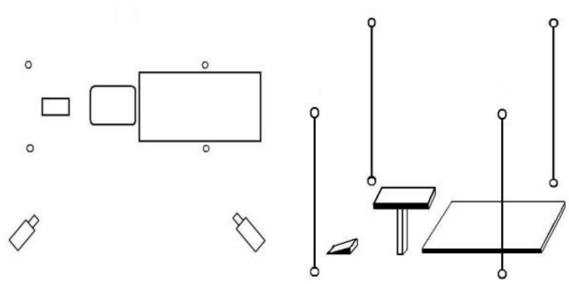


Figure 2. *Calibration volume and vaulting apparatus.*

The data was digitized utilizing the SIMI MOTION System (SIMI Reality Motion Systems, Germany) software. In each frame, the gymnast's head centre and hand, wrist, elbow, shoulder, hip, knee, ankle, and toe on both sides of his body were digitized**.** A 14-segment model of the human body was created based on 17 body points. The data were manually digitized by an experienced researcher. For the location of the center of mass (CoM), the Gubitz model (Gubitz, 1978) was used. For each vault, approximately 75 frames were digitized. These included every frame from five frames prior to the board touchdown to five after the mat touchdown. The time of contact was defined as the time from the first frame when the gymnast contacted the board or table to the first frame when he lost contact with the board or table. The time of flight was defined as the time from the first frame when the gymnast lost contact with the board or table to the first frame when he contacted the table or landing mat (Takei et al., 2000; 2003). From these critical instants, the on-board, first flight, on-table and second flight phases were defined (Figure 3). First flight phase began when the gymnast lost contact with the board and ended just before contact with the table. Second flight phase began when the gymnast left the top surface of the table and continued until the end of the reconstructed data sequence. On-board contact phase and on-table contact phase started 0.02 s after the end of the corresponding flight phase and ended 0.02 s before the subsequent flight phase. For HSP vaults, on-table contact was performed with both hands simultaneously. For TSK vaults, on-table contact was performed with an alternating hand action. The heights of CoM of critical instants were measured from the floor (Takei, 2007). Official distance of second flight phase was measured from the end of vaulting table to gymnast landing mat contact point. Relative heights of CoM were determined as differences between height of CoM in board take off and table touchdown, table touchdown and table take off, and table to touchdown and mat touch down. For HSP vaults angles at table touchdown and table take off were defined as the angle between the left horizontal line and a line joining CoM with the contact point (both hands at table touchdown and table take off). For TSK vaults, angles were defined as the angle between the left horizontal line and the line connecting the CoM to middle point between the two hands (both hands at table touchdown and table take off).

The 3D DLT method was used for calculating 3D coordinates of the digitized body parts (Abdel-Aziz & Karara, 1971). The raw data was smoothed using a low pass filter with the cut-off frequency of 8 Hz (Bartlett, 2007).

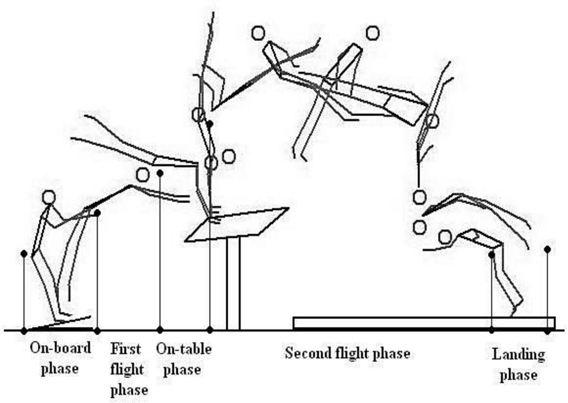


Figure 3. *Stick figure diagram with five phases of selected Handspring vault.*

The accuracy of reconstruction was determined by estimating the location of six known points distributed through the calibration volume. Reconstruction accuracy was 0.016 m within the 7 m field of view. A sample vault trial was digitized twice to evaluate digitizer reliability (Kerwin & Irwin, 2010). Reliability based on repeat digitization of a sample sequence were < 3 % for spatial parameters, < 4.5 % for velocity parameters and < 3 % for angular parameters. The temporal, spatial, velocity and angular variables in critical phases of vault were chosen on the basis of previous studies which had studied similar research questions (Dilmann et al., 1985; Takei & Kim, 1990; Takei, 1998, 2007; Takei et al., 2003; Bradshaw et al., 2010).

The mean and standard deviations (*M* ± *SD*) were calculated for each variable. To establish the differences between the means, the Cohen´s (1988) effect size (*ES*) was calculated and interpreted as < 0.2 trivial, 0.2 - 0.6 small, 0.6 - 1.2 moderate, 1.2 - 2.0 large, 2.0 - 4.0 very large and > 4.0 perfect (Hopkins, 2002). The effect of > 1.2 was considered to be practically significant (Manning, Irwin, Gittoes & Kerwin, 2010).

RESULTS

No significant differences between the two groups in height and mass (*ES* < 0.2) were found. The results of the study are summarized in Tables 1 and 2. With regard to temporal results, a significant effect size was found in the duration of the first flight phase and a perfect effect size in the on table phase. A significant effect size was found in the duration of the second flight phase (Table 1). The spatial results showed a significant effect sizes in the height of CoM at the table touchdown, the relative height of board take-off to table touchdown and table touchdown to table take-off. A significant effect were observed in the horizontal displacement of CoM at the first flight phase, and the peak height of CoM during the second flight phase (Table 1). The velocity parameters showed a significant effect size in the horizontal velocity at board take-off and change in the vertical of velocity on the table (Table 2). With regards to angular variables, a significant effect size was found in the angle at table touchdown and in the angular velocity around the longitudinal axis during second flight phase (Table 2)

Table 1. *Descriptive statistics and effect size for temporal and spatial variables in the Handspring (HSP) and Tsukahara (TSK) vault groups.*

Variable	M ± SD (HSP)	M ± SD (TSK)	ES	Effect
Time (s)				
On board	0.10 ± 0.02	0.12 ± 0.02	1.00	moderate
First flight	0.16 ± 0.02	0.10 ± 0.02	**3.00**	**very large**
On table	0.16 ± 0.02	0.26 ± 0.02	**5.00**	**perfect**
Second flight	0.96 ± 0.06	0.88 ± 0.04	**1.57**	**large**
Horizontal displacement of CoM (m)				
First flight	0.80 ± 0.23	0.56 ± 0.21	**1.09**	moderate
Second flight	3.41 ± 0.24	3.03 ± 0.18	**1.31**	**large**
Official distance of second flight	2.66 ± 0.31	2.29 ± 0.19	0.66	**large**
Height of CoM at critical instants (m)				
Board take-off	1.24 ± 0.10	1.23 ± 0.07	0.12	trivial
Table touchdown	1.79 ± 0.11	1.55 ± 0.11	**2.18**	**very large**
Table take-off	2.28 ± 0.10	2.33 ± 0.06	0.60	moderate
Peak of second flight	2.85 ± 0.17	2.66 ± 0.12	**1.29**	**large**
Mat touchdown	0.89 ± 0.12	0.89 ± 0.09	0	trivial
Relative height of take-off (m)				
Board take-off to table touchdown	0.55 ± 0.09	0.32 ± 0.13	**2.06**	**very large**
Table touchdown to table take-off	0.49 ± 0.06	0.78 ± 0.12	**3.06**	**very large**
Table take-off to mat touchdown	-1.39 ± 0.11	-1.44 ± 0.10	0.48	small

M, mean; SD, standard deviation; ES, Cohen´s inter-vault effect size; Effect, verbal expression of the effect of size (Hopkins, 2002); s, seconds; m, meters

Table 2. *Descriptive statistics (M ± SD) and effect size (ES) for velocity and angular variables in the Handspring (HSP) and Tsukahara (TSK) vault groups.*

Variable	M ± SD (HSP)	M ± SD (TSK)	ES	Effect
Resultant velocity (m/s)				
Board take-off	6.20 ± 0.36	6.10 ± 0.48	0.23	small
Table take-off	4.60 ± 0.48	4.33 ± 0.35	0.64	moderate
Horizontal velocity (m/s)				
Board take-off	5.00 ± 0.33	5.39 ± 0.42	1.03	moderate
Change on table	-1.45 ± 0.30	-1.95 ± 0.24	**1.83**	**large**
Table take-off	3.55 ± 0.30	3.44 ± 0.41	0.31	small
Vertical velocity (m/s)				
Board take-off	3.71 ± 0.27	3.35 ± 0.38	1.09	moderate
Table touchdown	3.36 ± 0.39	3.37 ± 0.26	0.03	trivial
Change on table	-0.35 ± 0.15	-0.60 ± 0.22	**1.32**	**large**
Table take-off	3.01 ± 0.24	2.77 ± 0.26	0.95	moderate
Angles during critical instants (°)				
Angle at table touchdown	38.10 ± 5.34	46.36 ± 5.28	**1.56**	**large**
Angle at table take-off	82.57 ± 6.29	85.22 ± 4.40	0.49	small
Angular velocity (°/s)				
Longitudinal axis second flight	584.97 ± 32.96	811.28 ± 38.04	**6.36**	**perfect**
Transversal axis second flight	585.00 ± 33.00	614.55 ± 30.26	0.93	moderate

M, mean; SD, standard deviation; ES, Cohen´s inter-vault effect size; Effect, verbal expression of the effect of size (Hopkins, 2002); m/s, meters per second; °, degrees; °/s, degrees per second

DISCUSSION

The aim of this study was to compare key kinematic parameters of the difficult Handspring and Tsukahara vault groups performed by elite male gymnasts during a World Cup competition.

There were moderate differences in the on the board support duration (Table 1). Bradshaw and Sparrow (2001) characterize an explosive take-off from the board by a short board contact time that resulted in an increased in post-flight time. In the current study values of board contact time were shorter to those that were reported by Takei et al. (2003) for difficult HSP vault (Roche vault) and Bradshaw et al. (2010) for TSK group (Tsukahara layout) performed by male gymnasts. A very large effect sizes were found in the duration of first flight phase and table contact (Table 1). Cuk and Karacsony (2004) states that the duration of the first flight phase and the table support phase differs according to the group of vaults. In the current study, the duration of the table support was significantly longer for TSK vaults as the gymnast touches the table with an alternating hand action (Table 1). A brief contact time on the table is likely to translate the gymnast's approach and take-off velocity into a longer post-flight time and distance, allowing the gymnast more time to complete more complex skills in the air (Bradshaw, 2004; Bradshaw et al., 2010). In the current study the duration of on-table phase contact were shorter than what was previously reported by Dillman et al. (1985). This indicated that the gymnasts in current study were able to execute a more explosive take-off from the vaulting table than from the old vaulting horse. One reason of on-board and on-table contact time differences may be due to an increase in run-up velocity. In a previous study reported by Naundorf et al. (2008) authors found an increase in run-up velocities from 1997 to 2007 for HSP and TSK group vaults. In the current study, a large effect size was found in the duration of the second flight phase (Table 1). The horizontal displacement of CoM during the first and second flight phase was greater in the HSP vault group. The rapid touching of the vaulting table with the first hand in TSK vaults results in shorter displacement of CoM during the first flight phase. The fact that TSH vaults are executed from the middle of the table and the HSP vaults from the front part, affects the horizontal displacement of CoM during the second flight phase, and the official distance of 2nd flight. The horizontal distances of the flight are affected by the horizontal velocity and time in the air. A large effect size was determined in the height of CoM at the peak of the post-flight phase (Table 1). This indicated that the HSP vault group requires larger amplitude of the second flight phase. Takei (1998) reported that the amplitude of the second flight phase is governed by the horizontal displacement of CoM, the peak height of CoM in the second flight phase and the duration of the second flight phase. The determinants of the CoM motion after take-off (from the spring board and from the vault table) are determined by the (relative) position of the CoM at that instant and its velocity. Although TSK vaults in our study include more twists around the longitudinal axis in the second flight phase, they require lower amplitude. This is probably caused by the gymnasts initiating the twist around the longitudinal axis already on the table, using the twist technique known as the contract twist (Yeadon, 1993a). On the other hand, in case of the HSP vaults, the twists around the longitudinal axis occur only after the take-off (aerial twist) and they are more challenging for the extent of the movement during the second flight phase (Yeadon, 1993b).

With regards to velocity parameters, a large effect size of the board take-off horizontal velocity was determined while the TSK vaults showed higher horizontal velocity of CoM. However, there were no significant differences between the two vault groups in the board take-off resultant velocity. At the same time, no differences in the velocity parameters at the table contact and moderate effect size in the table take-off were found (Table 2). In spite of the differences in the duration of the table contact, it is obvious that, in both vault groups, it is necessary to reach a high horizontal and vertical velocity during the table take-off to successfully execute the vault. The horizontal and vertical velocity at table take-off is decisive for the horizontal distance and height of the second flight phase, respectively. Irwin and Kerwin (2009) reported that one of the effects of the vaulting table, compared with the old vaulting table is the production of higher vertical take-off velocity. A large effect size was found at the angle of the table touchdown and angle at the take-off from the table (Table 2). The TSK vault group shows a greater angle at the table touchdown than the HSP vault group. The take-off from the vaulting table was completed before the handstand position was reached and did not exceed 90° in both groups of vaults. Li (1998) reported that when the take-off angle surpasses 90°, the second flight becomes short and low. With regards to the number of twists during the second flight phase a nearly perfect effect size was observed in the angular velocity around longitudinal axis. However, both vaults showed similar angular velocity around the transversal axis. Thus, the HSP vaults have more problems for acquiring the necessary angular momentum around longitudinal axis and needs more time, and more height for completed all twists during second flight phase.

Although our study has brought some interesting findings in the field of kinematics of the examined group of vaults, to understand this issue better, it is necessary to work with a wider set of top-level gymnasts under the conditions of a real competition and to broaden the research to vaults from other vault groups (e.g. Yurchenko group). However, small sample sizes are a common feature when undertaking research at elite competition (Kerwin & Irwin, 2010; Manning et al., 2010).

CONCLUSIONS

In conclusion, this study compared the key kinematic parameters of difficult HSP and TSK vaults performed by elite male gymnasts during a World Cup competition. The greatest differences between both groups of vaults were caused by the different technique of the first flight phase and thus the execution of the contact and take-off from the vaulting table. In both groups of vaults, the take-off from the table is executed with high vertical and horizontal velocity that ensures both, sufficient height of the vault and sufficient horizontal distance from the table. Although both types of vaults are awarded the same initial points for difficulty, the HSP group requires larger amplitude in the second flight phase and can be considered more difficult to perform. In case of the HSP vaults the gymnasts need more time in the second flight phase to initiate and complete the twists around the longitudinal axis. With a higher level of understanding of the mechanical and technical differences in the different groups of vaults, coaches will have more knowledge at their disposal in order to select techniques effectively and therefore develop a more efficient coaching process and reduce the risk of injury.

REFERENCES

Adbel-Aziz, Y.I. & Karara, H.M. (1971). Direct linear transformation for comparator coordinates in to object space coordinates in close range photogrammetry. In *Proceeding of the ASP Symposium in Closerange Photogrammetry*. Urbana, IL: American Society of Photogrammetry.

Atikovic, A. & Smajlovic, N. (2011). Relation between vault difficulty values and biomechanical parameters in men´s artistic gymnastics. *Science of Gymnastics Journal*, 3, 3, 91-105.

Bartlett, R. (2007). *Introduction in to biomechanics: Analysing human movement patterns* (2nd ed). Abingdon, UK: Routledge, Taylor and Francis group.

Bradshaw, E. (2004). Target-directed running in gymnastics: a preliminary exploration of vaulting. *Sports Biomechanics*, 3, 1, 125-144.

Bradshaw, E., Hume, P., Calton, M. & Aisbett, B. (2010). Reliability and variability of day-to-day vault training measures in artistic gymnastics. *Sport Biomechanics*, 9, 2, 79-97.

Bradshaw, E. & Sparrow, W.A. (2001). The approach, vaulting performance, and judge´s score in women´s artictic gymnastics. In *International Society of Biomechanics in sport 2001: Scientific proceeding* (pp. 311-314). San Francisco: Univerzity of San Francisco.

Brüggemann, G.P. (2005). Biomechanical and biological limits in artistic gymnastics. In. Q. Wang (Ed.), *XXIII International Symposium of Biomechanics in sport* (pp. 15-24). Beijing: China Society of Sport Biomechanics.

Cohen, J. (1988). *Statistical power analysis for the behavioral science* (2nd ed.). New Jersey: Lawrence Erlbaum.

Cuk, I. & Forbes, W. (2010). How apparatus difficulty affect all around results in men´s artistic gymnastics. *Science of Gymnastics Journal*, *2*(3), 57-63.

Cuk, I. & Karacsony, I. (2004). *Vault: Methods, Ideas, Curiosities, History*. Ljubljana: ŠTD Sangvinčki.

Dillman, C.J., Cheetham, P.J. & Smith, S.L. (1985). A kinematic analysis of men's Olympic long horse vaulting. *International Journal of Sport Biomechanics, 1*, 96-110.

Farana, R., Jandacka, D. & Irwin, G. (2013). Influence of different hand positions on impact forces and elbow loading during the round off in gymnastics: a case study. *Science of Gymnastics Journal*, *5*(2), 5-14.

Farana, R., Jandacka, D., Uchytil, J., Zahradnik, D. & Irwin, G. (in press). Musculoskeletal loading during the round-off in female gymnastics: The effect of hand position. *Sports Biomechanics*.

Farana, R. & Vaverka, F. (2012). The effect biomechanical variables on the assessment of vaulting in top-level artistic female gymnasts in World cup competition. *Acta Universitas Palackianae Olomucensis. Gymnica*, *42*(2), 49-57.

Fédération Internationale de Gymnastique. (2013). *2013 – 2016 CODE OF POINTS Men's Artistic Gymnastics*. Lausanne: Fédération Internationale de Gymnastique.

Gubitz, H. (1978). *Zur analytischen Bestimmung der Lage des Koerperschwerpunktes*. International Symposium, Berlin: Germany.

Hopkins, W.G. (2002). *A scale of magnitudes for effect statistics*. In A New View of Statistics. Retrived from: www.sportsci.org/resource/stats/effectmag.html.

Irwin, G., Hanton, S., & Kerwin, D. (2005). The conceptual process of skill progression development in artistic gymnastics. *Journal of Sport Sciences*, *23*(10), 1089-1099.

Irwin, G. & Kerwin, D.G. (2009). The influence of the vaulting table on the handspring front somersault. *Sports Biomechanics, 8*(2), 114-128.

Kerwin, D., Harwood, M.J. & Yeadon, M.R. (1993). Hand placement techniques in long horse vaulting. *Journal of Sports Sciences, 11*(4), 329-35.

Kerwin, D.G. & Irwin, G. (2010). Musculoskeletal work preceding the outward and inward Tkachev on uneven bars in artistic gymnastics. *Sports Biomechanics, 9*(1), 16-28.

Li, S. (1998). Main technical analyse of the motion trajectory influencing the horse-vaulting movement. In *XVI International Symposium of Biomechanics in Sports*. Konstanz: Germany.

Manning, M.L., Irwin, G., Gittoes, M.J. & Kerwin, D.G. (2011). Influence of longswing technique on the kinematics and key release parameters of the straddle Tkachev on uneven bars. *Sports Biomechanics, 10*(3), 161-173.

McGinnis, P.M. (2005). *Biomechanics of sport and exercise* (2nd ed.). Champaign, IL: Human Kinetics.

Naundorf, F., Brehmer, S., Knoll, K., Bronst, A. & Wagner, R. (2008). Development of velocity for vault runs in artistic gymnastics for last decade. In Y.H. Kwon, J. Shim, J.K. Shim, and I.S. Shin (eds.), *XXVI International Symposium of Biomechanics in Sports*. Seoul: Korea.

Prassas, S., Kwon, Y.H. & Sands, W.A. (2006). Biomechanical research in artistic gymnastics: A rewiew. *Sports Biomechanics*, *5*(2), 261-291.

Rand, T. (2003). New vaulting table. *Technique*, 23, 1, 9-10.

Takei, Y. (1998). Three-dimensional analysis of handspring with full turn vault: Deterministic model, coaches' beliefs, and judges' scores. *Journal of Applied Biomechanics*, *14*, 190-210.

Takei, Y. (2007). The Roche vault performed by elite gymnasts: Somersaulting technique, Deterministic model, and Judge´s scores. *International Journal of Applied Biomechanics*, *23*, 1-11.

Takei, Y. & Kim, J. (1990). Techniques used in performing the handspring and salto forward tucked vault at the 1988 Olympic games. *International Journal of Sports Biomechanics*, *6*, 111-138.

Takei, Y., Blucker, E., Nohara, H., & Yamashita, N. (2000). The Hecht vault performed at the 1995 World Gymnastics Championships: Deterministic model and judges' scores. *Journal of Sports Sciences*, *18*, 849-863.

Takei, Y., Dunn, H. & Blucker, E. (2003). Techniques used in high-scoring and low-scoring 'Roche' vaults performed by elite male gymnasts. *Sports Biomechanics*, 2, 141-162.

Yeadon, M.R. (1993a). The biomechanics of twisting somersaults. Part II: Contact twist. *Journal of Sports Sciences*, *11*, 199-208.

Yeadon, M.R. (1993b). The biomechanics of twisting somersaults. Part III: Aerial twist. *Journal of Sports Sciences*, *11*, 209-218.

Corresponding author:

Roman Farana, Ph.D.
University of Ostrava
Human Motion Diagnostic Center
Czech Republic
Varenska 40a
Ostrava, Czech Republic
phone: +420732778109
email: roman.farana@osu.cz

A REVIEW ON THE CHANGES OF THE EVALUATION SYSTEM AFFECTING ARTISTIC GYMNASTS' BASIC PREPARATION: THE ASPECT OF CHOREOGRAPHY PREPARATION

Olyvia Donti[1], Anastasia Donti[2], Kalliopi Theodorakou[1]

[1] Faculty of Physical Education and Sport Science, University of Athens, Greece

[2] Hellenic Gymnastics Federation, Federal Coach of Women's Team

Review article

Abstract

The Code of Points, the International Gymnastics Federation document directing gymnasts' training process in every Olympic Cycle, evaluates artistic gymnastics performances. The aim of this study was twofold: first to examine the most important changes of the Code of Points since 1996, affecting gymnasts' basic preparation and in particular the changes concerning choreography. Second, this paper aimed to review the relevant literature on the topic of choreography preparation in artistic gymnastics and to analyze finalists' performances in official competitions, thus exploring the contribution of choreography preparation in gymnasts' difficulty score. For the purpose of the present study Women's Artistic Gymnastics Codes of Points since 1996 were analyzed. In addition, the content of the finalists performances on floor exercises and balance beam in the Olympic Games of London 2012, World Championship in Antwerp, 2013 and European Championship in Moscow 2013 were also analyzed. The results of this study demonstrated that basic preparation of artistic gymnasts is an ongoing process, structured on the principles of "profile elements" and virtuosity of execution. Gymnasts' basic preparation focuses on choreography as a means of faultless execution and at the same time choreography preparation provides a new direction of developing difficulty while slowing down the "acrobatisation" and preserving the aesthetic quality of the sport.

Keywords*: technique, execution, artistry.*

INTRODUCTION

Artistic gymnasts' preparation is a long-term process based on the concepts of early sport specialization and high training load (Arkaev & Sutsilin, 2004). This long-term process includes anticipating the standards of the sport in the years to come (Rozin, 1997). Therefore, for coaches and specialists, it is necessary to make a prognosis of the future demands of the sport given by the International Federation of Gymnastics (F.I.G) rules -Code of Points- and the international tendencies as observed in official competitions and literature (Terekhina, 1997).

Code of Points is the F.I.G document that provides the means of evaluating gymnastics exercises at all level competitions and at the same time is guiding coaches and gymnasts in the content and the structure of the training process (Code of

Points of Women's Artistic Gymnastics; W.A.G, 2013-16). Over the last decade, the Code of Points has changed substantially directing a new system of artistic gymnastics preparation. For the current Olympic cycle, 2013-2016, the final score of every artistic gymnastics performance is the sum of the scores of difficulty, execution, composition and artistry given by two panels of judges. The focus of the new rules is artistry, stressing the need to reshape a gymnast's routine into an artistic performance. The composition of a routine is based "on the movement vocabulary of the gymnast, as well as the choreography of those elements and movements, that is the mapping out of the body's movements over space and time in harmony with the selected music" (Code of Points of Women's Artistic Gymnastics; W.A.G, 2013-16, section 13, p.1). These demands are the result of a long-term choreography and dance preparation starting from a young age and continuing throughout a gymnast's career. Previous research examined the issue of choreography preparation in artistic gymnastics (Borissenkko, 2000; Gula, 1990; McDermott, 2009; Morel, 1987) and in other "aesthetic sports" –rhythmic gymnastics, ice-skating, aerobic, synchronized swimming- as it was considered to be important for the overall quality of performance (Karpenko, 1976; 2003; Lissitskaia, 1984, Lissitskaia & Zaglada, 1997; Morel, 1987; Rumba, 2013).

The evaluation system of Women's Artistic Gymnastics -Code of Points- is significantly affecting gymnasts' basic technical preparation since optimal basic preparation is considered to be the foundation of gymnastics elements (Smolevski & Gaverdofski, 1999) structuring athletes' future technical development and overall performance (Arkaaev & Sutsilin, 1997). However, to the authors' knowledge, there is not any research in artistic gymnastics in the current Olympic cycle, examining how the changes of the Code of Points are reflected in gymnasts' basic preparation and integrated in the long-term training schedule of gymnasts.

Analyzing the performance of elite athletes is advancing understanding of the training and competition parameters with a view to improve future outcomes. The performance of athletes in Olympic Games and World Championships allows exploring the tendencies of the sport and provides additional and accurate information to coaches and gymnasts. In the current Olympic cycle, there is no study regarding both, theoretical considerations on gymnastics performance and applied perspective examining competition parameters. Therefore, the aim of the present study was twofold: first, to examine the most important changes of the rules since 1996, affecting gymnasts' basic preparation and in particular the changes concerning artistry and choreography. Second, this paper aimed to review the relevant literature on the topic of choreography preparation in artistic gymnastics and examine its importance for gymnasts' preparation.

METHODS

The methodology of this paper includes: a) a review of the changes of Women's Artistic Gymnastics Code of Points since 1996 until today in order to depict the most critical changes of the rules directing basic gymnasts' preparation b) a review of the relevant literature on the topic of choreography preparation in artistic gymnastics, its content and artistic criteria and c) registration of the finalists' performances on balance beam and floor of the three major F.I.G official competitions (Olympic Games of London 2012, World Championship in Antwerp, 2013 and European Championship in Moscow 2013) ~~from~~ by the authors (FIG-judges since 1987, category II) in order to examine the contribution of gymnastics elements in ~~the~~ athlete's difficulty score.

Changes in Women Artistic Gymnastics Code of Points

The establishment of the F.I.G rules of 1996 excluded the compulsory routines from the official competitions. As a result, the Olympic Games of Sydney (2000) were the first in the history of gymnastics where gymnasts competed only in optional exercises. Compulsory exercises were characterized by faultless execution of basic elements and were believed to contribute in the formation of a "gymnastic school" of movements since they included elements of low difficulty but representing different structural technical groups (Alekperov, et al. 1985). They were also considered as the most objective and common for all gymnasts criterion of ranking because judges made specific deductions for typical mistakes in low difficulty, basic elements (Alekperov, et al. 1985). However, they were not spectacular and easy to understand for the media and the audience consequently, they were excluded from competition. As a result, the stress of the competition was transferred to the optional performances and a serious increase of the difficulty level was immediately noticed: new elements were executed, a new category of E-value difficulty -the highest in that Olympic cycle- appeared in the Code of Points, and the prohibition of the repetition of an element (an element should be executed only once in order to receive difficulty value, bonification, and/or connection value) were the most important changes. In 2000, the highest difficulty value was E, in 2004, a new category of G difficulty value was added and currently, there are two new difficulty value categories, H and I. The evolution of difficulty in gymnastics is considered to be an expected process comprising an increase in the number and the connections of difficult elements performed in an exercise, as well as an increase in the difficulty of the technical structure of the elements (Terekhina, Titov, & Turisheva, 1991; Turisheva, 1986).

Another decisive modification of the rules was the change of gymnasts' age limit (Women's Artistic Gymnastics Code of Points, 1996) in order to compete to official F.I.G competitions (Olympic Games, World Championships). Until 1996, 15 years old female gymnasts had the right to participate to official competitions and in the World Championship preceding and serving as qualification for the Olympic Games, 14 years old gymnasts had also the right to take part. Thus, once athletes achieved a high level of performance they had the right to compete at an international level. This was considered as a negative tendency imposing an extreme training load in a very young age: systematic training was starting from a very young age (5-6 years old) and was scheduled on a daily basis (20-25 hours a week) for approximately 250-300 days a year (Smolefski & Gaverdofski, 1999). For athletes competing internationally, the training load was even higher and in some cases, for talented athletes aiming to take part in major competitions, the process of training was intentionally accelerated (Rozin, 1997). By the age of 15-16 years, young gymnasts had already been training and competing for a decade. During this critical stage of development, young gymnasts experienced rapid physiological, neurologic, and psychological growth, and participation in competitive gymnastics placed excessive physical and psychological load on them (Tofler, Stryer, Micheli, & Herman, 1996). Currently due to the minimum age-limit of 16 years, gymnasts competing internationally are becoming "older". According to the F.I.G report (Newsletter 34, December 2013) in 2007, the average age of gymnasts was 18.27 years, and in the World Championship of 2013, it has become 19.16 years of age. The extension of the duration of the available training years is a favorable condition for all the parameters affecting gymnasts' well being and for the coaches to redefine athletes' technical skill development according to international standards.

The judging system has also changed in 2000 and every competition is evaluated by two panels of judges. Currently, there are two judges-panels: Difficulty-Panel judges (D-Panel) are evaluating the technical difficulty, the connection value of the elements, the composition requirements and they keep a control score for execution. Execution-Panel judges (E-Panel) are making deductions for technical faults and artistry. Evidently, the quality of execution is a decisive factor for the score that a gymnast can achieve. Especially between leading athletes representing traditionally "gymnastic" countries, who have a very high level of difficulty in their competitive exercises and original and innovative composition, the factor of execution is of paramount importance in order to win or lose (Terekhina, 1997).

The abolishment of "ten" (10) as the maximum score (Code of Points 2005-2008) and the introduction of a "world record" philosophy in gymnastics -since the score that a gymnast can take nowadays in competition has no upper limit- was considered as a determining factor for the content of gymnastics exercises. This change of the rules resulted in a rapid development and concentration of difficulty in the competitive routines (unpublished observations). As a result, discussions were held among specialists about what is more important in gymnastics, difficulty, execution or the aesthetic components of a composition and towards which direction gymnastics would evolve.

The intention of the new Code of Points of 2013-16 was to offer a viewpoint focusing on composition, artistry and choreography of gymnastics performance. Taking the position that aesthetic aspects should contribute in the final score of a gymnast, specific criteria and respective deductions were established for the artistry of performance, the composition and the choreography on floor and balance beam as well as for the body posture, and leg position in all the apparatuses. In addition, from the eight elements that should be included in the difficulty score of an exercise on balance beam and floor, minimum three should be leaps, jumps, turns, or balances; hence elements that are the result of a long-term choreography preparation. This new direction gives the gymnasts the possibility to choose elements from other than acrobatics technical groups that fit their individual capacities. In addition, the score on uneven bars or vault is very often defined by deductions in body alignment, relaxed feet, precision and balance, all skills that are based on choreography preparation. Choreography deductions can be small (0.10p) or medium (0.30p) and are added up each time a mistake appears. In a sport where the winner is decided from a difference of tenths of a point, the gymnast with the most adequate level of choreography preparation has the better chance for success.

The changes in the evaluation system of artistic gymnastics, affect the content and the structure of the training process. Some changes enhanced difficulty evolution of the routines, while others focused on execution. At the moment, the demands of the rules are high difficulty, faultless execution and at the same time aesthetic composition and choreography, in an attempt to highlight the aesthetic value of the sport.

Choreography preparation in artistic gymnastics

Choreography preparation is the process of learning and improving the basic principles, movements and elements of classical dance (Lobjanidje, 1980) and it is introduced in artistic gymnastics from the art of classical ballet. During its application in the training system of gymnasts, choreography preparation has acquired special characteristics and athletic direction (Lissitskaia, 1984). According to the definition of Karpenko (2003), choreography is a form of expressing the inner world of a gymnast, her special characteristics and capacities. However, the traditional methods of dance classes were developed many years ago aiming to produce highly skilled and artistically expressive dancers-not gymnasts (Gula, 1990). Keeping this in mind, it is important to distinguish which elements of the art form are essential to the gymnast's performance. The main differences between gymnasts and dancers are in the methods of training the gymnast to dance and in the necessity for an economical -in time consuming- dance instruction (Gula, 1990). It is a common belief that it takes ten years of daily professional classes to create a dancer (Lawson, 1984). In contrast, 10 years old gymnasts should be able to execute difficult leaps, jumps and turns on the beam and floor exercises and at 16 years of age a gymnast's level of choreography preparation should reach the high standards required to cope with the demands of international level competition. In addition, the teaching goals and the basic dance principles of choreography have a different direction in gymnastics (Gula, 1990). Through acquiring a conscious and controlled movement, the aim of choreography preparation in artistic gymnastics is to demonstrate artistry, expressiveness, musicality, personal style and faultless execution of the gymnastics elements on floor and beam (Savelieva, 1996).

In her research, Borissenko, (2000) demonstrated that in the content of choreography preparation in artistic gymnastics, co-exist elements of special technical preparation (general skills of gymnastics "education" and style), special physical preparation (development of coordination capacities such as static and dynamic balance, rhythmic abilities, spatial and temporal orientation, and specific endurance), psychological preparation (kinetic memory, imagination, attention span and mental processing of movements), and aesthetic preparation of the gymnasts (development of expressiveness, dancing interpretation of the music, and general movement education). Borissenko (2000) concluded that the role of choreography in the preparation of gymnasts is critical thus being in line with previous research in former Eastern Europe supporting the notion that choreography classes affect all the aspects of gymnasts' preparation and consequently, gymnast's scores in the all-around (Lissitskaja, 1984; Morel, 1987, Lissitskaja & Zaglada, 1997).

For the evaluation of choreography preparation in competition, the international gymnastics community is using the criteria of the Code of Points. However, during competition it is the level of preparation – *preparedness* (Zatsiorski, 1995)- that is evaluated and not the process of preparation. Therefore, in order to define the level of dance preparation in training in the different gymnastics disciplines several systems of choreography criteria have been proposed; these criteria are founded on the basis of creating movement patterns and principles from classical ballet (Borissenko, 2000; Karpenko, 1976; Lazarenko, 1978). The most recent system is the system proposed by Borissenko (2000) that is composed of two groups of criteria: the first group has a technical direction and consists of criteria that evaluate the level of dance education of the gymnasts' movements and the quality of elements' execution. In other words, all the movements that are executed in the choreography and all the gymnastic elements are judged for their technical adequacy. The second group has aesthetic and artistic direction, and evaluates rhythmic, and dance interpretation of the music, expression, personal style, inspiration and originality of the composition. According to Borissenko (2000), the most important aesthetic criteria that a composition should fulfill are expressiveness, originality and showmanship. Expressiveness is defined as the capacity of a gymnast to express emotions through movements, by creating with her body beautiful lines in a logical succession according to the "theme" of the choreography and the music (Plehanova, 2006). Original in artistic gymnastics is the composition that apart from traditional or classical forms of movements includes new elements or new ways of connecting elements or a new way to correlate the body of the gymnast and the apparatus (Borissenko, 2000). Finally, ~~as~~ showmanship is defined as the capacity of a gymnast to give a certain style to the performance and to contact emotionally with the audience (Borissenko, 2000).

Performance analysis of the qualifiers in the finals of official F.I.G competitions

According to Women's Artistic Gymnastics Code of Points (2013-16), gymnasts should be able to execute elements from five and six different structural technical groups on the balance beam and floor exercises respectively. These elements represent a broad variety of acrobatic and gymnastic elements contributing to the difficulty score of a gymnast. In order to examine the contribution of gymnastics elements in the difficulty score of artistic gymnasts, the performances of the qualifiers in apparatus finals were registered and analyzed. In particular, the performances of the gymnasts qualifying for Competition III in the Olympic Games in London (2012), (Table 1) the Word Championship in Antwerp (2013) (Table 2) and the European Championship in Moscow (2013) (Table 3) were analyzed.

Table 1. *Difficulty values of acrobatic and gymnastic elements of the finalists on floor exercises and balance beam in Olympic Games-London 2012.*

Floor exercises		
Participants	Acrobatic elements	Gymnastic elements
Afanasyeva (RUS)	1F, 1E, 1D, 2C	3D
Wieber (USA)	1H, 1E, 2D, 1C	1D, 2C
Raisman (USA)	1F, 2E, 1D, 1C	2D, 1C
Ponor (ROM)	1F, 2E, 1D	1E, 1D, 2C
Mitchell (AUS)	2E, 2D	3D, 1C
Ferrari (ITA)	1H, 1E, 1D, 1C	4D
Mustafina (RUS)	2E, 2D, 1C	1D, 2C
Izbasa (ROM)	3E, 1D	2D, 2C
Average difficulty score (in points)	2.01p	1.29p
Difficulty score	3.30p	
Percentage of acrobatic and gymnastic elements in the difficulty score	60.91%	39.01%
Balance Beam		
Sui (CHN)	1F, 2E, 2D	1E, 1D, 1C
Ponor (ROM)	1G, 3D, 1C	1E, 1D, 1C
Deng (CHN)	2E, 3D	1E, 1D, 1C
Iordache (ROM)	1F, 1E, 3D	2D, 1C
Afanasyeva (RUS)	5D	1D, 2C
Douglas (USA)	1F, 1E, 2D, 1C	1E, 1D, 1C
Komova (RUS)	1G, 1F, 3D	1D, 2C
Raisman (USA)	1G, 1E, 3D	1D, 2C
Average difficulty score (in points)	2.28p	1.11p
Difficulty score	3.39p	
Percentage of acrobatic and gymnastic elements in the difficulty score	67.26%	32.74%

As can be seen the contribution of gymnastic elements to the difficulty score of a gymnast varies from 32.74% to 45.50%, representing a parameter of paramount importance in the ranking of the gymnasts.

DISCUSSION

The aim of this study was to examine the most important changes in Women's Artistic Gymnastics Code of Points since 1996, affecting gymnasts' basic preparation and in particular the changes concerning artistry and choreography. The relations between the changes of the evaluation system and the content of basic preparation of gymnasts will enable further understanding of the evolution of artistic gymnasts' preparation. Furthermore, a literature review on the topic of choreography preparation in artistic gymnastics, examined its components, criteria and importance. Lastly, a registration of the content and the difficulty score of the finalists in the official F.I.G competitions allows exploring the tendencies of the sport.

Basic technical preparation is the process of learning and improving the technique of basic skills representing different structural technical groups of a specific quantity, quality of execution, and increasing difficulty according to the gymnast's age, stage and individual capacities (Smolevski & Gaverdofski, 1999). For coaches and specialists it is important to consider that basic technical preparation should have long-term characteristics and should be planned according to the international tendencies of gymnastics evolution and the anticipation of the technical development of the sport, as also reflected in the changes of the Code of Points (Arkaev, 1997; Rozin, 1997). In other words, it is not only about the decision of *what* the gymnasts should learn but also *how* they should learn it in order to be successful after 6-8years training when the time comes to win or lose. However, what was noticed in previous Olympic cycles - even in the competitive routines of high-level gymnasts- was that coaches ~~tend~~ used to lead their athletes towards "comfortable" elements and combinations that gave high difficulty and elevated starting value in the exercise, without considering the structure group and the technical profile of these elements and the stage of development of the athlete (Terekhina, 1997, Savelieva, 1997). Therefore, basic preparation was lead into a limited pattern, not depending on the perspective of the evolution of the athlete and not enabling the athlete to adapt to the future demands of the sport. This negative tendency, threatened the overall level of performance and it was even stronger in national and age-group competitions (Donti, 2000).

However, Arkaev, (1994) in his research on "global preparation" (all types of preparation, such as physical, technical, tactical and theoretical integrated in order to achieve maximum competitive performance) of the Russian national team pointed out that optimal basic preparation is not limited to young age but it is an ongoing process continuing throughout a gymnast' career and adapting to the demands of the sport in every Olympic Cycle. This process should be structured on the principles of execution of "profile elements" and "virtuosity" of execution even of basic skills (Arkaev & Rozin, 1994; Arkaev & Sutsilin, 2004). "Profile elements" are considered the elements that if correctly executed, they form the technical basis for learning more difficult and complex elements from the same element group (Smolefski & Gaverdofski, 1999). According to gymnastics experts, learning "profile" elements from all the elements groups is enabling the gymnasts to adapt to future evolution of difficulty with the least possible effort (Arkaev & Sutsilin, 2004).

Virtuosity is the main factor characterizing the level of technical execution of gymnastics elements, expressed by high competition score, artistry, individual style and precision (Arkaev & Rozin, 1994). However, in the basis of "virtyosity" is lying the execution of basic gymnastics elements with technical parameters of more difficult elements (Arkaev & Sutsilin, 2004). It is a common knowledge that it takes years of preparation to learn a stretched salto backward on floor exercises but if correctly executed, it takes weeks to learn a double salto (unpublished observations).

A condition of achieving a high level of quality of execution is systematic and adequate choreography preparation (Borissenko, 2000; Karpenko, 2003). In addition, choreography preparation is the means of learning and improving different techniques of gymnastics elements (jumps, leaps, turns, balances) which are critical for the final score that a gymnast can take. The results of this study demonstrated that the contribution of gymnastics elements in the difficulty score of competitive routines of elite gymnasts is varying from 32.74% to

45.50%. In particular, on floor exercises, since the Olympic Games of London (2012) to the European Championship of Moscow (2013), the tendency of using more gymnastic and choreography elements is obvious, mainly to the leading athletes who are adequately prepared to execute faultlessly both, high-risk acrobatic skills and difficult gymnastics elements. On the other hand, on the balance beam, due to the increased necessity for stability, and to avoid a fall, gymnasts choose more “secure” gymnastic skills and combinations. This score represents the actual tendency of slowing down the process of “acrobatisation”of the sport and at the same time, it preserves the aesthetic quality, the measure and the showmanship of gymnastics sports.

REFERENCES

Alekperov, C.M., Allaxverdiev, F.A., Ivanov, B.B.., Kicelev, V.I., Maliceva, O.M., Perfilev,, D.G., & Popova, E.G. (1985). Klassifikatsionie programmmi kak coctavnaia tsast sistemi texnitseckoi podgotovki gimnastov (Compulsory routines as a part of gymnasts’ technical preparation) (in Russian). In Alekperov, C.M. (ed.) *Technical preparation in modern aristic gymnastics* (pp. 10-20). Leningrad: Physical Education and Sport.

Arkaev, L.G. (1994). *Integralnaia podgotovka gimnastov –na primere cbornoi komandi ctrani* (*Global preparation of gymnasts-on the example of the Russian national team*) (in Russian). Unpublished Doctoral Thesis, National State Academy of Physical Education, P.F. Lesgaft, S. Petersburg, Russia.

Arkaef, L.G. (1997). 1-my Championaty Rossii po gimnastike-cto let (dostizenia, problem I perspektivi), (One hundred years since the first National Championship of Russia (achievements, problems and prospects of Russian gymnastics). *Teoria I praktika fizitseskoi kyltyri (Theory and Practice of Physical Education)* (in Russian) *11*, 2-7.

Arkaef, L.G. & Rozin, E.G. (1994). *Sportivnoe masterctvo I spetsialnaia texnitseskaia podgotovlenoct gimnastov. Methodi diagnostiki I otsenki* (*Athletic perfection and special technical preparedness of gymnasts. Diagnostic and evaluation methods)* (in Russian). Methodical and Teachinig notes for Universities and National teams, Moscow: Physical education, Culture and Science.p.43.

Arkaef, L.G & Sutsilin, N.G. (1997). Metodologitseskie osnovi covremenoi podgotovki gimnastov vicokovo klasa (Methodological bases of contemporary preparation of elite gymnasts). *Teoria I praktika fizitseskoi kyltyri* (*Theory and Practice of Physical Education*), (in Russian), *11,* 7-26.

Arkaev, L.J. & Sutsilin, N.G. (2004). *Kak gotovits championov* (*How to prepare champions*). Fijkultura I sport (Physical Education and sport), (in Russian), p.315.

Borissenko, S.I. (2000). Povicenie icpolnitseskovo masterstva gimnastok na ocnove covercencvovania xoreografitseskoi podgotovki (*Improvement of gymnasts’ executional skill based on the improvement of their choreographic preparation*)(in Russian). Monography, St. Petersburg, Russia: State Academy of Physical Education P.F. Lesgaft.

Code of Points of Women’s Artistic Gymnastics, (W.A.G), 2013-16, International Federation of Gymnastics (F.I.G).

Code of Points of Women’s Artistic Gymnastics, (W.A.G), 2009-12, International Federation of Gymnastics (F.I.G).

Code of Points of Women’s Artistic Gymnastics, (W.A.G), 2005-2008, International Federation of Gymnastics (F.I.G).

Code of Points of Women’s Artistic Gymnastics, (W.A.G), 2001-2004, International Federation of Gymnastics (F.I.G).

Code of Points of Women’s Artistic Gymnastics, (W.A.G), 1996-2000, International Federation of Gymnastics (F.I.G).

Donti O. (2000). *Covercenstvovanie spetsialnoi texnitseskoi podgotovlenosti gymnastok 9-12 let (Development of special technical preparation of artistic gymnasts, aged 9-12 years old)* (in Russian). Unpublished Doctoral Thesis, National State Academy of Physical Education, P.F. Lesgaft, S. Petersburg, Russia.

F.I.G Report: Newsletter 34, December 2013

Gula D.A. (1990). *Dance choreography for competitive gymnastics*. Leisure Press, Champain, Illinois.

Karpenko, L.A. (1976). O vocpitanii virazitelnocti y zanimaioucixcia xydozesvenoi gimnastikoi (About the development of expressivity in athletes of rhythmic gymnastics). *Aktyalnie problem cportivnoi trenirovki* (*Contemporary problems of athletic training*),(in Russian). Leningrad, pp. 50-52.

Karpenko, L.A. (2003). *Xydozestvenaia Gimnastika* (*Rhythmic Gymnastics*), Russian Gymnastics Federation, St. Petersburg: Department of Physical Education, P.F. Lesgaft.p.380.

Lawson J. (1984). *Ballet class. Principles and Practice*. London: A. & C. Black Publishers.

Lazarenko, T.P. (1978). Kvalimetria v xydojestvenoi gimnastike (Qualimetry in Rhythmic Gymnastics), *Gimnastika (Gymnastics),* (in Russian), *1*, 33-39.

Lissitskaia, T.S. (1984). *Provedenie janiatii po xoreografii c gimnastkami* (*Choreography class with gymnastics athletes).* (in Russian). Teaching notes for students. State Academy of Physical Education and Athleticism, Russian State University of Physical Culture, Sport, Youth and Tourism (GTSOLIFK).

Lissitskaia, T.S. & Zaglada, B.E. (1997). Volnie ypraznenia zencin (Women's floor exercises). In Gaverdovski, G.K. (ed.) *Gymnastics All-Around* (pp. 3-16). Moscow: Physical Education and Athletism.

Lobjanidje, M.M. (1980). *Esthetika cportivnovo zrelica* (*Aesthetics of athletic performance)* (in Russian).Tbilisi.

McDermott E. (2009). Gymnastics choreography in a snap. http:// www.articlesbase.com.

Morel, F. (1987). *Choreographia v sporte (Choreography in sport*), Fizkyltyra I sport (Physical education and sport) (in Russian). Moscow, p 33.

Rozin, E.G. (1997). Nekotorie teoritiko-metodologitseskie aspect pedagogitsskovo kontrolia fizitseskovo sostoiania I podgotovlenosti sportsmenov (Some theoretical and methodological aspects of pedagogical control of athletes' physical preparation). *Teoria I praktika fizitseskoi kyltyri* (*Theory and Practice of Physical Education),* (in Russian), *11,* 41-44.

Rumba, O. (2014). Improving the quality of the rhythmic female gymnasts's feet performance by the means of traditional choreography. Science of Gymnastics, 5(3), 19-29.

Plehanova, M.E. (2006). *Aesthetitseskie aspect cportivno-texnitseskogo masterstva v cloznokordinatsionix vidax cporta (Aesthetic aspects of technical mastery in sports with difficult coordination)* (in Russian). Russian scientific-research institute of physical education and sport, p.168.

Savelieva, L.A. (1996). *Podgotovka trenerov-choreographov po cportivnoi gimnastike na osnove kompleksnovo analysa volnih-ypraznenii* (*Coaches-choreographers' preparation based on the floor exercises analysis)* (in Russian). Monography, St. Petersburg: Department of Physical Education Science P.F. Lesgaft.

Smolefski, V.M & Gaverdofski, U.K. (1999). *Sportivnaia gimnastika* (Artistic Gymnastics). Kiev: Olimpiskaia Literatyra.p.456.

Terekhina, R. (1997). *Kompleksnii analiz cportivnoi gimnastiki* (*Composite analysis of gymnastics).* (in Russian). St. Petersburg: Department of Physical Education, P.F. Lesgaft. p.45

Terekhina, R., Titov, G., & Turisheva, L. I. (1991). *Metodi ekcpertnoi otsenki icpolnitseskovo masterctvo gimnastov*, (*Evaluation methods of gymnasts'* *executional skill).* Teaching Notes, St. Peterburg: Department of Physical Education, P.F. Lesgaft p.31.

Tofler, I. R., Stryer, B. K., Micheli, L.J., & Herman L. R. (1996). Physical and Emotional Problems of Elite female gymnasts. *New England Journal of Medicine*, 335, 281-283.

Turisheva, L.I. (1986). *Komponenti icpolnitseskovo masterctva gimnastok I metodi ix otsenki* (*The components of gymnasts' executional skill and the method of their evaluation*). (in Russian). Unpublished doctoral thesis, St. Petersburg: Department of Physical Education, P.F. LESGAFT.

Zatsiorsky V.M. (1995). *Science and practice of strength training*. Human Kinetics, P.O Box 5076, Champaign, IL 61825-5076.p.242.

Corresponding author:

Olyvia Donti, PhD
Faculty of Physical Education and Sports Sciences,
41 Ethnikis Antistasis Str,
Daphne, 17237, Athens, Greece.
E-mail: odonti@phed.uoa.gr

INFLUENCE OF FUNDAMENTAL MOVEMENT SKILLS ON BASIC GYMNASTICS SKILLS ACQUISITION

Zoran Čuljak, Sunčica Delaš Kalinski, Ana Kezić, Đurđica Miletić

Faculty of Kinesiology, University of Split, Croatia

Original article

Abstract

This study was set to determine the existence of transfer of fundamental movement skills to the level of specialized gymnastics skills. 75 children (30 boys and 45 girls) represented the participants of the study. Fundamental movement skills were analyzed as well as twelve basic gymnastics skills according to the physical education curriculum that represent different apparatus in gymnastics all round competition. Significant influence of fundamental movement skills on all skills (criteria) is noticeable. According to the results of regression analysis, the participants who had better initial results in fundamental movement skills for surmounting obstacles also had better results of gymnastics skills in final measurement point. Highly structural connection of elements lies in the basis of high correlation of fundamental movement skills for surmounting obstacles and gymnastics skill springboard jump on the vault in sitting position which confirms Osgood's theory of positive transfer of similar skills.

Keywords: *level of performance, object manipulation, skills transfer, surmounting obstacles.*

INTRODUCTION

When learning gymnastics skills one has to stick to methodological principles of complex motor skills acquisition after reaching suitable level of simple motor skills (Delaš Kalinski, Miletić & Božanić, 2011). The acquisition of skills which isn't in accordance with current abilities of the one who learns could result in failure. In that matter, each gymnastics skill has a potentiality of vertical and horizontal progression which makes gymnastics one of the most attractive sports nowdays. In this sport, one can distinguish a path from natural movement to very complex acrobatic figures. Gymnastics is made of numerous discrete skills which turn to complex closed serial skills with the use of extraordinary inventiveness and originality.

The wide range of movements and positions makes it possible for children to develop a quality fund of sensory and motor pathways and make a positive stimulus on their psychosomatic status. Highly developed motor abilities and large movement skills fund can enable better everyday functioning. During that time, motor learning needs to be perceived as a process of gradual skills acquisition. This process starts with first incorrect, clumsy and slow attempts, over basic structures acquisition, to superior performance of skills in different circumstances.

Fundamental movement skills (FMS) are skills that unable children to interact and explore their environment. Besides being fundamental and irreplaceable in most human abilities and features, these movement structures make a firm base for the development of more advanced and complex movement skills (Gallahue & Donnelly, 2003; Payne & Isaacs, 2002.).

Although some FMS, like walking, are learned naturally throughout the developmental process, most of these skills have to be learned and further improved (Gallahue & Donnelly, 2003). A child whose FMS are not developed accordingly won't have quality basis upon which further specific movement patterns are developed. Besides, if FMS are not mastered in young age, motor activities advancement throughout life can be disrupted (Williams, 2003).

Gymnastics belongs to a group of basic sports that are defined as physical activities which contain such educational possibilities that can only partially be overcome with other sport disciplines. Also, doing basic sports in educational process of children from early age develops morphological characteristics that are fundamental for other sports (Gallahue & Ozmun, 2006).

Numerous studies that deal with abilities needed for successful gymnastics skills performance have been published: speed (Bradshaw, 2004; Lindner et al., 1991), strength (Lindner et al., 1991; Bradshaw & Rossignol, 2004), endurance (Bradshaw & Rossignol, 2004), agility (Daly et al., 2001), flexibility (Kirbi et al., 1981; Delaš et al., 2007; Maffulli et al., 1994), balance (Lindner et al., 1991; Peltenburg et al., 1982), and explosive strength (Bencke et al., 2002; Jemni et al., 2006; Delaš et al., 2007; Delaš et al., 2008). However, little research that point out to the selection and influence of FMS for quality basic and complex gymnastics skills acquisition exist (Leguet, 1987) and they all refer to the period of 80's and 90's. It is important to scientifically justify these relationships now days since International Gymnastics Federation (FIG) throughout their Foundation courses also uses these pedagogical tools.

The main problem of this research is to determine the existence of skills transfer between FMS and some basic artistic gymnastics skills. Empirical confirmation of such statements are often missing, but experiential knowledge of gymnastics experts witness the important role of FMS in gymnastics motor skills acquisition. In addition, due to gymnastics characteristics and benefits that active participation gives, experts state that gymnastics motor skills often have positive transfer on other motor skills. Although, hypothetically, a positive skills transfer from FMS to gymnastics skills can be expected, no experimental confirmation exists. In that matter, this research has an original scientific significance in experimental skills transfer research. Such transfer results can be expected according to: (1) identical elements theory (Thorndike, 1914) which originally hypothesized that transfer was based on the number of common elements shared by two skills. Osgood (1949) specified that rather than identical elements, it was similarities between the stimulus and response conditions of the two fundamental task; and (2) appropriate processing theory (Morris, Bransford & Franks, 1977) hypothesized that positive transfer is expected when practice conditions require learners to engage in problem – solving processes similar to those that the criterion task requires. More recent studies support earlier findings and indicate that such practice should be as variable as possible so that learners can explore and discover their own solutions, as well as the need for practice sessions to mimic the range of variations experienced during a competition (Williams & Hodges, 2005).

The main aim of this research is to determine the existence of transfer of FMS to the level of specialized gymnastics skills. This could be determined by measuring the influence of FMS in initial measuring point on the level of specialized gymnastics skills in the final point of measurement.

Before the realization of the main aim certain preliminary work has to be done: (1) determination of the metric characteristics of FMS and gymnastics skills, and (2) analysis of differences between the initial and final measurement point in gymnastics skills for determination of the learning process.

METHODS

75 children (30 boys and 45 girls) represented the participants of the study. They were all in the age of seven (± 6 months) from „Petar Bakula" elementary school, Mostar, Bosnia and Herzegovina. Boys averaged 132.0 cm in height and 31.4 kg in weight and with a BMI of 17.3, while girls averaged 129.6 cm in height and 29.3 kg in weight and with a BMI of 16.8. Boys and girls in current research were treated as a unique sample because physical education curriculum from grade 1 to 4 implies coeducation. In this developmental period girls and boys are similar in morphological, motor and functional features (Babin, Bavčević & Prskalo, 2010) as well as in fundamental movement skill development (Appache, 2005; Mc Kenzie et al., 1998).

FMS are analyzed according to research of Žuvela (2009) and Žuvela et al. (2011) in which FMS assessment instruments for young school children were constructed and validated. The first phase of those researches included the construction of 24 tests for assessment of FMS: six tests for each of the four motor skills area (object manipulation skills, resistance overcoming skills, space covering skills and surmounting obstacles skills) (Mraković, Metikoš & Findak, 1993). After metric indicators being precisely defined, the tests which had the highest factor scores were chosen to enter the final product: polygon. The following tests that are supposed to represent the certain motor area the best are: tossing and catching the volleyball against a wall consecutively; running across obstacles; carrying the medicine balls; and straight running.

The variables for basic gymnastics skills assessment were chosen according to the physical education curriculum and represent different apparatus in gymnastics all round competition. Certain aspects were respected when choosing the skills: (1) the variables were also teaching topics that need to be adopted in high level; (2) all skills can be practicable according to school's material terms; (3) according to previous research (Delaš Kalinski, 2009), same and similar gymnastics motor skills were applied in 7 year old pupils according to their abilities and pre-knowledge.

The following basic gymnastics skills were analyzed:

1. Bridge (MO)
2. Forward roll (KNP)
3. Descended backward roll (KNTK)
4. Blade stand (SNL)
5. Handstand against wall (SNRVP)
6. Dominant frontal cartwheel (PSČ)
7. Ring swinging with backswing mount (LJSZK)
8. Straight jump of springboard (SNDOD)
9. Springboard jump on the vault in sitting position (NSRK)
10. Switching positions on the rings (PVSK)
11. Walking on a small beam (HNG)
12. Jump-off of small beam (SPNNG)

The research was carried out during the first semester of 2011/2012 school year. Experimental procedure was conducted in school gym during official physical education classes led by highly experienced professional teacher. The procedure lasted 18 weeks in total, 39 school units, respectively. Artistic gymnastics motor skills formed the basis of the program (12 topics). Some of the traditional teaching topics from the official curriculum were inserted in the program as well (14 topics). Those topics contributed to the diversity of the experimental program itself and served as an excellent psychophysical preparation. Also, some of them served as an introduction to the methodology of the gymnastics motor skills training.

The participants were introduced to the skills that needed to be performed before the actual measurements of the FMS and gymnastics skills videotaping. Furthermore, every assignment and skill was explained and then demonstrated. Before the beginning of the assessment, participants had one probe and none of the tests were administered before the examiners were completely sure that the participants understood the assignment. After initial evaluation and videotaping, parents' approvals were collected and kinesiological treatment begun.

Videotaping of the final gymnastics skills learning stage was conducted after 18 weeks of experimental kinesiological program. This was followed by evaluation of the gymnastics skills by five judges. All judges were gymnastics coaches with more than 10 years of practice in the sport. The methodology of the skills' quality assessment (knowledge of performance) according to five-point Likert scale was based on research of Delaš Kalinski (2009), Miletić et al. (2004) and Božanić & Miletić (2011). A student was assigned 5 points if the performance was carried out without any mistakes and 1 point if the student was unable to perform the element. Small mistakes in the performance were graded with 4 points, medium mistakes with 3 points and great mistakes in performance were graded with 2 points.

The data were analyzed with the use of STATISTICA Windows 7.0 program, and the level of significance was set at $p<0.05$. Mean values, standard deviations, Kolmogorov-Smirnov test, Inter-item correlation and Cronbach alpha coefficients were calculated in terms of evaluating the objectivity and sensitivity of each of the FMS and gymnastics skills in initial and final measurement point. T test for dependent samples was used to determine significant changes in level of gymnastics motor skills from initial to final measurement point. For determining the transfer of FMS in initial measurement point (predictors) to the level of acquisition of gymnastics skills in the final measurement point (criterions), 12 regression analyses were calculated.

RESULTS

Table 1. *Metric characteristics of the FMS in initial measurement point (K-S -Kolmogorov-Smirnov test of normality, IIr – Inter-item correlation, αc - Cronbach alpha coefficient).*

Variable	Mean	SD	MIN	MAX	K-S	IIr αc
MBIHO	10.90	2.49	6.61	17.96	0.11	0.93
	10.20	2.10	6.21	17.10	0.13	
	10.46	2.12	6.51	17.22	0.15	0.97
PREPR	7.47	2.30	4.26	14.33	0.11	0.96
	7.16	2.23	4.34	16.00	0.12	
	7.31	2.23	4.50	15.00	0.13	0.98
ODINP	12.63	2.17	6.21	20.00	0.06	0.83
	11.24	1.97	6.89	16.32	0.09	
	11.79	1.82	6.77	16.11	0,10	0.92
PPRTR	5.31	0.63	4.26	7.12	0.07	0.80
	5.33	0.66	4.11	7.81	0.09	
	5.34	0.58	4.31	7.00	0.06	0.91

d=0.15 for N=75 ($p<0.05$)

Legend: MBIHO - tossing and catching the volleyball against a wall consecutively, PREPR - running across obstacles, ODINP - carrying the medicine balls, PPRTR - straight running

Table 2. *Descriptive statistics of gymnastics skills in initial (I) and final (F) measurement point: (Cronbach alpha (αc) and Kolmogorov Smirnov tests (K-S)).*

Variable	Mean (I)	SD (I)	αc (I)	K-S (I)	Mean (F)	SD (F)	αc (F)	K-S (F)
MO	1.84	0.96	0.97	0.24	3.64	1.08	0.98	0.14
KNP	1.90	0.66	0.96	0.20	3.56	0.82	0.96	0.14
KNTK	1.71	0.61	0.95	0.22	3.50	1.00	0.98	0.12
SNL	1.93	0.88	0.96	0.14	2.56	1.25	0.97	0.12
SNRVP	1.18	0.41	0.96	0.42	2.55	1.25	0.98	0.15
PSČ	1.46	0.76	0.98	0.37	2.67	1.32	0.99	0.11
LJSZK	1.79	0.71	0.96	0.21	3.25	0.85	0.96	0.11
SNDOD	1.57	0.53	0.92	0.17	3.20	0.90	0.97	0.14
NSRK	1.73	0.65	0.95	0.16	3.08	1.11	0.98	0.10
PVSK	1.27	0.60	0.98	0.45	2.49	1.45	0.99	0.23
HNG	2.23	0.55	0.93	0.18	3.55	0.84	0.96	0.10
SPNNG	2.16	0.43	0.93	0.35	3.66	0.81	0.96	0.12

d=0.15 za N=75 ($p<0.05$)

Table 3. *Results of regression analyses between FMS in initial measurement point and gymnastics skills in final measurement point.*

	MBIHO	PREPR	ODINP	PPRTR	R	R²	p
	Beta	Beta	Beta	Beta			
MO	-0.01	-0.34*	-0.13	0.03	0.38	0.14	0.02
KNP	-0.11	-0.38*	-0.08	-0.07	0.52	0.27	0.00
KNTK	-0.13	-0.31*	0.09	-0.17	0.47	0.22	0.00
SNL	-0.09	-0.43*	0.03	-0.04	0.49	0.24	0.00
SNRVP	-0.03	-0.51*	0.03	-0.05	0.54	0.29	0.00
PSČ	-0.08	-0.43*	-0.06	-0.08	0.55	0.30	0.00
LJSZK	-0.07	-0.52*	0.07	-0.09	0.59	0.35	0.00
SNDOD	-0.10	-0.31*	0.11	-0.32*	0.57	0.33	0.00
NSRK	-0.01	-0.54*	-0.21	0.00	0.65	0.42	0.00
PVSK	-0.08	-0.44*	-0.05	-0.05	0.54	0.29	0.00
HNG	-0.14	-0.38*	-0.11	-0.04	0.55	0.30	0.00
SPNNG	0.03	-0.30*	-0.13	-0.25	0.55	0.30	0.00

Legend: MBIHO - tossing and catching the volleyball against a wall consecutively, PREPR - running across obstacles, ODINP - carrying the medicine balls, PPRTR - straight running; * - significant predictor

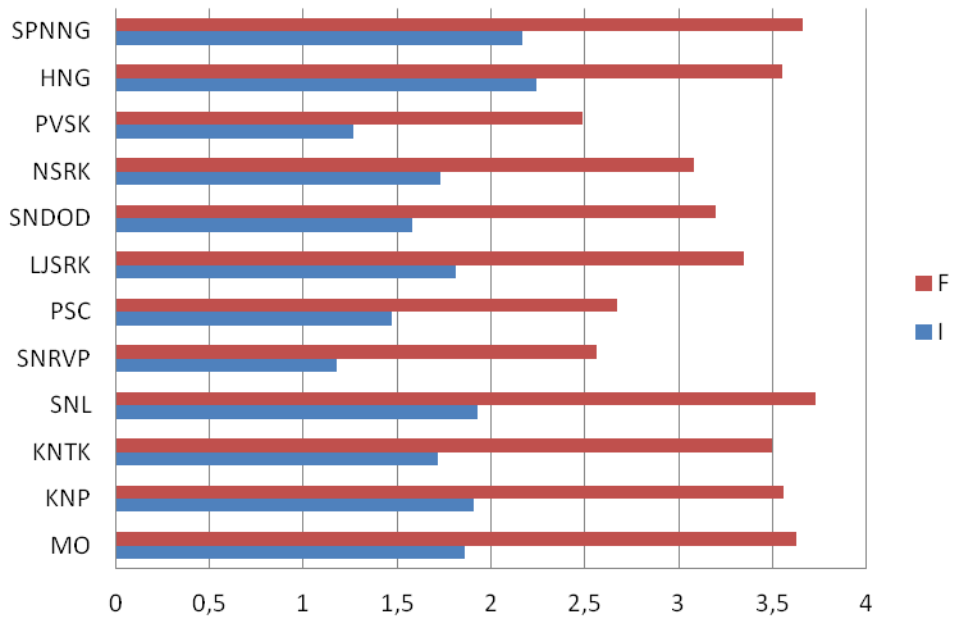


Figure 1. *Analysis of differences between initial (I) and final (F) measurement point in evaluation of gymnastics skills according to t test for dependent samples.*

According to descriptive statistics and K-S test results (Table 1) all FMS tests have satisfactory sensitivity. It is obvious from Table 2 that initial sensitivity in gymnastics skills tests proved not to be good, while in final measurement point the same tests have good sensitivity results. FMS objectivity parameters prove to be satisfactory, where Cronbach alpha ranges from .91 to .98 (Table 1) while for gymnastics skills tests Cronbach alpha ranges from .92 to .98 (initial) and .96 to .99 (final).

Figure 1 shows analysis of differences between initial and final measurement point in evaluation of gymnastics skills determined by t tests for dependent samples. According to significant differences gained we can establish significant progress in all of the skills which is a proof of efficient motor learning process. The biggest differences between the means in initial and final measurement point were noticed in blade stand (1.93 - 3.73), while the smallest differences occurred in dominant frontal cartwheel (1.47 - 2.67).

Table 3 represents the regression analyses results between the predictors (initial FMS) and different criterions (represented by gymnastics skills in final measurement point). Generally, significant influence of FMS (object manipulation, surmounting obstacles, resistance overcoming, space covering) on all skills (criterions) is noticeable. The level of significance in all analyses is 0.00, accept in bridge element, where the significance is 0.02. It is also noticeable how FMS for object manipulation and resistance overcoming haven't got significant influence on any of the gymnastics skills, while FMS for space covering has significant predictive influence only in straight jump of springboard element (Beta = -0.32). Opposed to this, FMS for surmounting obstacles has a significant statistical influence on all of the applied gymnastics skills.

By further inspection, we notice that the highest correlation exists between the predictors and the springboard jump on the vault in sitting position element (R=.65). Coefficient of determination has a value of 0.42 which means that the predictors explain 42% of criterion variance. The value of partial regression coefficient (Beta) in surmounting obstacles is -0.54. Opposed to high correlation value, the lowest R value (R=.38) was noticed in bridge element. Coefficient of determination has a value of 0.14 which means that the predictors explain 14% of criterion variance. Beta coefficient in surmounting obstacles is -0.34. In all other analyses the FMS predictors explain 22% to 35% of criterion variance – depending on a gymnastics skill.

Significant partial regression coefficient of FMS for straight running is noticeable only in straight jump of springboard element. This is also the only gymnastics skill in which two different FMS areas play significant roles – surmounting obstacles and space covering skills.

DISCUSSION

Questionable sensitivity of gymnastics skills tests in initial measurement point has been expected since the tasks on the beginning of the learning process are somewhat difficult for the children and their acquisition demands time and practice. For that matter, only the final level of gymnastics skills has been used for the research of transfer of knowledge. This kind of development in gymnastics skills acquisition has been researched by Delaš, Miletić & Božanić (2011) in 7 year old boys and girls. When comparing the results it can be noticed that the level of gymnastics skills (bridge, blade stand and forward roll) in the initial point of this research is lower than in the mentioned study. However, the values of means in the retention point do coincide. Regardless that the authors analyzed the level of skills separately by gender, we can conclude that the period of 18 weeks and 39 school lessons is enough for appropriate acquisition of basic gymnastics skills but that the possible differences in initial point occurred due to pre-knowledge or physical activity of children which are assumptions that need to be researched more thoroughly.

According to the results of regression analysis, the participants who had better initial results in FMS for surmounting obstacles also had better results of gymnastics skills in final measurement point. Highly structural connection of elements lies in the basis of high correlation of FMS for surmounting obstacles and gymnastics skill *springboard jump on the vault in sitting position* which confirms Osgood’s theory of positive transfer of similar skills.

According to the results of differences between initial and final measurements of gymnastics skills it can be concluded that the treatment was well planned and realized because students improved all gymnastics skills. These results can directly be applicable in physical education curriculum preparation where specific training frequencies need to be determinate and optimal gymnastics skills frequencies defined.

Students recorded the biggest progress in blade stand skill, while the smallest progress was made in dominant frontal cartwheel. A total frequency for blade stand was seven, while dominant frontal cartwheel had only one frequency more. Despite the fact that blade stand can be considered as simple gymnastics skill and dominant frontal cartwheel as complex gymnastics skill this treatment prescribed the same training time. So, the answer to the question what influences effective learning besides skill complexity needs to be found elsewhere. It is possible that style and learning strategy also have an effect on learning (Gardner, 2006; Kolb, 2005; Gregorc, 2006) within which authors analyze four kinds of premises: environmental, emotional, sociological and psychological. Besides this, fatigue, anxiety and lack of motivation can also affect motor learning efficiency (Coker, 2009). For more precise learning development parameters, more research needs to be done besides skills complexity.

The reasons why participants had higher level of FMS for surmounting obstacles and therefore learned all gymnastics skills easier could be: (1) their structural similarity or, (2) structural complexity of two motor skills areas (FMS for surmounting obstacles and gymnastics skills). Lots of FMS for surmounting obstacles (like jumping, landing, vaulting, wriggling and climbing) represent basic gymnastics skills in their original or modified form (like landing with or without running start, with or without swing, on one or both feet etc.). This is why it isn't always possible to categorize a skill exclusively in a certain group of FMS or gymnastics skills. This is a reason why artistic gymnastics is classified as basic kinesiological activity (sport).

According to their basic structure FMS for surmounting obstacles are similar to basic gymnastics skills, but besides that they are connected to FMS for space covering (like walking, running, crawling) and FMS for resistance overcoming (like hanging) in a modified form. These connections make FMS for surmounting obstacles probably the most complex skills when compared to other FMS areas. This complexity is probably the reason why statistically significant influence on all gymnastics skills occurred.

In case FMS for surmounting obstacles and gymnastics skills are observed through demands for some motor abilities their similarity can be noticeable. Arm, leg and shoulder strength, as well as coordination, balance and speed are crucial for gymnastics skills performance. On the other hand, arm and shoulder strength and coordination play an important role while climbing, coordination is vital in wriggling and jumps, vaults and landings demand leg power and coordination as well. Once again it can be concluded that this type of FMS (surmounting obstacles) probably belongs to a group of complex FMS because their movement structure clearly depends on multiple factors and engage a series of body regions. So, the importance of FMS for surmounting obstacles is apparent as it serves as a great base for all gymnastics skills upgrades.

In further result interpretation it is important to emphasize that the generalization of chosen tests for FMS (object manipulation, surmounting obstacles, resistance overcoming, space covering) was done according to research of Žuvela (2009). To successfully learn basic gymnastics skills students don't need to possess high levels of FMS for object manipulation (throwing, catching, juggling) or FMS for resistance overcoming (lifting, carrying, pushing, pulling). FMS for space covering (crawling, walking, running, rolling) are important for successful performance of straight jump of springboard element. According to this, it is possible that the students who had also higher and lower level of FMS gained different grades in gymnastics skills (from 1 to 5). Also, it can be concluded that higher initial level of FMS for surmounting obstacles is necessary for the seven year olds to be more successful in learning process of gymnastics skills. Therefore, this group of motor skills (FMS) has massive importance in forming the anthropological basis (Findak et al., 2000) on which gymnastics skills can be easily adopted.

In conclusion, while determining the transfer of initial FMS level on final gymnastics skills level one area of FMS for surmounting obstacles clearly allocated. The students who had higher level of FMS for surmounting obstacles learned the gymnastics skills more easily and where more successful in mastering all analyzed gymnastics skills. The reason could be the structural similarity and structural complexity of the two groups of skills. Gained results confirm the theory about positive learning transfer based on similarity of skills. Further research is necessary to determine other factors of influence on efficiency of gymnastics skills acquisition besides skill complexity, such as styles and strategies of learning, as well as student motivation. It is also important to determine the influence of physical and anthropometric qualities on transfer of gymnastics skills, since research (Collard et al., 2007) show that the transfer of gymnastics skills on other sport activities most probably depends on those qualities.

In the light of PE curriculum, it is crucial for the teachers to know that gymnastics elements can be implemented in the program earlier than provided because results prove their appropriateness. Also, if FMS skills for surmounting obstacles are insufficiently applied in PE classes, one can expect later difficulties in learning basic gymnastics skills. The strong connection of gymnastics skills and natural forms of movement (FMS) allocates the necessity of gymnastics skills application in PE classes, especially because this fact confirms similar goals of the programs.

REFERENCES

Apache R. R. (2005). Activity –based intervention in motor skill development. *Perceptual and Motor Skills*, *100* (3), 1011-20.

Babin, J., Bavčević, T., Prskalo, I. (2010). Comparative analysis of the specially programmed kinesiological activity on motor area structural changes of male pupils aged 6 to 8. *Croatian Journal of Education*, *12*(1), 79-96.

Bencke, J., Damsgaard, R., Saekmose, A., Jorgensen, P., Jorgensen, K, Klausen, K. (2002). Anaerobic power and muscle strength characteristics of 11 years old elite and non-elite boys and girls from gymnastics, team handball, tennis and swimming. *Scandinavian Journal of Science and Medicine in Sports, 12* (3), 171-178.

Božanić, A. & Miletić, Đ. (2011). Differences between the sexes in technical mastery of rhythmic gymnastics. *Journal of Sports Sciences*, *29*(4), 337-343.

Bradshaw, E. (2004). Target-directed running in gymnastics: a preliminary exploration of vaulting. *Sports Biomechanics*, *3*(1), 125-144.

Bradshaw, E. J. & Le Rossignol, P. (2004). Anthropomet and biomechanical field measures of flor and vault ability in 8 to 14 year old talent – selected gymnasts. *Sports Biomechanics, 3*(2), 249-262.

Coker C. A, (2009) Motor Learning and Control for Practitioners, *HH Publishers*

Collard, L., Oboeuf, A., Ahmaidi, S. (2007). Motor skills transfer from gymnastics to swimming. *Perceptual & Motor Skills, 105*(1), 15-26.

Daly, R. M., Bass, S. L., Finch, C. F. (2001). Balancing the risk of injury to gymnasts: how efective are the counter measures? *British Journal of Sports Medicine*, *35* (1), 8-18.

Delaš Kalinski S., Miletić, Đ., Božanić, A. (2011). Gender – based progression and acquisition of gymnastic skills in physical education. *Croatian Journal of Education, 13*(3), 4-24.

Delaš Kalinski, S. (2009). Learning dynamics of artistic gymnastics motor skills. (Doctoral thesis). Zagreb: Faculty of Kinesiology.

Delaš, S., Babin, J., Katić, R. (2007). Effects of biomotor structures on performance on competitive gymnastics elements in elementary school female sixth-graders. *Collegium Antropologicum*, *31*(4), 979-985.

Delaš, S., Zagorac, N., Katić, R. (2008). Effects of biomotor structures on performance on competitive gymnastics elements in elementary school male sixth-graders. *Collegium Antropologicum*, *32*(2), 443-449.

Findak, V., Metikoš, D., Mraković, M, Neljak, B., Prot, F. (2000). *Motorička znanja*. Zagreb: Fakultet za fizičku kulturu.

Gallahue, D. L., Donnelly, F. C. (2003). *Developmental physical education for all children* (4th ed.). Champaingn, IL: Human Kinetics.

Gallahue, D. L., Ozmun, J. C. (2006). Understanding Motor Development: Infants, Children, Adolescent, Adults, 6th ed. Sydney: McGraw-Hill.

Gardner, H. (2006). Multiple intelligences: new horisonts. New York. Basic Books.

Gregorc, A. F. (2006). The mind styles model: theory, principles, and applications. Columbia, CT: Gregorc.

Jemni, M., Sands, W. A., Friemel, F., Stone, M. H. Cooke, C. B. (2006). Any effect of gymnastics training on upper -body and lower-body aerobic and power components in national and international male gymnasts? *Journal of Strength and Conditioning Research*, *20*(4), 899-907.

Kirbi, R. L., Simms, F. C., Symingtone, V. J., Garner, J. B. (1981). Flexibility and musculosceletal symptomatology in female gymnasts and age–matched controls. *American Journal of Sports Medicine*, *9*(3), 160-164.

Kolb, D. (2005). Learning styles inventory: version 3.1. Boston: Hay Group.

Leguet, J. (1987). As ações motoras em Gymnastics esportiva. São Paulo: Manole.

Lindner, K. J., Caine, D. J., Johns, D. P. (1991). Withdrawal predictors among physical and performance characteristics of female competitive gymnasts. *Journal of Sports Sciences, 9*(3), 259-272.

McKenzie, T. L., Alcaraz, J. E., Sallis, J. F. et al. (1998). Effects of a physical educat on program on children's manipulative skills. *Journal of Teaching in Physical Education*, *17*(3), 327-41.

Miletić, D., Katić, R. & Maleš, B. (2004). Some anthropological factors of performance in rhythmic gymnastics novices. *Collegium Antropologicum,* 28, 727-737.

Morris, C. D., Bransford, J. D. & Franks, J. J. (1977). Levels of processing versus transfer appropriate processing. Journal of Verbal learning and Verbal Behavior, *16*, 519-33.

Mraković, M., Metikoš, D. and Findak, V. (1993) Theoretical model of classification of motor knowledge. *Kinesiology 25,* 132-140.

Osgood, C. E. (1949). The similarity paradox in human learning. *Psihological review, 56,* 132-43.

Payne, V.G., Isaacs, L. D. (2002). Human motor development: A lifespan approach, 5th ed. Boston, MA: McGraw-Hill.

Peltenburg, A. L., Erich, W. B. Bernink, M. J., Huisveld, I. A. (1982). Selection of talented female gymnasts, aged 8 to 11, on the basis of motor abilities with special reference to balance: a retrospective study. *International Journal of Sports Medicine*, 3*(1)*, 37-42.

Thorndike, E. L. (1914). Educational psychology. New York. Columbia University.

Williams, A.M., Hodges, N.J. (2005). Practice, instruction and skill acquisition: Challenging tradition. *Journal of Sport Sciences, 23*(6), 637-650.

Williams,W. (2003). Using your personal digital assistant to store lesson plans. *Journal of Physical education*, *Recreation & Dance*, 73(3).

Žuvela, F. (2009). Construction and validation of fundamental movement skills measuring instrument. (Doctoral thesis). Split: Faculty of Kinesiology.

Žuvela, F., Božanić, A., Miletić, Đ. (2011). POLYGON – A new fundamental movement skills test for 8 year old children: construction and validation. *Journal of Sports Science and Medicine*, *10*.

Maffulli, N. N., King, J. B., Helms, P. P. (1994). Training in elite young athletes (the training of young athletes (TOYA) study): Injuries, flexibility and isometric strength. *British Journal of Sports Medicine*, *28*(2), 123-136.

Corresponding author:

Ana Kezić, PhD
Faculty of Kinesiology - University of Split;
Teslina 6; Split – 21000, Croatia
Phone: +385 21 302 440
Fax: +385 21 385 399
e – mail: anakezic@kifst.hr

RELATION BETWEEN ACROBATIC ELEMENTS KNOWLEDGE AND ALPINE SKIING PARALLEL TURNS AMONG PHYSICAL EDUCATION STUDENTS

Edin Mujanović, Almir Atiković, Amra Nožinović Mujanović

University of Tuzla, Faculty of Physical education and Sport, Bosnia and Herzegovina

Original article

Abstract

The main aim of this study was to determine the correlation of motor knowledge of acrobatic elements with successful performance of parallel turns in alpine skiing. An additional aim was to determine whether there is a difference between groups divided on the basis of knowledge of alpine skiing. The research was conducted on a sample of 27 students enrolled in the third year of study at the Faculty of Sport, by the chronological age of 21-23 years. The sample of variables consisted of 14 variables to assess knowledge of acrobatic elements and one variable to assess the performance of the ski element parallel turns. The results indicate a statistically significant correlation between some acrobatic elements (e.g. with roll forward r= .438) with performance of parallel turns at the level of significance (p<0.05). Students, who have acquired the technique of acrobatic elements on the higher level or on the level of stabilization and automation with minor mistakes, achieve better results when learning the element of skiing technique – parallel turns. Based on the analysis of results we can conclude that some elements of acrobatics and skiing can interconnect according to the requirements for the motor abilities required for successful performance of acrobatic elements and we can say that the learning of acrobatic elements on higher level have a positive influence on the learning of element of alpine ski technique.

Keywords: *motor knowledge, acrobatics, skiing, students.*

INTRODUCTION

Skiing belongs to the activities which take place in specific conditions of the outside environment, and the success in Alpine disciplines is primarily dependent on the level of adopted specific motor knowledge of alpine skiing (Franjko, 2007; Cigrovski, Matković & Prlenda, 2009), but also on the level of motor abilities of speed, strength, coordination, balance and functional abilities of aerobic and anaerobic endurance (Andersen, Montgomery & Turcotte, 1990; Klika & Malina, 1997; Reid, Johnson, Kipp, Albert & White, 1997; Dolenec & Žvan, 2001; Mujanović, 2005; Cigrovski, 2007; Mujanović & Krsmanović, 2008; Cigrovski, Matković & Matković, 2008). Skiing as a sport sets the great physical and mental efforts in front of the skiers, requiring from them exceptional agility, coordination, strength and endurance, since the winner in competitive skiing today is decided by only of a one-hundredth of a second (Cigrovski & Matković, 2003).

All-round development of young athletes implies the use of various sports contents, and will create good conditions for future specialization in a particular sport, which also applies to alpine skiing. The reason for this approach is the fact that none of the sports branch ensures overall development of the organism of a young athlete. Therefore, fitness training of most young athletes contains elements of different basic sports such as gymnastics, athletics or swimming (Kostelić, 2005; Franjko, 2007; Živčić & Krističević, 2008). In addition to basic motor abilities for success in alpine skiing significant role have cognitive and psychological factors which for success have an equal or greater significance (Axtell et al., 1997; Neumayr et al., 2003).

Sport gymnastics is classified in the group of conventional sports, considering that the aesthetic component and acyclic movement are based on strict rules of the Code of Points (FIG, 2013). Because of the structural complexity of movements in sport gymnastics, great attention is given to the execution of the basic acrobatics that later evolves into more complex and more difficult elements (Živčić, Furjan Mandić and Horvatin Fučkar, 2007). Due to this, training must be directed towards the achievement of a model execution, toward maintaining and improving it over a long period of time (Sands, W.M.A. et al., 1999). The importance of acrobatics in sport gymnastics is evident in the quantity of the elements performed in gymnastics compositions. Acrobatic elements are important in the procedure of teaching gymnastics elements on other apparatuses (Karascony and Čuk, 2005). Acrobatics is acyclic sport characterized by a great diversity of movement and with its many and varied elements have a very positive impact on the development of the overall coordination of movement (Bolkovič & Kristan, 1998). According to Živčić & Krističević, (2008) acrobatics is acyclic sport that encompasses a large number of various simple and complex static and dynamic elements with precisely defined technique, which can be interconnected and combined. Acrobatic elements have a significant influence on the ability to move the body in space, which improves overall coordinative motor ability of the entire body and its parts. Also, very accurate and fast work and alternating activation of individual muscles and muscle groups, acrobatics develop all forms of strength, where the explosive strength is the most important (Živčić, 2007; Cigrovski & Matković, 2007). When athlete performs certain acrobatic elements, the range of motion in certain joints and joint systems is very important, as well as an aesthetic component, which is manifested through the accuracy of the position of the body and body parts. Therefore, the acrobatics requires but also affects on the development of flexibility as one of the essential motor abilities. The most significant characteristic of acrobatics is the specific strength of the upper body, required for the performance of most acrobatic elements.

Acrobatics is very widespread in all sports branches. It should be noted that many sports use acrobatic elements for easier mastering of certain specific movements (Kostelić, 2005). Therefore, it is not uncommon that wrestlers, judo players and in general martial art athletes, track and field athletes such as high and pool vault jumpers, skiers, snowboarders and other athletes practicing acrobatics elements for easier and more successful mastering of certain jumps, falls, throws, turns and also their significant influence on development of coordination abilities. Also, acrobatic elements are an integral part of some sports, such as diving, acrobatic rock 'n' roll, skydiving, ice skating, acrobatic skiing, etc. Planning of training for alpine skiers need to be based on all-round preparation (Kostelić, 2005), keeping in mind that tests to assess the explosive strength (jumps) have the highest predictive value for success in alpine skiing (Bosco, 1997; Žvan & Lešnik, 2000). The aim of this study is to determine the correlation of acrobatic skills with performance of ski technique element, parallel turns, at students of the third year of the Faculty of Sport. Knowledge about the different factors that may improve skiing performance might help to prevent injury and improve the level of specific motor knowledge of alpine skiing with the means of gymnastics-acrobatics.

METHODS

The test sample included 27 male students enrolled in the third year of study at the Faculty of Sport, by the chronological age of 21-23 years. Students who participated were healthy, without those excused from physical education for health reasons, and they all gave their written consent to participate in testing. All students were regularly involved in the subjects of acrobatics and skiing with lectures and exercise for one semester and none of the examinees had practice the acrobatics or skiing before. The study was approved by the ethics committee of the Faculty of Sport. The teaching process of the subject sports gymnastics that takes place in the winter semester of the third year of university studies contains exercises in gymnastics hall: the basic elements of acrobatics and jumps on a mini trampoline, for 30 hours during the semester and lectures for 45 hours during the semester.

In determining the level of motor knowledge of acrobatic elements, the examinees were evaluated in fourteen elements as follows: RF = Roll forward, HRF = Handstand roll forward, RD = Roll dive, RB = Roll backward, RBH = Roll backward to handstand, TCLR = Two cartwheels on left side following right side, ROB = Round off backward, ROF = Round off forward, FS = Front scale, SSS = Supported shoulder stand, SJ = Straight jump, TJ = Tucked jump, PSJ = Pike straddle jump, SJT = Straight jump with turn 360^0. In determining the level of specific motor knowledge of alpine skiing the examinees were evaluated in performance in one element of ski technique PT= Parallel turns.

The acrobatic tests, with description of movements and certain mistakes, were used by authors (Novak, Kovač & Čuk, 2008; Krističević, Živčić, Cigrovski, Simović & Rački, 2010; Živčić Marković & Breslauer, 2011; Kovač, 2012). Description of movements during performance of parallel turns and common mistakes are explained by the authors (Jurković & Jurković, 2005; Mujanović, 2005; Cigrovski, 2007; Weller, 2007-13). The analytical method of assessment is used.

Evaluation of motor knowledge of acrobatic elements was carried out at gym hall with set-up of six mats placed one behind the other touching along shorter side. Each mat was 2m long and 1m wide with height/thickness of 6cm. All jumps were performed on mini trampolines were set-up was with 15m for run with 2 mats placed behind the mini trampoline (for safety reasons), where each mat was 2.5m long and 2m wide with height/thickness of 20cm.

Specific motor knowledge of alpine skiing, parallel turns, was evaluated on the slope of an incline 15^o-16^o (blue track in Mariborsko pohorje ski resort). Set-up of the slope was with 10m of width and 30m of length and marked by safety fence. Criteria with measurement scale and description of standards that are based on the quality of execution for acrobatic tests and ski test are presented in (Table 1). All students who participated in this study were subjected to testing under the same conditions.

The data was collected during evaluation. Evaluation of ski technique element was carried out with the students during the morning hours between 09:00 and 10:00 and after that in the afternoon hours between 14:00 and 15:00 the examinees participated in evaluations of motor knowledge of acrobatic elements. After warming up, the test task was explained and demonstrated to the students; following that students performed the task three times under the same conditions. Performances of the task were evaluated with the unique protocol by three examiners who are familiar with the way of the assessment. The examiners had to fulfil the following conditions: they had to have a University degree in Physical education and sport and to have the theoretical and practical knowledge of alpine skiing and acrobatic elements. Examiners in this study are professors with years of experience of work in various sports clubs and Faculty of physical education and sport. Before the assessment, they carefully read the description of task and criteria (Table 1). Afterwards, they independently assessed all performances. Only better performance of performed ski element and acrobatic elements was used in the analysis. After evaluation of better performance, we calculated the final grade for each examinee in each task as the arithmetic average of the ratings assigned by the three examiners. For evaluation, they used points from 0 to 5 point measuring scale, according to the criteria, where grade 5 is the highest/best. Kovač (2012) conclude that with appropriate criteria, sufficiently precise for the evaluator, every PE teacher who is well prepared for the evaluation could objectively and reliably evaluate different motor skills, and according to stated the assumption is that the examiners in this study with respect to theoretical and practical knowledge have a high level of objectivity and reliability.

Also authors Majerič, Kovač, Dežman & Strel (2005) conclude that the analytical method of assessment is most appropriate for testing and evaluating at the end of the entire athletics programme when students have already mastered the test exercise and their knowledge has already been tested, which is also the case in this study.

Data obtained in this study were analyzed using a software system for data. We used standard statistical procedures to determine the basic descriptive parameters of variables. Hypothesis that a variable is normally distributed was checked with the Skewness and Kurtosis coefficients. Spearman's rank correlation coefficient as a nonparametric measure of statistical dependence between two variables was used to determine values of correlation coefficients between acrobatic elements and skiing element. In order to determine whether there are differences between the groups, based on knowledge of skiing, we used Mann Whitney U test as a non-parametric test because a certain number of examinees have a higher value than others.

RESULTS AND DISCUSSION

Comparing the basic descriptive parameters (Table 2.), it is noted that the majority of measured motor knowledge of acrobatic elements show grades of arithmetic mean in the zone of medium values 1.802–4.136, with a standard deviation from .745 to 1.114. For skiing element PT arithmetic mean is 2.543, with a standard deviation .907. Results for Skewness and Kurtosis are in the acceptable range. Reliability of examiners is tested by Intraclass correlation coefficients (ICC) analysis and we can see high values of ICC in range of .778 - .951. According to the values of ICC we can say that there is a high reliability of examiners in this study.

Analyzing the results of other authors (Delaš Kalinski, Surjan Bilac & Atiković, 2012) for acrobatic knowledge on specific apparatuses, it can be seen that the lowest mean values on vault were achieved for the elements Squat vault and Squat vault with ½ turn (mean=3.87) and on the floor exercises for SSS =3.94, RB=3.77 and RD=3.98. Mean values of grades for specific apparatuses (vault, uneven bars, beam, floor and rings) are within the range of school grade “very good” (Uneven bars=4.06; Vault=4.09; Rings=4.14; Balance beam=4.20; Floor=4.23). Authors Cigrovski, Matković & Matković (2010) in their research came to a result where the two groups of ski beginners, for the demonstration of knowledge of alpine skiing in parallel turns after having conducted two different programs, obtained average grades 3.20 with a standard deviation .76 for the first group and 2.85 with a standard deviation .77 for the second group.

Table 1. *Criteria for knowledge evaluation.*

Measurement scale (points)	Description of standards - Skiing	Description of standards - Acrobatics
5	Student performs skiing element, with self confidence, without technical and aesthetic mistakes.	Student performs acrobatic element independently, with reliability, without technical and aesthetic mistakes.
4	Student performs skiing element with lack of self confidence and with discontinuous pushing of lower extremity joints onward and in the direction of new turn.	Student performs acrobatic element independently, but not with complete reliability; during the execution he/she makes small technical or aesthetic mistakes.
3	Student performs skiing element, with lack of self confidence, and with inappropriate load of skies at the beginning of the turn, and discontinued pushing of lower extremity joints onward, and in the direction of new turn.	Student performs acrobatic element independently, but not with complete reliability; during the execution he/she makes one large technical mistake and several small aesthetic mistakes; or several small technical and aesthetic mistakes.
2	Student performs skiing element without self confidence, with no moves along the longitudinal axis, with inappropriate load on skies at the beginning of the turn and without pushing of lower extremity joints onward and in the direction of new turn.	Student performs acrobatic element independently, but not reliably; execution includes large technical and aesthetic mistakes.
1	Student performs skiing element and makes all listed technical mistakes.	Student performs acrobatic element in easier conditions or environment (down the slope, over the shoulder, into kneeling or straddle position, with help).
0	Student is unable to perform skiing element. He moves down the slope but does not keep the skies in parallel; has uneven connection of turns; tempo of performance is too slow without appropriate closure of the turn.	Student cannot perform acrobatic element or does not execute all part of element.

Table 2. *Descriptive parameters of acrobatic and ski elements.*

Valid N27	Mean	Min	Max	Std. Deviation	Skewness	Kurtosis	Intraclass Correlation
SSS	4.136	1.667	5.000	.921	-.968	.492	.897
TCLR	2.346	1.000	4.333	.903	.183	-.936	.891
HRF	2.457	1.000	4.000	.921	-.157	-1.210	.864
RBH	1.914	1.000	4.333	.972	1.332	1.239	.897
ROB	2.222	1.000	4.667	1.054	.410	-.774	.936
ROF	1.802	1.000	4.667	1.079	1.183	.475	.951
SJ	3.691	2.333	5.000	.745	.235	-.911	.841
TJ	3.482	2.333	5.000	.759	.522	-.706	.778
PSJ	3.494	2.000	5.000	.997	-.255	-1.318	.884
SJT	2.457	1.000	4.000	1.114	-.035	-1.572	.943
FS	2.852	1.667	5.000	.781	.622	.727	.825
RF	3.531	2.000	5.000	.775	-.137	-.618	.838
RB	3.062	1.333	4.333	.857	-.192	-1.065	.881
RD	2.741	1.000	4.333	.770	-.151	.148	.813
PT	2.543	1.000	4.000	.907	-.122	-.979	.940

Test distribution is significant at the .01 level (2-tailed).

Table 3. *Spearman's rank correlation coefficient of results obtained for performance of acrobatic elements and ski element.*

Spearman's rho	SSS	TCLR	HRF	RBH	ROB	ROF	SJ	TJ	PSJ	SJT	FS	RF	RB	RD
PT	.351	.402*	.176	.397*	.333	.362	-.252	.145	.117	-.002	.229	.433*	.430*	.406*
Sig. 2-tailed	.073	.038	.380	.040	.090	.064	.204	.472	.561	.990	.251	.024	.025	.036

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4. *The results of two groups in the arithmetic mean ranks.*

	GRUPA	N	Mean Rank	Sum of Ranks		GRUPA	N	Mean Rank	Sum of Ranks
SSS	1	12	11.33	136.00	PSJ	1	12	10.46	125.50
	2	15	16.13	242.00		2	15	16.83	252.50
	Total	27				Total	27		
TCLR	1	12	11.17	134.00	SJT	1	12	12.46	149.50
	2	15	16.27	244.00		2	15	15.23	228.50
	Total	27				Total	27		
HRF	1	12	11.88	142.50	FS	1	12	11.38	136.50
	2	15	15.70	235.50		2	15	16.10	241.50
	Total	27				Total	27		
RBH	1	12	10.71	128.50	RF	1	12	9.63	115.50
	2	15	16.63	249.50		2	15	17.50	262.50
	Total	27				Total	27		
ROB	1	12	12.17	146.00	RB	1	12	10.17	122.00
	2	15	15.47	232.00		2	15	17.07	256.00
	Total	27				Total	27		
ROF	1	12	11.04	132.50	RD	1	12	10.38	124.50
	2	15	16.37	245.50		2	15	16.90	253.50
	Total	27				Total	27		
SJ	1	12	14.38	172.50	PT	1	12	6.50	78.00
	2	15	13.70	205.50		2	15	20.00	300.00
	Total	27				Total	27		
TJ	1	12	11.46	137.50					
	2	15	16.03	240.50					
	Total	27							

Table 5. *Significance of differences between groups.*

Elements	Test Statistics				
	Mann-Whitney U Test	Wilcoxon W	Z	Asymp. Sig. (2-tailed)	Exact Sig. [2*(1-tailed Sig.)]
SSS	58.000	136.000	-1.613	.107	.126[a]
TCLR	56.000	134.000	-1.678	.093	.103[a]
HRF	64.500	142.500	-1.256	.209	.217[a]
RBH	50.500	128.500	-1.956	.050	.053[a]
ROB	68.000	146.000	-1.086	.278	.300[a]
ROF	54.500	132.500	-1.869	.062	.083[a]
SJ	85.500	205.500	-.223	823	.829[a]
TJ	59.500	137.500	-1.511	.131	.139[a]
PSJ	47.500	125.500	-2.093	.036	.037[a]
SJT	71.500	149.500	-.911	.362	.373[a]
FS	58.500	136.500	-1.563	118	.126[a]
RF	37.500	115.500	-2.588	.010	.009[a]
RB	44.000	122.000	-2.279	.023	.025[a]
RD	46.500	124.500	-2.162	.031	.032[a]
PT	.000	78.000	-4.420	.000	.000[a]

The descriptive statistical parameters have shown that the students' scores for motor knowledge of acrobatic elements and specific motor knowledge of alpine skiing are in range of medium values. This indicates that their knowledge acquired during the duration of semester is without the complete movement structure so therefore they need to spend more instructional themes in acrobatic elements and alpine skiing element to overcome the elements at a higher level in order to reduce the number of errors during the performance at minimum to get higher scores. We can say that exercise has an important role in students' training because it effectively changes the properties and developing skills which would directly provide higher scores and also help in health promotion as an irreplaceable factor in all human activities.

The elements of acrobatics and alpine skiing can be correlated considering similar demands in terms of motor abilities, which are required for their successful performance, such as coordination, agility, orientation in space, compatibility in movement of certain body parts and the whole body, then static strength of the upper body, legs, arms and shoulders (Cigrovski & Matković, 2003; Cigrovski et al., 2008). In (Table 3) we can see coefficients of Spearman's rho correlation between acrobatic elements and ski element. Statistically significant correlation, at ($p<0.05$) level of significance, with specific motor knowledge of alpine skiing – parallel turns achieved variables RBH (r: .397), TCLR (r: .402), RD (r: .406), RB (r: .430), RF (r: .433).

Similar results of the research of correlation of acrobatic knowledge and result in specific motor knowledge of alpine skiing were confirmed by the authors (Krističević et al., 2010), where the same variables achieved high values of correlation coefficients: RF (r: 0.64;

$p<0.01$), RB (r: 0.58; $p<0.01$), RD (r: 0.65; $p<0.01$), TCLR (r: 0.63; $p<0.01$). On the basis of the correlation analysis we assume that learning acrobatic elements have a positive influence on the mastering of certain elements in alpine skiing. In addition to the direct correlation of motor knowledge of acrobatic elements with specific motor knowledge of alpine skiing during the implementation of acrobatic elements in fitness training we indirectly influence on the development of motor abilities, depending on the load level, the duration of training and the frequency of such training.

According to grades that we got for the performance of element of ski technique PT = parallel turns, based on the value of the mean (2.543) examinees were divided into two categories in order to determine whether there is the differences in knowledge of examinees in each category of specific motor knowledge of alpine skiing. This variable we named GROUP and the first category (1) consists of below-average examinees (score lower than 2.543) while the second category (2) consists of above-average examinees (score higher than 2.543).

Results of the Mann Whitney U test (Table 5.) have shown that the examinees differ on a statistically significant level in variables RBH $p=.050$, PSJ $p=.036$, RF $p=.010$, RB $p=.023$, RD $p=.031$, PT $p=.000$. If we look at the results of the Mean Rank (Table 4.) in these variables we see that the differences are in favor of second category (2), whose values for the performance of element of ski technique PT= parallel turns are defined as above-average. Based on this we can say that for greater succes in specific motor knowledge of alpine skiing – parallel turns it is necessary to have a higher level of motor knowledge of acrobatic elements.

Within a similar research, a group of authors (Živčić, 2007; Krističević et al., 2010) obtained the results showing that for the successful performance in one group of acrobatic elements (RF, RB, RD) is required coordination while the second group of acrobatic elements RBH is defined by the strength of arms, shoulders and the static strength of the upper body and for the successful performance in the third group of acrobatic elements PSJ is required strength of the legs and it can be assumed that this is based primarily according to the motor abilities required for successful performance of these elements.

In his research Mujanović (2005) got the results of the canonical analysis where it is isolated only one significant and positive pair of canonical factors (Canonicl R .73) that explains correlation of motor abilities and success in performing elements of technique in alpine skiing at the level of significance ($p\leq0.05$). It is also clearly noticeable that the largest projection of the vector of manifest variables to assess the motor abilities has an explosive strength of legs with correlation coefficient .577 and .582.

Cigrovski, Božić & Prlenda, (2012) in their research state that taking into account obtained results, it is possible to emphasize agility and static strength to contribute the most in learning the specific motor knowledge of alpine skiing – parallel turns.

Parallel turns are based primarily on the circular movements and movement along the vertical axis. In order to facilitate the change of direction a skier used accentuated movements vertically with intensive extension and flexion of the knee joint which resulting in unloading the tails of skis in the same rhythm from one to another direction. Also a very important element in the execution of parallel turns is properly co-ordinated performance of movement. Accordingly to described movements necessary to perform element of ski technique parallel turns, we can say that the acrobatic elements RB, RD and RF have the greatest significance on the statistical level and that they are more important for success in the execution of skiing than the acrobatic element RBH which is on the verge of statistical significance ($p=.050$). It is probably so because the main part of the acrobatic element RBH performs on the hands and it is less important for skiing, while for the performance of acrobatic elements RB, RD and RF is necessary coordination of the whole body with the take-off that must be parallel with the exact dosage of strength and direction which coincides with the movement during the performance of the specific motor knowledge of alpine skiing – parallel turns which results in unloading the tails of skis and setting of skiers shoulder axis in the direction of the new turn.

The dynamic structure of motion required during skiing activity of the whole body, but at the same time we must emphasize primarily normal leg action, i.e. cycle of stretching and bending for modulation of external forces in order to keep carved turn or dynamic equilibrium (Mester, 1997). Therefore it is essential to choose exercises for developing strength of the lower extremities among which is a statistically significant acrobatic element PSJ and for whose performance is primarily important explosive strength of the legs which is for skiers necessary for intensive extension and flexion of the knee joint and transition to the next turn. Also during the performance of PSJ athletes performed straddle shape during flights. This movement in skiing can occur in unwanted situations where there is a need to spread the legs to maintain balance.

Consequently it can be said that the some elements of acrobatics and skiing can interconnect according to the requirements for the motor abilities required for successful performance of acrobatic elements and we can say that the learning of acrobatic elements on higher level have a positive influence on the learning of element of alpine ski technique. Also, it can be said that the level of knowledge of acrobatic elements future skiers should adopt on the level of automation which is characterized by coordinating harmonization of movement that form the structure of a particular movement, which indirectly affects the development of motor abilities all in order to facilitate the acquisition of specific motor knowledge of alpine skiing.

CONCLUSION

The analysis of the results in this research has shown correlation between the level of knowledge in acrobatics and the level of specific motor knowledge of alpine skiing – parallel turns at students beginners in skiing. Correlation indicates that the students, who have acquired the technique of acrobatic elements on the higher level or on the level of stabilization and automation with minor mistakes, achieve better results when learning the element of skiing technique – parallel turns what is confirmed by Mann Whitney U test. We can say that the obtained results should be taken as a guide for skiing teachers when developing plans for beginner skiers as important fact to include some elements of acrobatics in the dry land training program for beginner skiers for a proper body preparation prior to skiing course. In fact, the versatile alpine skier can influence development and improvement of his motor abilities using a variety of exercises and tasks that are used in other sports. Based on the obtained results it can be assumed that learning of acrobatic elements, as additional training in skiing, can have a positive influence on the success of the performance of elements in alpine skiing – parallel turns. Whether this will be so or will alpine ski beginners learn alpine skiing better when they implement elements of acrobatic in their training we need to conduct an experiment with acrobatic training as the intervention and change in ski performance as the outcome.

As we can see this research confirms some findings of previous researches and we can say that acrobatics through applied exercises can develop certain motor abilities that are correlated with specific motor knowledge of alpine skiing – parallel turns.

REFERENCES

Andersen, RE., Montgomery, DL. Turcotte, RA. (1990). An on-site test battery to evaluate giant slalom skiing performance. *The Journal of Sports Medicine and Physical Fitness, 30*(3), 276-282.

Axtell, RS., Rinehardt, KF., Finn, JA., Stofan, JR., Martens, DW., Keneftick, RW. (1997). Physiological indices of elite junior alpine skiers. In: Muller, E., Schwameder, H., Kornexl, E. & Raschner, C. (Eds), *Science and skiing*. London: E&FN Spoon, 471-477.

Bolkovič, T. & Kristan, S. (1998). Akrobatika [Acrobatics. In Slovenian.]. Ljubljana: Faculty of sport

Bosco C. (1997). Evaluation and planning condition training for alpine skiers. In: Muller E, Schwameder H, Kornexl E, & Raschner C. (Eds), *Science and skiing.* London:E&FNSpoon, 229-250.

Cigrovski, V. (2007). Učinkovitost različitih metoda u procesu učenja skijaških znanja [Effectiveness of different methods in the process of learning skiing skills. In Croatian.]. (Unpublished doctoral dissertation). Zagreb: University of Zagreb, Faculty of Kinesiology.

Cigrovski, V. & Matković, B. (2003). Specifična kondicijska priprema skijaša [Specific fitness preparation of skiers]. In: Milanović, D., Jukić, I. (Eds), *Proceedings Conditioning of Athletes*, (pp. 518-520). Zagreb: Faculty of Kinesiology, University of Zagreb.

Cigrovski, V. & Matković, B. (2007). Prikaz nekih testova za procjenu eksplozivne snage kod mladih alpskih skijaša [Showing some tests to assess explosive strength in young alpine skiers]. In: *Proceedings Conditioning of Athletes* (pp. 308-311). Zagreb: Faculty of Kinesiology, University of Zagreb.

Cigrovski, V., Matković, B. & Matković, B. (2008). Koje motoričke sposobnosti doprinose boljem učenju elemenata skijaške tehnike [What are motor skills contribute to better learning elements of skiing]. In: Maleš, B., Miletić, Đ., Kondrić, M., Kvesić., M. (Eds), *Proceeding book of 3rd International Conference Contemporary Kinesiology, Mostar, 2008,* (pp. 54-59). Split: Faculty of Kinesiology, University of Split; Faculty of natural science, mathematics and education, University of Mostar; Faculty of Sport, University of Ljubljana.

Cigrovski, V., Matković, B. & Prlenda, N. (2009). Correlation between balance and learning of alpine skiing. *Croatian Sports Medicine Journal*, *24,* 25-29

Cigrovski, V., Matković, B. & Matković, B. (2010). Can we make the alpine ski learning more efficient by omitting the snow-plough technique? *SportLogia 6*(2), 51-57

Cigrovski, V., Božić, I., Prlenda, N. (2012). Influence of motor abilities on learning of alpine ski technique. *SportLogia* 8(2), 108–115

Delaš Kalinski, S., Surjan Bilac, M. & Atiković, A. (2012). Adekvatnost nastavnog programa ženske sportske gimnastike [The adequacy of the curriculum of female artistic gymnastics. In Croatian.] V: Kezić, A., Miletić, Đ., Krstulović, S., Grgantov, Z., Bavčević, T., (Eds.). *Proceeding book of 4th International Conference Contemporary Kinesiology, Split, 2012, (pp 537-544).* Split: Faculty of kinesiology, University of Split.

Dolenec, M. & Žvan, M. (2001). Competitive success of junior female alpine skiers in light of certain chosen tests of co-ordination. *Kinesiologia Slovenica*, 7*(1-2)*, 19-22.

FIG (2013). *Code of Points – Men's Artistic Gymnastics.* Fédération Internationale de Gymnastique

Franjko, I. (2007*). Faktori uspješnosti izvedbe skijaških elemenata* [Factors ski execution elements. In Croatian.]. (Unpublished master's thesis). Zagreb: Faculty of Kinesiology, University of Zagreb.

Jurković, N. & Jurković, D. (2005). Skiing: The Technique, Methodology and Training. Zagreb: Graphis d.o.o.

Karascony I. & Čuk, I. (2005). *Floor Exercises: methods, ideas, curiosities, history.* Ljubljana: ŠTD Sangvinčki.

Klika, RJ. & Malina, RM. (1997). Predicting skiing performance in 14-18 year old competitive alpine skiers. In: Muller, E., Schwameder, H., Kornexl, E., Raschner, C. (Eds), *Science and skiing*. London: E&FN Spoon, 273-284.

Kostelić, A. (2005). Prikaz i analiza kondicijske pripreme Ivice i Janice Kostelić tijekom sportske karijere (razvoj i rezultati). [Presentation and analysis of traning Ivica and Janica Kostelić during sports career (development and results). In Croatian.]. (Unpublished bachelor's thesis). Zagreb: Faculty of Kinesiology, University of Zagreb.

Kovač, M. (2012). Assessment Of Gymnastic Skills At Physical Education – The Case Of Backward Roll. *Science of Gymnastics Journal*, 4(3): 25-35.

Krističević, T., Živčić, K., Cigrovski, V., Simović, S. & Rački, G. (2010). Correlation of motor acrobatic skills with success in slalom and giant slalom in young alpine skiers. *Croatian Sports Medicine Journal*, 25: 9-15.

Majerič, M., Kovač, M., Dežman, B. & Strel, J. (2005). Analysis of three different ways of assessing motor abilities with the testing assignment of long jump with approach. In D. Milovanović & F. Prot (eds.), *Proceedings book. 4th International Scientific Conference on Kinesiology* (pp. 98–102). Zagreb: Faculty of Kinesiology, University of Zagreb.

Mejovšek, M. (2003). Uvod u metode znanstvenog istraživanja. [Introduction to the methods of scientific research. In Croatian.]. Zagreb: Faculty of Education and Rehabilitation Sciences, University of Zagreb.

Mester, J. (1997) Movement regulation in alpine skiing. V Proceedings book of 1st International Congress on Science and Skiing, St. Cristoph a. Arlberg (pp. 333-348). London: E&FN Spon.

Mujanović, E. (2005). Prediktivna vrijednost nekih morfoloških i motoričkih karakteristika za predviđanje uspjeha u tehnici skijanja studenata [Predictive value of some morphological and motor characteristics to predict the success of students in the technique of skiing. In Bosnian.]. (Unpublished master's thesis). Tuzla: Faculty of Physical Education and Sport, University of Tuzla.

Mujanović, E. & Krsmanović, R. (2008). Predictive value of motor abilities on the result in criteria variable ski short turns. *Sport Scientific and Practical Aspects*, *5*(1-2), 61-65.

Neumayr, G., Hoertnagl, H., Pfister, R., Koller, A., Eibl, G. & Raas, E. (2003). Physical and Physiological Factors Associated with Success in Professional Alpine Skiing. *International Journal of Sports Medicine*, 24(8): 571-575.

Novak, D., Kovač, M. & Čuk, I. (2008). *Gimnastična abeceda*. [Gymnastic alphabet. In Slovenian.]. Ljubljana: Faculty of Sport, University of Ljubljana.

Reid, RC., Johnson, SC., Kipp, RW., Albert, RW. & White, AT. (1997). Validity of sport-specific field tests fot elite and developing alpine ski racers. In: Muller, E., Schwameder, H., Kornexl, E., Raschner, C. (Eds), *Science and skiing*. London: E&FN Spoon, 285-296.

Sands, W.M.A. et al. (1999). Muscular Analysis of the Front Handspring. *Technique, 19(4)*, 5–8.

Živčić, K. (2007). Akrobatska abeceda u sportskoj gimnastici [Acrobatic alphabet in artistic gymnastics In Croatian.]. Zagreb: Faculty of Kinesiology. University of Zagreb.

Živčić, K., Furjan-Mandić, G. & Horvatin-Fučkar, M. (2007). The kinematic model of the bounce–off phase in some acrobatic elements with forward body rotation. Facta Universitatis - Physical Education and Sport, *5*(1), 9–18.

Živčić Marković, K. & Breslauer, N. (2011). Opis nastavnih tema i kriteriji ocjenjivanja – tjelesna i zdravstvena kultura u razrednoj nastavi [Description of curriculum topics and assessment criteria - physical education in elementary school], LIP Print, Zagreb.

Živčić, K. & Krističević, T. (2008). Specifične pripremne vježbi u akrobatici – Primjenjivo u drugim sportskim granama i vrstama tjelesne aktivnosti [Specific preparatory exercise in acrobatics - Applicable in other sporting disciplines and types of physical activity] *Conditioning training*, *6*(1): 22-29.

Žvan, M. & Lešnik, B. (2000). Correlation of some variables of explosive power and competitive successfulness of boys in alpine skiing. *Kinesiology*, *32*(1), 40-6.

Weller, S., (2007-13). Parallel turns. Available online at: http://www.mechanicsofsport.com/skiing/manoeuvres/parallel_turn.html (Accessed 20 July 2010).

Corresponding author:

Almir Atiković
University of Tuzla, Faculty of Physical education and Sport,
Bosnia and Herzegovina

E-mail: almir.atikovic@untz.ba

Slovenski izvlečki / Slovene Abstracts

Abie Grossfeld

110 LETNA ZGODOVINA SVETOVNIH PRVENSTEV V TELOVADBI

V članku je predstavljen zgodovinski pogled na spremembe v 110 letni zgodovini svetovnih prvenstev v telovadbi od leta 1903 do leta 2013. V vsej zgodovini je bilo veliko sprememb v načinu tekmovanj, dosežkih ekip in posameznikov, predstavitvi posameznih prvin, povečevanju težavnosti prvin, sojenju, načinu ocenjavanja, številu članov ekip na tekmovanju, starostne omejitve, spremmbe orodij, načinu izobraževanja in usposabljanja trenerjev in sodnikov, razširjanju inofromacij in povečevanju medijske odmevnosti.

Ključne besede: zgodovina, telovadba, pravila, sodniki

Georgios Papadopoulos, Vasilios Kaimakamis, Dimitrios Kaimakamis. Miltiadis Proios

OSNOVNE ZNAČILNOSTI PRAVIL IN TEKMOVANJ V TELOVADBI OD LETA 1896 DO 1912

Od prve polovice devetnajstega stoletja so si telovadci prizadevali za pravično ocenjevanje, ko se je pričelo s preprostimi oblikami tekmovanja. V naslednjih letih so bili preskušani različni tekmovalni sistemi in pravila, ki niso bila sprejeta in uporabljana med vsemi državami in zvezami. Dve mednarodni združenji (MOK in FIG) sta organizirali mednarodna tekmovanja (olimpijske igre in mednarodna tekmovanja), kjer so sodelujoče države sprejele pravila prirejena za posamezno tekmovanje. Pomanjkanje splošno sprejetih pravil je povzročilo veliko problemov na šestih olimpijskih igrah v obravnavanem obdobju. To dejstvo je ustvaril sumničavost med telovadci in še posebej v okviru obeh mednarodnih zvez, ki sta imeli neposreden vpliv na napredek in razvoj tega športa.

Ključne besede: telovadba, olimpijske igre, tekmovalni sistemi, pravila, sojenje

William A Sands, Brent Alumbaugh, Jeni R McNeal, Steven Ross Murray, Michael H Stone

PRIMERJAVA VPLIVA VZMETI NA PARTERJU NA ODRIVE PRI SKOKIH V SMERI NAZAJ

V zadnjih desetletjih se je veliko izvajalo akrobatske skoke na parterju z vzmetmi. Za vzmeti se je uporabljalo različne elastične materiale in njih oblike s ciljem povečanja odrive hitrosti in blaženja doskoka. Cilj raziskave je bil ugotoviti uspešnost standardne cilindrične vzmeti (10.7 cm višine x 5 cm premera, 9 col) in drugačne vzmeti (10.7 cm višine , stožčaste s premerom od 5 cm na 6.7 cm diameter, 9 col) pri odrivih. Na vzorcu deklet (14.8±2.8 let, 159.0±7.2 cm višine, 49.3±7.1 kg mase) so bili izmerjeni kontaktni časi in hitrost gibanja težišča telesa. Podatki so bili merjeni s sistemom Vicon^{TM}, ki je meril 43 točk z 10 kamerami pri hitrosti 200 Hz. Rezultati so kazali visoko zanesljivost. Analiza je vsebovala 2x3 ANOVA za ponovljene meritve. Med vzmetmi ni bilo ugotovljenih razlik v kontaktnih časih niti v hitrosti gibanja težišča telesa pri odrivu nazaj. Razlike v obliki vzmeti lahko povzročijo drugačen koeficient razteznosti in hitrosti povratki v prvotno stanje, vendar se te razlike zadušijo s sposobnostjo prilagoditve telovadke, preproge in podloge pod preprogo ter vrste lesenih ali fiberglasovih plošč parterja.

Ključne besede: vzmetni parter, salto nazaj, skoki, primerjava.

Roman Farana, Jaroslav Uchytil, David Zahradník, Daniel Jandacka, Frantisek Vaverka

RAZLIKE V KLJUČNIH KINEMATIČNIH ZNAČILNOSTIH TEŽKIH PRESKOKOV TIPA PREMET SALTO IN CUKAHARA PRI VRHUNSKIH TELOVADCIH

Cilj naloge je bil primerjati ključne kinematične značilnosti dveh različnih vrst preskokov pri vrhunskih telovadcih na tekmovanjih za svetovni pokal. V raziskavi je sodelovalo 20 telovadcev, ki so nastopali na svetovnem pokalu na Češkem leta 2010 in 2011. Telovadci so izvajali skoke premet salto naprej in cukahara skoke s težavnostjo 5.2. Preskoki so bili snemani z dvema kamerama s hitrostjo 50 Hz. Podatki so bili analiziran s pomočjo SIMI MOTION programske opreme. Primerjava je pokazala značilne razlike v tehniki skokov. Čeprav obe vrsti skokov delita enako težavnost, so skoki tipa premet naprej salto naprej težji, saj zahtevajo večjo amplitude v drugem letu.

Ključne besede: kinamatična analiza, telovadba, tehnika.

Olyvia Donti, Anastasia Donti, Kalliopi Theodorakou

VPLIV PRAVIL NA SPREMEMBE V OSNOVNI PRIPRAVI TELOVADK: PRIMER KOREOGRAFSKE PRIPRAVE

FIG Pravila za ocenjevanje so dokument, ki usmerja vadbo telovadk v vsakem olimpijskem ciklu posebej in tudi ocenjuje izvedbo telovadkinih sestav. Študija je imela dva cilja. Najprej ugotoviti, kakšne so bile spremembe pravil od leta 1996 in kako so vplivala na spremembo vadbe ter kako so te spremembe vplivale na spremembo vadbe koreografije. Ob tem smo pregledali dosegljivo literaturo na področju koreografske priprave ter analizirali izvedbe finalistk na uradnih tekmovanjih, ter vpliv koreografske priprave na težavnost sestav na parterju in na gredi. Anlizirana so bila naslednja tekmovanja: OI 2012 v Londonu, SP 2013 v Antwerpnu in EP 2013 v Moskvi. Osnovna priprava je nepretrgan proces, ki je postavljen na osnovi modela prvine in njegove virtuozne izvedbe. Telovadkina osnovna koreografska priprava je usmerjena v izvedbo preprostih prvin brez napake, ki so osnova za izvedbo težjih koreografskih prvin, ki povečajo težavnost sestave, ter zmanjšajo akrobatsko naravnanost le-te in tako ohranjajo značilnost športa kot umetnosti.

Ključne besede: tehnika, izvedba, umetnost

Zoran Čuljak, Sunčica Delaš Kalinski, Ana Kezić, Đurđica Miletić

VPLIV OSNOVNIH GIBALNIH SPRETNOSTI NA UČENJE TELOVADNIH PRVIN

Cilj naloge je bil ugotoviti poveznaost in prenos znanja osnovnih gibalnih spretnosti na telovadno znanje. Merjenih je bilo 75 otrok (30 dečkov in 35 deklic). Preverjali smo znanje osnovnih gibalnih znanj in znanje 12 telovadnih prvin, ki so vključene v učni načrt in predstavljajo del telovadnega mnogoboja. Opazen je značilen vpliv osnovnih gibalnih znanj na znanje telovadnih prvin. Regresijska analiza je pokazala, da so otroci z boljšo sposobnostjo premagovanja ovir, bolje znali telovadne prvine, prav tako pa tudi bolje napredovali v času poskusa. Tako se je potrdila Osgoodova teorija o pozitivnem prenosu znanja med podobnimi vsebinami.

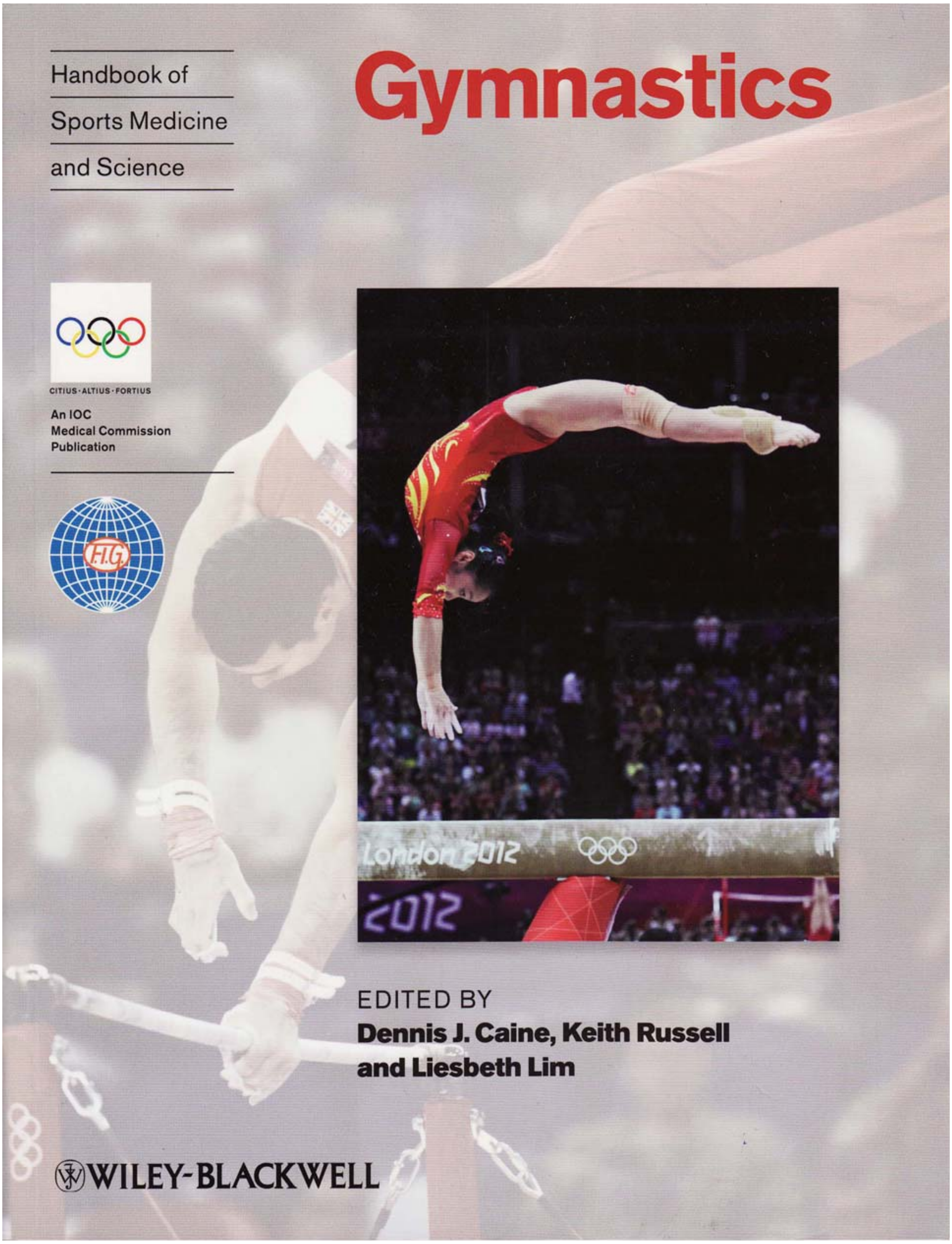
Ključne besede: stopnja izvedbe, ročne spretnosti, prenos znanja, premagovanje ovir

Edin Mujanović, Almir Atiković, Amra Nožinović Mujanović

POVEZANOST ZNANJA PRVIN AKROBATIKE IN ZNANJA VZPOREDNEGA ZAVOJA ALPSKEGA SMUČANJA PRI ŠTUDENTIH TELESNE VZGOJE

Prvi cilj raziskave je bil ugotoviti povezanost med znanjem akrobatskih prvin in uspešnostjo izvajanja smučarskega vzporednega zavoja. Drugi cilj pa je bil ugotoviti ali se razlikujejo uspešna/neuspešna skupina pri smučarskem znanju tudi pri znanju akrobatskih prvin. Vzorec 27 študentov telesne vzgoje (starih 21-23 let) tretjega letnika Fakultete za telesno vzgojo in šport je bil merjen na 6 stopenjski lestvici znanja pri obeh športih. Rezultati kažejo na značilno povezanost znanja obeh športnih področij. Študenti, ki so bolje obvladovali znanje akrobatike so bili tudi uspešnejši pri učenju in znanju smučarskega vzporednega zavoja.

Ključne besede: gibalno znanje, akrobatika, smučanje, študenti


Handbook of
Sports Medicine
and Science
Gymnastics
CITIUS·ALTIUS·FORTIUS
An IOC
Medical Commission
Publication
F.I.G.
London 2012
2012
EDITED BY
Dennis J. Caine, Keith Russell
and Liesbeth Lim
WILEY-BLACKWELL

This edition first published 2013, © 2013 International Olympic Committee
Published by John Wiley & Sons, Ltd

Wiley-Blackwell is an imprint of John Wiley & Sons, formed by the merger of Wiley's global Scientific, Technical and Medical business with Blackwell Publishing.

Registered office:
John Wiley & Sons, Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial offices:
9600 Garsington Road, Oxford, OX4 2DQ, UK
The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK
111 River Street, Hoboken, NJ 07030-5774, USA

For details of our global editorial offices, for customer services and for information about how to apply for permission to reuse the copyright material in this book please see our website at www.wiley.com/wiley-blackwell

Library of Congress Cataloging-in-Publication Data
Gymnastics / edited by Dennis J. Caine, PhD, Keith Russell, PhD, Liesbeth Lim, MD.
pages cm — (Handbook of sports medicine and science)
Includes bibliographical references and index.
ISBN 978-1-118-35758-3 (softback : alk. paper)—ISBN 978-1-118-35753-8—
ISBN 978-1-118-35754-5 (mobi)—ISBN 978-1-118-35756-9 (pdf)—
ISBN 978-1-118-35757-6 (pub) 1. Gymnastics. 2. Gymnastics injuries. 3. Gymnasts—Health and hygiene.
4. Sports medicine. I. Caine, Dennis John, 1949- II. Russell, Keith, 1944- III. Lim, Liesbeth.
RC1220.G95G96 2013
617.1'027644—dc23

2013007055

A catalogue record for this book is available from the British Library.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

Cover image: Main image: © 2012 / Comité International Olympique (CIO) / HUET, John.
Background image: © 2012 / Comité International Olympique (CIO) / HUET, John.

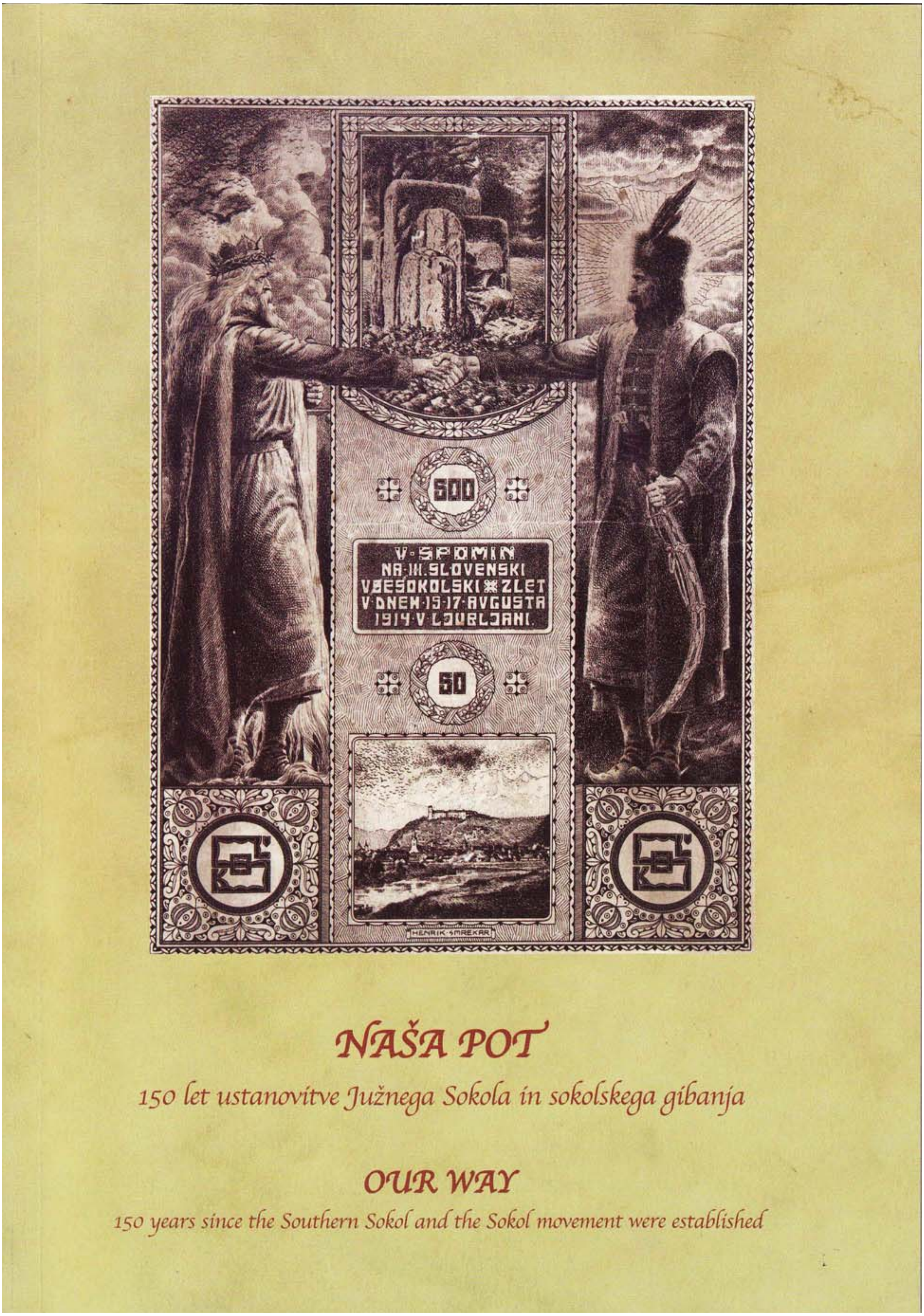
Cover design by OptaDesign.co.uk

Set in ITC Stone Serif Std 8.75/12pt by Aptara Inc., New Delhi, India
Printed and bound in Malaysia by Vivar Printing Sdn Bhd

1 2013

Contents

v


500
V SPOMIN
NA III. SLOVENSKI
VSESOKOLSKI ZLET
V DNEH 15-17 AVGUSTA
1914 V LJUBLJANI.
50
HENRIK SMREKAR
NAŠA POT
150 let ustanovitve Južnega Sokola in sokolskega gibanja
OUR WAY
150 years since the Southern Sokol and the Sokol movement were established

KAZALO

4

5